ICES HAWG REPORT 2011

ICES ADVISORY COMMITTEE

ICES CM 2011/ACOM:06

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

16 - 24 March 2011

ICES Headquarters, Copenhagen

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

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

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

Recommended format for purposes of citation:

ICES. 2011. Report of the Herring Assessment Working Group for the area South of 62 deg N (HAWG), 16 - 24 March 2011, ICES Headquarters, Copenhagen. ICES CM 2011/ACOM:06 .744 pp.

Contents

Executive Summary

The ICES herring assessment working group (HAWG) met for 7 days in March 2011 to assess the state of 7 herring stocks and 3 sprat stocks. The working group conducted update assessments for four of the herring stocks. No analytical assessments were carried out for the remaining four herring stocks although available survey and/or fishery data were examined. No update assessments were possible for any of the sprat stocks.

The SSB of **North Sea autumn spawning herring** in autumn 2010 was estimated as 1.30 million t. $F_{2\text{-}6}$ in 2010 was estimated at 0.12, below the target $F_{2\text{-}6}$ of 0.2. The year classes from 2002 are estimated to be among the weakest since the late 1970s. In particular, the most recent year class, 2010, was estimated to be about 80% higher than 2008, but still lower than long term average. Best estimates of catches in 2010 were 187 000 t, a slight increase from 168 000 t in 2009. The **Western Baltic spring spawning** stock's SSB is now estimated around 95 000 t and has declined substantially in the last three years. Fishing mortality in 2009 was 0.30, closer to the proxy for F_{MSY} (0.25) than in previous years. Recruitment has declined consistently from 2003 to 2008. When maturing, these poor year classes are expected to have a reducing effect on the spawning stock biomass. The **Celtic Sea autumn and winter spawning** stock has continued to increase, and remains in a state of recovery. SSB in 2010 was estimated as 114 000 t, and mean $F_{2\text{-}5}$ remained at a very low estimate (0.08). Catch in 2009/2010 was among the lowest in the time series (8 300 t). Two strong and two weak year classes have recruited recently. **West of Scotland autumn spawning** stock's SSB (in 2010) was estimated as 62 000 t. The stock is currently fluctuating at a low level and is being exploited below estimated F_{MSY}. Recruitment has been low since 1998. Catch in 2010 was 19 900 t, a slight increase from 2009. **West of Ireland (Division VIaS and VIIb,c) autumn- and winter/spring-spawning** stock cannot be assessed analytically because no tuning data are yet available. However, there are indications that the stock is at a low level, with a series of low recruitments. Current levels of SSB and F are unknown. Catch in 2010 was 10 200 t, not very different from the catch in 2009 (10 400 t). **Irish Sea autumn spawning** herring was not assessed analytically. Survey indicators and exploratory assessments suggest increasing SSB, whilst stable fishing effort suggests a stable or declining F. Catches (4 900 t in 2010) have been close to TAC level in recent years. Catches of the **Clyde spring spawning** stock were 300 t in 2010, but no sampling or other information was available.

Given the poor datasets, no reliable estimates of stock status of **North Sea sprat** were possible. Catches in 2010 were 144 000 t at the level of the catches in 2009 (133 000 t). The data available for **sprat in Division IIIa** were too sparse to perform an assessment. The total landings were 10 700 t in 2010, compared to 9 200 t in 2009. **Sprat in VIId,e** catch had almost doubled a level of 4 400 t compared to the catches in 2009 (2 700 t). No assessment of this stock was possible. For the first time a presentation of **Celtic Sea sprat** was made in the group. The total catches in 2010 was estimated to 8 100 t. There was not performed assessment on sprat in this eco-region as further work is required to determine stock structures and identity.

A generic term of reference was to consider the F_{MSY} framework in the preliminary drafting of advice, which the group did for all stocks, where this was possible.

The working group commented on special requests from MFSDSG and SIASM in the section dealing with ecosystem related issues.

The working group also commented on the quality and availability of data, the problems with estimating the amounts of discarded fish, the use of the data system INTERCATCH, and provided an overview of some of the roles of herring in the ecosystem.

1 Introduction

1.1 Participants

Valerio Bartolino	Sweden
Steven Beggs	UK/Northern Ireland
Maurice Clarke (Co-Chair)	Ireland
Lotte Worsøe Clausen (Co-Chair)	Denmark
Mark Dickey-Collas	The Netherlands
Afra Egan	Ireland
Katja Enberg	Norway
Tomas Gröhsler	Germany
Joachim Gröger	Germany
Emma Hatfield	UK/Scotland
Niels Hintzen	The Netherlands
Cecilie Kvamme	Norway
Susan Mærsk Lusseau	UK/Scotland
Henrik Mosegaard	Denmark
Peter Munk	Denmark
Mark Paine	Switzerland and Denmark
Beatriz Roel	UK/England & Wales
Norbert Rohlf	Germany
Barbara Schoute	ICES Secretariat
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2010/2/ACOM06 The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Maurice Clarke, Ireland and Lotte Worsøe Clausen*, Denmark, will meet at ICES Headquarters, 16–24 March 2011 to:

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

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

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

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

HAWG will report by 4 April 2011 for the attention of ACOM.

Fish Stoc k	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Perform assessment	Advice
her-3a22	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Y	Update
her-47d3	Herring in Subarea IV and Division IIIa and VIId	Germany	NL	UK (Scotland)	Y	Update

	(North Sea Autumn spawners)					
her-irls	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Ireland	Ireland		Y	Update
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland		Y	Same advice as last year
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)		Y	Same advice as last year
her-vian	Herring in Division VIa (North)	UK (Scotland)	UK S		Y	Update
spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	Norway	Denmark	-	Y	Same advice as last year
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Y	Update
spr-eche	Sprat in Division VIId,e	Norway	-	-	N	Catch statistics only
spr-celt	Sprat in the Celtic Seas					Collate data

The Generic Terms of Reference for all working groups are presented below:

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

b) Update, quality check and report relevant data for the working group:

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

   ii) Abundance survey results;

   iii) Environmental drivers.

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

c) Produce an overview of the sampling activities on a national basis based on the INTERCATCH database and report the use of InterCatch;

d) In cooperation with the Secretariat, update the description of major regulatory changes (technical measures, TACs, effort control and management plans) and comment on the potential effects of such changes including the effects of newly agreed management and recovery plans.

e) For each stock update the assessment by applying the agreed assessment method (analytical, forecast or trends indicators) as described in the stock annex. If no stock annex is available this should be prepared prior to the meeting.

f) Produce a brief report of the work carried out by the Working Group. This report should summarise for the stocks and fisheries where the item is relevant:

   i) Input data (including information from the fishing industry and NGO that is pertinent to the assessments and projections);
   ii) Where misreporting of catches is significant, provide qualitative and where possible quantitative information and describe the methods used to obtain the information;
   iii) Stock status and 2012 catch options;
   iv) Historical performance of the assessment and brief description of quality issues with the assessment;
   v) Mixed fisheries overview and considerations;
   vi) Species interaction effects and ecosystem drivers;
   vii) Ecosystem effects of fisheries;
   viii) Effects of regulatory changes on the assessment or projections;

g) Where appropriate, check for the need to reopen the advice in autumn based on the new survey information and the guidelines in AGCREFA (2008 report).

h) For the stocks where the advice is marked 'collate data', available data should be collected and presented as far as possible. If information is available for more than or only part of the area, the header for the stock can be adapted (please discuss with the secretariat).

   a) In the EG report please indicate how advice for this stock can be given in future; both what timing (data availability over the year) and analytical / trends based assessment options are concerned.

   b) A draft advice sheet should be produced that presents available information and informs about the status of the stock assessment possibilities.

Special request ToR 2) Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision.

Special request ToR 3) Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.

Special request ToR 4) Take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP).

Special request ToR 5) Provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

Special request ToR 6) Identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

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

ToR	Stock	Addressed in Section
1 a) – g)	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Section 2
1 a) – g)	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Section 3
1 a) – g)	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Section 4
1 a) – g)	Herring in Division VIa (North)	Section 5
1 b) – f)	Herring in Divisions VIa (South) and VIIb,c	Section 6
1 b) – f)	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	Section 7
1 a) – g)	Sprat in Subarea IV (North Sea)	Section 8
1 b) – f)	Sprat in Division IIIa (Skagerrak - Kattegat)	Section 9
Collate data	Sprat in the Celtic Seas	Section 10
1 b) – c) and f)	Sprat in Division VIId,e	Section 11
Collate data	Stocks with limited data	Section 11
SR ToR 2	-	Section 1.8
SR ToR 3	-	Section 1.8
SR ToR 4	-	Section 1.8
SR ToR 5	-	Section 1.8
SR ToR 6	-	Section 1.8

1.3 Working Group's response to special requests

Two special requests were received by HAWG in 2011. Both came from other ICES groups, the Marine Strategy Framework Directive Steering Group (MSFDSG) and the Strategic Initiative on Area Based Science and Management (SIASM).

From MFSDSG came the following TORs:

Identify elements of the EGs work that may help determine status for the 11 Descriptors set out in the Commission Decision.

Provide views on what good environmental status (GES) might be for those descriptors, including methods that could be used to determine status.

From SIASM, came the following TORs:

Take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP).

Provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

Identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

As these TORs relate to the ecosystem, they are dealt with in Section 1.8.

1.4 Reviews of groups or projects important for the WG

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

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

HAWG was informed about the WGCHAIRS meeting in January 2010. A wide array of initiatives being led by the ACOM leadership was communicated to working group chairs. The presentation focused on the following main outcome relevant for HAWG:

Recommendations: Guidelines on to Experts Groups on drafting recommendations has been made available, and chairs are encouraged to follow them. ICES advice is provided by ACOM and it is important to minimise the risk of other text being interpreted as ICES advice.

WD; documentation: There had been incidences where WD's in EG reports were used as basis for advice but were not available to the reviewers. It was stressed that WD should if used when making draft advice, it must be assured that the WD is available for other than HAWG members, either fully documented as part of the HAWG report, or included as an annex to the HAWG report, or provided with a link in the HAWG report to a site where the information in the WD can be accessed.

Marine Strategy Framework Directive: A new ACOM-SCICOM steering group has been set up: MSFDSG; the group mainly wants feedback on elements of HAWG work that may help determine status for 11 descriptors identified by the Commission and HAWG's view on what Good Environmental Status (GES) might be for those descriptors and evaluation methods.

Marine Spatial Planning: Another ACOM-SCICOM steering group has been set up: SIASAM (Strategic Initiative on Area Based Science and Management); this group mainly wants feedback from HAWG on the report of the WG on Science for area-based management: Coastal and Marine Spatial Planning in Practice. Furthermore HAWG will have to identify spatially resolved data for e.g. spawning grounds, fishery activity, habitats, etc

Ecosystem Drivers and biodiversity: Progress has been made towards incorporating ecosystem drivers in ICES advice e.g. through the integrated assessments WGs. However, there are more people working on increasing ecosystem knowledge compared with how to use this knowledge in providing advice. In addition, as long as the users of the advice manage fisheries on a single species basis, the incentives are not there. Multispecies and integrated advice is requested in non-traditional fisheries management fora, such as marine spatial planning. Working at a finer spatial resolution might make help in this regard, but the heavy workload remains a problem. It is certainly not straightforward to include ecosystem drivers, few cause and effect relationship have withstood the test of time. It was suggested that expertise should be shared between EG and that the benchmarking process could be a way to speed up the process of providing integrated advice.

MP evaluations: Formal management strategy evaluation or evaluations of management plans are to be done outside of assessment EG's in special EGs set up specifically for that purpose. STECF has developed guidelines on how to evaluate management plans and ICES will work with STECF to evaluate 4 cod management plans in 2011. An evaluation of the ability to achieve biomass, F and catch targets is relatively simple with FLR, but the evaluation becomes more complicated when more factors have to be taken into account.

Inter Catch: The HAWG is the top-student of the class using it for all our stocks; there are still some EG's which aren't using InterCatch of various reasons (lack of time; alternative databases e.g. Fishframe). COST developed some code facilitating to export data into InterCatch

PGCCDBS: The importance of EG's including the PGCCDBS table of data-related issues in the report was stressed. When filling in the data table, it is also useful if EGs indicate not only what data they need, but also what data they are unlikely to use (e.g. age data for grenadiers). All chairs highlighted that it is important for ICES to close the loop with the PGCCDBS, i.e. the recommendations from the PGCCDBS should be considered by the EGs and implemented, but this may have to wait a benchmark assessment. ICES could also forward PGCCDBS recommendations to clients and member states. PGCCDBS requested EG's to apply the score card to detect bias in sampling, which was decided to be a generic part of benchmark assessments. PGCCDBS was asked to consider the best way to present sampling intensity information in EG reports and to advise on minimum and target sampling intensity for collecting biological information.

WKFRAME II: The WGCHAIRS had a joint session with WKFRAME2 during which the importance of having appropriate pa reference points was stressed. WKFRAME2 is further referred in section 1.4.8.

Table of Contents for EG reports: The table of content of assessment EG report was briefly discussed. A few new standard sections have been added to the report format: Intercatch section, EC data tables, in a particular format, as an annex, Recommendations, Data contact person for PGCDBS and new species: describe data and studies available.

Benchmarks: Benchmarks for 2011 and 2012 were presented. A general discussion of the benchmark process did result in a request to the Secretariat will prepare a description of the process to choose benchmark species. This will be distributed to Chairs for their comment and input. It was stressed that it is important to ensure that the benchmark group has the expertise to review the assessment method used (e.g. GADGET for tusk).

Advice format: Minor changes in the advice sheet were proposed for 2011. Most importantly for the EG's was that the hierarchical system of advice was made clear; if an agreed Management plan exists it has the highest priority. If such a plan does not exist, then the transition or MSY and PA should be applied. New traffic lights were introduced with quantitative symbols (colour) and qualitative (grey scale).

1.4.2 Working Group for International Pelagic Surveys [WGIPS]

The Working Group for International Pelagic Surveys (WGIPS, formerly PGHERS) met at the Marine Institute, Bergen, Norway from 17.01.11 – 21.01.11 under the chairman Karl-Johan Stæhr (DTU-Aqua, Hirtshals, Denmark) to: coordinate acoustic and larvae surveys in the North Sea, Malin Shelf and Western Baltic; combine recent survey results for assessment purposes and to clarify parameters influencing these calculations. The group consisted of 11 participants from seven different nations.

Review of larvae surveys in 2009/2010: six survey métiers were covered in the North Sea. The herring larvae sampling period was still in progress at the time of WGIPS meeting, thus sample examination and larvae measurements have not yet been completed. The information necessary for the larvae abundance index calculation will be ready for, and presented at the Herring Assessment Working Group (HAWG) meeting in March 2011. The same is true for larvae surveys from the Baltic.

Results from larvae survey in the Irish Sea indicate a similar distribution pattern for 2010 as seen in previous years, with the highest abundance of herring larvae to the east and north of the Isle of Man. A difference in distribution pattern is, however, evident to the north of the Isle of Man with a westward expansion not routinely observed. The point estimate of production in the north eastern Irish Sea was slightly below the time series average.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2010: Seven acoustic surveys were carried out during late June and July 2010 covering the North Sea, West of Scotland and Malin Shelf area. The estimate of the North Sea autumn spawning herring spawning stock is at 3.0 million tonnes. This is 15% higher than the estimate from the previous year (2.6 million tonnes).

The West of Scotland estimate of SSB from the Scottish survey is 308 055 tonnes, a 47% decrease on the previous year. The Scottish survey values are used in the assessment. The estimate for the whole of the VIaN area, from the combined survey of Scottish, Irish and Northern Irish vessels, is 253 000 tonnes. This was lower than the estimate from the previous year. The combined survey detected a strong 2009 year-class that dominates the estimate of immature fish. The strong 2007 year-class observed in the previous year showed up in the estimate again this year.

This is the third year of the synoptic survey, covering what is currently considered the Malin Shelf population of herring. This provided an estimate comprising four herring stocks to the west of the British Isles: the West of Scotland in Division VIaN; the Clyde; Divisions VIaS and VIIb, c; and the Irish Sea. The SSB estimate was 303 000 tonnes and is largely dominated by the West of Scotland estimate. Compared to the previous year, when no 0-group fish were detected, a strong year class of 0-group fish, dominating the numbers and biomass of immature fish of the Malin Shelf population, was observed this year.

The estimates of western Baltic spring-spawning herring SSB were 101 000 tonnes and 981 million herring, which is lower than last year's estimate. The stock is dominated by 1- and 2-ring fish; however, this year's estimated abundance of 1- and 2-ringers is considerably less than previous years, dating back to 2002.

Sprat: The total abundance in 2010 of North Sea sprat provided an estimated biomass of 354 000 tonnes. This is a decrease by nearly 50% in terms of biomass when compared to last year and is at a medium-level in the 2000–2010 time series. In terms of abundance, it is the sixth highest estimate. In 2006–2008, there was a downward trend in North Sea sprat. The majority of the stock consists of mature sprat. The sprat stock is dominated by 1- and 2-year old fish representing more than 90% of the biomass.

In Division IIIa, sprat was abundant in both the Kattegat and Skagerrak (44F9). The biomass has significantly decreased to 18 500 tonnes, about half of the estimate from 2009.

Western Baltic acoustic surveys in autumn 2010: A joint German-Danish acoustic survey was carried out with RV "Solea" in the western Baltic in October 2010. The estimate of western Baltic spring-spawning herring is about 208 900 tonnes in Subdivisions 22–24. As in former years, young herring dominated the abundance estimates. However, total abundance and biomass estimates increased significantly, compared to the record low values from 2009.

The estimated total sprat stock is around 109 900 tonnes. The present high estimates of sprat in number and biomass are caused by a strong, new year class, which is about 5 times greater than in 2009.

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

SGHERWAY was convened in 2008 to explore and evaluate the series of recommendations produced by the EU funded WESTHER project (Q5RS-2002-01056) which suggested that, in the current stock assessment setup for herring to the west of the British Isles, two of the basic assumptions of stock assessment are violated.

Currently the herring to the west of the British Isles are fished, managed and assessed separately as four ICES stocks 1: VIa North; 2: VIaS and VIIb,c; 3: VIIaN and 4: Celtic Sea and VIIj. Analytical assessments for VIa North are accepted by ICES in most years and have been accepted for the Celtic Sea and VIIj ICES stock for the last two. Analytical assessments have been rejected by ICES for VIaS and VIIb,c or VIIaN for many years.

A combined ICA assessment of the three stocks VIaN, VIaS/VIIb,c and VIIaN (the Malin Shelf metapopulation) was explored and its utility for advisory purposes investigated. It was found that the combined ICA assessment gives important information on the Malin Shelf metapopulation, though it is unlikely to be useful for management advice purposes because it does not provide sufficient information on the status of the individual components.

Alternative management strategies for the Malin shelf metapopulation were investigated to show how it could be sustainably managed, approaching MSY levels. The tools evaluated did not, under all conditions, suffice to manage the components of the metapopulation sustainably. The results showed that managing metapopulations is only possible with detailed information on fisheries independent data. However, whenever subcomponents of the metapopulation differ considerably in abundance, sustainable management is impossible for the smallest subcomponent. The VIIaN ICES stock should therefore continue to be assessed and managed separately. Where there is uncertainty of stock identification fishing mortality should be kept at low levels. Should identification rates increase, fishing mortality may also be increased.

The evaluation of the utility of a synoptic acoustic survey in the summer for the Hebrides, Malin and Irish shelf areas was based on results of a combined survey programme in 2008 and 2009, and an analysis of time-series of existing surveys in the area. The survey covers all areas in which mixing of the various western herring stocks is likely to occur at that time and could be used to establish time-series for the constituent components of the Malin Shelf stock complex. However, such time-series will not be available for a number of years. The amount of mixing between stocks cannot be estimated by the current sampling regime in the Malin Shelf survey. Consequently, a sampling programme has been developed to allow proper identification of fish population origins, making use of otolith and body shape techniques. Analyses will be compared to fish of known spawning origin collected during the EU project WESTHER. This sampling programme has been initiated in the 2010 synoptic acoustic survey.

1.4.4 JAKFISH

The EU FP7 research project JAKFISH (Judgement and Knowledge in Fisheries Involving Stakeholders, 2008-2011) was aimed at addressing the potential mismatch experienced between certain policy problems and the scientific tools to solve them, and on a lack of transparency in the soundness of scientific results. In particular the project has aimed at "investigating the roles that scientists play to help formulating policies, and how governance approaches can be developed which enable policy decisions to address uncertainty and complexity based on research and with the participation of stakeholders." This research is articulated around a number of case-studies involving participatory modelling with stakeholders around management issues. The management of WBSS herring was thus chosen as a relevant case study.

A series of HCRs were tested in the case study (Figure 1.4.4) and a comparison between the HCR suggested in the Non-Paper (Target F= 0.25, and F=0 if SSB<110kT,) and the preferred HCR suggested during the JAKFISH collaborative process (Target F=0.25, and sloped F if SSB<110kT, lower panel in Figure 4.1.1) showed that the Non-Paper approach provided a quicker recovery of SSB during the first years of implementation – as expected given that the low level of current SSB (around 110kT) would lead to immediate fishery closure. However, over the long-term (average simulation results for the period 2018-2032), no significant difference in the results could be observed between both HCR with regard to average SSB level, risk of SSB falling below 110 kT and average yield. However, the agreed scenario in JAKFISH reduced significantly the average inter-annual variability in yield in the long-term.

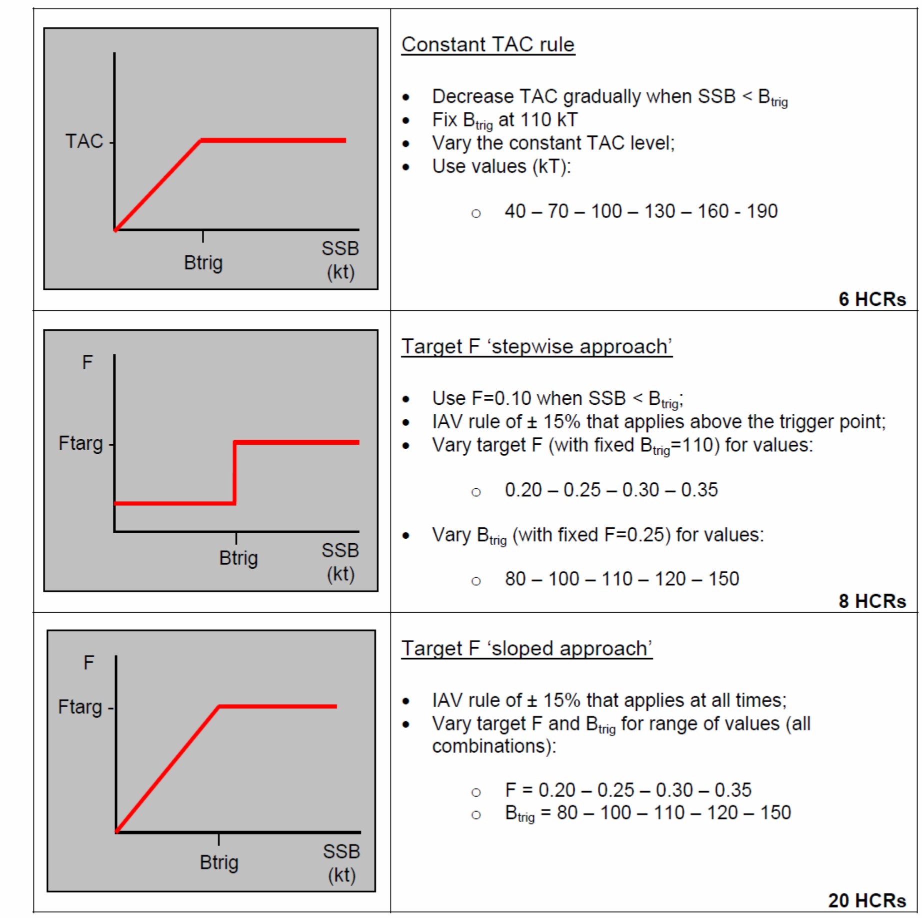


Figure 1.4.4 Various HCR shapes tested upper panel: Constant TAC rule, middle panel: Target F stepwise approach, lower panel: Target F sloped approach.

Involving stakeholders in an "extended peer review" process has acted as a natural and positive driving force for changing the whole perspective in fisheries management, from top-down short-term advice to bottom-up long-term commitment. The need to justify and explain the reasoning behind the scientific models, the outcomes of which will directly impact the livelihood of the stakeholders involved, leads to an auto-evaluation of the quality and soundness of the scientific knowledge (illustrated by the pedigree matrices), which in turns focuses the attention towards the most uncertain but important factors. This drives a natural and shared understanding that these factors should then be accounted for in the models, but with large confidence intervals around parameter values and related natural processes, and that the policy decisions should account for the potential risks linked to them. And if scientific uncertainty cannot be resolved, then the management must adapt to it and be precautionary. In some simulations being run with the same underlying dynamic of the herring stock, but with assumed perfect levels of knowledge, the uncertainty in management outcomes was considerably reduced, and higher yields were allowed. The participatory modelling process makes it easier to understand this fact, and for it to then be accepted.

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

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

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

The intersessional work was related to developing a strategy for the analysis of between-reader variation of ageing and maturity staging, the further development of a forum for age readers, the review of relevant conferences and self-sampling programmes, as well as creating an overview page on past age-reading workshops and exchanges.

The Group reviewed reports from relevant Expert Groups with respect to recommendations addressed to PGCCDBS. As a feedback mechanism from data users (mainly assessment WGs and benchmark assessment WKs) to the PG, 'data contact persons' have been nominated with a set of tasks to report on data problems and function as link between data collectors and data users. PGCCDBS acts as an advisory group on the further development of InterCatch. It did work best in the cases where the contact person was a member of both the AWG and PGCCDBS, which is the case for HAWG. HAWG 2009 appointed Lotte Worsøe Clausen (DTU Aqua) as contact person for the PGCCDBS and she is continuing this task in 2011.

Recent changes in data collection (e.g. through the revised EU DCF) were reviewed and the need for workshops was defined.

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

1.4.6 WKHERMP

The workshop on the evaluation of the long-term management plan for North Sea herring [WKHERMP] was set up by ICES to answer a request from the EU and Norway on the future of the management plan for North Sea autumn spawning herring. There were nine participants of the workshop that took place in March 2011. The approach of WKHERMP was one of a qualitative assessment of the questions from EU/Norway within the framework of the herring assessment working group and the previous investigations of the North Sea herring management plan (e.g. WKHMP which met in 2008). All of the considerations were carried out within a single stock and single species approach and did not consider multispecies interactions or the role of herring within the North Sea ecosystem.

WKHERMP found no substantive changes to the biology or ecology of herring to suggest that the simulations from WKHMP 2008 were no longer applicable (recruitment, growth, maturity, migrations). Although the fishing behaviour of some fleets may have recently altered, these potential changes were judged unlikely to impact on other aspects of the management plan. The quality of the stock assessment may have changed in recent years. This change in quality could have implications in terms of understanding the signal to noise ratio from the assessment and the functioning of the simulations of the management plan.

The management plan was evaluated. The management plan appears to operate well in relation to the objectives of consistency with the precautionary approach and a rational exploitation pattern, but not in relation to achieving stable and high yield. The main weakness appears to be the 15% IAV limit on TAC change which leads to unnecessarily restricted TACs when the stock is improving.

A scientific analysis of B_{pa} should be carried out. Although it is no longer used for management considerations nor part of the management plan, B_{pa} is widely used in the classification of the stock status thus it is important to the industry.

The current $F_{2\text{-}6}$ of 0.25 is consistent with the MSY approach under the current low recruitment regime. The management plan is also considered consistent with the MSY approach, although the trade-off between stability and high yield will limit the maximising of yield in some circumstances.

There is no basis to further adjust the harvest control rule to account for recruitment variability or trends.

In view of the exceptional increase in the estimated SSB in 2010, WKHERMP noted that it was better to have a management plan that is able to be responsive to large changes in the biology of the stock, or assessment uncertainty, than mechanisms for within-year revisions within the management plan.

WKHERMP recommend that further work on the management plan be carried out in 2011, prior to the December decisions by the EU and Norway, to develop mechanisms that avoid the unwanted side-effects of the present plan. This work cannot be carried out during the 2011 herring assessment working group.

1.4.7 WKWATSUP

The overall outcome of WKWATSUP was a TAC setting procedure alternative to the procedures suggested evaluated by the joint request from the EC Commission and Norway. WKWATSUP suggest that the TAC should first be set for the WBSS according to the FMSY or FMSY transition framework for WBSS alone. If the NSAS is greatly impacted by management of the WBSS, this rule needs to be re-evaluated. Following this, the fraction taken in the eastern part of the North Sea (parts of Sub Divisions IVb and IVaE) should be subtracted from the total TAC for the WBSS before sharing the TAC between Division IIIa and Subdivisions 22-24. Subsequently the best estimates of the proportions of the NSAS and WBSS in the catch by fleet should be used to calculate the combined catch options in compliance with the targeted catch for WBSS.

The 50:50 share of the WBSS TAC between Division IIIa and Subdivisions 22-24 was not specifically evaluated by WKWATSUP. It was viewed as a political choice and thus all evaluations of TAC setting procedures were performed applying a 50:50 share of the TAC between Division IIIa and Subdivisions 22-24, though using three different approaches as how to include the share taken in the North Sea. WKWATSUP recommends a seasonal closure of the herring fishery in parts of the eastern North Sea. However, until such is implemented, the suggested approach by the WKWATSUP mentioned above should be applied.

WKWATSUP showed that the selection patterns of the C and F fleets were very different and thus choices about the share between Division IIIa and Subdivisions 22-24 are likely to have an impact on the sustainable exploitation of the stock.

WKWATSUP summarised the existing knowledge on migrations and area distributions for NSAS and WBSS based on literature and recent catch and survey data. The general migration routes are known, however, an end-to-end spatial lifecycle-closure model could be developed, encompassing active migrations of spawning components and larval drift, to investigate the connection, interactions and spatial distribution of herring. There are large amounts of empirical data available with which to verify the model, although the paucity of knowledge about overwintering and feeding locations and processes will challenge its construction.

WKWATSUP reviewed the sampling for stock proportions in the mixed catches of herring. There was clearly a mis-match between sampling intensity and catch distribution, particularly in relation to the part of the WBSS that migrates into the eastern North Sea during summer feeding migrations and WKWATSUP made recommendations as how to improve the sampling scheme.

The methodology currently used to estimate stock proportions at age in the mixed catches of herring was evaluated and recent development using a statistical modelling approach was presented by WKWATSUP. Some problems are still unresolved, but the group recommends further refinement and peer-review of this approach with an incitement to apply the approach during the next HAWG.

1.4.8 WKFRAME II and WCFRAME

In 2011, WKFRAME II, the Workshop on Implementing the ICES F_{MSY} Framework met for 4 days in January. Some aspects of the report were dealt with by ACOM Web Conference (WCFRAME) in March, giving guidance on various aspects of advice provision in 2011.

WKFRAME considered the ICES MSY HCR in some detail, suggesting alternative forms, particularly in relation to B_{lim}. WKFRAME suggested that adopting a singular approach will make it possible to give advice using the ICES MSY framework which is consistent with both the PA and MSY approaches. WCFRAME did not give definitive guidance on what action should be taken for stocks that are below B_{lim}, but suggested that each case should be dealt with using expert judgement.

WCFRAME has established that ICES advice for 2012 will take an hierarchical approach to advice. Agreed management plans will take precedence. A list of such plans has been provided by ACOM. For this working group, there are three such plans: North Sea herring long term management plan, the VIa North herring long term management plan and the Celtic Sea herring rebuilding plan.

In 2011 the transition scheme will be step 2 of 5 steps towards achieving F_{MSY} by 2015. The scheme to be followed for advice for 2012 is provided in the text table below.

	IF	MSY	Transition to MSY
ICES 2010 + WKFRAME-2	**SSB_{2012} >= MSY $B_{trigger}$**	Fadv=Fmsy	- and F_{2011} <= Fmsy then: Fadv=Fmsy (no transition required) - and **F_{2011} > Fmsy** then: Fadv=min{(0.6*F_{2010}+0.4*Fmsy); Fpa} where: F_{2010} is **current year estimate** of F_{2010}
ICES 2010 + WKFRAME-2	**SSB_{2012} < MSY $B_{trigger}$**	Fadv=Fmsy*SSB_{2012}/$B_{trigger}$	Fadv=min{(0.6*F_{2010} +0.4*(Fmsy*SSB_{2012}/$B_{trigger}$)); Fpa} where: F_{2010} is **current year estimate** of F_{2010}
ICES 2010	**SSB_{2012} <<< MSY $B_{trigger}$ (e.g below B_{lim}) and/or signs of R failure**	Fadv=Fmsy*SSB_{2012}/$B_{trigger}$	More rapid transition; application of $F_{MSY-HCR}$ as soon as possible and additional conservation measures if appropriate; F=0

WKFRAME also considered an MSY approach to be applied in cases where no analytical assessment is available. The group provided some guidance on how to proceed with advice formulation in such cases. This approach should be useful to HAWG in drafting advice for sprat stocks and also some data-poor herring stocks such as the Clyde herring.

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 2009 catch data was v1.6.4. These data were then further processed with the SALLOC-application (Patterson, 1998). This program gives the required standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set. This allows recalculation of data in the future, or storage and analyses in other tools like InterCatch (see section 1.5.4), choosing the same (subjective) decisions currently made by the WG. Ideally, all data for the various areas should be provided on the standard spreadsheet and processed similarly, resulting in a single output file for all stocks covered by this working group. National catch data submission was due by 24th February 2011. All nations generally deliver their data in due time or only a very few days later. All nations submitted catch and sampling data via the official exchange spreadsheets, and some of them loaded data into the InterCatch database.

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

1.5.2 Sampling

Quality of sampling for the whole area

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

Area	Official Catch	Sampled Catch	Age Readings	Age Readings per 1000t
IVa(E)	9586	3825	82	9
IVa(W)	108973	98142	6516	60
IVb	29547	23546	1708	58
IVc	3691	1674	30	8
VIId	22832	14709	1581	69
VIIa(N)	4894	3719	1517	310
VIa(N)	22510	14294	1909	85
IIIa	37229	33376	6795	5
Celtic, VIIj	8370	8370	2528	302
VIa(S), VIIb,c	7423	7423	2006	270

The EU sampling regime

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

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

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

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

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

1.5.3 Terminology

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

1.5.4 Intercatch

InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models." Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. Comparisons between InterCatch and conventional used systems (e.g., Salloc and spreadsheets) were carried out annually since 2007. During HAWG 2011, InterCatch was fully operational. The comparison is available for a collection of stocks (her_47d3, her_vian, her_3a22, her_irls, her_irlw, her nirs). Maximum discrepancies between the systems are presented in Table 1.5.2. These are in general small. A five percent difference occurs in the mean weight-at-age for 0-wr herring for NSAS. In absolute numbers these are 7.5 (Salloc) to 7.8 gram (InterCatch). The overall landings calculated by both procedures for North Sea herring stock matches by 4 t. InterCatch was for the first time also used for the stock in the Baltic Sea. While CATON matches well between the conventional system and IC, larger discrepancies up to 8 % occur in 1-ringers.

In principle, the stock coordinators found that InterCatch is a helpful tool that it has the potential to reduce errors and work load of the stock coordinators. Many improvements have been implemented. The output files from InterCatch become more comparable to the information from the conventional systems than in former years, but information on catch by rectangle and length distribution is still not included.

During HAWG, there was no time for a more detailed comparison at the area level. This may be done by correspondence between stock-coordinators and ICES InterCatch team.

1.6 Methods Used

1.6.1 ICA

“Integrated Catch-at-age Analysis” (ICA: Patterson, 1998; Needle, 2000) combines a statistical separable model of fishing mortality for recent years with a conventional VPA for the more distant past. Population estimates are tuned by abundance or

CPUE indices from commercial fisheries or research-vessel surveys, which may be age-structured or not as required. ICA is run using FLICA which performed the same analysis as the original version but from an FLR platform (Fisheries Library in R). FLICA was used to assess all herring stocks in HAWG with the exception of herring in VIaS and VIIb,c.

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

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

This year new diagnostic plots were developed to show anomalies in stock weights at age, as well as to show time trends at age for, e.g., stock weights or catch weights. In addition, functions have been developed to produce the standard graph output used within the advice sheets and to estimate reference points. It should be noted however that these reference points should be interpreted as proxies.

Exploratory survey-based analysis was conducted using the SURBA software package for the Irish Sea. SURBA is a development of the RCRV1A model of Cook, 1997. It assumes a separable model of fishing mortality, and generates relative estimates for population abundance (and absolute estimates for fishing mortality) by minimising the sum-of-squares differences between observed and fitted survey-derived abundance. The method is described in detail in Needle (2003) and the software is available on the ICES network. SURBA has been used to produce comparative stock analyses in several ICES assessment Working Groups (e.g., WGNSSK, WGNSDS, WGCSE), and has been scrutinised by the ICES Working Group on Methods of Fish Stock Assessment (WGMG, 2003 and 2004). The version of the software available to HAWG 2010 was Version 3.0.

1.6.3 FLR and MFDP

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

1.6.4 Medium term projections

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

1.6.5 F_{MSY} management simulations

For the medium term projections to outline F_{MSY} in Section 1.3, the HCS10 software was used. This is a medium term projection program designed for exploring harvest control rules, without doing a full assessment as part of the annual simulation loop. The program is a recently revised and updated version of the HCM/HCS software that has been used for evaluation of management plans in the past (mackerel, blue whiting in particular). It has an age based population model in the background with stochastic recruitments but fixed weights and maturities, an 'observation' (assessment) model that produces a noisy basis for management decisions, a management rule module with various options, and an implementation module that translates management decisions into real removals, again with noise. Yield and biomass per recruit is calculated as a by-product.

For the present purpose, the program was run over 50 years with a range of fixed fishing mortalities as the management decision rule, with no modifications.

The program with manual and example files is available from the author, and in the HAWG 2010 SharePoint site.

1.6.6 Separable VPA

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

1.6.7 Repository setup for HAWG

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

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

1.6.8 Taylor plots

HAWG has this year pioneered the use of the "Taylor diagram" as a way to visualize and interpret the outputs from a stock-assessment model. Taylor diagrams (Taylor 2001) are common tools in the climate sciences used to examine the outputs of global circulation models. Such models typically produce vast quantities of data (terabytes or more) at high temporal and spatial scales: comparing these outputs against observations can thus be a challenging task. In response, the community has developed a series of techniques to allow the ready comparison of observations and modeled values. Whilst fisheries science and stock assessments do not generate the same quantities of data, the same methods can readily be applied to aid in the interpretation of our models (Payne 2011).

One of the most common of these is the so-called Taylor-diagram (Taylor 2001). The diagram is based on the realization that there is a mathematical relationship between four of the most commonly employed metrics for evaluating model performance: the correlation coefficient between the observed and modeled data, r, the standard deviations of the modeled, σ_m and observed data, σ_o, and the centered root-mean-square of the difference between the observed and modeled data, E'. The relationship between these four values mimics the law of cosines and therefore can be used to construct a plot. More details are available in (Taylor 2001) and (Payne 2011).

An example of such a diagram applied to the WBSS assessment is shown in Figure 1.6.1. The key to interpreting the figure is to understand that it is not a standard Cartesian plot, but rather a radial plot, where points are specified according to their angle from the vertical, and distance (radius) from the origin. The angular direction in this case represents the correlation coefficient – note that the scale is non-linear. The distance from the origin represents the standard deviation of the observations, normalized by the standard deviation of the modeled values. The points therefore should be as close as possible to the 1.0 point on the horizontal axis – this is the point where the correlation coefficient is 1.0 and the variability of the model and the observations are the same: the closer to this reference point a set of observations lies, the better the agreement between the model and the observations.

In the case of the WBSS diagram (Figure 1.x.1), we can see that it is the GerAS survey that has the best agreement between the modeled and actual observations. The GerAS points are also closely grouped together, suggesting similarities in their properties and agreement with the model. The HERAS time series show poorer agreement with the models – the age 3, 4, and 5 values are closely grouped, but we note that the age 6 values show appreciably poorer agreement with the model. The N20 index appears to be fitted well by the model.

These results are in agreement with the general understanding of this assessment (Payne 2009; HAWG 2008), and whilst there is nothing new in these results, we have essentially reduced dozens of output figures down to a single diagram. The Taylor diagram therefore offers a simple and concise way to summarise the outputs of an assessment (Payne 2011) and has been used throughout this report for that purpose.

1.6.9 Two-stage Biomass Model

A two-Stage Biomass model for the assessment of Irish Sea VIIa(N) herring given additional variance in the recruitment index (Roel *et al.* 2009) 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 limits recruitment variability in Irish Sea herring on the basis of information available for other herring stocks and estimates an additional variance which represents variability related to the presence of Celtic Sea juveniles.

The model is fitted to biomass indices of 1-ringer fish and to aggregated biomass indices for the 2-rings+ from Northern Ireland acoustic surveys.

Limitations in the age-composition data and potential interannual variation in the selection pattern of the fishery favour an assessment method, such as the two-stage biomass method, which is based on a simplified age structure and does not require separability assumptions.

1.6.10 VIT Software

The VIT software (Lleonart and Salat, 1997) is extensively used for Mediterranean stocks for which only one year of catch at age data exists. The model fits a rudimentary VPA to catch at age data from a single year (pseudo-cohort analysis) and derives from it, population abundances, F at age and a yield per recruit curve.

1.7 Discarding and unaccounted mortality by Pelagic fishing Vessels

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

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

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

In the area considered by HAWG, three nations reported on discard observations from fleets in 2010. Scotland incorporated discards in the catch data by stock. 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 2.2) and VIaN (see Section 5.2) herring. The Netherlands estimated herring discards from sorting of approximately 600 tonnes (CV=65%) in 2009 but sampling was not at a high enough resolution to allocate the catch in individual stocks (Helmond & van Overzee WD). This estimate is for all Dutch flagged vessels across the entire ICES area. The fleet has total landings is over 300 000 tonnes of fish per year in the ICES area. The estimates were based on observer trips and in 2010 included observations from Pelagic Freezer Trawler vessels from the Netherlands, Germany and England. These discards are the processing (sorted) discards and have been routinely monitored since 2003. Observers also report flushing of the tanks by pelagic vessels. It is difficult to robustly estimate the biomass of fish released in this manner. It could be considered tank slippage. The best estimate for the Dutch fleet was 4300 tonnes in 2010, which is similar to last year (Helmond & van Overzee WD). From 2006 to 2010 less than 5% of hauls observed were discarded directly from the tanks. There appears to be no size selection for landed herring compared to discarded herring in the Dutch fleet.

Germany runs an observer programme which reported no discard of herring from pelagic vessels in 2010. At least six trips carried observers. Ireland also conducts a discard observer scheme for herring fisheries, though to date, no instances of discarding have been reported.

No other nations reported on discards of herring in the pelagic fisheries, either because they did not occur, catches were not sampled for discards or there were difficulties with raising procedures. 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. Recent regulations have been introduced to constrain discarding and slippage of catch in EU waters. Discarding has been illegal in Norwegian waters for many years and the requirements for the reporting of slippage are currently under review. Slippage events are counted against quota in Norway.

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, MSFD and SIASM for sprat and herring

1.8.1 Ecosystem drivers for fisheries advice

The traditional ICES approach to fisheries science and management has focused on single species dynamics without considering environmental or ecosystem interactions of drivers. The system is generally assumed to be stable and much management advice is given based on the assumption of equilibrium in the system and stationarity in the relationships. These assumptions are not appropriate, especially for herring or sprat stocks (Nash *et al*., 2009). Thus ICES needs to consider environmental variability, the impact of environmental drivers and changes in productivity and carrying capacity.

Whilst progress has been made towards incorporating ecosystem drivers in advice, e.g. through integrated assessment WGs, finding appropriate ecosystem drivers for implementation into fisheries advice is an area that needs to be further developed by ICES over the coming years. This includes gaining more knowledge on the ecosystem drivers than on how to apply these in advice. Moreover, very few cause-and-effect relationships have withstood the test of time (Myers, 1998) and may not even exist in ecosystems which are also likely to exhibit alternative stable states.

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

However, significant shifts in the environment that can affect any herring life stages are often called regime changes. But detecting structural breaks in processes is an ambitious task. This might be the reason that in the past HAWG has struggled to detect broad scale shifts and study their implication on herring and sprat stocks. However, new informative techniques have been developed more recently that allow judging the complex nature of such structural breaks or shifts (Groeger *et al*., 2011) and coupled bio-physical have been developed to simulate changes in the system (Hinrichsen *et al*., 2011). Moreover, the proposed shiftograms, alertograms and concentrograms allow for early warnings, given changes in one or a number of variables as well as larger concentrations of shift signals.

HAWG will use the North Sea herring as a case study to show how despite much research into drivers, HAWG can still not provide a robust approach, other than qualitative statements, for incorporating drivers into the advice.

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

Beside broad scale changes generating regime shifts, it is obvious that North Sea herring dynamics co-vary with environmental variability (Payne *et al*., 2009; Groeger *et al*., 2010; Dickey-Collas *et al*., 2010). Whilst the direct mechanisms are not known (Nash and Dickey-Collas, 2005; Brunel, 2010) and the spatial and temporal scales of covariance with the environment are still unclear (Petitgas *et al*., 2009; Röckmann *et al*., 2011; Fässler *et al*., in press) the productivity and distribution of herring have been shown to vary with the environment .

Variability in advection from the spawning grounds to the nursery grounds has long been thought to be a crucial factor (Corten, 1986; Bartsch *et al*., 1989; Munk and Christensen, 1990), but unequivocal support for this hypothesis has not been forthcoming (Dickey-Collas *et al*., 2009). Physiological modelling of temperature-specific food requirements suggest that the spawning periods utilized are the most favourable ones for larval growth and survival (Hufnagl *et al*., 2009). Indeed, changes in the planktonic system have been suggested as critical for recruitment (Cushing, 1992; Payne *et al*., 2009), but clear evidence is lacking. Variations in bottom temperature near the spawning grounds (Nash and Dickey-Collas, 2005; Payne *et al*., 2009), predation by jellyfish (Lynam *et al*., 2005), bottom-up processes (Hufnagl *et al*., 2009), and competition with other species (Corten, 1986) have been proposed as mechanisms that also affect recruitment. Groeger *et al*. (2010) suggests the changes in productivity are linked, with a forward lag of two and five years, to North Atlantic climatic indices. Other factors may also affect growth and survival of larval and juvenile herring (disease, storms, contaminants), but with some exceptions (Tjelmeland and Lindstrom, 2005) it has not been possible to include any environmental factors in recruitment models that can be used in routine assessments.

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

Whereas most of the variations in size-at-age observed can be explained by density-dependent mechanisms, there are also indications of environmental effects. Modelling the growth of juvenile herring during the period of stock decline (1961–1981), Heath *et al*. (1997) explained the interannual variability in growth rate (superimposed on the main trend of density-dependent growth) by environmental fluctuations (hydrographic conditions and plankton abundance). For juvenile and adult life stages, Brunel and Dickey-Collas (2010) established that temperature significantly explained variations in growth between cohorts of North Sea herring from the mid-1980s. Cohorts experiencing warmer conditions throughout their lifetime attained higher growth rates, but had a shorter life expectancy and smaller asymptotic size. There is, however, no current model to disentangle the various causes of variability in historical growth.

The environment also influences the migration of North Sea herring (Dickey-Collas *et al* 2010b; 2010c; Röckmann *et al*., 2011). There are currently no models to help either fully investigate these processes or understand how changes will affect the assessment or management of North Sea herring. Likewise the impact on herring on the North Sea ecosystem is difficult to predict (Dickey-Collas *et al*., 2010a). It is highly probable that the herring population impacts on the cod productivity (Speirs *et al*. 2010; Fauchald, 2010) with simulations suggesting that the cod stock cannot recover with a large herring population in the North Sea (Speirs *et al*., 2010).

Stock-recruitment relationships are no longer being considered as stationary (Chaput *et al*., 2005; Stige *et al*., 2006). It is still unclear as to whether North Sea autumn spawning herring has a stock to recruit or recruitment to stock relationship (Cushing and Bridger, 1966; Nash *et al*., 2009; Groeger *et al*., 2010). The former would imply that spawning biomass and the environment jointly influence the productivity and carrying capacity of the stock, whereas the later would suggest that it is only the environment that impacts on the dynamics. Determining whether a stock to recruit or recruit to stock relationship exists will influence choices about the most appropriate management of a stock in a variable environment. Brunel *et al*. (2010) assumed a stock to recruit relationship and they suggest that environmental harvest control rules (eHCRs) are beneficial when the environmental signal is strong and the environmental conditions are worsening, but in situations with little change, there is no appreciable benefit to developing eHCRs. The current North Sea herring rule was adjusted in 2008 to account for the lower productivity of the stock and developing these eHCRs does require an underlying understanding of the processes, which currently are lacking.

Thus it is clear from the North Sea herring example that despite many studies into environmental drivers of stock productivity leading to much improved understanding of the cause of variability in production, at present the potential to include this understanding into the provision of management advice it limited. HAWG considers that information on the environmental drivers of productivity of the stocks is very patchy, and mostly lacking (Table 1.8.1). HAWG acknowledges that this area requires targeted research efforts.

1.8.2 The marine strategy framework directive (MSFD)

As of 1 September 2010 under the Marine Strategy Framework Directive (MSFD) the EU Commission published a catalogue of criteria and methodological standards on good environmental status (GES) of marine waters (Commission Decision: notified under document C(2010) 5956; text with EEA relevance; 2010/477/EU; L 232/14 Official Journal of the European Union of 2.9.2010). The Annex of this document is divided in two parts where Part A contains the "General conditions of application of the criteria for good environmental status" and Part B the "Criteria for good environmental status relevant to the descriptors of Annex I to Directive 2008/56/EC" where Part B includes a list of 11 descriptors that are (bold denotes of relevance to HAWG):

1. **Descriptor 1: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.**
2. Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.
3. **Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.**
4. **Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.**
5. Descriptor 5: Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
6. **Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.**
7. Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Descriptor 9: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. **Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.**

ICES has now been asked

- to identify elements of the EGs work that may help determine status for the 11 descriptors set out in the Commission Decision
- to provide views on what good environmental status might be for those descriptors, including methods that could be used to determine status.

Given this request, among the above 11 descriptors HAWG felt that it could comment on five (1, 3, 4, 6 and 11 as shown in bold in the list above).

Descriptor 1 – Biodiversity. HAWG regularly carries out assessments that are linked to the three sub-categories "Species Level", "Habitat Level" and "Ecosystem Level". Related to "Species Level" HAWG assesses/determines annually

- the distributional range and pattern of the various herring and sprat stocks and stock components dealt with in the WG
- the population size and biomass including the status of the recruitment and the spawning stock biomass (SSB)
- the population condition including demographic characteristics (e.g. length size, age class structure, sex ratio, fecundity rates, natural and fishing mortality rates) the population genetic structure to identify stock units

Because of the current single species nature of the HAWG assessments, with respect to "Habitat level" only marginal work is done to estimate habitat distribution, habitat extent and habitat condition. The work here focuses mainly on detecting the abiotic habitat conditions related to specific herring components and locations during scientific surveys (egg and larvae stages, spawning sites; IHLS, IBTS, etc). Similarly only marginal work is done regarding the ecosystem structure ("Ecosystem level").

Descriptor 3 –commercial fish. HAWG annually explores the status of herring and sprat stocks in the study area. The primary indicator for the level of pressure of the fishing activity is the fishing mortality (F). To achieve or maintain good environmental status it is assessed where fishing mortality is in relation to F_{MSY}, and for many stocks whether the management plans conform to the MSY approach. To achieve this goal long term management plans are already established for some of the herring stocks in the study area. The F values are usually estimated from appropriate analytical assessments based on the analysis of catch (taken as all removals from the stock, including discards and unaccounted catch) at age and ancillary information. Where the knowledge of the population dynamics of the stock do not allow to carry out simulations, scientific judgement of F values associated to the yield-per-recruit curve (Y/R), combined with other information on the historical performance of the fishery or on the population dynamics of similar stocks, is used. The value for the indicator that reflects F_{MSY} is determined based on the ICES MSY framework rules which includes the analysis of observed historical trends of the indicator combined with other information on the historical performance of the fishery.

As part of the annual stock assessments performed by HAWG the reproductive capacities of the herring stocks are determined using the Spawning Stock Biomass (SSB). The SSB values are usually estimated from appropriate analytical assessments based on the analysis of catch at age information. Where an analytical assessment allows the estimation of SSB, these values can be compared to appropriate reference points of stock status.

HAWG is aware that WGIPS has been asked to comment in 2011 on the appropriateness of the acoustic survey for determining the indicators on population age and size distribution (Proportion of fish larger than the mean size of first sexual maturation; Mean maximum length across all species found in research vessel surveys; 95 % percentile of the fish length distribution observed in research vessel surveys). HAWG will wait for the input of WGIPS before it will comment on this descriptor 3.3.

Descriptor 4 –food webs. HAWG studies the dynamics of important forage fish, herring and sprat. Thus it provides important data on the dynamics of populations relevant to the ecosystems around Denmark, the North Sea and the waters around the UK and Ireland.

Descriptor 6 – sea bed integrity. Although most pelagic fisheries do not often impact the sea bed, HAWG recommends that an assessment of the potential pressure on the seabed by pelagic fishing be carried out. HAWG also views indicators of the state of gravel beds as important.

Descriptor 11 – Introduction of energy. HAWG acknowledges recent studies on the effect of marine noise on pelagic fish. It cannot provide expertise on this matter but pelagic fish have been studied with regards to this matter.

1.8.3 The strategic initiative on area based science and management (SIASM).

ACOM and SCICOM have setup a Strategic Initiative on Area-based Science and Management (SIASM). The steering Group of SIASM held a workshop on Marine Spatial Planning in 2010, which produced a concrete work programme. Working closely with the ICES Data Centre and other relevant groups, SIASM aims to define and quantify viable ecosystem features necessary to deliver goods and services, and to define and quantify its vulnerability, cumulative impacts, and synergies. SIASM will translate this capacity into advice, and communicate it to clients, Member Countries, stakeholders, and the scientific community. However, the last paragraphs of the 2010 Marine Spatial Planning Workshop report summarize the potential spatial planning needs; in a set of questions it is pointed out how ICES WGs can contribute; the bullet points relevant to HAWG are:

- ICES should define scenarios and set priorities for both pressures and ecosystems status. These should reflect the needs of planners, managers and decision-makers. Has or can the WG considered, identified or developed priorities or scenarios (or behaviour or ecosystem models that could be used) in terms of natural or anthropogenic pressures and/or ecosystem status, function, structure, and/or process that could be helpful in setting good environmental status (MSFD-GES) or for marine spatial planning.
- ICES should identify what indicators are available for assessment purposes and suggest ones where these are lacking and also identify which species and habitats need protection, i.e. what are the key species and habitats. Has or can the WG identify indicators for assessing which species or habitats need protection or which might be key indicator species for assessing the effects of human activities. Particular consideration should be give to assessing the impacts of very large renewable energy plans with a view to identifying/predicting the potentially catastrophic outcomes. For such plans tipping point/carrying capacity analyses, models and indicators are needed.
- ICES should also prepare spawning site maps, fishery activity maps and habitat maps covering system function and process, methods to assess resistance and resilience of ecosystems (vulnerability mapping), assessment of connectivity (e.g. life history traits), carrying capacity, impacts (including cumulative) and potential synergies. Can the WG provide or identify where any such maps may exist? Suggestions on how such maps could be generated or where data for their production could be found should also be provided.
- ICES should prepare a spatial/temporal map of fisheries management/regulation under the CFP or national regulation – scale/extent/duration/ closures/restrictions etc. In addition the maps showing the areas of each of the RAC would be helpful. This will facilitate the incorporation of fisheries management into the planning process at an early stage. Has the WG prepared or is it aware of the existence of such maps or could it provide data / information that assist in their preparation?

Given this, the following 2011 ToRs to ICES EGs which have been added by SIASM and were circulated by ICES are welcome by HAWG:

(1) take note of and comment on the Report of the Workshop on the Science for area-based management: Coastal and Marine Spatial Planning in Practice (WKCMSP) http://www.ices.dk/reports/SSGHIE/2011/WKCMSP11.pdf

(2) provide information that could be used in setting pressure indicators that would complement biodiversity indicators currently being developed by the Strategic

Initiative on Biodiversity Advice and Science (SIBAS). Particular consideration should be given to assessing the impacts of very large renewable energy plans with a view to identifying/predicting potentially catastrophic outcomes.

(3) identify spatially resolved data, for e.g. spawning grounds, fishery activity, habitats, etc.

In addressing point (2) of the SIASM ToRs, HAWG could provide catch (by rectangle and quarter) and VMS (geo-referenced at different time intervals) data comprising information from fishing activities that can be used to set pressure indicators.

In addressing point (3) of the SIASM ToRs, HAWG could further provide:

- data from larvae surveys including IHLS data sets (North Sea) and data derived from the Rügen herring larvae surveys (Baltic Sea). These data contain spatially resolved biological information related to the spawning grounds of herring (larvae abundances, length frequencies of larvae, etc) plus spatially resolved habitat information
- IBTS data that contain spatially resolved survey catch and effort data; the IBTS data sets also include MIK data as well as spatially resolved habitat information
- Acoustic data originating from various surveys in the study area of HAWG.

1.9 Pelagic Regional Advisory Council [Pelagic RAC]

In 2011, the Pelagic RAC sent a communication to the HAWG regarding its perception of status of several stocks. HAWG has considered these issues, and pays attention to them below. HAWG provides information that is used by ACOM, and only ACOM is mandated to provide advice for ICES. Hence this section cannot be considered as ICES advice.

North Sea

For the North Sea herring, the RAC questioned the utility of the 15% TAC fluctuation constraint. The RAC also expressed its concern that the provision that 50% of the IIIa TAC can be caught in Subarea IV contributes additional mortality to the North Sea stock. Finally the RAC noted that 44 600 t of Norwegian spring spawning herring were caught in IV, and expressed the concern that these fish may in fact be North Sea herring.

WKHMP discussed the management plan for North Sea herring and found it working well in relation to the objectives of consistency with the precautionary approach and a rational exploitation pattern, but not in relation to achieving stable and high yield. The main weakness appears to be the 15% IAV limit on TAC change which leads to unnecessarily restricted TACs when the stock is improving.

HAWG views unpredictable management decisions, e.g. the provision that 50% of the IIIa TAC can be taken in Subarea IV, as being difficult to handle. The provision of scientifically sound catch options in a complicated management area is impaired by these changes to the management regime.

Regarding the potential catch of NSAS under the NSS TAC, IMR analysed data from 2009, from the spawning season. The result of the analyses show that the herring caught from 70ºN to 59ºN in January-April without any doubts all belongs to the NSS herring stock. Compared with the North Sea herring caught in area 42 in May-July, the NSS herring is significantly larger at the same age. In fact the largest herring at the same age are the ones migrating to the southernmost spawning grounds in 2009.

This has also been demonstrated in the period 1995-2000, when the NSS herring also visited the southernmost spawning grounds.

Western Baltic spring spawners

For western Baltic spring spawning herring, the RAC members having been involved in the JAKFISH project have questioned the knowledge base for determining catch compositions in areas where WBSS herring is caught together in a mix with North Sea herring. It was questioned whether the sampling scheme in area IIIa reflects the distribution of catches in time and space well enough to provide a solid basis for extrapolating observed mixing percentages to fleet scale. Also it was questioned whether there was enough evidence to justify strong advice about introducing additional conservation measures to prevent catches of WBSS herring in the transfer area (IVa East) from increasing.

The WKWATSUP reviewed the sampling for stock proportions in the mixed catches of herring. There was clearly a mismatch between sampling intensity and catch distribution, particularly in relation to the part of the WBSS that migrates into the Eastern North Sea during summer feeding migrations and the WKWATSUP made recommendations as how to improve the sampling scheme which have been forwarded to PGCCDBS in 2011.

A closure of parts of the Eastern North Sea during the summer feeding migration period for WBSS could potentially protect the part of the SSB which migrates to this area. However, this needs to be scientifically examined and validated before any firm recommendations can be put forward concerning this matter.

The RAC noted that fishermen targeting herring in area IIIa observe much more herring then they would expect based on the WBSS herring assessment. They have suggested that local stocks have re-established themselves in area IIIa.

Several local stocks have been identified in the area (Bekkevold *et al*., 2005, 2007) and it is not unlikely, that fishermen may target these while fishing in the IIIa area. The size of these local stocks is not assessed in the current assessment of herring in the IIIa area. The presence of local stock components in IIIa may call for a modification of the current sampling strategy if those components are to be given higher priority to be included in the assessment of the stock mixing in the area. It is however important to notice that the local stock component in IIIa is likely to be less than 5% of the all herring present in the area but more robust estimates should be provided in the future to confirm those estimates.

In the case of herring in VIaS/VIIbc the RAC disagrees with the HAWG perception that the stock has decreased to a low level. The RAC noted that the industry does not share the perception that the stock is at a low level, and that experience from the fishing grounds suggests that herring abundance is high. HAWG continues to try to improve estimation of the status of this stock, see Section 6. These efforts include:

- Age reading analyses
- Efforts to split the MSHAS survey abundances
- Exploration of alternative assessments.

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

Assessment Working Group (AWG) recommendations

During HAWG 2010, Lotte Worsøe Clausen (DTU Aqua) compiled all issues relevant to PGCCDBS in the table "Stock Data Problems Relevant to Data Collection" (included it in the HAWG 2010 report). The PGCCDBS reviewed AWG reports with respect to recommendations addressed to PGCCDBS. The relevant recommendations for HAWG and the PGCCDBS response is listed in the below table.

AWG/WK	Stock	Data problem	How to be addressed/ by whom	PGCCDBS Comments
HAWG	Western Baltic spring-spawning herring	Sampling of mixed stock in Transfer area: Not adequate sampling of the mixed stock in the transfer area (IVaE); this results in a transfer of old, heavy NSS into IIIa (as the VS split gives them the ID 'spring'), inflating the SSB.	Sampling of herring from the Transfer area should be covering all quarters and the entire ALK; but in particular in the Transfer area, so the entire SD IVaE Age-Length Key is not applied to the transfer area. Stock ID should be performed following an agreed protocol. PGCCDBS should recommend a bilateral agreement between Norway, Sweden and Denmark to facilitate this sampling. The DCF should hold financing opportunities for this work.	PGCCDBS recommends that National Laboratories should have a Data Compilation workshop to consider stock separation and assessment data quality..
HAWG	Clyde herring	Catches have increased in 2009; no sampling performed on this stock?	Sampling of age-weight-length information needed. Should be a part of the DCF for relevant countries	In general, data delivery to EGs is a national responsibility. Problems with this should be taken up with National Delegates and/or ACOM members. Data Compilations Lists from RCMs could in future provide EGs with an overview of existing data.
HAWG	ViaS/VIIbc herring	Consider effect mixed autumn and spring	Interreader calibration within Ireland	Expertise of interpretation of

AWG/WK	Stock	Data problem	How to be addressed/ by whom	PGCCDBS Comments
		spawners on interpre-tation of winter ring		winter ring with differimg birth dates available in Ireland

Stock Data Problems Relevant to Data Collection

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

Stock	Data Problem	How to be addressed in DCR	By who
Stock name	***Data problem identification***	***Description of data problem and recommend solution***	***Who should take care of the recommended solution and who should be notified on this data issue.***
HERAS survey Combined acoustic; all countries	Stock ID on mixed catches	Incorporate splitting methodology and sampling of individuals for this in the survey design. G*et al*l participating countries to split their herring into stock ID's.	*WGIPS + recommendation by PGCCDBS*
WBSS	Stock ID on mixed catches	Increase and/or redesign sampling for spawning data in herring catches in ICES area IVa and IIIa and 22-24	*PGCCDBS to re-iterate this through the DCF to the National laboratories*
Sprat in the Celtic Seas (Subareas VI and VII)	Discrepancy between WG data and official recorded data	Discrepancies between the WG historical data on catches of sprat in this eco-region and the FishStat impairs the impression of the historical exploration of sprat in the eco-region. The National laboratories will be approached by HAWG to check historical data.	*National laboratories need to check this and report back to HAWG. In the future, these catches should be part of the data exchange sheet*
Sprat in North Sea	Maintaining the sprat acoustic survey of the North Sea	HAWG is planning a benchmark assessment of North Sea sprat in 2013. The acoustic survey will probably form an important component of the assessment. Thus the acoustic survey of the North Sea should maintain at least both herring and sprat as the target species of the survey.	*WGIPS and national laboratories*

Stock	Data Problem	How to be addressed in DCR	By who
Herring in VIaS, VIIb, c	Age reading of stock components	The effect of possible changes of autumn, winter and spring spawning components in VIaS/VIIbc, will have an impact on the catch at age data. Investigate the effect that the interpretation of the last winter ring may have in this mixed stock, bearing in mind that the birth date is the 1st January.	*National Laboratories and PGCCDBS*
North Sea Sprat	Commercial landing are too poorly sampled. (quarter 4 with most catches: 0.1 samples per 1000 tonnes instead of the recommended level of 0.5 samples per 1000 tonnes)	Increase sampling commercial catches, particularly with regards to spatiotemporal coverage	Recommendation by PGCCDBS to follow sampling recommendations by the DCF
Clyde herring	Poor sampling has been performed for this stock for years	Sampling of age-weight-length information needed	*PGCCDBS: this sampling should be a part of the DCF for relevant countries*
Components within the Malin shelf herring acoustic survey (MSHAS)	Stock ID on mixed catches	Incorporate splitting methodology and sampling of individuals for this in the survey design. G*et al*l participating countries to split their herring into stock IDs	*Recommendation by PGCCDBS to the National Laboratories to initiate this*
Components within the Malin shelf herring acoustic survey (MSHAS)	Continuation of this survey is mandatory. In 2011 UK(Northern Ireland) will no longer participate	Written into the DCF by the relevant countries	*Recommendation by PGCCDBS to included in the DCF*
All	HAWG is concerned to learn that there is a strong likelihood that certain countries will lose their pelagic observer programmes in 2011.	All efforts be made to maintain observer coverage across fleets that catch a substantial proportion of pelagic fish	*FUNDAMENTAL DEMAND. PGCCDBS must make this a fundamental part of the DCF*

Stock	Data Problem	How to be addressed in DCR	By who
All	HAWG is concerned about the lack of information on discarding levels in the herring fisheries. Currently only one nation reports its discard for inclusion in the assessment. This nation is about to lose its pelagic observer programme (see above point)	All efforts should be made to maintain observer coverage across fleets that catch a substantial proportion of pelagic fish and to report on the observed discard levels.	*PGCCDBS*
North Sea, VIaN and VIaS & VIIb,c	With the addition of a new VIa MIK survey to the collection of surveys that provide potential indices, there is a requirement for understanding the catchability of small larvae with this gear, based on experimental observations. This has implications for both the new VIaN survey and for our understanding of the current IBTS0 (North Sea) survey.	Standard MIK net mesh should be tested along with a finer mesh to determine the selectivity curve	*WGIBTS*
Herring in VIIaN	Age reading of stock components	The effect of possible changes of autumn and winter spawning components in VIIaN, may have an impact on the catch at age data and survey numbers at age. Investigate the effect that the interpretation of the last winter ring may have in this mixed stock, bearing in mind that the birth date is the 1st January.	*National Laboratories and PGCCDBS*
Herring in VIIaN	Stock ID on mixed catches and survey estimates.	Incorporate splitting methodology of individuals in catch and survey.	*Recommendation by PGCCDBS to the National Laboratories to initiate this*

1.11 Stock overview

The WG was able to perform analytical assessment for 4 of the 9 stocks investigated. Results of the assessments are presented in the subsequent sections of the report and are summarized below and in Figures 1.11.1 - 1.11.3.

North Sea autumn spawning herring (her-47d3) is the largest stock assessed by HAWG. The spawning stock biomass was low in the late 1970s and the fishery was closed for a number of years. This stock began to recover until the mid-1990s, when it appeared to decrease again rapidly. A management scheme was adopted to halt this decline. Based on the WG assessment the stock is classified as being at full reproductive capacity and is being harvested sustainably but below F_{MSY} and management plan target. The SSB in autumn 2010 was estimated at 1.30 million tonnes, at the B_{pa} value. F2-6 in 2010 was estimated at 0.12, below the target F2-6 of 0.20. Recruitment appears still in the same low regime since 2002. An increase in SSB is expected throughout 2011, and under the management plan also in 2012 and 2013 to levels above 2 million tonnes. SSB is expected to be well above $B_{trigger}$, and therefore also B_{pa}, in 2011 and 2012.

Western Baltic Spring Spawners (her-3a22) is the only spring spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the Subdivisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners. Our assessment found that SSB had a 9.5% decrease from 2009, and has been estimated around 95,000 tonnes for 2010. This is the lowest value observed for the whole time series. Beside this, fishing mortality in 2010 has been estimated 0.30, thus considerably smaller than in 2009 (0.52), but it is still higher than F_{msy} (0.25). The increase in 2010 recruitment brings it back to long term average (approx. 4 billion), however the uncertainty on the estimate remains high.

Herring in the Celtic Sea and VIIj (her-irls): The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj have been considered to exploit the same stock. For the purpose of stock assessment and management, these areas have been combined since 1982. The update assessment, conducted in 2010, showed a further small increase of SSB (114 000 tonnes) supporting previous indications of a recovery of the stock. According to our assessment the stock continues to be above B_{pa}, and mean F_{2-5}, although slightly higher than in 2009, remains at historical low level. Short term projections under the rebuilding plan show a rather stable trajectory of the stock for the next year.

Herring in VIa North (her-vian): The stock was larger in the 1960s when the productivity of the stock was higher. The stock experienced a heavy fishery in the mid-70s following closure of the North Sea fishery. The fishery was closed before the stock collapsed. It was opened again along with the North Sea. In the mid 1990s there was substantial area misreporting of catch into this area and sampling of catch deteriorated. Area misreporting was reduced to a very low level and information on catch has improved, and in recent years misreporting has remained relatively low. In the absence of precautionary reference points other than B_{lim}, the state of the stock cannot be evaluated. SSB in 2010 has been estimated at approximately 61 500 tonnes, a 23% decrease from 2009. Fishing mortality in 2010 was estimated 0.27 (+19% on 2009), still above the F target of the management plan (0.25). Recruitment continues to be low since 1998. WG considerations remain mostly unchanged from previous years, the stock is currently fluctuating at a low level.

Herring in VIa South and VIIbc (her-irlw) are considered to consist of a mixture of autumn- and winter/spring-spawning fish. The winter/spring-spawning component is distributed in the northern part of the area. The main decline in the overall stock since 1998 appears to have taken place on the autumn-spawning component, and this is particularly evident on the traditional spawning grounds in VIIb. However, there are indications that the stock is on a historically low level. The current levels of SSB and F are not precisely known, as there is no tuned assessment available for this stock, but in all our explorations SSB has been estimated below B_{pa} and B_{lim}. Estimates of F for recent years are likely to exceed 0.5, though current F is unknown. In 2010 recruitment appears to increase regardless the terminal F values used, but no sign of recovery has been found for this stock.

Herring in the Irish Sea (her-nirs) comprises two spawning groups (Manx and Mourne). This stock complex experienced a very low biomass level in the late 1970s with an increase in the mid-1980s after the introduction of quotas. The stock then declined from the late 1980s onwards. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability in spawning migrations and mixing with the Celtic Sea stock. Acoustic surveys indicate a significant increase in 1+ herring biomass in the Irish Sea since 2007, maintained throughout 2010. There is evidence from surveys that recent recruitment has increased. Trends in SSB have increased while catches have been relatively stable since the 1980s, and close to TAC levels in recent years.

North Sea Sprat (spr-nsea) is a short-lived species, mainly targeted by the Danish fleet in the North Sea. The catches are usually dominated by recruits (age 1) but 2010 catches reported a considerable contribution of larger fish (age 2-5+). The stock is known to experience large fluctuations in size. The stock biomass estimated from the acoustic surveys (HERAS) was 376,000 tonnes in 2010, as compared to the peak estimate of the time series in 2009 (556,000 tonnes). The state of the stock is uncertain; no analytical assessment is available for North Sea sprat.

Sprat in IIIa (spr-kask) is mostly caught by a small-meshed industrial fishery. Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. For this reason the sprat fishery in IIIa is controlled by a herring by-catch quota (6,659 tonnes in 2011) as well as by-catch percentage limits. No major changes in fishing technology or fishing patterns have been reported. Reliable landings data for this area are available since 1996. Landings have been rather stable during the last few years. The state of the stock is uncertain; no analytical assessment is available for sprat in IIIa.

Sprat in the Celtic Sea (spr-irls): The stock structure of sprat populations in this ecoregion (Subareas VI and VII) is not clear, and further work for the identification of management units for sprat is certainly required. Most sprat in the Celtic Seas ecoregions are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. No advice or TAC has been given in 2009-2010 for sprat in this ecoregion. The quality and amount of information available for sprat is rather heterogeneous across this composite area. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e., VIa and VIIa), while acoustic surveys started in 1991, with some gaps in the timeseries. Technical problem affected the reliability of 2010 acoustic data. Groundfish surveys, could provide relative estimates of recruitment, but further work is certainly needed. Preliminary data exploration gives the broad picture that in recent years sprat biomasses have been approximately 25% of those observed in the early 1990s. The state of the stock is uncertain; no analytical assessment is available for sprat in the Celtic Sea ecoregion.

1.12 Benchmark process

HAWG has made some strategic decision regarding the future benchmarking of its stocks (Table 1.12). In 2012 it is proposed to benchmark North Sea and Irish Sea herring stocks. In 2013 it is proposed to benchmark the western Baltic spring spawning herring stock. In 2014 it is proposed to explore a combined assessment of the North Sea and western Baltic stocks, in the context of a state space framework.

It is expected that many of the methodological developments that will be explored in North Sea/western Baltic joint process may have utility for the western herring stocks. It is the ambition of HAWG to explore such approaches in a joint assessment of the western stocks from 2015 onwards.

However some of the individual western stocks should be benchmarked before 2015. This process is expected to solve some of the problems with tuning data and other inputs as well as choosing the most appropriate model for each. Both VIaN and the VIaS/VIIbc stocks would benefit from benchmarking. Before this happens it is necessary to successfully split the Malin Shelf survey (MSHAS) according to season of spawning. By 2014, 5 synoptic MSHAS surveys will be available and a benchmark of VIaS/VIIbc could be attempted if the splitting is complete.

Table 1.12. HAWG schedule of benchmarks in future.

Stock	Ass status	Latest benchmark	Benchmark next year	Planning Year +2	Further planning	Comments
NSAS	Update	2006	Yes	No	Consider NSAS/WBSS joint assessment in benchmark after 2014	
WBSS	Update	2008	N	Yes	Consider NSAS/WBSS joint assessment in benchmark after 2014	
VIaN	Update	2005	NO	No	2014/2015	Consider stock mixing with VIaS/VIIbc
Celtic Sea	Update	2008	No	No	After 2012	Consider stock mixing withVIIaN

VIaS/VIIbc	Exploratory	Never	No	No	2014/2015	Consider stock mixing with VIaS/VIIbc
VIIaN	Exploratory	Never	Yes	No		Consider stock mixing with Celtic Sea
Sprat NS	None	2009	No	Yes	2013 or 2014	9 years of acoustics then available
Sprat IIIa	None	2009	No	Yes	2013 or 2014	9 years of acoustics then available
Sprat Celtic	None	Never	No	No		Need to evaluate stock identity

NSAS / Irish Sea Benchmark planning

Preliminary discussions regarding the upcoming benchmark of the North Sea autumn spawning and Irish sea herring stocks were held. A number of key themes and issues were identified as a result of these discussions, and were agreed to form the basis for the benchmark process.

The most important concept expressed was that all work needs to be performed in a collaborative, collegiate manner, both between institutes contributing to the assessments and between the stocks. HAWG has suffered in the past from an "archipelago" approach, where work was performed in a manner that was isolated from others that could potentially benefit from it. Such an approach is not viewed as sustainable, particularly when the individuals involved move on. It was therefore agreed that as much work as possible needs to be generic and collaborative, involving a broad group of people, thereby ensuring both ownership of the assessment and the sustainability of the approach.

However, concerns were also raised about the technical capacity of the group and the skills available. The modern trend in stock assessment is a move away from the deterministic VPA approach towards more mathematically and computationally intensive statistical models: such changes can present challenges in terms of the skill levels involved in the group. HAWG agreed that the approach described above should be tailored to ensure that all members of the group can participate. Assessment work must not be forced back into the "archipelago" trap by the fact that only a small group of people have the ability to use and develop the assessment tools. Collaboration and cooperation, even if it occurs at the expense of a more advanced assessment, are therefore essential.

Finally, the importance of uncertainties in all data sources was emphasized by the group. Wherever possible, effort should be put into providing all data with an estimate the associated precision. Whilst it may not be possible to fully utilize these estimates in the current assessment models at the moment, an understanding of the uncertainty involved provides an invaluable basis for assessing the significance of both trends and inter-annual variations.

A preliminary "brainstorming" exercise was performed during the course of HAWG to identify lines of investigation that need to be pursued during the course of the benchmarking process. The collaborative approach taken above provided the basis for this exercise, with scientists representing all stocks in HAWG working together to find a common approach to the common issues at hand. Five main lines of investigation were identified, and individuals within the group took responsibility each of these "work packages". i.e.

1. Stochastic Catch (Niels Hintzen, IMARES)
    - Spatial and temporal sampling coverage of catches, including fleets
    - Catch reporting issues
    - Improved estimation of discarding
2. Understanding Surveys (Norbert Rohlf, BSH)
    - Assessment of the validity of survey indices, including underlying assumptions
    - Use of spatial information from surveys
    - Treatment of outliers in index calculations
    - Accuracy and precision of survey estimates
3. Assessment & Forecast Methods (Mark Payne, DTU Aqua)
    - Development of new assessment methodology
        - Multifleet-multistock assessment methods
        - Incorporation of uncertainties into the assessment
    - Refinement of short-term forecasting algorthims
        - Improve clarity and communication
        - Incorporation and propagation of uncertainties
4. Life History (Mark Dickey-Collas, IMARES)
    - Including process based understanding
    - Improved understanding of natural mortality at all life stages
    - Understanding variation in growth
    - Understanding variability in maturity
    - Species interactions (competition, predation)
    - Understanding migration patterns
5. Stock Structure (Lotte Worsoe Clausen, DTU Aqua / Emma Hatfield, Marine Scotland)
    - Integration of stock component dynamics into assessment
    - Dynamics of the stock components
    - Inter-stock and component mixing

- Development of component resolved survey indices

The HAWG benchmark group also developed several recommendations viewed to be of critical importance to a successful benchmark of these stocks.

- Geostatistics. Many of the questions raised, particularly around the surveys, are best solved taking into account both the spatial and statistical nature of the raw data we have available. However, the working group currently lacks expertise in the field of geostatistics. HAWG therefore requests that ICES and interested institutes provide such expertise to the benchmark process
- Pre-meeting. ICES has set the benchmark meeting for North Sea and Irish Sea herring down for January 2012. However, the HAWG 2011 meeting was the first opportunity that the group had to discuss the proposed benchmark. Given the short lead-in time and the desire for all work to be collaborative in nature, a pre-meeting was therefore viewed as essential. HAWG there requests ICES to establish a three-day data compilation and model development workshop prior to the main benchmark meeting.

1.13 Structure of the report

The report details the available information on the catch, fisheries and biology of the stocks and then the stock assessments, the projections, the quality of the assessments and management considerations for each stock. This information and analyses are given in chapters for each of the seven major stocks considered by HAWG. Despite this structure, it is important to realise that there are many links between the stocks and/or areas. (e.g., North Sea and herring caught in IIIa; VIaN herring and the North Sea; VIaS, VIIbc, Irish Sea and VIaN herring and Celtic Sea and Irish Sea herring).
In 2011 HAWG carried out four assessments:

(1) Western Baltic spring spawning herring,
(2) North Sea autumn spawning herring,
(3) VIaN autumn spawning herring and
(4) Celtic Sea autumn and winter spawning herring.

These were update assessments in 2011. Irish Sea herring and North Sea sprat were exploratory assessments. One stock with poor data (IIIa sprat) is described in Section 9. Section 10 covers sprat in the Celtic Seas ecoregion, including sprat in VIIde. Section 11 covers with limited data (no catch at age sampling) and no current ongoing research. These are Clyde herring (part of VIaN) and herring in the English/Bristol Channel (VIIe,f) and herring in Subarea VIII. A new addition to the group in 2011 was sprat in the Celtic Seas ecoregion. The group has compiled available data, but did not draft advice. The group has sought assistance from SIMWG, the Stock Identification ICES WG, on stock structure of sprat populations in this ecoregion.

Medium term predictions have not been performed in 2011. This is because work is now focussing on developing the F_{MSY} framework for the stocks.

1.14 Recommendations

Please see Annex 2

Table 1.5.1 Available disaggregated data for the HAWG per March 2011. X: Multiple spreadsheets (usually .xls); W: WG-data national input spreadsheets (xls); D: Disfad inputs and Alloc-outputs (ascii/txt); I: Intercatch input

Stock	Catchyear	Format				Comments
		X	W	D	I	
Western Baltic Sea:						
IIIa and SD 22-24	1991-2000	X				raw data, provided by Jørgen Dalskov, Mar. 2001, splitting revised
(her_3a22)	1998	X				provided by Jørgen Dalskov, Mar. 2001, splitting revised
	1999	X				provided by Jørgen Dalskov, Mar. 2001, splitting revised, catch data 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	W	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	W	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	W	D	(I)	provided by Mikael van Deurs, Mar. 2007
	2007	X	W	D	I	provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2009
	2009	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2010
	2010	X	W		I	provided by Lotte Worsøe Clausen and Tomas Gröhsler, Mar. 2011
Celtic Sea and VIIj						
(her_irls)	1999	X				provided by Ciarán Kelly, Mar. 2000
	2000	X				provided by Ciarán Kelly, Mar. 2001
	2001			D		provided by Ciarán Kelly, Mar. 2002
	2002			D		provided by Ciarán Kelly, Mar. 2003
	2003			D		provided by Maurice Clarke, Mar. 2004
	2004			D		provided by Maurice Clarke, Mar. 2005
	2005			D		provided by Maurice Clarke, Mar. 2006
	2006			D	I	provided by Maurice Clarke, Mar. 2007
	2007		W		I	provided by Afra Egan, Mar. 2008
	2008		W		I	provided by Afra Egan, Mar. 2009
	2009		W		I	provided by Afra Egan, Mar. 2010
	2010		W		I	provided by Afra Egan, Mar. 2011
Clyde						
(her_clyd)	1999	X				provided by Mark Dickey-Collas, Mar. 2000
	2000-2003					included in VIaN
Irish Sea						
(her_nirs)	1988-2003	X				updated by SG HICS, March 2004
	1998	X				provided by Mark Dickey-Collas, Mar. 2000
	1999	X				provided by Mark Dickey-Collas, Mar. 2000
	2000	X	W			provided by Mark Dickey-Collas, Mar. 2001
	2001	X	W			provided by Mark Dickey-Collas, Mar. 2002
	2002	X	W			provided by Richard Nash, Mar. 2003
	2003	X	W			provided by Richard Nash, Mar. 2004
	2004	X	W			provided by Beatriz Roel, Mar. 2005
	2005		W			provided by Steven Beggs, Mar. 2006
	2006		W		I	provided by Steven Beggs, Mar. 2007
	2007		W		I	provided by Steven Beggs, Mar. 2008
	2008		W		I	provided by Steven Beggs, Mar. 2009
	2009		W		I	provided by Steven Beggs, Mar. 2010
	2010		W		I	provided by Steven Beggs, Mar. 2011
North Sea						
(her_47d3, her_nsea)	1991	X				provided by Yves Verin, Feb. 2001
	1992	X				provided by Yves Verin, Feb. 2001
	1993	X				provided by Yves Verin, Feb. 2001
	1994	X				provided by Yves Verin, Feb. 2001
	1995	X	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1996	(X)	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1997	(X)	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1998	(X)	W	D		provided by Yves Verin, Mar. 2000, updated Oct 2003
	1999		W	D		provided by Christopher Zimmermann, Mar. 2000, updated Oct 2003
	2000		W	D		provided by Christopher Zimmermann, Mar. 2001, updated Oct 2003
	2001		W	D		provided by Christopher Zimmermann, Mar. 2002
	2002		W	D		provided by Christopher Zimmermann, Mar. 2003
	2003		W	D		provided by Christopher Zimmermann, Mar. 2004
	2004		W	D		provided by Christopher Zimmermann, Mar. 2005
	2005		W	D		provided by Christopher Zimmermann, Mar. 2006
	2006		W	D	I	provided by Norbert Rohlf, Mar. 2007
	2007		W	D	I	provided by Norbert Rohlf, Mar. 2008
	2008		W	D	I	provided by Norbert Rohlf, Mar. 2009
	2009		W	D	I	provided by Norbert Rohlf, Mar. 2010
	2010		W	D	I	provided by Norbert Rohlf, Mar. 2011

Table 1.5.1: Available disaggregated data for the HAWG per March 2011. continued

West of Scotland (VIa(N))						
(her_vian)	1957-1972	x				provided by John Simmonds, Mar. 2004
	1997	X				provided by Ken Patterson, Mar. 2002
	1998	X				provided by Ken Patterson, Mar. 2002
	1999		W	D		provided by Paul Fernandes, Mar. 2000, W included in North Sea
	2000		W	D		provided by Emma Hatfield, Mar. 2001, W included in North Sea
	2001		W	D		provided by Emma Hatfield, Mar. 2002, W included in North Sea
	2002		W	D		provided by Emma Hatfield, Mar. 2003, W included in North Sea
	2003		W	D		provided by Emma Hatfield, Mar. 2004, W included in North Sea
	2004		W	D		provided by John Simmonds, Mar. 2005, W included in North Sea
	2005		W	D		provided by Emma Hatfield, Mar. 2006, W included in North Sea
	2006		W	D		provided by Emma Hatfield, Mar. 2007
	2007		W	D	I	provided by Emma Hatfield, Mar. 2008
	2008		W	D	I	provided by Emma Hatfield, Mar. 2009
	2009		W	D	I	provided by Emma Hatfield, Mar. 2010
	2010		W	D	I	provided by Emma Hatfield, Mar. 2011
West of Ireland						
(her_irlw)	1999	X	(W)			provided by Ciaran Kelly, Mar. 2000
	2000	X	(W)			provided by Ciaran Kelly, Mar. 2001
	2001			D		provided by Ciaran Kelly, Mar. 2002
	2002			D		provided by Ciaran Kelly, Mar. 2003
	2003			D		provided by Maurice Clarke, Mar. 2004
	2004			D		provided by Maurice Clarke, Mar. 2005
	2005			D		provided by Afra Egan, Mar. 2006
	2006			D	I	provided by Afra Egan, Mar. 2007
	2007		W		I	provided by Afra Egan, Mar. 2008
	2008		W		I	provided by Afra Egan, Mar. 2009
	2009		W		I	provided by Afra Egan, Mar. 2010
	2010		W		I	provided by Afra Egan, Mar. 2011
Sprat in IIIa						
(spr_kask)	1999	X	(W)			provided by Else Torstensen, Mar. 2000
	2000	X	(W)			provided by Else Torstensen, Mar. 2001
	2001	X	(W)	D		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)	D		provided by Mikael van Deurs, Mar. 2007
	2007	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2009
	2009		W		I	provided by Cecilie Kvamme, Mar. 2010
	2010		W		I	provided by Cecilie Kvamme, Mar. 2011
Sprat in the North Sea						
(spr_nsea)	1999	X	(W)			provided by Else Torstensen, Mar. 2000
	2000	X	(W)			provided by Else Torstensen, Mar. 2001
	2001	X	(W)	D		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)	D		provided by Mikael van Deurs, Mar. 2007
	2007	X	(W)	D	I	provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	(W)	D	I	provided by Lotte Worsøe Clausen, Mar. 2009
	2009		W		I	provided by Cecilie Kvamme, Mar. 2010
	2010		W		I	provided by Cecilie Kvamme, Mar. 2011
Sprat in VIId & e						
(spr_ech)	1999	X	(W)			provided by Else Torstensen, Mar. 2000
	2000	X	(W)			provided by Else Torstensen, Mar. 2001
	2001	X	(W)	D		provided by Lotte Askgaard Worsøe, Mar. 2002
	2002	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2003
	2003	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2004
	2004	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	(W)	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	(W)	D		provided by Mikael van Deurs, Mar. 2007
	2007	X	(W)	D	I	provided by Else Torstensen, Mar. 2008
	2008	X	(W)	D	I	provided by Else Torstensen, Mar. 2009
	2009		W		I	provided by Cecilie Kvamme, Mar. 2010
	2010		W		I	provided by Cecilie Kvamme, Mar. 2011
National Data						
Germany: Western Bal	1991-2000	X				provided by Tomas Gröhsler, Mar. 2001 (with sampling)
Germany: North Sea	1995-1998		W			provided by Christopher Zimmermann, Mar 2001 (without sampling)
Norway: Sprat	1995-1998		W			provided by Else Torstensen, Mar 2001 (without sampling)
Sweden	1990-2000		W			provided by Johan Modin, Mar 2001 (without sampling)
UK/England & Wales	1985-2000	X				database output provided by Marinelle Basson, Mar. 2001 (without sampling)
UK/Scotland	1990-1998		W			provided by Sandy Robb/Emma Hatfield, Mar. 2002

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

her-vian

2010	canum			2010	weca		
wr	sallocl	InterCatch	% difference	wr	sallocl	InterCatch	% difference
1	10074	10246	98	1	0.082	0.082	100
2	20340	20472	99	2	0.155	0.155	100
3	16331	16404	100	3	0.188	0.188	100
4	9958	9931	100	4	0.213	0.213	100
5	14608	14523	101	5	0.234	0.234	100
6	6322	6284	101	6	0.239	0.240	100
7	4322	4304	100	7	0.237	0.237	100
8	5389	5411	100	8	0.240	0.240	100
9+	13199	13125	101	9+	0.255	0.255	100
Sum	100544	100700	100				

North Sea (47d3)

2010	CANUM	CANUM	Proportion	2010	WECA	WECA	Proportion
wr	Salloc	IC	Match (%)	wr	Salloc	IC	Match (%)
0	574895	574065	100.1%	0	0.008	0.008	95.4%
1	280728	273118	102.8%	1	0.057	0.057	99.4%
2	293887	288432	101.9%	2	0.129	0.129	100.1%
3	236804	232813	101.7%	3	0.167	0.167	99.8%
4	126241	124393	101.5%	4	0.191	0.191	100.0%
5	83893	84779	99.0%	5	0.220	0.222	99.4%
6	61542	60365	102.0%	6	0.219	0.220	99.8%
7	33305	33382	99.8%	7	0.216	0.216	99.8%
8	59142	59718	99.0%	8	0.233	0.235	99.5%
9+	54533	54050	100.9%	9+	0.244	0.246	99.0%
Sum	1804971	1785115	101.1%				

Baltic (3a22)

2010	CANUM	CANUM	Proportion	2010	WECA	WECA	Proportion
wr	Salloc	IC	Match (%)	wr	Salloc	IC	Match (%)
0	12448	12394	100.4%	0	0.009	0.009	100.0%
1	68683	75083	91.5%	1	0.050	0.046	108.1%
2	134822	136419	98.8%	2	0.075	0.077	97.9%
3	83113	82970	100.2%	3	0.109	0.109	100.3%
4	47664	46833	101.8%	4	0.136	0.135	100.3%
5	29968	29979	100.0%	5	0.164	0.165	99.7%
6	18181	18589	97.8%	6	0.179	0.181	99.3%
7	11680	10996	106.2%	7	0.199	0.198	100.8%
8+	11745	11262	104.3%	8+	0.205	0.206	100.0%
Sum	418304	424525	98.5%				

Her IRLW		WG Excel	Intercatch	% Deviation
Caton	Ring	10241	10241	0.00%
Canum	1	1271.08	1271.08	0.00%
Canum	2	13507.11	13507.112	0.00%
Canum	3	20127.1	20127.096	0.00%
Canum	4	6541.323	6541.32	0.00%
Canum	5	7588.488	7588.489	0.00%
Canum	6	6780.425	6780.426	0.00%
Canum	7	2562.748	2562.754	0.00%
Canum	8	660.631	660.634	0.00%
Canum	9	189.285	189.287	0.00%
Weca	1	0.104	0.10	0.00%
Weca	2	0.131	0.13	0.00%
Weca	3	0.168	0.17	0.00%
Weca	4	0.189	0.19	0.00%
Weca	5	0.201	0.20	0.00%
Weca	6	0.212	0.21	0.00%
Weca	7	0.218	0.22	0.00%
Weca	8	0.226	0.23	0.00%
Weca	9	0.229	0.23	-0.17%

HER IRLS		WG Excel	Intercatch	% Deviation
Caton		8370	8370	0.00%
Canum	1	2468.46	2468.46	0.00%
Canum	2	20928.557	20928.521	0.00%
Canum	3	8183.303	8183.263	0.00%
Canum	4	15916.593	15916.566	0.00%
Canum	5	4845.902	4845.928	0.00%
Canum	6	11592.351	11592.38	0.00%
Weca	1	0.075	0.0748	0.00%
Weca	2	0.108	0.1080	0.00%
Weca	3	0.129	0.1293	0.00%
Weca	4	0.142	0.1419	0.00%
Weca	5	0.155	0.1546	0.00%
Weca	6	0.159	0.1587	-0.12%

Her-nirs

Caton	Ring	WG Excel	Intercatch	% Deviation
Canum	1	9587.941	9589.083	0.01
Canum	2	17627	17685.46	0.33
Canum	3	6679.087	6710.468	0.47
Canum	4	6200.597	6302.952	1.65
Canum	5	3200.051	3235.585	1.11
Canum	6	924.6077	943.156	2.01
Canum	7	370.4796	373.105	0.71
Canum	8	145.6063	145.606	0.00
Canum	9+	39.29986	39.299	0.00
Weca	1	0.052644	0.05265	0.01
Weca	2	0.10642	0.10646	0.04
Weca	3	0.131259	0.13125	-0.01
Weca	4	0.145252	0.14524	-0.01
Weca	5	0.152546	0.15256	0.01
Weca	6	0.163615	0.16362	0.00
Weca	7	0.175143	0.17501	-0.08
Weca	8	0.163147	0.16315	0.00
Weca	9+	0.203658	0.20366	0.00

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

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

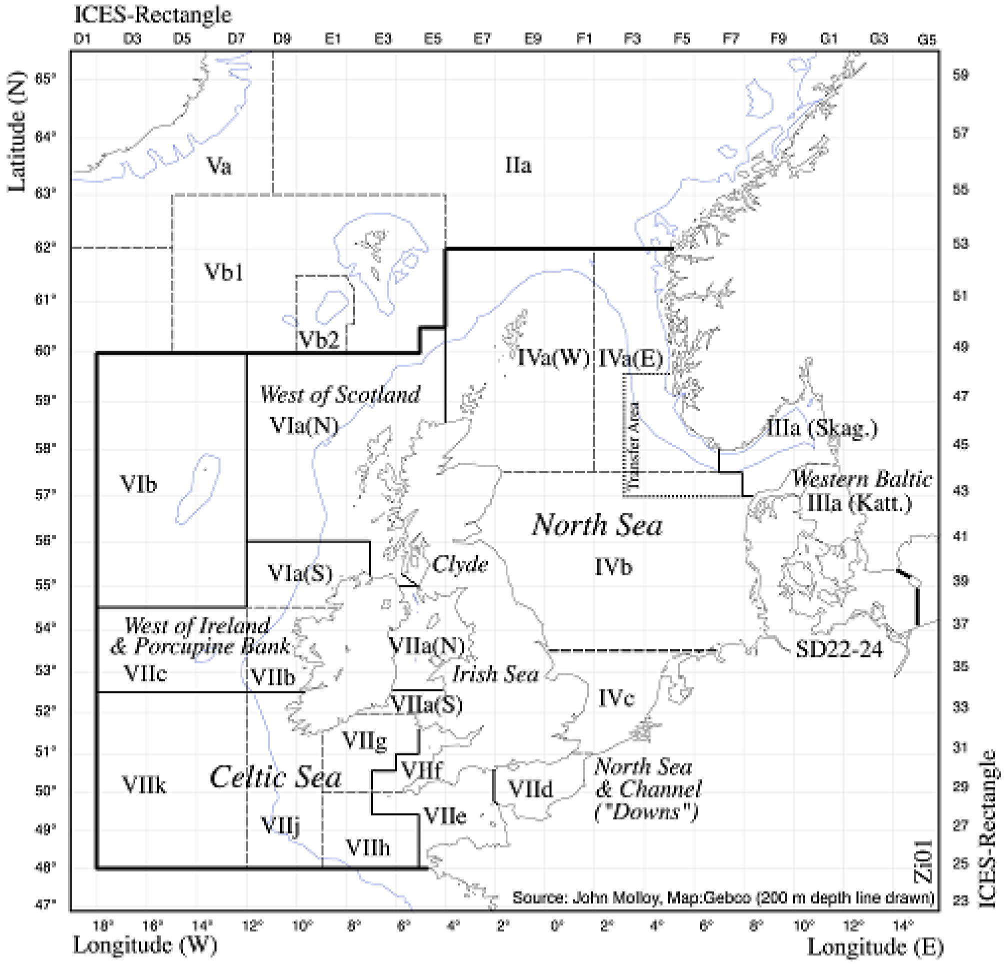


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

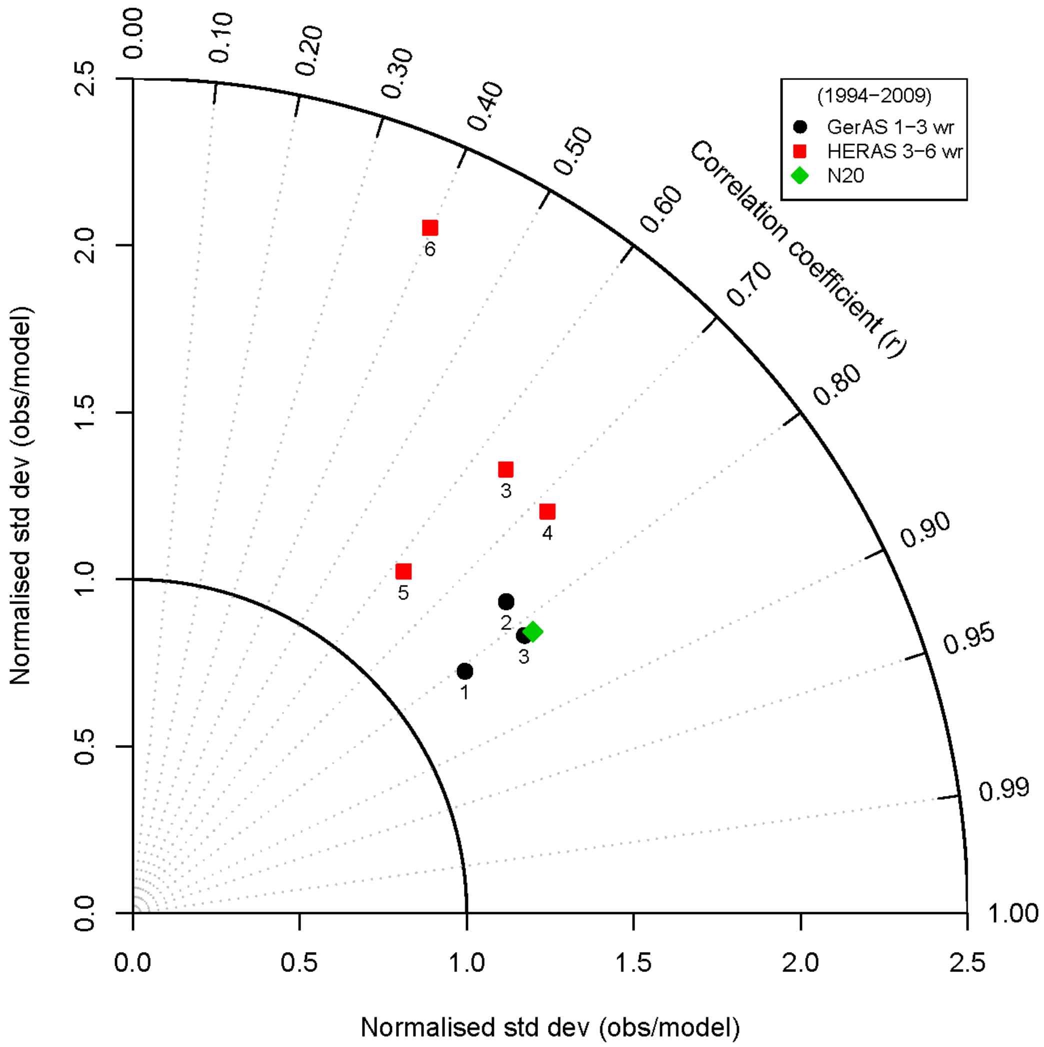


Figure 1.6.1. Example of a Taylor diagram (Taylor 2001, Payne 2011), in this case for WBSS herring. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modeled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labeled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.

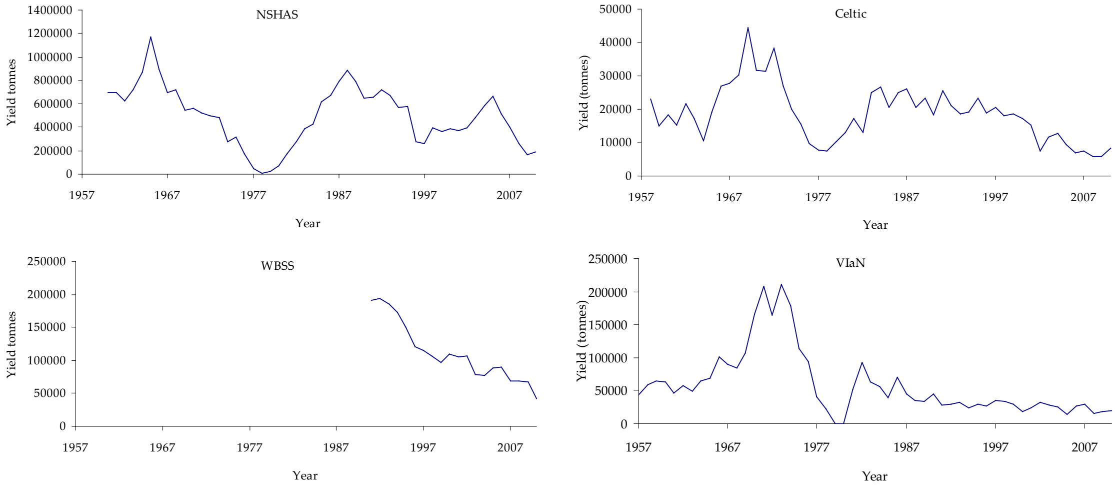


Figure 1.11.1 WG estimates of catch (yield) of the herring stocks presented in HAWG 2011.

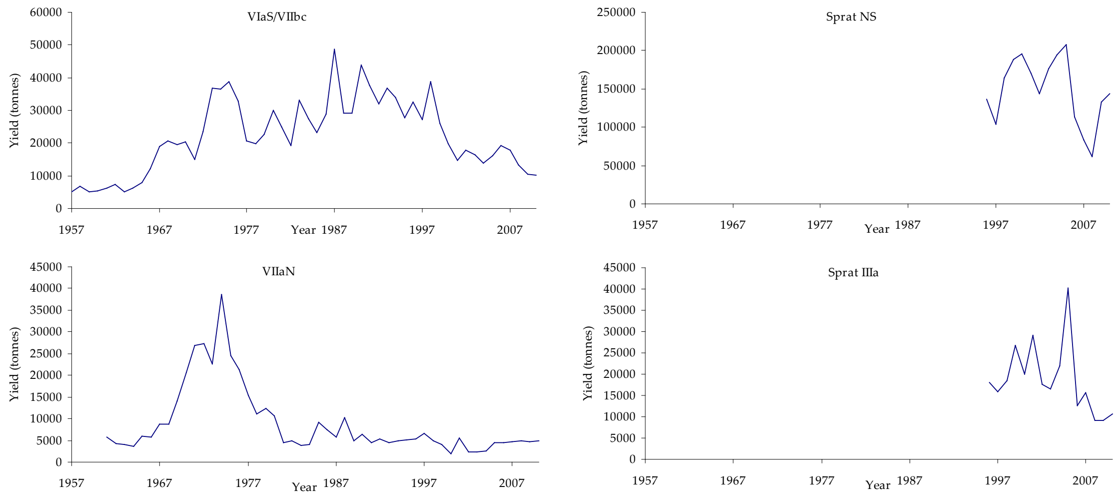


Figure 1.11.1 (cont). WG estimates of catch (yield) of the herring and sprat stocks presented in HAWG 2011.

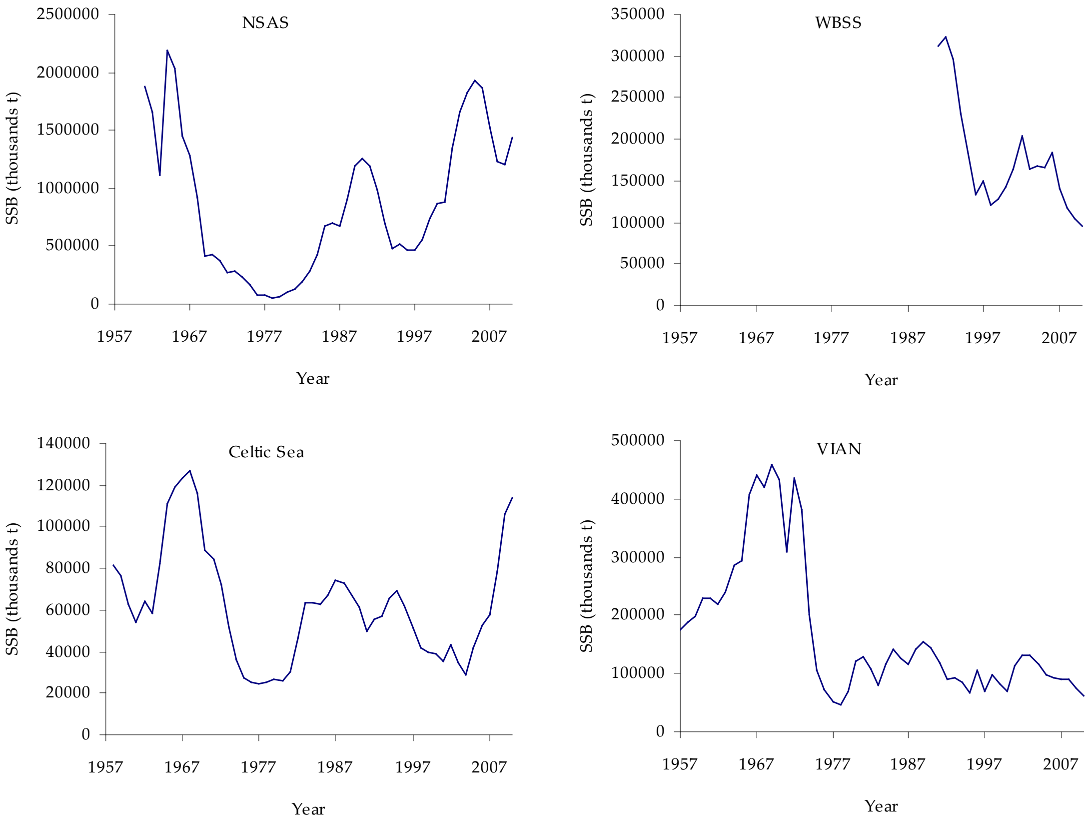


Figure 1.11.2 Spawning stock biomass estimates of the 4 herring stocks for which analytical assessments were presented in HAWG 2011.

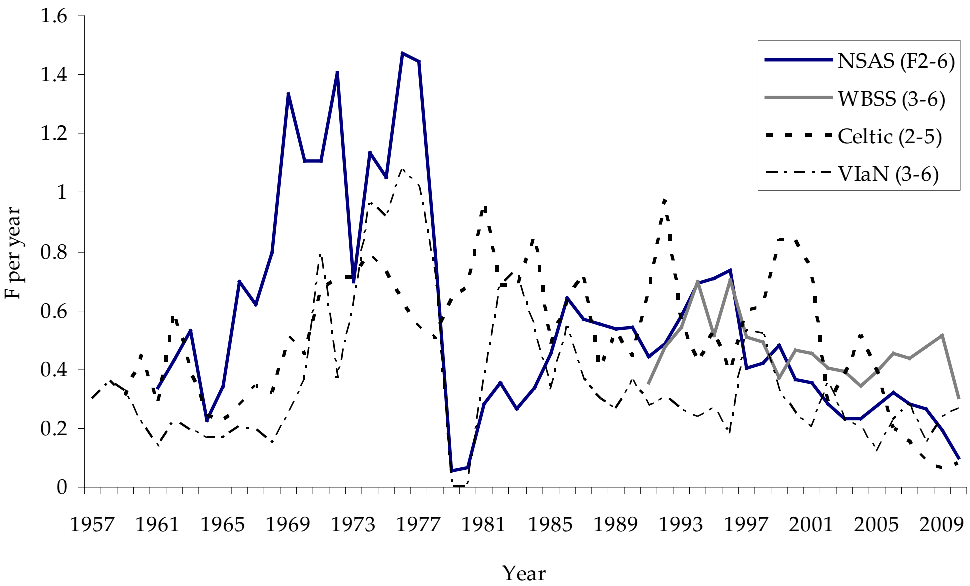


Figure 1.11.3 Estimates of mean F of the 4 herring stocks for which analytical assessments were presented in HAWG 2011.

2 North Sea Herring

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2010 and 2011

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

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

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

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

The final TAC adopted by the management bodies for 2010 was 164 300 t for Area IV and Division VIId, whereof not more than 15 319 t should be caught in Division IVc and VIId. For 2011, the total TAC was increased by 22% to 216 539 t (200 000 t for the A-Fleet), including a TAC of 26 536 t for Division IVc and VIId.

The by-catch TAC for fleet B in the North Sea was 13 587 t for 2010 and is increased by 22% to 16 539 t for 2011, in line with the TAC for the human consumption fleet. As North Sea autumn spawners are also caught in Division IIIa, regulations for the fleets operating in this area have to be taken into account for the management of the WBSS stock (see Section 3). Catches of herring in the Thames estuary are not included in the TAC. For a definition of the different fleets harvesting North Sea herring see the Stock Annex and Section 2.7.2.

2.1.2 Catches in 2010

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

The catch figures in Tables 2.1.1 - 2.1.5 are mostly provided by WG members and may or may not reflect national catch statistics. These figures can therefore **not** be used for legal purposes. 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 bycatch by other small-mesh fisheries in the North Sea may be an underestimate. The total WG catch of all herring caught in the North Sea in 2010 amounted to 174 600 t.

Landings of herring taken as bycatch in the Danish small-meshed fishery in the North Sea have decreased by 7% to 9 071 t as compared to last year (Table 2.1.6). These industrial herring catches were much lower than the by-catch TAC set by the EU (13 587 t).

In the Norwegian industrial fishery, herring by-catch has increased in 2010 to 4 451 t (compared to 3 576 t last year).

Official catches by the human consumption fishery were 165 500 t in 2010. This is an overshoot of 1% of the TAC. Working Group catches in the human consumption fishery were in the same order of magnitude in 2010 (165 600 t, increase by 6% from last year).

In the southern North Sea and the eastern Channel, the total catch sums to 26 520 t. The separate TAC for this area was 15 319 t, so landings in IVc and VIId overexploit the TAC by 73%. This is a large change compared to 2009, when landings (21 923 t) were in good accordance with the TAC (23 567 t).

The total North Sea TAC and catch estimates for the years 2005 to 2010 are shown in the table below (adapted from Table 2.1.6). Since the introduction of yearly bycatch ceilings in 1996, these ceilings have never been exceeded.

Year	2005	2006	2007	2008	2009	2010
TAC HC ('000 t)	535	455	341	201	171	164
"Official" landings HC ('000 t)[1]	547	478	354	219	157	166
Working Group catch HC ('000 t)	617	498	381	236	156	166
Excess of landings over TAC HC ('000 t)	83	43	40	35	0	1
By-catch ceiling ('000 t) [2]	50	42	32	19	16	14
Reported by-catches ('000 t) [3]	22	12	7	9	10	9
Working Group catch North Sea ('000 t)	639	511	388	245	166	175

HC = human consumption fishery

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

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

3 provided by Denmark only.

2.1.3 Regulations and their effects

Landings taken in the North Sea but reported from other areas such as Divisions IIa and IIIa and from Division VIaN have further decreased in 2010. The estimate of the total amount of catch in the North Sea (A- and B-Fleet) does not exceed the total TAC. While the B-Fleet has not taken the TAC in 2010 (and has never done), the catch in the human consumption fishery is approximately the same as the TAC.

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

In 2011, half of the EU quota for Division IIIa could be taken in the North Sea and Norway can take up to 50% of its quota for Division IIIa in Norwegian waters of the North Sea.

In the North Sea, Norway can take up to 50 000 t of its quota in EU-waters in Divisions IVa and IVb.

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. While the majority of catches is still taken in Subdivision IVaW, the proportion of catches taken in Division IVb have reduced by roughly 50%. Increasing fuel prices may have had an impact on the travelled distance during shipping trips, resulting in fishing activities somewhat closer to the coastline or home port.

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

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

2.2 Biological composition of the catch

Biological information (numbers, weight, catch (SOP) at age and relative age composition) on the catch as obtained by sampling of commercial catches is given in Tables 2.2.1 to 2.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately by area for herring caught in the North Sea, 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 Section 3.2 and in the Stock Annex 2. Note that splitting was only applied to the WG 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 1995-2010 (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 2000 – 2010.

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

2.2.1 Catch in numbers-at-age

The total number of herring taken in the North Sea (1.5 billion fish) and the total number of NSAS (1.8 billion fish) have increased by 7% and 12%, as compared to last year. 0- and 1-ringers contributed 40% of the total catch in numbers of NSAS in 2010 (Table 2.2.5). In 2010, 0- and 1-ringer catch has further decreased by 1% and 14%, respectively, as compared to 2009. Most of these herring are still taken in the B-Fleet. Catches of 0- and 1-ringers are mostly taken in Divisions IVb and IVc, where they amount to almost 80% of the catch in numbers. Roughly 30% of the total catch by number in the North Sea consist of the age group 4+ winter ringers.

Western Baltic and local Division IIIa spring-spawners (WBSS) are taken in the eastern North Sea during the summer feeding migration (see Stock Annex 3 and Section 3.2.2). These catches are included in Table 2.1.1 and listed as IIIa type. Table 2.2.8 specifies the estimated catch numbers of WBSS caught in the North Sea, which are transferred from the North Sea assessment to the assessment of Division IIIa/Western Baltic in 1995-2010. After splitting the herring caught in the North Sea and IIIa between stocks, the total catch of North Sea Autumn spawners was 187 600 tonnes.

Area	Allocated	Unallocated	Discards	Total
IVa West	108 960	-	13	108 973
IVa East	9 586	-	-	9 586
IVb	29 548	-	-	29 548
IVc/VIId	26 520	-	-	26 520
	Total catch in the North Sea			174 627
	Autumn spawners caught in Division IIIa (SOP)			13 759
	Baltic spring spawners caught in the North Sea (SOP)			-774
	Blackwater spring spawning herring			-85
	Other spring spawners			0
	Total catch NSAS used for the assessment			**187 612**

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian spring-spawners and local fjord-type spring spawning herring are taken in Division IVa (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in Tables 2.1.1 to 2.1.6, but are listed separately in the respective catch tables. Along with the increasing biomass of these spring spawning herring, the catches have increased to 56 900 t in 2010 (44 560 t in 2009).

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. Catches were only 85 t in 2010.

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

2.2.3 Data revisions

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

2.2.4 Quality of catch and biological data, discards

As in previous years, some nations provided information on misreported and unallocated catches of herring in the North Sea and adjacent areas. The **Working Group**

catch, which include estimates of all fleets (and discards and misreported or unallocated catches; see Section 1.5), was estimated to be in the same order of magnitude as the official catch.

Information on discards is low in 2010. The final figure for discards as used in the assessment was only 13 t, based on the raised discards for one fleet. As discards are likely to occur in all national fisheries, this figure may be an underestimate. Discard data have not been consistently available for the whole time series and are only included in the assessment when reported. Besides discarded catches, also considerable loss of herring may occur during catch processing, e.g. flushing of tanks and slippage from the net. Little information is available about the amount of this loss, but is thought to amount to larger quantities.

The amount of sampling of the commercial landings has improved in 2010 and covers 81% of the total catch (2009: 70%). The number of herring weighed and measured has increased considerably and is twice as high as in 2009 (Table 2.2.12). It should be observed that "sampled catch" in Table 2.2.12 refers to the proportion of the reported catch to which sampling was applied. This figure is limited to 100% but might in fact exceed the official landings due to sampling of discards, unallocated and misreported catches.

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (here defined as each combination of fleet/nation/area and quarter). Of 85 different *reported* metiers, 37 were sampled in 2010. The recommended sampling level of more than 1 sample per 1 000 t catch has been met for 16 metiers, (12 in 2009). For age readings (recommended level >25 fish aged per 1 000 t catch) also 16 metiers appear to be sampled sufficiently (2009: 13).

In the human consumption fishery, Divisions IVc and VIId were not sampled in the 2nd and 3rd quarter at all. The amount of samples representing catches in the B-Fleet is insufficient. Only two metiers were sampled in an adequate manner.

On the other hand, some of the metiers yielded very little catch. In 38 metiers the catch is below 1 000 t. The total catch in these metiers sums to 3 782 t, so the remaining 48 metiers represent 170 800 t of the official catch (almost 98%). Of these 48 metiers, 18 were sampled and 11 of them fulfil the recommended level of more than 1 sample per 1 000 t catch and than 25 age readings per 1 000 t catch.

However, the catch of France, Lithuania, and the Faroe Islands from the North Sea has not been sampled. According to the DCF regulations, some catches of UK (England) and Sweden were landed into and sampled by other nations.

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

2.3 Fishery independent information

2.3.1 Acoustic Surveys in the North Sea (HERAS), West of Scotland VIa(N) and the Malin Shelf area (MSHAS) in June–July 2010

Seven surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge between 200 and 400 m depth. The individual surveys and the survey methods are given in the report of the Working Group for International Pelagic Surveys (WGIPS; ICES CM 2011/SSGESST:02). The vessels, areas and dates of cruises are given in Table 2.3.1.1 and in Figure 2.3.1.1.

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

The North Sea autumn spawning herring spawning stock was estimated at 3.0 million tonnes and 14 200 million herring (Table 2.3.1.2). In term of biomass this is 15 % higher compared to the previous year. The strong 2000 year class of herring is now incorporated in the 9+ group. The abundance of the 2006 year class (age 3 this year) is consistent with a strong estimate of fish at age 2 last year, indicating that the 2007 estimate of age 0 fish was more precise than previously assumed. The current estimate also confirms a healthy 2008 year class already observed in the previous year.

The spatial distribution of mature and immature autumn spawning herring is shown in Figures 2.3.1.2 and 2.3.1.3 respectively. The distribution of adult herring in the North Sea is still concentrated in the areas close to the Fladen grounds, but seems to stretch out somewhat towards the north, east of the Shetland Islands.

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

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

Herring larvae surveys were conducted in September and December 2010 and in January 2011. They cover stations in the Orkney/Shetland area, Buchan and the central North Sea in the second half of September. The southern North Sea was surveyed on three occasions in December 2010 and January 2011 (Figures 2.3.2.1 – 2.3.2.4). The survey effort in vessel days and numbers of samples taken is comparable to previous years.

As anticipated, newly hatched larvae spatial distributions varied between areas and time periods. The total number of newly hatched larvae decreased in all observed areas, with the exception of the southern North Sea. Some abundance estimates are influenced by larvae patchiness, especially in the December survey in the southern North Sea (Table 2.3.2.1, Figure 2.3.2.5). However, the overall abundance of newly hatched larvae in all three observations in the southern North Sea in 2010 is high and comparable to last year. The total estimates for the two most recent years in this area are the highest on record and the proportion of Downs offspring in the total larvae abundance has a strong increasing trend for at least the last five years.

The updated MLAI time-series is shown in Table 2.3.2.1. Based on this year's abundance estimates, the MLAI for the whole North Sea is the second highest on record (Figure 2.3.2.6).

Detailed information on survey results are given in the Report of the Herring Larvae Surveys in the North Sea (Rohlf & Gröger, WD 10).

2.3.3 International Bottom Trawl Survey (IBTS-Q1)

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

2.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area is used as recruitment index for the stock. This year's IBTS0 index is based on 586 depth-integrated hauls with the ring-net. Due to research vessel problems, the Swedish sampling in the Skagerrak-Kattegat area (IIIa) was not carried out this year. Index values are calculated as described in the WG report of 1996 (ICES 1996/ACFM:10), however, for the 2010 year class without information from IIIa. The series of estimates is shown in Table 2.3.3.1. The new index value of 0-ringer abundance of the 2010 year class is estimated at 77.0.

The index estimate is the same as last year's estimate for the 2009 year class. This is about 70% of the long term mean, and shows a continuation of the series of relatively poor recruitments starting from the 2002 year class. The 0-ringers caught in 2011 were predominantly found in a dense concentration off the Scottish coast and in the Moray Firth while abundances in southern areas of the North Sea were low (Figure 2.3.3.1). This pattern of distribution differs from the preceding two year classes, where concentrations were seen further from the coast and extended further to the south. Note that there is no distributional data for the Skagerrak/Kattegat for 2011. Concentrations of Downs herring larvae were apparent from ring net catches in the area of the English Channel, however, due to their small size (many below 12 mm mean length) most of these will not contribute to the recruitment index at a scale comparable to estimates based on larger larvae (> 20 mm). Hence, these small larvae are not included in the standard procedure of index estimation and not illustrated in the Figure 2.3.3.1.

A long term trend in the distributional patterns of 0-ringers is apparent from the changes in absolute and relative abundance of 0-ringers in the western part of the North Sea, as illustrated in Figure 2.3.3.2. In this figure the relative abundance is given as the number of 0-ringers in the area west of 2°E relative to the total number of 0-ringers in the given year class. Since the year class 1982, when the relative abundance was 25%, a general increase in abundance has been seen for the western part. In the last decade, the majority of 0-ringers have been distributed in this area. The proportion for the present year class is 81%.

2.3.3.2 The 1 to 5+ ringer herring abundances (IBTS-1 to 5+ indices)

1-ringer abundance

The 1-ringer recruitment estimate (IBTS-1 index) is based on trawl catches in the entire survey area. The time series for year classes 1977 to 2009 is shown in Table 2.3.3.2. This year's 1-ringer catches indicate a stronger recruitment of the 2009 year class, 51% above the long term mean. Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in February 2009, 2010 and 2011. Across years, the main areas of 1-ringer distribution are in the German Bight and south of Dogger Bank. For the 2009 year class, high abundances in the area off the German Bight and in an area off the Swedish coast contributed to the relatively high index estimate.

The Downs herring hatch later than the autumn spawned herring and generally appear 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 both 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 45% of this year's group of 1-ringers is smaller than 13 cm.

2-5+ ringer abundances

Table 2.3.3.3 shows the time-series of abundance estimates of 2-5+ ringers from the 1st quarter IBTS for the period 1983-2011. The present 2011 index for 2-ringers is 60% of the long term mean; this estimate is strongly influenced by high catches along the Swedish coast. The 3-5+ ringer indices are dominated by a single large catch in the English Channel and are all well above their long term means.

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 from the North Sea acoustic survey (HERAS) as well as the mean weights-at-age in the catch from 1996 to 2010 for comparison. The data for 2010 were sourced from Table 2.3.1.2. and Table 2.2.2. In the third quarter most fish are approaching their peak weights just prior to spawning.

In 2010, almost all age groups have lower mean weights-at-age when compared to 2009. Only 5-ringers in the acoustic survey were slightly higher in mean weight and 1-ringers in the catch have increased as well. This pattern was observed in both the acoustic survey and catch data indicating that these increased weights are not merely survey noise.

Generally, mean weight of the older fish (4+wr) in the acoustic survey has been declining since 1996. In 2009, sizeable increases in weight for the 4- to 7-ringers have been observed. However, the general tendency of declining weights-at-age seems to have continued in 2010 (Figure 2.4.1.1).

Variations in size-at-age in North Sea herring can to a large extent be explained by density dependent mechanisms but also seem to be affected by environmental effects to some degree (reviewed in Dickey-Collas *et al.*, 2010). In particular, it has been noted that the very strong 2000 year class, which was competing with an already large herring stock biomass, has been growing slower than other year classes throughout. This was still evident in 2010 where this cohort is included in the 9+ group.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2010 were estimated from the North Sea acoustic survey (Table 2.4.2.1). The method and justification for the use of values derived from a single year's data was described fully in ICES (1996/ACFM:10).

For 2-ringers the proportions mature in 2010 was 45% which is very low compared to the most recent years, but not unprecedented in the time series (Table 2.4.2.1). The very large 2000 year class was the most recent to display such delayed maturity emphasising the negative relation between year class size, and its growth and therefore maturity. However, only a small drop in the weights of 2-ringers in 2010 was observed in both the survey and the catches, and such a dramatic drop in maturity was therefore not expected. It is striking that immature 2-wr herring show increasing mean weights and lengths in the last two years (Figure 2.4.2.1). This indicates that their weight increases but maturity is delayed.

The reliability of the maturity estimates was investigated through the relevant national institutes. HAWG is satisfied that the estimates are reliable. The potential for errors in maturity staging has been addressed by WGIPS in 2008 (then PGHERS) and is not considered to be problematic now (ICES CM 2008/LRC:01). A further workshop on maturity staging of herring is also planned later in 2011.

However, the low proportion of mature 2-wr herring has a large impact on the SSB estimate in the assessment. It is approximately 150 000 t, when compared to estimates derived from last year's proportion of 90% mature fish in that age group.

Compared to 2009 the 3-ringers were considered slightly less mature at 90% and 4-ringers were all still fully mature in the 2010 survey (Table 2.4.2.1.).

2.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS0 and the IBTS-1 indices are available. Further, the 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 0-ringer and 1-ringer recruitment indices

The estimation of 0-ringer abundance (IBTS0 index) predicts the year class strength one year before the strength is estimated from abundance of 1-ringers (IBTS-1 index). The relationship between year class estimates from the two indices is illustrated in Figure 2.5.1 and described by the fitted linear regression. Last year's prediction of the 2009 year class was somewhat lower than this year's IBTS-1wr index of the year class (circled in the figure). In the past there was generally good agreement between the indices in their description of temporal trends in recruitment (Figure 2.5.2), but in recent years (the 2009 and the 2006-2007 year classes) the predicted levels of recruitment deviate. Among possible explanations for this deviation is the underestimation of the Downs component by the IBTS0 index as discussed in an earlier report (ICES 2009/ACOM 03, sections 2.3.3.1-2).

2.5.2 Trends in recruitment from the assessment

Abundances of recruiting North Sea herring are estimated from the assessment (see the temporal trend of recruitment in Figure 2.6.3.1). The recruitment declined during the 60s and the 70s, followed by a marked increase in the early 80s. After the strong 1985 year class recruitment declined again until the appearance of the strong year classes 1998-2000. During the following years the recruitment declined. The recent observations of 1- and 2-ringer abundances indicate some increase in recruitment since the low of the 2002-2004 year classes.

2.5.3 North Sea short-term recruitment forecast using the CDARM model

At HAWG 2010 the **C**limate-**D**riven **A**RIMAX **R**ecruitment **M**odel (CDARM)

$$
\begin{aligned}
(1\text{-}B)R_t = \mu + & \frac{\omega_1}{(1-\delta_{1,1}B-\delta_{1,2}B^2-\delta_{1,4}B^4)}(1\text{-}B)\,\mathrm{NAO}_{t-5} \\
+ & \frac{\omega_2}{(1-\delta_{2,1}B-\delta_{2,2}B^2)}(1\text{-}B)\,\mathrm{AMO}_{t-3} \qquad (1) \\
+ & \varepsilon_t
\end{aligned}
$$

developed by Gröger *et al.* (2010) has been updated in 2010 using the recruitment information for years 1970 to 2009 to give new parameter estimates (see text table below). To cross-check this updated model's performance with reality, forecasts for years 2010, 2011 and 2012 have been performed before the 2010 assessments began. Whilst the forecasts for years 2010 and 2011 were added to Table 2.5.3.1 (last two grey shaded cells), the forecast for 2012 was not as this has been indicated to be relatively uncertain by cross-iteration diagnostics (Gröger *et al.*, 2010).

Type	Variable associated	Parameter	Estimate
Intercept		μ	17168.9
Overall regression factor	Winter NAO	ω_1	-4848780
Denominator factor	Winter NAO	$\delta_{1,1}$	-0.56909
Denominator factor	Winter NAO	$\delta_{1,2}$	-0.45183
Denominator factor	Winter NAO	$\delta_{1,4}$	-0.02623
Overall regression factor	Winter AMO	ω_2	29090041
Denominator factor	Winter AMO	$\delta_{2,1}$	0.47168
Denominator factor	Winter AMO	$\delta_{2,2}$	-0.87219

In equation (1) $B^l = y_{t-l}$ is a shift parameter of order l and $(1\text{-}B)^d = (y_t - y_{t-d})$ a differentiation parameter of order d. The CDARM parameter estimates for this time period are given in the text table above. As per convention, autoregressive (AR) terms of exogenous input variables appear in the denominator of rational transfer functions, while moving average (MA) terms would appear in the numerator. In this case the CDARM model contains only AR terms for both, winter NAO and winter AMO. The three denominator factors $\delta_{1,1}$, $\delta_{1,2}$, and $\delta_{1,4}$ for winter NAO arise from the fact that winter NAO has been identified as an AR subset model of order 3 in a previous step (AR order p=(1 2 4); see equation (1)), whereas the two denominator factors $\delta_{2,1}$ and $\delta_{2,2}$ for winter AMO originate from the fact that winter AMO has been identified as an AR subset model of order 2 in a previous step (AR order p=(1 2); see equation (1)).

The estimated recruitment index time series (TS) in Table 2.5.3.1 consists of *ex-ante* predictions (hindcasts) for years 1970 to 2009 and *ex-post* (forward) forecasts for years 2010 and 2011. The *ex-post* forecasts for years 2010 and 2011 correspond highly with the recruitment values modelled from ICA.

The CDARM SAS code (version 9.24) including all data (recruitment, winter NAO, winter AMO) for period 1960 to 2009 is archived in the sharepoint system of HAWG 2011.

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

North Sea herring was classed as an update assessment in 2011 by ACOM. A benchmark assessment is scheduled for the beginning of 2012, before the regular herring Working Group meeting in 2012. The choice of assessment model, catch and survey weightings and the length of separable period were not explored in 2011, and for justification of the approach refer to the benchmark assessment (ICES CM 2006/ACFM:20) and Simmonds (2003; 2009). Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is FLICA.

Acoustic (HERAS ages 1-9+), bottom trawl (IBTS-Q1 ages 1-5+), IBTS0 and MLAI larvae (IHLS) 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. In recent years, including the most recent assessment, it has been observed that the indices for IBTS-Q1 are noisy when used in the assessment. The WG still shares the opinion however that the assessment is best executed including all surveys (Simmonds, 2009).

This year's assessment is an update assessment. The input data and the performance of the assessment have been carefully scrutinised to check for potential problems, but no changes to the methods or development of the model took place in 2011. From these analyses it was noted that the proportion mature of 2wr fish was estimated to be low, while the weight of these fish was only on average 10 grams smaller than last year's 2wr fish. The 2wr fish in 2009 were regarded amongst the heaviest in the time series. Further discussion on the low maturity of the 2wr fish in 2010 is given in Section 2.4.2. The diagnostics do not indicate any significant pattern or unreliable data points (Figure 2.6.1.1 to Figure 2.6.1.16).

The assessment fit to the acoustic survey (ages 4-9+) over the years 2005-2009 has resulted in larger residuals, a pattern also observed and described in preceding assessment reports. However, this year's indices have a markedly better fit to the assessment, discontinuing the period of negative residuals patterns. One possible explanation of the lack of fit in the acoustic survey could be if the herring population has moved partly out of the survey area. This has, however, not been studied yet. The IBTS survey continues to result in a noisy signal, especially for the 2wr herring (Figure 2.6.1.17). The internal consistency of the IBTS survey is low.

The MLAI index remains high, at a level just below that observed in 2009. The 2010 estimate represents, together with the 2009 estimate, the highest values in the entire time series. As anticipated, the stock assessment did not fit this value well (Figures 2.6.1.16 to 2.6.1.18). A possible explanation for the high MLAI index is the contribution of the expanding Downs component in recent years. The underlying model assumes constant contribution from each spawning component to the MLAI index. However, with the increased contribution of the Downs component this assumption might be violated in the more recent period. The WG decided to keep this value in the final stock assessment. 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.

Overall the catch residuals are small.

Figures 2.6.1.19 to 2.6.1.21 show retrospective estimates of SSB, recruitment, mean F_{2-6}, selectivity pattern and year class cohorts, by removing one year of data at a time, up to 10 years in total. A revision of SSB was observed in the 2010 assessment where the 2006 year class was perceived to be markedly different from the perception in the two prior years. The perception of the 2006 year class has not changed this year, however, the perception of the 2007 and 2008 year classes has changed, increasing the estimated size of these two year classes in turn leading to an upward revision in SSB. One possible explanation for the changing perception might be found in the contrast in the catch data. The juvenile fishing mortality is low (below 0.05 yr^{-1}) and the IBTS-Q1 is regarded as a noisy index, therefore the information does not show a very clear pattern. Year classes are only targeted by the main adult fishery from the 2wr and onwards. Hence, from 2wr the perception might become more reliable as more data are available. The changing perception of SSB is also reflected in the analytical retrospective pattern of F, showing downward revisions over the past years. The retrospective estimates of recruitment in the years 2008 and 2009 (the 2007 and 2008 year classes) deviate more than observed in the rest of the retrospective pattern, as was already pointed out above. Figure 2.6.1.21 shows the retrospective pattern of the number per cohort. This pattern is consistent over the years as well, with exception for the 2007 and 2008 year classes. Selectivity seems to have shifted towards younger ages while reducing selectivity on older ages (Figure 2.6.1.19). It should be noted, however, that estimates of fishing mortality on all ages are low and that the contrast available in the catch data, used to estimate selectivity, therefore is low as well. As fishing mortality is now estimated to be similar to natural mortality, the importance of natural mortality estimates increases.

Figure 2.6.1.22 shows the 'otolith' plot, representing the uncertainty of the fit of the assessment model in terminal F and SSB. The 99% confidence interval of SSB indicates that the stock is above B_{lim} and the mean indicates a biomass just above B_{pa}.

Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers- and weights-at-age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic and IBTS survey (see Figures 2.6.1.23 to 2.6.1.30). It was observed that the estimates of weight-at-age in the catch have gone down in the 2010 assessment while weights-at-age in the stock for ages 2-7 have increased over the past three years. The weights-at-age used in the assessment are taken as average weights-at-age, as estimated in the acoustic survey, over the past three years. No further issues were raised by this exercise.

2.6.2 Exploratory Assessment for NS herring

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

2.6.3 Final Assessment for NS herring

In accordance with the settings described in the Stock Annex, the final assessment of North Sea herring was carried out by fitting the integrated catch-at-age model (ICA, in the FLR environment - version 1.4-12 – 08 October 2009 15:16:26). The input data and model settings are shown in Tables 2.6.3.1 – 2.6.3.11, the ICA output is presented in Tables 2.6.3.13 – 2.6.3.21, the stock summary in Table 2.6.3.12 and Figure 2.6.3.1 and model fit and parameter estimates in Table 2.6.3.21. Diagnostics of the catch for the separable period are shown in Figure 2.6.3.2. Figure 2.6.3.3 shows the agreed management plan including the biomass trigger points and contains the F_{2-6} estimates of the past 9 years, as well as including the prognosis for 2011.

The spawning stock at spawning time in 2010 is estimated at approximately 1.30 million tonnes [1.1, 1.5 million tonnes (95% CI)] below the revised estimated 1.44 million tonnes in 2009. The reduction is primarily due to the low maturity of 2wr in the population. The estimate of 0wr fish in 2010 (2009 year class) is estimated to be at approximately 3.9 billion [1.59, 5.18 billion (95% CI)], above the long term geometric mean (see Table 2.6.3.14 and Figure 2.6.3.4). The perception of the year class strength of the 2008 year class has been revised to have a similar size to the 2009 year class. Both the 2008 and 2009 year class are estimated to be approximately 1.5 times above the low recruitment observed in the years 2002 till 2008. The strong 2000 year class is still in the population, but in the plusgroup at age 9wr in 2010, but its influence on the population is small. The 2007 year class (2wr in 2010) is now estimated to be 59% larger than the estimate from the HAWG 2010 stock assessment (see Section 2.10). Mean F_{2-6} in 2010 is estimated at approximately 0.12 [0.096, 0.143 yr^{-1} (95% CI)], which is below the management agreement target F, while mean F_{0-1} is 0.02, also below the agreed target. The updated assessment estimated an F_{2-6} of 0.10 in 2009, lower than estimated in the 2010 stock assessment.

2.6.4 State of the Stock

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

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at full reproductive capacity and is being harvested sustainably but below F_{MSY} and management plan target. The SSB in autumn 2010 was estimated at 1.30 million t, just above B_{pa}. F_{2-6} in 2010 was estimated at 0.12, below the target F_{2-6} of 0.2. The 2008 and 2009 year classes are estimated above the long term recruitment geometric mean.

2.7 Short term predictions

Short term predictions for the years 2011, 2012 and 2013 were done with code developed in R software, mimicking the MFDP programme. In 2009 the results of both methods were extensively compared to ensure that they both gave identical results. In the short term predictions, recruitment is assumed constant for the years 2012 and 2013 within the same recruitment regime since 2002 (geometric mean of 2001 to 2009 year classes).

For the intermediate year, no overshoot for the A fleet was assumed, as the catches equalled the TAC in 2010. Negotiations between the EU and Norway resulted in the allowance of 50% of the TAC in the Kattegat-Skagerrak area to be taken in the North Sea. Therefore, the TAC by the A fleet is increased by 15 000 tonnes. For the B-fleet the agreed by-catch ceiling in 2011 has been used. For the C and D fleets, the fraction of North Sea autumn spawning herring caught in IIIa vs. the fraction of western Baltic spring spawning herring in the same area is used to derive C and D fleet catches, based on projected TAC's in IIIa for these fleets. See Table 2.7.1 – 2.7.11 for other inputs. The procedure followed is described in Stock Annex 2 and Annex 3 and has been the same for several years now.

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

a) No fishing;
b) The EU-Norway management plan
c) A roll over TAC from 2011 to 2012 of 200 kt for the A fleet;
d) The EU–Norway Harvest Control Rule as implemented within the management plan (no restriction on TAC change);
e) A 15% decrease in the A fleet TAC between 2011 and 2012;

Since the current management plan only stipulates overall fishing mortalities for juveniles and adults, making fleet-wise predictions for four fleets that are more or less independent provides different options for 2012. The consequence of other combinations of catch options can be explored on request.

For options b, c, d and e, the C and D fleets are assumed to have a North Sea autumn spawner catch for 2011 of 3.9 and 1.7 thousand tonnes respectively. In 2012 and 2013 they are assumed to have a North Sea autumn spawner catch of 5.1 and 0.6 thousand tonnes respectively. **All predictions are for North Sea autumn spawning herring only.** The results are presented in Table 2.7.12.

2.7.1 Comments on the short-term projections

HAWG assumed recruitment survival to not have changed since 2002. Therefore, the recruitment in the forecasted years is assumed to be similar to the year classes 2001 to 2009. An increase in SSB is expected from 2010 to 2011, mainly driven by the maturing 2007 year class. The SSB is expected to increase under the management plan both in 2012 and further in 2013 to levels above 2 million tonnes. SSB is expected to be well above $B_{trigger}$, and therefore also B_{pa}, in 2011 and 2012.

The estimated impact of the juvenile fishery is assumed to be low. It has not been investigated to what extent changes in natural mortality would affect the current advice, or if indeed such changes are taking place. Some of the important predator stocks are currently in a rebuilding condition. In the projections it is expected that the 2007 year class matures similarly to the average 3wr fish, as they do not show signs of lower growth rates.

The predicted catch according to the management plan for 2011 implies an increase in TAC of 15%.

2.8 Medium term predictions and HCR simulations

Medium term predictions were not done.

2.9 Precautionary and Limit Reference Points and FMSY targets

The precautionary reference points for this stock were adopted in 1998.

The Blim

The 1998 Study Group on Precautionary Approach to Fisheries Management determined reference points for North Sea herring that were adopted by ICES (ICES CM 1998/ACFM:10). The B_{lim} (800 000 tonnes) was set at a level below which the recruitment may become impaired and was also the formally used MBAL. In 2007, WKREF (ICES CM 2007/ACFM:05) explored limit reference points for North Sea herring and concluded that there is no basis for changing B_{lim}. In 2011, WKHERMP agreed that there was still no basis for changing B_{lim}. A low risk of SSB falling below B_{lim} was therefore the basis of ICES precautionary advice.

Fpa and Bpa

The targets used in the management plan (which began in 1997) were recommended by the Study Group on Precautionary Approach to Fisheries Management and adopted by ICES as the precautionary reference points (ICES CM 1998/ACFM:10). This means that the precautionary reference points were taken from the already existing management plan. In the management plan, the target fishing mortalities were intended as targets and not as bounds. They were based on an investigation of risk to falling below 800 000 t SSB, F_{MSY} and consideration of fisheries on both juvenile and adult herring (ICES CM 1997/ACFM:08).

B trigger

The B trigger of the management plan ($B_{MGTtrigger}$) was changed in November 2008 from 1.3.million to 1.5 million tonnes after evaluation and consultation with the stakeholders. Thus currently the $B_{MGTtrigger}$ and B_{pa} are different at 1.5 million tonnes and 1.3 million tonnes respectively. The lower $B_{trigger}$ of 800 000 tonnes relates to the B_{lim} (see above). **$B_{MGTtrigger}$ is a harvest rule parameter and is not a reference point by which to judge stock status.**

FMSY target and trigger for new advisory framework

ACOM agreed with HAWG that F_{MSY} for this stock was 0.25. This was decided in 2010. This choice was supported by WKFRAME2. There is no ICES MSY framework biomass trigger point for this stock, as the management plan is thought to have primacy over the ICES MSY framework when providing advice.

HAWG considers that the parameters of the management plan conform to the MSY approach, although the limit on annual TAC change may not maximise yield.

2.10 Quality of the assessment

The assessment this year was classified as an update, following the procedures and settings specified in Stock Annex 3. In previous years, the assessment of North Sea herring has been regarded as relatively consistent, and the diagnostics indicate a similar classification for this year. The perception of the 2007 and 2008 year classes however has changed in comparison to last year's assessment. These changes in perception have altered the time series resulting in increased SSB and lower Fs, and therefore introducing retrospective bias.

Extra attention was given to the cluster of negative residuals in the acoustic survey (HERAS), ages 4-9+ over the past 5 years. The reason for this cluster of residuals is not clear. This year, however, the residuals in the last year were small and positive.

This year the larval index (MLAI) was the second highest of the series. In recent years there has been a conflict between the assessment model and the MLAI index, resulting in a sequence of positive residuals. The spawning component abundance index (SCAI: Payne 2010; see Section 2.12), originally designed to estimate the abundances by spawning component, can also be used as an alternative way to process the same larval survey data. This newly generated time series also indicated a high larval abundance, supporting the results of the MLAI and indicating that more work needs to be done to understand the results of this larval survey.

The information from the IBTS-Q1 survey continues to be noisy. The HAWG is still of the opinion however that the assessment is best executed including all surveys (Simmonds, 2009). As noted in Section 3.2.1, sampling for splitting the catches between NSAS and WBSS in IVaE is still problematic. However, sampling was considered sufficient to base the calculation of the split in the transfer area on 2010 samples only. The impact on the assessment of split factors has not been explored.

The data from the stock summary table is compared with the stock summary from the 2010 assessment and the first year (intermediate year) of the 2011 short term prediction. The projected $F_{2\text{-}6}$ for 2010 for the intermediate year, from HAWG 2010 was 0.12 (see text table below). The estimated $F_{2\text{-}6}$ from this Working Group for 2010 is also 0.12. HAWG 2010 assumed no over-catch, however, reallocating spring and autumn spawners to respectively IIIa and IV has resulted in higher catches in 2010. The projected biomass of herring in 2010 is very similar to the 2011 estimate. This is caused by the lower maturity of the maturing 2wr cohort offsetting the large increase in the estimates of the 2007 and 2008 year classes. The 2007 and 2008 year class are now estimated to be 59% and 29% greater in abundance respectively than estimated in 2010 (Figure 2.10.1). There has been very little change in the perception of the 2006 year class, which was revised up in the 2010 assessment. Thus in the last two stock assessments, it has been estimates of recruitment that have affected substantially the quality of the assessment.

A likely explanation for this change in quality is the impact of the increasing Downs component resulting in an underestimation of the IBTS0 index (see ICES 2009/ACOM 03, sections 2.3.3.1-2). This highlights the importance of understanding the productivity and biology of North Sea herring for the effective provision of operational advice to populate the management plan (see Dickey-Collas *et al*., 2010).

	2010 Assessment				**2011 Assessment**				**Percentage change in estimate 2011/2010**			
Year	Rec	SSB	Catch	$F_{2\text{-}6}$	Rec	SSB	Catch	$F_{2\text{-}6}$	Rec	SSB	Catch	$F_{2\text{-}6}$
2008	16409	1038	258	0.22	26079	1206	258	0.19	+59%	+16%	-	-14%
2009	29751	1289	168	0.11	38290	1442	168	0.10	+28%	+12%	-	-9%
2010*	26719	1317	165	0.12	38849	1301	188	0.12	+45%	-1%	+14%	0%

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

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 has been a separate TAC for herring in Divisions IVc and VIId as part of the total North Sea TAC.

Historically, the TAC for herring in IVc and VIId has been set as a proportion of the total North Sea TAC and this has varied between 6 and 16% since 1986. The proportion has been relatively high, particularly between 2002 and 2005. However, ICES in 2005 expressed concerns regarding Downs herring and recommended that the proportion used to determine the TAC should be set to the long term average of the proportions used since 1986 (around 11%). For 2010, it was set at 15 319 tonnes and at 26 536 tonnes for 2011, which represents respectively 9 % and 13.5 % of the total human consumption TAC for Divisions IVc and VIId (Figure 2.11.1).

The persistent tendency to overfish the Downs TAC was markedly reduced since 2005 (Figure 2.11.2), but in 2010, landings were 80% higher than the TAC and amounted to 26 520 tonnes.

Historically, the Downs herring has been considered highly sensitive to overexploitation (Burd, 1985; Cushing, 1968; 1992). It expresses different growth dynamics and recruitment patterns to the more northern spawning components. However, recent studies indicate that in recent years, the Downs component has come to make up the largest component of the stock (see Section 2.12). Furthermore, the directed fishery in Q4 and Q1 targets aggregations of spawning herring. Preliminary studies undertaken by HAWG (ICES CM 2006/ACFM:20) based on population profiles suggested that total mortality (Z) was significantly higher for the 1998 and 1999 year classes of Downs herring compared to herring caught in the northern part of the North Sea.

Downs herring is also taken in other herring fisheries in the North Sea and mixes with other components of North Sea herring in the summer whilst feeding. There is also a summer industrial fishery in the eastern North Sea exploiting 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 (Bierman *et al*., 2010).

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 believed to be smaller than those from the more northern, autumn spawning sites. The separation of this smaller sized components has been set as <13 cm. Both the total abundance and the relative proportion of this smaller size component has, on average, been relatively high for the year classes 1995 to 2002 although there is considerable variation between year classes (Table 2.3.3.2 and Figure 2.11.3). For example, these values suggest that around 70% of the 2002 year class came from Downs production (Figure 2.11.4). Since then the level of contribution by the Downs component has generally been lower. However, for the 2009 year class contribution seem to be at a high level with 48% and the abundance estimate shows a level comparable to the 2002 year class (Figure 2.11.4).

As mentioned in Section 2.3.3.1 the ring net hauls for 0-ringers during the IBTS in this area also include Downs herring larvae. However, at the time of the IBTS survey (January/February) these herring larvae are relatively small compared to larvae from other stocks. Therefore these small larvae (separated as <20 mm) have until now been excluded from the standard estimation of 0-ringer recruitment (IBTS0 index). Furthermore, recent studies showed that the daily mortality rates of newly hatched larvae of North Sea herring have increased over the time series and there are uncertainties on the mortality level for these small larvae (Fässler *et al*., 2011 (WD04) and Section 2.12).

Since 2007, the IBTS 1st quarter survey area has been extended to the eastern English Channel, and both additional GOV hauls and ring-net sampling are carried out in this area to provide more information on Downs herring (ICES CM 2007/ACFM:11). However, the time series of data including this improved coverage of Downs herring larval distributions is not of sufficient length and consistency to be incorporated in the IBTS0 index estimation. The possibilities and consequences of including these larvae in the IBTS0 index were investigated during the HAWG meeting in 2009 (ICES 2009/ACOM 03, Section 2.3.3.1 and 2.10.2).

Since 2007, acoustic data recorded in January show large herring schools along the French coast. Figure 2.11.5 shows the catch composition (percentage by age) of the pelagic hauls carried out on these schools. Every year, the 3wr and 4wr dominate the catch; in 2011, these age-groups represent respectively 50% and 36%. The mean density of these shoals of herring, which were regularly found during the survey in a localised area, could, however, not be precisely estimated, and could not be raised to the whole area due to the spatial heterogeneity. Furthermore, large schools close to the coast in shallow and inaccessible waters were detected with a horizontal echo sounder.

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

2.12 North Sea spawning components

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

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

The spawning component abundance index (SCAI: Payne 2010) was developed to characterise the relative dynamics of the individual North Sea spawning components. Briefly, the SCAI is a statistical model designed to analyse the larval abundance indices (LAIs) produced by the IHLS. Typically these time series are plagued by missing observations, high sampling noise and differences in the spawning intensity between surveys. The SCAI model, however, is robust to these problems, gives a good fit to the data, and proves capable of both handling and predicting missing observations well. Furthermore, the sum of the fitted abundance indices across all components proves a good proxy for the biomass of the total stock, even though the model utilizes information at the individual-component level.

The SCAI indices show that there are appreciable differences in the dynamics of the individual components (Figure 2.12.1). The Orkney–Shetland component appears to have recovered faster from historic depletion events than the other components, whereas the Downs component has been the slowest. The Orkney-Shetland, Buchan and Banks components show broadly similar dynamics, with peaks in abundance occurring during the late 1980s-early 1990s and again in the early 2000s. The Downs component, however, appears to have a different set of dynamics: recovery from the 1970s stock collapse was much slower in this component, and the late 1980s peak displayed by the other three components is relatively weak. In recent times, however, the Downs component has grown dramatically to the point where it is now the largest component in the stock.

The SCAI indices can also be used to look at the relative composition of the stock (Figure 2.12.2). The composition of the stock has changed appreciably over time. The largest fraction of the total SSB in the past 35 years has generally been represented by the Orkney–Shetland component (on average 50%), but the ratio has ranged between 25 and 80%. In recent years, however, the Downs component has increased rapidly and in 2011 now represents more than 50% of the combined stock.

The environment at the spawning grounds of the northern components is very similar (Röckmann *et al*., 2011) in terms of the trends and variability of salinity and temperature. The environment at the Downs spawning area is very different from the northern grounds, with different absolute temperatures and different trends and variability. These differences are driven by the northern North Sea being influenced by far field effects and the southern North by more local processes (Berx & Hughes, 2009; Hjøllo *et al*., 2009). The mortality of the larvae is also different (Figure 2.12.3) with different trends over time (Fassler *et al*., in press). This provides further evidence to support the hypothesis of Cushing (1992) that the dynamics of the components differed.

2.13 Management Considerations

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

The stock is managed according to the EU-Norway Management agreement which was updated in November 2008 (see Stock Annex 3). In 2008, WKHMP examined the performance of this management plan and the plan is consistent with the precautionary approach. In 2011, WKHERMP re-examined the management plan. WKHERMP concluded that the management plan appears to operate well in relation to the objectives of consistency with the precautionary approach and a rational exploitation pattern, but not in relation to achieving simultaneous stable and high yield. The main weakness appears to be the 15% IAV limit on TAC change which leads to restricted TACs when the stock is improving. The current F_{2-6} of 0.25 is consistent with the MSY approach under the current low recruitment regime. The management plan is also considered consistent with the MSY approach, although the trade-off between stability and high yield will limit the maximising of yield in some circumstances. There is no basis to further adjust the harvest control rule to account for recruitment variability or trends. WKHERMP recommended that further work on the management plan be carried out in 2011, prior to the December decisions by the EU and Norway, to develop mechanisms that avoid the unwanted side-effects of the present plan.

The fishing mortality is reliably estimated by the stock assessment. Fishing mortality is now below the target set by the management plan. The estimation of SSB is currently less precise as a result of revisions to recruiting year classes estimates (year classes 2006, 2007 and 2008). This revises the numbers of fish in the stock upwards. These revisions are thought to be due to the relative increase in the Downs component, reducing the precision of the estimates of recruitment from the surveys (see Section 2.5). The 2007 year class (2wr in 2010) was unusually immature (45% compared to the expected 75-85%). The reasons for this are unknown (see Section 2.4.2). Thus the SSB in 2010 is smaller than anticipated if average maturity was assumed. However, when this year class is fully mature it is expected to contribute to a further increase in the SSB in 2011 and 2012.

The current estimates of the 2008 and 2009 year classes are above the geometric mean of the time series and the year class of 2007 and 2008 have been revised upwards. HAWG still considers the stock to be in a low productivity phase as the survival ratio between newly hatched larvae and recruits is still much lower than prior to 2001. The management plan has proved to be an effective tool for maintaining sustainable exploitation and conserving the North Sea herring stock in this lower productivity regime.

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

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

The options selected for the C- and D-fleets are compatible with the advised exploitation of western Baltic spring spawners of 3.9 and 1.7 thousand tonnes of North Sea autumn spawning herring for C and D fleets respectively.

The North Sea autumn spawning herring stock also includes the Downs herring component (herring in Divisions IVc and VIId). The Downs stock has increased greatly in recent years (see Section 2.12). The management of this component was discussed in detail in 2007 (ICES CM 2007 ACFM:11). There is no update to this advice.

2.14 Ecosystem considerations

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

Herring is considered to have a major impact on most other fish stocks as predator and is itself as prey for fish, seabirds and sea mammals in the North Sea area (Dickey-Collas *et al*., 2010). Recent work using process-oriented length-based ecosystem modelling (Speirs *et al*., 2010) and correlative approaches (Fauchald, 2010) suggests a link between a large herring biomass and the repression of the North Sea cod recovery. This suggests that through herring predation on cod eggs and larvae, a strong cod recruitment is unlikely with the current state of the North Sea ecosystem.

The human consumption fisheries for herring are considered relatively clean, with little by-catch of other fish, charismatic mega-fauna and almost no disturbance of the sea bed. The evidence from observer programmes suggest that discarding of herring is not widespread. Juvenile herring are caught as a bycatch of industrial fisheries and these vessels catch a range of fish species. Most of these bycatches are monitored and included in the catch statistics.

2.15 Changes in the environment

This stock has recently produced seven below average year classes in a row, which has never been observed before (Payne *et al*., 2009). The 2008 and 2009 recruitments are at the geometric mean of the series, but the survival ratio between newly hatched larvae and the recruits suggests that herring are still in a lower productivity phase. The change in survival rate co-varies with an increase in the mortality rate of the very young larvae (Fassler *et al*., in press). The specific reasons for this are not known but there appears to be a similarity in the trend with the inverse of stock biomass and temperature. The pattern in the recruitment time series also shows a correlation to the climatic forcing of the North Atlantic, via the NAO (North Atlantic Oscillation) and the AMO (Atlantic Multidecadal Oscillation; Gröger *et al*., 2010). It is thought that the climatic signal integrates many of the local processes affecting the larvae including changes in temperature, salinity, water column stability, turbulence, primary production and zooplankton community. Whilst studies of the specific processes are ongoing, the apparent correlation with the climate can be used to investigate future trends in recruitment.

The environment also influences the growth of individual North Sea herring. Most of the variations in size-at-age observed can be explained by density-dependent mechanisms; however, temperature also plays a role. Temperature significantly explains the variation in growth between cohorts of North Sea herring since the mid-1980s (Brunel and Dickey-Collas, 2010). Cohorts experiencing warmer conditions throughout their lifetime attain higher growth rates, but have shorter life expectancy and smaller asymptotic size, and *vice- versa* for herring experiencing colder conditions.

Table 2.1.1: Herring caught in the North Sea (Sub-area IV and Division VIId). Catch in tonnes by country, 2001 – 2010. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	**2001**	**2002**	**2003**	**2004**	**2005**
Belgium	-	23	5	8	6
Denmark [6]	67096	70825	78606	99037	128380
Faroe Islands	1082	1413	627	402	738
France	24880	25422	31544	34521	38829
Germany	29779	27213	43953	41858	46555
Netherlands	51293	55257	81108	96162	81531
Norway [1]	75886	74974	112481	137638	156802
Poland	-	-	-	-	458
Sweden	3695	3418	4781	5692	13464
USSR/Russia	-	-	-	-	99
UK (England)	14582	13757	18639	20855	25311
UK (Scotland)	26719	30926	40292	45331	73227
UK (N.Ireland)	1018	944	2010	2656	2912
Unallocated landings	27362 [5]	31552 [5]	31875 [5]	48898 [5]	57788
Total landings	323392	335724	445921	533058	626101
Discards	-	17093	4125	17059	12824
Total catch	**323392**	**352817**	**450046**	**550117**	**638925**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	6449	6652	2821	7079	7039
Thames estuary [2]	107	60	84	62	74
Others [3]	1097	0	308	0	0
Norw. Spring Spawners [4]	7108	4069	979	452	417

Country	**2006**	**2007**	**2008**	**2009**	**2010**
Belgium	3	1	-	-	-
Denmark [6]	102322	84697	62864	46238	45869
Faroe Islands	1785	2891	2014	1803	3014
France	49475	24909	30347	18114	17745
Germany	40414	14893	8095	5368	7670
Netherlands	76315	66393	23122	24552	23872
Norway [1]	135361	100050	59321	50445	46816
Lithuania	-	-	-	-	90
Sweden	10529	15448	13840	5299	4395
Russia	-	-	-	-	-
UK (England)	22198	15993	11717	652	10770
UK (Scotland)	48428	35115	16021	14006	14373
UK (N.Ireland)	3531	638	331	-	-
Unallocated landings	18764	26641	17151	-726	0
Total landings	509125	387669	244823	165751	174614
Discards	1492	93	224	91	13
Total catch	**510617**	**387762**	**245047**	**165842**	**174627**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	10954	1070	124	3941	774
Thames estuary [2]	65	2	7	48	85
Others [3]	0	0	0	0	0
Norw. Spring Spawners [4]	626	685	2721	44560	56900

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

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

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

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

5 may include misreported catch from VIaN and discards

6 Including any by-catches in the industrial fishery

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

Country	2001	2002	2003	2004	2005
Denmark [1]	17770	26422	48358	48128	80990
Faroe Islands	192	-	95	-	
France	8164	10522	11237	10941	13474
Germany	17753	15189	25796	17559	22278
Netherlands	17503 [3]	18289	25045	43876	36619
Norway	11653	10836	34443	36119	66232
Poland	-	-	-	-	458
Sweden	1418	2397	2647	2178	8261
Russia	-	-	-	-	99
UK (England)	12283	10142	12030	13480	15523
UK (Scotland)	25105	30014	39970	43490	71941
UK (N. Ireland)	1018	944	2010	2656	2912
Unallocated landings	24725 [2]	14201 [2]	14115 [2]	28631 [2]	39324 [2]
Misreporting from VIa North					
Total Landings	137584	138956	215746	247058	358111
Discards		17093	4125	15794	10861
Total catch	**137584**	**156049**	**219871**	**262852**	**368972**

Country	2006	2007	2008	2009	2010
Denmark [1]	60462	45948	28426	16550	25092
Faroe Islands	580	1118	2	288	1110
France	18453	8570	13068	7067	6412
Germany	18605	4985	498	-	505
Netherlands	39209	42622	11634	11017	13593
Norway	38363	40279	40304	25926	38897
Lithuania	-	-	-	-	90
Sweden	4957	7658	7025	1435	2310
Russia	-	-	-	-	-
UK (England)	12031	11833	8355	578	7384
UK (Scotland)	47368	35115	14727	10249	13567
UK (N. Ireland)	3531	638	331	-	-
Unallocated landings	10981 [2]	22215	14952	-977	0
Misreporting from VIa North					
Total Landings	253048	220981	139322	72133	108960
Discards	1492	93	194	91	13
Total catch	**254540**	**221074**	**139516**	**72224**	**108973**

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

[2] May include misreported catch from VIaN and discards

[3] Including 1057 t of local spring spawners

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

Country	2001	2002	2003	2004	2005
Denmark [1]	18466	17846	7401	16278	5761
Faroe Islands	890	1365	359	-	738
France	-	-	-	-	-
Germany	-	81	54	888	-
Netherlands	-	-	-	-	-
Norway [2]	56904	63482	62306	100443	89925
Sweden	517	568	1529	1720	3510
Unallocated landings	0	3959	9988	0	0
Total landings	76777	87301	81637	119329	99934
Discards	-	-	-	-	-
Total catch	**76777**	**89303**	**83640**	**119329**	**99934**
Norw. Spring Spawners [4]	7108	4069	979	452	417

Country	2006	2007	2008	2009	2010
Denmark [1]	8614	2646	1587	499	-
Faroe Islands	975	577	400	700	719
France	-	-	-	-	-
Germany	34	-	-	-	-
Netherlands	-	263	-	-	-
Norway [2]	90065	54424	17474	6981	7362
UK (Scotland)	83	-	-	-	-
Sweden	2857	640	-	1735	1505
Unallocated landings	0	-96 [3]	0	0	0
Total landings	102628	58454	19461	9915	9586
Discards	-	-	-	-	-
Total catch	**102628**	**58454**	**19461**	**9915**	**9586**
Norw. Spring Spawners [4]	626	685	2721	44560	56900

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

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

Country	2001	2002	2003	2004	2005
Denmark 1	30277	26387	22574	33857	41423
Faroe Islands	-	48	173	402	-
France	7796	4214	7918	10592	10205
Germany	8340	7577	12116	13823	14381
Netherlands	24160	13154	19115	23649	10038
Norway	7329	656	15732	1076	645
Sweden	1760	453	605	1794	1694
UK (England)	814	317	2632	2864	3869
UK (Scotland)	1614	289	322	1841	1286
Unallocated landings 3	-22885	4052	-2401	8300	10233
Total landings	59205	57147	78786	98198	93774
Discards 2				1265	1963
Total catch	**59205**	**57147**	**78786**	**99463**	**95737**

Country	2006	2007	2008	2009	2010
Denmark 1	32277	35990	32230	29164	19671
Faroe Islands	200	1196	1612	815	1185
France	17385	8421	9687	4316	2349
Germany	14222	2205	2415	1061	1994
Netherlands	13363	8550	904	3164	830
Norway	6933	5347	1543	17538	557
Sweden	2715	7150	6815	2129	580
UK (England)	4924	577	833	2	1577
UK (Scotland)	977	-	1293	3757	805
Unallocated landings 3	2364	-203	-904	-166	0
Total landings	95360	69233	56428	61780	29548
Discards 2			30		
Total catch	**95360**	**69233**	**56458**	**61780**	**29548**

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

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

Country	**2001**	**2002**	**2003**	**2004**	**2005**
Belgium	-	23	5	8	6
Denmark	583	170	273	774	206
France	8750	10686	12389	12988	15150
Germany	3686	4366	5987	9588	9896
Netherlands	9630	23814	36948	28637	34874
UK (England)	1485	3298	3977	4511	5919
UK (Scotland)	-	623	-	-	-
Unallocated landings	25522 [3]	5336	8170	9963	8231
Total landings	49656	50318	67749	68473	74282
Discards [2]		-	-	-	-
Total catch	**49656**	**50318**	**67749**	**68473**	**74282**
Coastal spring spawners included above [1]	147 [4]	60	84	62	74

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

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

Table 2.1.6 ("The Wonderful Table") HERRING in Subarea IV, Division VIId and Division IIIa. Figures in thousand tonnes.

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

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Sub-Area IV and Division VIId: TAC (IV and VIId)														
Recommended Divisions IVa, b	254	265	265	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-	-
Recommended Divisions IVc, VIId	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	-	-
Expected catch of spring spawners														
Agreed Divisions IVa,b [1]	229	240	240	240	223	340.5	393.9	460.7	404.7	303.5	174.6	147.4	149.0	173.5
Agreed Div. IVc, VIId	25	25	25	25	42.7	59.5	66.1	74.3	50.0	37.5	26.7	23.6	15.3	26.5
Bycatch ceiling in the small mesh fishery	22	30	36	36	36	52.0	38.0	50.0	42.5	31.9	18.8	16.0	13.6	16.5
CATCH (IV and VIId)														
National landings Divisions IVa,b [2]	245	261	261	272	261	354.5	427.7	502.3	439.2	326.8	201.2	145.0	148.1	
Unallocated landings Divisions IVa,b	44	22	35	2	24	23.7	36.9	49.6	13.3	21.9	14.0	-1.1	0.0	
Discard/slipping Divisions IVa,b [3]	-	-	-	-	17	4.1	17.1	12.8	1.5	0.1	0.2	0.1	0.0	
Total catch Divisions IVa,b [4]	289	283	296	273	303	382.3	481.6	564.6	454.0	348.8	215.4	143.9	148.1	
National landings Divisions IVc, VIId [3]	23	29	23	24	43	59.5	56.5	66.1	51.2	34.3	26.5	21.5	26.5	
Unallocated landings Divisions IVc,VIId	27	22	27	26	7	8.2	12.0	8.2	5.4	4.7	3.1	0.4	0	
Discard/slipping Divisions IVc, VIId [3]	-	-	-	-	0	-	-	-	-	-	-	-	-	
Total catch Divisions IVc, VIId	49	50	50	50	50	67.7	68.5	74.3	56.6	39.0	29.6	21.9	26.5	
Total catch IV and VIId as used by ICES [4]	**338**	**333**	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.62**	**387.8**	**245.0**	**165.8**	**174.6**	
CATCH BY FLEET/STOCK (IV and VIId) [7]														
North Sea autumn spawners directed fisheries (Fleet A)	316	313	322	296	323	434.9	529.5	610.0	487.1	379.6	236.3	152.1	164.8	
North Sea autumn spawners industrial (Fleet B)	14	15	18	20	22	12.3	13.6	21.8	11.9	7.1	8.6	9.8	9.1	
North Sea autumn spawners in IV and VIId total	**330**	**329**	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**	**386.7**	**244.9**	**161.9**	**173.9**	
Baltic-IIIa-type spring spawners in IV	8	5	7	6	7	2.8	7.1	7.0	11.0	1.1	0.1	3.9	0.8	
Coastal-type spring spawners	0.1	0.1	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	
Norw. Spring Spawners caught under a separate quota in IV [14]	29	32	26	7	4	1.0	0.5	0.4	0.6	0.7	2.7	44.6	56.9	
Division IIIa: TAC (IIIa)														
Predicted catch of autumn spawners	58	43	53	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended spring spawners	- [12]	- [12]	- [12]	- [12]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended mixed clupeoids	-	-	-	-	-	-	-	-	-	-	-	-	-	
Agreed herring TAC	80	80	80	80	80	80.0	70.0	96.0	81.6	69.4	51.7	37.7	33.9	30.0
Agreed mixed clupeoid TAC														
Bycatch ceiling in the small mesh fishery	17	19	21	21	21	21.0	21.0	24.2	20.5	15.4	11.5	8.4	7.5	6.7
CATCH (IIIa)														
National landings	120	86	108	90	79	76.0	61.1	90.8	88.9	47.3	38.2	38.8	37.3	
Catch as used by ICES	108	79	99	82	73	68.1	52.7	69.6	51.2	47.4	38.2	38.8	37.3	
CATCH BY FLEET/STOCK (IIIa) [7]														
Autumn spawners human consumption (Fleet C)	59	28	36	34	17	24.1	13.4	22.9	11.6	16.4	9.2	5.1	12.0	
Autumn spawners mixed clupeoid (Fleet D) [13]	6	8	13	12	9	8.4	10.8	9.0	3.4	3.4	3.7	1.5	1.8	
Autumn spawners other industrial landings (Fleet E)														
Autumn spawners in IIIa total	**61**	**34**	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**	**19.8**	**12.9**	**6.5**	**13.8**	
Spring spawners human consumption (Fleet C)	40	40	45	33	38	31.6	16.8	32.5	30.2	25.3	23.0	29.4	23.0	
Spring spawners mixed clupeoid (Fleet D) [13]	3	3	5	3	9	4.0	11.2	5.1	5.9	2.3	2.2	2.9	0.5	
Spring spawners other industrial landings (Fleet E)														
Spring spawners in IIIa total	**43**	**43**	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**	**27.6**	**25.2**	**32.3**	**23.5**	
North Sea autumn spawners Total as used by ICES	**392**	**363**	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**	**406.5**	**257.9**	**168.4**	**187.6**	

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

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2010. 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	48.6	0.0	0.0	0.0	0.0	476.8	49.5	0.0	476.8	49.5	574.9	526.3
1	197.0	2.0	0.0	2.0	51.8	22.1	8.1	0.2	75.9	8.3	281.3	84.3
2	43.3	12.2	0.0	12.2	143.9	41.0	4.4	41.9	197.0	46.3	286.7	243.4
3	0.3	16.3	0.5	15.7	145.2	29.3	4.2	38.6	190.2	42.8	233.3	233.5
4	0.1	5.7	1.0	4.7	82.2	25.8	1.1	9.4	112.8	10.5	123.4	124.3
5	0.1	2.0	0.4	1.6	56.8	16.8	0.2	7.8	75.2	8.0	83.3	83.6
6	0.0	3.9	0.5	3.4	35.4	9.9	2.5	11.7	48.7	14.2	62.9	63.4
7	0.1	2.2	0.3	1.9	20.2	4.2	0.8	6.9	26.3	7.6	34.0	34.2
8	0.0	3.1	0.3	2.8	38.1	10.1	1.0	7.2	50.9	8.2	59.1	59.4
9+	0.0	7.3	0.7	6.6	40.0	1.7	1.5	5.6	48.3	7.0	55.3	56.0
Sum	289.6	54.7	3.8	50.9	613.5	637.7	73.3	129.2	1302.0	202.5	1794.1	1508.3
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	14.9	0.0	0.0	14.9	0.0	14.9	14.9
1	38.7	0.4	0.0	0.4	2.4	0.8	1.2	0.0	3.6	1.2	43.5	4.8
2	30.3	2.8	0.0	2.8	20.3	1.3	1.9	0.3	24.4	2.2	56.9	26.6
3	0.1	3.5	0.0	3.5	33.2	1.1	0.9	4.7	37.7	5.5	43.4	43.3
4	0.0	1.3	0.3	1.0	16.0	11.0	0.2	1.1	28.0	1.3	29.3	29.5
5	0.0	0.4	0.1	0.3	7.1	2.3	0.1	0.5	9.7	0.6	10.2	10.3
6	0.0	0.5	0.1	0.4	0.7	0.1	0.3	1.9	1.3	2.2	3.5	3.6
7	0.0	0.4	0.1	0.3	4.6	0.7	0.2	0.9	5.6	1.0	6.7	6.7
8	0.0	0.5	0.1	0.4	4.7	2.4	0.1	0.3	7.6	0.4	8.0	8.1
9+	0.0	0.9	0.2	0.7	0.8	0.0	0.2	1.3	1.5	1.5	3.0	3.2
Sum	69.1	10.7	0.8	9.9	89.8	34.7	5.0	11.0	134.4	15.9	219.4	151.1
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	52.7	0.0	0.0	52.7	0.0	52.7	52.7
1	40.1	0.7	0.0	0.7	15.7	2.0	0.1	0.0	18.3	0.1	58.5	18.4
2	8.0	6.1	0.0	6.1	73.8	11.5	0.0	0.0	91.3	0.1	99.4	91.4
3	0.1	9.2	0.0	9.2	61.1	5.7	0.0	0.2	75.9	0.3	76.3	76.2
4	0.1	2.5	0.2	2.3	20.5	1.9	0.0	0.1	24.7	0.1	25.0	25.0
5	0.0	0.5	0.0	0.4	7.0	0.0	0.0	0.0	7.5	0.0	7.5	7.5
6	0.0	2.2	0.2	2.1	8.8	1.0	0.0	0.1	12.0	0.1	12.1	12.2
7	0.0	1.2	0.1	1.1	3.0	0.0	0.0	0.0	4.1	0.0	4.2	4.3
8	0.0	1.5	0.1	1.4	7.0	1.8	0.0	0.0	10.1	0.0	10.2	10.3
9+	0.0	3.9	0.3	3.6	9.6	0.0	0.0	0.1	13.2	0.1	13.3	13.6
Sum	48.5	27.8	1.0	26.8	206.4	76.8	0.2	0.5	310.0	0.7	359.2	311.7
Quarter: 3												
0	45.7	0.0	0.0	0.0	0.0	326.2	0.2	0.0	326.2	0.2	372.0	326.4
1	59.1	0.2	0.0	0.2	12.9	5.4	0.0	0.0	18.4	0.0	77.5	18.4
2	4.7	2.9	0.0	2.9	41.1	12.9	0.0	0.3	56.9	0.3	61.9	57.2
3	0.1	3.0	0.5	2.5	41.2	12.1	0.0	0.3	55.8	0.4	56.2	56.7
4	0.0	0.9	0.3	0.6	31.0	11.4	0.0	0.1	43.0	0.1	43.1	43.3
5	0.1	0.4	0.1	0.3	30.9	13.4	0.0	0.1	44.6	0.1	44.7	44.7
6	0.0	0.7	0.1	0.6	17.0	7.0	0.0	0.1	24.5	0.2	24.7	24.8
7	0.0	0.4	0.0	0.3	9.8	3.4	0.0	0.1	13.5	0.1	13.6	13.7
8	0.0	0.5	0.0	0.5	19.0	5.6	0.0	0.1	25.2	0.1	25.2	25.2
9+	0.0	1.7	0.0	1.7	20.0	1.5	0.0	0.1	23.2	0.1	23.2	23.2
Sum	109.6	10.7	1.2	9.5	222.9	398.7	0.2	1.2	631.2	1.4	742.2	633.8
Quarter: 4												
0	3.0	0.0	0.0	0.0	0.0	83.0	49.3	0.0	83.0	49.3	135.2	132.2
1	59.2	0.8	0.0	0.8	20.9	13.9	6.8	0.2	35.6	7.1	101.8	42.6
2	0.3	0.4	0.0	0.4	8.7	15.3	2.5	41.3	24.4	43.8	68.4	68.2
3	0.0	0.6	0.0	0.6	9.8	10.4	3.4	33.3	20.8	36.7	57.4	57.4
4	0.0	1.1	0.2	0.9	14.8	1.5	0.9	8.1	17.1	9.0	26.1	26.4
5	0.0	0.7	0.1	0.5	11.9	1.1	0.1	7.2	13.5	7.3	20.8	21.0
6	0.0	0.4	0.1	0.3	8.9	1.7	2.2	9.5	10.9	11.7	22.6	22.7
7	0.0	0.2	0.0	0.2	2.7	0.2	0.6	5.9	3.0	6.5	9.5	9.5
8	0.0	0.6	0.1	0.4	7.3	0.2	0.9	6.8	8.0	7.7	15.7	15.8
9+	0.0	0.8	0.2	0.6	9.6	0.1	1.2	4.1	10.3	5.4	15.7	15.9
Sum	62.4	5.5	0.8	4.7	94.4	127.5	67.9	116.5	226.5	184.4	473.3	411.7

Table 2.2.2: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2010. 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	**0.008**	**0.000**	**0.000**	**0.000**	**0.007**	**0.015**	**0.000**	**0.007**	**0.015**	**0.008**	**0.008**
1	**0.051**	**0.080**	**0.068**	**0.087**	**0.051**	**0.037**	**0.113**	**0.076**	**0.039**	**0.057**	**0.072**
2	**0.077**	**0.131**	**0.132**	**0.137**	**0.134**	**0.095**	**0.150**	**0.136**	**0.145**	**0.129**	**0.138**
3	**0.122**	**0.154**	**0.157**	**0.166**	**0.176**	**0.166**	**0.167**	**0.167**	**0.167**	**0.167**	**0.167**
4	**0.149**	**0.201**	**0.200**	**0.195**	**0.182**	**0.186**	**0.187**	**0.192**	**0.187**	**0.191**	**0.192**
5	**0.191**	**0.201**	**0.206**	**0.223**	**0.229**	**0.189**	**0.205**	**0.224**	**0.204**	**0.220**	**0.222**
6	**0.221**	**0.210**	**0.211**	**0.220**	**0.237**	**0.205**	**0.207**	**0.222**	**0.207**	**0.219**	**0.219**
7	**0.216**	**0.223**	**0.219**	**0.216**	**0.235**	**0.210**	**0.207**	**0.220**	**0.207**	**0.216**	**0.217**
8	**0.205**	**0.248**	**0.236**	**0.236**	**0.232**	**0.231**	**0.222**	**0.236**	**0.223**	**0.233**	**0.234**
9+	**0.000**	**0.235**	**0.235**	**0.252**	**0.265**	**0.243**	**0.209**	**0.250**	**0.216**	**0.244**	**0.245**
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.005	0.000	**0.005**	**0.005**
1	0.016	0.066	0.066	0.052	0.060	0.020	0.000	0.055	0.020	**0.019**	**0.047**
2	0.072	0.129	0.129	0.119	0.107	0.037	0.102	0.119	0.045	**0.090**	**0.113**
3	0.117	0.154	0.154	0.148	0.133	0.134	0.134	0.148	0.134	**0.146**	**0.146**
4	0.000	0.195	0.195	0.153	0.148	0.160	0.161	0.153	0.161	**0.154**	**0.153**
5	0.000	0.188	0.188	0.159	0.171	0.175	0.174	0.163	0.174	**0.164**	**0.163**
6	0.000	0.210	0.210	0.203	0.207	0.191	0.189	0.206	0.189	**0.195**	**0.196**
7	0.231	0.207	0.207	0.160	0.172	0.192	0.191	0.165	0.191	**0.170**	**0.169**
8	0.000	0.232	0.232	0.177	0.173	0.195	0.192	0.180	0.192	**0.180**	**0.180**
9+	0.000	0.235	0.235	0.223	0.204	0.202	0.200	0.228	0.200	**0.214**	**0.215**
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.005	0.000	**0.005**	**0.005**
1	0.018	0.063	0.063	0.074	0.066	0.076	0.000	0.073	0.076	**0.035**	**0.073**
2	0.076	0.130	0.130	0.129	0.132	0.129	0.103	0.130	0.123	**0.125**	**0.130**
3	0.117	0.151	0.151	0.156	0.156	0.169	0.134	0.156	0.138	**0.156**	**0.156**
4	0.149	0.208	0.208	0.191	0.163	0.219	0.160	0.191	0.175	**0.191**	**0.191**
5	0.187	0.183	0.183	0.214	0.230	0.242	0.175	0.212	0.192	**0.212**	**0.212**
6	0.221	0.209	0.209	0.205	0.193	0.219	0.191	0.204	0.194	**0.205**	**0.204**
7	0.197	0.228	0.228	0.206	0.212	0.257	0.192	0.212	0.197	**0.213**	**0.212**
8	0.205	0.261	0.261	0.222	0.203	0.225	0.195	0.224	0.203	**0.225**	**0.224**
9+	0.000	0.235	0.235	0.226	0.205	0.234	0.202	0.228	0.205	**0.228**	**0.228**
Quarter: 3											
0	0.007	0.000	0.000	0.000	0.005	0.005	0.000	0.005	0.005	**0.005**	**0.005**
1	0.074	0.068	0.068	0.088	0.043	0.067	0.000	0.075	0.067	**0.075**	**0.075**
2	0.111	0.132	0.132	0.160	0.137	0.143	0.141	0.153	0.141	**0.149**	**0.153**
3	0.134	0.157	0.157	0.192	0.194	0.188	0.167	0.191	0.167	**0.189**	**0.190**
4	0.000	0.210	0.210	0.224	0.219	0.223	0.185	0.222	0.187	**0.221**	**0.222**
5	0.194	0.223	0.223	0.247	0.241	0.250	0.196	0.245	0.199	**0.243**	**0.245**
6	0.000	0.207	0.207	0.234	0.253	0.248	0.211	0.239	0.211	**0.237**	**0.238**
7	0.000	0.233	0.233	0.248	0.249	0.273	0.207	0.248	0.208	**0.246**	**0.247**
8	0.000	0.266	0.266	0.264	0.268	0.271	0.216	0.265	0.217	**0.263**	**0.265**
9+	0.000	0.235	0.235	0.273	0.272	0.262	0.213	0.271	0.214	**0.267**	**0.270**
Quarter: 4											
0	0.015	0.000	0.000	0.000	0.015	0.015	0.000	0.015	0.015	**0.015**	**0.015**
1	0.072	0.104	0.104	0.099	0.051	0.040	0.113	0.080	0.042	**0.073**	**0.074**
2	0.084	0.149	0.149	0.138	0.137	0.139	0.150	0.137	0.150	**0.146**	**0.145**
3	0.000	0.187	0.187	0.186	0.171	0.173	0.172	0.178	0.172	**0.175**	**0.174**
4	0.000	0.186	0.186	0.183	0.180	0.191	0.191	0.183	0.191	**0.186**	**0.185**
5	0.000	0.207	0.207	0.205	0.197	0.193	0.207	0.204	0.207	**0.206**	**0.205**
6	0.000	0.225	0.225	0.210	0.198	0.207	0.211	0.208	0.210	**0.212**	**0.209**
7	0.000	0.209	0.209	0.210	0.185	0.214	0.209	0.208	0.210	**0.211**	**0.209**
8	0.000	0.213	0.213	0.214	0.202	0.233	0.224	0.213	0.225	**0.221**	**0.219**
9+	0.000	0.234	0.234	0.234	0.234	0.250	0.213	0.234	0.221	**0.230**	**0.230**

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2010. Mean length-at-age (cm) in the catch, by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(W)	IVb	IVc	VIId	IVa & IVb all	IVc & VIId
Quarters: 1-4									
0	**n.d.**	**0.0**	**n.d.**	**0.0**	**10.5**	**13.8**	**0.0**	**10.5**	**13.8**
1	**n.d.**	**20.6**	**n.d.**	**21.8**	**18.4**	**18.1**	**23.3**	**20.8**	**18.2**
2	**n.d.**	**24.1**	**n.d.**	**24.8**	**24.8**	**22.4**	**25.6**	**24.8**	**25.3**
3	**n.d.**	**26.1**	**n.d.**	**27.0**	**27.2**	**26.7**	**26.6**	**26.9**	**26.6**
4	**n.d.**	**28.1**	**n.d.**	**28.4**	**28.3**	**27.6**	**27.5**	**28.4**	**27.5**
5	**n.d.**	**28.7**	**n.d.**	**29.5**	**30.0**	**27.6**	**28.3**	**29.6**	**28.2**
6	**n.d.**	**28.5**	**n.d.**	**29.4**	**29.7**	**28.7**	**28.4**	**29.4**	**28.5**
7	**n.d.**	**29.0**	**n.d.**	**29.3**	**30.0**	**28.5**	**28.5**	**29.4**	**28.5**
8	**n.d.**	**30.7**	**n.d.**	**30.0**	**30.4**	**29.5**	**28.6**	**30.1**	**28.7**
9+	**n.d.**	**29.2**	**n.d.**	**30.2**	**30.5**	**29.7**	**28.7**	**30.1**	**28.9**
Quarter: 1									
0	n.d.	0.0	n.d.	0.0	9.8	0.0	0.0	9.8	0.0
1	n.d.	19.3	n.d.	18.8	18.6	16.0	0.0	18.8	16.0
2	n.d.	24.2	n.d.	24.8	24.2	18.6	23.5	24.7	19.3
3	n.d.	26.3	n.d.	27.3	26.3	25.5	25.5	27.2	25.5
4	n.d.	27.8	n.d.	27.7	27.8	26.8	27.0	27.8	27.0
5	n.d.	28.2	n.d.	28.2	29.5	27.1	27.1	28.5	27.1
6	n.d.	28.4	n.d.	28.1	29.0	28.2	28.3	28.3	28.2
7	n.d.	28.7	n.d.	28.5	28.5	28.2	28.2	28.5	28.2
8	n.d.	30.2	n.d.	29.4	29.6	28.4	28.4	29.5	28.4
9+	n.d.	29.0	n.d.	28.7	28.6	28.6	28.6	28.9	28.6
Quarter: 2									
0	n.d.	0.0	n.d.	0.0	9.8	0.0	0.0	9.8	0.0
1	n.d.	18.5	n.d.	20.0	19.0	20.4	0.0	19.9	20.4
2	n.d.	24.0	n.d.	24.1	24.8	24.3	23.5	24.2	24.1
3	n.d.	25.9	n.d.	26.0	26.5	26.7	25.5	26.0	25.6
4	n.d.	28.1	n.d.	27.5	27.0	28.9	26.8	27.5	27.3
5	n.d.	28.1	n.d.	28.3	29.0	29.4	27.1	28.3	27.7
6	n.d.	28.5	n.d.	28.3	28.6	29.2	28.2	28.4	28.3
7	n.d.	29.0	n.d.	28.5	28.3	29.9	28.2	28.7	28.3
8	n.d.	31.1	n.d.	28.9	29.0	29.2	28.4	29.2	28.6
9+	n.d.	29.1	n.d.	28.9	28.6	29.5	28.6	29.0	28.6
Quarter: 3									
0	n.d.	0.0	n.d.	0.0	9.8	9.8	0.0	9.8	9.8
1	n.d.	19.0	n.d.	21.7	16.0	18.6	0.0	20.0	18.6
2	n.d.	23.9	n.d.	25.8	24.8	24.6	25.2	25.5	25.1
3	n.d.	26.1	n.d.	27.8	28.0	27.1	26.5	27.8	26.5
4	n.d.	28.0	n.d.	29.2	29.1	28.9	27.3	29.2	27.4
5	n.d.	29.0	n.d.	30.0	30.3	29.7	27.9	30.1	27.9
6	n.d.	28.2	n.d.	29.7	30.8	30.0	28.4	30.0	28.5
7	n.d.	29.1	n.d.	30.1	30.4	30.5	28.4	30.2	28.4
8	n.d.	31.0	n.d.	30.6	31.3	30.3	28.6	30.8	28.6
9+	n.d.	28.9	n.d.	30.8	30.6	30.4	28.7	30.6	28.8
Quarter: 4									
0	n.d.	0.0	n.d.	0.0	13.8	13.8	0.0	13.8	13.8
1	n.d.	23.5	n.d.	23.5	19.3	18.4	23.3	21.8	18.5
2	n.d.	26.5	n.d.	26.2	25.0	25.3	25.6	25.5	25.6
3	n.d.	27.7	n.d.	28.2	26.8	27.0	26.8	27.5	26.8
4	n.d.	28.6	n.d.	28.6	27.5	27.8	27.6	28.5	27.6
5	n.d.	29.2	n.d.	29.6	28.3	27.7	28.4	29.5	28.3
6	n.d.	29.7	n.d.	29.8	26.4	28.7	28.5	29.3	28.5
7	n.d.	29.0	n.d.	29.0	27.4	28.6	28.5	28.9	28.5
8	n.d.	29.6	n.d.	29.8	28.5	29.6	28.6	29.7	28.8
9+	n.d.	30.6	n.d.	30.6	30.6	29.9	28.7	30.6	29.0

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 2010. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS
Quarters: 1-4											
0	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**3.2**	**0.7**	**0.0**	**3.2**	**0.7**	**4.3**
1	**10.0**	**0.2**	**0.0**	**0.2**	**4.5**	**1.1**	**0.3**	**0.0**	**5.8**	**0.3**	**16.1**
2	**3.3**	**1.6**	**0.0**	**1.6**	**19.7**	**5.5**	**0.4**	**6.3**	**26.8**	**6.7**	**36.8**
3	**0.0**	**2.5**	**0.1**	**2.4**	**24.2**	**5.1**	**0.7**	**6.4**	**31.7**	**7.1**	**38.9**
4	**0.0**	**1.2**	**0.2**	**1.0**	**16.0**	**4.7**	**0.2**	**1.8**	**21.7**	**2.0**	**23.7**
5	**0.0**	**0.4**	**0.1**	**0.3**	**12.6**	**3.8**	**0.0**	**1.6**	**16.8**	**1.6**	**18.5**
6	**0.0**	**0.8**	**0.1**	**0.7**	**7.8**	**2.3**	**0.5**	**2.4**	**10.8**	**2.9**	**13.8**
7	**0.0**	**0.5**	**0.1**	**0.4**	**4.4**	**1.0**	**0.2**	**1.4**	**5.8**	**1.6**	**7.4**
8	**0.0**	**0.8**	**0.1**	**0.7**	**9.0**	**2.3**	**0.2**	**1.6**	**12.0**	**1.8**	**13.8**
9+	**0.0**	**1.7**	**0.2**	**1.5**	**10.1**	**0.5**	**0.4**	**1.2**	**12.1**	**1.5**	**13.6**
Sum	**13.8**	**9.6**	**0.8**	**8.8**	**108.2**	**29.6**	**3.7**	**22.7**	**146.6**	**26.4**	**186.8**
Quarter: 1											
0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	**0.1**
1	0.6	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	**0.8**
2	2.2	0.4	0.0	0.4	2.4	0.1	0.1	0.0	2.9	0.1	**5.2**
3	0.0	0.5	0.0	0.5	4.9	0.1	0.1	0.6	5.6	0.7	**6.3**
4	0.0	0.2	0.0	0.2	2.4	1.6	0.0	0.2	4.3	0.2	**4.5**
5	0.0	0.1	0.0	0.1	1.1	0.4	0.0	0.1	1.6	0.1	**1.7**
6	0.0	0.1	0.0	0.1	0.1	0.0	0.1	0.4	0.3	0.4	**0.7**
7	0.0	0.1	0.0	0.1	0.7	0.1	0.0	0.2	0.9	0.2	**1.1**
8	0.0	0.1	0.0	0.1	0.8	0.4	0.0	0.1	1.4	0.1	**1.4**
9+	0.0	0.2	0.0	0.2	0.2	0.0	0.0	0.3	0.3	0.3	**0.6**
Sum	**2.8**	**1.8**	**0.2**	**1.6**	**12.9**	**3.0**	**0.4**	**1.8**	**17.5**	**2.2**	**22.5**
Quarter: 2											
0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.0	**0.3**
1	0.7	0.0	0.0	0.0	1.2	0.1	0.0	0.0	1.3	0.0	**2.1**
2	0.6	0.8	0.0	0.8	9.5	1.5	0.0	0.0	11.8	0.0	**12.5**
3	0.0	1.4	0.0	1.4	9.5	0.9	0.0	0.0	11.8	0.0	**11.9**
4	0.0	0.5	0.0	0.5	3.9	0.3	0.0	0.0	4.7	0.0	**4.7**
5	0.0	0.1	0.0	0.1	1.5	0.0	0.0	0.0	1.6	0.0	**1.6**
6	0.0	0.5	0.0	0.4	1.8	0.2	0.0	0.0	2.4	0.0	**2.5**
7	0.0	0.3	0.0	0.3	0.6	0.0	0.0	0.0	0.9	0.0	**0.9**
8	0.0	0.4	0.0	0.4	1.5	0.4	0.0	0.0	2.3	0.0	**2.3**
9+	0.0	0.9	0.1	0.8	2.2	0.0	0.0	0.0	3.0	0.0	**3.0**
Sum	**1.4**	**4.9**	**0.2**	**4.7**	**31.8**	**3.7**	**0.0**	**0.1**	**40.2**	**0.1**	**41.7**
Quarter: 3											
0	0.3	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1.6	0.0	**2.0**
1	4.4	0.0	0.0	0.0	1.1	0.2	0.0	0.0	1.4	0.0	**5.7**
2	0.5	0.4	0.0	0.4	6.6	1.8	0.0	0.0	8.7	0.0	**9.3**
3	0.0	0.5	0.1	0.4	7.9	2.3	0.0	0.1	10.6	0.1	**10.7**
4	0.0	0.2	0.1	0.1	6.9	2.5	0.0	0.0	9.6	0.0	**9.6**
5	0.0	0.1	0.0	0.1	7.6	3.2	0.0	0.0	10.9	0.0	**10.9**
6	0.0	0.2	0.0	0.1	4.0	1.8	0.0	0.0	5.9	0.0	**5.9**
7	0.0	0.1	0.0	0.1	2.4	0.8	0.0	0.0	3.4	0.0	**3.4**
8	0.0	0.1	0.0	0.1	5.0	1.5	0.0	0.0	6.7	0.0	**6.7**
9+	0.0	0.4	0.0	0.4	5.5	0.4	0.0	0.0	6.3	0.0	**6.3**
Sum	**5.2**	**1.9**	**0.2**	**1.7**	**47.1**	**16.2**	**0.0**	**0.2**	**65.0**	**0.2**	**70.4**
Quarter: 4											
0	0.0	0.0	0.0	0.0	0.0	1.2	0.7	0.0	1.2	0.7	**2.0**
1	4.3	0.1	0.0	0.1	2.1	0.7	0.3	0.0	2.8	0.3	**7.4**
2	0.0	0.1	0.0	0.1	1.2	2.1	0.3	6.2	3.3	6.6	**9.9**
3	0.0	0.1	0.0	0.1	1.8	1.8	0.6	5.7	3.7	6.3	**10.0**
4	0.0	0.2	0.0	0.2	2.7	0.3	0.2	1.5	3.1	1.7	**4.8**
5	0.0	0.1	0.0	0.1	2.4	0.2	0.0	1.5	2.8	1.5	**4.3**
6	0.0	0.1	0.0	0.1	1.9	0.3	0.4	2.0	2.3	2.5	**4.7**
7	0.0	0.0	0.0	0.0	0.6	0.0	0.1	1.2	0.6	1.4	**2.0**
8	0.0	0.1	0.0	0.1	1.6	0.0	0.2	1.5	1.7	1.7	**3.4**
9+	0.0	0.2	0.0	0.1	2.2	0.0	0.3	0.9	2.4	1.2	**3.6**
Sum	**4.3**	**1.0**	**0.2**	**0.9**	**16.4**	**6.8**	**3.2**	**20.6**	**24.0**	**23.9**	**52.2**

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2010. 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	16.8%	0.0%	0.0%	0.0%	0.0%	74.8%	67.5%	0.0%	36.6%	24.4%	32.0%	34.9%
1	68.0%	3.7%	0.7%	3.9%	8.4%	3.5%	11.1%	0.2%	5.8%	4.1%	15.7%	5.6%
2	15.0%	22.3%	0.9%	23.9%	23.4%	6.4%	6.0%	32.5%	15.1%	22.9%	16.0%	16.1%
3	0.1%	29.7%	13.8%	30.9%	23.7%	4.6%	5.8%	29.9%	14.6%	21.1%	13.0%	15.5%
4	0.1%	10.5%	26.2%	9.3%	13.4%	4.0%	1.6%	7.3%	8.7%	5.2%	6.9%	8.2%
5	0.0%	3.6%	10.3%	3.1%	9.3%	2.6%	0.3%	6.0%	5.8%	4.0%	4.6%	5.5%
6	0.0%	7.1%	13.8%	6.6%	5.8%	1.6%	3.4%	9.1%	3.7%	7.0%	3.5%	4.2%
7	0.0%	4.0%	7.2%	3.8%	3.3%	0.7%	1.0%	5.3%	2.0%	3.8%	1.9%	2.3%
8	0.0%	5.7%	9.3%	5.4%	6.2%	1.6%	1.3%	5.6%	3.9%	4.0%	3.3%	3.9%
9+	0.0%	13.3%	17.8%	13.0%	6.5%	0.3%	2.0%	4.3%	3.7%	3.5%	3.1%	3.7%
Sum 3+	0.2%	74.0%	98.5%	72.1%	68.1%	15.3%	15.4%	67.4%	42.4%	48.6%	36.3%	43.4%
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	0.0%	43.0%	0.0%	0.0%	11.1%	0.0%	6.8%	9.9%
1	55.9%	3.9%	0.0%	4.3%	2.7%	2.3%	24.6%	0.0%	2.7%	7.7%	19.8%	3.2%
2	43.9%	26.2%	0.0%	28.3%	22.6%	3.9%	37.9%	2.6%	18.2%	13.6%	25.9%	17.6%
3	0.2%	32.6%	0.0%	35.2%	37.0%	3.1%	17.2%	42.8%	28.1%	34.8%	19.8%	28.7%
4	0.0%	11.8%	31.6%	10.2%	17.8%	31.7%	3.8%	10.3%	20.8%	8.3%	13.4%	19.6%
5	0.0%	3.9%	10.3%	3.3%	7.9%	6.6%	1.7%	4.3%	7.2%	3.5%	4.7%	6.8%
6	0.0%	4.8%	12.9%	4.1%	0.8%	0.4%	6.3%	17.4%	0.9%	14.0%	1.6%	2.4%
7	0.0%	3.8%	10.2%	3.3%	5.2%	1.9%	3.0%	7.9%	4.2%	6.3%	3.0%	4.4%
8	0.0%	5.0%	13.3%	4.3%	5.3%	7.0%	1.1%	2.9%	5.6%	2.4%	3.6%	5.3%
9+	0.0%	8.1%	21.7%	7.0%	0.9%	0.1%	4.3%	11.8%	1.1%	9.4%	1.4%	2.1%
Sum 3+	0.2%	69.9%	100.0%	67.4%	74.7%	50.9%	37.5%	97.4%	68.0%	78.7%	47.4%	69.3%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	68.7%	0.0%	0.0%	17.0%	0.0%	14.7%	16.9%
1	82.7%	2.4%	0.0%	2.5%	7.6%	2.6%	27.5%	0.0%	5.9%	7.0%	16.3%	5.9%
2	16.6%	21.9%	0.0%	22.7%	35.7%	14.9%	27.3%	2.7%	29.5%	9.0%	27.7%	29.3%
3	0.2%	33.0%	0.0%	34.2%	29.6%	7.4%	14.9%	44.7%	24.5%	37.0%	21.2%	24.4%
4	0.3%	9.1%	21.3%	8.7%	9.9%	2.5%	9.6%	9.9%	8.0%	9.8%	6.9%	8.0%
5	0.1%	1.7%	4.0%	1.6%	3.4%	0.0%	4.5%	4.4%	2.4%	4.5%	2.1%	2.4%
6	0.0%	8.1%	18.9%	7.7%	4.3%	1.4%	7.6%	16.4%	3.9%	14.1%	3.4%	3.9%
7	0.1%	4.4%	10.2%	4.2%	1.5%	0.0%	1.8%	7.8%	1.3%	6.3%	1.2%	1.4%
8	0.0%	5.4%	12.5%	5.1%	3.4%	2.4%	3.1%	2.8%	3.3%	2.9%	2.8%	3.3%
9+	0.0%	14.1%	33.0%	13.4%	4.6%	0.1%	3.7%	11.3%	4.3%	9.3%	3.7%	4.4%
Sum 3+	0.7%	75.8%	100.0%	74.9%	56.7%	13.7%	45.3%	97.3%	47.6%	83.9%	41.3%	47.9%
Quarter: 3												
0	41.7%	0.0%	0.0%	0.0%	0.0%	81.8%	84.1%	0.0%	51.7%	14.3%	50.1%	51.5%
1	53.9%	1.7%	2.2%	1.6%	5.8%	1.3%	2.7%	0.0%	2.9%	0.5%	10.4%	2.9%
2	4.3%	27.3%	2.7%	30.3%	18.4%	3.2%	3.7%	26.3%	9.0%	22.5%	8.3%	9.0%
3	0.1%	28.3%	43.7%	26.4%	18.5%	3.0%	2.2%	29.0%	8.8%	24.5%	7.6%	8.9%
4	0.0%	8.1%	25.0%	6.0%	13.9%	2.9%	2.7%	7.3%	6.8%	6.5%	5.8%	6.8%
5	0.0%	3.9%	10.8%	3.1%	13.8%	3.4%	1.4%	5.1%	7.1%	4.5%	6.0%	7.1%
6	0.0%	6.8%	12.2%	6.1%	7.6%	1.8%	1.0%	12.6%	3.9%	10.6%	3.3%	3.9%
7	0.0%	3.4%	3.4%	3.4%	4.4%	0.8%	0.6%	7.1%	2.1%	6.0%	1.8%	2.2%
8	0.0%	4.9%	0.0%	5.5%	8.5%	1.4%	0.6%	6.9%	4.0%	5.9%	3.4%	4.0%
9+	0.0%	15.6%	0.0%	17.6%	9.0%	0.4%	0.9%	5.6%	3.7%	4.8%	3.1%	3.7%
Sum 3+	0.1%	71.0%	95.1%	68.0%	75.8%	13.6%	9.5%	73.7%	36.4%	62.8%	31.1%	36.6%
Quarter: 4												
0	4.7%	0.0%	0.0%	0.0%	0.0%	65.1%	72.5%	0.0%	36.6%	26.7%	28.6%	32.1%
1	94.9%	14.1%	0.0%	16.3%	22.1%	10.9%	10.1%	0.2%	15.7%	3.8%	21.5%	10.3%
2	0.4%	7.5%	0.0%	8.7%	9.2%	12.0%	3.6%	35.5%	10.8%	23.7%	14.5%	16.6%
3	0.0%	10.6%	0.0%	12.2%	10.3%	8.2%	4.9%	28.6%	9.2%	19.9%	12.1%	13.9%
4	0.0%	19.6%	28.9%	18.1%	15.7%	1.2%	1.4%	7.0%	7.6%	4.9%	5.5%	6.4%
5	0.0%	12.3%	18.1%	11.4%	12.6%	0.9%	0.2%	6.2%	6.0%	4.0%	4.4%	5.1%
6	0.0%	7.0%	10.4%	6.5%	9.4%	1.4%	3.2%	8.2%	4.8%	6.4%	4.8%	5.5%
7	0.0%	4.0%	5.9%	3.7%	2.8%	0.1%	0.9%	5.1%	1.3%	3.5%	2.0%	2.3%
8	0.0%	10.3%	15.2%	9.5%	7.8%	0.2%	1.4%	5.8%	3.5%	4.2%	3.3%	3.8%
9+	0.0%	14.6%	21.5%	13.5%	10.2%	0.1%	1.8%	3.6%	4.6%	2.9%	3.3%	3.9%
Sum 3+	0.0%	78.4%	100.0%	74.9%	68.7%	12.0%	13.8%	64.4%	36.9%	45.7%	35.5%	41.0%

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.

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

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

2009	Fleet A		Fleet B		Fleet C		Fleet D		TOTAL	
Total		Mean		Mean		Mean		Mean		**Mean**
Winter rings	Numbers	Weight	Numbers	Weight	Numbers	Weight	Numbers	Weight	**Numbers**	**Weight**
0	39.6	0.017	493.7	0.009	1.0	0.018	115.8	0.009	**650.0**	**0.009**
1	20.9	0.076	77.5	0.036	49.6	0.086	27.9	0.013	**175.9**	**0.051**
2	240.8	0.148	12.7	0.086	6.4	0.102	0.6	0.089	**260.5**	**0.144**
3	108.0	0.181	0.4	0.149	0.3	0.081	0.0	0.100	**108.8**	**0.181**
4	96.5	0.216	0.0	0.000	0.2	0.207	0.0	0.186	**96.7**	**0.216**
5	87.6	0.216	0.0	0.000	0.0	0.000	0.0	0.000	**87.6**	**0.216**
6	39.5	0.239	0.2	0.312	0.0	0.000	0.0	0.000	**39.7**	**0.239**
7	57.6	0.243	0.0	0.000	0.0	0.000	0.0	0.000	**57.6**	**0.243**
8	112.1	0.248	0.0	0.000	0.1	0.269	0.0	0.263	**112.2**	**0.248**
9+	34.1	0.273	0.0	0.000	0.0	0.000	0.0	0.000	**34.1**	**0.273**
TOTAL	836.5		584.5		57.7		144.3		1,623.0	
SOP catch	**157.8**		**8.4**		**5.1**		**1.5**		**172.8**	

Figures for A fleet include 3 576 t unsampled bycatch in the industrial fishery

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

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

Table 2.2.7: Catch at age (numbers in millions) of North Sea herring, 1995-2010. SG Rednose's revisions for 1995-2001 are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1995	6294	484	1319	818	244	122	57	43	69	29	9480
1996	1795	645	488	516	170	57	22	9	17	4	3723
1997	364	174	565	428	285	109	31	12	19	6	1993
1998	208	254	1084	525	267	179	89	14	17	4	2642
1999	968	73	487	1034	289	134	70	28	10	2	3096
2000	873	194	516	453	636	212	82	36	15	3	3019
2001	1025	58	678	473	279	319	92	39	18	2	2982
2002	319	490	513	913	294	136	164	47	34	7	2917
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
2005	919	408	203	487	1326	480	577	116	108	39	4664
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090
2009	533	98	253	108	96	88	40	58	112	34	1421
2010	526	84	243	234	124	84	63	34	59	56	1508

Table 2.2.8: Catch at age (numbers in millions) of WBSS Herring taken in the North Sea, and transferred to the assessment of the spring spawning stock in IIIa, 1995-2010.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1995	0.0	0.0	22.4	11.0	14.9	4.0	2.9	1.9	0.7	0.0	57.8
1996	0.0	0.0	0.0	2.8	0.8	0.4	0.1	0.1	0.3	0.0	4.5
1997	0.0	0.0	2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998	0.0	5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999	0.0	0.0	3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000	0.0	0.0	8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7
2009	0.0	0.0	1.0	2.1	3.4	1.4	1.7	4.5	1.8	1.4	17.2
2010	0.0	0.0	0.0	0.5	1.0	0.4	0.5	0.3	0.3	0.7	3.8

Table 2.2.9: Catch at age (numbers in millions) of NSAS taken in IIIa, and transfered to the assessment of NSAS, 1995 - 2010. SG Rednose's revisions and revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8+		Total
1995	1145	1181	147	10	3	1	1	0	0		2487
1996	516	961	154	13	3	1	1	0	0		1649
1997	68	305	125	20	1	1	0	0	0		521
1998	51	729	145	25	19	3	3	1	0		977
1999	598	231	133	39	10	5	1	1	0		1017
2000	232	978	115	20	21	7	3	1	0		1377
2001	808	557	140	15	1	0	0	0	0		1521
2002	411	345	48	5	1	0	0	0	0		811
2003	22	445	182	13	16	2	1	1	0		682
2004	88	71	180	21	6	10	2	2	1		380
2005	96	307	159	16	5	2	2	0	0		590
2006	35	150	50	10	3	3	1	0	0		253
2007	68	189	77	2	0	1	0	1	0		339
2008	86	87	72	2	0	0	0	0	0		247
2009	117	78	7	0	0	0	0	0	0		202
2010	49	197	43	0	0	0	0	0	0		290

Table 2.2.10: Catch at age (numbers in millions) of the total NSAS stock 1995 - 2010. 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
1995	7438	1665	1444	817	232	119	55	41	69	29	11909
1996	2311	1606	642	526	172	58	23	9	17	4	5368
1997	431	480	688	447	285	109	31	12	19	6	2507
1998	260	978	1220	538	276	176	89	15	17	4	3572
1999	1566	304	616	1059	294	136	69	28	10	2	4084
2000	1105	1172	623	463	647	213	82	36	15	2	4358
2001	1833	614	806	477	274	312	89	37	17	2	4463
2002	730	835	553	903	284	133	161	46	33	7	3687
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606
2010	575	281	287	233	123	83	63	34	59	55	1794

Table 2.2.11: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and NSAS caught in Div. IIIa in 2000 – 2010. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IIIa	2000	0.076	0.103	0.162	0.190	0.184	0.186	0.177	-
	2001	0.073	0.105	0.128	0.133	0.224	0.170	0.192	-
	2002	0.104	0.126	0.144	0.164	0.180	0.180	0.218	-
	2003	0.067	0.123	0.150	0.163	0.191	0.214	0.187	-
	2004	0.070	0.121	0.141	0.152	0.170	0.187	0.178	-
	2005	0.071	0.106	0.155	0.173	0.185	0.200	0.209	-
	2006	0.079	0.117	0.140	0.186	0.191	0.216	0.207	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
	2009	0.101	0.082	0.206	0.000	0.000	0.000	0.269	-
	2010	0.077	0.122	0.149	0.191	0.221	0.216	0.205	-
IVa(E)	2000	0.130	0.154	0.172	0.195	0.202	0.218	0.261	0.256
	2001	0.121	0.148	0.165	0.177	0.197	0.220	0.262	0.238
	2002	0.130	0.154	0.167	0.189	0.198	0.212	0.229	0.238
	2003	0.122	0.154	0.162	0.177	0.189	0.203	0.213	0.218
	2004	0.119	0.133	0.171	0.185	0.212	0.192	0.218	0.252
	2005	0.117	0.146	0.153	0.202	0.209	0.233	0.262	0.265
	2006	0.125	0.149	0.164	0.175	0.214	0.224	0.229	0.254
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
	2009	0.139	0.167	0.208	0.219	0.232	0.245	0.253	0.288
	2010	0.131	0.154	0.201	0.201	0.210	0.223	0.248	0.235
IVa(W)	2000	0.127	0.159	0.187	0.214	0.237	0.271	0.293	0.265
	2001	0.138	0.168	0.193	0.222	0.235	0.266	0.285	0.296
	2002	0.144	0.161	0.191	0.211	0.230	0.242	0.261	0.263
	2003	0.130	0.167	0.184	0.202	0.224	0.237	0.259	0.276
	2004	0.131	0.155	0.193	0.220	0.242	0.251	0.246	0.299
	2005	0.122	0.158	0.174	0.213	0.229	0.245	0.275	0.267
	2006	0.145	0.156	0.180	0.193	0.230	0.251	0.247	0.286
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
	2009	0.152	0.180	0.211	0.223	0.266	0.251	0.252	0.278
	2010	0.137	0.166	0.195	0.223	0.220	0.216	0.236	0.252
IVb	2000	0.118	0.173	0.194	0.224	0.229	0.251	0.240	0.268
	2001	0.105	0.150	0.176	0.188	0.199	0.206	0.244	0.275
	2002	0.086	0.149	0.161	0.206	0.214	0.189	0.270	0.241
	2003	0.098	0.161	0.178	0.195	0.214	0.214	0.222	0.281
	2004	0.118	0.143	0.186	0.214	0.234	0.239	0.297	0.308
	2005	0.132	0.172	0.187	0.217	0.220	0.245	0.253	0.252
	2006	0.097	0.141	0.172	0.183	0.202	0.220	0.232	0.239
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
	2009	0.140	0.188	0.228	0.219	0.223	0.243	0.255	0.255
	2010	0.134	0.176	0.182	0.229	0.237	0.235	0.232	0.265

Table 2.2.11 continued: Comparison of mean weight (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and NSAS caught in Div. IIIa in 2000 – 2010. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IVa & IVb	2000	0.125	0.162	0.185	0.210	0.227	0.258	0.275	0.263
	2001	0.129	0.156	0.180	0.202	0.217	0.242	0.275	0.285
	2002	0.119	0.157	0.177	0.203	0.219	0.228	0.253	0.253
	2003	0.113	0.163	0.178	0.190	0.210	0.225	0.239	0.255
	2004	0.122	0.147	0.187	0.210	0.227	0.233	0.247	0.266
	2005	0.121	0.157	0.172	0.212	0.225	0.242	0.269	0.265
	2006	0.123	0.150	0.174	0.187	0.222	0.239	0.238	0.269
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
	2009	0.142	0.183	0.217	0.221	0.248	0.248	0.253	0.277
	2010	0.136	0.167	0.192	0.224	0.222	0.220	0.236	0.250
IVc & VIId	2000	0.106	0.133	0.150	0.180	0.194	0.203	-	-
	2001	0.113	0.138	0.171	0.167	0.171	0.168	0.180	-
	2002	0.108	0.123	0.153	0.170	0.187	0.219	0.208	-
	2003	0.103	0.127	0.144	0.168	0.176	0.188	0.200	0.227
	2004	0.099	0.113	0.135	0.162	0.184	0.191	0.186	0.224
	2005	0.122	0.132	0.139	0.170	0.207	0.228	0.237	0.245
	2006	0.119	0.125	0.153	0.152	0.178	0.205	0.209	0.219
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
	2009	0.156	0.162	0.197	0.197	0.211	0.192	0.219	0.244
	2010	0.145	0.167	0.187	0.204	0.207	0.207	0.223	0.216
Total	2000	0.122	0.159	0.180	0.202	0.217	0.247	0.275	0.263
North Sea	2001	0.118	0.149	0.177	0.198	0.213	0.238	0.267	0.288
Catch	2002	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252
	2003	0.104	0.158	0.174	0.184	0.205	0.222	0.232	0.256
	2004	0.100	0.138	0.183	0.201	0.216	0.228	0.246	0.272
	2005	0.099	0.153	0.166	0.208	0.223	0.240	0.257	0.278
	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252
	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273
	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273
	2010	0.138	0.167	0.192	0.222	0.219	0.217	0.234	0.245

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

Table 2.2.12: Sampling of commercial landings of North Sea herring (Div. IV and VIId) in 2010 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is limited by 100 % but might exceed the official landings due to sampling of discards, unallocated and misreported catches. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each *reported* combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official Catch	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Denmark (A)	1	2	2	100%	12782	2	53	256	n
	2	1	1	100%	2807	1	32	176	n
	3	2	2	100%	18914	13	341	1634	n
	4	2	2	100%	2294	3	53	411	y
total		7	7	100%	36798	19	479	2477	n
Denmark (B)	1	2	1	55%	161	2	5	5	y
	2	2	0	0%	289	0	0	0	n
	3	3	1	52%	3051	10	346	537	y
	4	3	2	82%	5569	30	138	189	y
total		10	4	69%	9071	42	489	731	y
England	1	1	0	0%	36	0	0	0	n
and Wales*	2	3	0	0%	15	0	0	0	n
	3	3	2	100%	8964	34	850	4166	y
	4	2	1	99%	1756	2	50	297	y
total		9	3	99%	10771	36	900	4463	y
Faroe	1	2	0	0%	1829	0	0	0	n
Island	4	1	0	0%	1185	0	0	0	n
total		3	0	0%	3013	0	0	0	n
France	1	3	0	0%	1312	0	0	0	n
	2	2	0	0%	42	0	0	0	n
	3	4	0	0%	8970	0	0	0	n
	4	3	0	0%	7423	0	0	0	n
total		12	0	0%	17747	0	0	0	n
Germany	1	1	1	100%	210	6	529	2625	y
	2	2	2	100%	141	3	352	356	y
	3	2	1	51%	618	2	237	238	y
	4	3	2	99%	6702	39	920	13754	y
total		8	6	95%	7671	50	2038	16973	y
Lithuania	3	1	0	0%	90	0	0	0	n
total		1	0	0%	90	0	0	0	n
Netherlands	1	2	1	69%	789	6	150	903	y
	2	3	2	98%	3092	34	850	6582	y
	3	2	2	100%	11099	30	750	3887	y
	4	3	3	100%	8892	8	200	1107	n
total		10	8	99%	23873	78	1950	12479	y
Norway	1	2	0	0%	2531	0	0	0	n
	2	3	3	100%	28169	23	711	1518	n
	3	3	1	42%	2572	1	30	52	n
	4	3	1	91%	13544	13	398	799	n
total		11	5	89%	46816	37	1139	2369	n
Scotland	1	2	0	0%	164	0	0	0	n
	2	2	1	92%	2525	7	589	1375	y
	3	3	2	97%	11459	17	1301	4690	y
	4	2	0	0%	237	0	0	0	n
total		9	3	93%	14384	24	1890	6065	y
Sweden	2	3	1	68%	3405	8	1032	1032	y
	3	1	0	0%	430	0	0	0	n
	4	1	0	0%	560	0	0	0	n
total		5	1	53%	4395	8	1032	1032	y
grand total		85	37	81%	174628	294	9917	46589	y
Period total	1	17	5	69%	19814	16	737	3789	n
Period total	2	21	10	96%	40485	76	3566	11039	y
Period total	3	24	11	80%	66168	107	3855	15204	y
Period total	4	23	11	76%	48161	95	1759	16557	y
Total for stock 2010		85	37	81%	174628	294	9917	46589	y
Human Cons. only		75	33	82%	165557	252	9428	45858	y
Total for stock 2008		93	29	76%	227895	217	8663	36232	n
Total for stock 2009		76	29	70%	166566	170	5444	20654	y
Human Cons. only 2009		66	26	69%	156797	143	4804	19477	n

* majority of catches landed to Ijmuiden, the Netherlands

Table 2.3.1.1: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2010. Vessels, areas and cruise dates.

VESSEL	PERIOD	AREA	RECTANGLES
Celtic Explorer (IR)	18 Jun – 07 July	53°-56°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2
Charter west Sco (SCO)	28 June – 17 July	55°30′-60°30′N, 4°-10°W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E5, 48E4-E5, 49E5
Johan Hjort (NOR)	3 July – 2 August	57°-62°N, 2°-5°E	43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Scotia (SCO)	28 June –18 July	58°30′-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E6-F1
Tridens (NED)	28 June – 23 July	54°– 58°30′N, 4° W–2°/ 6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F2, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER)	25 June – 13 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN)	03 July– 23 July	Kattegat and North of 56°N, east of 6°E	41 F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Table 2.3.1.2: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2010. Total numbers (millions of fish) and biomass (thousands of tonnes) of North Sea autumn spawning herring in the area surveyed in the pelagic acoustic surveys, with mean weight and mean length by age ring.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0	12,226	69	0.00	5.7	9.4
1	14,577	560	0.01	38.4	16.9
2	4,237	583	0.45	137.7	24.9
3	4,216	772	0.90	183.1	27.1
4	2,453	562	1.00	229.2	28.9
5	1,246	305	0.98	244.9	29.4
6	1,332	311	1.00	233.1	29.0
7	688	163	1.00	237.4	29.2
8	1,110	280	1.00	251.9	29.7
9+	1,619	407	1.00	251.2	29.6
Immature	29,473	985		33.4	14.5
Mature	14,231	3,027		212.7	28.2
Total	43,705	4,011	0.33	91.8	19.0

Table 2.3.1.3: Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1986-2010. For 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 2010 estimates are from the summer survey in Divisions IVa,b and IIIa excluding estimates of Division IIIa/Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1986	1,639	3,206	1,637	833	135	36	24	6	8	7,542	942
1987	13,736	4,303	955	657	368	77	38	11	20	20,165	817
1988	6,431	4,202	1,732	528	349	174	43	23	14	13,496	897
1989	6,333	3,726	3,751	1,612	488	281	120	44	22	16,377	1,637
1990	6,249	2,971	3,530	3,370	1,349	395	211	134	43	18,262	2,174
1991	3,182	2,834	1,501	2,102	1,984	748	262	112	56	12,781	1,874
1992	6,351	4,179	1,633	1,397	1,510	1,311	474	155	163	17,173	1,545
1993	10,399	3,710	1,855	909	795	788	546	178	116	19,326	1,216
1994	3,646	3,280	957	429	363	321	238	220	132	13,003	1,035
1995	4,202	3,799	2,056	656	272	175	135	110	84	11,220	1,082
1996	6,198	4,557	2,824	1,087	311	99	83	133	206	18,786	1,446
1997	9,416	6,363	3,287	1,696	692	259	79	78	158	22,028	1,780
1998	4,449	5,747	2,520	1,625	982	445	170	45	121	16,104	1,792
1999	5,087	3,078	4,725	1,116	506	314	139	54	87	15,107	1,534
2000	24,735	2,922	2,156	3,139	1,006	483	266	120	97	34,928	1,833
2001	6,837	12,290	3,083	1,462	1,676	450	170	98	59	26,124	2,622
2002	23,055	4,875	8,220	1,390	795	1,031	244	121	150	39,881	2,948
2003	9,829	18,949	3,081	4,189	675	495	568	146	178	38,110	2,999
2004	5,183	3,415	9,191	2,167	2,590	317	328	342	186	23,722	2,584
2005	3,113	1,890	3,436	5,609	1,211	1,172	140	127	107	16,805	1,868
2006	6,823	3,772	1,997	2,098	4,175	618	562	84	70	20,199	2,130
2007	6,261	2,750	1,848	898	806	1,323	243	152	65	14,346	1,203
2008	3,714	2,853	1,709	1,485	809	712	1,749	185	270	20,355	1,784
2009	4,655	5,632	2,553	1,023	1,077	674	638	1,142	578	31,526	2,591
2010	14,577	4,237	4,216	2,453	1,246	1,332	688	1,110	1,619	43,705	3,027

Table 2.3.2.1: North Sea herring - MLAI time-series and 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	12.9
1974	758	421	101	284	81		1184		10		7.9
1975	371	50	312			90	77	1	2		2.8
1976	545	81		1	64	108			3		2.5
1977	1133	221	124	32	520	262	89	1			6.1
1978	3047	50		162	1406	81	269	33	3		7.3
1979	2882	2362	197	10	662	131	507		111	89	13.8
1980	3534	720	21	1	317	188	9	247	129	40	9.3
1981	3667	277	3	12	903	235	119	1456		70	13.5
1982	2353	1116	340	257	86	64	1077	710	275	54	19.9
1983	2579	812	3647	768	1459	281	63	71	243	58	25.5
1984	1795	1912	2327	1853	688	2404	824	523	185	39	45.8
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	70.1
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.5
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.8
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.5
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	126.9
1990		10144	4590	2045	19955	1239	975	2552	1204		165.0
1991	1021	2397		2032	4823	2110	1249	4400	873		87.9
1992	189	4917		822	10	165	163	176	1616		40.5
1993		66		174		685	85	1358	1103		28.6
1994	26	1179				1464	44	537	595		20.0
1995		8688					43	74	230	164	20.5
1996		809		184		564		337	675	691	40.6
1997		3611		23				9374	918	355	53.1
1998		8528		1490	205	66		1522	953	170	66.6
1999		4064		185		134	181	804	1260	344	55.7
2000		3352	28	83		376		7346	338	106	37.4
2001		11918		164		1604		971	5531	909	123.4
2002		6669		1038			3291	2008	260	925	104.5
2003		3199		2263		12018	3277	12048	3109	1116	250.6
2004		7055		3884		5545		7055	2052	4175	308.9
2005		3380		1364		5614		498	3999	4822	183.8
2006	6311	2312		280		2259		10858	2700	2106	112.8
2007		1753		1304		291		4443	2439	3854	161.0
2008	4978	6875		533		11201		8426	2317	4008	180.5
2009		7543		4629		4219		15295	14712	1689	466.7
2010		2362		1493		2317		7493	13230	8073	380.4

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

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

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

Year class	Year of sampling	All1-ringers in total area (IBTS-1 index) (no/hour)	Small<13cm 1-ringers in total area (no/hour)	Proportion of small in total area vs. all sizes	Small<13cm 1-ringers in North Sea (no/hour)	Proportion of small in North Sea vs. all sizes	Proportion of small in IIIa vs small in total area
1977	1979	168	11	0.07	12	0.07	0
1978	1980	316	108	0.34	106	0.34	0.09
1979	1981	495	51	0.1	41	0.08	0.26
1980	1982	798	177	0.22	185	0.23	0.03
1981	1983	1270	192	0.15	185	0.15	0.11
1982	1984	1516	346	0.23	297	0.2	0.2
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	0.1	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	0.2	0.09
1998	2000	3725	1117	0.3	991	0.27	0.17
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	4065	1553	0.38	1471	0.36	0.12
2001	2003	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	1321	302	0.23	302	0.23	0.07
2006	2008	1816	436	0.24	464	0.26	0.01
2007	2009	2344	737	0.31	626	0.27	0.21
2008	2010	1202	292	0.24	301	0.25	0.04
2009	2011	**2935**	1331	0.45	1407	0.48	0.02

Table 2.3.3.3. North Sea herring. Indices of 2-5+ ringers from the 1st quarter IBTS

Year of sampling	2-ringer no/h	3-ringer no/h	4-ringer no/h	5+ ringer no/h
1983	139	45	14	24
1984	161	61	27	10
1985	722	282	42	28
1986	782	276	79	28
1987	918	116	59	49
1988	4163	792	58	25
1989	875	339	89	9
1990	462	280	269	71
1991	693	259	222	146
1992	437	193	55	92
1993	787	223	45	66
1994	1167	213	69	43
1995	1393	279	37	7
1996	198	33	10	8
1997	507	163	31	20
1998	792	96	21	18
1999	451	501	98	36
2000	199	155	59	9
2001	1129	317	94	68
2002	658	338	25	20
2003	1556	612	360	53
2004	451	777	112	171
2005	214	356	389	131
2006	1464	330	252	339
2007	50	18	8	41
2008	233	146	202	232
2009	136	21	11	46
2010	50	35	46	90
2011	422	573	419	466

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

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

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 2010.

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

Table 2.5.3.1. North Sea herring. Estimated recruitment index TS consisting of *ex-ante* predictions (hindcasts) for period 1960 to 2009 and *ex-post* (true) forecasts for years 2010 and 2011. The *ex-post* forecasts for 2010 and 2011 are indicated by greyed cells.

Year	Prediction/Forecast	Year	Prediction/Forecast
1970	40889312.39	1993	51890527.82
1971	27403793.73	1994	32803967.56
1972	20577925.37	1995	55511661.40
1973	35995924.05	1996	57151261.45
1974	12765872.33	1997	21529816.06
1975	1699335.57	1998	35543467.42
1976	10146572.78	1999	38891315.78
1977	6454681.62	2000	62617820.18
1978	-2933962.99	2001	69466523.65
1979	9939278.55	2002	62063768.17
1980	2703519.71	2003	21779174.40
1981	26614032.56	2004	29122042.78
1982	53739116.51	2005	25856552.19
1983	49524124.54	2006	31968509.38
1984	65101919.79	2007	13391585.49
1985	46634923.44	2008	12766825.67
1986	79499074.02	2009	26713193.62
1987	111715839.16	2010	34135668.24
1988	65361810.34	2011	38770600.39
1989	43888761.55		
1990	52004900.51		
1991	41668338.54		
1992	30927250.82		

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	1972-2010	1973-2010
IBTS 1st Quarter (Trawl survey)	1-5wr	1971-2011	1984-2011
Acoustic (+trawl)	1wr	1995-2010	1997-2010
	2-9+wr	1984-2010	1989-2010
IBTS0	0wr	1977-2011	1992-2011

Table 2.6.3.1 NORTH SEA HERRING. CATCH IN NUMBER

Units : thousands

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

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

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

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

Table 2.6.3.1 cont NORTH SEA HERRING. CATCH IN NUMBER

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

age \ year	2006	2007	2008	2009	2010
0	878637	621005	798284	650043	574895
1	222111	235553	235022	175923	280728
2	401087	219115	331772	259434	293887
3	310602	417452	184771	106738	236804
4	464620	285746	199069	93321	126241
5	997782	309454	137529	86137	83893
6	252150	629187	118349	37951	61542
7	247042	147830	215542	53130	33305
8	63035	133388	74339	110394	59142
9	43377	23362	42919	32737	54533

Table 2.6.3.2 NORTH SEA HERRING. WEIGHTS AT AGE IN THE CATCH

Units : kg

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271
9	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

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

Table 2.6.3.2 cont NORTH SEA HERRING. WEIGHTS AT AGE IN THE CATCH

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

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

age	2008	2009	2010
0	0.0079	0.0094	0.0075
1	0.0535	0.0514	0.0571
2	0.1288	0.1440	0.1292
3	0.1796	0.1811	0.1669
4	0.1812	0.2158	0.1912
5	0.1832	0.2162	0.2203
6	0.2157	0.2390	0.2193
7	0.2161	0.2428	0.2160
8	0.2560	0.2476	0.2334
9	0.2726	0.2724	0.2438

Table 2.6.3.3 NORTH SEA HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

year

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

year

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

year

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

year

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

year

age	2008	2009	2010
0	0.008	0.007	0.007
1	0.058	0.061	0.052
2	0.130	0.137	0.142
3	0.164	0.181	0.190
4	0.181	0.197	0.216
5	0.195	0.210	0.224
6	0.218	0.223	0.234
7	0.226	0.234	0.240
8	0.253	0.255	0.256
9	0.260	0.259	0.265

Table 2.6.3.4 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	2005	2006	2007	2008	2009	2010
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
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1

Table 2.6.3.5 NORTH SEA HERRING. PROPORTION MATURE

Units : NA

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

age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.7	0.75	0.8	0.85	0.82
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	0.93	0.94
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00

age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.91	0.86	0.50	0.47	0.73	0.67	0.61	0.64	0.64	0.69	0.67	0.77	0.87	0.43	0.70
3	0.97	0.99	0.99	0.61	0.93	0.95	0.98	0.94	0.89	0.91	0.96	0.92	0.97	0.93	0.65
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2005	2006	2007	2008	2009	2010
0	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00
2	0.76	0.66	0.71	0.86	0.89	0.45
3	0.96	0.88	0.92	0.98	1.00	0.90
4	0.96	0.98	0.93	0.99	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00

Table 2.6.3.6 NORTH SEA HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year															
age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year															
age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year															
age	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year						
age	2005	2006	2007	2008	2009	2010
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

Table 2.6.3.7 NORTH SEA HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age \ year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2005	2006	2007	2008	2009	2010
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

Table 2.6.3.8 NORTH SEA HERRING. SURVEY INDICES

```
MLAI - Configuration

"Herring" "in" "Sub-area" "IV," "Divisions" "VIId" "&" "IIIa" "(autumn-
spawners)"
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      1973      2010        NA        NA
Index type : biomass

MLAI - Index Values

Units  :  NA
     year
age     1973  1974  1975  1976  1977  1978   1979  1980   1981   1982   1983
  all 12.892 7.676 2.777 2.458 6.081 7.276 13.765 9.251 13.521 19.859 25.456
     year
age     1984   1985   1986   1987    1988   1989    1990   1991   1992   1993
  all 45.835 70.134 36.524 64.774 128.523 126.86 164.982 87.928 40.524 28.643
     year
age     1994   1995   1996   1997   1998   1999   2000    2001    2002    2003
  all 19.982 20.474 40.646 53.077 66.596 55.731 37.392 123.398 104.485 250.644
     year
age      2004    2005    2006    2007    2008    2009    2010
  all 308.878 183.782 112.811 160.992 180.456 466.652 380.386

MLAI - Index Variance (Inverse Weights)

Units  :  NA
     year
age       1973     1974     1975     1976     1977     1978     1979     1980
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       1981     1982     1983     1984     1985     1986     1987     1988
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       1989     1990     1991     1992     1993     1994     1995     1996
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       1997     1998     1999     2000     2001     2002     2003     2004
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
     year
age       2005     2006     2007     2008     2009     2010
  all 1.666667 1.666667 1.666667 1.666667 1.666667 1.666667
```

TABLE 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

```
IBTS0 - Configuration

"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported
from VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
     0.00      0.00        NA   1992.00   2011.00      0.08      0.17
Index type : number

IBTS0 - Index Values

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

IBTS0 - Index Variance (Inverse Weights)

Units  :  NA
   year
age     1992     1993     1994     1995     1996     1997     1998     1999
  0 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302
   year
age     2000     2001     2002     2003     2004     2005     2006     2007
  0 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302 1.587302
   year
age     2008     2009     2010     2011
  0 1.587302 1.587302 1.587302 1.587302

IBTS-Q1: 1-5+ wr - Configuration

"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported
from VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      5.00      5.00   1984.00   2011.00      0.08      0.17
Index type : number
```

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

IBTS-Q1: 1-5+ wr - Index Values

Units : NA

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

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

age	2000	2001	2002	2003	2004	2005	2006	2007
1	3725.131	2499.391	4064.829	2765.059	979.036	1001.585	923.167	1321.005
2	199.374	1129.308	658.154	1556.082	451.015	214.191	1490.917	50.033
3	154.691	317.069	338.153	611.890	777.324	356.007	331.024	18.250
4	58.838	93.886	25.048	359.989	112.374	388.922	251.689	7.937
5	8.952	68.284	19.936	53.166	171.231	131.481	338.811	41.284

age	2008	2009	2010	2011
1	1815.860	2344.155	1220.940	2934.736
2	232.906	136.269	49.555	422.070
3	146.192	21.459	34.853	572.857
4	202.100	11.223	45.944	419.102
5	232.335	46.427	89.950	465.734

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

IBTS-Q1: 1-5+ wr - Index Variance (Inverse Weights)

Units : NA

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

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

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

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

age \ year	2008	2009	2010	2011
1	2.127660	2.127660	2.127660	2.127660
2	3.571429	3.571429	3.571429	3.571429
3	100.000000	100.000000	100.000000	100.000000
4	100.000000	100.000000	100.000000	100.000000
5	100.000000	100.000000	100.000000	100.000000

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

Acoustic survey (HERAS): 1-9+ wr - Configuration

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

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1989.00	2010.00	0.54	0.56

Index type : number

Acoustic survey (HERAS): 1-9+ wr - Index Values

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	-1	-1	-1	-1	-1	-1	-1	-1	9361000
2	4090000	3306000	2634000	3734000	2984000	3185000	3849000	4497000	5960000
3	3903000	3521000	1700000	1378000	1637000	839000	2041000	2824000	2935000
4	1633000	3414000	1959000	1147000	902000	399000	672000	1087000	1441000
5	492000	1366000	1849000	1134000	741000	381000	299000	311000	601000
6	283000	392000	644000	1246000	777000	321000	203000	99000	215000
7	120000	210000	228000	395000	551000	326000	138000	83000	46000
8	44000	133000	94000	114000	180000	219000	119000	133000	78000
9	22000	43000	51000	104000	116000	131000	93000	206000	159000

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	4449000	5087000	24736000	6837000	23055000	9829400	5183700	3114100	6822800
2	5747000	3078000	2923000	12290000	4875000	18949400	3415900	2055100	3772300
3	2520000	4725000	2156000	3083000	8220000	3081000	9191800	3648500	1997200
4	1625000	1116000	3140000	1462000	1390000	4188900	2167300	5789600	2097500
5	982000	506000	1007000	1676000	794600	675100	2590700	1212900	4175100
6	445000	314000	483000	450000	1031000	494800	317100	1174900	618200
7	170000	139000	266000	170000	244400	568300	327600	139900	562100
8	45000	54000	120000	98000	121000	145500	342050	126500	84300
9	121000	87000	97000	59000	149500	177700	185600	106700	70400

age \ year	2007	2008	2009	2010
1	6261000	3714000	4655000	14577000
2	2750000	2853000	5632000	4237000
3	1848000	1709000	2553000	4216000
4	898000	1485000	1023000	2453000
5	806000	809000	1077000	1246000
6	1323000	712000	674000	1332000
7	243000	1749000	638000	688000
8	152000	185000	1142000	1110000
9	65000	270000	578000	1619000

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

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

Units : NA

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

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

age \ year	2003	2004	2005	2006	2007	2008	2009
1	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302	1.587302
2	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903	1.612903
3	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353	5.882353
4	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000	10.000000
5	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111	11.111111
6	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000	12.500000
7	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
8	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714	14.285714
9	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000	20.000000

age \ year	2010
1	1.587302
2	1.612903
3	5.882353
4	10.000000
5	11.111111
6	12.500000
7	14.285714
8	14.285714
9	20.000000

Table 2.6.3.9 NORTH SEA HERRING. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	9	9	1960	2010	2	6

Table2.6.3.10 NORTH SEA HERRING. FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : TRUE
sr.age      : 1
lambda.age  : 0.1 0.1 3.67 2.87 2.23 1.74 1.37 1.04 0.94 0.91
lambda.yr   : 1 1 1 1 1
lambda.sr   : 0.1
index.model : power linear linear linear
index.cor   : F
sep.nyr     : 5
sep.age     : 4
sep.sel     : 1
```

Table 2.6.3.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

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

Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

Table 2.6.3.12 NORTH SEA HERRING. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 2-6) f	Landings tonnes	Landings SOP
1960	12092313	3747903	1884122	0.3367	696200	1.1830
1961	108850059	4364354	1662930	0.4315	696700	1.1348
1962	46272455	4397754	1115220	0.5290	627800	1.1705
1963	47657565	4628953	2189201	0.2260	716000	0.8602
1964	62786575	4797400	2031515	0.3434	871200	1.0656
1965	34895343	4344785	1450013	0.6952	1168800	1.1496
1966	27859139	3316825	1281010	0.6194	895500	1.0707
1967	40256391	2814536	919752	0.7982	695500	1.1757
1968	38698817	2521305	412840	1.3363	717800	1.2551
1969	21581561	1905139	423877	1.1052	546700	0.9674
1970	41073298	1921888	374629	1.1050	563100	0.9657
1971	32307965	1849446	266051	1.4049	520100	1.0747
1972	20861031	1549562	288353	0.6960	497500	0.9197
1973	10102051	1156018	233410	1.1348	484000	0.9575
1974	21699985	912051	162051	1.0521	275100	0.9680
1975	2825521	680402	81658	1.4716	312800	0.9343
1976	2721846	358662	77952	1.4443	174800	0.9530
1977	4329404	210504	47622	0.8028	46000	1.1979
1978	4596094	224925	64889	0.0527	11000	1.2152
1979	10602593	382131	107141	0.0642	25100	1.0056
1980	16719547	630494	131011	0.2836	70764	1.0936
1981	37864017	1158667	195611	0.3515	174879	1.0081
1982	64754769	1843295	278530	0.2640	275079	0.9786
1983	61829567	2719425	432633	0.3380	387202	1.0771
1984	53460997	2865147	679075	0.4553	428631	1.0543
1985	80939722	3463006	699476	0.6436	613780	1.0419
1986	97653052	3473722	679590	0.5723	671488	1.1373
1987	86232161	3938023	901038	0.5522	792058	1.0173
1988	42292084	3622901	1195264	0.5365	887686	1.1641
1989	39183711	3312158	1251149	0.5444	787899	1.0335
1990	35866636	2978465	1186874	0.4416	645229	1.0515
1991	33636441	2716907	982498	0.4893	658008	1.0197
1992	62152334	2438080	705132	0.5814	716799	0.9950
1993	50270235	2520045	474742	0.6897	671397	1.0231
1994	34559978	2026875	512077	0.7068	568234	1.0498
1995	41738842	1846118	463304	0.7386	579371	1.0084
1996	50017440	1629136	463868	0.4016	275098	0.9987
1997	29137096	1957688	563131	0.4194	264313	1.0006
1998	28102834	2086762	739391	0.4828	391628	1.0018
1999	69449799	2371556	869482	0.3656	363163	1.0000
2000	42389537	2929463	886094	0.3547	388157	1.0004
2001	97487442	3364925	1344693	0.2852	374065	0.9901
2002	34766152	4166329	1658085	0.2339	394709	0.9974
2003	20060339	3913739	1822444	0.2303	482281	1.0153
2004	26095303	3635587	1933120	0.2759	587698	0.9985
2005	16577102	3171867	1871370	0.3192	663813	1.0033
2006	22114044	2621499	1526159	0.2812	514597	0.9950
2007	30340022	2392366	1234365	0.2674	406482	1.0056
2008	26079173	2394029	1206034	0.1945	257870	1.0040
2009	38289832	2610448	1442422	0.0986	168443	1.0023
2010	38849289	2859555	1301092	0.1175	187611	1.0034

Table 2.6.3.13 NORTH SEA HERRING. ESTIMATED FISHING MORTALITY

Units : f

year

age	1960	1961	1962	1963	1964	1965
0	0.02573320	0.01858961	0.004857751	0.01478962	0.01258591	0.007143397
1	0.25617242	0.12932790	0.089679642	0.12407101	0.30843555	0.246122752
2	0.43507633	0.61826849	0.250112005	0.29755233	0.38899821	0.775348441
3	0.32713850	0.35114514	0.629159979	0.27538687	0.41244696	0.738974053
4	0.33725442	0.40638571	0.419352079	0.22819444	0.37009415	0.776911178
5	0.26537157	0.40218955	0.529860473	0.14942452	0.30987935	0.659365447
6	0.31858098	0.37972626	0.816610240	0.17964419	0.23545396	0.525183638
7	0.59302394	0.25568350	0.631325941	0.28425670	0.27770084	0.450293556
8	0.56819273	0.50832960	0.600166613	0.33161533	0.55454154	0.838022951
9	0.56819273	0.50832960	0.600166613	0.33161533	0.55454154	0.838022951

year

age	1966	1967	1968	1969	1970	1971
0	0.02145713	0.02563521	0.03481117	0.00823815	0.03510075	0.03396986
1	0.18523552	0.29803814	0.30024512	0.32910200	0.26805990	0.60216378
2	0.59205513	0.42222497	1.32717864	0.78438673	0.97282347	0.88261263
3	0.70824214	0.80455683	1.87207332	0.91235419	1.26695224	1.21470754
4	0.57195343	0.92444459	1.07139747	0.87417114	1.33012980	1.22647457
5	0.83514089	0.82811220	1.23401594	1.05394430	0.87565878	1.08393609
6	0.38982219	1.01152956	1.17674095	1.90113501	1.07946516	2.61678229
7	0.39455717	1.52624948	1.61035508	1.30753923	4.13299523	2.70177231
8	0.71207047	1.10669324	1.62146851	1.36069931	1.79965941	2.02762290
9	0.71207047	1.10669324	1.62146851	1.36069931	1.79965941	2.02762290

year

age	1972	1973	1974	1975	1976	1977	1978
0	0.05830196	0.04619976	0.07491123	0.1576024	0.1471000	0.09771067	0.04560347
1	0.57822569	0.67385669	0.45203520	0.6879136	0.2497792	0.29811844	0.20047837
2	0.81218192	1.02222411	1.02840476	1.3142552	1.3386528	0.22590573	0.02431079
3	0.80143804	1.33395629	0.97328720	1.5031833	1.4475075	1.40986161	0.04268949
4	0.79956033	0.98791581	0.99435138	1.3745073	1.7317656	0.43885191	0.10392790
5	0.54958975	0.95128564	1.18652930	1.8885954	1.6094982	1.18648142	0.01711792
6	0.51701073	1.37860378	1.07807478	1.2775369	1.0939467	0.75264937	0.07526583
7	0.09840184	0.80382334	0.77383414	2.0279402	1.5150624	0.77888732	0.06279681
8	1.01682491	1.56395728	1.32506586	2.0368114	1.6277197	0.98526257	0.19186101
9	1.01682491	1.56395728	1.32506586	2.0368114	1.6277197	0.98526257	0.19186101

year

age	1979	1980	1981	1982	1983	1984	1985
0	0.08372731	0.12584949	0.4821645	0.3344693	0.3995588	0.2263717	0.0852665
1	0.16699091	0.11327456	0.2857054	0.2251645	0.2517829	0.2051328	0.3828898
2	0.09491923	0.36476977	0.3243862	0.2608986	0.3023941	0.3146588	0.4042348
3	0.06676805	0.42055439	0.2765156	0.5089983	0.3250840	0.4302158	0.6718703
4	0.09419295	0.29878647	0.3049633	0.2484782	0.4374260	0.5386997	0.7394562
5	0.05219707	0.26682760	0.4159604	0.1553002	0.2774710	0.6296259	0.6672648
6	0.01280278	0.06704901	0.4355027	0.1465552	0.3474636	0.3633286	0.7351532
7	0.42247081	0.10492186	0.9638405	0.2326800	0.3970131	0.7052534	0.5657169
8	0.24151228	0.34347450	0.6503644	0.4254900	0.5231238	0.6277581	0.8858924
9	0.24151228	0.34347450	0.6503644	0.4254900	0.5231238	0.6277581	0.8858924

year

age	1986	1987	1988	1989	1990	1991	1992
0	0.06191268	0.1613364	0.1246373	0.1302757	0.05888683	0.1178491	0.2966564
1	0.31576029	0.3721575	0.5798242	0.4306755	0.45254277	0.3082560	0.3871894
2	0.45959779	0.4062663	0.3554627	0.3981259	0.37680073	0.5738080	0.5728707
3	0.52240984	0.5058867	0.4008518	0.4097632	0.36928020	0.4543899	0.4976420
4	0.58307527	0.5888959	0.5826898	0.5559813	0.46687012	0.4572091	0.5722155
5	0.55655746	0.6187567	0.6637763	0.6580872	0.50037058	0.4824516	0.5454786
6	0.73977218	0.6411137	0.6795187	0.6998792	0.49457245	0.4784711	0.7185477
7	0.82962999	0.6244173	0.7030711	0.7171702	0.67860532	0.4256969	0.6981589
8	0.83196250	0.8152895	0.9531102	0.8620383	0.79148971	0.7031240	0.8742984
9	0.83196250	0.8152895	0.9531102	0.8620383	0.79148971	0.7031240	0.8742984

Table 2.6.3.13 cont. NORTH SEA HERRING. ESTIMATED FISHING MORTALITY

age	1993	1994	1995	1996	1997	1998	1999
0	0.3759339	0.2258746	0.3211345	0.07542518	0.02364231	0.01469927	0.03622188
1	0.4219845	0.2458919	0.2924358	0.25299368	0.04532040	0.15765524	0.04808452
2	0.6684901	0.6832678	0.5993335	0.30759915	0.28570767	0.26638049	0.24280614
3	0.6411742	0.7160884	0.8657347	0.48945206	0.38998067	0.40477424	0.41657352
4	0.7314638	0.9127046	0.8665282	0.41721969	0.51035723	0.42172169	0.38334681
5	0.7100916	0.5546597	0.8262931	0.47758701	0.45081211	0.60470822	0.33518900
6	0.6971324	0.6671316	0.5351948	0.31617073	0.46018639	0.71665475	0.44992879
7	0.8697147	0.4736552	0.6405867	0.14142154	0.24324650	0.37631622	0.45458480
8	1.0156145	0.8452386	0.9216411	0.53152288	0.41459144	0.56233922	0.41125857
9	1.0156145	0.8452386	0.9216411	0.53152288	0.41459144	0.56233922	0.41125857

age	2000	2001	2002	2003	2004	2005	2006
0	0.04196875	0.03011566	0.03370007	0.02946521	0.04418701	0.1010568	0.05553518
1	0.07768960	0.06683746	0.03869352	0.08165508	0.04651483	0.1300405	0.06633768
2	0.22404073	0.12322363	0.13918405	0.12159885	0.13154457	0.1776790	0.20402178
3	0.30920616	0.29051302	0.21598631	0.19304015	0.20570512	0.2182857	0.25395944
4	0.45949314	0.29367780	0.26993913	0.27673825	0.29362224	0.2966418	0.32178477
5	0.46926549	0.38689966	0.21128804	0.33789558	0.38178936	0.4047342	0.34294253
6	0.31149184	0.33154874	0.33323803	0.22202300	0.36708105	0.4986192	0.28318733
7	0.39113289	0.20760917	0.26636759	0.36902719	0.31114608	0.4055804	0.27826901
8	0.40400681	0.30859710	0.26225064	0.30075350	0.30321706	0.4142285	0.32178477
9	0.40400681	0.30859710	0.26225064	0.30075350	0.30321706	0.4142285	0.32178477

age	2007	2008	2009	2010
0	0.05281154	0.03842186	0.01947015	0.02320384
1	0.06308425	0.04589554	0.02325741	0.02771737
2	0.19401586	0.14115191	0.07152826	0.08524487
3	0.24150440	0.17570114	0.08903596	0.10610994
4	0.30600334	0.22262591	0.11281494	0.13444888
5	0.32612346	0.23726385	0.12023266	0.14328906
6	0.26929885	0.19592237	0.09928301	0.11832200
7	0.26462175	0.19251965	0.09755869	0.11626702
8	0.30600334	0.22262591	0.11281494	0.13444888
9	0.30600334	0.22262591	0.11281494	0.13444888

Table 2.6.3.14 NORTH SEA HERRING. ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1960	1961	1962	1963	1964	1965
0	12092313.4	108850059.1	46272454.6	47657564.60	62786574.98	34895342.6
1	16403718.2	4335499.3	39306178.4	16940193.30	17274851.08	22809004.0
2	3707664.6	4670824.5	1401452.1	13219619.80	5504787.06	4668399.1
3	7734930.3	1777709.7	1864638.3	808476.95	7272860.95	2763836.8
4	607271.8	4565864.9	1024475.5	813757.51	502585.26	3942057.5
5	754405.9	392180.4	2751709.2	609466.47	586086.84	314087.4
6	433712.5	523511.5	237349.2	1465742.27	474926.19	389003.6
7	294062.9	285374.1	324028.9	94909.35	1108178.40	339578.6
8	310307.3	147049.6	199960.0	155945.53	64629.15	759584.8
9	342641.0	229764.9	201118.5	189362.43	141790.95	144192.4

age	1966	1967	1968	1969	1970	1971
0	27859139.3	40256391.13	38698816.68	21581561.34	41073297.935	32307964.8939
1	12745904.1	10031237.16	14434678.91	13749436.71	7874275.330	14588849.0971
2	6560275.6	3896093.76	2739199.72	3932944.77	3639680.333	2215639.9042
3	1592759.0	2688484.05	1892217.60	538206.57	1329764.310	1019255.4300
4	1080739.8	642252.10	984541.39	238276.42	176953.724	306679.9674
5	1640156.4	551944.60	230565.81	305142.37	89950.569	42341.1087
6	146981.3	643811.51	218183.29	60735.01	96238.950	33906.3228
7	208180.4	90060.67	211849.57	60861.12	8210.266	29588.0038
8	195862.3	126956.92	17711.85	38302.74	14895.443	119.1217
9	484631.0	268849.95	118682.34	35087.54	15143.700	14771.0872

age	1972	1973	1974	1975	1976
0	20861030.5207	10102050.602	21699984.839	2825520.501	2721845.8733
1	11488470.0495	7239708.118	3548548.599	7406813.569	887887.8994
2	2939071.4568	2370541.100	1357607.824	830691.720	1369556.1936
3	679042.6275	966486.234	631848.349	359629.637	165339.9347
4	247675.6756	249446.850	208452.411	195461.262	65489.6048
5	81396.3296	100741.699	84043.125	69780.834	44739.4173
6	12959.4126	42510.046	35208.029	23215.050	9552.1279
7	2240.7692	6992.315	9690.409	10839.527	5854.8119
8	1796.0624	1837.521	2832.014	4044.276	1290.7961
9	653.1136	787.509	1557.608	1665.290	516.3184

age	1977	1978	1979	1980	1981
0	4329403.5785	4596093.659	10602592.784	16719546.8114	37864017.470
1	864339.4259	1444436.264	1615433.382	3587197.5083	5423433.021
2	254440.3093	236003.612	434847.775	502888.0784	1178328.258
3	266024.7174	150379.265	170636.629	292971.9293	258681.576
4	31832.7645	53182.406	117974.800	130682.1809	157515.270
5	10486.8890	18571.798	43371.378	97152.1296	87705.254
6	8095.8920	2896.909	16519.248	37248.1639	67319.538
7	2894.5140	3451.150	2431.184	14757.0875	31517.837
8	1164.3949	1201.932	2932.662	1441.8222	12022.761
9	321.1046	1802.897	488.777	360.4556	2404.552

Table 2.6.3.14 cont. NORTH SEA HERRING. ESTIMATED POPULATION ABUNDANCE

age \ year	1982	1983	1984	1985	1986	1987
0	64754768.752	61829567.33	53460996.95	80939722.44	97653052.09	86232160.61
1	8600641.094	17049793.08	15253711.82	15683052.22	27342388.94	33767818.38
2	1499337.928	2526088.90	4876146.31	4570808.55	3934134.41	7335150.40
3	631100.919	855666.20	1383031.84	2637143.67	2260204.46	1840602.75
4	160626.576	310588.05	506131.39	736432.49	1102770.97	1097511.60
5	105062.891	113364.02	181461.13	267226.51	318098.58	556967.05
6	52353.639	81390.53	77721.59	87480.47	124068.25	164976.64
7	39407.170	40913.75	52028.69	48901.32	37949.73	53573.77
8	10877.682	28254.93	24889.68	23255.51	25130.63	14978.75
9	3323.736	31080.42	41707.02	28581.19	27348.04	15353.22

age \ year	1988	1989	1990	1991	1992	1993
0	42292083.65	39183711.49	35866635.9	33636440.90	62152334.35	50270234.83
1	26996488.76	13735209.90	12654152.6	12440044.54	10998522.16	16995218.06
2	8562144.94	5561582.28	3284738.6	2960750.15	3362432.33	2747170.59
3	3619773.91	4445480.91	2766980.8	1669436.85	1235696.32	1404658.03
4	908651.53	1984882.69	2416028.1	1565924.75	867704.97	615077.26
5	551093.68	459101.75	1030020.3	1370608.48	896970.28	443029.47
6	271442.23	256756.60	215117.6	565077.66	765522.41	470381.52
7	78625.04	124490.66	115382.1	118701.53	316870.15	337650.30
8	25962.22	35220.18	54985.0	52965.67	70169.61	142641.31
9	14423.45	15713.62	22719.5	26896.63	41707.96	68134.51

age \ year	1994	1995	1996	1997	1998	1999
0	34559977.72	41738841.56	50017440.49	29137096.40	28102834.277	69449799.344
1	12698440.86	10143384.77	11137275.86	17063583.51	10468490.519	10187598.707
2	4099838.27	3653140.80	2785384.52	3181344.77	5999200.270	3289430.992
3	1042979.42	1533694.85	1486246.40	1517079.02	1771092.031	3405002.525
4	605694.05	417276.18	528319.04	745874.21	840974.553	967366.436
5	267811.70	220009.43	158732.45	314971.03	405126.653	499116.586
6	197067.19	139160.01	87127.92	89088.75	181574.955	200234.969
7	211963.00	91506.79	73731.46	57466.76	50878.816	80239.330
8	128034.02	119433.13	43633.55	57916.83	40770.555	31599.157
9	85234.08	50653.64	10018.34	17578.70	9201.705	6379.464

age \ year	2000	2001	2002	2003	2004	2005
0	42389536.934	97487442.30	34766151.74	20060338.84	26095302.9	16577101.9
1	24640275.076	14953311.98	34799670.27	12365918.63	7165511.6	9184968.8
2	3571860.626	8387082.27	5145360.10	12316186.78	4192466.0	2516237.3
3	1911538.586	2114981.17	5492969.85	3316504.29	8079383.3	2723028.1
4	1837989.218	1148782.06	1295028.74	3623653.46	2238645.9	5384962.9
5	596590.264	1050408.37	774935.48	894575.26	2486172.8	1510210.3
6	322999.478	337634.88	645506.08	567642.45	577352.8	1535652.2
7	115533.754	214039.13	219294.66	418550.11	411360.0	361901.6
8	46082.303	70698.89	157362.13	152025.57	261849.4	272686.5
9	7761.263	10626.54	39554.17	36498.08	127440.2	180626.9

age \ year	2006	2007	2008	2009	2010
0	22114044.1	30340021.6	26079173.5	38289832.0	38849289.0
1	5512209.5	7695823.0	10587310.3	9232364.4	13814437.3
2	2966930.1	1897672.0	2658051.8	3720137.4	3318317.2
3	1560623.8	1792311.3	1157904.6	1709911.4	2565702.6
4	1792226.8	991165.5	1152578.5	795257.6	1280698.4
5	3621790.9	1175477.1	660421.4	834748.9	642811.3
6	911662.6	2325711.7	767628.5	471356.3	669745.8
7	843948.3	621466.9	1607575.7	570996.8	386190.7
8	218282.9	578143.5	431583.5	1199863.3	468635.3
9	165222.4	92889.7	225553.4	322155.2	455006.9

Table 2.6.3.15 NORTH SEA HERRING. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2011
0	28717709.7
1	13964046.7
2	4943120.8
3	2257398.2
4	1889141.3
5	1013041.0
6	503992.9
7	538386.3
8	311084.4
9	730607.1

Table 2.6.3.16 NORTH SEA HERRING. FITTED SELECTION PATTERN

Units : NA

age	2006	2007	2008	2009	2010
0	0.1725849	0.1725849	0.1725849	0.1725849	0.1725849
1	0.2061554	0.2061554	0.2061554	0.2061554	0.2061554
2	0.6340318	0.6340318	0.6340318	0.6340318	0.6340318
3	0.7892214	0.7892214	0.7892214	0.7892214	0.7892214
4	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
5	1.0657513	1.0657513	1.0657513	1.0657513	1.0657513
6	0.8800520	0.8800520	0.8800520	0.8800520	0.8800520
7	0.8647675	0.8647675	0.8647675	0.8647675	0.8647675
8	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
9	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000

Table 2.6.3.17 NORTH SEA HERRING. PREDICTED CATCH IN NUMBERS

Units : NA

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

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

Table 2.6.3.17 cont. NORTH SEA HERRING. PREDICTED CATCH IN NUMBERS

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

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

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

age \ year	2006	2007	2008	2009	2010
0	758590.04	990843.2	623336.00	467438.49	564338.36
1	224863.12	298945.3	301342.33	134419.19	239257.93
2	475471.18	290530.4	303369.05	222256.89	234754.32
3	318573.24	349936.0	169596.20	132216.73	234523.15
4	470525.91	249280.7	219316.24	80813.06	153492.91
5	1003472.58	312137.2	133006.59	90080.90	81759.37
6	214463.63	523676.7	130184.68	42429.60	71191.75
7	195536.02	137806.6	268332.91	50548.27	40377.79
8	57307.35	145404.6	82123.05	121928.55	56166.38
9	43377.00	23362.0	42919.00	32737.00	54533.00

Table2.6.3.18 NORTH SEA HERRING. CATCH RESIDUALS

Units : thousands NA

age	2006	2007	2008	2009	2010
0	0.146910345	-0.467217156	0.24737872	0.32977075	0.018533409733205403968
1	-0.012314611	-0.238324577	-0.24856780	0.26908323	0.159844073667030683 8718
2	-0.170127902	-0.282111348	0.08949795	0.15466847	0.224655820787712540 1541
3	-0.025340058	0.176419319	0.08569691	-0.21406521	0.009678471748201600 6246
4	-0.012631169	0.136523875	-0.09686319	0.14390664	-0.195461620685074527 4703
5	-0.005687031	-0.008633398	0.03343610	-0.04476915	0.025761737468371449 0946
6	0.161883959	0.183553981	-0.09531618	-0.11155029	-0.145657138040751199 5259
7	0.233813761	0.070211627	-0.21907264	0.04981297	-0.192572446389135010 2251
8	0.095261215	-0.086257956	-0.09958299	-0.09937946	0.051622937377908108 2696
9	0.000000000	0.000000000	0.00000000	0.00000000	-0.000000000000000001 110223

Table 2.6.3.19 NORTH SEA HERRING. PREDICTED INDEX VALUES

MLAI

Units : NA NA

age	1973	1974	1975	1976	1977	1978	1979	1980
all	16.44596	10.65108	4.710014	4.456631	2.478575	3.582355	6.508117	8.269039

age	1981	1982	1983	1984	1985	1986	1987	1988
all	13.32637	20.29727	34.28685	58.64577	60.74928	58.69868	82.12345	114.9669

age	1989	1990	1991	1992	1993	1994	1995	1996
all	121.3948	114.0068	91.03707	61.33465	38.29595	41.90785	37.19996	37.25391

age	1997	1998	1999	2000	2001	2002	2003	2004
all	46.92828	64.89866	78.71086	80.5044	132.276	169.7471	189.9640	203.7769

age	2005	2006	2007	2008	2009	2010
all	196.0510	153.7920	119.4584	116.2013	143.7991	127.1856

Table 2.6.3.19 cont NORTH SEA HERRING. PREDICTED INDEX VALUES

```
IBTS0

Units  :  NA NA
   year
age     1992     1993     1994     1995     1996     1997    1998     1999
  0 161.0473 128.9743 90.34665 107.8221 133.2378 78.12021 75.4315 185.9111
   year
age     2000     2001    2002     2003     2004     2005     2006     2007
  0 113.3916 261.1646 93.0953 53.74515 69.78533 44.01727 59.05463 81.04934
   year
age     2008     2009     2010 2011
  0 69.79248 102.7134 104.1655   77

IBTS-Q1: 1-5+ wr

Units  :  NA NA
   year
age       1984       1985       1986       1987       1988       1989
  1 2167.01502 2179.04958 3831.04476 4698.09883 3659.76219 1897.04524
  2  584.38145  541.68889  463.02092  869.07176 1020.90930  659.60950
  3  121.75949  225.26088  196.70412  160.51764  319.84986  392.37353
  4   28.82074   40.89558   62.44795   62.10492   51.45779  112.78168
  5   11.87480   14.11989   16.61281   25.18031   29.22698   27.64566
   year
age       1990       1991       1992       1993       1994       1995
  1 1742.96374 1744.65712 1527.34604 2349.85431 1794.83323 1425.37744
  2  390.61330  343.52083  390.17168  314.99014  469.21925  422.50517
  3  245.46229  146.53059  107.87531  120.44506   88.59868  127.86941
  4  138.81720   90.08171   49.20333   34.19062   32.91483   22.80703
  5   45.51605   67.90549   65.19839   44.80152   27.82122   19.09054
   year
age       1996       1997       1998       1999       2000       2001
  1 1572.77699 2473.04677 1496.05601 1475.99152 3556.72608 2161.38130
  2  334.10894  382.65034  723.32576  397.77834  432.94584 1029.49207
  3  129.88103  134.23417  156.42023  300.28157  170.85313  189.47903
  4   30.54449   42.62321   48.59316   56.16510  105.70237   67.44985
  5   12.03443   17.21846   21.53009   26.36625   34.97722   54.48875
   year
age       2002       2003      2004      2005     2006       2007       2008
  1 5047.73991 1784.08680 1038.3516 1317.1662 796.7954 1112.89147 1534.32198
  2  630.32051 1512.08628  514.0791  306.7662 360.5231  230.88205  325.53844
  3  496.71547  300.76460  731.5379  246.1658 140.4550  161.55805  105.23500
  4   76.26257  213.21100  131.4413  316.0568 104.8602   58.10592   68.27647
  5   60.06887   67.31625  124.8401  123.5137 187.0871  156.35563  121.67486
   year
age       2009       2010      2011
  1 1341.75356 2006.55423 2028.2851
  2  459.59729  409.25288  609.6423
  3  157.09625  235.21858  206.9538
  4   47.76059   76.70687  113.1493
  5  113.35688   87.23957  103.3154
```

Table 2.6.3.19 cont NORTH SEA HERRING. PREDICTED INDEX VALUES

Acoustic survey (HERAS): 1-9+ wr

Units : NA NA

age \ year	1989	1990	1991	1992	1993	1994	1995
1	NA	NA	NA	NA	NA	NA	NA
2	5784708.55	3456827.49	2795896.55	3176850.47	2462572.5	3645358.9	3401642.6
3	5496791.30	3498375.93	2014192.01	1455832.24	1529275.8	1089674.5	1475758.2
4	2370071.25	3029799.00	1974196.51	1026882.92	666868.4	594391.0	420022.3
5	525786.76	1286527.18	1728887.70	1092890.53	493073.3	324664.7	229701.6
6	279093.63	261784.63	693781.03	823620.25	512076.3	218104.6	165607.3
7	123071.70	116512.26	137752.56	316551.12	306938.6	239578.6	94355.6
8	33296.49	54038.41	54646.20	65891.21	123927.8	122164.5	109268.5
9	35564.72	53455.62	66435.43	93763.48	141718.6	194701.5	110947.4

age \ year	1996	1997	1998	1999	2000	2001
1	NA	10732649.54	6189965.79	6398059.75	15224761.09	9294681.12
2	3045030.69	3520029.42	6708809.26	3726523.64	4088461.82	10147468.60
3	1758922.35	1896373.97	2195954.26	4194509.66	2498002.16	2792423.76
4	680875.49	913250.71	1081132.53	1270145.27	2314285.20	1584595.95
5	200761.78	404279.24	477795.14	682701.41	758017.42	1396481.75
6	116960.44	110485.34	195558.73	249730.67	434711.47	449423.47
7	100045.77	73729.36	60670.21	91649.57	136649.56	280046.01
8	49473.78	70030.90	45450.67	38278.64	56046.36	90618.22
9	27194.83	50887.14	24558.30	18501.27	22598.62	32608.54

age \ year	2002	2003	2004	2005	2006	2007	2008
1	21968213.8	7624021.6	4504002.3	5514142.3	3427221.7	4793455.1	6657098.3
2	6170924.7	14914585.2	5049272.5	2954548.2	3433638.1	2208301.6	3184401.9
3	7555855.3	4619957.1	11176618.2	3740927.7	2102346.6	2431053.7	1628440.1
4	1809799.9	5045146.4	3088016.2	7415759.4	2434222.0	1357947.4	1653190.9
5	1134722.3	1221797.4	3314584.2	1988174.6	4932875.4	1615877.3	953324.0
6	858430.8	802499.6	753637.3	1864637.9	1246218.8	3203564.4	1100919.4
7	277798.0	501103.0	508425.4	424657.6	1062121.2	788017.9	2120859.7
8	206906.2	195701.0	336619.7	329788.3	277761.9	742092.8	579966.6
9	124509.3	112482.0	392221.1	522986.4	503336.3	285447.6	725644.5

age \ year	2009	2010
1	5877865.6	8773534.8
2	4630776.8	4099551.9
3	2522165.8	3749108.5
4	1211685.8	1928241.9
5	1285078.2	977124.5
6	712914.1	1002421.2
7	793700.6	531320.0
8	1712772.3	661051.6
9	1100954.7	1536578.1

Table 2.6.3.20 NORTH SEA HERRING. INDEX RESIDUALS

MLAI

Units : NA

age \ year	1973	1974	1975	1976	1977	1978	1979
all	-0.2434732	-0.327563	-0.5283196	-0.5950451	0.8974853	0.708561	0.749079

age \ year	1980	1981	1982	1983	1984	1985
all	0.1122133	0.01449943	-0.02182911	-0.2978105	-0.2464675	0.1436525

age \ year	1986	1987	1988	1989	1990	1991
all	-0.4744477	-0.2373193	0.1114636	0.04403633	0.3695781	-0.03474850

age \ year	1992	1993	1994	1995	1996	1997
all	-0.4144505	-0.2904352	-0.7406412	-0.5971519	0.08714354	0.1231233

age \ year	1998	1999	2000	2001	2002	2003
all	0.02581755	-0.3452446	-0.7668551	-0.06947565	-0.4852659	0.2771989

age \ year	2004	2005	2006	2007	2008	2009	2010
all	0.4159207	-0.06462474	-0.3098874	0.2983869	0.4401628	1.177166	1.095539

IBTS0

Units : NA

age \ year	1992	1993	1994	1995	1996	1997	1998
0	0.220113	0.3879369	0.1183734	0.1637048	-0.2239905	0.639639	-0.351048

age \ year	1999	2000	2001	2002	2003	2004	2005
0	0.2718999	0.1898632	-0.1954437	0.5527373	0.01211072	-0.3889136	0.3311977

age \ year	2006	2007	2008	2009	2010
0	0.3415818	-0.7787494	-0.9204902	-0.06967983	-0.3008779

age \ year	2011
0	-0.000000000005385914

IBTS-Q1: 1-5+ wr

Units : NA

age \ year	1984	1985	1986	1987	1988	1989
1	-0.35752144	-0.03824754	-0.3637548	-0.24072826	0.1828800	0.2062426
2	-1.28617265	0.28684287	0.5242385	0.05428137	1.4056345	0.2829598
3	-0.68418194	0.22461241	0.3388125	-0.32210183	0.9061136	-0.1476488
4	-0.06941527	0.02874061	0.2352030	-0.04535627	0.1189394	-0.2325458
5	-0.14831223	0.68251043	0.5247408	0.66090930	-0.1540589	-1.1771699

age \ year	1990	1991	1992	1993	1994	1995
1	-0.4958361	-0.3044407	-0.1859764	0.1731234	-0.02412386	-0.0574822
2	0.1680568	0.7018111	0.1123458	0.9162217	0.91131085	1.1929106
3	0.1308603	0.5680637	0.5821545	0.6141153	0.87745213	0.7785665
4	0.6619549	0.8998092	0.1079113	0.2756440	0.74024104	0.4748902
5	0.4488733	0.7661471	0.3472626	0.3803270	0.42377561	-1.0695751

age \ year	1996	1997	1998	1999	2000	2001
1	0.1841953	0.5772092	0.41951910	-0.6732033	0.04626154	0.14529959
2	-0.5256172	0.2804738	0.09018768	0.1247362	-0.77543018	0.09253951
3	-1.3739063	0.1920763	-0.49174590	0.5125340	-0.09937471	0.51484104
4	-1.0974832	-0.3336235	-0.84804906	0.5584968	-0.58583940	0.33069691
5	-0.3985033	0.1464950	-0.18795253	0.2993053	-1.36281994	0.22568119

Table 2.6.3.20 cont NORTH SEA HERRING. INDEX RESIDUALS

age	2002	2003	2004	2005	2006	2007
1	-0.21656893	0.43815529	-0.05882135	-0.27389889	0.1472122	0.1714313
2	0.04321051	0.02868078	-0.13087653	-0.35921770	1.4195905	-1.5292242
3	-0.38451892	0.71022464	0.06070825	0.36894496	0.8573036	-2.1806995
4	-1.11338831	0.52379120	-0.15672757	0.20745682	0.8755666	-1.9907322
5	-1.10296461	-0.23598257	0.31597947	0.06251039	0.5938683	-1.3316581

age	2008	2009	2010	2011
1	0.1684706	0.5579476	-0.49679788	0.3694269
2	-0.3348456	-1.2157198	-2.11125008	-0.3677012
3	0.3287249	-1.9907145	-1.90937598	1.0181404
4	1.0851975	-1.4482356	-0.51256800	1.3094062
5	0.6468279	-0.8926599	0.03059597	1.5058280

Acoustic survey (HERAS): 1-9+ wr

Units : NA

age	1989	1990	1991	1992	1993	1994
1	NA	NA	NA	NA	NA	NA
2	-0.34667301	-0.044612258	-0.059649220	0.16158976	0.19205813	-0.1350025
3	-0.34241903	0.006446201	-0.169589876	-0.05494455	0.06807101	-0.2614236
4	-0.37250120	0.119388343	-0.007727344	0.11062192	0.30202177	-0.3985760
5	-0.06641702	0.059940279	0.067166701	0.03692516	0.40734286	0.1600063
6	0.01389958	0.403739691	-0.074457664	0.41398414	0.41696671	0.3864665
7	-0.02527540	0.589111011	0.503886608	0.22140101	0.58508708	0.3080159
8	0.27873766	0.900654089	0.542415028	0.54819332	0.37325778	0.5837030
9	-0.48031181	-0.217651673	-0.264404863	0.10361543	-0.20025328	-0.3962704

age	1995	1996	1997	1998	1999	2000
1	NA	NA	-0.1367383	-0.330250208	-0.2293065	0.4853366
2	0.1235550	0.3898995	0.5266011	-0.154743498	-0.1911958	-0.3355583
3	0.3242680	0.4734530	0.4367638	0.137642207	0.1190911	-0.1472366
4	0.4699506	0.4677974	0.4560822	0.407498682	-0.1293804	0.3051219
5	0.2636625	0.4376739	0.3964891	0.720409253	-0.2995209	0.2840245
6	0.2035864	-0.1667159	0.6657552	0.822213522	0.2290100	0.1053341
7	0.3801831	-0.1867872	-0.4717597	1.030345624	0.4165017	0.6660766
8	0.0853156	0.9889064	0.1077722	-0.009964967	0.3440919	0.7613126
9	-0.1764566	2.0248492	1.1392940	1.594740728	1.5480686	1.4568220

age	2001	2002	2003	2004	2005	2006
1	-0.307093275	0.04828609	0.2540739	0.14055268	-0.5713759	0.68852002
2	0.191561648	-0.23572860	0.2394327	-0.39080317	-0.3630213	0.09406452
3	0.098993199	0.08424741	-0.4051312	-0.19551215	-0.0250175	-0.05130795
4	-0.080524091	-0.26391256	-0.1859885	-0.35404671	-0.2475442	-0.14888103
5	0.182453964	-0.35630434	-0.5932175	-0.24640409	-0.4942027	-0.16678376
6	0.001282004	0.18317844	-0.4835778	-0.86569402	-0.4618839	-0.70105723
7	-0.499155464	-0.12808800	0.1258377	-0.43952512	-1.1103554	-0.63634355
8	0.078312145	-0.53647520	-0.2964121	0.01600298	-0.9582086	-1.19238244
9	0.592963178	0.18291558	0.4573038	-0.74823188	-1.5895342	-1.96706521

age	2007	2008	2009	2010
1	0.2670884	-0.58357423	-0.23325180	0.50770516
2	0.2193772	-0.10989341	0.19573998	0.03297780
3	-0.2742208	0.04828582	0.01215117	0.11736873
4	-0.4135595	-0.10729252	-0.16927311	0.24070312
5	-0.6955496	-0.16415593	-0.17664016	0.24307964
6	-0.8843622	-0.43582303	-0.05613085	0.28426332
7	-1.1764593	-0.19277732	-0.21836807	0.25842434
8	-1.5855937	-1.14261472	-0.40533217	0.51828342
9	-1.4796713	-0.98863824	-0.64435911	0.05225072

Table 2.6.3.21 NORTH SEA HERRING. FIT PARAMETERS

	Value	Std.dev
F, 2006	0.321783771248	0.10621648
F, 2007	0.306002344957	0.10984911
F, 2008	0.222624907605	0.11388838
F, 2009	0.112813936102	0.11231985
F, 2010	0.134447878471	0.11227312
Selectivity at age 0	0.172583853423	0.33781927
Selectivity at age 1	0.206154423949	0.33250623
Selectivity at age 2	0.634030822199	0.09889506
Selectivity at age 3	0.789220427946	0.09620104
Selectivity at age 5	1.065750283035	0.09992415
Selectivity at age 6	0.880050988150	0.10888468
Selectivity at age 7	0.864766496809	0.12613221
Terminal year pop, age 0	38849288.015846230090	0.20980053
Terminal year pop, age 1	13814436.345066158101	0.15885983
Terminal year pop, age 2	3318316.158483601641	0.11378055
Terminal year pop, age 3	2565701.560659476556	0.10109600
Terminal year pop, age 4	1280697.438186891144	0.09611026
Terminal year pop, age 5	642810.299886112334	0.09977344
Terminal year pop, age 6	669744.848127788049	0.10695260
Terminal year pop, age 7	386189.695735376386	0.12808564
Terminal year pop, age 8	468634.302008281287	0.14323581
Last true age pop, 2006	218281.921514861489	0.24572909
Last true age pop, 2007	578142.541303446516	0.19363952
Last true age pop, 2008	431582.451503771241	0.17292266
Last true age pop, 2009	1199862.251218227204	0.15156559
Recruitment prediction	28717709.651650473475	0.30049390
Index 1, biomass, K	1.190555651626	0.04812270
Index 1, biomass, Q	0.000006683656	0.63527424
Index 2, age 0 numbers, Q	0.000003047105	0.06966101
Index 3, age 1 numbers, Q	0.000165161644	0.06548276
Index 3, age 2 numbers, Q	0.000129415878	0.08380718
Index 3, age 3 numbers, Q	0.000095253961	0.43866194
Index 3, age 4 numbers, Q	0.000061675810	0.43867891
Index 3, age 5 numbers, Q	0.000034236709	0.43885448
Index 4, age 1 numbers, Q	1.117696757700	0.08128725
Index 4, age 2 numbers, Q	1.526999311514	0.06434582
Index 4, age 3 numbers, Q	1.729178088859	0.12080690
Index 4, age 4 numbers, Q	1.712835086363	0.15718569
Index 4, age 5 numbers, Q	1.737716394273	0.16585082
Index 4, age 6 numbers, Q	1.687675815852	0.17617841
Index 4, age 7 numbers, Q	1.549574042200	0.18868608
Index 4, age 8 numbers, Q	1.604727401442	0.18925971
Index 4, age 9 numbers, Q	3.841825462449	0.22226248
SRR, a	56423798.104192271829	0.22092487
SRR, b	377572.737495324051	0.49214922

	Lower.95.pct.CL	Upper.95.pct.CL
F, 2006	0.261306881610	0.396257438000
F, 2007	0.246728489977	0.379516103423
F, 2008	0.178086094012	0.278302748797
F, 2009	0.090522004344	0.140595474782
F, 2010	0.107890980963	0.167541641240
Selectivity at age 0	0.089010777041	0.334624496634
Selectivity at age 1	0.107437931600	0.395573945635
Selectivity at age 2	0.522311033618	0.769646929940
Selectivity at age 3	0.653597439176	0.952985502318
Selectivity at age 5	0.876190021410	1.296321160975
Selectivity at age 6	0.710924239898	1.089412483466
Selectivity at age 7	0.675356294950	1.107298620885

Table 2.6.3.21 cont NORTH SEA HERRING. FIT PARAMETERS

Terminal year pop, age 0	25751186.838553905487	58609616.279065795243
Terminal year pop, age 1	10118332.687694909051	18860681.638188004494
Terminal year pop, age 2	2655007.782804796007	4147340.809683398809
Terminal year pop, age 3	2104512.377105755731	3127957.131534453481
Terminal year pop, age 4	1060805.668419120368	1546170.026243142551
Terminal year pop, age 5	528632.620790908346	781648.852886643726
Terminal year pop, age 6	543087.105154890451	825941.469307733700
Terminal year pop, age 7	300449.844029535132	496397.265819586872
Terminal year pop, age 8	353923.408360044006	620524.395479863044
Last true age pop, 2006	134849.377466234146	353334.944183563697
Last true age pop, 2007	395553.870287597878	845014.606535850558
Last true age pop, 2008	307516.934856151755	605701.317012457061
Last true age pop, 2009	891489.341653427691	1614903.683793174103
Recruitment prediction	15935446.289094524458	51752980.912802517414
Index 1, biomass, K	1.096235158597	1.284876144654
Index 1, biomass, Q	0.000001924233	0.000023215094
Index 2, age 0 numbers, Q	0.000002658219	0.000003492883
Index 3, age 1 numbers, Q	0.000145267730	0.000187779962
Index 3, age 2 numbers, Q	0.000109811913	0.000152519605
Index 3, age 3 numbers, Q	0.000040316838	0.000225050314
Index 3, age 4 numbers, Q	0.000026103806	0.000145722255
Index 3, age 5 numbers, Q	0.000014485435	0.000080919369
Index 4, age 1 numbers, Q	0.953083354163	1.310741643652
Index 4, age 2 numbers, Q	1.346066674652	1.732252154574
Index 4, age 3 numbers, Q	1.364604557836	2.191152627930
Index 4, age 4 numbers, Q	1.258683066564	2.330852071510
Index 4, age 5 numbers, Q	1.255462751589	2.405215338411
Index 4, age 6 numbers, Q	1.194876278813	2.383719310456
Index 4, age 7 numbers, Q	1.070531616862	2.242978791509
Index 4, age 8 numbers, Q	1.107388866116	2.325425251900
Index 4, age 9 numbers, Q	2.485100702543	5.939245387045
SRR, a	36593780.104510642588	86999620.793759629130
SRR, b	143904.626857731637	990664.269889341784

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

Units : kg

, , unit = A

age \ year	2008	2009	2010	2011	2012	2013
0	0.0079	0.0094	0.0075	0.009004851	0.009004851	0.009004851
1	0.0535	0.0514	0.0571	0.074442920	0.074442920	0.074442920
2	0.1288	0.1440	0.1292	0.142474175	0.142474175	0.142474175
3	0.1796	0.1811	0.1669	0.176076687	0.176076687	0.176076687
4	0.1812	0.2158	0.1912	0.196317864	0.196317864	0.196317864
5	0.1832	0.2162	0.2203	0.207298469	0.207298469	0.207298469
6	0.2157	0.2390	0.2193	0.225531814	0.225531814	0.225531814
7	0.2161	0.2428	0.2160	0.225433333	0.225433333	0.225433333
8	0.2560	0.2476	0.2334	0.246133333	0.246133333	0.246133333
9	0.2726	0.2724	0.2438	0.263666667	0.263666667	0.263666667

, , unit = B

age \ year	2008	2009	2010	2011	2012	2013
0	0.0079	0.0094	0.0075	0.007474209	0.007474209	0.007474209
1	0.0535	0.0514	0.0571	0.042583928	0.042583928	0.042583928
2	0.1288	0.1440	0.1292	0.057150241	0.057150241	0.057150241
3	0.1796	0.1811	0.1669	0.111133333	0.111133333	0.111133333
4	0.1812	0.2158	0.1912	0.047500000	0.047500000	0.047500000
5	0.1832	0.2162	0.2203	0.068466667	0.068466667	0.068466667
6	0.2157	0.2390	0.2193	0.167666667	0.167666667	0.167666667
7	0.2161	0.2428	0.2160	0.000000000	0.000000000	0.000000000
8	0.2560	0.2476	0.2334	0.000000000	0.000000000	0.000000000
9	0.2726	0.2724	0.2438	0.000000000	0.000000000	0.000000000

, , unit = C

age \ year	2008	2009	2010	2011	2012	2013
0	0.0079	0.0094	0.0075	0.02728388	0.02728388	0.02728388
1	0.0535	0.0514	0.0571	0.07641517	0.07641517	0.07641517
2	0.1288	0.1440	0.1292	0.08989030	0.08989030	0.08989030
3	0.1796	0.1811	0.1669	0.10408668	0.10408668	0.10408668
4	0.1812	0.2158	0.1912	0.16505935	0.16505935	0.16505935
5	0.1832	0.2162	0.2203	0.11960520	0.11960520	0.11960520
6	0.2157	0.2390	0.2193	0.13232516	0.13232516	0.13232516
7	0.2161	0.2428	0.2160	0.13980448	0.13980448	0.13980448
8	0.2560	0.2476	0.2334	0.22388107	0.22388107	0.22388107
9	0.2726	0.2724	0.2438	0.00000000	0.00000000	0.00000000

, , unit = D

age \ year	2008	2009	2010	2011	2012	2013
0	0.0079	0.0094	0.0075	0.01062934	0.01062934	0.01062934
1	0.0535	0.0514	0.0571	0.01951393	0.01951393	0.01951393
2	0.1288	0.1440	0.1292	0.07112595	0.07112595	0.07112595
3	0.1796	0.1811	0.1669	0.10785506	0.10785506	0.10785506
4	0.1812	0.2158	0.1912	0.10660133	0.10660133	0.10660133
5	0.1832	0.2162	0.2203	0.06222495	0.06222495	0.06222495
6	0.2157	0.2390	0.2193	0.05371477	0.05371477	0.05371477
7	0.2161	0.2428	0.2160	0.06133062	0.06133062	0.06133062
8	0.2560	0.2476	0.2334	0.14054798	0.14054798	0.14054798
9	0.2726	0.2724	0.2438	0.00000000	0.00000000	0.00000000

Table2.7.2 NORTH SEA HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

, , unit = A

age \ year	2008	2009	2010	2011	2012	2013
0	0.008	0.007	0.007	0.007	0.007	0.007
1	0.058	0.061	0.052	0.052	0.052	0.052
2	0.130	0.137	0.142	0.142	0.142	0.142
3	0.164	0.181	0.190	0.190	0.190	0.190
4	0.181	0.197	0.216	0.216	0.216	0.216
5	0.195	0.210	0.224	0.224	0.224	0.224
6	0.218	0.223	0.234	0.234	0.234	0.234
7	0.226	0.234	0.240	0.240	0.240	0.240
8	0.253	0.255	0.256	0.256	0.256	0.256
9	0.260	0.259	0.265	0.265	0.265	0.265

, , unit = B

age \ year	2008	2009	2010	2011	2012	2013
0	0.008	0.007	0.007	0.007	0.007	0.007
1	0.058	0.061	0.052	0.052	0.052	0.052
2	0.130	0.137	0.142	0.142	0.142	0.142
3	0.164	0.181	0.190	0.190	0.190	0.190
4	0.181	0.197	0.216	0.216	0.216	0.216
5	0.195	0.210	0.224	0.224	0.224	0.224
6	0.218	0.223	0.234	0.234	0.234	0.234
7	0.226	0.234	0.240	0.240	0.240	0.240
8	0.253	0.255	0.256	0.256	0.256	0.256
9	0.260	0.259	0.265	0.265	0.265	0.265

, , unit = C

age \ year	2008	2009	2010	2011	2012	2013
0	0.008	0.007	0.007	0.007	0.007	0.007
1	0.058	0.061	0.052	0.052	0.052	0.052
2	0.130	0.137	0.142	0.142	0.142	0.142
3	0.164	0.181	0.190	0.190	0.190	0.190
4	0.181	0.197	0.216	0.216	0.216	0.216
5	0.195	0.210	0.224	0.224	0.224	0.224
6	0.218	0.223	0.234	0.234	0.234	0.234
7	0.226	0.234	0.240	0.240	0.240	0.240
8	0.253	0.255	0.256	0.256	0.256	0.256
9	0.260	0.259	0.265	0.265	0.265	0.265

, , unit = D

age \ year	2008	2009	2010	2011	2012	2013
0	0.008	0.007	0.007	0.007	0.007	0.007
1	0.058	0.061	0.052	0.052	0.052	0.052
2	0.130	0.137	0.142	0.142	0.142	0.142
3	0.164	0.181	0.190	0.190	0.190	0.190
4	0.181	0.197	0.216	0.216	0.216	0.216
5	0.195	0.210	0.224	0.224	0.224	0.224
6	0.218	0.223	0.234	0.234	0.234	0.234
7	0.226	0.234	0.240	0.240	0.240	0.240
8	0.253	0.255	0.256	0.256	0.256	0.256
9	0.260	0.259	0.265	0.265	0.265	0.265

Table 2.7.3 NORTH SEA HERRING. STOCK IN NUMBER

Units : NA

, , unit = A

age \ year	2008	2009	2010	2011	2012
0	26079173.5	38289832.0	38849289.0	28717709.7	27088123.3
1	10587310.3	9232364.4	13814437.3	13964046.7	10154675.8
2	2658051.8	3720137.4	3318317.2	4943120.8	5027967.3
3	1157904.6	1709911.4	2565702.6	2257398.2	3373508.6
4	1152578.5	795257.6	1280698.4	1889141.3	1651594.4
5	660421.4	834748.9	642811.3	1013041.0	1483326.8
6	767628.5	471356.3	669745.8	503992.9	785275.0
7	1607575.7	570996.8	386190.7	538386.3	399741.4
8	431583.5	1199863.3	468635.3	311084.4	431319.2
9	225553.4	322155.2	455006.9	730607.1	818561.8

, , unit = B

age \ year	2008	2009	2010	2011	2012
0	26079173.5	38289832.0	38849289.0	28717709.7	27088123.3
1	10587310.3	9232364.4	13814437.3	13964046.7	10154675.8
2	2658051.8	3720137.4	3318317.2	4943120.8	5027967.3
3	1157904.6	1709911.4	2565702.6	2257398.2	3373508.6
4	1152578.5	795257.6	1280698.4	1889141.3	1651594.4
5	660421.4	834748.9	642811.3	1013041.0	1483326.8
6	767628.5	471356.3	669745.8	503992.9	785275.0
7	1607575.7	570996.8	386190.7	538386.3	399741.4
8	431583.5	1199863.3	468635.3	311084.4	431319.2
9	225553.4	322155.2	455006.9	730607.1	818561.8

, , unit = C

age \ year	2008	2009	2010	2011	2012
0	26079173.5	38289832.0	38849289.0	28717709.7	27088123.3
1	10587310.3	9232364.4	13814437.3	13964046.7	10154675.8
2	2658051.8	3720137.4	3318317.2	4943120.8	5027967.3
3	1157904.6	1709911.4	2565702.6	2257398.2	3373508.6
4	1152578.5	795257.6	1280698.4	1889141.3	1651594.4
5	660421.4	834748.9	642811.3	1013041.0	1483326.8
6	767628.5	471356.3	669745.8	503992.9	785275.0
7	1607575.7	570996.8	386190.7	538386.3	399741.4
8	431583.5	1199863.3	468635.3	311084.4	431319.2
9	225553.4	322155.2	455006.9	730607.1	818561.8

, , unit = D

age \ year	2008	2009	2010	2011	2012
0	26079173.5	38289832.0	38849289.0	28717709.7	27088123.3
1	10587310.3	9232364.4	13814437.3	13964046.7	10154675.8
2	2658051.8	3720137.4	3318317.2	4943120.8	5027967.3
3	1157904.6	1709911.4	2565702.6	2257398.2	3373508.6
4	1152578.5	795257.6	1280698.4	1889141.3	1651594.4
5	660421.4	834748.9	642811.3	1013041.0	1483326.8
6	767628.5	471356.3	669745.8	503992.9	785275.0
7	1607575.7	570996.8	386190.7	538386.3	399741.4
8	431583.5	1199863.3	468635.3	311084.4	431319.2
9	225553.4	322155.2	455006.9	730607.1	818561.8

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

Units : f

, , unit = A

age \ year	2008	2009	2010	2011	2012	2013
0	0.03842186	0.01947015	0.02320384	0.000000000	0.000000000	0.000000000
1	0.04589554	0.02325741	0.02771737	0.005086439	0.004036824	0.004848317
2	0.14115191	0.07152826	0.08524487	0.073872876	0.058628795	0.070414515
3	0.17570114	0.08903596	0.10610994	0.109368446	0.086799655	0.104248358
4	0.22262591	0.11281494	0.13444888	0.139690518	0.110864597	0.133150901
5	0.23726385	0.12023266	0.14328906	0.143665432	0.114019265	0.136939729
6	0.19592237	0.09928301	0.11832200	0.113116723	0.089774454	0.107821159
7	0.19251965	0.09755869	0.11626702	0.121621777	0.096524443	0.115928049
8	0.22262591	0.11281494	0.13444888	0.141052245	0.111945324	0.134448878
9	0.22262591	0.11281494	0.13444888	0.141052245	0.111945324	0.134448878

, , unit = B

age \ year	2008	2009	2010	2011	2012	2013
0	0.03842186	0.01947015	0.02320384	0.038046087	0.058793661	0.021447503
1	0.04589554	0.02325741	0.02771737	0.006043129	0.009338613	0.003406659
2	0.14115191	0.07152826	0.08524487	0.003472631	0.005366352	0.001957607
3	0.17570114	0.08903596	0.10610994	0.003060654	0.004729712	0.001725365
4	0.22262591	0.11281494	0.13444888	0.002110629	0.003261614	0.001189813
5	0.23726385	0.12023266	0.14328906	0.010958783	0.016934908	0.006177732
6	0.19592237	0.09928301	0.11832200	0.018627623	0.028785776	0.010500843
7	0.19251965	0.09755869	0.11626702	0.000000000	0.000000000	0.000000000
8	0.22262591	0.11281494	0.13444888	0.000000000	0.000000000	0.000000000
9	0.22262591	0.11281494	0.13444888	0.000000000	0.000000000	0.000000000

, , unit = C

age \ year	2008	2009	2010	2011	2012
0	0.03842186	0.01947015	0.02320384	0.000001129696	0.000002387894
1	0.04589554	0.02325741	0.02771737	0.003727171177	0.007878304057
2	0.14115191	0.07152826	0.08524487	0.003660668928	0.007737734999
3	0.17570114	0.08903596	0.10610994	0.000042667908	0.000090189244
4	0.22262591	0.11281494	0.13444888	0.000033881982	0.000071618003
5	0.23726385	0.12023266	0.14328906	0.000053753819	0.000113622078
6	0.19592237	0.09928301	0.11832200	0.000000000000	0.000000000000
7	0.19251965	0.09755869	0.11626702	0.000106180600	0.000224439130
8	0.22262591	0.11281494	0.13444888	0.000000000000	0.000000000000
9	0.22262591	0.11281494	0.13444888	0.000000000000	0.000000000000

age \ year	2013
0	0.000003606441
1	0.011898619692
2	0.011686317940
3	0.000136213011
4	0.000108164826
5	0.000171603670
6	0.000000000000
7	0.000338970904
8	0.000000000000
9	0.000000000000

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

, , unit = D

age \ year	2008	2009	2010	2011	2012	2013
0	0.03842186	0.01947015	0.02320384	0.001532507	0.002122135	0.001752730
1	0.04589554	0.02325741	0.02771737	0.006613413	0.009157906	0.007563770
2	0.14115191	0.07152826	0.08524487	0.001037358	0.001436479	0.001186428
3	0.17570114	0.08903596	0.10610994	0.000000000	0.000000000	0.000000000
4	0.22262591	0.11281494	0.13444888	0.000000000	0.000000000	0.000000000
5	0.23726385	0.12023266	0.14328906	0.000000000	0.000000000	0.000000000
6	0.19592237	0.09928301	0.11832200	0.000000000	0.000000000	0.000000000
7	0.19251965	0.09755869	0.11626702	0.000000000	0.000000000	0.000000000
8	0.22262591	0.11281494	0.13444888	0.000000000	0.000000000	0.000000000
9	0.22262591	0.11281494	0.13444888	0.000000000	0.000000000	0.000000000

Table 2.7.5 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA

, , unit = A

age \ year	2008	2009	2010	2011	2012	2013
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
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1

, , unit = B

age \ year	2008	2009	2010	2011	2012	2013
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
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1

, , unit = C

age \ year	2008	2009	2010	2011	2012	2013
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
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1

, , unit = D

age \ year	2008	2009	2010	2011	2012	2013
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
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1

Table 2.7.6 NORTH SEA HERRING. PROPORTION MATURE

Units : NA

, , unit = A

age	2008	2009	2010	2011	2012	2013
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.86	0.89	0.45	0.7333333	0.7333333	0.7333333
3	0.98	1.00	0.90	0.9600000	0.9600000	0.9600000
4	0.99	1.00	1.00	0.9966667	0.9966667	0.9966667
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
9	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = B

age	2008	2009	2010	2011	2012	2013
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.86	0.89	0.45	0.7333333	0.7333333	0.7333333
3	0.98	1.00	0.90	0.9600000	0.9600000	0.9600000
4	0.99	1.00	1.00	0.9966667	0.9966667	0.9966667
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
9	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = C

age	2008	2009	2010	2011	2012	2013
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.86	0.89	0.45	0.7333333	0.7333333	0.7333333
3	0.98	1.00	0.90	0.9600000	0.9600000	0.9600000
4	0.99	1.00	1.00	0.9966667	0.9966667	0.9966667
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
9	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

, , unit = D

age	2008	2009	2010	2011	2012	2013
0	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
1	0.00	0.00	0.00	0.0000000	0.0000000	0.0000000
2	0.86	0.89	0.45	0.7333333	0.7333333	0.7333333
3	0.98	1.00	0.90	0.9600000	0.9600000	0.9600000
4	0.99	1.00	1.00	0.9966667	0.9966667	0.9966667
5	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
6	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
7	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
8	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000
9	1.00	1.00	1.00	1.0000000	1.0000000	1.0000000

Table 2.7.7 NORTH SEA HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

, , unit = A

	year					
age	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

	year					
age	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

	year					
age	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

	year					
age	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

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

Units : NA

, , unit = A

age \ year	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

age \ year	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

age \ year	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

age \ year	2008	2009	2010	2011	2012	2013
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

Table 2.7.9 NORTH SEA HERRING. Recruitment in 2012

```
27088123
```

Table 2.7.10 NORTH SEA HERRING. Recruitment in 2013

```
27088123
```

Table 2.7.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

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

Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

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

Outlook assuming a TAC constraint for fleet A in 2011, proportion of 2010 by-catch ceiling taken applied to 2011 for fleet B

Basis: Intermediate year (2011) with catch constraint

F fleet A	F fleet B	F fleet C	F fleet D	F_{0-1}	F_{2-6}	Catch fleet A	Catch fleet B	Catch fleet C	Catch fleet D	SSB 2011
0.116	0.022	0.002	0.004	0.031	0.125	215.0[1]	11.0	3.9	1.7	1714

[1]Includes a transfer of 50% of the Norwegian quota and 50% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2012)

	F-values by fleet and total						Catches by fleet				Biomass			
	fleet A	fleet B	fleet C	fleet D	F0-1	F2-6	fleet A	fleet B	fleet C	fleet D	SSB 20121)	SSB 2013	%SSB change 2)	%TAC change fleet A 3)
a	0	0	0	0	0	0	0	0	0	0	2177	2602	27%	-100%
b	0.107	0.034	0.004	0.006	0.046	0.12	230.0	17.9	6.8	1.9	2013	2166	17%	+15%
c	0.092	0.034	0.004	0.006	0.046	0.106	200.0	17.9	6.8	1.9	2033	2215	19%	0%
d	0.236	0.035	0.004	0.006	0.050	0.25	478.4	17.9	6.8	1.9	1845	1778	8%	+139%
e	0.078	0.034	0.004	0.006	0.045	0.091	170.0	17.9	6.8	1.9	2053	2265	20%	-15%

Weights in '000 t.

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

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

2) SSB (2012) relative to SSB (2011).

3) Calculated landings (2012) relative to TAC 2011 for the A fleet.

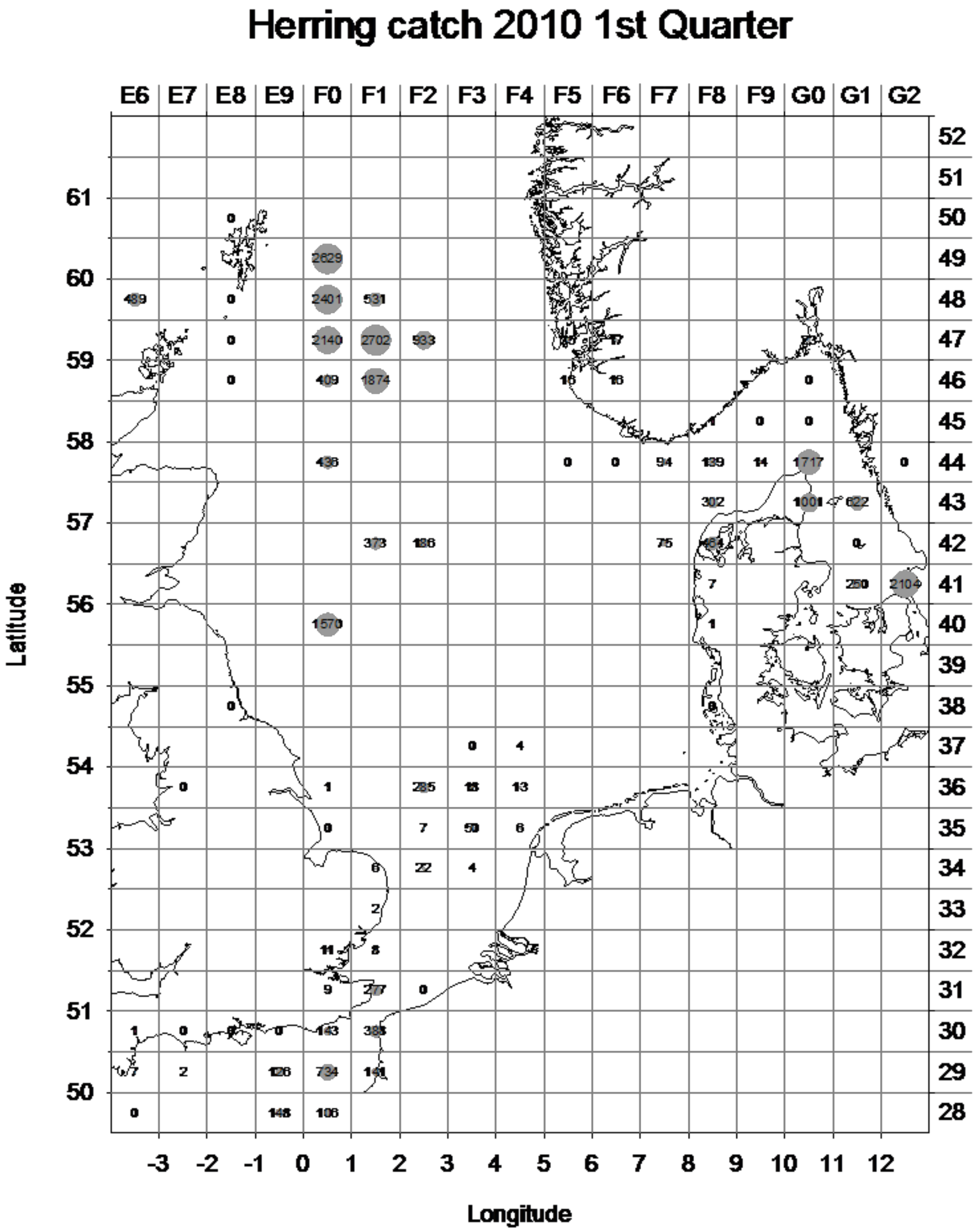


Figure 2.1.1a: : Herring catches in the 1st quarter in the North Sea, in Div. VIId, Div. IIIa, SD 22 and SD 24 (in tonnes) in 2010 by statistical rectangle. WG estimates (if available).

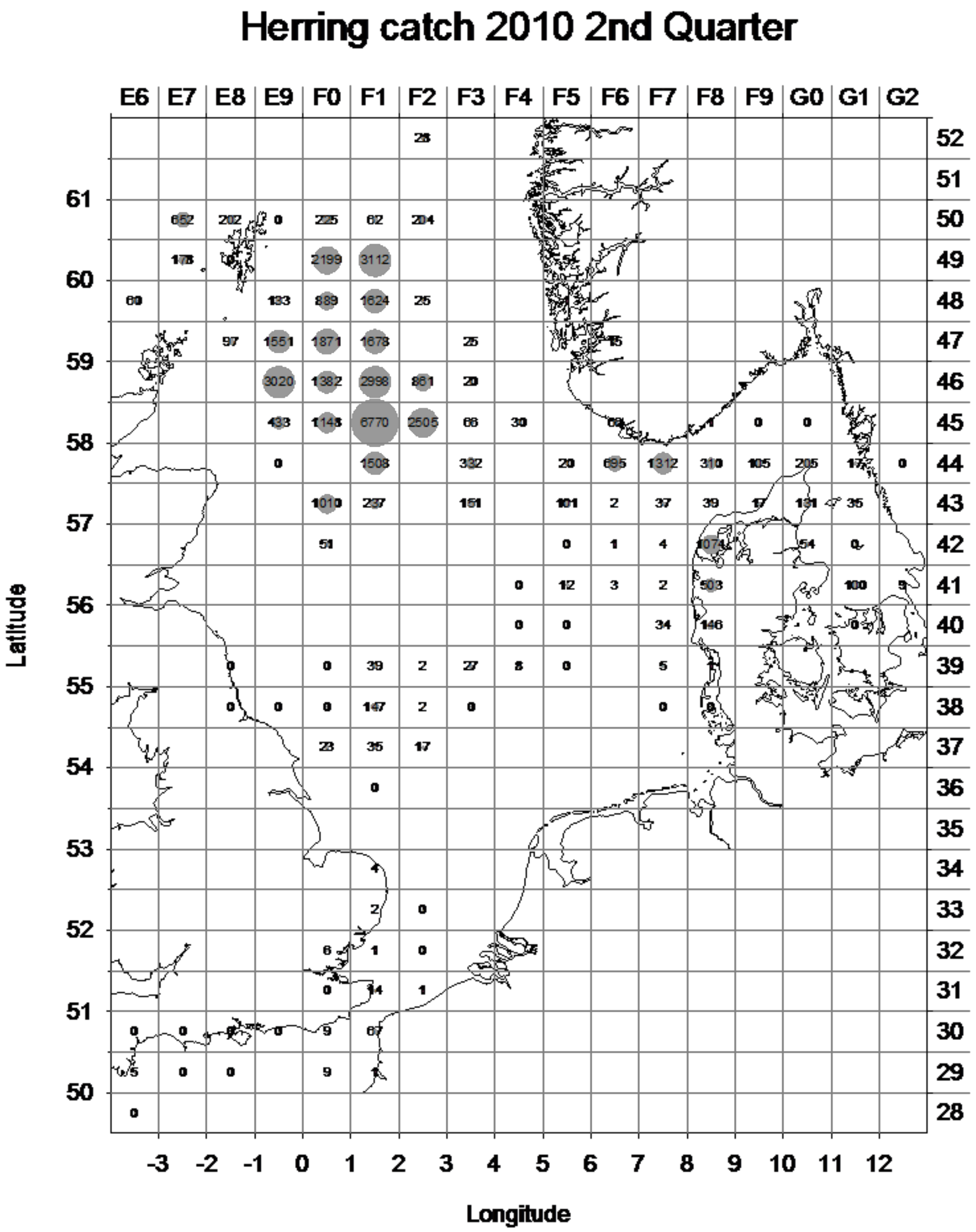


Figure 2.1.1b: Herring catches in the 2nd quarter in the North Sea, in Div´. VIId, Div. IIIa, SD 22 and SD 24 (in tonnes) in 2010 by statistical rectangle. WG estimates (if available).

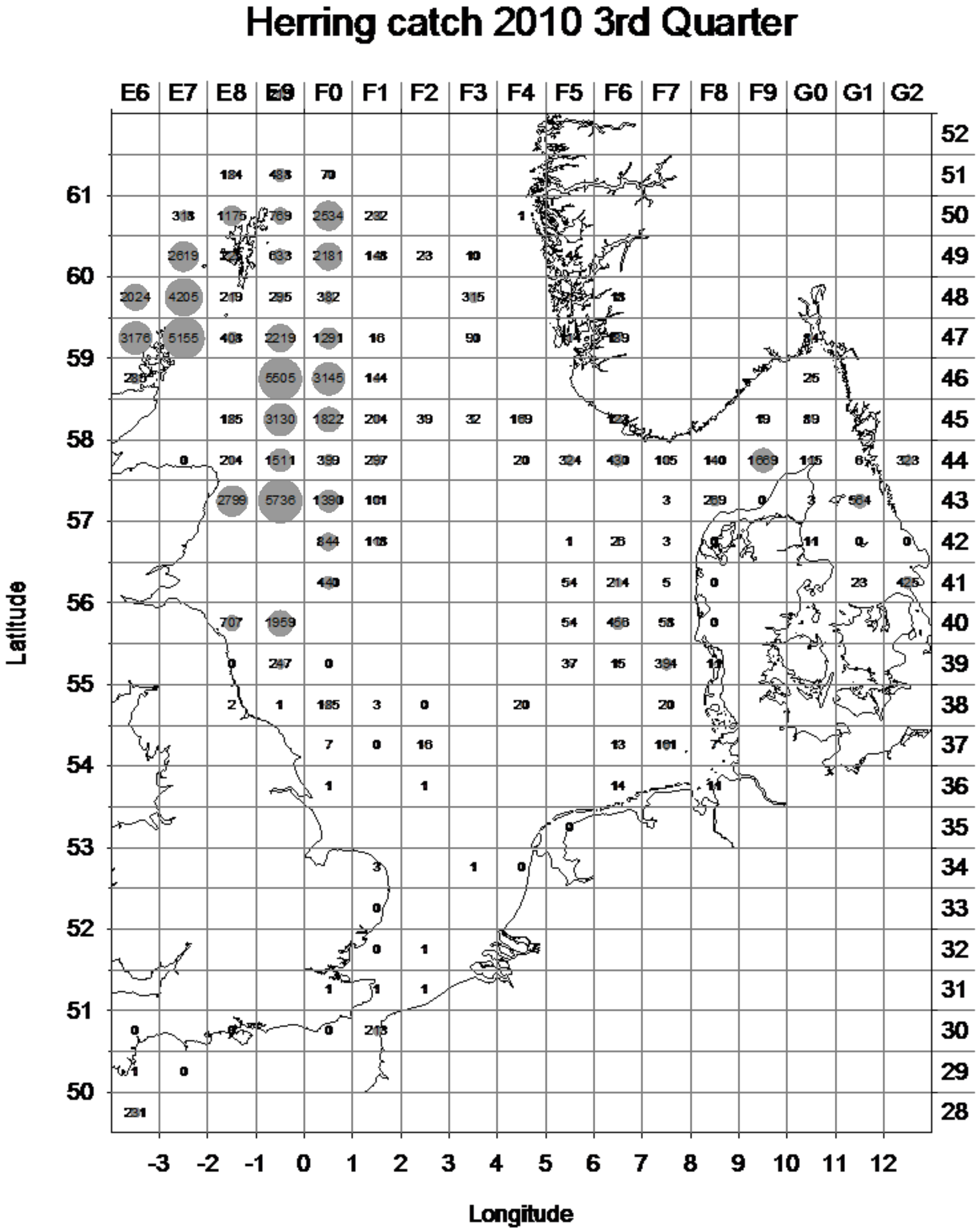


Figure 2.1.1c: Herring catches in the 3rd quarter in the North Sea, in Div. VIId, Div. IIIa, SD 22 and SD 24 (in tonnes) in 2010 by statistical rectangle. WG estimates (if available).

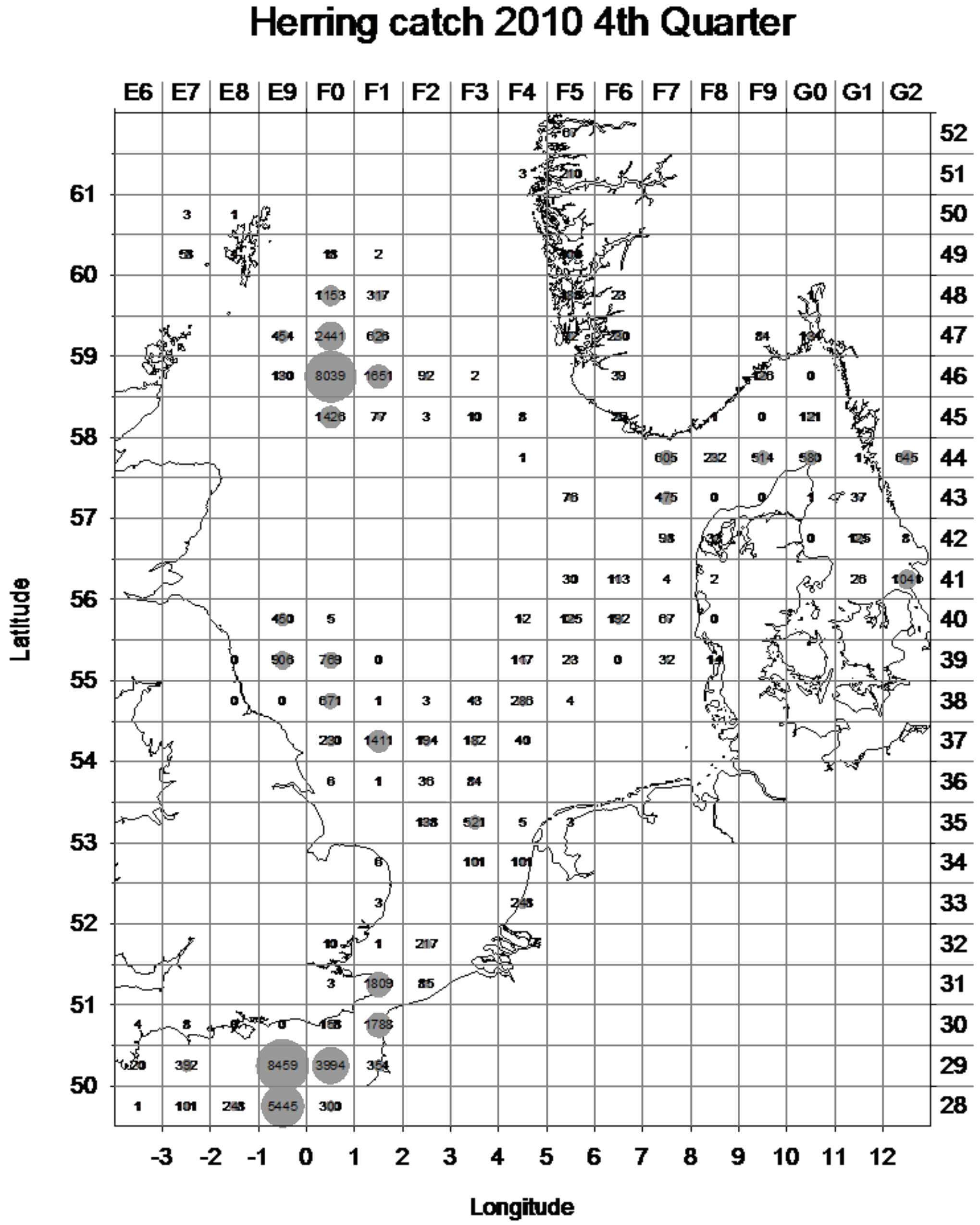


Figure 2.1.1d: Herring catches in the 4th quarter in the North Sea, in Div. VIId, Div. IIIa, SD 22 and SD 24 (in tonnes) in 2010 by statistical rectangle. WG estimates (if available).

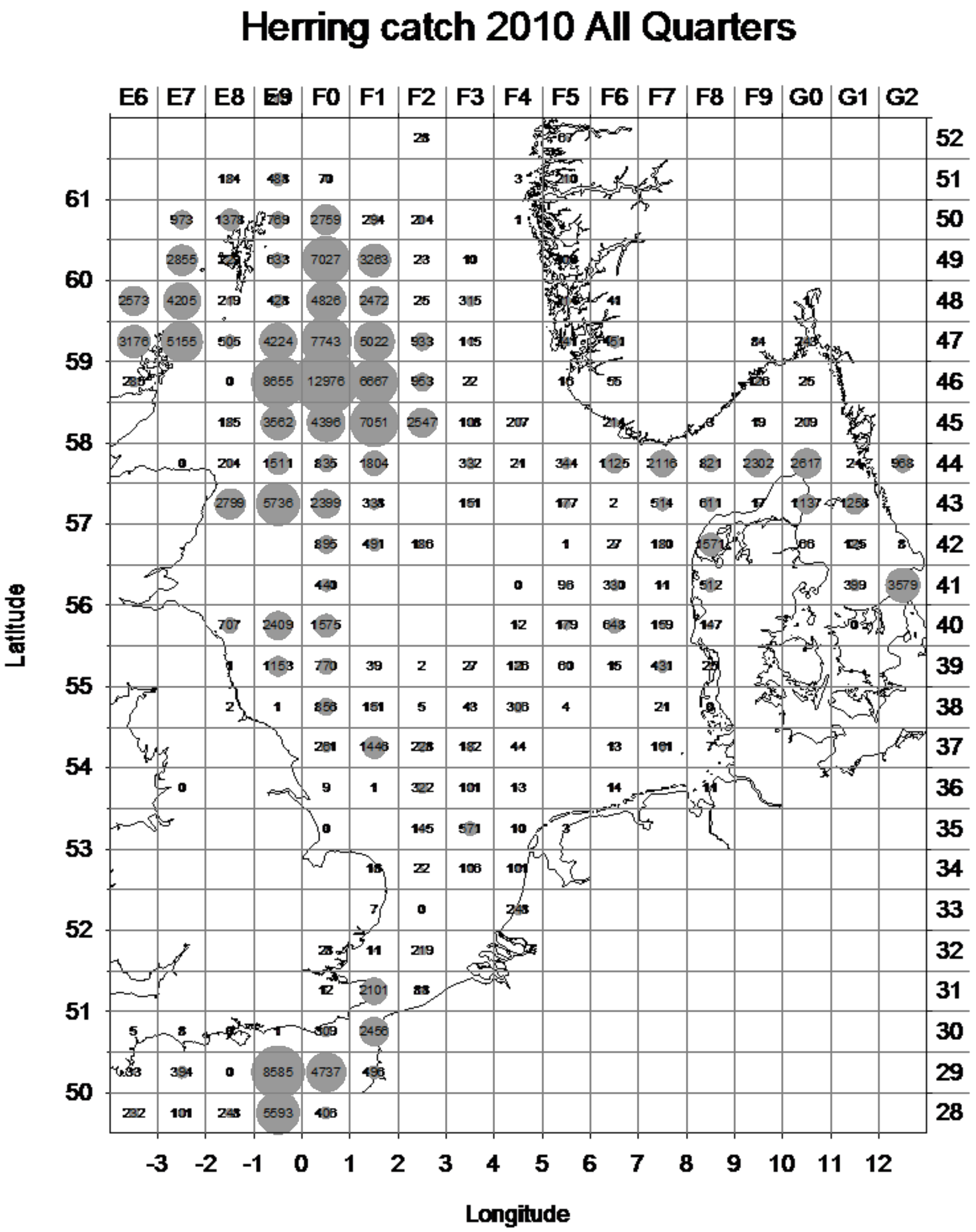
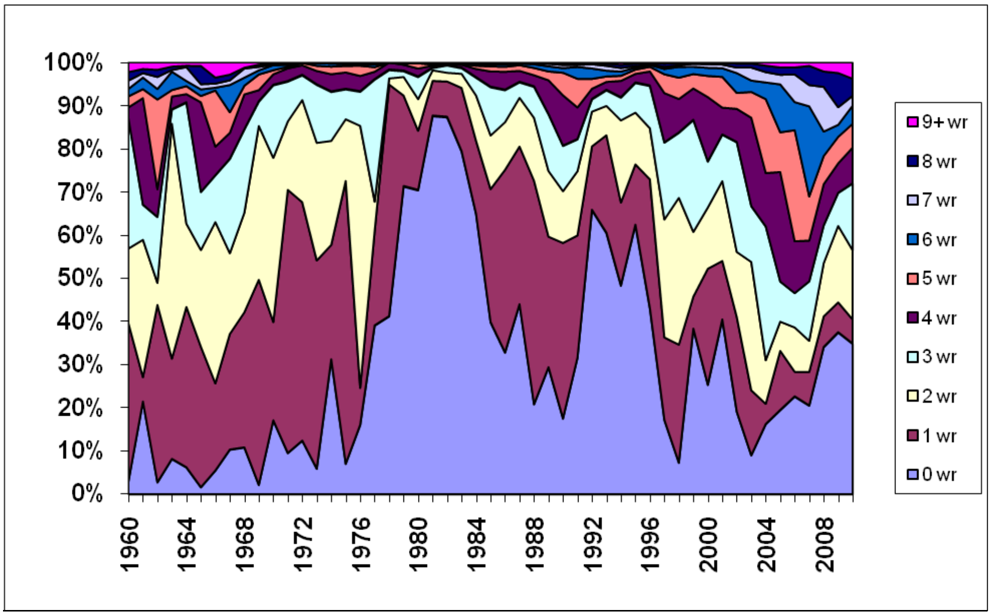


Figure 2.1.1e: Herring catches in all quarters in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2010 by statistical rectangle. WG estimates (if available).



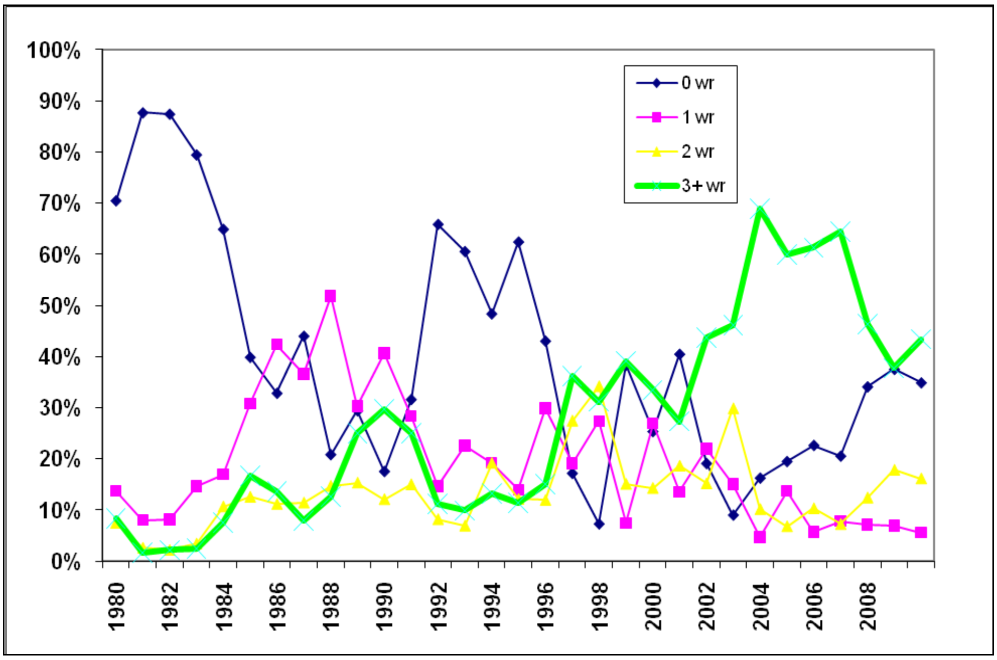


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring in the North Sea (upper, 1960-2010, and lower panel, 1980-2010).

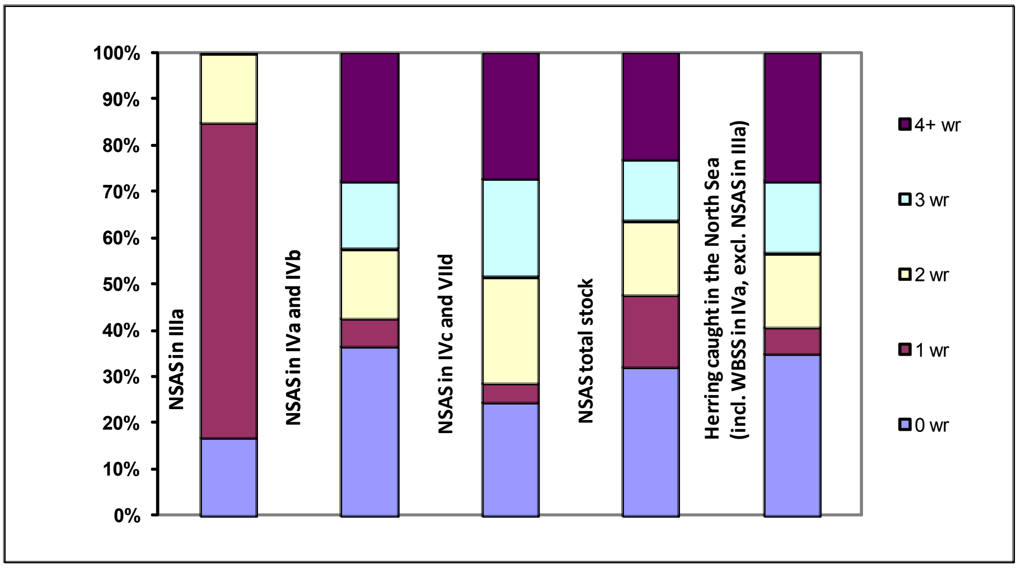


Figure 2.2.2: Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2010.

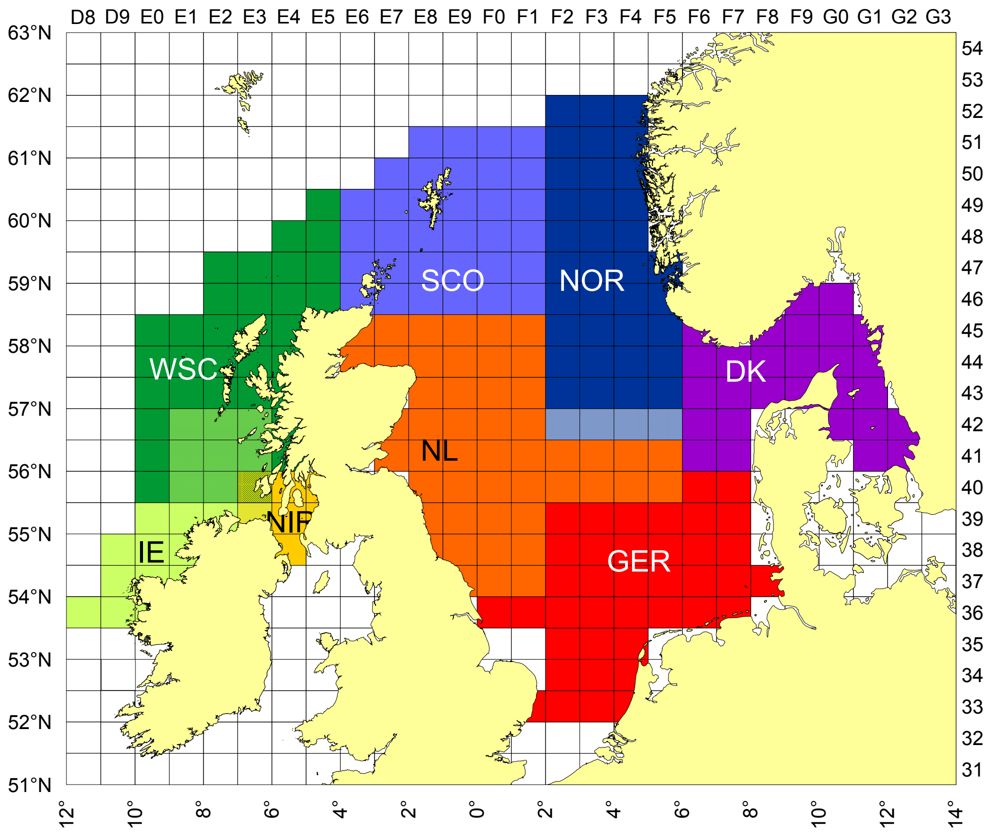


Figure 2.3.1.1: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2010. Survey area coverage by rectangle and nation (IE = Celtic Explorer; NIR = Corystes; WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Multi-coloured rectangles indicate overlapping coverage by two or more nations (e.g. 40E1-40E3). Rectangles 42F2-42F5 were interpolated from surrounding ones.

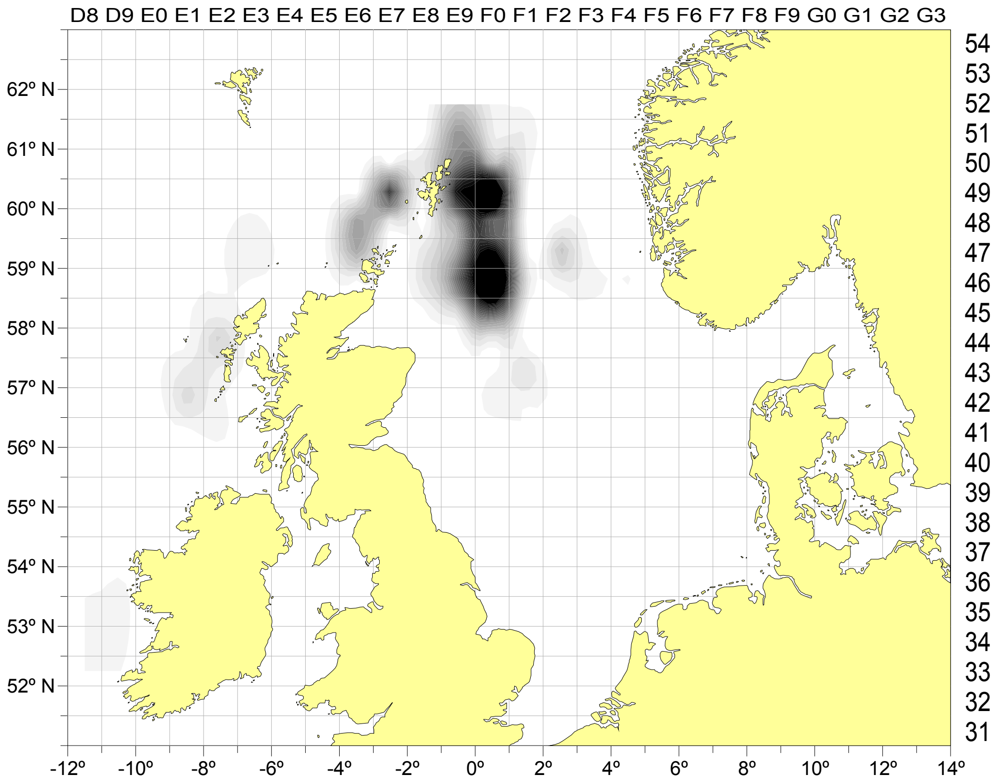


Figure 2.3.1.2: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2010. Biomass of mature autumn spawning herring from the combined acoustic survey (maximum value = 220 000 t).

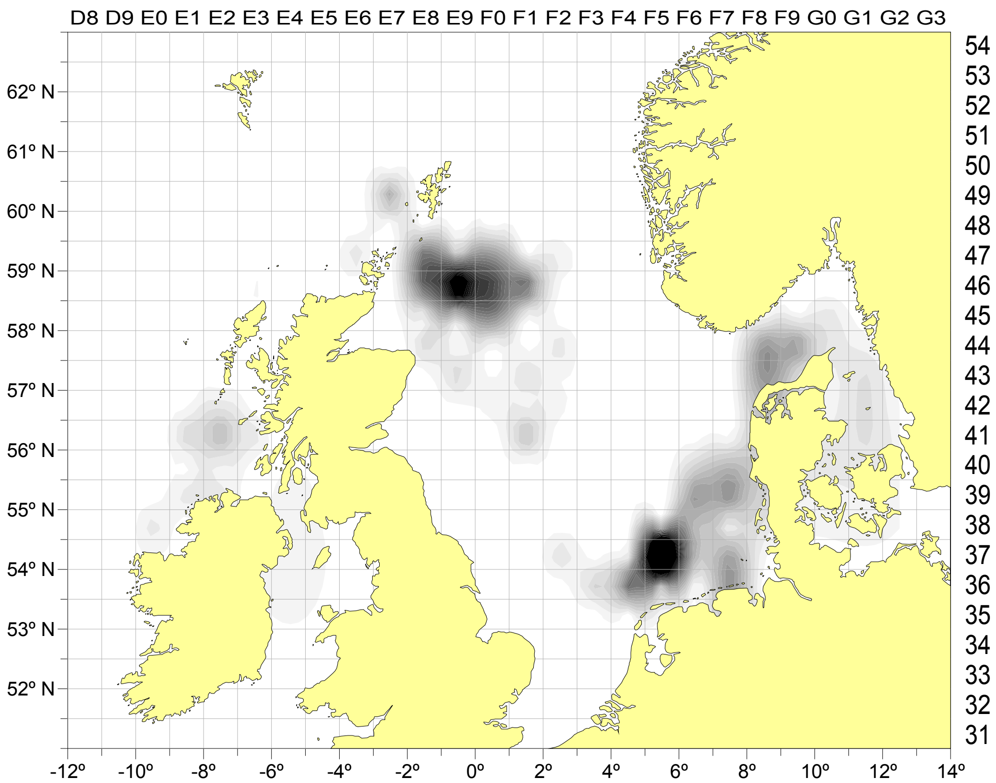


Figure 2.3.1.3: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2010. Biomass of immature autumn spawning herring from the combined acoustic survey (maximum value = 57 500 t).

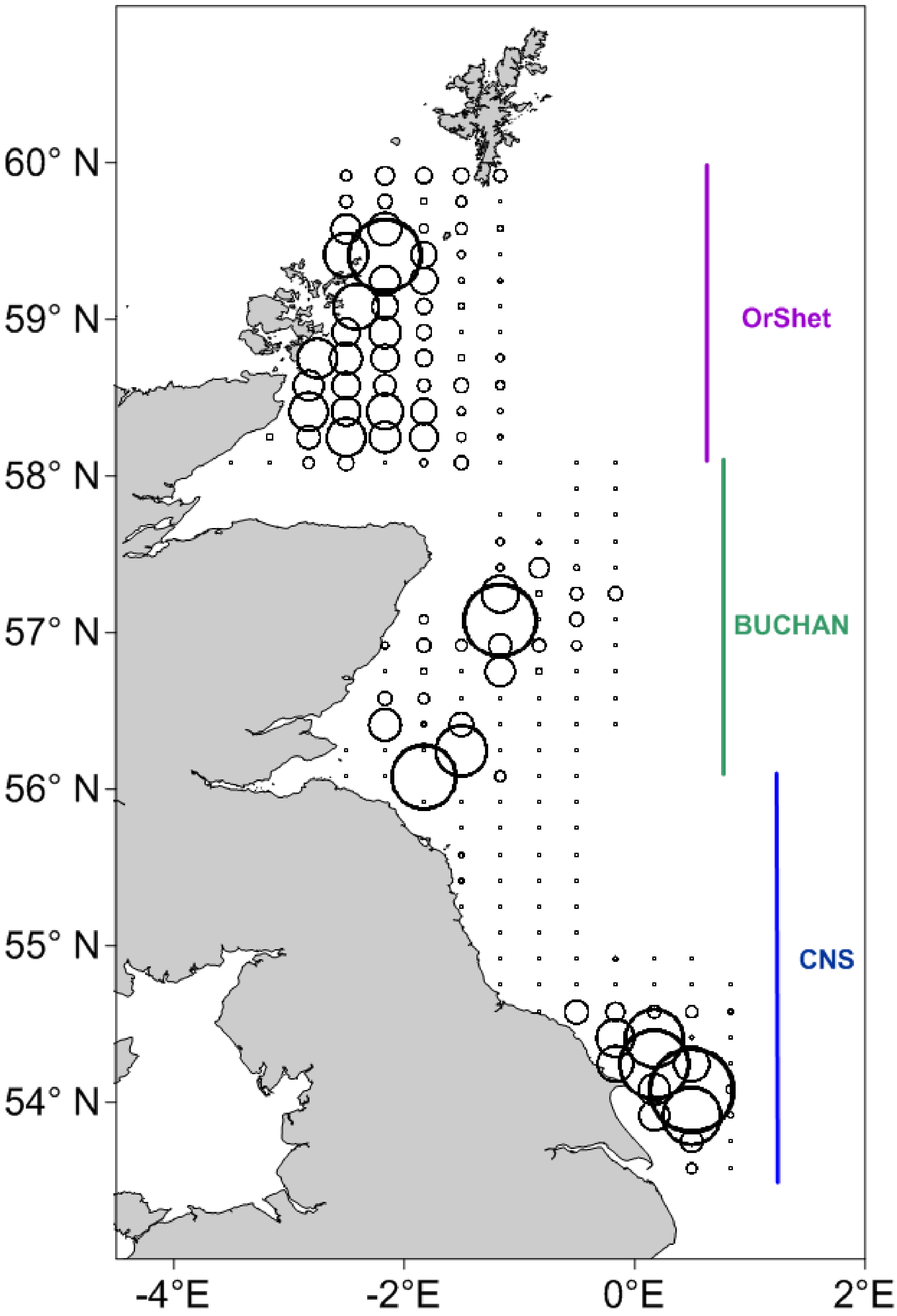


Figure 2.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetland, Buchan and Central North Sea area (16-30 September 2010, scale 0.64 cm =1 600 n/m²).

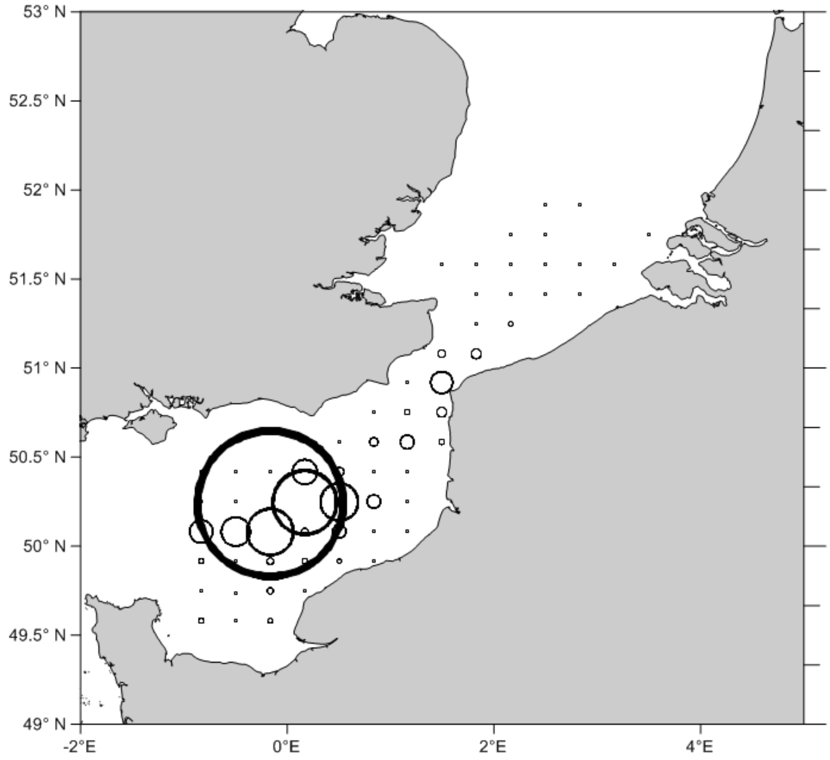


Figure 2.3.2.2. North Sea herring - Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 December 2010, scale 0.64 cm =3 000 n/m²).

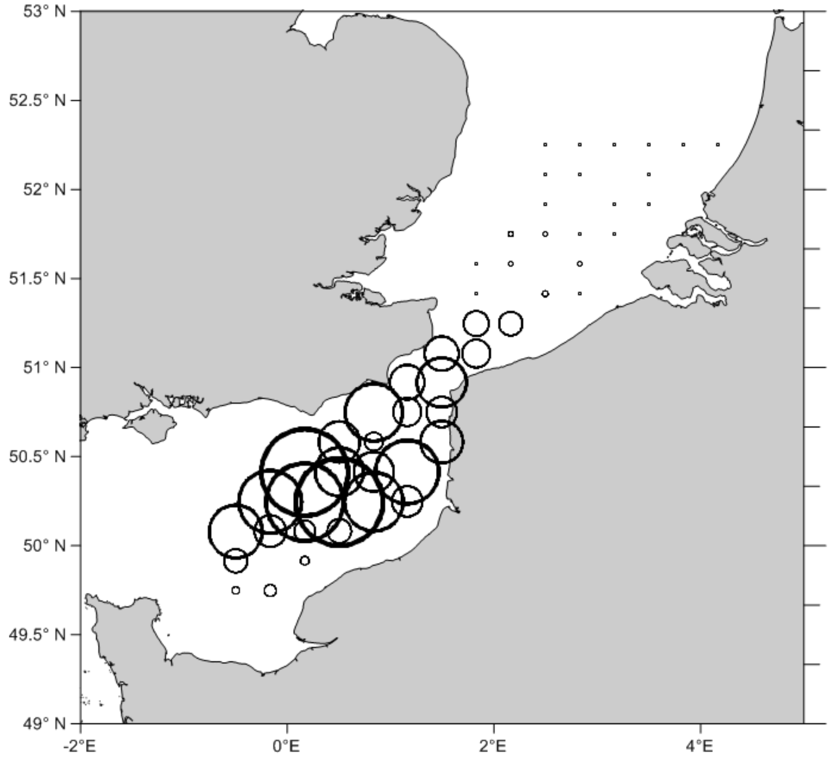


Figure 2.3.2.3. North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (01-15 January 2011, scale 0.64 cm = 3 000 n/m²).

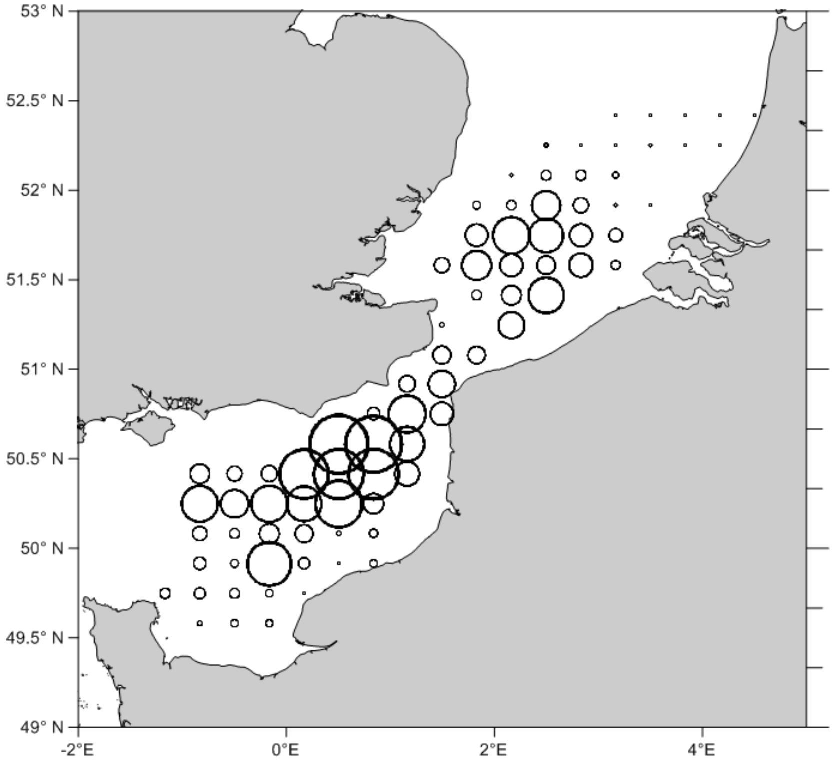


Figure2.3.2.4. North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 January 2011, scale 0.64 cm = 3 000 n/m²).

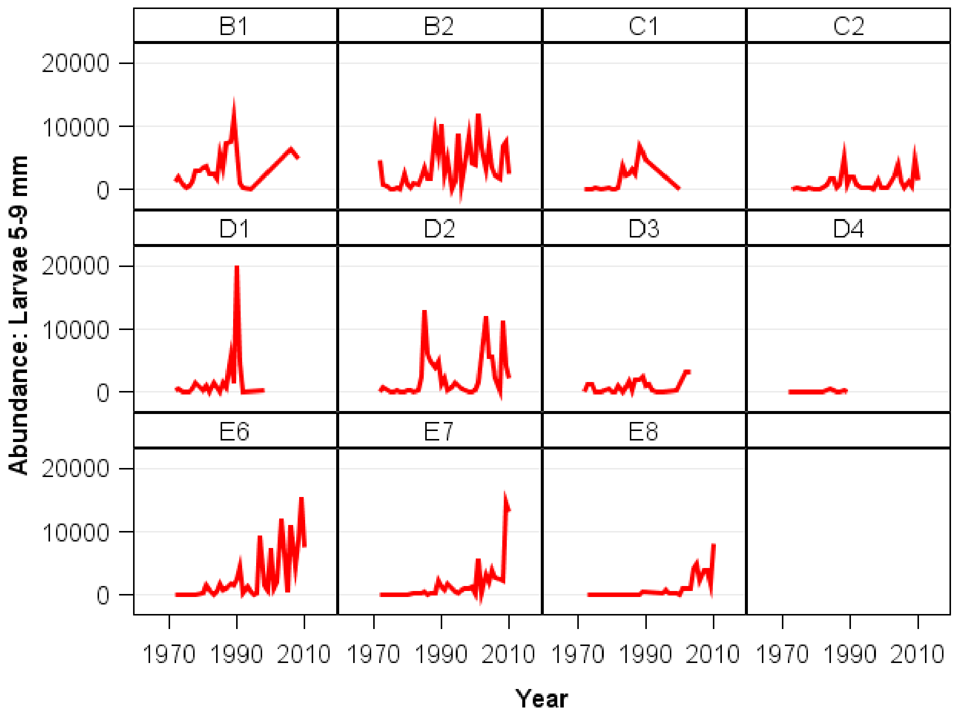


Figure 2.3.2.5: North Sea herring. Larval Abundance Index time-series (B = Orkney/Shetland 1st and 2nd fortnight, C = Buchan 2nd fortnight, D = Central North Sea 2nd fortnight, E = Southern North Sea all 3 fortnights).

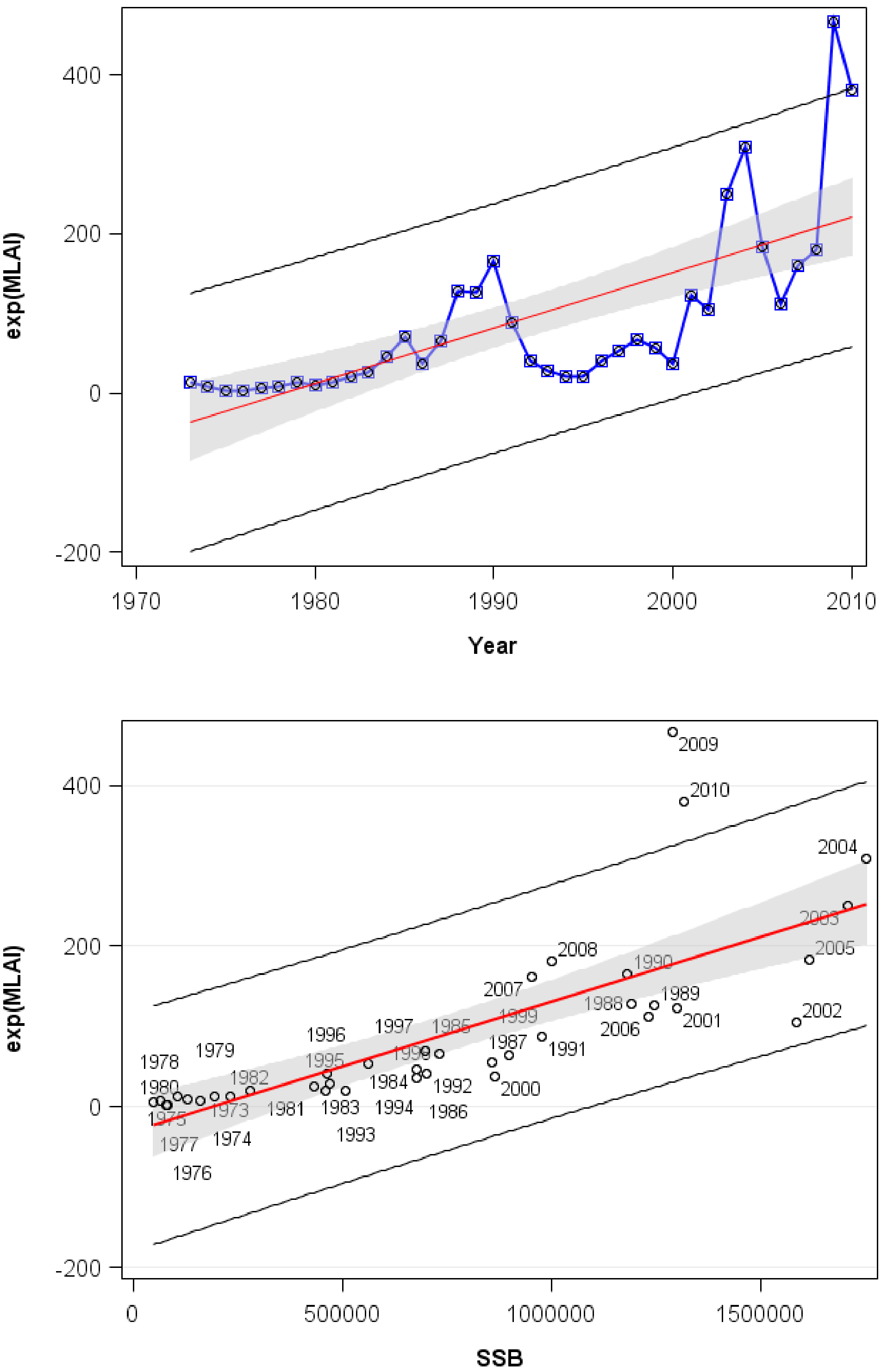


Figure 2.3.2.6: North Sea herring. Time series (upper panel) and scatter plot (lower panel) of the MLAI estimates (r = 0.775, p < 0.0001). Both panels with correspondence and regression line, respectively, as well as with 95% confidence limits for the individual values and 95% confidence bands for the mean. The SSB estimates of the lower panel are taken from the ICA-output of the previous year.

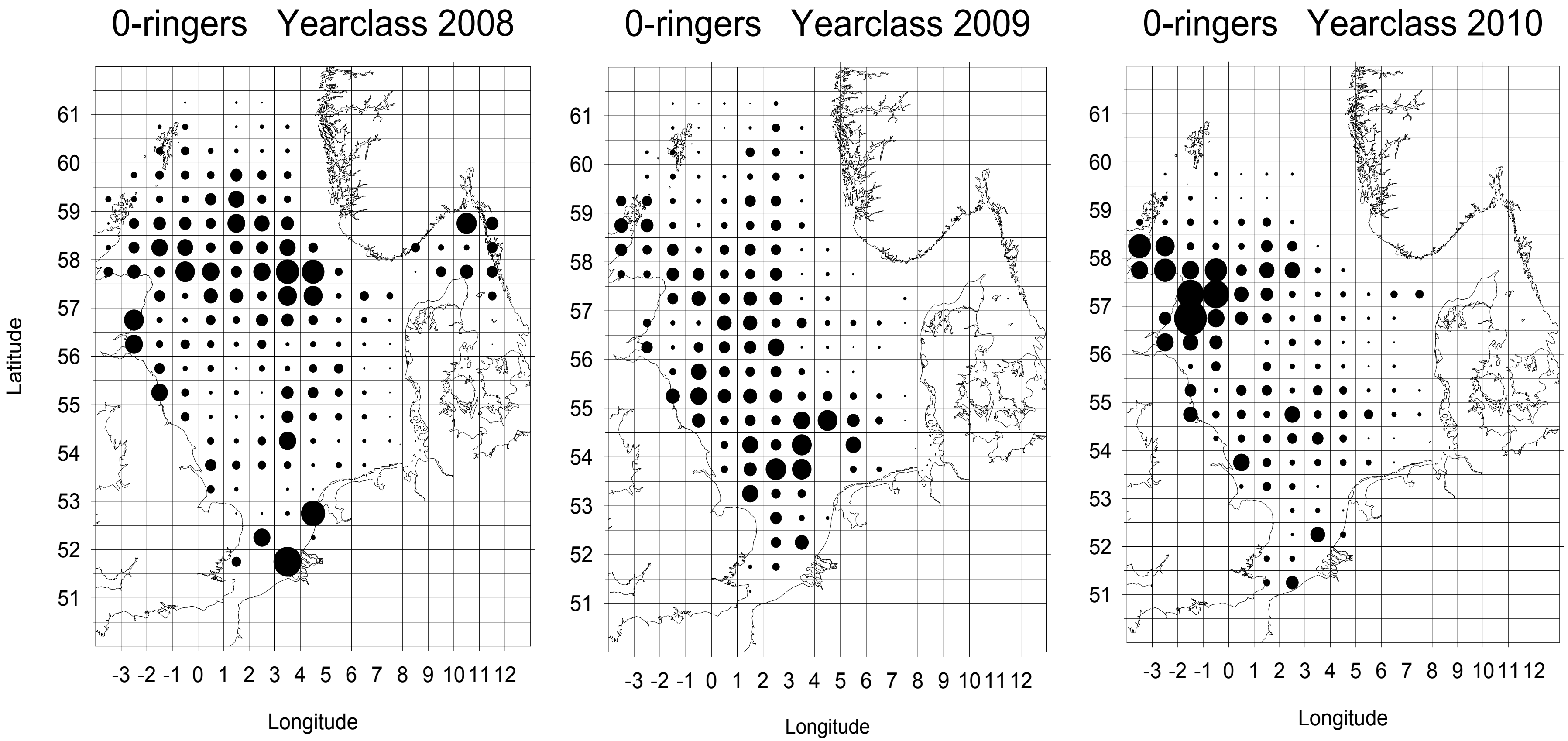


Figure 2.3.3.1. North Sea herring. Distribution of 0-ringer herring, year classes 2008-2010. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2009-2011. Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1 m^{-2}. Note that there is no distributional data for the Skagerrak/Kattegat for 2011.

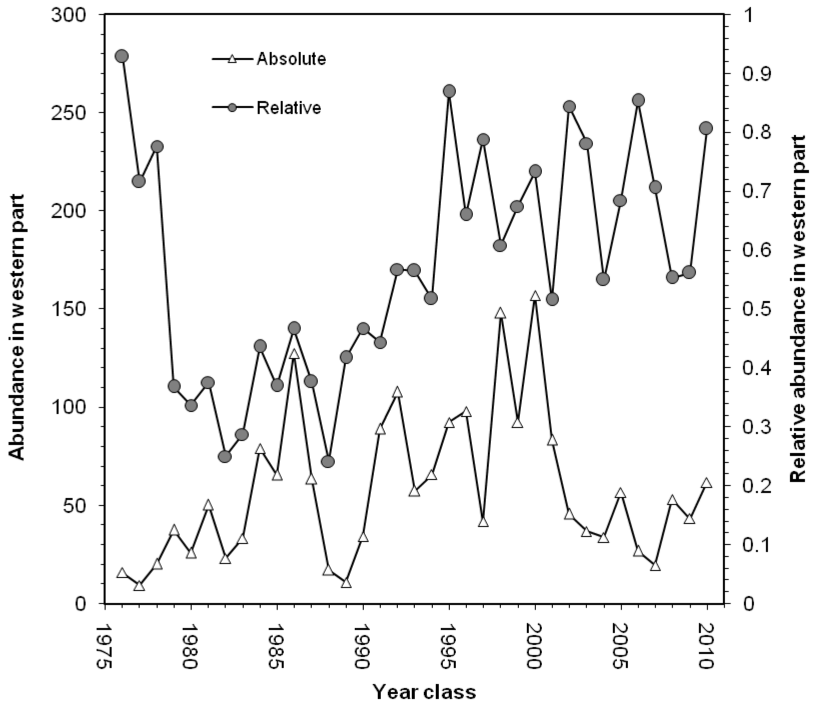


Figure 2.3.3.2. North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS, the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number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

.

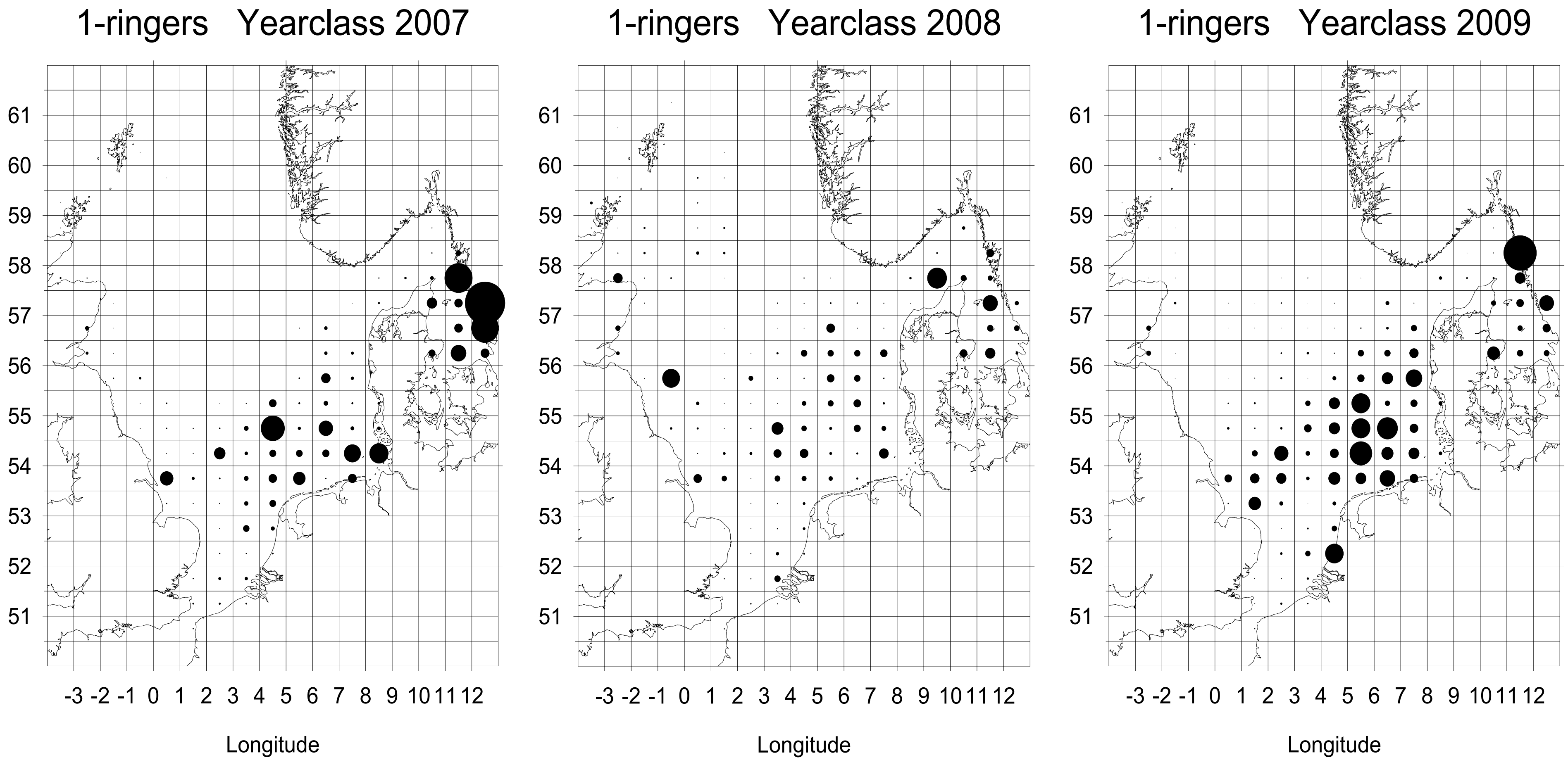
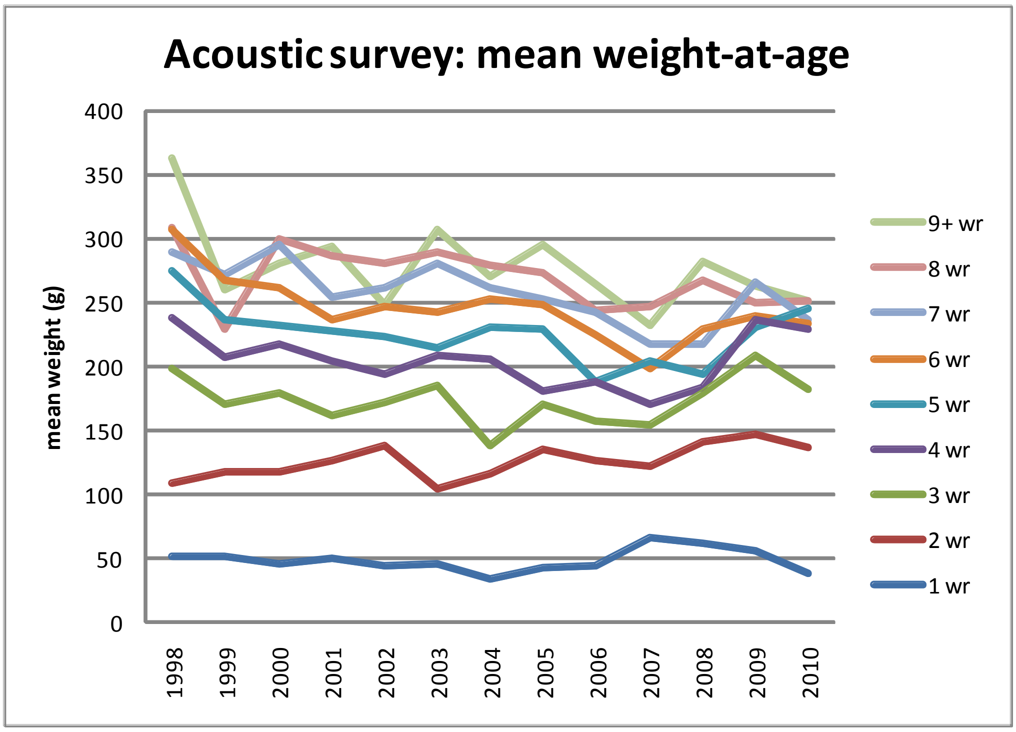


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2007-2009. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in February 2009-2011. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.



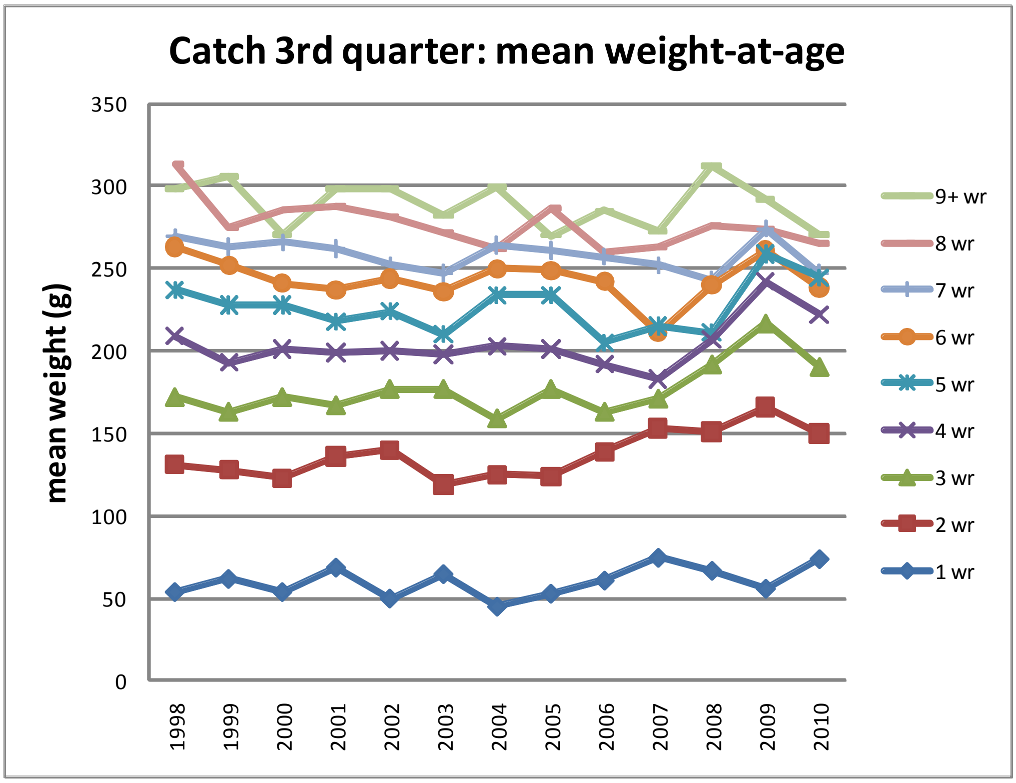


Figure 2.4.1.1. North Sea Herring. Mean weight-at-age for the 3rd quarter in Divisions IV and IIIa from the acoustic survey and mean weight-in-the-catch for comparison.

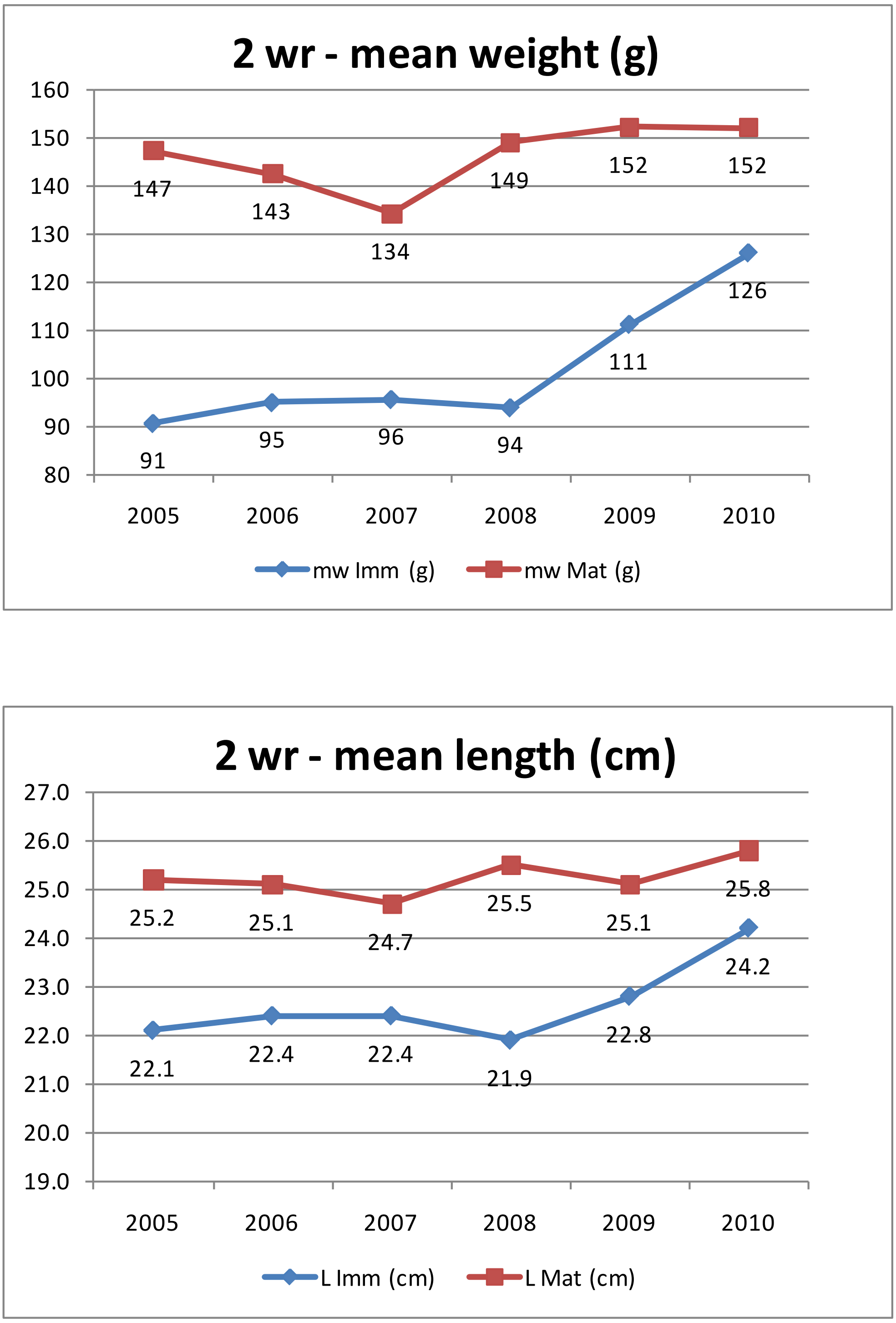


Figure 2.4.2.1. North Sea Herring. Mean weight-at-age (upper panel) and mean length-at-age (lower panel) for immature and mature in North Sea acoustic survey since 2005.

Figure 2.5.1. North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2008. The 2009 year class relation is circled; the present 0-ringer index for year class 2010 is indicated by an arrow.

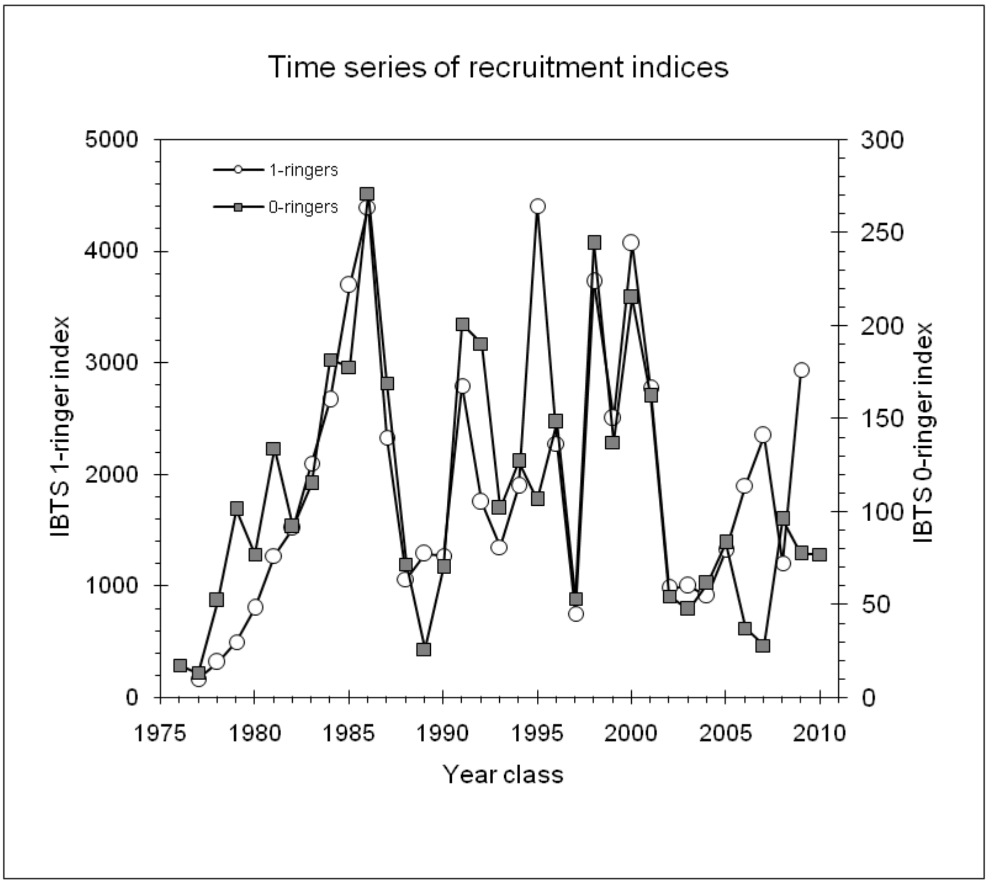


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2010 for 0-ringers, year classes 1977-2009 for 1-ringers.

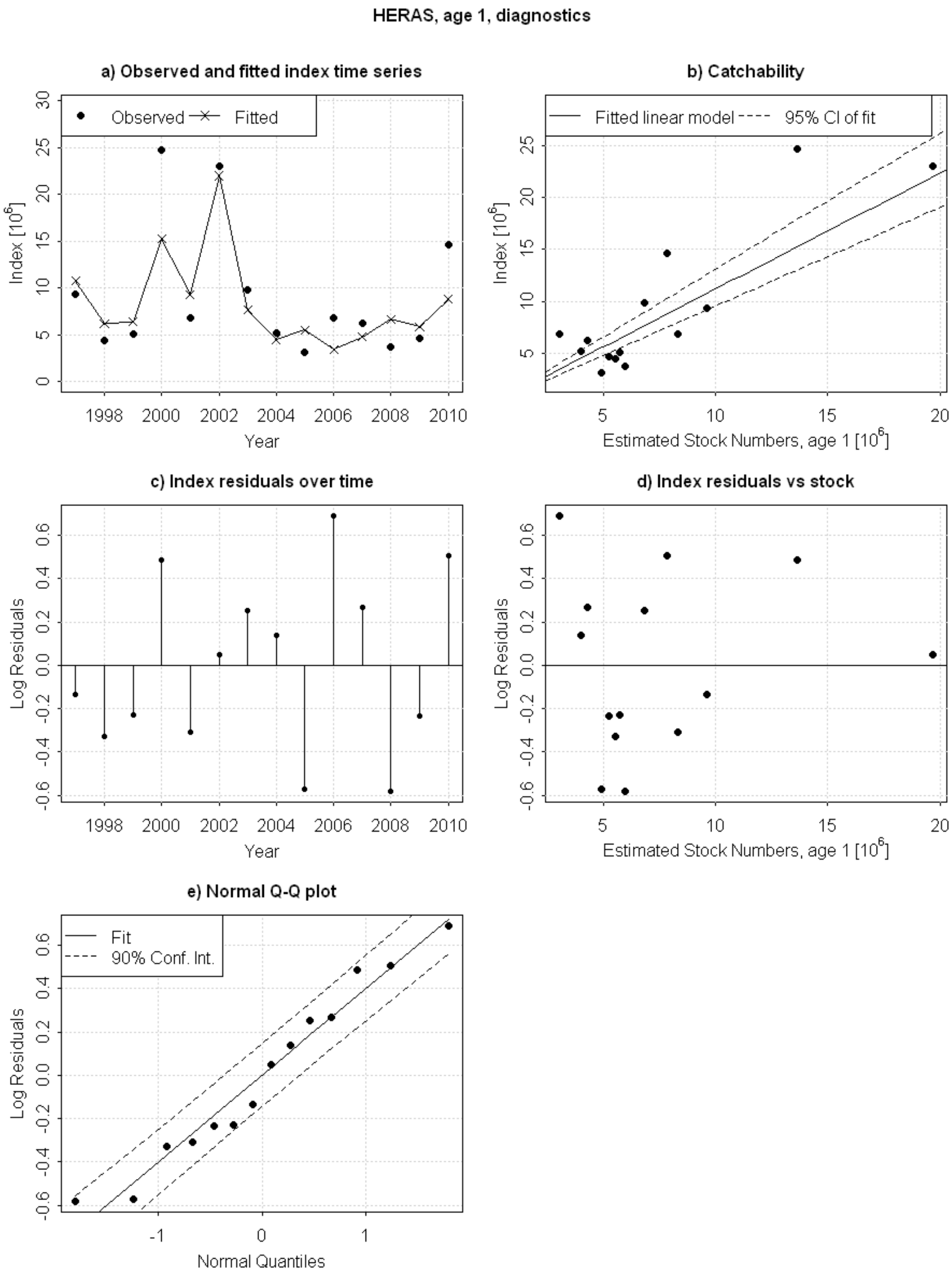


Figure 2.6.1.1 North Sea herring. Diagnostics of Acoustic survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1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

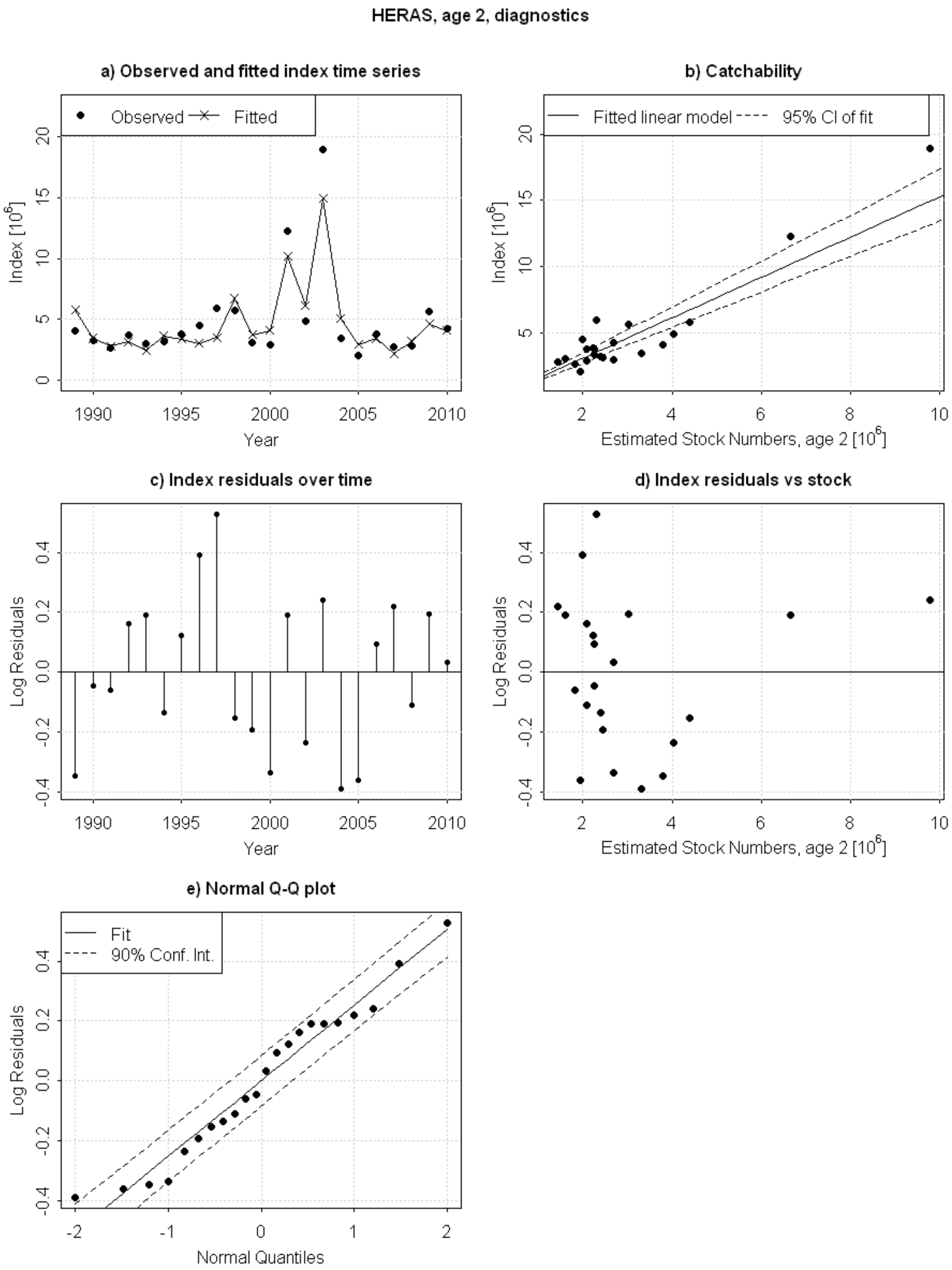


Figure 2.6.1.2. North Sea herring. Diagnostics of Acoustic survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2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

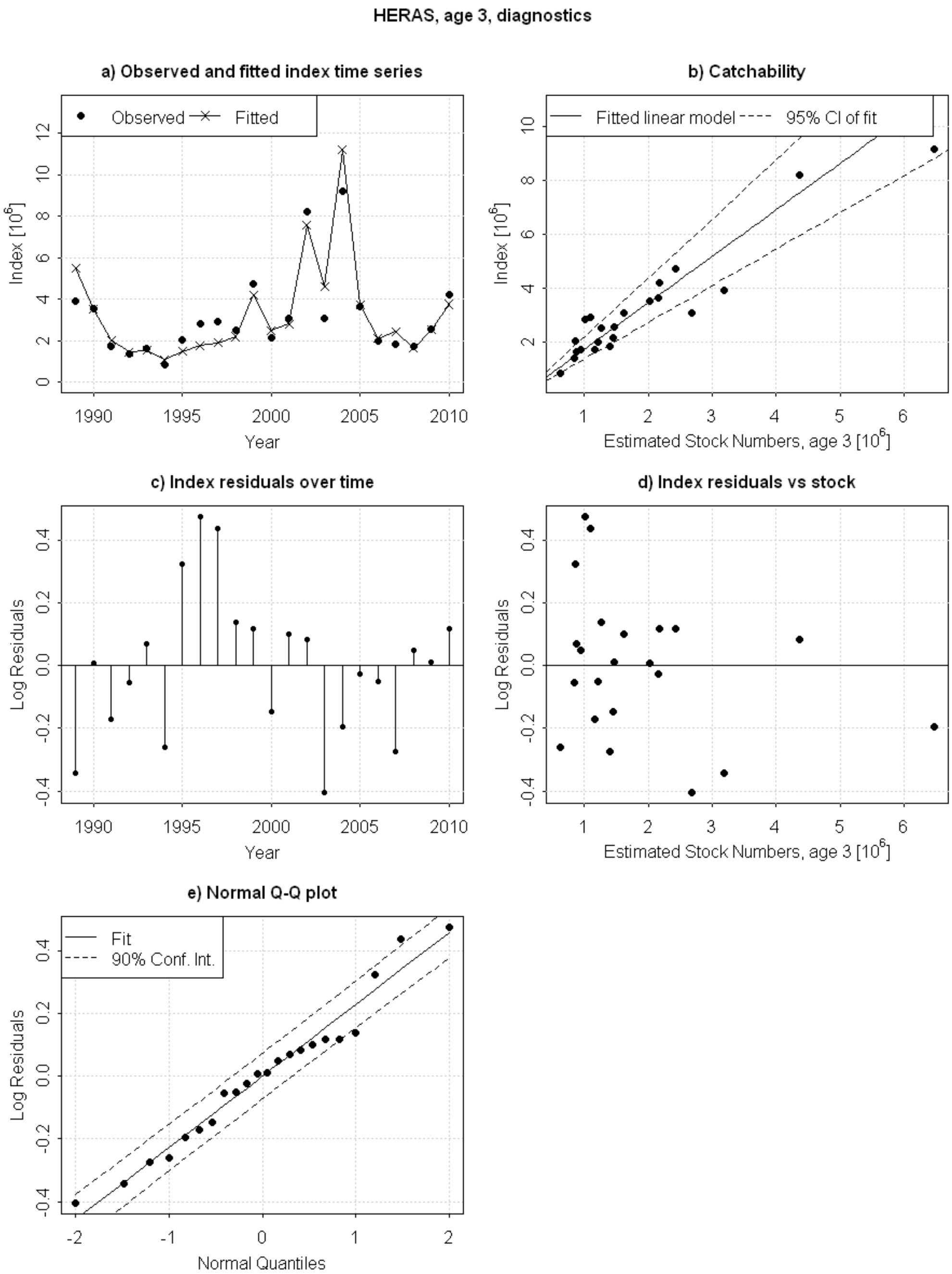


Figure 2.6.1.3. North Sea herring. Diagnostics of Acoustic survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr . Top right: scatterplot of index observations versus VPA estimates of numbers at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

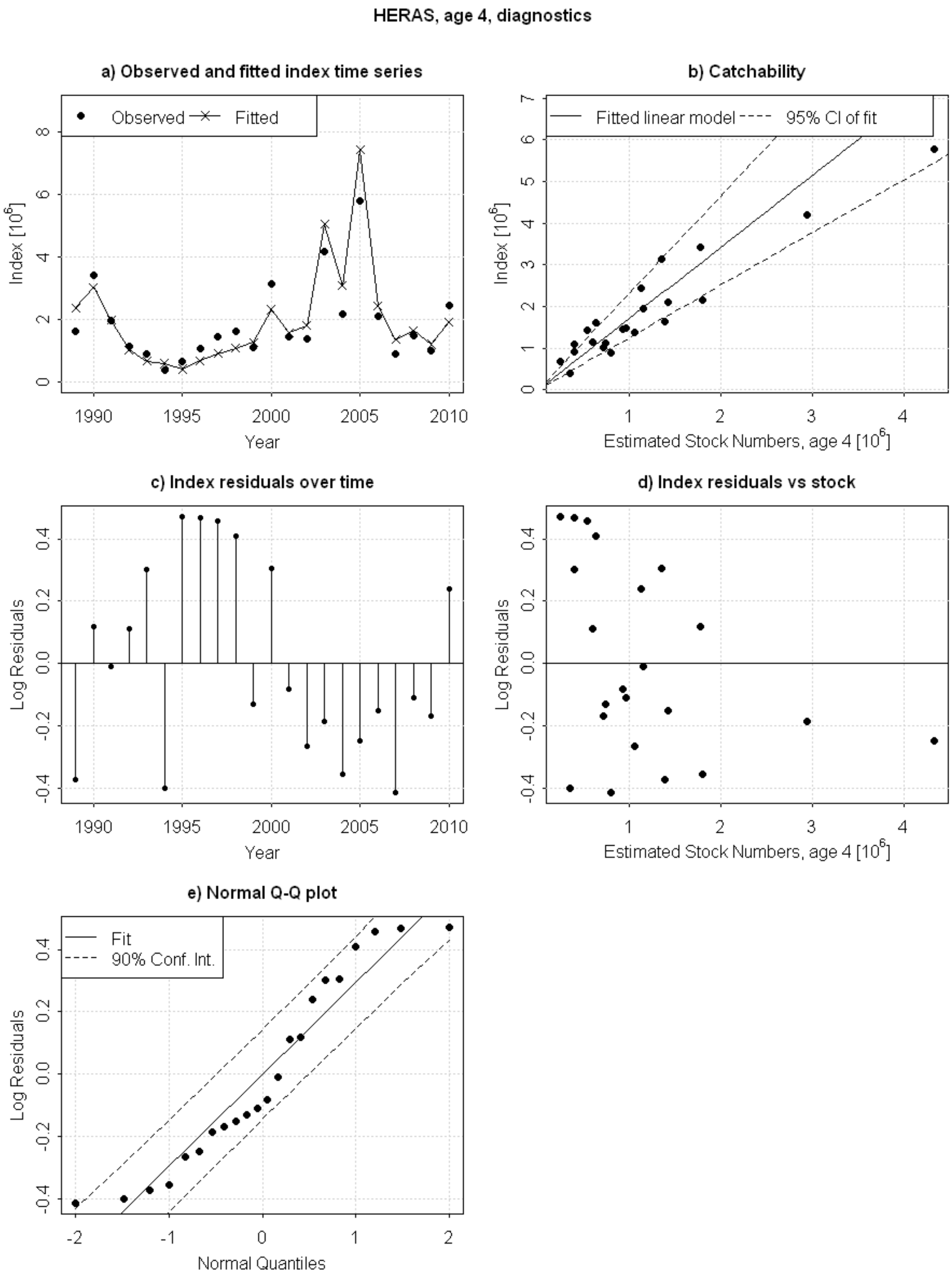


Figure 2.6.1.4. North Sea herring. Diagnostics of Acoustic survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4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

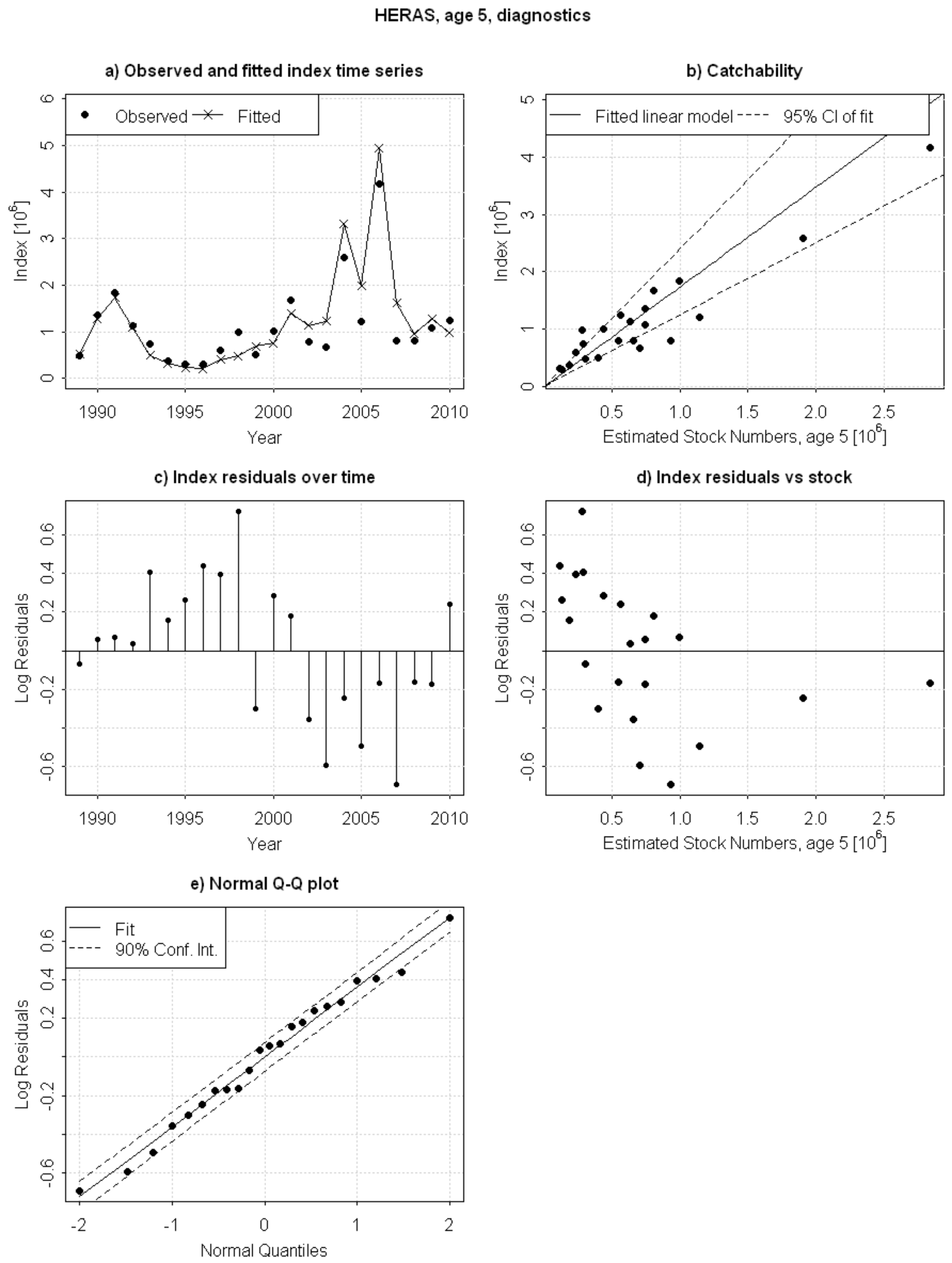


Figure 2.6.1.5. North Sea herring. Diagnostics of Acoustic survey catchability at 5 wr from the final ICA assessment. Top left: VPA estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5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

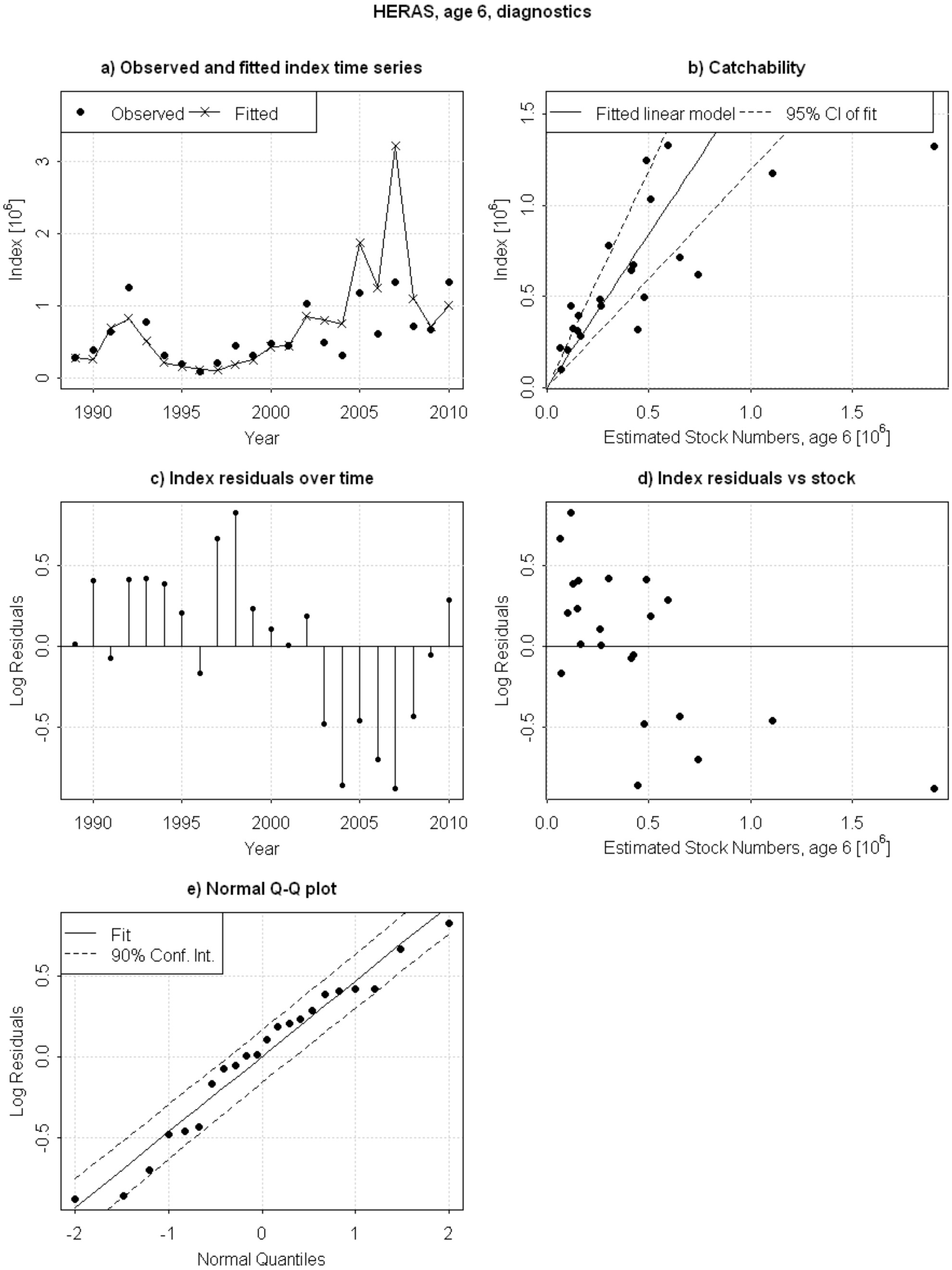


Figure 2.6.1.6. North Sea herring. Diagnostics of Acoustic survey catchability at 6 wr from the final ICA assessment. Top left: VPA estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 6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

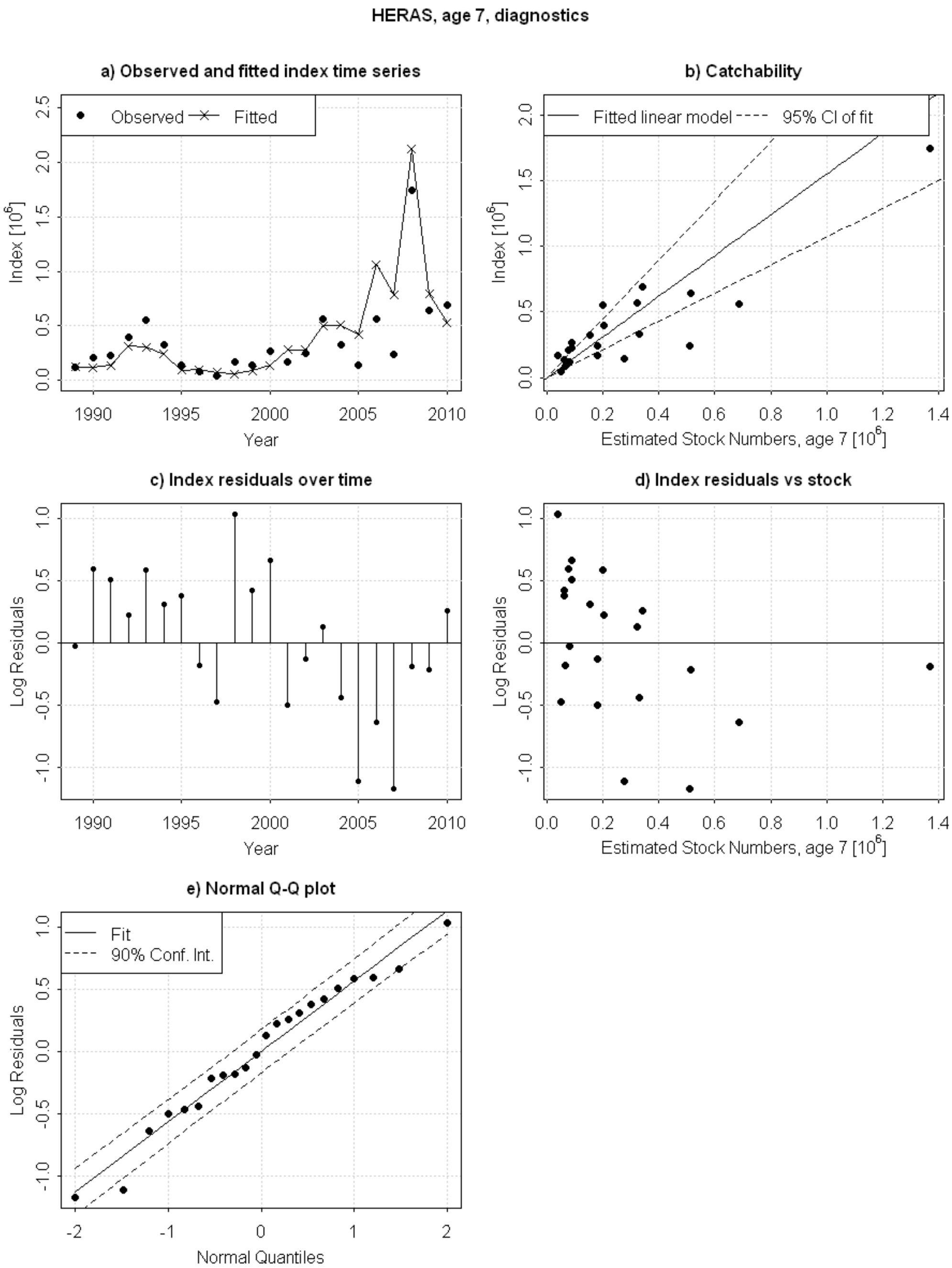


Figure 2.6.1.7. North Sea herring. Diagnostics of Acoustic survey catchability at 7 wr from the final ICA assessment. Top left: VPA estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 7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

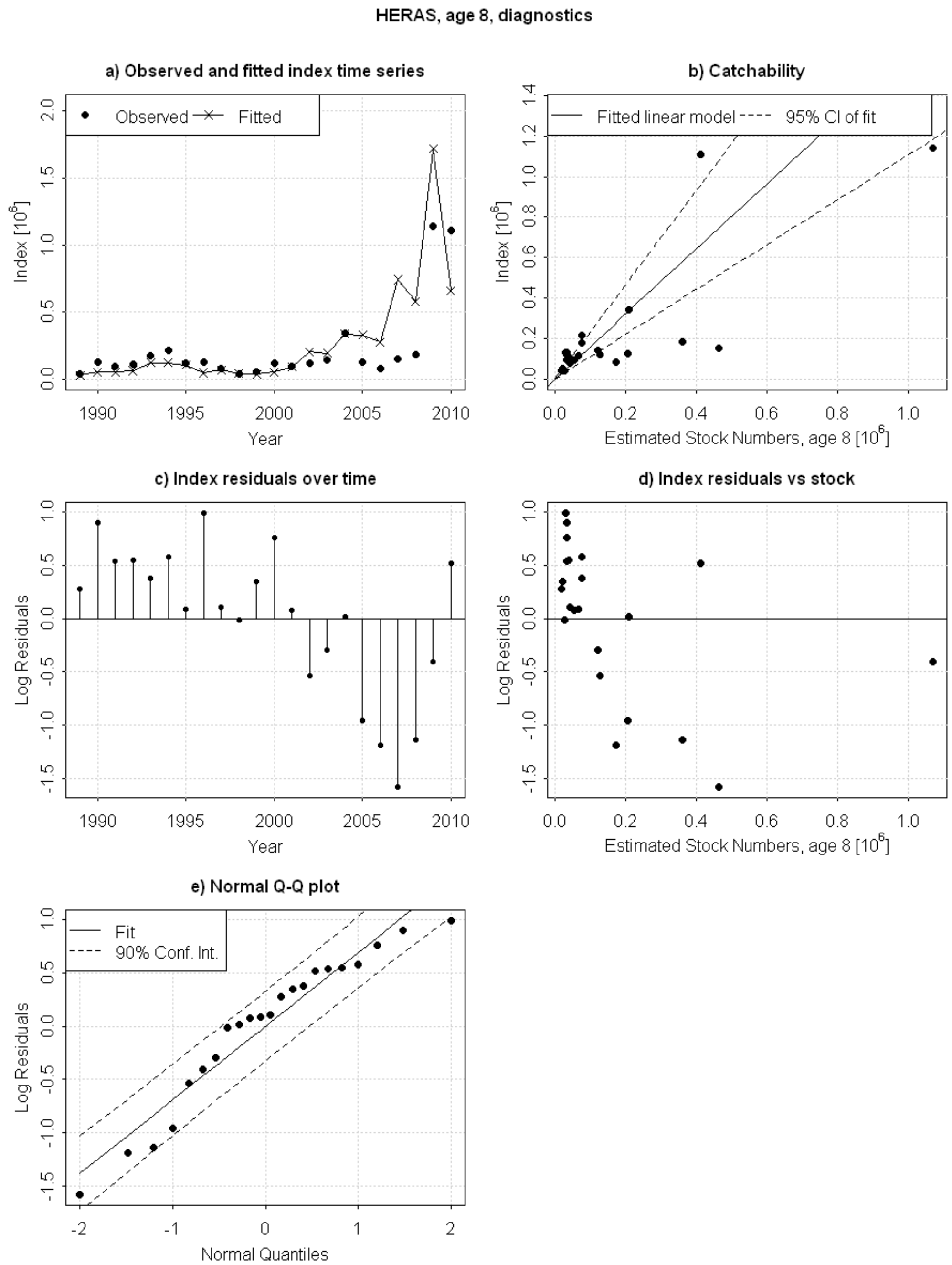


Figure 2.6.1.8. North Sea herring. Diagnostics of Acoustic survey catchability at 8 wr from the final ICA assessment. Top left: VPA estimates of numbers at 8 wr (line) and numbers predicted from index abundance at 8 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 8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

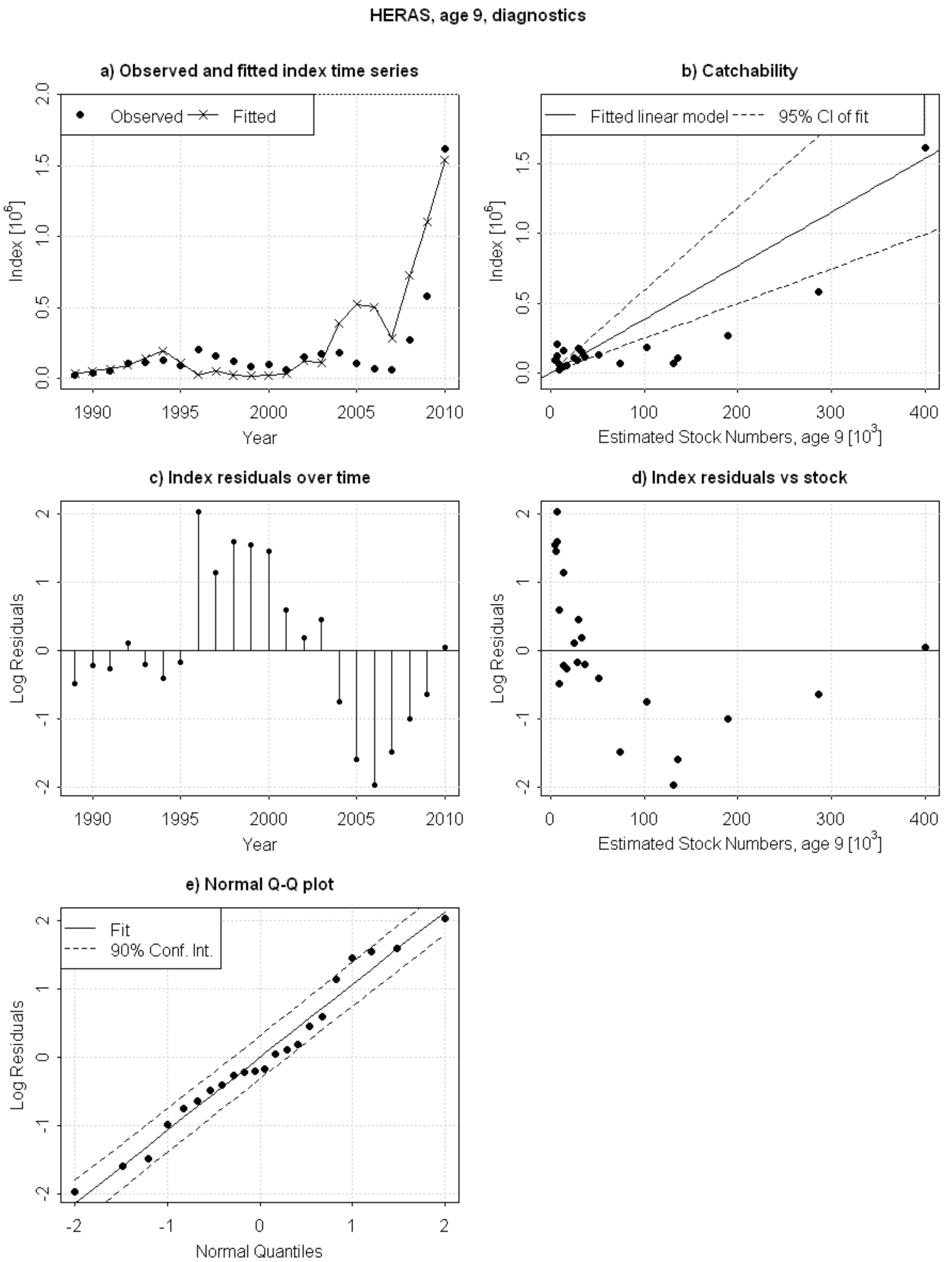


Figure 2.6.1.9. North Sea herring. Diagnostics of Acoustic survey catchability at 9+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 9+ wr (line) and numbers predicted from index abundance at 9+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at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

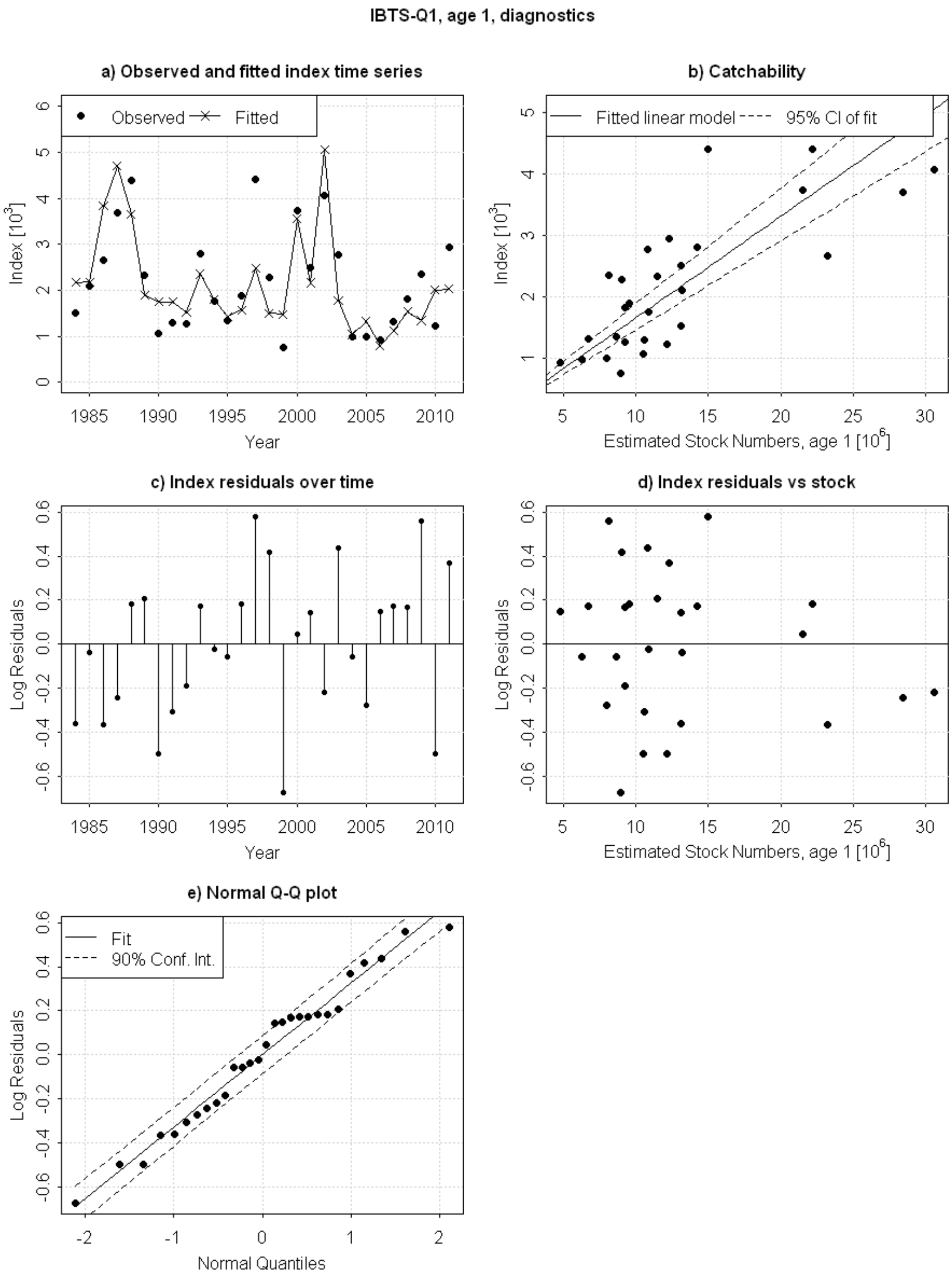


Figure 2.6.1.10. North Sea herring. Diagnostics of IBTS survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr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

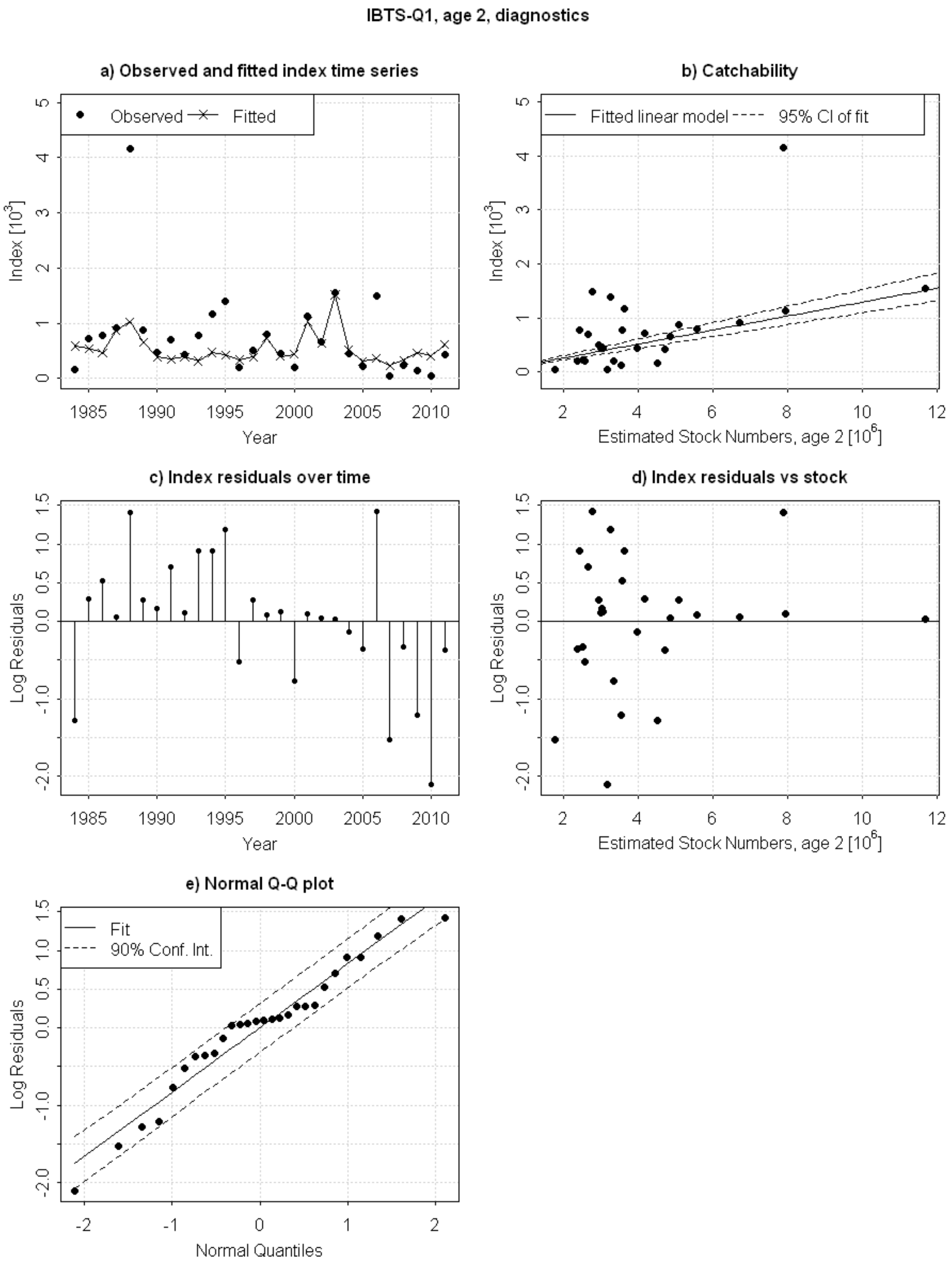


Figure 2.6.1.11. North Sea herring. Diagnostics of IBTS survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr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

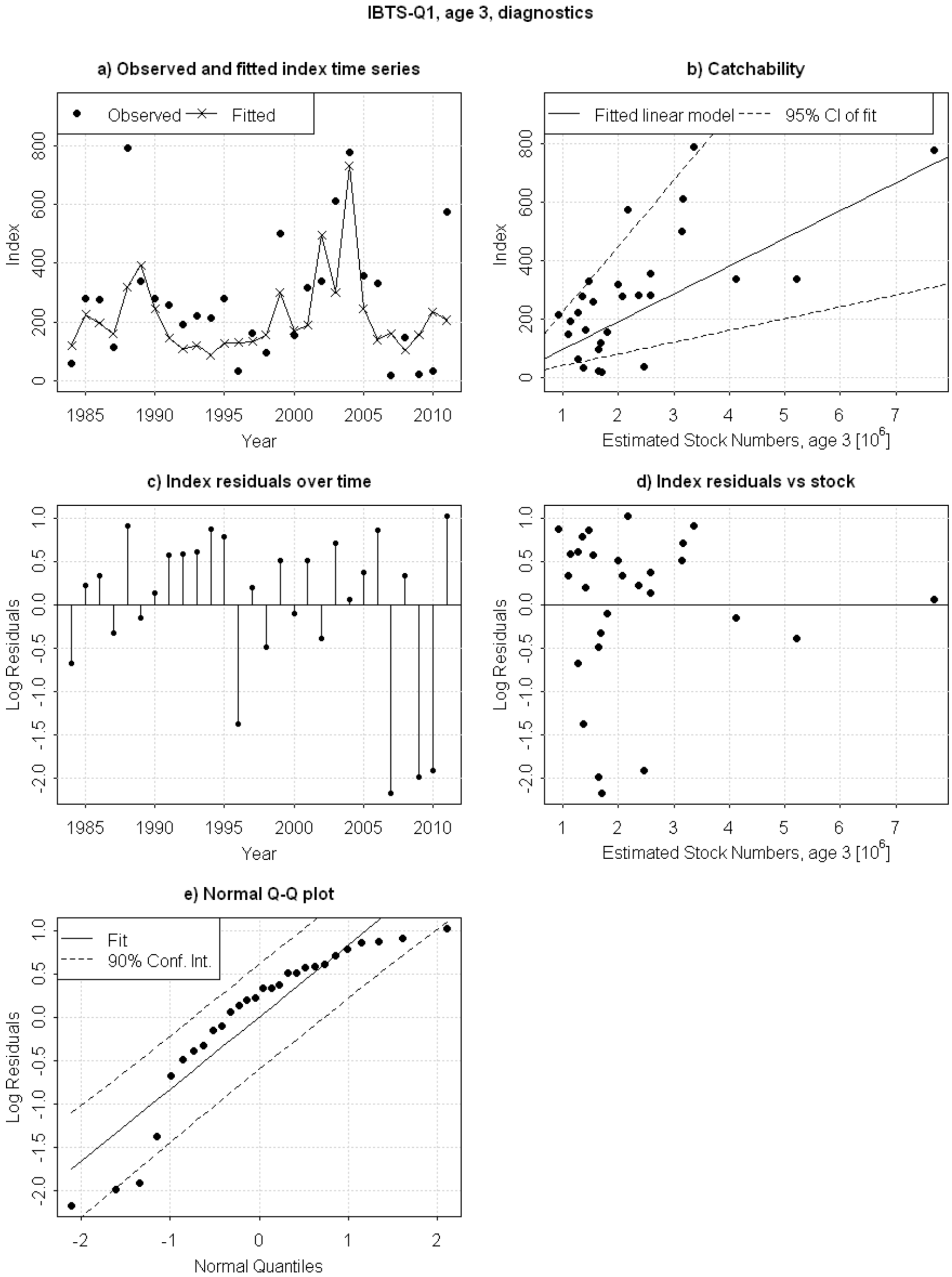


Figure 2.6.1.12. North Sea herring. Diagnostics of IBTS survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr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

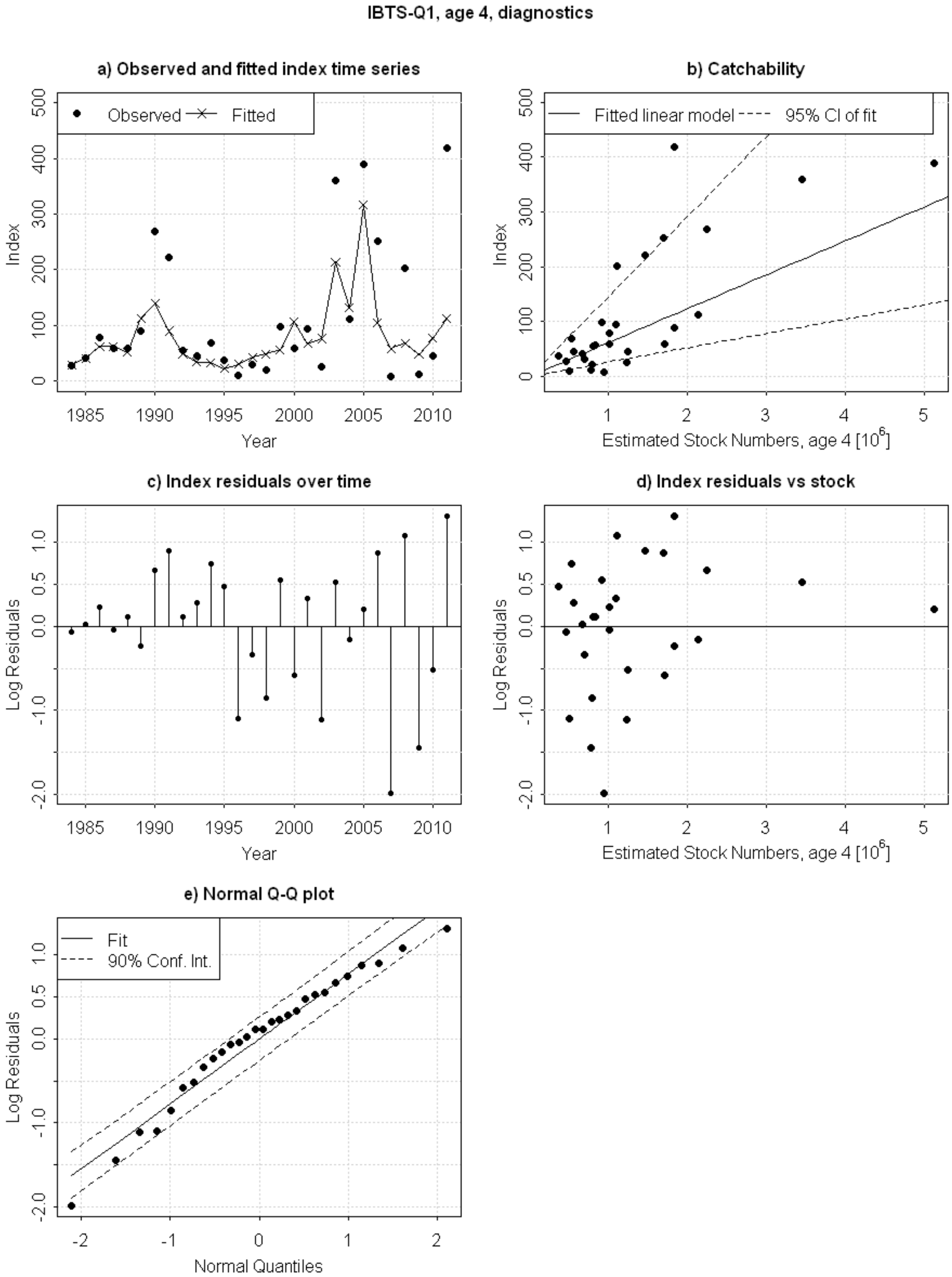


Figure 2.6.1.13. North Sea herring. Diagnostics of IBTS survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr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

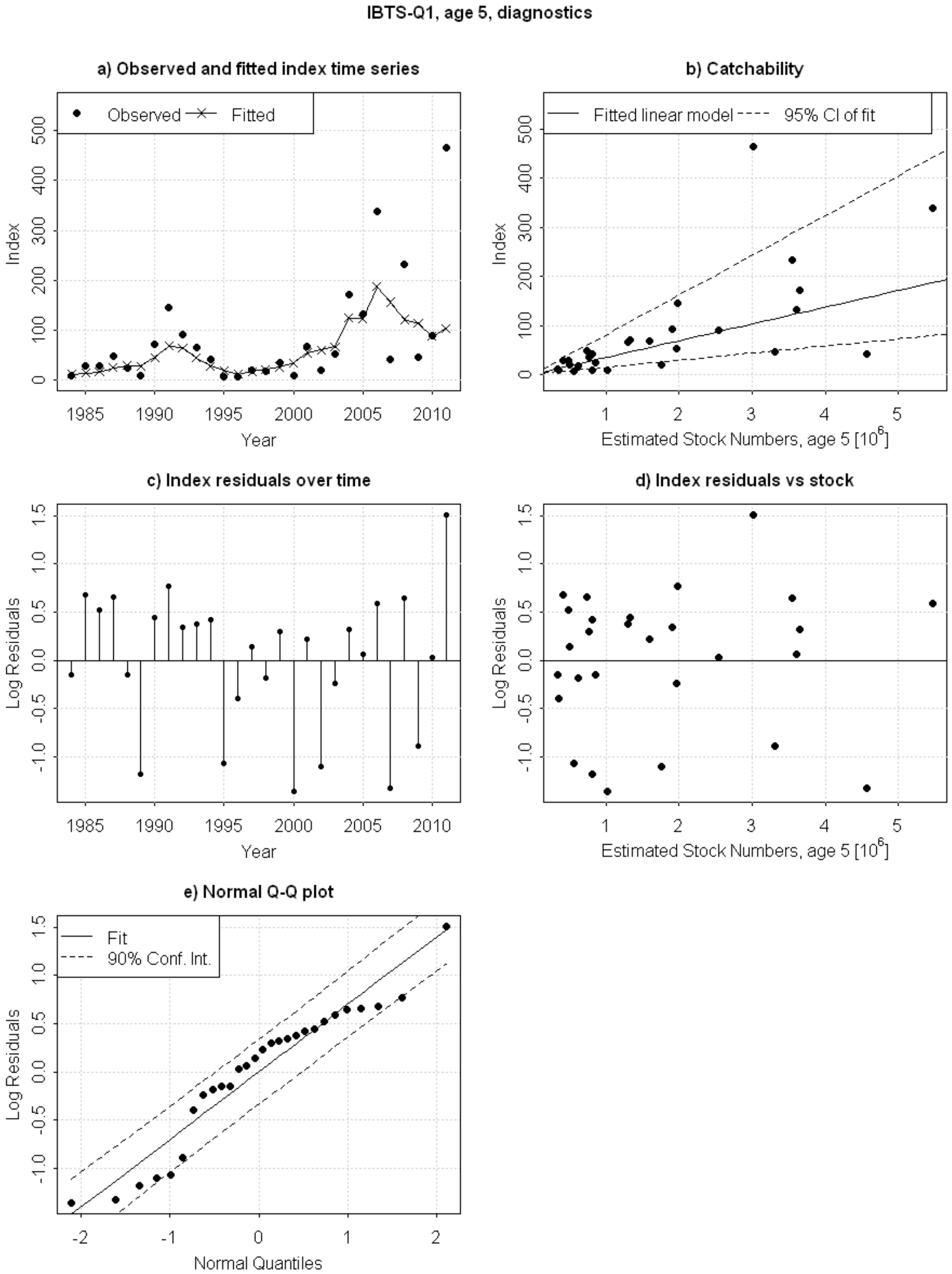


Figure 2.6.1.14. North Sea herring. Diagnostics of IBTS survey catchability at 5+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 5+ wr (line) and numbers predicted from index abundance at 5+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5+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

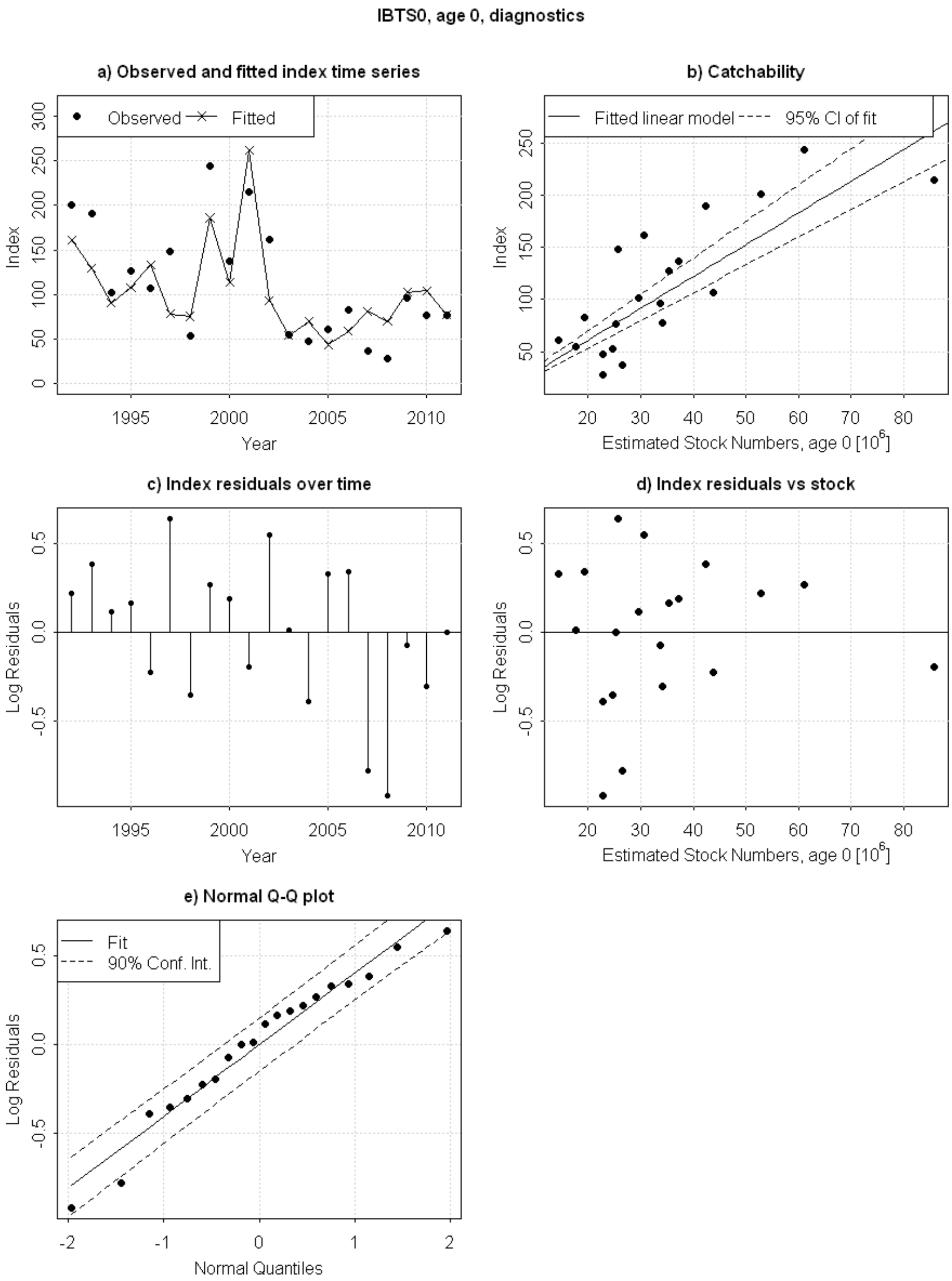


Figure 2.6.1.15. North Sea herring. Diagnostics of IBTS0 survey catchability at 0 wr from the final ICA assessment. Top left: VPA estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at 0 wr. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

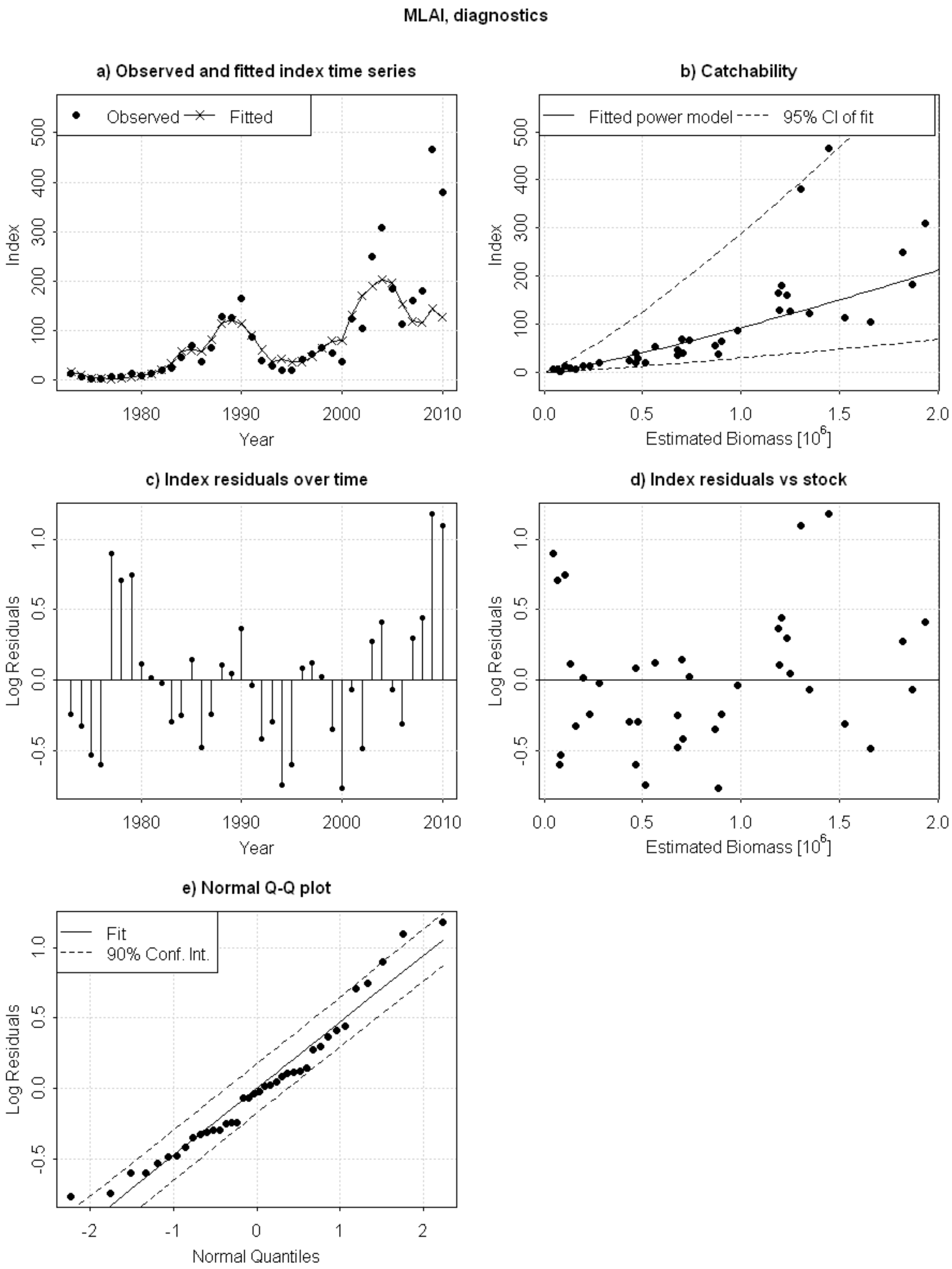


Figure 2.6.1.16. North Sea herring. Diagnostics of MLAI survey catchability at all ages from the final ICA assessment. Top left: VPA estimates of biomass of all ages and biomass predicted from index abundance for all ages. Top right: scatterplot of index observations versus VPA estimates of all ages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

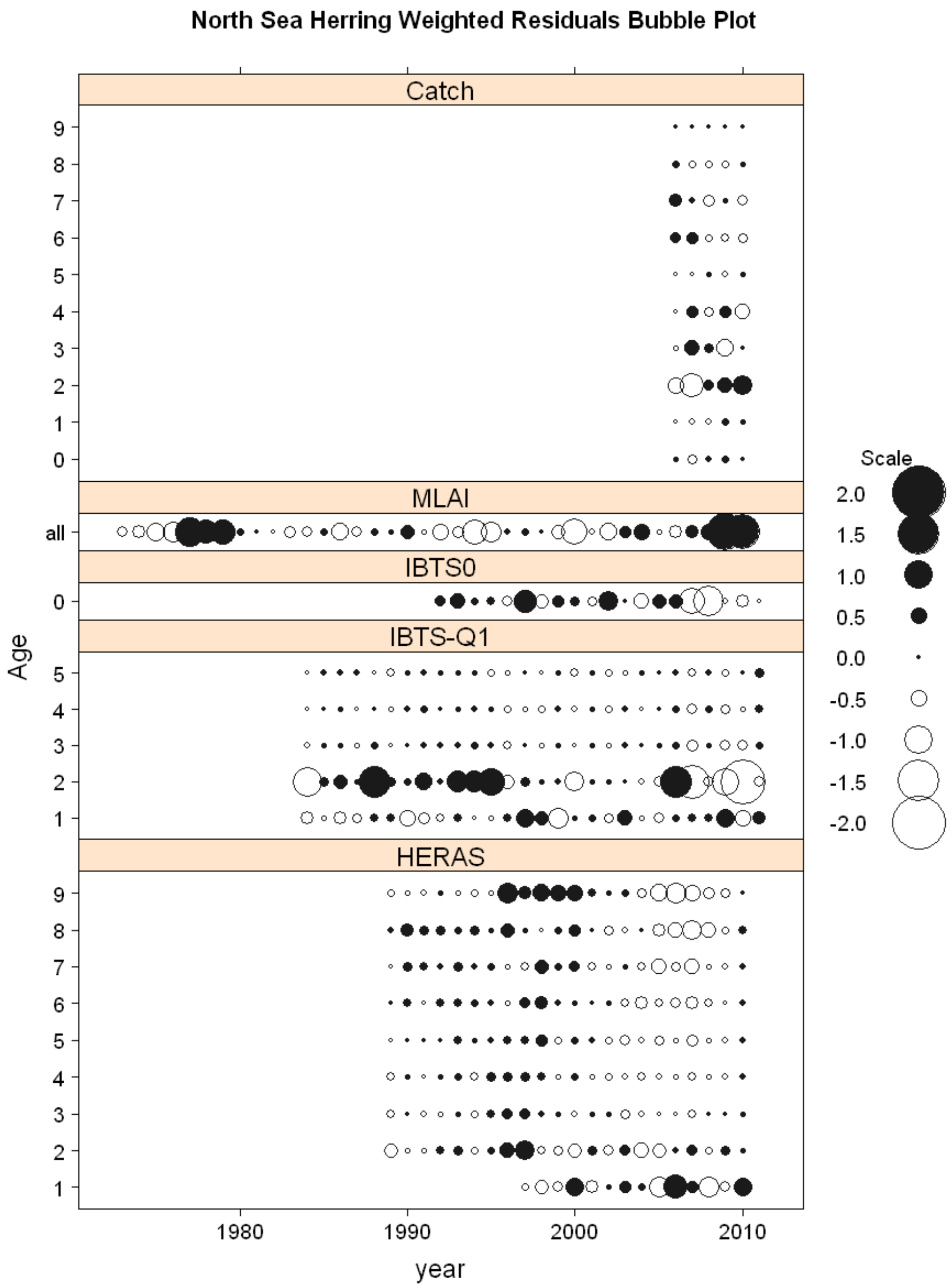


Figure 2.6.1.17. North Sea herring. Weighted Residuals of surveys and catch for the assessment up to 2009.

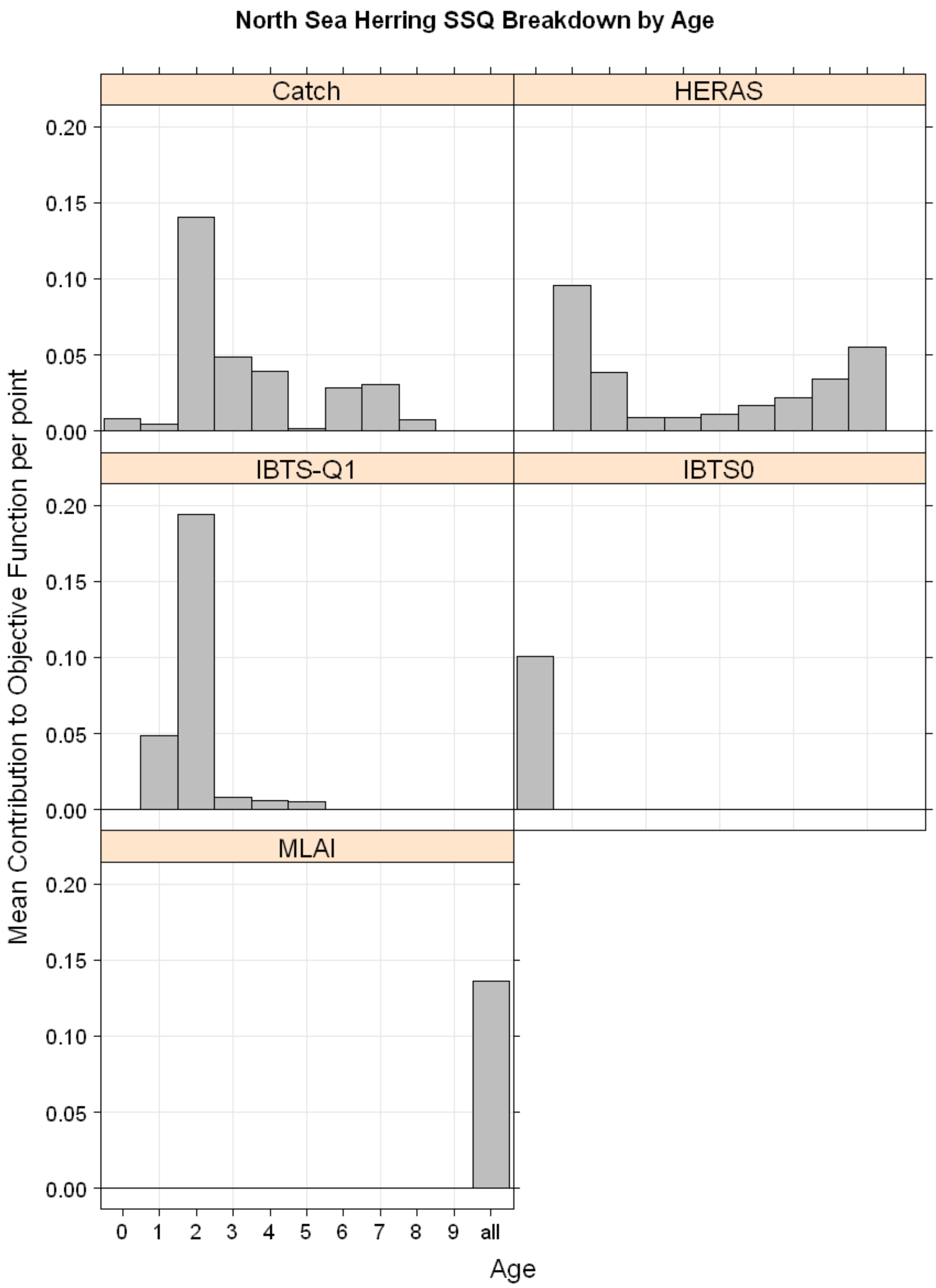


Figure 2.6.1.18. North Sea herring. Mean contribution of each indices or catch to the objective function by age.

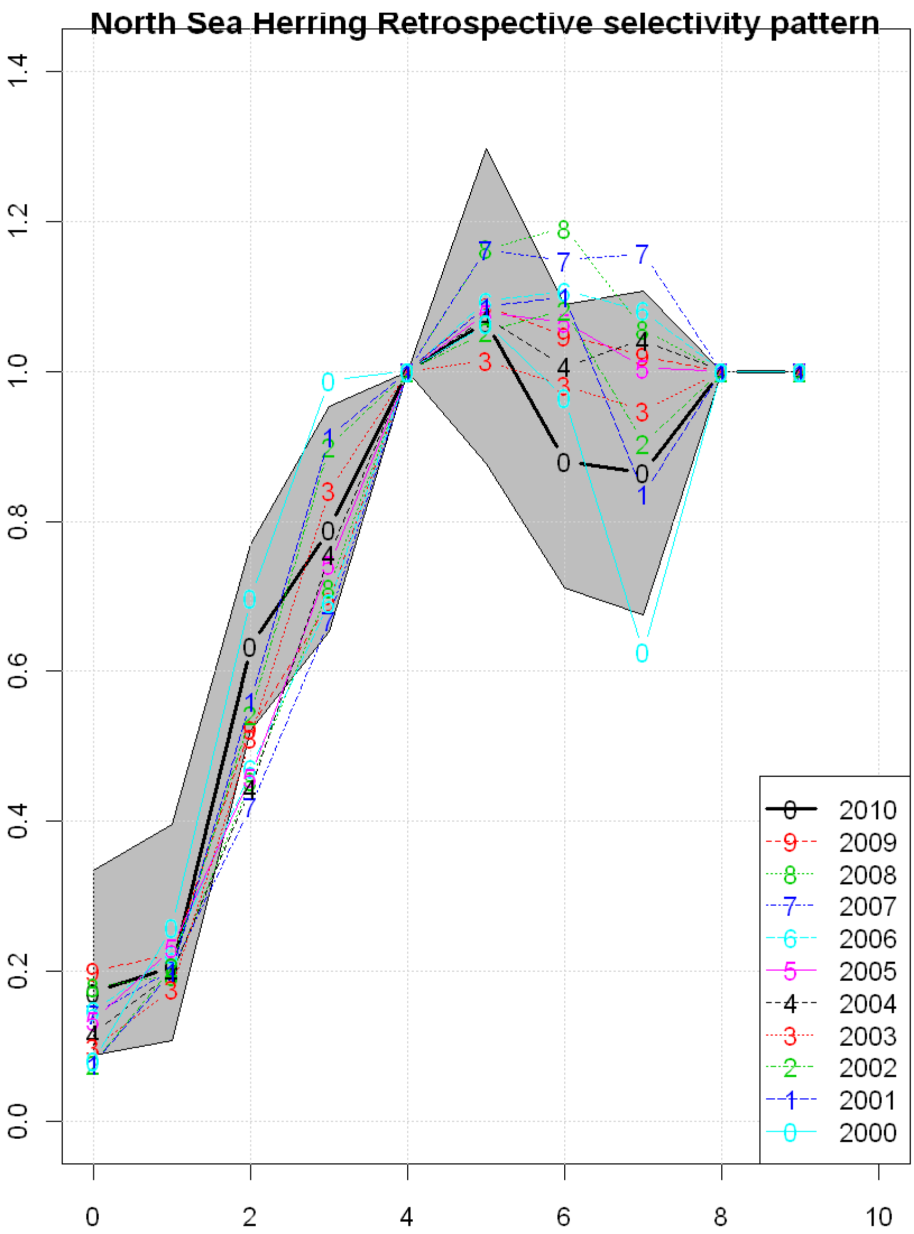


Figure 2.6.1.19. North Sea herring. Retrospective selectivity pattern for the year 2000 till 2009.

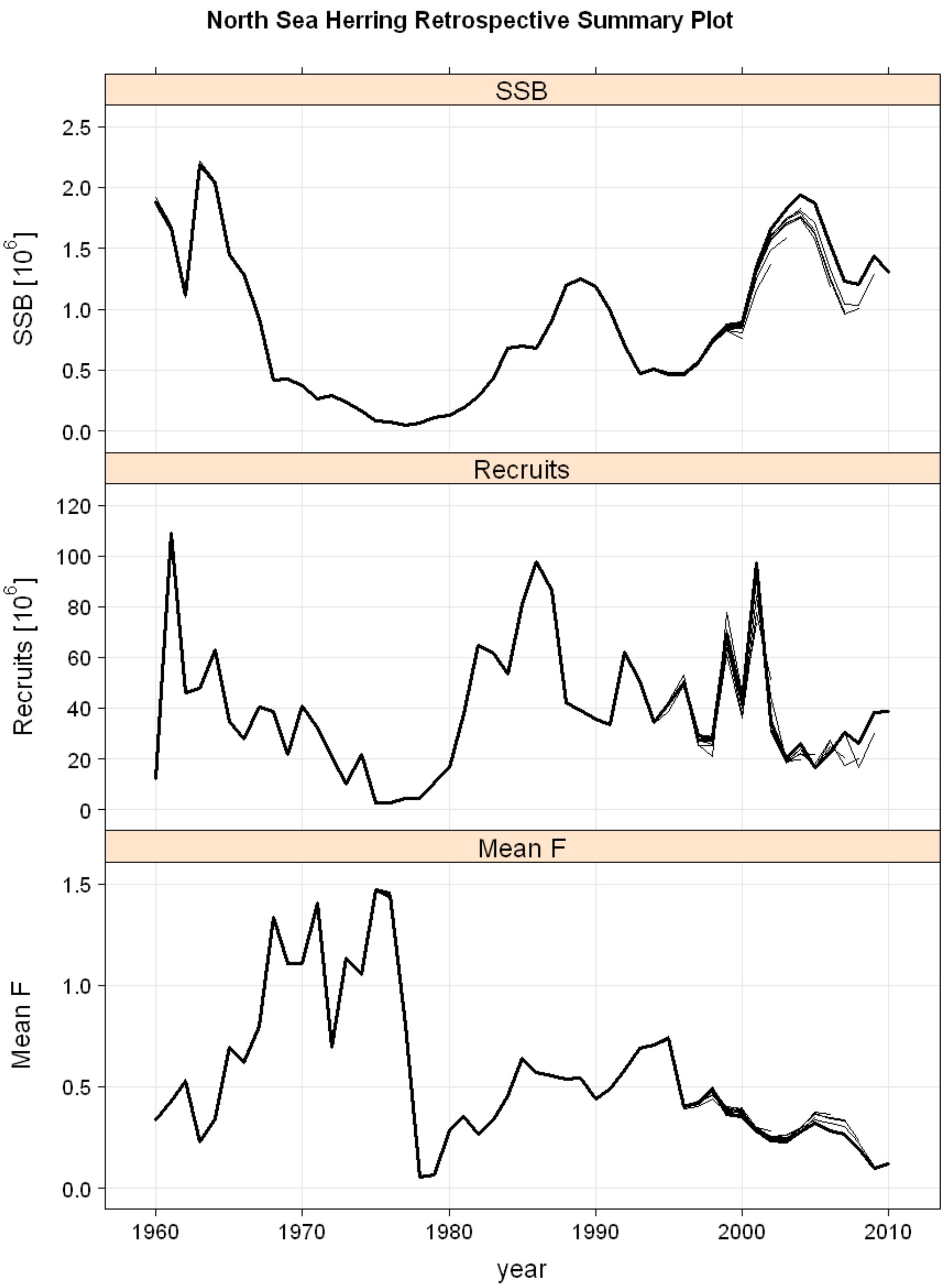


Figure 2.6.1.20. North Sea herring. Retrospective pattern plots for SSB, Recruits and $F_{2\text{-}6}$

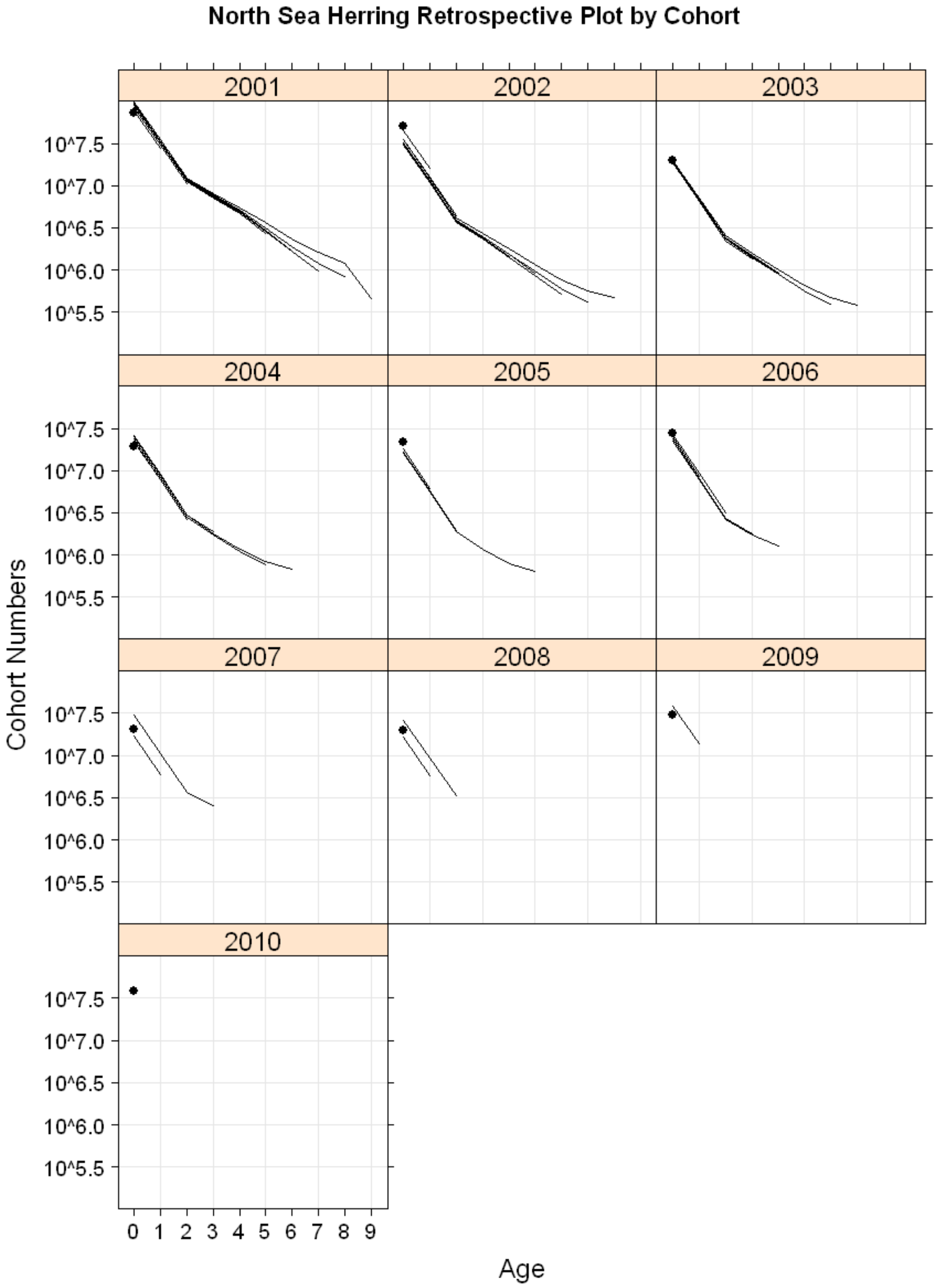


Figure 2.6.1.21. North Sea Herring. Year class cohort retrospectives for cohorts that contribute the current stock of North Sea herring.

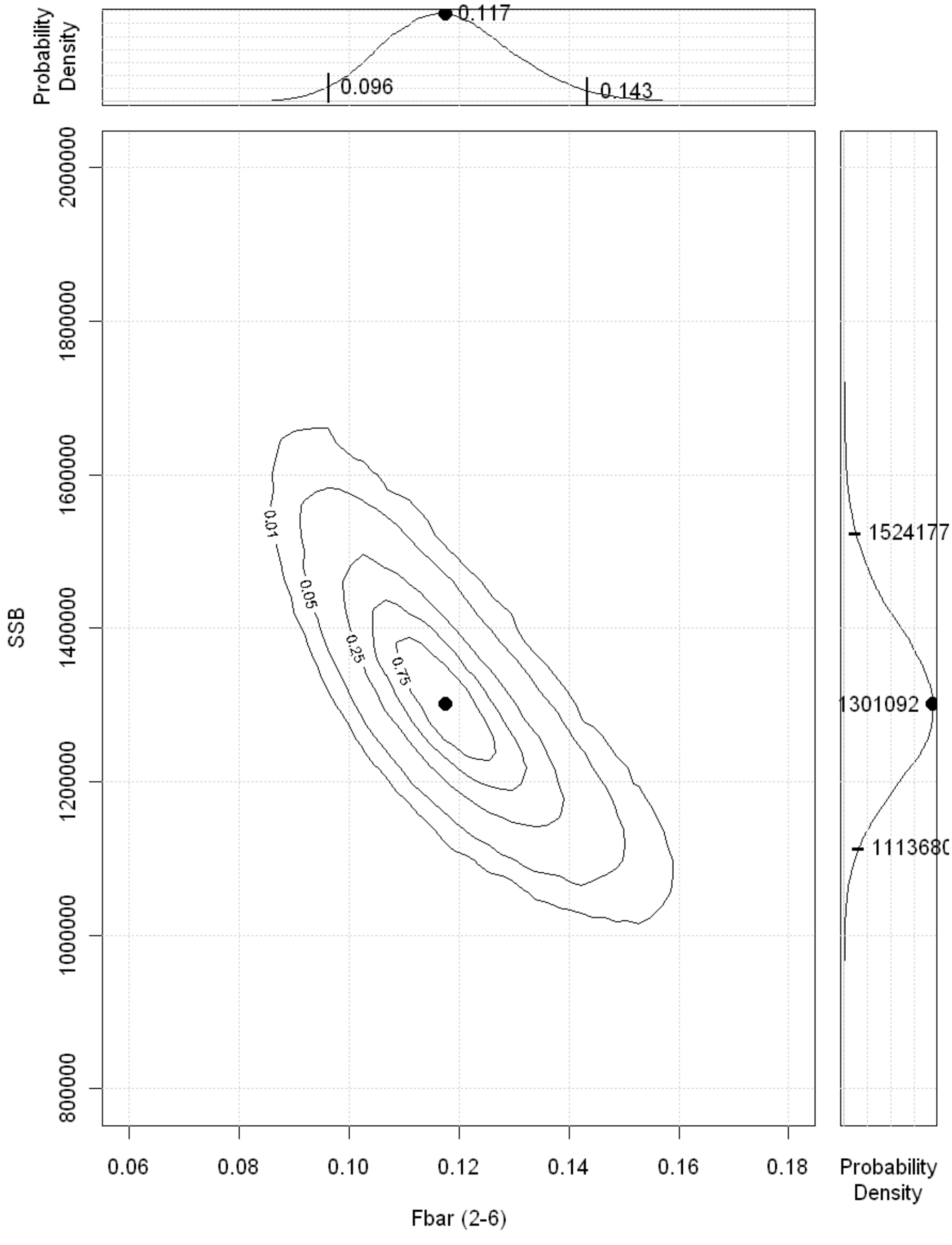


Figure 2.6.1.22 Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

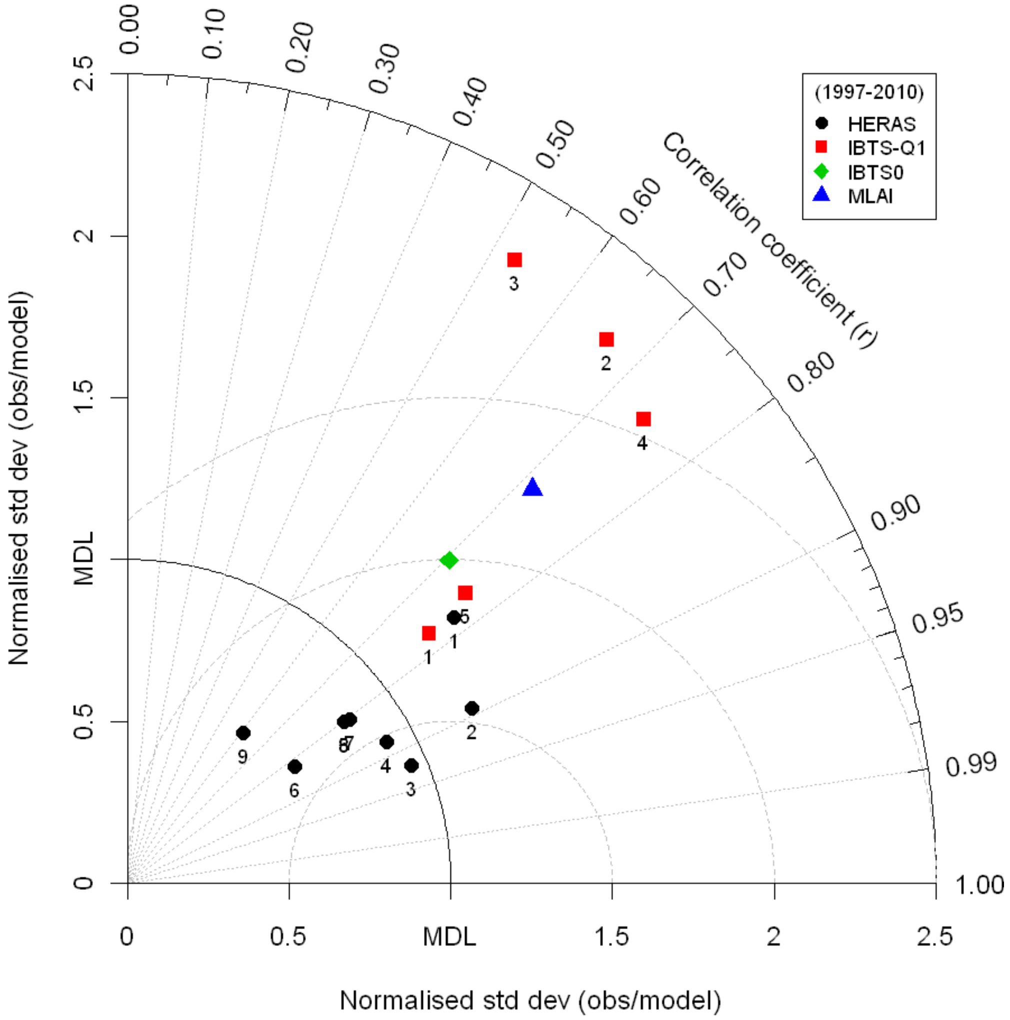


Figure 2.6.1.23 Example of a Taylor diagram (Taylor 2001, Payne 2011) for North Sea herring. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modelled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modelled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labelled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.

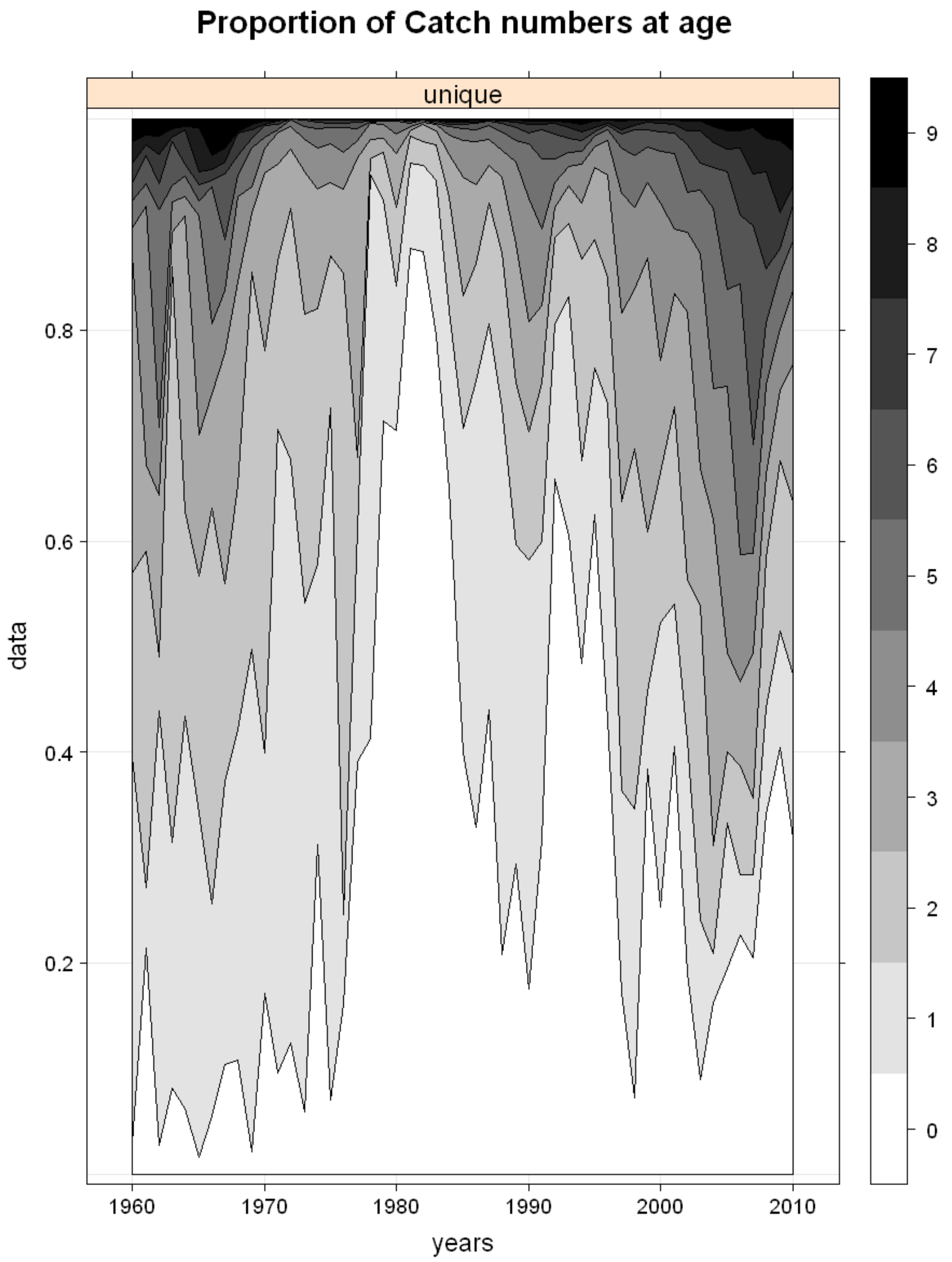


Figure 2.6.1.24 North Sea Herring. Proportion of catch numbers at age.

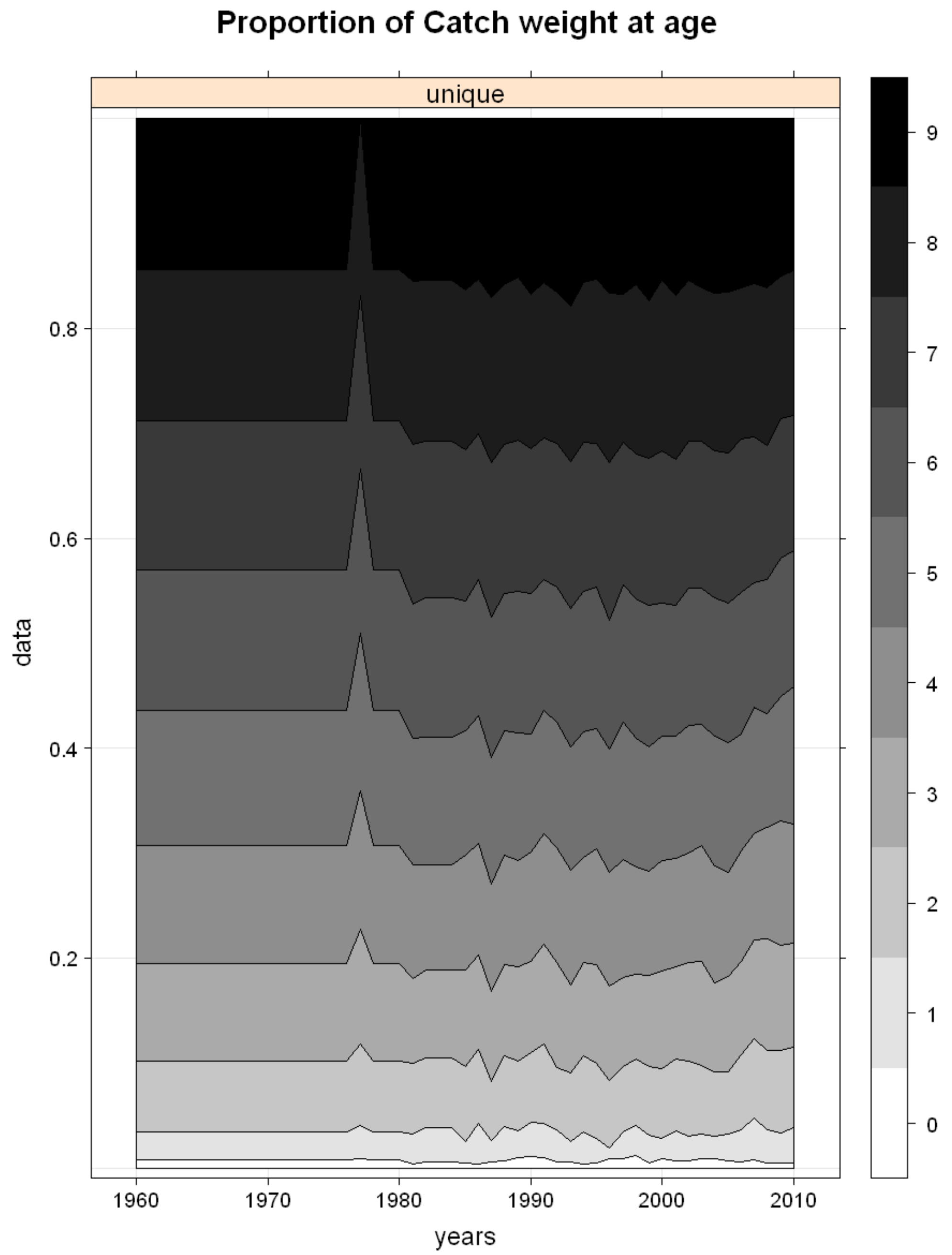


Figure 2.6.1.25 North Sea Herring. Proportion of catch weight at age.

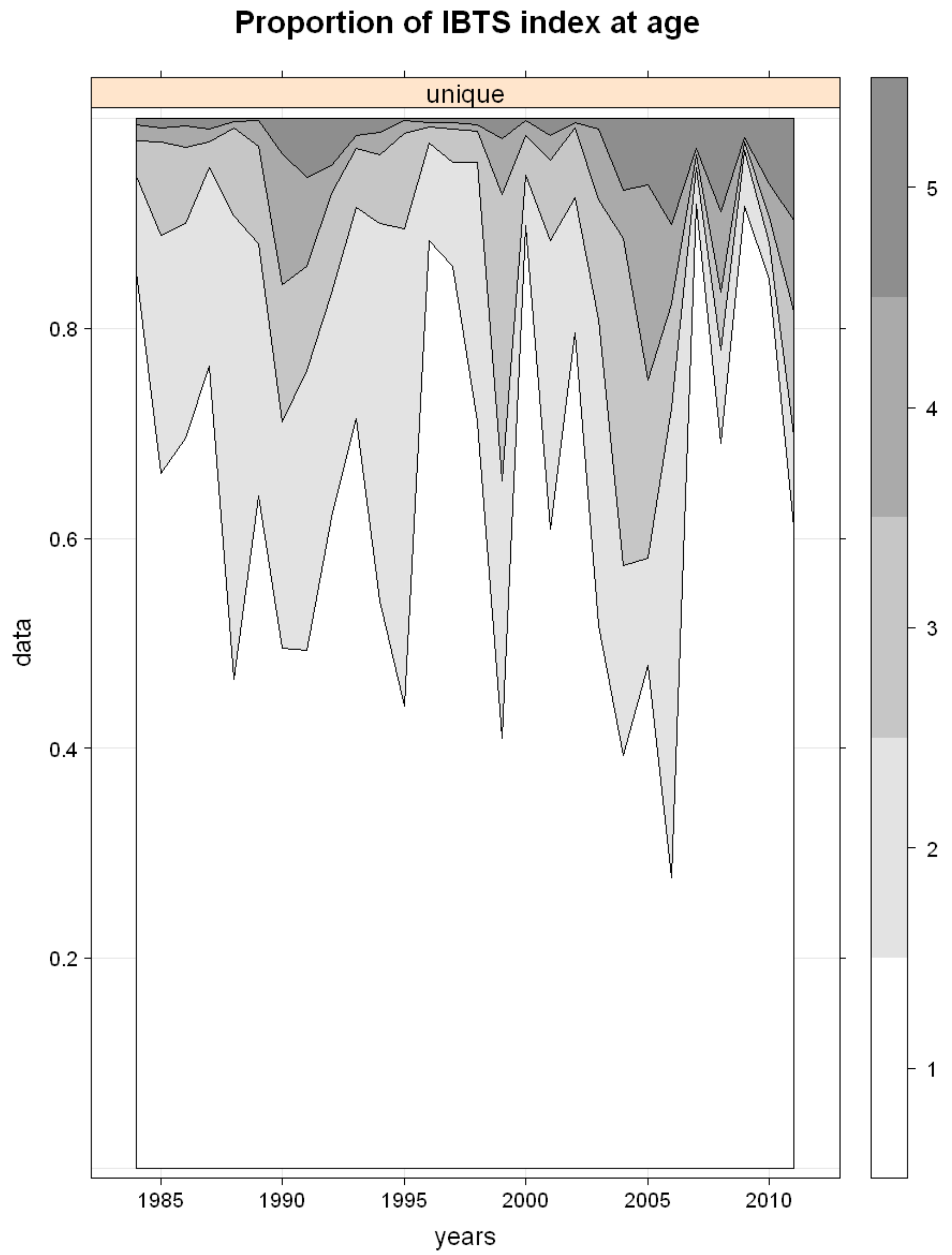


Figure 2.6.1.26 North Sea Herring. Proportion of IBTS index at age.

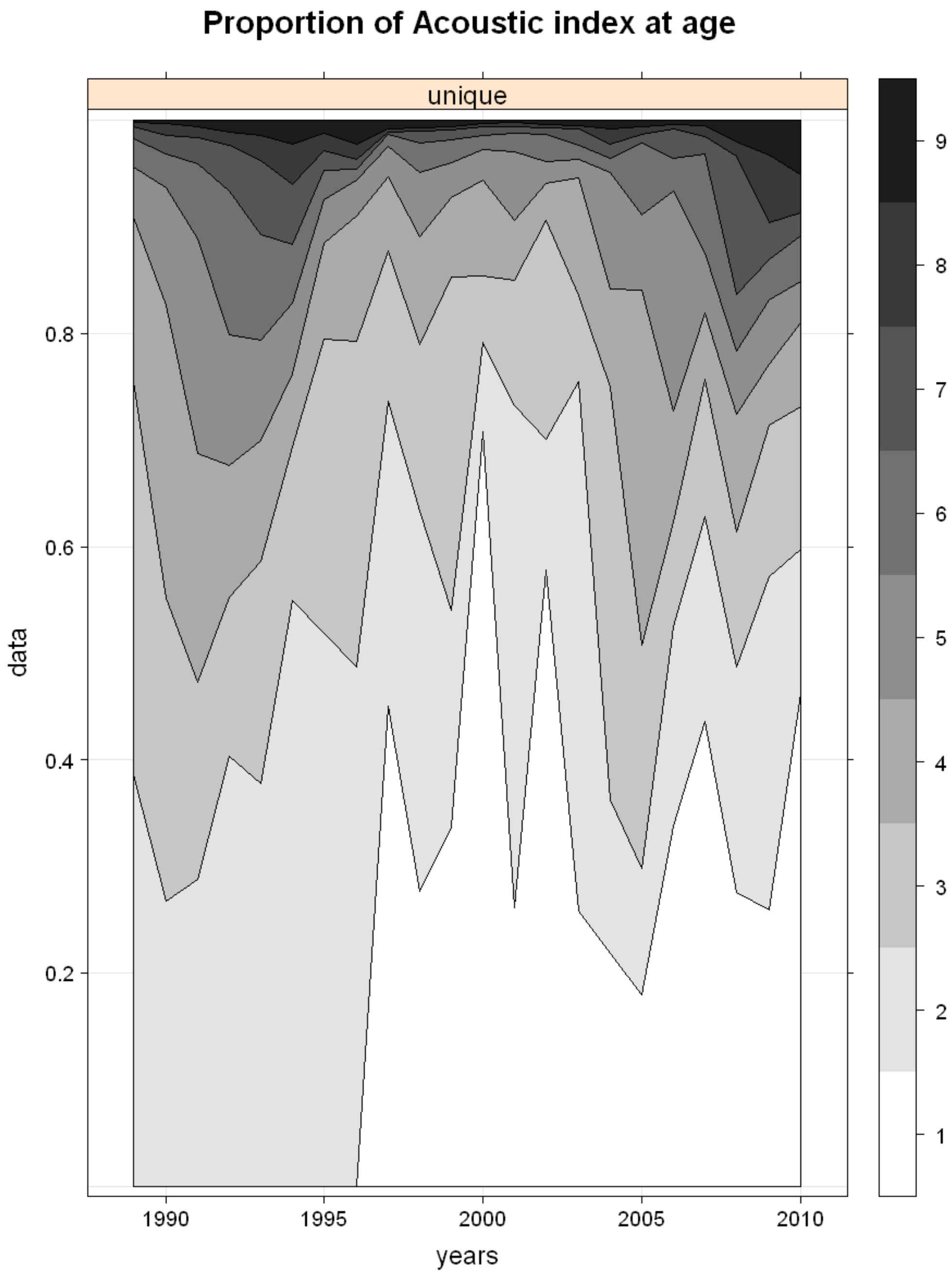


Figure 2.6.1.27 North Sea Herring. Proportion of Acoustic index at age.

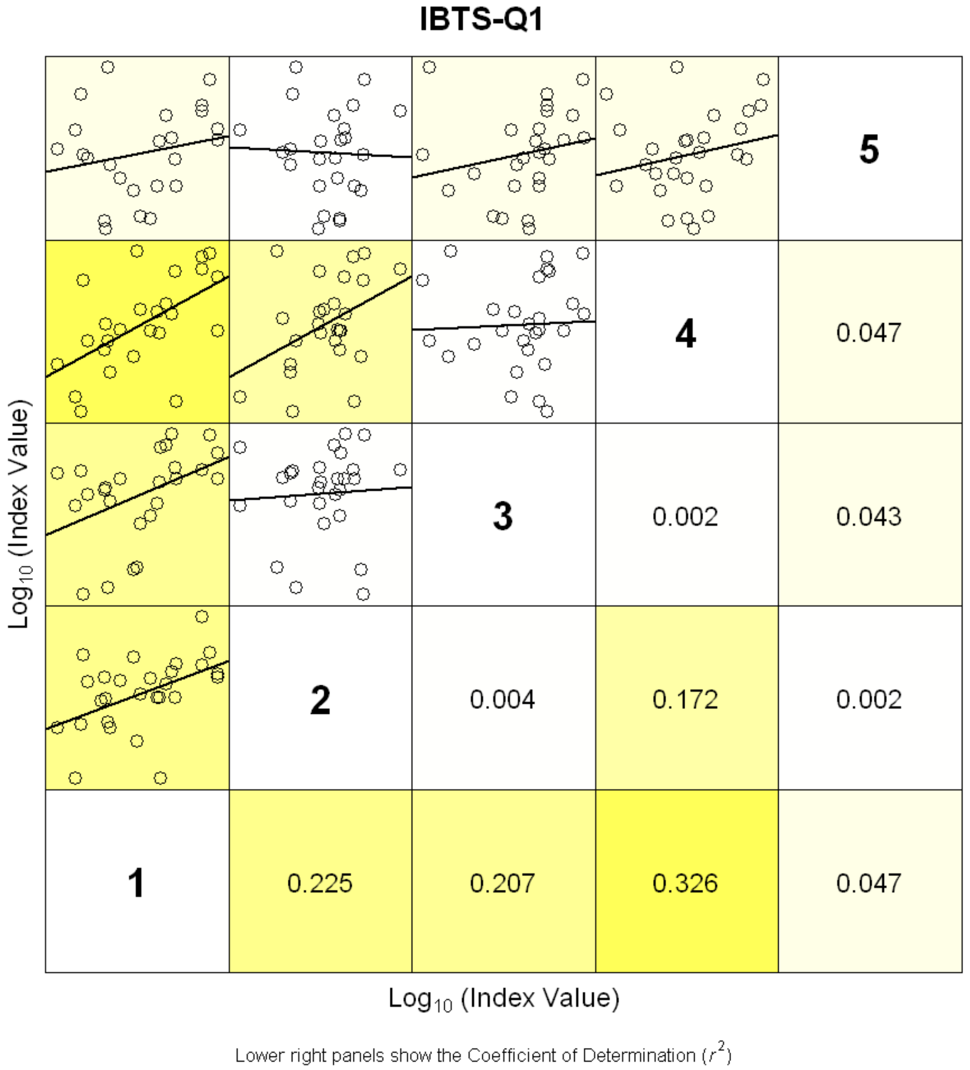


Figure 2.6.1.28 North Sea Herring. Correlation coefficient diagram for IBTS survey.

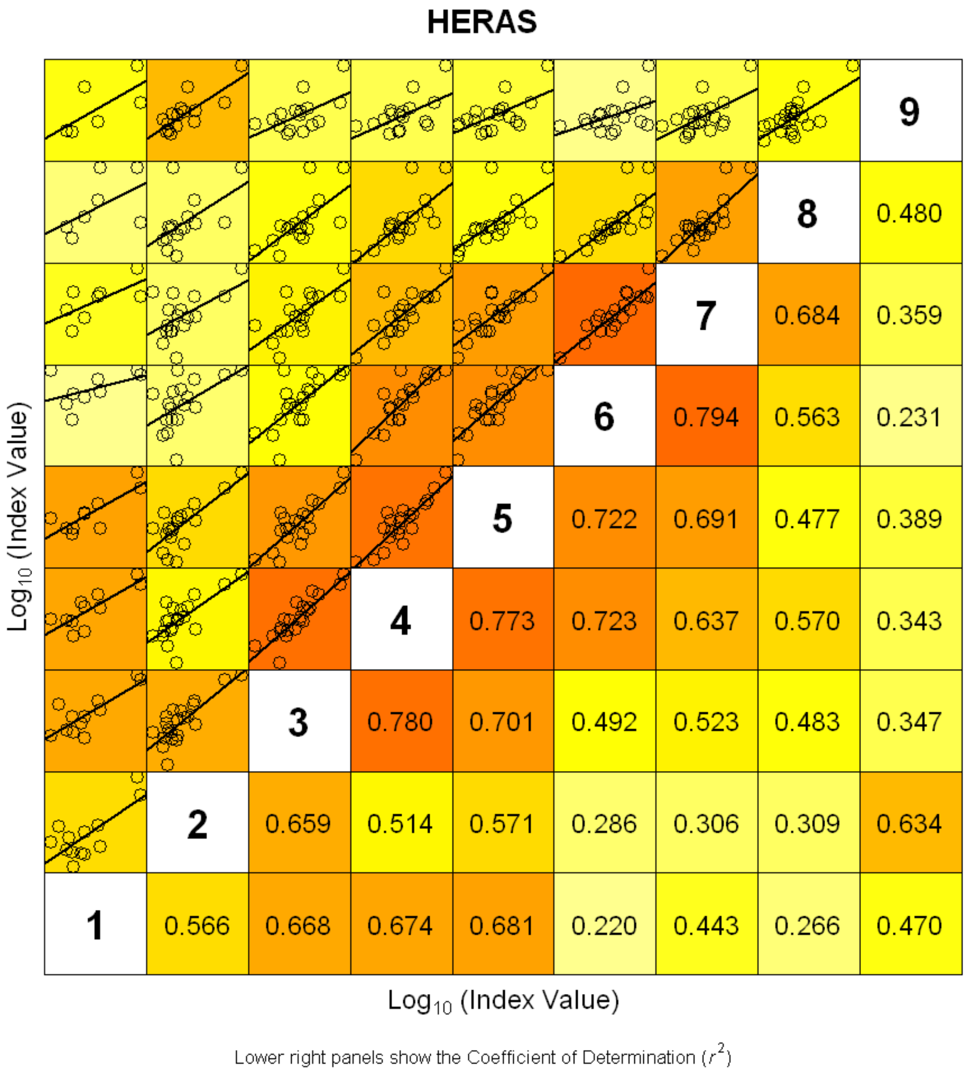


Figure 2.6.1.29 North Sea Herring. Correlation coefficient diagram for Acoustic survey.

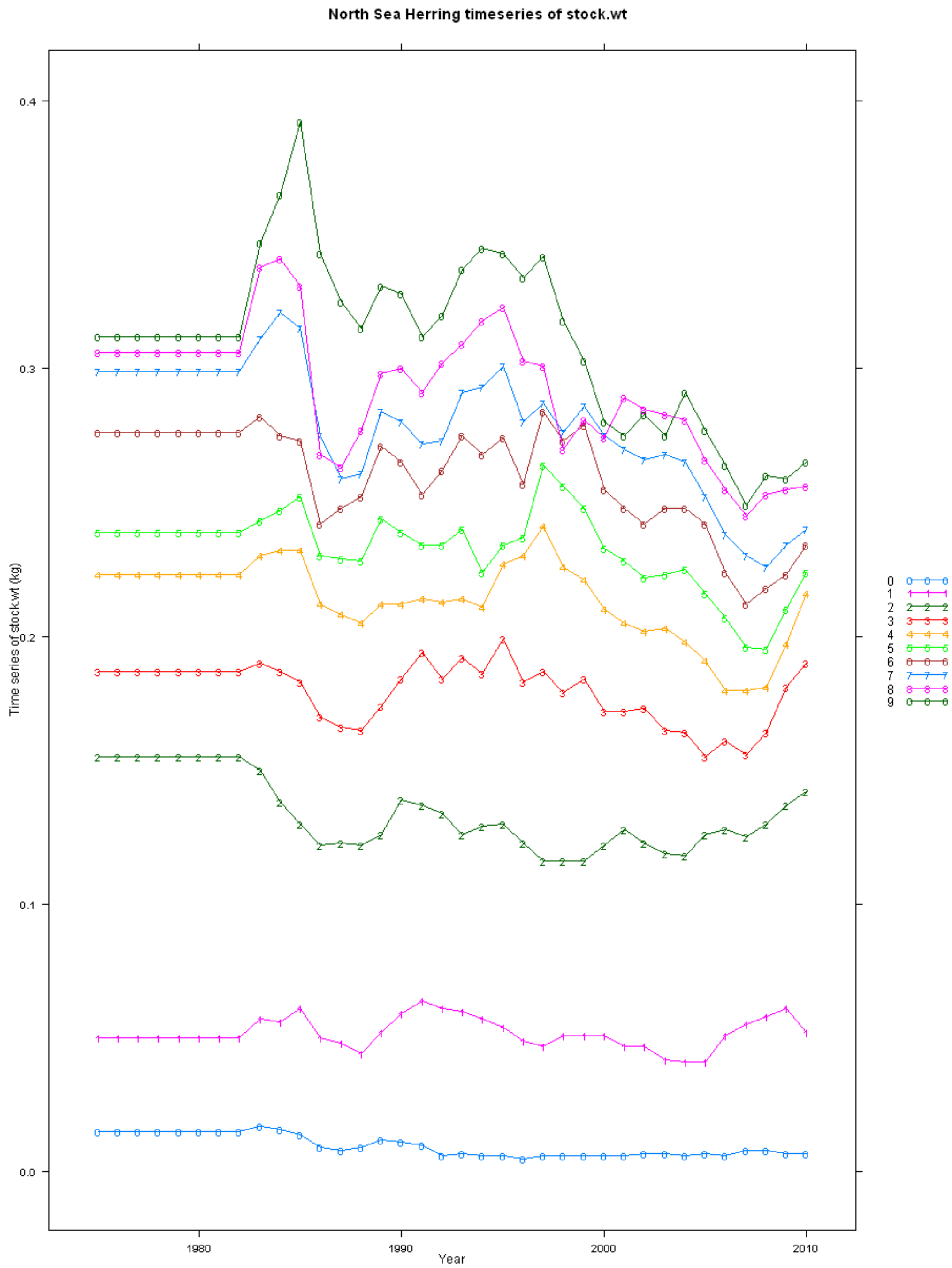


Figure 2.6.1.30 North Sea Herring. Weight at age in the stock over time.

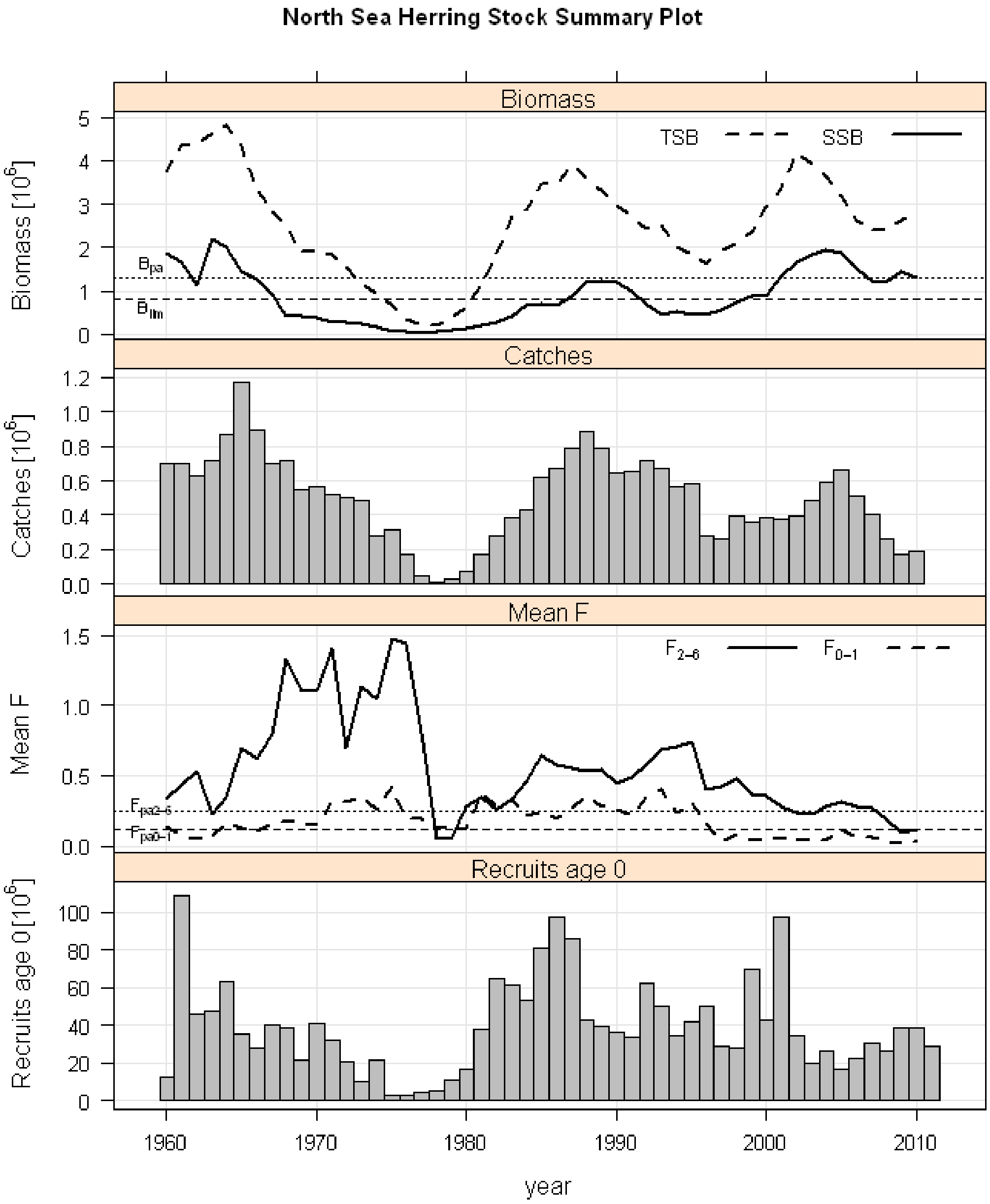


Figure 2.6.3.1. North Sea herring. Stock summary plot for SSB, recruitment and mean F on ages 2-6.

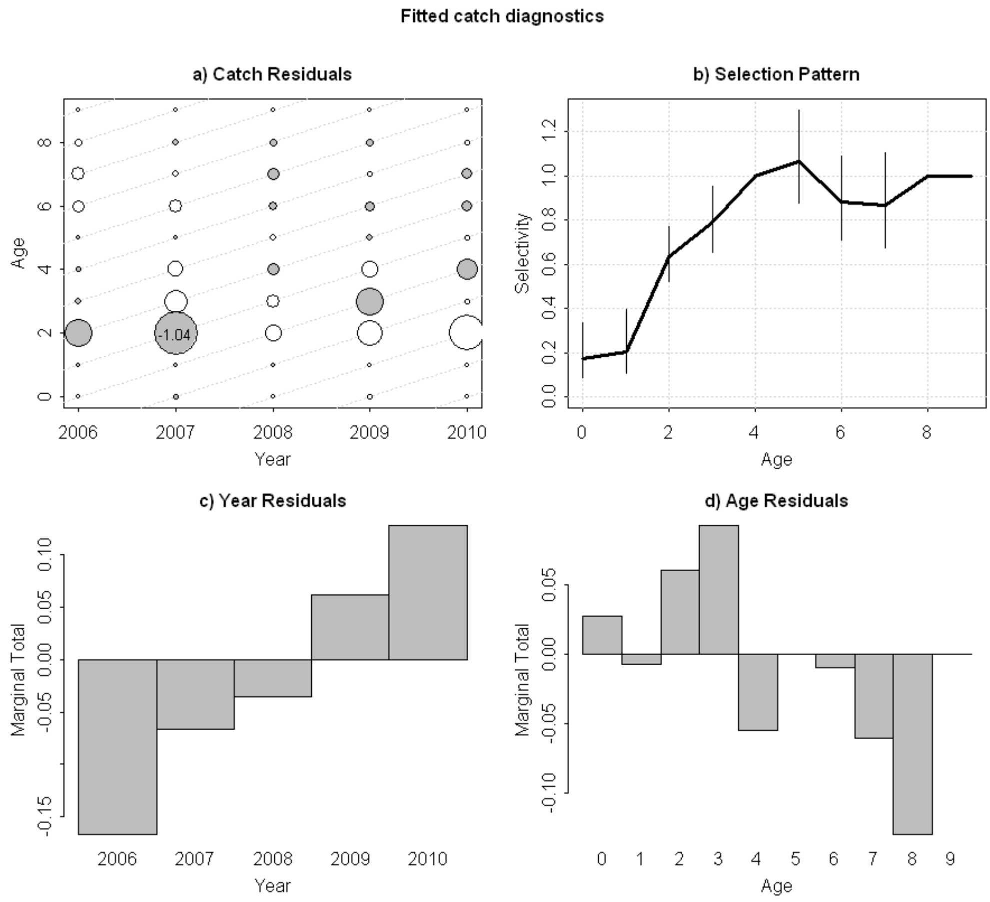


Figure 2.6.3.2. North Sea herring. Diagnostics of selection pattern from the final ICA assessment. Top left: bubbles plot of log catch residuals by age (weighting applied) and year (5 yr separable period). Top right: estimated selection parameters (relative to 4 wr) with 95% confidence intervals. Bottom left: marginal totals of log residuals by year. Bottom right: marginal totals of log residuals by age (wr).

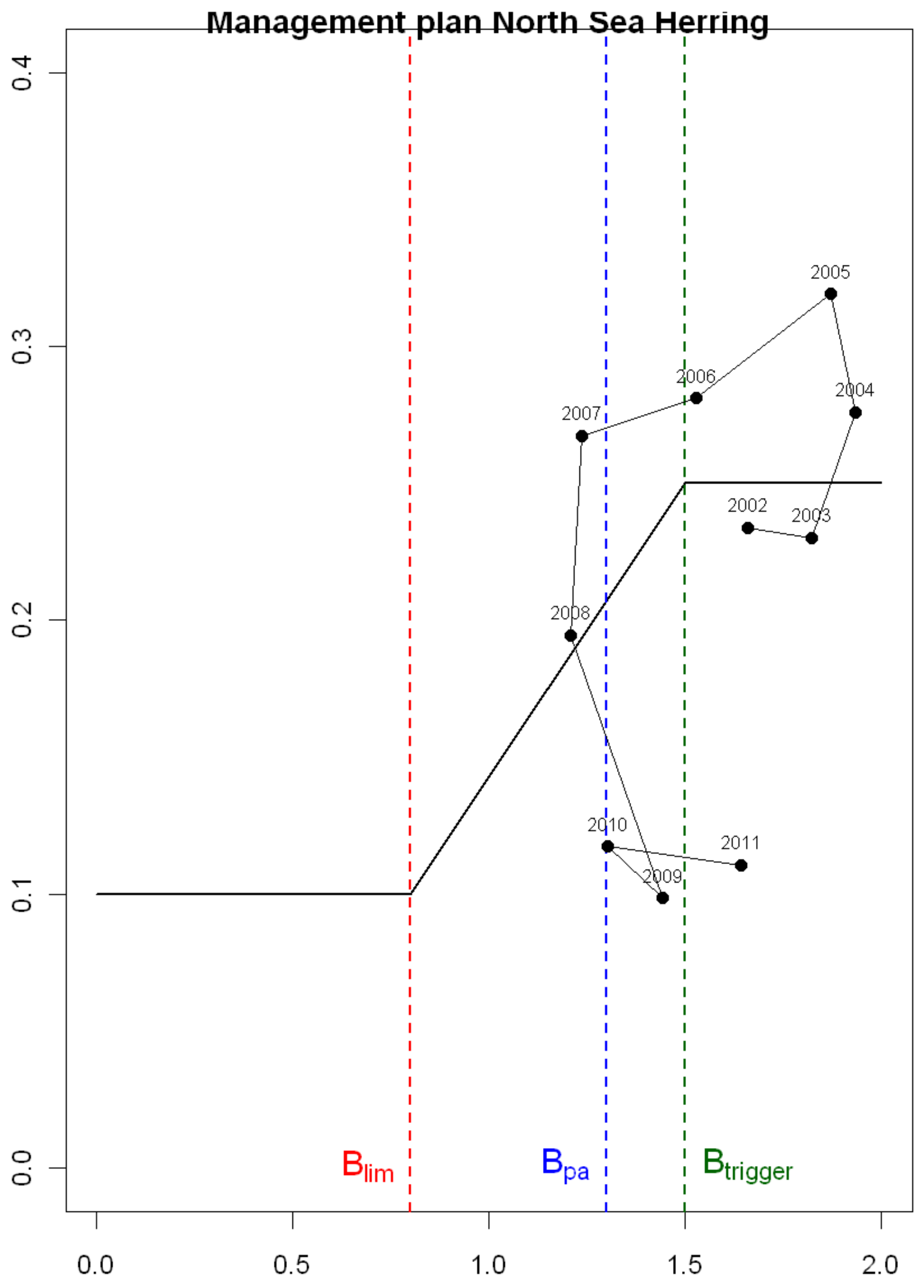


Figure 2.6.3.3. North Sea herring. Agreed management plan for adult fishery (A-fleet, ages 2-6) including trigger biomass points (B_{lim} and $B_{trigger}$) and B_{pa}. Black dots represent realised estimated fishing mortalities from 2002 untill 2008. Fishing mortality in 2009 is estimated based on the agreed TACS for the A-fleet from the short term prediction (see section 2.7).

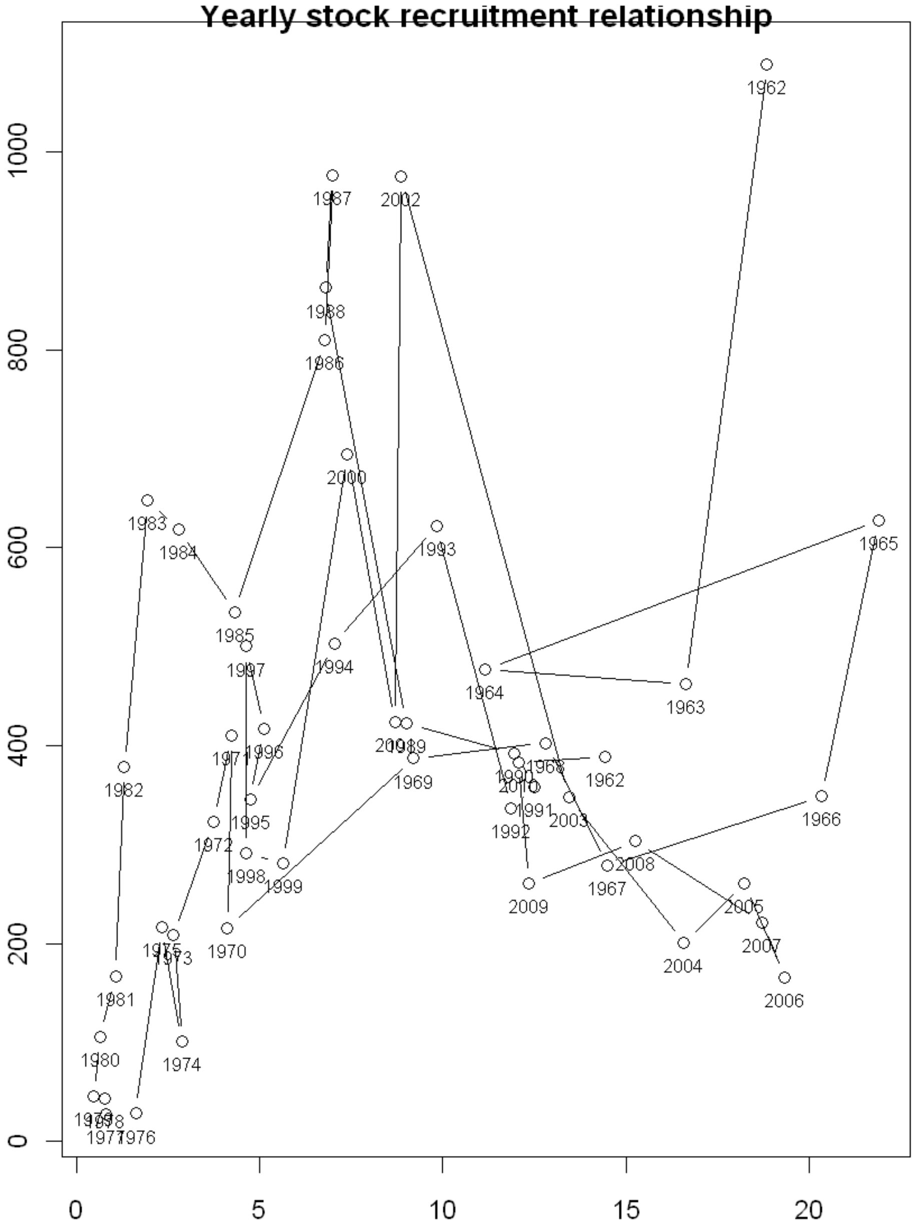


Figure 2.6.3.4. North Sea herring. Stock and recruit plot. Each point labelled by year class.

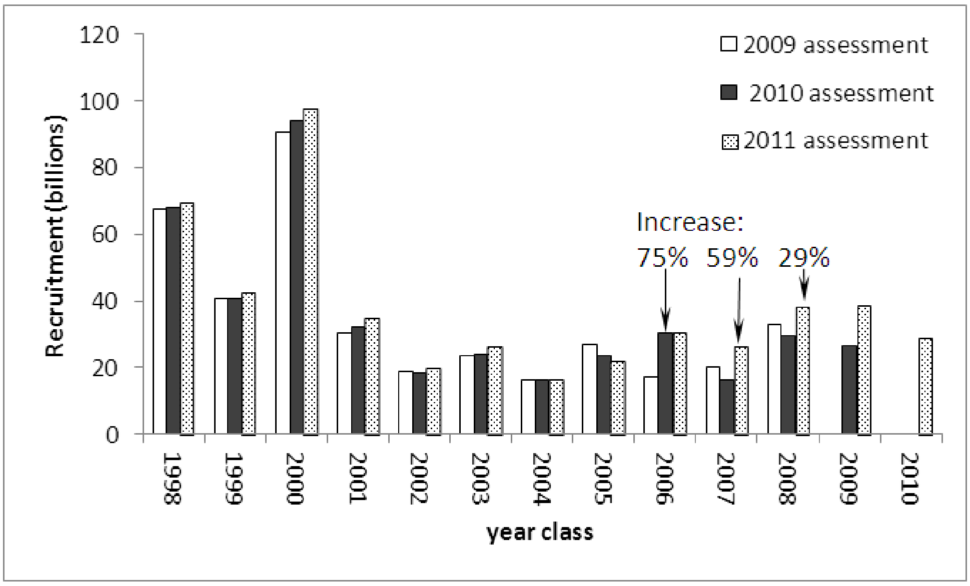


Figure 2.10.1. North Sea Herring. Estimates of recruitment (by year class) from stock assessments in the three most recent years (2009-2011). The increases in year class strength that impact on SSB estimation in recent years are highlighted.

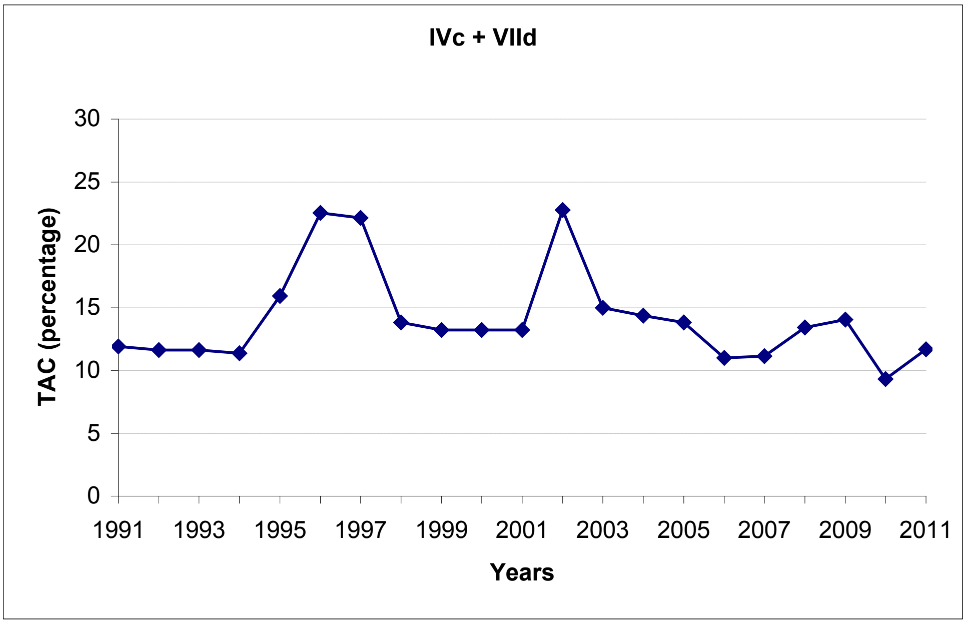


Figure 2.11.1. North Sea herring. TACs (percentage) for Sub Divisions IVc and VIId

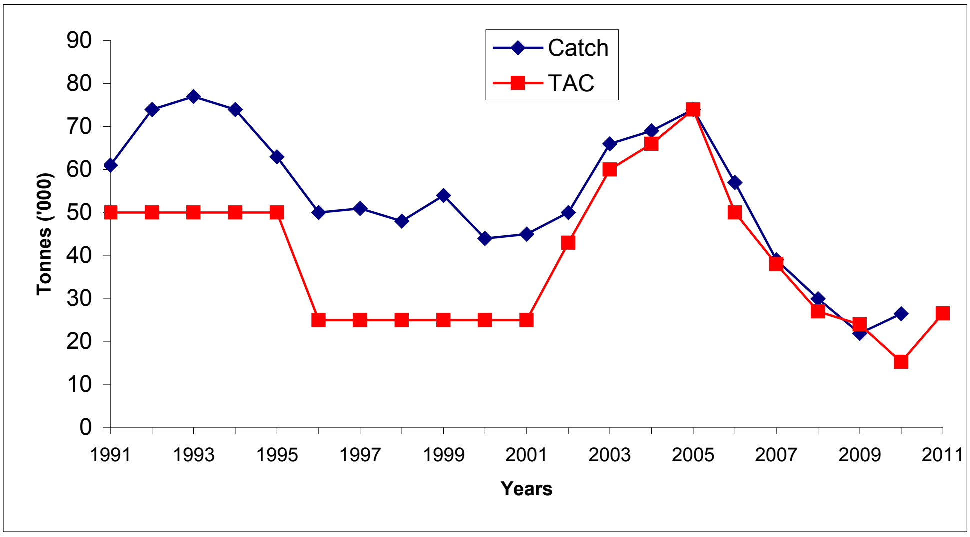


Figure 2.11.2. Downs herring in IVc and VIId. Comparison of historical catches and TACs

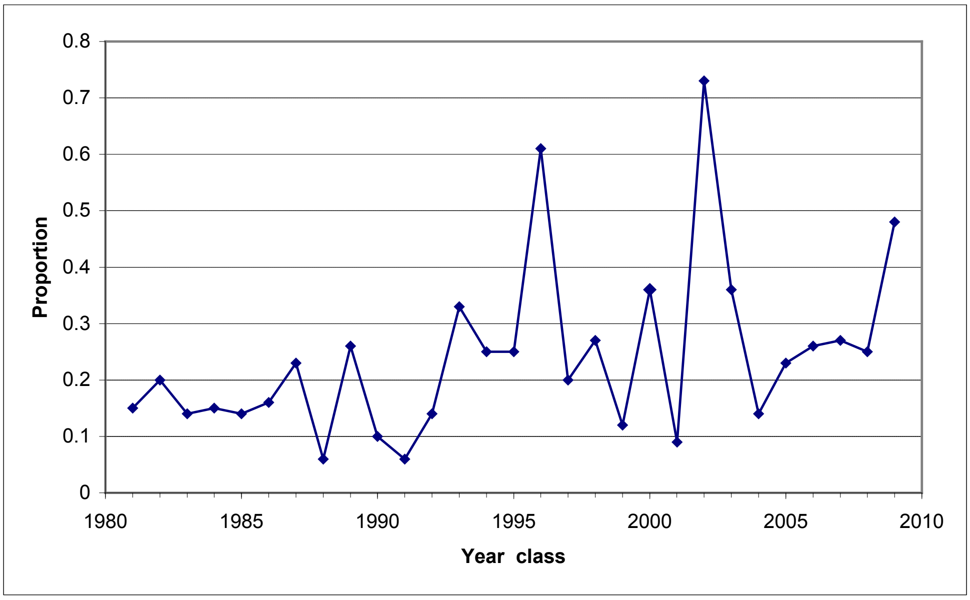


Figure 2.11.3. Downs herring. Proportion of small 1-ringers versus all sizes in the North Sea (from table 2.3.3.2).

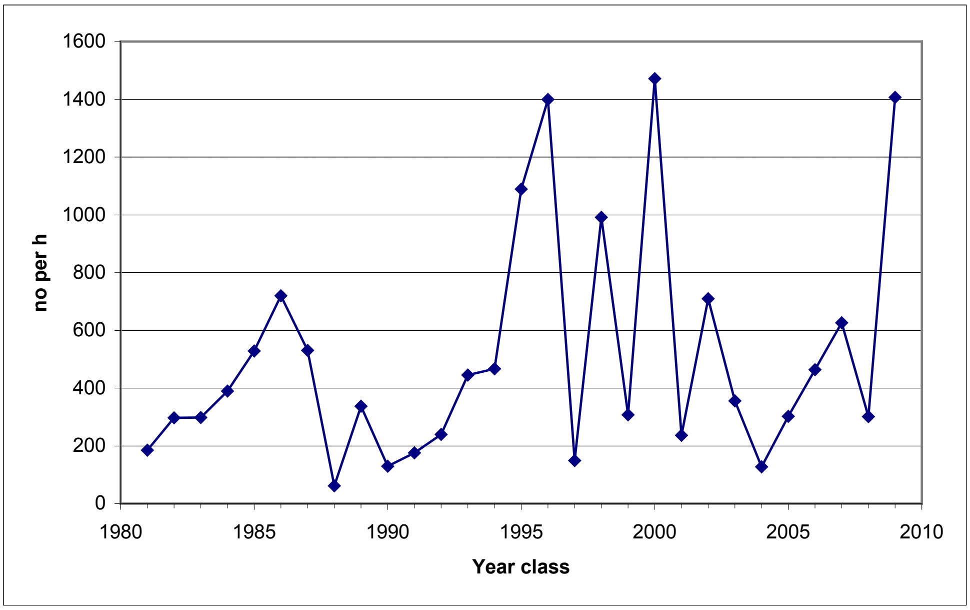


Figure 2.11.4. Downs herring. Index of small (<13cm) 1-ringers in the North Sea (from table 2.3.3.2).

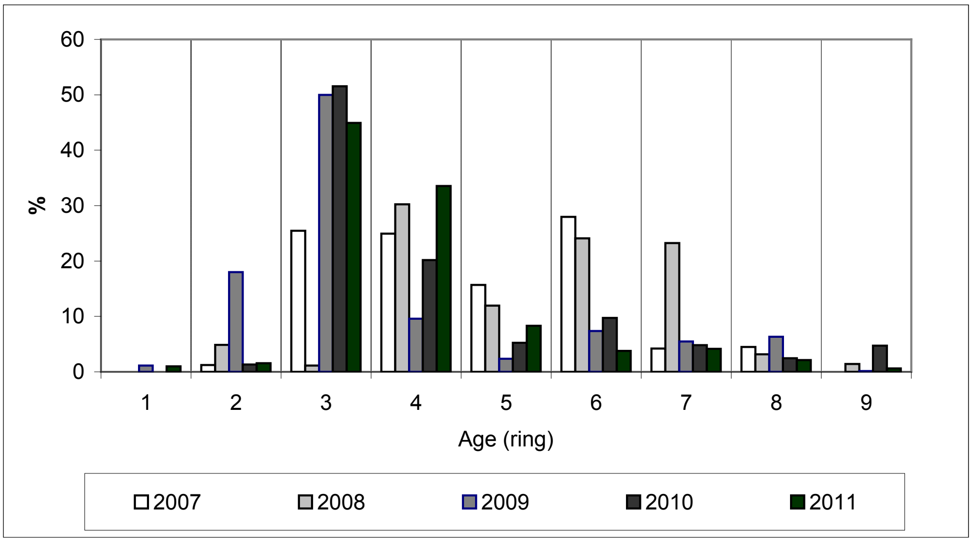


Figure 2.11.5. Downs herring. Catch composition (percentage by age) from pelagics hauls in the Eastern English Channel during IBTS 2007 to 2011.

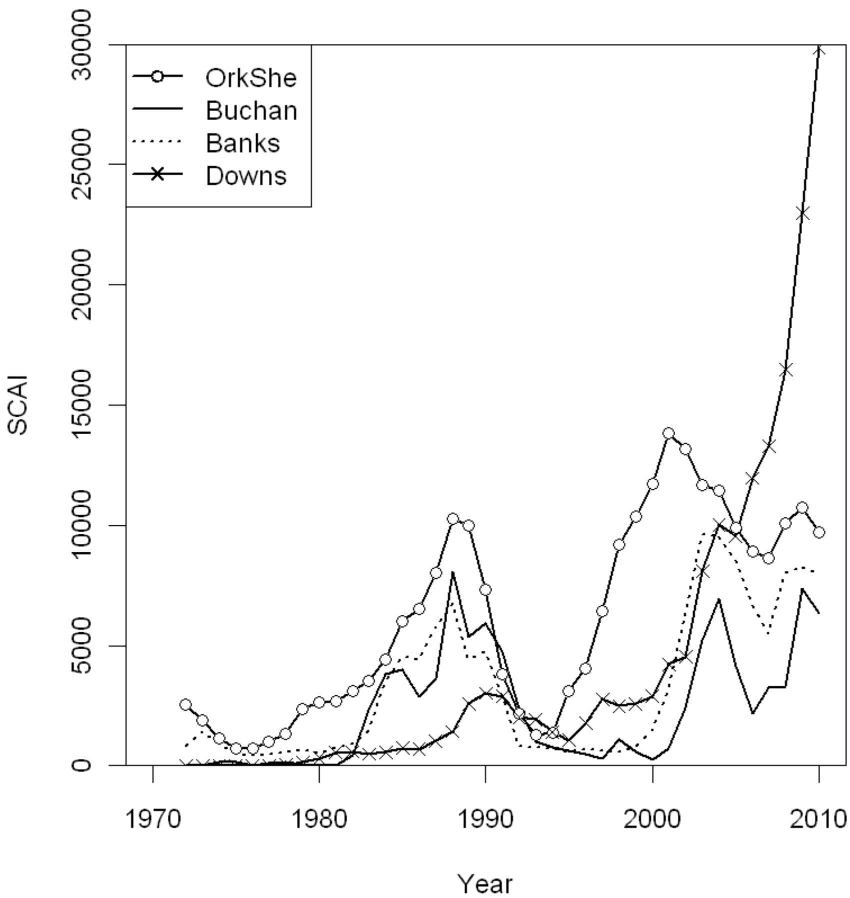


Figure 2.12.1. North Sea herring. Spawning component abundance indices (SCAI: Payne 2010) for each of the four generally recognised spawning components in the North Sea

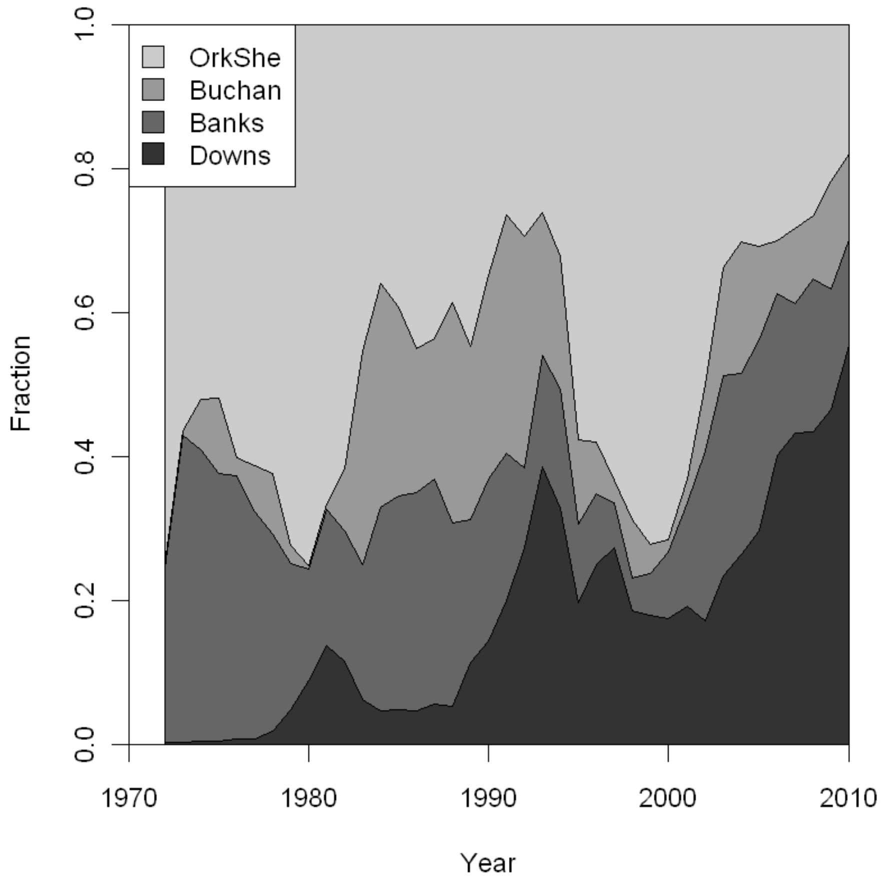


Figure 2.12.2. North Sea herring. Relative contribution of each spawning component to the total North Sea stock, based on the spawning component abundance indices (SCAI: Payne 2010)

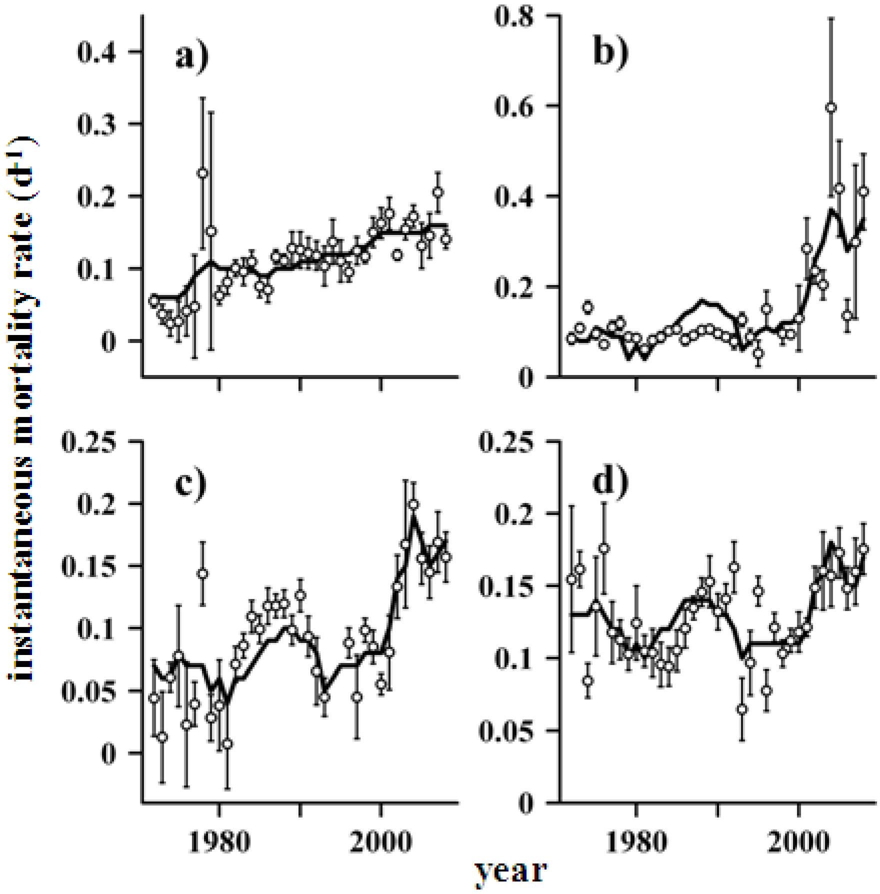


Figure 2.12.3. North Sea herring. Estimated mean mortality rates of herring larvae from the four different spawning components in the North Sea: (a) Downs, (b) Banks, (c) Buchan and (d) Orkney/Shetland taken from Fassler *et al* in press. Error bars represent 95% confidence intervals. Fitted trends in the mortality rates estimated by dynamic factor analysis (DFA) are represented by the black lines. Please note the different scales used on the y-axes.

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

3.1 The Fishery

3.1.1 Advice and management applicable to 2010 and 2011

A benchmark assessment was carried out in 2008. In the absence of a management plan and agreed target and precautionary reference points ICES advised that fishing mortality should be less than the F related to high long-term yield (F = 0.25). This would correspond to landings of less than 37,200 t in 2011 as estimated by the last year assessment (ICES CM 2010/ACOM:06).

The EU and Norway agreement on a herring TAC for 2010 was 33,855 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 7,515 t to be taken in the small mesh fishery. For 2011, the EU and Norway agreement on herring TACs in Division IIIa was 30,000 t for the human consumption fleet and a by-catch ceiling of 6,659 t to be taken in the small mesh fishery.

Previous to 2006 no special TAC for Subdivisions 22-24 was set. In 2010, a TAC of 22,692 t was set on the Western Baltic stock component. The TAC for 2011 was set at 15,884 t.

3.1.2 Catches in 2010

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

Landings from 1989 to 2010 are given in Table 3.1.1 and Figure 3.1.1. In 2010 the total landings in Division IIIa and Subdivisions 22–24 have decreased to 55,200 t, which is the lowest value of the time series (1986-2010). The decrease in landings in 2010 is particularly evident in the Subdivisions 22-24, where all landings were decreased due to TAC regulations and differences in allocation of catches from one ICES square to Subdivision. As in previous years the 2010 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 2003 to 2010 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

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

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

	TAC	DK	GER	FI	PL	SWE	EC	NOR	FAROE
	2010								
Div. IIIa fleet-C	33,855	13,986	224			14,630	29,340	4,515	500
Div. IIIa fleet-D	7,515	6,424	57			1,034	7,515		
SD 22-24 fleet-F	22,692	3,181	12,519	2	2,953	4,037	22,692		
% of IIIa taken in IV								-20%	
	2011								
Div. IIIa fleet-C	30,000	12,368	198			12,938	25,504*	4,496	NA
Div. IIIa fleet-D	6,659	5,692	51			916	6,659		
SD 22-24 fleet-F	15,884	2,227	8,763	1	2,067	2,826	15,884		
% of IIIa taken in IV EU waters							-50%		
% of IIIa taken in IV Norw. waters								-50 %	

* 495 of the EC TAC not distributed

3.1.3 Regulations and their effects

Before 2009, HAWG has calculated a substantial part of the catch reported as taken in Division IIIa in fleet C actually has been taken in Subarea IV. These catches have been allocated to the North Sea stock and accounted under the A-fleet. Misreported catches have been moved to the appropriate stock for the assessment. However, from 2009 and on this pattern of misreporting of catches into Division IIIa is not believed to occur, based on information from both the industry and VMS estimates. Thus no catches were moved out of Division IIIa to the North Sea in 2010.

Regulations allowing quota transfers from Division IIIa to the North Sea were introduced as an incentive to decrease misreporting primarily for the Norwegian part of the fishery, and the percentage has gradually been reduced until 2010. In 2011 the EU – Norway agreement allows 50% of the Division IIIa quotas for human consumption to be taken in the North Sea. The optional transfer of quotas from one management area to another introduce more than necessary uncertainty for catch predictions and thus influence the quality of the stock projections. ICES deals with this in a pragmatic way assuming that this transfer is fully effectuated but only applied in 2011.

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

3.1.3.1 Changes in fishing technology and fishing patterns

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

3.2 Biological composition of the catch

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

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

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

The total numbers and mean weight-at-age of the WBSS and NSAS landed from Kattegat, Skagerrak, and Division IIIa respectively 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 + Division IIIa in 2010 was estimated to be 27 500 t, and has thereby decreased compared to 2009 (36 200 t). The 2010 estimate is the second lowest of the time series (Table 3.2.13).

Total catches of WBSS from the North Sea, Division IIIa, and Subdivisions 22-24 respectively, by quarter, was estimated for 2010 (Table 3.2.14). Additionally, the total catches of WBSS in numbers and tonnes, divided between the North Sea and Division IIIa and Subdivisions 22–24 respectively for 1993–2010, are presented in Tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division IIIa amounted to 13 759 t in 2010, which is in the lower end of the time series (Table 3.2.17).

The transfer of WBSS from Division IV into Division IIIa and the transfer of NSAS from Division IIIa into Division IV in 2010 are shown in the text table below:

Year	Stock	Transfer route	Tonnes
2010	WBSS	IVaE to IIIa	772
2010	NSAS	IIIa to IVaE	13 759

3.2.1 Quality of Catch Data and Biological Sampling Data

No quantitative estimates of discards were available to the Working Group. However, the amount of discards for 2010 is assumed to be insignificant, as in previous years.

Some Danish landings, reported as taken in a specific ICES Square (41G2; an area in the southern Kattegat, which is a part of the Baltic area: Gilleleje, DK - Kullen, S - Helsingborg, S - Helsingør, DK), has been reported to either Subdivision 23 or Kattegat. In the allocation of catches reported to the HAWG these landings are listed under Kattegat; thus the TAC may appear under utilised for SD 22-24, however, this discrepancy is due to the different perception of which area this particular square belongs to.

Table 3.2.4 shows the number of fish aged by country, area, fishery and quarter. The overall sampling in 2010 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.

Splitting of catches into WBSS and NSAS in Division IIIa were based on Danish and Swedish analyses of otolith micro-structure of hatch type and extended with discriminant analysis calibrated with hatch type and applied on production samples with classification parameters: herring length weight and age as well as otolith metrics (see Stock annex). The total sample size for hatch type was 3523 with 57% of the samples in Division IIIa North and 43% in IIIa South.

Sampling for split of catches in the transfer area in Division IVa East in 2010 was based on 608 Norwegian VC observations and the applied method was based on the average VC by age group and quarter as described in the stock annex.

3.3 Fishery Independent Information

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

As a part of Baltic International Acoustic Survey (BIAS); a joint German-Danish acoustic survey (GERAS) was carried out with R/V "SOLEA" between 4 and 22 October 2010 in the Western Baltic, covering Subdivisions 21, 22, 23 and 24. A full survey report is given in the 'Report of the Working Group for International Pelagic Surveys (WGIPS)' (ICES CM 2011/SSGESST:02). The time series has been revised in 2008 (ICES 2008/ACOM:02) to include the southern part of SD 21. The years 1991-1993 were excluded from the assessment due to different recording method and 2001 was also excluded from the assessment since SD 23 was not covered during that year (ICES 2008/ACOM:02). Only ages 1-3 are included in the assessment.

The results for 2010 are presented in Table 3.3.1a. Survey results of GERAS since 2007 have shown a decline in mean weights per age group. Additionally, there is an uncharacteristic decrease in mean weight with increasing age more evident for age classes >3. The 2010 survey results also showed a distinct peak in age class 3 as compared to previous years. However, no signs of a strong year class were found in 2007. Instead, the year classes 2007 and 2008 are amongst the lowest observed since 2002. Checks and comparisons of Subdivision-based length distributions of herring (see ICES CM 2011/SSGESST:02) in the 2009 and 2010 surveys showed nothing conspicuous – both in SD 21 and 22 young year classes (0–2) are dominated by lengths mostly below 20 cm. As in previous years, large fractions of adult herring were identified in SD 23 (Öresund) with length classes between 20 and 30 cm largely represented. Length classes corresponding to age 0-2 contributed only for a small fraction in SD 23. In SD 24, length distribution differs from that in SD 23, but it is consistent with the distribution observed in 2009. In SD 24 the majority of fishes are between 8.25 cm and ca. 15.25 cm (~age 0 and 1) and a smaller fraction between ca. 15.25 and 22.25 cm (~age 2 and 3). Contribute of fish older than age 3 was only marginal in this subdivision. Analysis of the mean weight at age however showed that the decline in weight with increasing age is mostly pronounced in SD 24. This could suggest potential mixing in SD 24 of separate herring stocks with different growth characteristics, namely WBSS and Central Baltic Herring (CBH) coming from easterly adjacent areas. Consequently, abundance estimates for WBSS would be affected by biased indices from SD 21-24 due to unaccounted occurrence of CBH. A method to separate WBBS and CBH in SD 24 was presented during the meeting (WD 02: Gröhsler, Oeberst, Schaber). The results applying a separation function based on length at age-distributions and growth parameters (Bertalanffy growth parameters) for the period 2006-2010 are shown in Table 3.3.1b. In 2006, overall differences in abundance, biomass and mean weight at age between original data (present approach) and data with removed fraction of CBH (proposed approach) are rather small. The "new" data result in slightly reduced numbers and biomass of age classes 2 -7 and an overall increased mean weight at age. In 2007 and 2008, there are also small differences in abundance and biomass but major changes affect the mean weight at age. This resulted in more consistent mean weight at age for WBSS during the last part of the time series. Largest differences between original and CBH adjusted data are obvious in 2009 and 2010. This largely applies to the mean weights in both years which again seem more realistic, but is also evident in a significant biomass loss within the 3 w-ring group. However, both in 2009 and 2010 cohorts still show negative mortalities after exclusion of CBH.

Quality checks of data before and after adjusting for stock mixing were performed by comparing linear correlations between annual abundances of different age groups (age group x/age x+1) in the years 2006-2010 (WD 02: Gröhsler, Oeberst and Schaber). Overall, r^2 of the linear regressions with no adjustment for stock mixing showed very poor correlation, with $r^2 \leq 0.15$ for all the age groups except in one case (w-rings 1 to 2, $r^2=0.62$). The new proposed index showed improved internal consistency in the data.

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

The Herring acoustic survey (HERAS) was conducted from 3 to 23 July 2010 and covered the Skagerrak and the Kattegat. Details of the survey are given in the 'Report of the Working Group for International Pelagic Surveys (WGIPS)' (ICES CM 2011/SSGESST:02). The 1999 was excluded from the assessment due to different survey area coverage. The estimates of the Western Baltic spring spawning herring stock are 162000 tonnes and 2030 million individuals, which is among the lowest observed values in the time series. The stock is dominated by 1 and 2 ringer fish, although the 1 ringers are below the long term mean (1992-2010: 1,570 millions). The results from this survey are summarised in Table 3.3.2. Only ages 3-6 and data from 1993 onwards are used in the assessment.

3.3.3 Larvae Surveys

Herring larvae surveys (Greifswalder Bodden and adjacent waters; SD 24) were conducted in the western Baltic at weekly intervals during the 2010 spawning season (March to June). The larval index was defined as the total number of larvae that reach the length of 20 mm (N20; Table 3.3.3) (Oeberst *et al*, 2009). The values estimated for

N20 in 2010 is the largest since 2003 and it is about 4 times larger than the record low 2008 estimate (Table 3.3.3).

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

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

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and thus been the same since 1991 (ICES 1992/Assess:13), although large year-to-year variations in the percentage mature have been observed (Gröhsler and Müller, 2004). A Workshop on Sexual Maturity Staging of Herring and Sprat is taking place during 2011 in order to, amongst other things, establish correspondence between old and new scales to convert time series and propose optimal sampling strategy to estimate accurate maturity ogives.

The same maturity ogive was used as in the last year assessment (ICES CM 2010/ACOM:06):

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

3.5 Recruitment

Indices of recruitment of 0-ringer western Baltic spring spawning herring (WBSS) in Subdivisions 22-24 for 2010 were available from the revised larval survey and are described in Section 3.3.3 and Oeberst *et al.*, 2007 (WD 7 to the HAWG 2007 (ICES 2007/ACFM:11)).

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

3.6.1 Input data

3.6.1.1 Catch data

Catch in numbers at age from 1991 to 2010 were available for Subdivision IVa (East), Division IIIa and Subdivisions 22-24 (Table 3.6.1; Figure 3.6.1.1). Years before 1991 are excluded due to lack of reliable data for splitting spawning type and also due to a large change in fishing pattern caused by changes in the German fishing fleets (ICES 2008/ACOM:62).

Mean weights at age in the catch vary annually and are available for the same period as the catch in numbers (Table 3.6.2; Figure 3.6.1.3). Proportions at age (by weight) thus reflect the combined variation in numbers at age and weight at age (Figure 3.6.1.2).

3.6.1.2 Biological data

Estimates of the mean weight of individuals in the stock (Tables 3.2.14 (Q1) and Figure 3.6.3) are available for all years considered.

Natural mortality was assumed constant over time and equal to 0.3, 0.5, and 0.2 for 0-ringers, 1-ringers, and 2+ -ringers respectively (Table 3.6.4). The estimates of natural mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2) as no new values were available.

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

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

3.6.1.3 Surveys

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

3.6.2 Assessment method

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

3.6.3 Assessment configuration

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

- The period for the separable constraint: 5 years (2006-2010)
- The weighing factor to all indices: lambda = 1
- A linear catchability model for all indices
- The reference F set at age 4 and the selection=1 for the oldest age
- The catch data were down-weighted to 0.1 for 0-ringer herring
- No stock-recruitment model was fitted
- Errors in index values are assumed to be correlated.
- Plus group is set to age 8+.

3.6.4 Data exploration

An exploration assessment was performed to look at the effect of the revisions proposed above that were made to the GERAS survey. The revision of the GERAS data could not be seen to qualitatively improve the pattern of residuals. (e.g. comparison of Figure 3.6.4.1 and 3.6.5.13). Strong year effects are present in both runs, and were not eliminated by the revision. Whilst the residuals in some years decreased, in other years they increased. From a purely qualitative point of view, the residuals of the fit could not be seen to improve.

Quantitative comparisons of the effect of the GERAS time series revisions on the assessment can be performed and visualised using a Taylor diagram (Taylor, 2001;

Payne 2011). Comparison of the standard assessment and that using the revised GERAS survey using this technique (Figure 3.6.4.2) shows that the revision of the GERAS generally improved the agreement between the modelled and observed GERAS data. The correlation coefficients, *r*, for the three timeseries in GERAS increased appreciably, and the three points moved closer towards the origin.

The revision did not lead to a change in the perception of the stock (Figure 3.6.4.3). The revised estimates of SSB and Fbar during the period of the revision generally fell within both the corresponding confidence intervals and the retrospective scatter. Similarly, the downwards trend in spawning stock biomass and the poor recruitment in recent years were maintained. It was therefore concluded that the effect of the revision did not have a significant impact on our perception of the stock. However, the improvements in the model fit were promising and warrant further investigation.

3.6.5 Final run

The results of the assessment are given in Tables 3.6.8-21. The estimated SSB for 2010 is 95 000 [71 000, 129 000 (95% CI)] tonnes. The mean fishing mortality (ages 3-6) is estimated as 0.30 [0.20, 0.46 (95% CI)] yr^{-1}. (Figure 3.6.5.1).

After a marked decline from over 300 000 tonnes in the early 1990s to a low of 120 000 tonnes in the late 1990s, the SSB of this stock recovered somewhat, reaching a secondary peak of around 200 000 tonnes in the early 2000s (Figure 3.6.5.2). After a small peak in 2006 coinciding with the maturing of the 2003 year-class; the SSB has declined four years in a row to the lowest observed SSB in the time series.

Fishing mortality on this stock was high in the mid 1990s, reaching a maximum of over 0.7 yr^{-1}. In 1999-2007 $F_{3\text{-}6}$ stabilised around 0.4, but increased again in the latter half of the 2000s. The most recent estimate of $F_{3\text{-}6}$ suggests a significant decrease – however, it should be remembered that the terminal year values are generally poorly estimated and often subject to a strong retrospective pattern (Figure 3.6.5.14).

The reason for the recent increase of F is twofold: The productivity of the stock have been decreasing for the last years while the F was kept high at around 0.4, in 2004-2008 the recruitment kept decreasing; each year setting a new point for the lowest observed recruitment in the time series. Secondly there has been a period with area misreporting between the North Sea and the Skagerrak. Early in 2009 a revised enforcement of the Danish legislation ended this practice. The part of WBSS herring in the IIIa catches was therefore substantially higher.

After a long period of decreasing recruitment during the 2000s, recruitment to the stock appears to have increased from the 2006-2008 lows. However, caution is warrented, particularly about the high estimate of the 2010 year class, which is essentially based on a single observation and is therefore extremely imprecise.

The catch residuals are generally free from patterns (Figure 3.6.5.3). The marginal totals of residuals between the catch and the separable model are small overall; the apparent pattern of decreasing residuals through time and negative age residuals on either side of the reference age, is therefore without significant effect.

The individual diagnostics for the three surveys generally show acceptable fits (Figures 3.6.5.4 – 3.6.5.11). The residuals appear to be distributed randomly, and the assumption of normal distribution is generally held up. Most survey-ages appear to have at least one significant outlier. Generally, however, the agreement between the data and the fitted model appears good through all data sources.

The assessment model objective function is generally dominated by the surveys rather than the catch data (Figure 3.6.5.12): this is not surprising as the FLICA method fits many more parameters to the catch data than the survey data. The agreement between the model and the GERAS survey is generally better than that of the HERAS survey. The N20 larval index shows the worst fit, on average. These results are also reflected in the Taylor diagram for this assessment (Figure 3.6.5.17), which also shows that the agreement between the model and observations is greater for GERAS than HERAS.

Some patterns are apparent in the residuals (Figures 3.6.5.13). The HERAS survey shows appreciable year effects, with some years showing either positive or negative residuals across all ages. The German acoustic survey appears to give a more random pattern. The N20 index shows an improving fit in latter years, with one large dominating residual in its first year. The residuals are generally small (e.g. less than 0.5), but are dominated by a few outlying points. No cohort or age effects are apparent.

Retrospective analysis suggests the assessment method gives a relatively consistent perception of the stock and its development (Figure 3.6.5.14). The changes from year-to-year are generally less than the uncertainty of the estimated values (ICES 2008/ACOM:62) and are therefore consistent with the level of confidence in our estimates.

Retrospective analysis of the selectivity pattern for this fishery suggests a stable selection pattern (Figure 3.6.5.15), especially in the most recent years covered by the separable period. Such a result suggests that the assumption of a constant selectivity in the fishery, a key criterion for the application of the FLICA method, is valid.

The stock-recruitment plot for this stock (Figure 3.6.5.16) does not show any clear relationship between stock-size and recruitment.

The Taylor diagram (Taylor 2001; Payne 2011) for WBSS herring (Figure 3.6.5.17) shows that the GERAS survey has the best agreement between the modeled and actual observations. The GERAS points are closely grouped together, suggesting similarities in their properties and agreement with the model. The HERAS time series show poorer agreement with the models – the age 3, 4, and 5 values are closely grouped, but we note that the age 6 values show appreciably poorer agreement with the model. The N20 index appears to be fitted well by the model. These results are in agreement with the general understanding of this assessment (Payne 2009; ICES 2008/ACOM:02).

3.6.6 State of the stock

The stock has decreased systematically and consistently during the second half of the 2000s and is now at the lowest observed level in the time series. Very high fishing mortalities and a sequence of poor year classes have driven this stock consistently downwards during the second half of the 2000s. The model suggests fishing mortality has reduced considerably in 2010: however, the estimate value of 0.30 yr^{-1} is still higher than F_{msy} (0.25 yr^{-1}).

The N20 larval survey in 2010 suggested one of the strongest year classes since 2001. However, this survey is conducted before the main mortality on juveniles occurs, so it is as yet unclear whether this will result in a strong year class entering the fishery. The 2009 year class, which was previously estimated to be equally strong, was revised downwards by around 50% this year.

Recruitment has declined consistently from 2003 to 2008. When maturing, these poor year classes are expected to have a reducing effect on the spawning stock biomass.

3.6.7 Comparison with previous years perception of the stock

This year's assessment is an update assessment, and employs the same methodology as the Benchmark Assessment in 2008. The changes in the SSB and fishing mortality of the stock are minor between last year's assessment and the current assessment. However, there has been a significant downwards revision of recruitment to the 2009 year class.

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

Category	Parameter	Assessment in 2010	Assessment in 2011	Diff. 11-10 (+/-) %
ICA results	SSB (t) 2008	120 000	117 000	-3%
	F(3-6) 2008	0.45	0.47	+4%
	Recr. ('000) 2008	1076630	1479130	+37%
	SSB 8t) 2009	105 000	105 000	0 %
	F(3-6) 2009	0.52	0.51	-2 %
	Recr. ('000) 2009	3484636	2159680	-38%

3.6.8 Short term predictions

Short term predictions were made with the MFDP package.

3.6.9 Input data

Stock numbers at age at the beginning of 2011 were taken from the ICA assessment, except for age 0. For age 0 both in 2010 and 2011, the geometric mean recruitment (2005-2009) was assumed considering the recent low recruitment. The selection at age was taken from the ICA assessment (average of 2008-2010). Arithmetic averages over the years 2008-2010 were used for mean weights at age in the catch and in the stock, as well as maturities at age. The input data are shown in Table 3.7.1.

3.6.10 Intermediate year 2011

A catch constraint was assumed for the intermediate year by the following procedure.

1) The EU – Norway agreement allows an optional transfer of 50% of the TAC for herring in Division IIIa into the Subarea IV in the North Sea. Based on information from the fishing industry on the most probable behaviour of fishing fleet to this situation 50 % was subtracted from the TAC for human consumption in Division IIIa as the basis for the catch constraint in 2011. This choice has great influence on the perception of the stock development in 2011 and 2012.
2) Misreporting of catches from the North Sea into Division IIIa is no longer assumed to occur after 2008. Therefore no account was taken in the compilations.
3) The catch by each of the two fleets fishing for human consumption (C- and F-fleet) in 2010 was close to the TACs and an assumed TAC utilisation of 1 is assumed for the intermediate year. The proportion of the TAC taken in

the small meshed fishery (D-fleet) has varied between 31% and 52% during the last three years and an average TAC utilisation of 45% is assumed for the intermediate year.

4) The catch of herring in Division IIIa consists of both WBSS and NSAS components. The expected catch of WBSS in Division IIIa was calculated assuming the same WBSS proportions in the catch of each fleet in 2011 and 2012 as the average of 2008-2010 in Division IIIa. Furthermore a constant amount of 772 t of WBSS taken in Division IVaE by the A-fleet in 2010 is assumed in 2011.

5) The fractions of the total catch of WBSS in Division IIIa and Subdivisions 22-24 taken by each of the three fleets C, D, and F, in 2008-2010 are assumed to be equal to the utilised TAC in the respective areas times the proportion of WBSS in the catches.

6) 772 t of WBSS is assumed taken in Division IVaE by the A-fleet.

7) The shares of the WBSS catches in IIIa and other areas in the recent 3 years 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, whereas the Subdivision 22-24 TAC is assumed to be only WBSS herring.

8) Summarising: predicted catches of WBSS and NSAS by fleet in IIIa are based on the recent 3 years patterns of 1) fraction of WBSS catches taken by each fleet plus a constant catch of WBSS in IVaE and 2) proportion of the two stocks in the catches of the different fleets. These assumptions give the expected catch by fleet in 2011.

The resulting expected catch of WBSS in 2011 following this scheme was 29 041 t.

	2010				2011				
Calculation of Interme-diate year catch constraint (2010)	Catch of WBSS	Catch of NSAS	TAC-catch WBSS+ NSAS*	Catch of NSAS+ WBSS	Catch as asssumed proportion of TAC **	TAC-catch WBSS+ NSAS *	Realised TAC catch in 2010	proportion of WBSS in catch	catch of WBSS in 2010
A-fleet	772			772				100%	772
C-fleet	22,975	11,978	33,855	34,953	1	15,000	15,000	74%	11,125
D-fleet	549	1,781	7,515	2,330	0.448	6,659	2,983	42%	1,260
F-fleet	17,917		22,692	17,917	1	15,884	15,884	100%	15,884
Total (Div. IIIa, SD 22-24 and IVaE)	42,214	13,759	64,062	55,972			33,867		29,041

*After accounting for EU-Norway agreed transfer of quota from Division IIIa to the North Sea (15 000 t in 2011).

**The D-fleet is calculated as the average utilisation of the by-catch ceiling over the years 2008-2010

3.6.11 Catch options for 2012

The output of the short-term prediction, based on a catch constraint in the intermediate year 2011 of 29 041 t, is given in Table 3.7.2 and in Figure 3.7.1.

1) Zero catch.

2) F2012 = 0.25, which is FMSY.

3) A 15% reduction of all fleet-wise WBSS TACs for 2011, converted into a total herring catch by assuming that the TAC is completely taken in Division IIIa and Subdivision 22-24. The catches of WBSS herring are then calculated by assuming that the proportion of WBSS in each fleet's catch is equal to the mean over 2008-2010.

4) As for option 3, but with no change in the WBSS TAC.

5) As for option 3, but with a 15% increase in the WBSS TAC.

3.6.12 Exploring a range of total WBSS catches for 2012 (advice year)

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

A constant catch of 772 t of WBSS caught in the A-fleet in Division IVa East.

This constant amount is subtracted from each of the WBSS TAC options presented and thereafter a 50:50 allocation between Division IIIa and Subdivisions 22-24 of the remaining WBSS TAC is assumed.

Each of the fleets C and D takes a constant share of the WBSS based upon the mean of the recent three years 2008-2010.

There will not be allowed any transfer of quotas from the C-fleet to the A-fleet.

The total TAC is taken

The average 2008-2010 proportions of WBSS by fleet hold for 2012. (The proportions of WBSS in catches were 74.2% in the C-fleet, 42.2% in the D-fleet and 100% in the F-fleet).

The table below gives the 2012 fleet wise catch options for the Western Baltic spring spawners and North Sea autumn spawners in Division IIIa, in Subdivisions 22–24, and in Subarea IVaE for the catch options described in section 3.7.3:

1) F=0 not shown, 2) F_{MSY}=0.25 3) $F_{-15\%TAC}$=0.214, 4) F_{TAC}=0.256, and 5) $F_{+15\%TAC}$=0.300

Catch option for the WBSS and NSAS herring stock in 2011												
Catch option for the WBSS herring stock		WBSS herring				NSAS herring		Total catches of both stocks in Division IIIa and Subdivisions 22-24				
Option	Total catches of WBSS herring*	IVaE	Division IIIa		SD22-24	Division IIIa		Division IIIa		SD 22-24		TAC development
		Fleet A*	Fleet C	Fleet D	Fleet F	Fleet C	Fleet D	Fleet C**	Fleet D	Fleet F	Fleets A+ C+D+F	Total area
2	42 657	772	19 551	1 417	20 943	6 810	1 938	26 362	3 355	20 943	51 432	15.2%
3	37 103	772	16 959	1 232	18 166	5 907	1 686	22 866	2 919	18 166	44 662	-15%
4	43 627	772	20 004	1 449	21 428	6 968	1 983	26 972	3 432	21 428	52 543	0%
5	50 152	772	23 049	1 666	24 690	8 029	2 279	31 078	3 945	24 690	60 424	15%

* total catches of WBSS herring include a constant catch of 772 t WBSS taken by the A-fleet in Div. IVa East

1) Zero catch not shown in the table. After an increase of SSB to 125 861 t in 2012 the SSB further increases to 174 775 t in 2013.
2) The F_{MSY} option will give a yield of 42 657 t in 2012, with an increase of SSB to 122 892 t in 2012 and to 136 776 t in 2013.
3) This 15% reduced TAC option gives a yield in 2012 of 37 103 t, and a SSB of 123 312 t. With this assumption the SSB increase in 2013 to 141 622 t, well above the suggested breakpoint of 110 000 t.
4) This TAC roll over option gives a catch in 2012 of 43 627 t. This option is very similar to option 2) based on $F_{MSY,}$ with an increase from 122 818 t in 2012 to 135 933 t in 2013, above the breakpoint of 110 000 t.
5) This 15% increased TAC gives a catch in 2011 of 50 152 t. With this assumption the SSB increase from 122 309 t in 2012 to 130 288 t in 2013, both still above the breakpoint of 110 000 t.

3.7 Reference points

No precautionary reference points are defined for this stock. No new information was available (ICES 2009 ACOM:38).

According to the last year interpretation and analysis (ICES CM 2010/ACOM:06), the long term maximum exploitation target (F_{MSY}) for WBSS is F=0.25. In agreement with this view, long term management plans for the WBSS herring are being developed based on F_{MSY} (see WKWATSUP (ICES CM 2010/ACOM:64) and JAKFISH (ICES CM 2010/P:07)). The work is based on stochastic modeling of population dynamics, assessment and management implementation. The development is an ongoing process in order to reach common grounds on science input to management decision. This scientific process has presently come to an end.

3.8 Quality of the Assessment

The assessment this year was classified as an update, following the procedures and settings specified in the Stock annex 4. In 2010, the assessment of WBSS was regarded as reliable and consistent, and the diagnostics indicate a similar classification for this year.

Variability around retrospective analysis was consistent with previous years. Model residuals were examined for all the components (catch and survey indices), and no major undesirable pattern was observed.

Mean weight-at-age estimated from the German acoustic survey (GERAS) shows a reduction in the weights of older fish since 2007, that together with marked differences in the length distributions across SD22-24, could indicate important stock mixing between WBSS and Central Baltic Herring (CBH) in this area (Section 3.3.1). Preliminary analyses suggested that if not accounted, the influence of CBH in certain years could affect our estimates of WBSS herring abundance. However, the WG recommended further investigations to address this relevant issue before it could be used to improve the assessment.

Apparently underutilised TACs for SD 22-24 are related to different interpretations in allocation of catches of a particular ICES rectangle, but the issue has been considered irrelevant for the assessment of this stock.

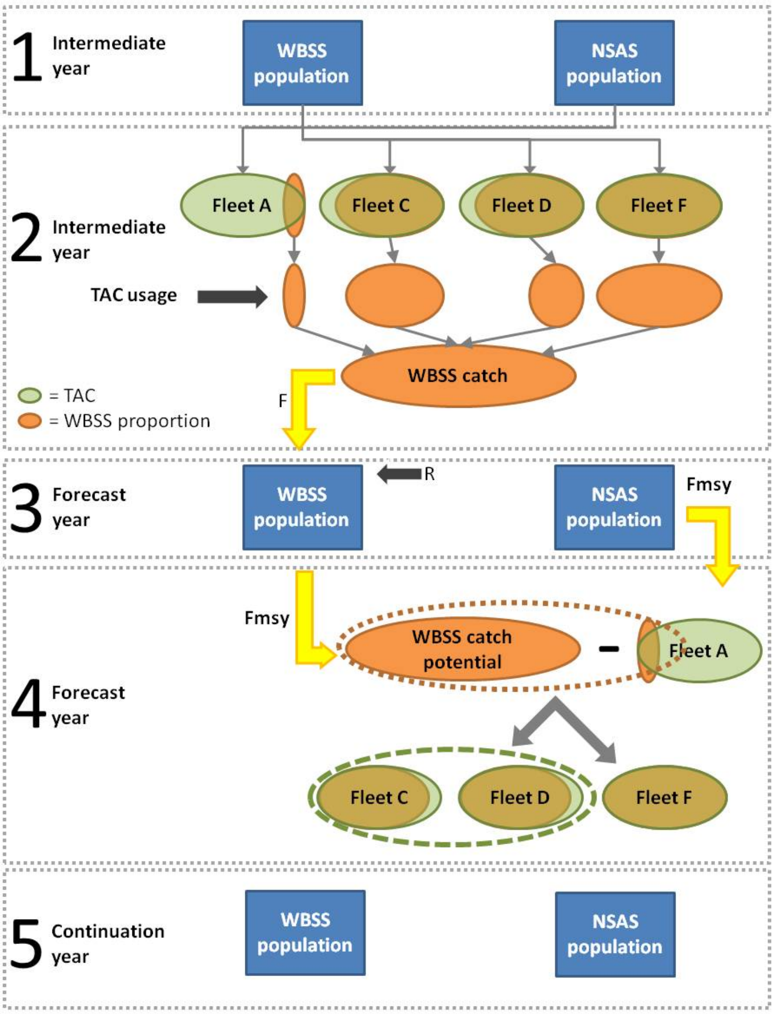
3.9 Management Considerations

Quotas in Division IIIa

The quota for the C-fleet and the by-catch quota for the D-fleet are set for both stocks of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) together (see Section 2.7). 50% of the EU and Norwegian quotas can be transferred from Division IIIa and taken in SubArea IV as NSAS in 2011. ICES assumes this will be effectuated.

ICES catch predictions versus management TAC

ICES gives advice on catch options for the entire distribution of the two herring stocks separately, whereas herring is managed by areas (see the following text diagram). The procedure of setting TACs in ICES area IIIa and 22-24 takes into account the occurrence of different fleets, catches of both WBSS and NSAS herring, utilization of TACs and the proportion of NSAS and WBSS that mix in the areas. In the flowchart below a schematic:



Box 1: Each year, estimation of the WBSS and NSAS stock size is made using a stock assessment model. Stock size estimation, together with the estimated pattern of harvesting are used as the starting point for the short term forecast.

Box 2: To derive at a TAC proposal in the forecast year, first the intermediate year (the year where the TAC has already been agreed on) catches need to be resolved. Four different fleets catch WBSS, the A fleet (within the IVaEast area where they take it as a mixture of mainly NSAS and partly WBSS), the C and D fleet (within the IIIa area where they take it as a mixture of mainly WBSS and partly NSAS) and the F fleet (within area 22-24 where they only take WBSS). Each of these fleets target herring taking into account a fleet share of the total TAC. Only part of this TAC is WBSS catches and not all fleets utilize their full TAC fleet share. This results in an estimate of the intermediate year WBSS catches. Given WBSS stock size and these intermediate year catches, the fishing mortality the WBSS stock was exploited at can be estimated.

Box 3: Based on the estimated fishing mortality we can now calculate the survivors from the intermediate year to the forecast year, assuming an incoming recruitment. The calculation of the stock size in the forecast year is needed to project catches in the forecast year.

Box 4: The EC targets to g*et al*l stocks exploited at Fmsy by the year 2015. From now until 2015 there is an Fmsy transition period. Therefore, catches of WBSS in forecast year are assumed to be caught at Fmsy levels too, appropriately taking the transition equation into account (see transition eq. 5.2.1). The potential WBSS catches are used to define the total TAC in ICES area IIIa and 22-24. Therefore, first the WBSS catches taken by the A fleet in the North Sea need to be taken into account. It is up to expert knowledge where these catches are subtracted from (either the C and D fleet share, or the C, D and F fleet shares). It is the intention to split the remainder between the F and the C & D fleet according to a 50% - 50% ratio. To derive the C and D fleet TAC however, a proportion of NSAS needs to be added here because of the mixed fishery on both WBSS and NSAS by these fleets. Therefore, the TAC of the C and D fleet is larger than the proposed catches of WBSS by these fleets. The ratio between the C and D fleet equals to 4:1.

Box 5: The TAC advice from box 4 is taken into the political arena. The result of this will be taken into account to calculate the WBSS population again the year after. Hence, box 5 is similar to box 1.

Equation 5.2.1: The FMSY transition equation applied

$$if(SSB < Bpa)\ F_{2011} = \min\left(0.8 * F_{2010} + 0.2 * Fmsy * \frac{SSB_{2010}}{Bpa}, Fpa\right)$$

$$if(SSB \geq Bpa) F_{2011} = \min(0.8 * F_{2010} + 0.2 * Fmsy, Fpa)$$

Development of a management plan for WBSS herring

ICES has in 2010 continued exploration of management options under different assumptions of fishing mortality and recruitment using stochastic simulation with and without TAC constraints, including changes in selection pattern and different levels of uncertainty in the assessment (ICES CM 2010/ACOM:64). A value for F_{MSY}=0.25, and a SSB breakpoint of 110 000 t equal to the lowest observed SSB below which the state of the stock is uncertain was established under last year assessment (ICES CM 2010/ACOM:06), and a maximum TAC variation of +/- 15% was supported by WKMAMPEL in 2009 (ICES 2009ACOM:38).

Further development of the management plan within the EU FP7-project "JAKFISH" involving stakeholders has suggested a harvest control rule that include a sloping change in F at SSB below a breakpoint.

Data used for catch options in 2011(intermediate year)

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

The procedure of deriving separate catches by stock and fleet is described in the stock annex for North Sea herring. The catch options for 2011 are based on the average share by fleet based on area TACs and the stock composition in catches for the most recent years 2008-2010.

One major change in the fishing pattern in 2009 had a dramatic effect on the development of the WBSS stock. National regulation and control initiatives have efficiently stopped misreporting which before 2009 amounted to more than 30%. This resulted in a continued increase in fishing mortality in 2009 and a decrease in SSB however enforcement of TAC regulations in 2010 decreased landings and fishing mortality considerably whereas SSB continued to decrease due to the poor year classes in the fishery.

In 2011 managers have added considerable uncertainty to predictions by the optional transfer of 50% of the quotas for human consumption in Division IIIa to the North Sea. If this transfer is effectuated the fishing mortality is greatly reduced and the SSB will increase from 97 452 t in 2011 to somewhat above the breakpoint of 110 000 t in 2012 with any of the suggested catch options. However if all of the C-fleet TAC is taken in IIIa the stock development will have a slower increase. HAWG has assumed that 50% of the C-fleet TAC will indeed be transferred to the A-fleet and thus base the catch options on a fishing mortality below F_{MSY} in 2011 (F=0.19).

Applying the F_{MSY} framework for WBSS herring (F_{MSY}=0.25) in the situation when SSB in the advice year (2012) is above the break-point and F< F_{MSY}, means applying a fishing mortality equal to F_{MSY}. A F_{MSY} of 0.25 will give a yield of 42 657 t in 2012, with an increase in SSB from 122 892 t in 2012 to 136 776 t in 2013. The fishing mortality corresponding to a TAC roll over is very similar to F_{MSY}, with an increase in SSB from 122 818 t in 2012 to 135 933 t in 2013.

The catches of WBSS in the C- and D-fleets comprise 44% of the total out-take of the WBSS stock, whereas the catches of NSAS by the same fleets only comprise 2.5% of the total out-take of the NSAS stock. The NSAS has experienced a decline in fishing mortality and subsequent increase in SSB. If the full TAC is not taken in IIIa the WBSS spawning stock biomass is likely to increase somewhat due to the decrease in fishing mortality whereas no above average contribution to stock improvement is expected from still poor incoming year classes. A consolidated reduced fishing mortality on the WBSS with a reduced uncertainty about the realised outtake should to be considered in the management of both stocks. The resulting catch options with the above assumptions were also used as constraints for short term predictions for the NSAS herring (see Section 2.7).

3.10 Ecosystem considerations

Herring in Division IIIa and Subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic into more saline waters of Division IIIa and the eastern parts of Division IVa. There are indications from parasite infections that yet unknown proportions of stock components spawning at the southern coast in the Baltic Sea may perform similar migrations. Herring in Division IIIa and Subdivisions 22–24 migrate back to Rügen area (SD 24) in the beginning of the winter for spawning. Further there are indications that Central Baltic herring in recent years have performed migrations into Subdivision 24.

Similarly to the North Sea herring, the Western Baltic herring has produced several poor year classes in the last decade. However, indications suggest that the declining trend might now be reversed and although the 2009 year class has been revised downwards the 2010 year class is back at the intermediate levels last observed in 2003.

In a recent recruitment analysis for different Baltic herring stocks, the Baltic Sea Index (BSI) reflecting Sea Surface Temperature (SST) was the main predictor for Western Baltic herring (Cardinale *et al*. 2009). There are no indications of systematic changes in growth or age at maturity, and a candidate key stage for reduced recruitment is probably the larval stage. Recruitment failure appears to have been initiated before the observed occurrence of the Ctenophore (*Mnemiopsis leidyi*) in the Western Baltic. The specific reasons for reduced larval survival are not known. Further investigation of the causes of the poor recruitment will require targeted research projects.

3.11 Changes in the Environment

There are no evident changes in the environment in the last decade that is thought to strongly affect productivity, migration patterns or growth of Western Baltic herring. Although there are indications that higher SST observed in the last decades might affect recruitment negatively the analyses were inconclusive and the observed SST effect rather weak (Cardinale *et al*. 2009).

Table 3.1.1 WESTERN BALTIC HERRING.
Total landings (both WBSS and NSAS) in 1989-2010 (1000 tonnes).
(Data provided by Working Group members 2011).

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998 [2]	1999 [2]
Skagerrak											
Denmark	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7	14.3	10.3	10.1
Faroe Islands											
Germany											
Lithuania											
Norway	1.6	5.6	8.1	13.9	24.2	17.7	16.7	9.4	8.8	8.0	7.4
Sweden	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9	46.9	36.4
Total	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8	56.0	65.2	53.9
Kattegat											
Denmark	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8	23.7	17.9
Sweden	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0	29.9	14.6
Total	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8	53.6	32.5
Sub. Div. 22+24											
Denmark	21.7	13.6	25.2	26.9	38.0	39.5	36.8	34.4	30.5	30.1	32.5
Germany	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8	9.0	9.8
Poland	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9	6.5	5.3
Sweden	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5	4.3	2.6
Total	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7	49.9	50.2
Sub. Div. 23											
Denmark	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2	0.4	0.5
Sweden	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1	0.3	0.1
Total	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3	0.7	0.6
Grand Total	**286.4**	**279.9**	**257.8**	**311.4**	**294.9**	**234.4**	**231.0**	**172.7**	**149.8**	**169.4**	**137.2**

Year	2000	2001 [5]	2002 [4]	2003	2004	2005	2006 [1,3]	2007	2008	2009	2010 [1]
Skagerrak											
Denmark	16.0	16.2	26.0	15.5	11.8	14.8	5.2	3.6	3.9	12.7	5.3
Faroe Islands						0.4			0.0	0.6	0.4
Germany				0.7	0.5	0.8	0.6	0.5	1.6	0.3	0.1
Lithuania											0.4
Norway	9.7							3.5	4.0	3.3	3.3
Sweden	45.8	30.8	26.4	25.8	21.8	32.5	26.0	19.4	16.5	12.9	17.4
Total	71.5	47.0	52.3	42.0	34.1	48.5	31.8	26.9	26.0	29.7	27.0
Kattegat											
Denmark	18.9	18.8	18.6	16.0	7.6	11.1	8.6	9.2	7.0	4.9	7.6
Sweden	17.3	16.2	7.2	10.2	9.6	10.0	10.8	11.2	5.2	3.6	2.7
Germany										0.6	0.0
Total	36.2	35.0	25.9	26.2	17.2	21.1	19.4	20.3	12.2	9.1	10.3
Sub. Div. 22+24											
Denmark	32.6	28.3	13.1	6.1	7.3	5.3	1.4	2.8	3.1	2.1	0.8
Germany	9.3	11.4	22.4	18.8	18.5	21.0	22.9	24.6	**22.8**	16.0	12.2
Poland	6.6	9.3		4.4	5.5	6.3	5.5	2.9	5.5	5.2	1.8
Sweden	4.8	13.9	10.7	9.4	9.9	9.2	9.6	7.2	7.0	4.1	2.0
Total	53.3	62.9	46.2	38.7	41.2	41.8	39.4	37.6	38.5	27.4	16.8
Sub. Div. 23											
Denmark	0.9	0.6	4.6	2.3	0.1	1.8	1.8	2.9	5.3	2.8	0.1 [7]
Sweden	0.1	0.2		0.2	0.3	0.4	0.7		0.3	0.8	0.9
Total	1.0	0.8	4.6	2.6	0.4	2.2	2.5	2.9	5.7	3.6	1.0
Grand Total	**162.0**	**145.7**	**128.9**	**109.5**	**92.8**	**113.6**	**93.0**	**87.7**	**82.3**	**69.9**	**55.2**

[1] Preliminary data.
[2] Revised data for 1998 and 1999
Bold= German revised data for 2008 (in HAWG 2010)
[3] 2000 tonnes of Danish landings are missing, see text section 3.1.2 (HAWG 2007)
[4] The Danish national management regime for herring and sprat fishery in Subdivision 22 was changed in 2002
[5] The total landings in Skagerrak have been updated for 1995-2001 due to Norwegian misreportings into Skagerral
[7] Official reported catches: 3,103 tonnes, see text section 3.2.1

Table 3.1.2 WESTERN BALTIC HERRING.
Landings (SOP) in 2003-2010 by fleet and quarter (1000 t).
(both WBSS and NSAS)

Year	Quarter	Div. IIIa		SD 22-24	Div. IIIa + SD 22-24
		Fleet C	Fleet D	Fleet F	Total
2003	1	10.9	7	20.3	38.2
	2	7.9	1.3	12.9	22.1
	3	21.9	0.9	1.5	24.3
	4	15	3.3	5.6	23.9
	Total	55.7	12.5	40.3	108.5
2004	1	13.5	2.8	20.4	36.7
	2	2.8	3.3	10.4	16.5
	3	8.2	10.8	2.4	21.4
	4	5.9	5.0	8.6	19.4
	Total	30.3	22.0	41.7	93.9
2005	1	16.6	6.1	20.4	43.1
	2	3.4	1.9	15.6	20.9
	3	23.4	3.4	1.9	28.7
	4	12.0	2.6	5.8	20.5
	Total	55.4	14.1	43.7	113.3
2006	1	15.3	5.9	15.1	36.2
	2	2.6	0.1	17.2	19.9
	3	15.7	0.8	3.0	19.5
	4	8.3	2.4	6.5	17.3
	Total	41.9	9.3	41.9	93.0
2007	1	7.7	3.0	18.8	29.5
	2	3.8	0.1	10.5	14.4
	3	22.4	0.8	1.7	24.9
	4	7.7	1.8	9.5	18.9
	Total	41.6	5.7	40.5	87.7
2008	1	8.2	3.9	18.4	30.5
	2	2.7	0.3	11.3	14.3
	3	14.9	0.6	6.0	21.5
	4	6.5	1.0	8.4	16.0
	Total	32.3	5.9	44.1	82.3
2009	1	11.1	2.7	19.5	33.2
	2	3.1	0.1	6.8	10.1
	3	14.3	0.9	1.4	16.6
	4	6.0	0.7	3.3	10.0
	Total	34.5	4.3	31.0	69.9
2010	1	8.4	1.1	10.2	19.8
	2	3.9	0.7	5.4	10.1
	3	13.4	0.4	0.4	14.3
	4	9.2	0.1	1.8	11.1
	Total	35.0	2.3	17.9	55.2

Table 3.2.1 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet (both WBSS and NSAS).
Division: Skagerrak Year: 2010 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.62	28	2.33	18	3.95	22
	2	33.65	75	0.02	37	33.66	75
	3	4.05	117			4.05	117
	4	1.55	156			1.55	156
	5	1.00	207			1.00	207
	6	0.58	241			0.58	241
	7	0.47	231			0.47	231
	8+	0.23	245			0.23	245
	Total	43.14		2.35		45.49	
	SOP		3,789		43		3,832
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.23	36	19.98	18	21.21	19
	2	36.43	76	0.16	37	36.59	76
	3	4.03	117			4.03	117
	4	2.17	149			2.17	149
	5	0.72	187			0.72	187
	6	0.26	221			0.26	221
	7	0.41	197			0.41	197
	8+	0.22	205			0.22	205
	Total	45.46		20.14		65.61	
	SOP		3,918		369		4,287
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			49.14	7	49.14	7
	1	60.50	77	0.35	39	60.84	76
	2	23.47	112			23.47	112
	3	16.20	134	0.10	114	16.30	134
	4	5.48	161			5.48	161
	5	2.99	194			2.99	194
	6	1.24	200			1.24	200
	7	0.73	197			0.73	197
	8+	1.16	221			1.16	221
	Total	111.76		49.58		161.34	
	SOP		11,559		367		11,926
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			2.49	17	2.49	17
	1	57.82	77	0.02	60	57.84	77
	2	8.40	114			8.40	114
	3	3.94	149			3.94	149
	4	1.35	174			1.35	174
	5	0.93	213			0.93	213
	6	0.95	233			0.95	233
	7	0.36	248			0.36	248
	8+	0.82	241			0.82	241
	Total	74.58		2.51		77.09	
	SOP		6,935		43		6,978
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0			51.63	7	51.63	7
	1	121.16	76	22.68	19	143.84	67
	2	101.94	87	0.18	37	102.12	87
	3	28.22	131	0.10	114	28.32	131
	4	10.55	160			10.55	160
	5	5.63	199			5.63	199
	6	3.04	220			3.04	220
	7	1.98	215			1.98	215
	8+	2.43	228			2.43	228
	Total	274.95		74.59		349.53	
	SOP		26,201		822		27,023

Table 3.2.2 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet (both WBSS and NSAS)
Division: Kattegat Year: 2010 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.19	30	39.33	15	39.52	15
	2	26.35	80	11.94	40	38.29	67
	3	9.57	121	0.10	75	9.67	120
	4	5.10	156	0.31	41	5.41	149
	5	1.26	179			1.26	179
	6	1.03	191			1.03	191
	7	0.56	210			0.56	210
	8+	0.23	184			0.23	184
	Total	44.29		51.69		95.98	
	SOP		4,644		1,094		5,738
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1			20.74	16	20.74	16
	2	0.03	88			0.03	88
	3	0.03	124			0.03	124
	4	0.01	159			0.01	159
	5	0.00	170	0.08	111	0.09	113
	6	0.00	192			0.00	192
	7	0.00	201			0.00	201
	8+	0.00	184			0.00	184
	Total	0.07		20.82		20.90	
	SOP		9		338		347
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			2.13	9	2.13	9
	1	12.70	65	0.64	44	13.33	64
	2	3.71	96	0.01	54	3.73	96
	3	4.04	117			4.04	117
	4	1.02	150			1.02	150
	5	0.20	168			0.20	168
	6	0.12	159			0.12	159
	7	0.11	174			0.11	174
	8+						
	Total	21.90		2.78		24.68	
	SOP		1,876		47		1,924
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.29	28	3.67	8	3.97	9
	1	28.16	53			28.16	53
	2	4.22	84			4.22	84
	3	1.38	143			1.38	143
	4	0.54	199			0.54	199
	5	0.09	165			0.09	165
	6						
	7	0.18	210			0.18	210
	8+	0.09	263			0.09	263
	Total	34.95		3.67		38.63	
	SOP		2,222		28		2,251
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.29	28	5.80	8	6.09	9
	1	41.05	56	60.71	16	101.76	32
	2	34.31	82	11.95	40	46.26	71
	3	15.01	122	0.10	75	15.11	121
	4	6.68	158	0.31	41	6.99	153
	5	1.55	177	0.08	111	1.64	174
	6	1.16	187			1.16	187
	7	0.85	205			0.85	205
	8+	0.32	206			0.32	206
	Total	101.22		78.96		180.18	
	SOP		8,752		1,508		10,260

Table 3.2.3 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age and quarter (WBSS).
Division: 22-24 Year: 2010 Country: ALL

		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	9.59	12	0.04	20	6.46	15	16.09	14
	2	6.26	37	1.02	68	15.93	52	23.21	49
	3	4.79	73	0.67	92	19.42	88	24.87	85
	4	1.97	114	0.47	128	14.54	118	16.98	118
	5	1.19	134	0.27	158	9.57	158	11.03	155
	6	1.26	158	0.11	167	6.27	179	7.64	175
	7	0.35	184	0.06	181	3.99	200	4.41	198
	8+	0.94	183	0.03	181	3.10	207	4.07	201
	Total	26.35		2.66		79.28		108.30	
	SOP		1,517		268		8,447		10,232
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.25	15	0.02	67	0.34	15	1.62	16
	2	0.22	46	0.00	104	1.25	53	1.47	52
	3	0.15	85	0.00	184	7.78	90	7.92	90
	4	0.06	104	0.00	191	8.10	132	8.17	132
	5	0.14	185	0.00	196	9.03	163	9.16	163
	6	0.08	189	0.00	198	5.18	171	5.27	171
	7	0.09	202	0.00	219	3.06	184	3.16	184
	8+	0.14	212			2.79	189	2.93	190
	Total	2.14		0.04		37.53		39.71	
	SOP		139		5		5,288		5,431
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.13	8	0.11	12	0.43	13	0.67	12
	1	0.01	37	0.52	41	0.97	38	1.50	39
	2	0.00	67	0.49	59	0.61	68	1.10	64
	3	0.00	133	0.67	90	0.40	104	1.07	96
	4	0.00	168	0.39	107	0.19	117	0.58	111
	5	0.00	200	0.31	133	0.11	131	0.42	132
	6	0.00	203	0.15	159	0.04	156	0.20	159
	7	0.00	217	0.07	207	0.02	189	0.09	202
	8+	0.00	204	0.07	181	0.03	168	0.11	177
	Total	0.16		2.77		2.80		5.73	
	SOP		3		245		179		427
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.56	12	0.38	12	1.68	13	2.62	12
	1	0.93	37	1.74	41	4.62	39	7.29	39
	2	0.55	71	1.62	58	3.37	64	5.54	63
	3	0.30	119	2.00	81	3.13	92	5.44	89
	4	0.14	141	1.02	85	1.55	99	2.72	96
	5	0.07	165	0.72	103	1.01	114	1.80	112
	6	0.03	207	0.32	113	0.44	131	0.79	126
	7	0.02	206	0.11	161	0.18	173	0.30	171
	8+	0.03	181	0.13	149	0.24	158	0.40	157
	Total	2.62		8.04		16.22		26.89	
	SOP		162		566		1,099		1,827
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.69	11	0.49	12	2.11	13	3.29	12
	1	11.78	15	2.32	41	12.38	26	26.49	22
	2	7.03	40	3.12	62	21.16	55	31.31	52
	3	5.24	76	3.34	85	30.73	89	39.31	87
	4	2.18	115	1.89	100	24.39	122	28.45	120
	5	1.40	140	1.31	122	19.72	158	22.42	155
	6	1.37	161	0.58	136	11.94	173	13.89	171
	7	0.47	189	0.23	179	7.26	192	7.96	192
	8+	1.11	187	0.23	163	6.16	197	7.51	194
	Total	31.27		13.52		135.84		180.63	
	SOP		1,821		1,084		15,012		17,917

Table 3.2.4 HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2010 available to the Working Group.

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	Denmark	1	2.0	3	377	375
		2	0.4	No data available		
		3	2.3	21	2057	827
		4	0.6	4	244	185
	Total		5.3	28	2,678	1,387
	Germany	1	-			
		2	-			
		3	-			
		4	0.1	1	92	91
	Total		0.1	1	92	91
	Norway	1	0.3	No data available		
		2	1.6	No data available		
		3	0.2	2	49	49
		4	1.2	No data available		
	Total		3.3	2	49	49
	Faroese	1	-			
		2	-			
		3	-			
		4	0.4	No data available		
	Total		0.4	0	0	0
	Lithuania	1	-			
		2	-			
		3	0.4	No data available		
		4	-			
	Total		0.4	0	0	0
	Sweden	1	1.5	9	721	721
		2	2.3	9	696	696
		3	9.0	21	827	827
		4	4.6	14	697	697
	Total		17.4	53	2,941	2,941
Kattegat	Denmark	1	4.0	7	832	315
		2	0.3	5	275	122
		3	1.4	12	1,100	438
		4	1.9	6	506	295
	Total		7.6	30	2,713	1,170
	Germany	1	-			
		2	-			
		3	0.00002	No data available		
		4	-			
	Total		0.0	0	0	0
	Sweden	1	1.8	9	675	675
		2	-			
		3	0.6	3	344	344
		4	0.4	1	136	136
	Total		2.7	13	1,155	1,155

Table 3.2.4 (cont.) HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2010

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**1**	0.092	8	540	214
		2	0.031	2	72	72
		3	0.002	6	314	235
		4	0.002	12	506	315
	Total		0.126	28	1,432	836
	Germany	**1**	1.4	2	1,147	295
		2	0.1	2	602	100
		3	0.001	No data available		
		4	0.2	1	631	102
	Total		1.7	5	2,380	497
Subdivision 23	**Denmark**	**1**	0.028	2	447	106
		2	0.005	No data available		
		3	0.087	1	70	56
		4	0.031	1	74	73
	Total		0.150	4	591	235
	Sweden	**1**	0.2	No data available		
		2	-			
		3	0.2	No data available		
		4	0.5	No data available		
	Total		0.9	0	0	0
Subdivision 24	**Denmark**	**1**	0.595	3	320	182
		2	0.034	No data available		
		3	0.001	No data available		
		4	0.007	No data available		
	Total		0.636	3	320	182
	Germany	**1**	5.1	13	6,499	1,556
		2	4.8	16	7,272	1,314
		3	0.1	No data available		
		4	0.5	2	1,291	276
	Total		10.5	31	15,062	3,146
	Poland	**1**	1.5	2	413	176
		2	0.3	2	310	108
		3	-			
		4	-			
	Total		1.8	4	723	284
	Sweden	**1**	1.30	5	699	699
		2	0.10	1	308	308
		3	0.04			
		4	0.60	4	463	463
	Total		2.03	10	1,470	1,470
Total	**Skagerrak**	**1-4**	**27.0**	**84**	**5,760**	**4,468**
	Kattegat	**1-4**	**10.3**	**43**	**3,868**	**2,325**
	Subdivision 22	**1-4**	**1.8**	**33**	**3,812**	**1,333**
	Subdivision 23	**1-4**	**1.1**	**4**	**591**	**235**
	Subdivision 24	**1-4**	**15.0**	**48**	**17,575**	**5,082**
	Total	**1-4**	**55.2**	**212**	**31,606**	**13,443**

Table 3.2.5 WESTERN BALTIC HERRING.
Samples of landings by quarter and area used to
to estimate catch in numbers and mean weight at age for 2010

	Country	Quarter	Fleet	Sampling
Skagerrak	**Denmark**	**1**	**C**	Danish sampling in Q1
		2	**C**	Danish sampling in Q1
		3	**C**	Danish sampling in Q3
		4	**C**	Danish sampling in Q4
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	German 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
	Faroese	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	No landings
		4	**C**	Danish sampling in Q4
	Denmark	**1**	**D**	Danish sampling in Q2
		2	**D**	Danish sampling in Q2
		3	**D**	Danish sampling in Q3
		4	**D**	Danish sampling in Q4
	Sweden	**1**	**D**	Swedish sampling in Q1
		2	**D**	Swedish sampling in Q2
		3	**D**	Swedish sampling in Q3
		4	**D**	Swedish sampling in Q4
	Norway	**1**	**C**	Danish sampling in Q1
		2	**C**	Danish sampling in Q1
		3	**C**	Norwegian sampling in Q3
		4	**C**	Norwegian sampling in Q3
Kattegat	**Denmark**	**1**	**C**	Danish sampling in Q1
		2	**C**	Danish sampling in Q1
		3	**C**	Danish sampling in Q3
		4	**C**	Danish sampling in 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
	Germany	**1**	**C**	No landings
		2	**C**	No landings
		3	**C**	Danish sampling in Q3
		4	**C**	No landings
	Denmark	**1**	**D**	Danish sampling in Q1
		2	**D**	Danish sampling in Q2
		3	**D**	Danish sampling in Q3
		4	**D**	Danish sampling in Q3
Subdivision 22	**Denmark**	**1**	**F**	Danish sampling in Q1
		2	**F**	Danish sampling in Q2
		3	**F**	Danish sampling in Q3
		4	**F**	Danish sampling in Q4
	Germany	**1**	**F**	German sampling in Q1 (+ Q1/Q2 in SD 24)
		2	**F**	German sampling in Q2 (+ Q2 in SD 24)
		3	**F**	German sampling in Q1/Q2 in SD 24
		4	**F**	German sampling in Q3 (+ Q4 in SD 24)

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

**Table 3.2.5 continued. WESTERN BALTIC HERRING.
Samples of landings by quarter and area used to
to estimate catch in numbers and mean weight by age for 2010**

	Country	Quarter	Fleet	Sampling
Subdivision 23	**Denmark**	**1**	**F**	Danish sampling in Q1
		2	**F**	Danish sampling in Q1
		3	**F**	Danish sampling in Q3
		4	**F**	Danish sampling in Q4
	Sweden	**1**	**F**	Swedish sampling in Q1 in SD 24
		2	**F**	No landings
		3	**F**	Swedish sampling in Q4 in SD 24
		4	**F**	Swedish sampling in Q4 in SD 24
Subdivision 24	**Denmark**	**1**	**F**	Danish sampling in Q1
		2	**F**	Danish sampling in Q1
		3	**F**	Danish sampling in Q3 in SD 23
		4	**F**	Danish sampling in Q4 in SD 23
	Germany	**1**	**F**	German sampling in Q1 (+ Q2 in SD 24)
		2	**F**	German sampling in Q2
		3	**F**	German sampling in Q4
		4	**F**	German sampling in Q4
	Poland	**1**	**F**	Polish sampling in Q1
		2	**F**	Polish sampling in Q2
		3	**F**	No landings
		4	**F**	No landings
	Sweden	**1**	**F**	Swedish sampling in Q1
		2	**F**	Swedish sampling in Q1
		3	**F**	Swedish sampling in Q4
		4	**F**	Swedish sampling in Q4

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

Table 3.2.6 WESTERN BALTIC HERRING.
Proportion of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) given in % in Skagerrak and Kattegat by age and quarter.
Year: 2010

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	93.49%	6.51%	169	88.46%	11.54%	208
	2	52.89%	47.11%	225	32.69%	67.31%	104
	3	2.86%	97.14%	70	0.00%	100.00%	78
	4	0.00%	100.00%	19	0.00%	100.00%	41
	5	0.00%	100.00%	9	0.00%	100.00%	16
	6	0.00%	100.00%	15	0.00%	100.00%	7
	7	7.14%	92.86%	14	0.00%	100.00%	5
	8	0.00%	100.00%	4	0.00%	100.00%	1
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	100.00%	0.00%	23	91.03%	8.97%	78
	2	22.00%	78.00%	50	0.00%	100.00%	5
	3	2.00%	98.00%	50	0.00%	100.00%	1
	4	6.67%	93.33%	30	0.00%	100.00%	0
	5	6.25%	93.75%	9	0.00%	100.00%	2
	6	6.25%	93.75%	2	0.00%	100.00%	1
	7	6.25%	93.75%	6	0.00%	100.00%	0
	8	6.25%	93.75%	1	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	89.24%	10.76%	288	85.05%	14.95%	107
	1	82.44%	17.56%	205	66.96%	33.04%	224
	2	18.08%	81.92%	177	11.96%	88.04%	92
	3	0.55%	99.45%	183	0.00%	100.00%	122
	4	0.00%	100.00%	80	0.00%	100.00%	33
	5	1.82%	98.18%	55	0.00%	100.00%	6
	6	0.00%	100.00%	18	0.00%	100.00%	4
	7	0.00%	100.00%	8	0.00%	100.00%	4
	8	0.00%	100.00%	8	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	84.06%	15.94%	69	21.74%	78.26%	92
	1	80.99%	19.01%	121	43.88%	56.12%	196
	2	0.00%	100.00%	65	6.00%	94.00%	50
	3	0.00%	100.00%	32	0.00%	100.00%	16
	4	0.00%	100.00%	9	0.00%	100.00%	7
	5	0.00%	100.00%	4	0.00%	100.00%	1
	6	0.00%	100.00%	0	0.00%	100.00%	0
	7	0.00%	100.00%	0	0.00%	100.00%	2
	8	0.00%	100.00%	1	0.00%	100.00%	1

Table 3.2.7 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Kattegat Year: 2010 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.17	30	34.79	15	34.96	15
	2	8.61	80	3.90	40	12.52	67
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	8.78		38.70		47.48	
	SOP		694		684		1,378
2	1			18.88	16	18.88	16
	2						
	3						
	4						
	5						
	6						
	7						
	8+						
	Total			18.88		18.88	
	SOP				299		299
3	0			1.81	9	1.81	9
	1	8.50	65	0.43	44	8.93	64
	2	0.44	96	0.00	54	0.45	96
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	8.95		2.24		11.18	
	SOP		593		35		628
4	0	0.06	28	0.80	8	0.86	9
	1	12.36	53			12.36	53
	2	0.25	84			0.25	84
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	12.67		0.80		13.47	
	SOP		672		6		679
Total	0	0.06	28	2.61	8	2.67	9
	1	21.02	57	54.10	16	75.12	27
	2	9.31	81	3.90	40	13.22	69
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	30.40		60.61		91.01	
	SOP		1,959		1,024		2,983

Table 3.2.8 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Skagerrak Year: 2010 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.51	28	2.18	18	3.69	22
	2	17.79	75	0.01	37	17.80	75
	3	0.12	117			0.12	117
	4						
	5						
	6						
	7	0.03	231			0.03	231
	8+						
	Total	19.46		2.19		21.65	
	SOP		1,394		40		1,434
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	1.23	36	19.98	18	21.21	19
	2	8.01	76	0.04	37	8.05	76
	3	0.08	117			0.08	117
	4	0.14	149			0.14	149
	5	0.04	187			0.04	187
	6	0.02	221			0.02	221
	7	0.03	197			0.03	197
	8+	0.01	205			0.01	205
	Total	9.56		20.02		29.58	
	SOP		702		364		1,066
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			43.85	7	43.85	7
	1	49.87	77	0.29	39	50.16	76
	2	4.24	112			4.24	112
	3	0.09	134	0.00	114	0.09	134
	4						
	5	0.05	194			0.05	194
	6						
	7						
	8+						
	Total	54.26		44.13		98.39	
	SOP		4,320		316		4,636
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			2.10	17	2.10	17
	1	46.83	77	0.01	60	46.85	77
	2						
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	46.83		2.11		48.94	
	SOP		3,603		36		3,639
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0			45.94	7	45.94	7
	1	99.44	76	22.46	18	121.90	65
	2	30.05	80	0.05	37	30.10	80
	3	0.28	122	0.00	114	0.29	122
	4	0.14	149			0.14	149
	5	0.10	191			0.10	191
	6	0.02	221			0.02	221
	7	0.06	216			0.06	216
	8+	0.01	205			0.01	205
	Total	130.11		68.45		198.56	
	SOP		10,019		756		10,775

Table 3.2.9 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: Kattegat Year: 2010 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.02	30	4.54	15	4.56	15
	2	17.74	80	8.04	40	25.77	67
	3	9.57	121	0.10	75	9.67	120
	4	5.10	156	0.31	41	5.41	149
	5	1.26	179			1.26	179
	6	1.03	191			1.03	191
	7	0.56	210			0.56	210
	8+	0.23	184			0.23	184
	Total	35.51		12.99		48.50	
	SOP		3,950		410		4,361
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1			1.86	16	1.86	16
	2	0.03	88			0.03	88
	3	0.03	124			0.03	124
	4	0.01	159			0.01	159
	5	0.00	170	0.08	111	0.09	113
	6	0.00	192			0.00	192
	7	0.00	201			0.00	201
	8+	0.00	184			0.00	184
	Total	0.07		1.94		2.02	
	SOP		9		39		48
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			0.32	9	0.32	9
	1	4.19	65	0.21	44	4.40	64
	2	3.27	96	0.01	54	3.28	96
	3	4.04	117			4.04	117
	4	1.02	150			1.02	150
	5	0.20	168			0.20	168
	6	0.12	159			0.12	159
	7	0.11	174			0.11	174
	8+						
	Total	12.96		0.54		13.50	
	SOP		1,283		13		1,296
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.23	28	2.87	8	3.10	9
	1	15.81	53			15.81	53
	2	3.97	84			3.97	84
	3	1.38	143			1.38	143
	4	0.54	199			0.54	199
	5	0.09	165			0.09	165
	6						
	7	0.18	210			0.18	210
	8+	0.09	263			0.09	263
	Total	22.28		2.87		25.15	
	SOP		1,550		22		1,572
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.23	28	3.19	8	3.42	9
	1	20.02	55	6.61	16	26.63	45
	2	25.00	83	8.05	40	33.05	72
	3	15.01	122	0.10	75	15.11	121
	4	6.68	158	0.31	41	6.99	153
	5	1.55	177	0.08	111	1.64	174
	6	1.16	187			1.16	187
	7	0.85	205			0.85	205
	8+	0.32	206			0.32	206
	Total	70.82		18.35		89.17	
	SOP		6,793		484		7,277

Table 3.2.10 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: Skagerrak Year: 2010 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.11	28	0.15	18	0.26	22
	2	15.85	75	0.01	37	15.86	75
	3	3.93	117			3.93	117
	4	1.55	156			1.55	156
	5	1.00	207			1.00	207
	6	0.58	241			0.58	241
	7	0.44	231			0.44	231
	8+	0.23	245			0.23	245
	Total	23.69		0.16		23.85	
	SOP		2,395		3		2,398
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1						
	2	28.41	76	0.13	37	28.54	76
	3	3.95	117			3.95	117
	4	2.02	149			2.02	149
	5	0.67	187			0.67	187
	6	0.25	221			0.25	221
	7	0.38	197			0.38	197
	8+	0.21	205			0.21	205
	Total	35.90		0.13		36.02	
	SOP		3,216		5		3,220
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			5.29	7	5.29	7
	1	10.62	77	0.06	39	10.68	76
	2	19.22	112			19.22	112
	3	16.11	134	0.10	114	16.21	134
	4	5.48	161			5.48	161
	5	2.93	194			2.93	194
	6	1.24	200			1.24	200
	7	0.73	197			0.73	197
	8+	1.16	221			1.16	221
	Total	57.50		5.45		62.95	
	SOP		7,239		50		7,290
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0			0.40	17	0.40	17
	1	10.99	77	0.00	60	10.99	77
	2	8.40	114			8.40	114
	3	3.94	149			3.94	149
	4	1.35	174			1.35	174
	5	0.93	213			0.93	213
	6	0.95	233			0.95	233
	7	0.36	248			0.36	248
	8+	0.82	241			0.82	241
	Total	27.75		0.40		28.15	
	SOP		3,333		7		3,340
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0			5.69	8	5.69	8
	1	21.72	77	0.22	25	21.94	76
	2	71.89	90	0.13	37	72.02	90
	3	27.94	131	0.10	114	28.03	131
	4	10.40	160			10.40	160
	5	5.53	199			5.53	199
	6	3.02	220			3.02	220
	7	1.92	215			1.92	215
	8+	2.42	228			2.42	228
	Total	144.84		6.14		150.97	
	SOP		16,182		65		16,248

Table 3.2.11 WESTERN BALTIC HERRING

Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***

Division: IIIa Year: 2010 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	1.68	28	36.97	15	38.65	16
	2	26.41	76	3.91	40	30.32	72
	3	0.12	117			0.12	117
	4						
	5						
	6						
	7	0.03	231			0.03	231
	8+						
	Total	28.24		40.89		69.12	
	SOP		2,088		724		2,812
2	1	1.23	36	38.86	17	40.09	18
	2	8.01	76	0.04	37	8.05	76
	3	0.08	117			0.08	117
	4	0.14	149			0.14	149
	5	0.04	187			0.04	187
	6	0.02	221			0.02	221
	7	0.03	197			0.03	197
	8+	0.01	205			0.01	205
	Total	9.56		38.90		48.46	
	SOP		702		663		1,365
3	0			45.66	7	45.66	7
	1	58.37	75	0.71	42	59.09	74
	2	4.69	111	0.00	54	4.69	111
	3	0.09	134	0.00	114	0.09	134
	4						
	5	0.05	194			0.05	194
	6						
	7						
	8+						
	Total	63.20		46.37		109.57	
	SOP		4,913		351		5,264
4	0	0.06	28	2.89	14	2.96	15
	1	59.19	72	0.01	60	59.20	72
	2	0.25	84			0.25	84
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	59.51		2.91		62.41	
	SOP		4,275		42		4,317
Total	0	0.06	28	48.55	7	48.61	7
	1	120.46	72	76.56	16	197.03	51
	2	39.36	80	3.95	40	43.31	77
	3	0.28	122	0.00	114	0.29	122
	4	0.14	149			0.14	149
	5	0.10	191			0.10	191
	6	0.02	221			0.02	221
	7	0.06	216			0.06	216
	8+	0.01	205			0.01	205
	Total	160.51		129.06		289.57	
	SOP		11,978		1,781		13,759

Table 3.2.12 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***Baltic Spring spawners***
Division: IIIa **Year: 2010** **Country: All**

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.13	28	4.69	15	4.82	16
	2	33.59	78	8.04	40	41.63	70
	3	13.51	120	0.10	75	13.61	119
	4	6.65	156	0.31	41	6.96	151
	5	2.26	192			2.26	192
	6	1.61	209			1.61	209
	7	1.00	219			1.00	219
	8+	0.46	214			0.46	214
	Total	59.20		13.15		72.35	
	SOP		6,345		413		6,758
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1			1.86	16	1.86	16
	2	28.44	76	0.13	37	28.56	76
	3	3.97	117			3.97	117
	4	2.04	149			2.04	149
	5	0.67	187	0.08	111	0.76	179
	6	0.25	221			0.25	221
	7	0.39	197			0.39	197
	8+	0.21	204			0.21	204
	Total	35.97		2.07		38.04	
	SOP		3,225		43		3,268
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0			5.61	7	5.61	7
	1	14.82	73	0.27	43	15.09	73
	2	22.49	110	0.01	54	22.51	110
	3	20.15	131	0.10	114	20.24	131
	4	6.50	159			6.50	159
	5	3.14	193			3.14	193
	6	1.36	196			1.36	196
	7	0.84	194			0.84	194
	8+	1.16	221			1.16	221
	Total	70.46		5.99		76.45	
	SOP		8,522		63		8,586
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.23	28	3.27	9	3.50	10
	1	26.80	63	0.00	60	26.80	63
	2	12.37	104			12.37	104
	3	5.32	148			5.32	148
	4	1.89	181			1.89	181
	5	1.02	209			1.02	209
	6	0.95	233			0.95	233
	7	0.54	235			0.54	235
	8+	0.91	243			0.91	243
	Total	50.03		3.27		53.30	
	SOP		4,883		29		4,912
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.23	28	8.88	8	9.11	8
	1	41.74	66	6.83	17	48.57	59
	2	96.89	88	8.18	40	105.07	84
	3	42.94	128	0.20	94	43.15	128
	4	17.08	159	0.31	41	17.39	157
	5	7.09	194	0.08	111	7.17	193
	6	4.18	211			4.18	211
	7	2.77	212			2.77	212
	8+	2.74	226			2.74	226
	Total	215.66		24.48		240.14	
	SOP		22,975		549		23,524

Table 3.2.13 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of *Western Baltic Spring* spawners in Division IIIa and the North Sea in the years 1993-2010.

Year	W-rings	0	1	2	3	4	5	6	7	8+	Total
1993	Numbers	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1,292.03
	Mean W.	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	
	SOP	2,435	9,612	25,696	27,936	14,120	10,167	8,027	4,541	1,966	104,498
1994	Numbers	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
	Mean W.	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	
	SOP	1,225	6,524	24,767	27,206	19,686	13,043	8,642	3,022	1,898	106,013
1995	Numbers	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
	Mean W.	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	
	SOP	902	12,551	19,970	13,517	14,823	6,065	4,404	2,747	1,696	76,674
1996	Numbers	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
	Mean W.	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	
	SOP	1,748	6,296	28,618	10,197	6,665	5,714	2,568	1,402	1,241	64,449
1997	Numbers	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
	Mean W.	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	
	SOP	498	3,648	12,176	22,913	4,656	2,489	879	337	480	48,075
1998	Numbers	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
	Mean W.	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	
	SOP	1,009	8,980	22,542	10,287	7,804	1,922	1,695	403	481	55,121
1999	Numbers	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
	Mean W.	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	
	SOP	477	9,698	13,012	14,048	5,232	3,225	749	373	366	47,179
2000	Numbers	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
	Mean W.	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	
	SOP	2,601	10,145	20,357	10,756	7,131	3,189	1,288	249	294	56,010
2001	Numbers	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
	Mean W.	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	
	SOP	1,096	1,875	15,863	12,093	4,657	3,371	1,852	780	492	42,079
2002	Numbers	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1,027.26
	Mean W.	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	
	SOP	709	11,795	13,162	15,848	7,632	2,046	1,435	481	435	53,544
2003	Numbers	52.11	63.02	182.53	65.45	64.37	21.47	6.26	4.35	1.81	461.38
	Mean W.	13.0	37.4	76.5	113.3	132.7	142.2	153.5	169.9	162.2	
	SOP	678	2,355	13,957	7,416	8,540	3,053	961	740	294	37,994
2004	Numbers	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
	Mean W.	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	
	SOP	695	9,047	7,869	11,005	2,652	2,651	769	279	111	35,078
2005	Numbers	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.51
	Mean W.	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	
	SOP	1,341	5,319	17,415	9,163	6,961	1,519	2,028	618	282	44,645
2006 c	Numbers	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.49
	Mean W.	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	
	SOP	121	3,847	9,584	12,907	6,972	9,765	2,199	2,159	1,134	48,688
2007	Numbers	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.22
	Mean W.	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	
	SOP	41	6,816	7,723	4,269	4,265	2,035	1,802	1,114	567	28,632
2008	Numbers	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.80
	Mean W.	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	98.02
	SOP	94	7,281	6,472	4,456	1,917	2,590	1,402	900	256	25,368
2009	Numbers	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.63
	Mean W.	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	90.89
	SOP	199	7,783	11,946	5,436	4,094	1,974	1,669	1,757	1,371	36,230
2010	Numbers	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.38
	Mean W.	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	106.71
	SOP	75	2,878	8,991	5,870	3,445	1,686	1,311	1,696	1,513	27,465

Data for 1995 to 2001 was revised in 2003.

[c] values have been corrected in 2007

Table 3.2.14 WESTERN BALTIC HERRING.
Landings in numbers (mill.), mean weight (g.) and SOP (t)
by age and quarter from. Western Baltic Spring Spawners
(values from the North Sea, see Table 2.2.1-2.2.5)
Division: IV + IIIa + 22-24 Year: 2010

		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	0.000	66.30	4.82	15.62	16.09	13.57	20.906	14.04
	2	0.000	128.60	41.63	70.25	23.21	49.03	64.837	62.65
	3	0.000	153.50	13.61	119.19	24.87	85.39	38.481	97.35
	4	0.256	195.00	6.96	150.83	16.98	118.09	24.203	128.33
	5	0.084	187.90	2.26	191.59	11.03	155.45	13.376	161.76
	6	0.104	210.10	1.61	208.95	7.64	175.09	9.355	181.31
	7	0.083	206.80	1.00	219.01	4.41	198.42	5.487	202.29
	8+	0.283	233.44	0.46	213.97	4.07	201.38	4.809	204.47
	Total	0.810		72.35		108.30		181.455	
	SOP		171		6,758		10,232		17,161
		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	0.000	62.50	1.86	15.85	1.62	16.07	3.48	15.95
	2	0.000	129.50	28.56	75.56	1.47	52.21	30.03	74.42
	3	0.000	151.20	3.97	117.25	7.92	89.68	11.90	98.89
	4	0.215	208.10	2.04	149.40	8.17	132.02	10.42	136.99
	5	0.041	182.60	0.76	179.00	9.16	163.49	9.96	164.75
	6	0.190	208.90	0.25	221.16	5.27	171.14	5.71	174.59
	7	0.103	227.70	0.39	197.20	3.16	184.44	3.65	187.01
	8+	0.459	242.32	0.21	204.43	2.93	189.78	3.60	197.33
	Total	1.008		38.04		39.71		78.76	
	SOP		227		3,268		5,431		8,926
		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	5.61	7.06	0.67	11.71	6.28	7.55
	1	0.03	67.80	15.09	72.71	1.50	38.85	16.61	69.65
	2	0.03	132.30	22.51	110.07	1.10	64.46	23.64	107.97
	3	0.52	157.30	20.24	130.62	1.07	95.60	21.84	129.54
	4	0.30	209.60	6.50	159.18	0.58	110.61	7.38	157.37
	5	0.13	222.90	3.14	192.65	0.42	132.41	3.68	186.88
	6	0.15	206.50	1.36	196.32	0.20	158.76	1.70	192.86
	7	0.04	233.10	0.84	194.42	0.09	202.44	0.97	196.76
	8+	0.00	233.81	1.16	220.99	0.11	176.81	1.27	217.30
	Total	1.19		76.45		5.73		83.37	
	SOP		218		8,586		427		9,231
		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	0.000	0.00	3.50	10.09	2.62	12.34	6.12	11.06
	1	0.000	104.00	26.80	62.55	7.29	39.16	34.09	57.55
	2	0.000	149.00	12.37	104.31	5.54	62.84	17.91	91.49
	3	0.000	187.00	5.32	147.65	5.44	89.14	10.75	118.07
	4	0.217	186.00	1.89	181.20	2.72	95.88	4.83	133.41
	5	0.136	207.00	1.02	209.17	1.80	111.77	2.96	149.63
	6	0.078	225.00	0.95	232.52	0.79	126.43	1.82	186.16
	7	0.045	209.00	0.54	235.31	0.30	170.70	0.89	211.94
	8+	0.276	225.30	0.91	242.72	0.40	156.55	1.58	217.82
	Total	0.752		53.30		26.89		80.94	
	SOP		158		4,912		1,827		6,896
		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	9.11	8.23	3.29	12.22	12.394	9.28
	1	0.03	67.80	48.57	59.26	26.49	22.19	75.083	46.19
	2	0.03	132.30	105.07	84.23	31.31	52.16	136.419	76.88
	3	0.52	157.30	43.15	127.88	39.31	87.06	82.970	108.73
	4	0.98	200.27	17.39	157.09	28.45	119.82	46.833	135.35
	5	0.39	205.56	7.17	193.21	22.42	154.80	29.979	164.64
	6	0.52	210.89	4.18	210.93	13.89	170.59	18.589	180.78
	7	0.27	219.04	2.77	211.68	7.96	191.86	10.996	197.51
	8+	1.02	235.24	2.74	225.73	7.51	194.10	11.262	205.51
	Total	3.76		240.14		180.63		424.525	
	SOP		772		23,524		17,917		42,214

Table 3.2.15 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) of *Western Baltic Spring Spawners* in Division IIIa + North Sea + Subdivisions 22-24 in the years 1993-2010

	W-rings	0	1	2	3	4	5	6	7	8+	Total
Year	**Area**										
1993	**Div. IV+Div. IIIa**	161.3	371.5	315.8	219.0	94.1	59.4	41.0	21.7	8.2	1130.8
	Subdiv. 22-24	44.9	159.2	180.1	196.1	166.9	151.1	61.8	42.2	16.3	973.7
1994	**Div. IV+Div. IIIa**	60.6	153.1	261.1	221.6	131.0	77.3	44.4	14.4	8.6	911.6
	Subdiv. 22-24	202.6	96.3	103.8	161.0	136.1	90.8	74.0	35.1	24.5	721.6
1995	**Div. IV+Div. IIIa**	50.3	302.5	204.2	97.9	90.9	30.6	21.3	12.0	7.2	816.9
	Subdiv. 22-24	491.0	1,358.2	233.9	128.9	104.0	53.6	38.8	20.9	13.2	1951.5
1996	**Div. IV+Div. IIIa**	166.2	228.1	317.7	75.6	40.4	30.6	12.6	6.7	5.6	883.6
	Subdiv. 22-24	4.9	410.8	82.8	124.1	103.7	99.5	52.7	24.0	19.5	917.1
1997	**Div. IV+Div. IIIa**	26.0	73.4	158.7	180.1	30.2	14.2	4.8	1.8	2.3	491.3
	Subdiv. 22-24	350.8	595.2	130.6	96.9	45.1	29.0	35.1	19.5	21.8	973.2
1998	**Div. IV+Div. IIIa**	36.3	175.1	315.1	94.5	54.7	11.2	8.7	2.2	2.1	700.0
	Subdiv. 22-24	513.5	447.9	115.8	88.3	92.0	34.1	15.0	13.2	12.0	818.4
1999	**Div. IV+Div. IIIa**	41.3	190.3	155.7	122.3	43.2	22.2	4.4	3.0	2.4	584.8
	Subdiv. 22-24	528.3	425.8	178.7	123.9	47.1	33.7	11.1	6.5	3.7	830.5
2000	**Div. IV+Div. IIIa**	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.6
	Subdiv. 22-24	37.7	616.3	194.3	86.7	77.8	53.0	30.1	12.4	9.3	1079.9
2001	**Div. IV+Div. IIIa**	121.7	36.6	208.1	111.1	32.1	19.7	9.8	4.2	2.4	545.6
	Subdiv. 22-24	634.6	486.5	280.7	146.8	76.0	48.7	29.3	14.1	4.3	1721.0
2002	**Div. IV+Div. IIIa**	69.6	577.7	168.3	134.6	53.1	12.0	7.5	2.4	2.0	1027.3
	Subdiv. 22-24	80.6	81.4	113.6	186.7	119.2	45.1	31.1	11.4	6.3	675.4
2003	**Div. IV+Div. IIIa**	52.1	63.0	182.5	64.0	62.2	20.3	5.9	3.8	1.6	455.5
	Subdiv. 22-24	1.4	63.9	82.3	95.8	125.1	82.2	22.9	13.1	7.0	493.6
2004	**Div. IV+Div. IIIa**	25.7	209.3	96.0	94.0	18.2	16.8	4.5	1.5	0.6	466.7
	Subdiv. 22-24	217.9	248.4	101.8	70.8	75.0	74.4	44.5	13.4	10.4	856.5
2005	**Div. IV+Div. IIIa**	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.5
	Subdiv. 22-24	11.6	207.6	115.9	102.5	83.5	51.3	54.2	27.8	11.2	665.5
2006 c	**Div. IV+Div. IIIa**	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.5
	Subdiv. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8
2007	**Div. IV+Div. IIIa**	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2008	**Div. IV+Div. IIIa**	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.8
	Subdiv. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2009	**Div. IV+Div. IIIa**	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.6
	Subdiv. 22-24	5.9	31.5	110.7	55.5	45.5	37.2	31.9	13.2	7.2	338.7
2010	**Div. IV+Div. IIIa**	9.1	48.6	106.1	45.2	20.8	8.6	5.9	7.2	5.9	257.4
	Subdiv. 22-24	3.3	26.5	31.3	39.3	28.5	22.4	13.9	8.0	7.5	180.6

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

[c] values have been corrected in 2007

Table 3.2.16 **WESTERN BALTIC HERRING.**
Mean weight (g) and SOP (tons) of *Western Baltic Spring Spawners* in Division IIIa + North Sea + Subdivisions 22-24 in the years 1993 - 2010

	W-rings	0	1	2	3	4	5	6	7	8+	SOP
Year	Area										
1993	Div. IV+Div. IIIa	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	104,498
	Subdiv. 22-24	16.2	24.5	44.5	73.6	94.1	122.4	149.4	168.5	178.7	80,512
1994	Div. IV+Div. IIIa	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	106,013
	Subdiv. 22-24	12.9	28.2	54.2	76.4	95.0	117.7	133.6	154.3	173.9	66,425
1995	Div. IV+Div. IIIa	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	76,674
	Subdiv. 22-24	9.3	16.3	42.8	68.3	88.9	125.4	150.4	193.3	207.4	74,157
1996	Div. IV+Div. IIIa	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	64,449
	Subdiv. 22-24	12.1	22.9	45.8	74.0	92.1	116.3	120.8	139.0	182.5	56,817
1997	Div. IV+Div. IIIa	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	48,075
	Subdiv. 22-24	30.4	24.7	58.4	101.0	120.7	155.2	181.3	197.1	208.8	67,513
1998	Div. IV+Div. IIIa	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	55,121
	Subdiv. 22-24	13.3	26.3	52.2	78.6	103.0	125.2	150.0	162.1	179.5	51,911
1999	Div. IV+Div. IIIa	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	47,179
	Subdiv. 22-24	11.1	26.9	50.4	81.6	112.0	148.4	151.4	167.8	161.0	50,060
2000	Div. IV+Div. IIIa	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	56,010
	Subdiv. 22-24	16.5	22.2	42.8	80.4	123.5	133.2	143.4	155.4	151.4	53,904
2001	Div. IV+Div. IIIa	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	42,079
	Subdiv. 22-24	12.9	22.3	46.8	69.0	93.5	150.8	145.1	146.3	153.1	63,724
2002	Div. IV+Div. IIIa	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	53,544
	Subdiv. 22-24	10.8	27.3	57.8	81.7	108.8	132.1	186.6	177.8	157.7	52,647
2003	Div. IV+Div. IIIa	13.0	37.4	76.5	112.7	132.1	140.8	151.9	167.4	158.2	37,075
	Subdiv. 22-24	22.4	25.8	46.4	75.3	95.2	117.2	125.9	157.1	162.6	40,315
2004	Div. IV+Div. IIIa	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	35,078
	Subdiv. 22-24	3.7	14.3	47.4	77.7	96.4	125.5	150.4	165.8	151.0	41,736
2005	Div. IV+Div. IIIa	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	50,765
	Subdiv. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	37,013
2006 c	Div. IV+Div. IIIa	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	25,965
	Subdiv. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	70,911
2007	Div. IV+Div. IIIa	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	28,632
	Subdiv. 22-24	11.9	27.8	57.3	74.9	106.3	121.3	140.8	162.7	185.5	39,548
2008	Div. IV+Div. IIIa	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	25,368
	Subdiv. 22-24	16.3	49.5	65.2	88.1	110.5	133.2	140.3	156.7	172.2	43,116
2009	Div. IV+Div. IIIa	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	36,230
	Subdiv. 22-24	10.5	28.3	48.1	90.5	123.7	145.2	160.4	171.2	181.8	31,032
2010	Div. IV+Div. IIIa	8.2	59.3	84.7	129.8	165.9	196.2	221.8	234.3	257.2	27,465
	Subdiv. 22-24	12.2	22.2	52.2	87.1	119.8	154.8	170.6	191.9	194.1	17,917

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

[c] values have been corrected in 2007

Table 3.2.17 WESTERN BALTIC HERRING.
Transfers of *North Sea autumn spawners* from Div. IIIa to the North Sea
Numbers ('000) and mean weight, SOP in (tonnes) 1993-2010.

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
1993	Number	2,795.4	2,032.5	237.6	26.5	7.7	3.6	2.7	2.2	0.7	5,109.0
	Mean W.	12.5	28.6	79.7	141.4	132.3	233.4	238.5	180.6	203.1	
	SOP	34,903	58,107	18,939	3,749	1,016	850	647	390	133	118,734
1994	Number	481.6	1,086.5	201.4	26.9	6.0	2.9	1.6	0.4	0.2	1,807.5
	Mean W.	16.0	42.9	83.4	110.7	138.3	158.6	184.6	199.1	213.9	
	SOP	7,723	46,630	16,790	2,980	831	460	287	75	37	75,811
1995	Number	1,144.5	1,189.2	161.5	13.3	3.5	1.1	0.6	0.4	0.3	2,514.4
	Mean W.	11.2	39.1	88.3	145.7	165.5	204.5	212.2	236.4	244.3	
	SOP	12,837	46,555	14,267	1,940	573	225	133	86	65	76,680
1996	Number	516.1	961.1	161.4	17.0	3.4	1.6	0.7	0.4	0.3	1,661.9
	Mean W.	11.0	23.4	80.2	126.6	165.0	186.5	216.1	216.3	239.1	
	SOP	5,697	22,448	12,947	2,151	565	307	145	77	66	44,403
1997	Number	67.6	305.3	131.7	21.2	1.7	0.8	0.2	0.1	0.1	528.7
	Mean W.	19.3	47.7	68.5	124.4	171.5	184.7	188.7	188.7	192.4	
	SOP	1,304	14,571	9,025	2,643	285	146	40	16	25	28,057
1998	Number	51.3	745.1	161.5	26.6	19.2	3.0	3.1	1.2	0.5	1,011.6
	Mean W.	27.4	56.4	79.8	117.8	162.9	179.7	197.2	178.9	226.3	
	SOP	1,409	41,994	12,896	3,137	3,136	547	608	211	108	64,045
1999	Number	598.8	303.0	148.6	47.2	13.4	6.2	1.2	0.5	0.5	1,119.4
	Mean W.	10.4	50.5	87.7	113.7	137.4	156.5	188.1	187.3	198.8	
	SOP	6,255	15,297	13,037	5,369	1,841	974	230	90	92	43,186
2000	Number	235.3	984.3	116.0	21.9	22.9	7.5	3.3	0.6	0.1	1,391.8
	Mean W.	21.3	28.5	76.1	108.8	163.1	190.3	183.9	189.4	200.2	
	SOP	5,005	28,012	8,825	2,377	3,731	1,436	601	114	13	50,115
2001	Number	807.8	563.6	150.0	17.2	1.4	0.3	0.5	0.0	0.0	1,540.8
	Mean W.	8.7	49.4	75.3	108.2	130.1	147.1	219.1	175.8	198.1	
	SOP	7,029	27,849	11,300	1,856	177	43	109	8	5	48,376
2002	Number	478.5	362.6	56.7	5.6	0.7	0.2	0.1	0.0	0.0	904.5
	Mean W.	12.2	38.0	100.6	121.5	142.7	160.9	178.7	177.4	218.6	
	SOP	5,859	13,790	5,705	684	106	26	21	8	5	26,205
2003	Number	21.6	445.0	182.3	13.0	16.2	1.8	1.1	1.2	0.2	682.4
	Mean W.	20.5	33.7	67.0	123.2	150.3	163.5	190.2	214.6	186.8	
	SOP	442	14,992	12,219	1,606	2,436	293	213	264	33	32,498
2004	Number	88.4	70.9	179.9	20.7	6.0	9.7	1.8	2.0	0.9	380.4
	Mean W.	22.5	55.3	70.2	120.6	140.9	151.7	170.6	186.6	178.5	
	SOP	1,993	3,921	12,638	2,498	851	1,479	312	367	154	24,214
2005	Number	96.4	307.5	159.2	16.2	5.4	2.4	2.3	0.5	0.2	589.9
	Mean W.	16.5	50.5	71.0	105.9	154.6	173.5	184.5	200.2	208.9	
	SOP	1,595	15,527	11,304	1,712	828	412	420	95	34	31,927
2006	Number	35.1	150.1	50.2	10.2	3.3	3.3	0.6	0.4	0.2	253.3
	Mean W.	14.3	53.5	79.2	117.6	140.2	185.5	190.4	215.6	206.9	
	SOP	503	8,035	3,975	1,200	456	620	107	81	37	15,015
2007	Number	67.7	189.3	76.9	2.1	0.4	1.4	0.3	0.6	0.0	338.7
	Mean W.	26.7	62.6	71.1	108.1	124.4	151.7	183.7	174.7	153.8	
	SOP	1,807	11,857	5,464	224	55	219	48	110	3	19,788
2008	Number	85.7	86.6	72.0	1.9	0.3	0.1	0.1	0.3	0.1	247.0
	Mean W.	16.2	57.6	86.4	109.1	138.7	167.7	175.4	203.1	197.7	
	SOP	1,386	4,986	6,222	205	35	25	10	67	13	12,949
2009	Number	116.8	77.5	7.0	0.4	0.2	0.0	0.0	0.0	0.1	202.0
	Mean W.	9.4	59.8	101.0	81.3	206.4	0.0	0.0	0.0	268.5	
	SOP	1,095	4,635	710	29	46	0	0	0	28	6,542
2010	Number	48.6	197.0	43.3	0.3	0.1	0.1	0.0	0.1	0.0	289.6
	Mean W.	7.5	50.6	76.8	122.3	149.3	191.3	221.5	216.3	204.5	
	SOP	364	9,975	3,325	35	22	19	4	13	3	13,759

Corrections for the years 1991-1998 was made in HAWG 2001, but are NOT included in the North Sea assessment.

Table 3.3.1a **WESTERN BALTIC HERRING. German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1993-2010 (September/October).**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002**	2003	2004	2005	2006	2007	2008	2009	2010
	Numbers in millions																	
W-rings																		
0	893	5,475	5,108	1,833	2,859	2,490	5,994	1,009	2,478	4,103	3,777	2,555	3,055	4,159	2,591	2,150	2,821	4,561
1	492	416	1,675	1,439	1,955	801	1,339	1,430	1,126	838	1,238	969	753	950	560	393	271	536
2	437	884	329	590	738	679	287	454	1,227	421	223	592	640	274	278	214	135	339
3	530	560	358	434	395	394	233	329	845	575	217	346	401	376	149	209	92	483
4	403	444	354	295	162	237	156	202	367	341	260	163	192	353	136	150	61	336
5	125	189	254	306	119	100	52	79	132	64	97	143	105	183	88	166	32	182
6	55	60	127	119	99	51	8	39	86	25	38	79	90	131	25	102	34	76
7	28	24	46	47	33	24	1	6	20	10	9	23	26	85	23	42	16	88
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	30	11	19	4	27
Total	2,976	8,053	8,277	5,083	6,409	4,785	8,072	3,551	6,290	6,389	5,869	4,882	5,279	6,542	3,860	3,445	3,465	6,628
3+ group	1,154	1,279	1,166	1,220	856	815	452	658	1,459	1,028	631	766	830	1,159	432	688	238	1,192
	Biomass ('000 tonnnes)																	
W-rings																		
0	12.8	66.9	58.5	16.6	28.5	23.8	71.8	13.8	31.2	38.2	33.9	23.1	33.1	43.9	25.8	24.8	30.1	39.9
1	19.5	14.5	58.6	46.6	76.4	39.9	51.1	57.5	48.2	34.2	44.8	35.9	30.1	38.8	23.0	17.7	10.3	24.3
2	21.7	41.0	20.9	29.1	43.5	50.1	22.0	28.4	75.9	30.0	16.1	34.5	48.6	19.7	20.8	12.5	8.4	29.3
3	33.8	40.7	30.1	31.0	35.9	35.3	27.5	27.7	77.2	56.8	22.0	27.7	36.2	35.9	12.6	17.7	6.3	38.7
4	25.7	43.0	40.1	21.2	22.3	28.0	16.7	24.1	38.0	40.4	34.2	18.4	22.7	37.4	12.5	14.3	3.8	29.3
5	12.7	24.2	27.3	37.1	16.7	11.4	6.8	9.3	18.5	9.0	14.6	17.3	14.4	27.2	8.9	16.8	2.5	21.7
6	7.1	12.3	14.9	16.1	14.0	6.2	0.9	5.6	13.3	3.5	5.7	12.2	14.5	19.9	2.9	8.8	2.2	11.5
7	2.3	5.3	9.3	6.1	5.3	3.7	0.3	1.2	3.9	1.1	1.3	3.4	5.2	14.6	2.6	3.5	1.0	9.3
8+	1.8	0.6	6.6	2.9	10.6	2.2	0.5	0.8	2.1	1.9	1.6	2.0	3.6	6.5	1.9	2.0	0.5	4.6
Total	137.3	248.5	266.3	206.8	253.3	200.5	197.5	168.4	308.1	215.0	174.2	174.6	208.3	243.9	111.0	118.0	65.0	208.6
3+ group	83.3	126.2	128.2	114.4	104.9	86.8	52.6	68.7	152.9	112.6	79.4	81.1	96.5	141.5	41.4	63.0	16.3	115.2
	Mean weight (g)																	
W-rings																		
0	14.3	12.2	11.5	9.0	10.0	9.5	12.0	13.7	12.6	9.3	9.0	9.0	10.8	10.5	10.0	11.5	10.7	8.8
1	39.7	34.8	35.0	32.4	39.1	49.8	38.2	40.2	42.8	40.8	36.2	37.0	40.0	40.8	41.0	45.0	38.1	45.3
2	49.7	46.4	63.7	49.4	58.9	73.8	76.6	62.6	61.8	71.1	72.3	58.3	76.0	71.9	74.8	58.4	62.4	86.4
3	63.9	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	90.2	95.3	84.6	84.7	68.3	80.1
4	63.6	97.0	113.3	71.7	137.2	118.4	106.9	119.4	103.4	118.3	131.2	112.6	118.3	106.2	92.0	95.5	62.4	87.3
5	101.4	127.7	107.6	121.6	140.8	114.1	130.3	117.3	140.4	141.8	150.2	121.0	136.7	148.9	100.9	100.7	77.2	119.5
6	127.7	203.9	117.7	134.6	141.0	120.8	106.6	145.5	154.8	142.6	150.2	154.7	161.3	151.7	116.8	86.5	66.1	151.4
7	81.0	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.5	110.9	156.6	151.0	201.8	171.5	109.3	83.4	65.0	105.2
8+	137.7	269.1	241.2	154.9	222.3	232.6	218.5	180.7	217.0	142.6	163.3	169.2	213.4	213.9	176.0	103.3	120.9	169.5
Total	46.1	30.9	32.2	40.7	39.5	41.9	24.5	47.4	49.0	33.6	29.7	35.8	39.5	37.3	28.7	34.3	18.8	31.5

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

**incl. mean for Sub-division 21, which was not covered by RV SOLEA

Table 3.3.1b **WESTERN BALTIC HERRING. German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1993-2010 (September/October).**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002**	2003	2004	2005	2006	2007	2008	2009	2010
Numbers in millions														***	***	***	***	***
W-rings																		
0	893	5,475	5,108	1,833	2,859	2,490	5,994	1,009	2,478	4,103	3,777	2,555	3,055	4,170	2,593	2,154	2,822	4,568
1	492	416	1,675	1,439	1,955	801	1,339	1,430	1,126	838	1,238	969	753	941	559	393	271	535
2	437	884	329	590	738	679	287	454	1,227	421	223	592	640	227	271	190	108	328
3	530	560	358	434	395	394	233	329	844	575	217	346	401	280	117	166	44	215
4	403	444	354	295	162	237	156	202	367	341	260	163	192	212	77	102	18	107
5	125	189	254	306	119	100	52	79	132	64	97	143	105	140	44	82	9	86
6	55	60	127	119	99	51	8	39	86	25	38	79	90	95	11	30	3	46
7	28	24	46	47	33	24	1	6	19	10	9	23	26	66	9	11	2	23
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	28	8	4	1	15
Total	2,976	8,053	8,277	5,083	6,409	4,785	8,072	3,551	6,289	6,389	5,869	4,882	5,279	6,158	3,688	3,132	3,277	5,922
3+ group	1,154	1,279	1,166	1,220	856	815	452	658	1,458	1,028	631	766	830	820	266	395	77	492
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	43.2	25.2	23.8	29.5	36.9
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	38.2	22.8	17.6	10.5	21.3
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	18.0	20.6	11.4	7.5	25.5
3	33.8	40.7	30.1	31.0	35.9	35.3	27.5	27.7	77.2	56.8	22.0	27.7	36.2	31.9	11.4	15.3	4.4	23.6
4	25.7	43.0	40.1	21.2	22.3	28.0	16.7	24.1	37.9	40.4	34.2	18.4	22.7	31.3	9.7	11.1	2.0	15.2
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	24.9	6.7	11.6	1.4	15.4
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	17.7	1.9	4.8	0.6	8.9
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	13.3	1.6	1.8	0.4	4.5
8+	1.8	0.6	6.6	2.9	10.6	2.2	0.5	0.8	2.1	1.9	1.6	2.0	3.6	6.3	1.7	0.8	0.2	3.0
Total	137.3	248.5	266.3	206.8	253.3	200.5	197.5	168.4	308.0	215.0	174.2	174.6	208.3	224.9	101.7	98.2	56.5	154.4
3+ group	83.3	126.2	128.2	114.4	104.9	86.8	52.6	68.7	152.8	112.6	79.4	81.1	96.5	125.5	33.1	45.4	9.0	70.6
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	10.4	9.7	11.0	10.4	8.1
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	40.6	40.8	44.8	38.6	39.9
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	79.4	76.1	60.1	70.1	77.7
3	63.9	72.8	84.1	71.5	91.1	89.5	118.2	84.3	91.4	98.7	101.3	80.1	90.2	114.3	96.9	92.1	101.8	109.8
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	147.3	126.4	108.8	110.6	141.6
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	177.9	153.3	141.1	153.8	180.3
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	187.0	171.3	162.5	190.9	193.6
7	81.0	225.2	199.6	129.9	160.2	157.2	237.9	204.5	198.6	110.9	156.6	151.0	201.8	201.8	189.6	153.9	197.4	197.1
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	228.3	211.0	206.4	178.8	196.8
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	36.5	27.6	31.3	17.2	26.1

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

**incl. mean for Sub-division 21, which was not covered by RV SOLEA

***** excl. Fraction of Central Baltic Herring in SD 24 (HAWG 2011)**

Table 3.3.2 WESTERN BALTIC HERRING. Acoustic surveys on the Spring Spawning Herring in the North Sea/Division IIIa in 1991-2010 (July).

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	1999**	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Numbers in millions																				
W-rings																				
0		3,853	372	964														112		
1		277	103	5	2,199	1,091	128	138	1,367	1,509	66	3,346	1,833	1,669	2,687	2,081	3,918	5,852	565	999
2	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930	1,342	2,217	3,621	1,160	398	511
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464	1,780	933	843	205	254
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490	499	333	161	115
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274	82	65
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176	86	24
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45	39	28
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44	65	34
Total	**5,177**	**10,509**	**5,779**	**3,339**	**6,867**	**2,673**	**2,088**	**3,248**	**3,201**	**4,696**	**1,481**	**7,002**	**3,807**	**3,926**	**4,939**	**6,786**	**9,199**	**8,839**	**1,601**	**2,030**
3+ group	**5,177**	**4,287**	**2,536**	**1,957**	**2,781**	**577**	**1,245**	**1,428**	**691**	**1,295**	**774**	**2,079**	**864**	**1,328**	**910**	**2,487**	**1,660**	**1,715**	**638**	**520**
Biomass ('000 tonnes)																				
W-rings																				
0		34.3	1	8.7																
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9	112.6	193.2	284.4	26.8	53.0
2	177.1	169.0	139	33.2	108.9	87.0	52.2	136.1	101.6	138.1	55.8	107.2	91.5	75.6	100.1	160.5	273.4	100.9	48.8	34.0
3	219.7	206.3	112	114.7	102.6	27.6	81.0	84.8	59.5	68.8	51.2	126.9	41.4	89.4	46.6	158.6	90.9	101.8	30.6	28.0
4	116.0	204.7	69	76.7	145.5	17.9	21.5	35.2	14.7	45.3	21.5	55.9	41.7	41.5	28.9	56.3	59.6	47.1	29.4	17.0
5	51.1	83.3	65	41.8	33.9	17.8	9.8	13.1	3.4	25.1	17.9	12.8	13.9	29.3	16.5	23.7	18.5	45.3	17.5	11.0
6	19.0	36.6	26	38.1	27.4	5.8	9.8	6.9	0.5	10.0	6.9	7.4	4.2	11.7	14.9	4.1	4.6	30.9	21.4	5.0
7	13.0	24.4	16	13.1	6.7	3.3	14.9	4.8	0.3	1.4	4.7	3.5	2.0	4.1	7.5	1.6	2.6	9.4	10.6	6.0
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9	0.0	1.9	8.7	19.8	8.0
Total	597.9	756.1	436.5	325.8	506.2	215.1	207.5	297.0	254.9	351.4	164.2	454.0	274.5	318.8	325.3	517.5	644.7	628.5	204.9	162.0
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3	244.4	178.2	243.2	129.3	75.0
Mean weight (g)																				
W-rings																				
0		8.9	4.0	9.0														6.3		
1		96.8	66.3	80.0	35.2	48.5	36.9	51.9	54.7	40.7	54.0	41.0	43.1	38.3	39.4	54.1	49.3	48.6	47.5	52.7
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6	72.4	75.5	87.0	122.7	65.8
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5	89.1	97.4	120.8	149.1	111.4
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7	114.8	119.5	141.4	182.9	150.9
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9	131.6	120.0	165.5	213.3	175.6
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7	153.2	136.6	175.6	248.3	198.0
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3	169.2	101.5	208.5	272.1	215.9
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2	178.0	138.3	196.7	304.7	234.8
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9	76.3	70.1	71.1	128.0	79.8

* revised in 1997

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

Table 3.3.3 WESTERN BALTIC HERRING. N20 Larval Abundance Index.

Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N20 (millions)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007*	1,829
2008*	1,622
2009	6,464
2010	7,037

*** small revision during HAWG 2010**

TABLE 3.6.1 WBSS HERRING. CATCH IN NUMBER

Units : thousands

year

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

year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	756285	150271	53489	243554	106906	7946	10721	9610	20734	12394
1	523163	659130	126876	457754	305171	148909	172044	149436	181083	75083
2	488816	281840	264855	197812	319225	187674	184735	136988	243007	136419
3	257837	321311	161251	164766	177833	233214	143904	135753	101330	82970
4	108097	172285	189432	93214	130394	150654	126861	92305	69937	46833
5	68376	57160	103648	91242	60639	98751	64996	89436	48091	29979
6	39092	38532	29117	48957	65695	42459	30199	45930	39750	18589
7	18307	13842	17452	14876	31231	32418	21256	17216	20907	10996
8	6687	8329	8819	11013	12620	17312	14759	17410	12529	11262

TABLE 3.6.2 WBSS HERRING. WEIGHTS AT AGE IN THE CATCH

Units : kg

year

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

year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.0123	0.0105	0.0132	0.00618	0.0140	0.0170	0.0139	0.0178	0.0126	0.00928
1	0.0243	0.0213	0.0315	0.02754	0.0272	0.0360	0.0506	0.0647	0.0479	0.04619
2	0.0593	0.0700	0.0671	0.06419	0.0721	0.0728	0.0709	0.0788	0.0711	0.07688
3	0.0862	0.0968	0.0907	0.10017	0.0938	0.0982	0.0854	0.0960	0.1032	0.10873
4	0.1089	0.1196	0.1079	0.10596	0.1106	0.1153	0.1141	0.1153	0.1390	0.13535
5	0.1567	0.1400	0.1223	0.13139	0.1228	0.1535	0.1288	0.1404	0.1534	0.16464
6	0.1560	0.1876	0.1319	0.15228	0.1493	0.1581	0.1564	0.1481	0.1709	0.18078
7	0.1556	0.1814	0.1603	0.16768	0.1619	0.1865	0.1673	0.1667	0.1924	0.19751
8	0.1713	0.1717	0.1625	0.15295	0.1736	0.1848	0.1903	0.1704	0.2146	0.20551

TABLE 3.6.3 WBSS HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

age	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	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1	0.0169	0.0164	0.0144	0.0131	0.0126	0.0185	0.0150	0.0180	0.0230	0.0140
2	0.0509	0.0637	0.0445	0.0456	0.0514	0.0621	0.0550	0.0680	0.0520	0.0626
3	0.0783	0.0905	0.0793	0.0811	0.0800	0.0953	0.0800	0.0860	0.0900	0.0974
4	0.1159	0.1239	0.1051	0.1092	0.1066	0.1174	0.1140	0.1100	0.1300	0.1283
5	0.1690	0.1736	0.1268	0.1440	0.1322	0.1659	0.1430	0.1390	0.1560	0.1618
6	0.1763	0.1983	0.1506	0.1628	0.1573	0.1710	0.1710	0.1430	0.1740	0.1813
7	0.1681	0.1980	0.1729	0.1932	0.1677	0.1858	0.1750	0.1410	0.1850	0.2023
8	0.1805	0.2036	0.1847	0.2076	0.1820	0.1871	0.1880	0.1580	0.1990	0.2045

TABLE 3.6.4 WBSS HERRING. NATURAL MORTALITY

Units : NA

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

age	2006	2007	2008	2009	2010
0	0.3	0.3	0.3	0.3	0.3
1	0.5	0.5	0.5	0.5	0.5
2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2
7	0.2	0.2	0.2	0.2	0.2
8	0.2	0.2	0.2	0.2	0.2

TABLE 3.6.5 WBSS HERRING. PROPORTION MATURE

Units : NA

year

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

year

age	2006	2007	2008	2009	2010
0	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00
2	0.20	0.20	0.20	0.20	0.20
3	0.75	0.75	0.75	0.75	0.75
4	0.90	0.90	0.90	0.90	0.90
5	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00

TABLE 3.6.6 WBSS HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

year

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

year

age	2006	2007	2008	2009	2010
0	0.1	0.1	0.1	0.1	0.1
1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.1
3	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1

TABLE 3.6.7 WBSS HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

year

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

year

age	2006	2007	2008	2009	2010
0	0.25	0.25	0.25	0.25	0.25
1	0.25	0.25	0.25	0.25	0.25
2	0.25	0.25	0.25	0.25	0.25
3	0.25	0.25	0.25	0.25	0.25
4	0.25	0.25	0.25	0.25	0.25
5	0.25	0.25	0.25	0.25	0.25
6	0.25	0.25	0.25	0.25	0.25
7	0.25	0.25	0.25	0.25	0.25
8	0.25	0.25	0.25	0.25	0.25

TABLE 3.6.8 WBSS HERRING/FINAL RUN. SURVEY INDICES

HERAS 3-6 wr - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
3.00	6.00	NA	1993.00	2010.00	0.58	0.67

Index type : number

HERAS 3-6 wr - Index Values

Units : NA

year

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

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

age	2007	2008	2009	2010
3	933000000	843000000	205000000	254000000
4	499000000	333000000	161000000	115000000
5	154000000	274000000	82000000	65000000
6	34000000	176000000	86000000	24000000

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

Units : NA

year

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

age	2008	2009	2010
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1

GerAS 1-3 wr - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	3.00	NA	1994.00	2010.00	0.77	0.83

Index type : number

GerAS 1-3 wr - Index Values

Units : NA

year

age	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	2004	2005	2006	2007	2008	2009	2010
1	968860	752980	950450	560000	392780	270930	535760
2	592360	640060	274460	278000	213500	134670	338780
3	346230	401070	376480	149000	209000	92270	482880

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

Units : NA

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age	2009	2010
1	1	1
2	1	1
3	1	1

```
N20 - Configuration
      min       max plusgroup   minyear   maxyear    startf      endf
      0.0       0.0        NA    1992.0    2010.0       0.3       0.5
Index type : number
N20 - Index Values
Units  :  NA
   year
age 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 2006 2007 2008 2009 2010
  0 3774 1829 1622 6464 7037
N20 - Index Variance (Inverse Weights)
Units  :  NA
   year
age 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 2007 2008 2009 2010
  0    1    1    1    1
```

TABLE 3.6.9 WBSS HERRING/FINAL RUN. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	8	8	1991	2010	3	6

TABLE 3.6.10 WBSS HERRING/FINAL RUN. FLICA CONFIGURATION SETTINGS

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

TABLE 3.6.11 WBSS HERRING/FINAL RUN. FLR, R SOFTWARE VERSIONS

```
R version 2.8.1 (2008-12-22)
Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows
Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows
Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

TABLE 3.6.12 WBSS HERRING/FINAL RUN. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 3-6) f	Landings tonnes	Landings SOP
1991	5001715	617657	311499	0.356	191573	1.000
1992	3654685	543054	323333	0.475	194411	1.000
1993	3108187	464197	295501	0.543	185010	1.000
1994	6178461	377562	231703	0.695	172438	1.000
1995	4046433	317660	182207	0.512	150831	1.000
1996	4491298	273180	134287	0.701	121266	1.000
1997	3988814	275348	150316	0.511	115588	1.000
1998	5614285	272747	121287	0.492	107032	1.000
1999	6455978	290364	128609	0.373	97240	1.000
2000	3415970	295915	142270	0.467	109914	1.000
2001	4456945	320824	163748	0.453	105803	1.000
2002	2949392	352944	203513	0.404	106191	1.000
2003	3864124	266947	163523	0.393	78309	1.000
2004	2611938	278782	167665	0.342	76815	1.000
2005	2028331	277906	165279	0.394	88406	1.000
2006	1585196	294102	184202	0.455	90549	1.000
2007	1620155	219092	141118	0.435	68997	0.988
2008	1479130	195780	117197	0.474	68484	1.015
2009	2159680	177799	105222	0.517	67262	1.000
2010	3961260	163736	95152	0.302	42214	1.000

TABLE 3.6.13 WBSS HERRING/FINAL RUN. ESTIMATED FISHING MORTALITY

Units : f

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0279	0.047	0.0797	0.0505	0.167	0.0451	0.115	0.120	0.107	0.053	0.217
1	0.2591	0.174	0.2982	0.1602	0.639	0.3787	0.306	0.352	0.236	0.319	0.319
2	0.3196	0.372	0.3514	0.4215	0.572	0.3789	0.359	0.404	0.395	0.368	0.333
3	0.4222	0.371	0.4748	0.5038	0.506	0.5624	0.491	0.405	0.427	0.400	0.332
4	0.3952	0.477	0.4964	0.6465	0.523	0.7135	0.428	0.528	0.358	0.415	0.428
5	0.3709	0.489	0.6335	0.7017	0.432	0.8157	0.481	0.499	0.393	0.539	0.407
6	0.2346	0.563	0.5659	0.9280	0.588	0.7135	0.642	0.537	0.315	0.513	0.643
7	0.4116	0.453	0.5491	0.5933	0.735	0.6915	0.535	0.553	0.426	0.514	0.497
8	0.4116	0.453	0.5491	0.5933	0.735	0.6915	0.535	0.553	0.426	0.514	0.497

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.0607	0.0161	0.114	0.0628	0.00712	0.0068	0.00742	0.0081	0.00472
1	0.3717	0.0814	0.229	0.2514	0.15603	0.1492	0.16262	0.1774	0.10349
2	0.3458	0.3034	0.210	0.2983	0.36084	0.3451	0.37607	0.4103	0.23933
3	0.3810	0.3406	0.314	0.2955	0.40740	0.3897	0.42460	0.4633	0.27021
4	0.3873	0.4061	0.338	0.4392	0.43099	0.4122	0.44918	0.4901	0.28586
5	0.4234	0.4267	0.350	0.3840	0.49800	0.4763	0.51902	0.5663	0.33030
6	0.4242	0.3976	0.367	0.4578	0.48354	0.4625	0.50395	0.5499	0.32071
7	0.4958	0.3462	0.364	0.4238	0.43099	0.4122	0.44918	0.4901	0.28586
8	0.4958	0.3462	0.364	0.4238	0.43099	0.4122	0.44918	0.4901	0.28586

TABLE 3.6.14 WBSS HERRING/FINAL RUN. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	5001715	3654685	3108187	6178461	4046433	4491298	3988814	5614285	6455978
1	4548841	3603427	2583190	2126222	4351708	2535444	3180646	2632817	3689147
2	2171382	2129178	1836113	1162748	1098667	1392515	1053036	1420298	1123564
3	1795620	1291440	1202199	1057879	624574	507455	780501	602337	776193
4	939352	963817	729770	612233	523328	308183	236760	390897	329073
5	628068	518005	489773	363689	262592	253948	123619	126318	188687
6	244323	354873	259951	212820	147620	139544	91967	62569	62816
7	43005	158205	165399	120860	68884	67099	55973	39619	29955
8	16022	67819	63485	80782	42865	54875	63687	36305	19228

age \ year	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3415970	4456945	2949392	3864124	2611938	2028331	1585196	1620155	1479130
1	4295588	2399949	2656781	2056302	2816766	1726719	1411098	1166015	1192099
2	1767314	1894516	1057695	1111120	1149750	1358965	814529	732230	609180
3	619848	1001274	1111968	612829	671658	763268	825685	464877	424526
4	414650	340029	588142	621980	356900	401842	465055	449805	257783
5	188371	224093	181435	326896	339263	208472	212066	247440	243861
6	104298	90006	122121	97273	174671	195820	116253	105520	125821
7	37518	51121	38750	65421	53511	99053	101428	58688	54403
8	29108	18673	23317	33059	39615	40026	54165	47875	52692

age \ year	2009	2010
0	2159680	3961260
1	1087670	1587035
2	614528	552447
3	342422	333790
4	227324	176400
5	134684	114007
6	118816	62591
7	62235	56132
8	35391	49740

TABLE 3.6.15 WBSS HERRING/FINAL RUN. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2011
0	NA
1	2920755
2	867951
3	356035
4	208576
5	108516
6	67085
7	37185
8	65129

TABLE 3.6.16 WBSS HERRING/FINAL RUN. FITTED SELECTION PATTERN

Units : NA

age	2006	2007	2008	2009	2010
0	0.0165	0.0165	0.0165	0.0165	0.0165
1	0.3620	0.3620	0.3620	0.3620	0.3620
2	0.8372	0.8372	0.8372	0.8372	0.8372
3	0.9453	0.9453	0.9453	0.9453	0.9453
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.1555	1.1555	1.1555	1.1555	1.1555
6	1.1219	1.1219	1.1219	1.1219	1.1219
7	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000

TABLE 3.6.17 WBSS HERRING/FINAL RUN. PREDICTED CATCH IN NUMBERS

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	2008	2009	2010
0	756285	150271	53489	243554	106906	9713	9496	9445	15042	16117
1	523163	659130	126876	457754	305171	161461	127994	141744	140187	123310
2	488816	281840	264855	197812	319225	224963	194810	174145	188744	106997
3	257837	321311	161251	164766	177833	252113	136851	134057	115962	71955
4	108097	172285	189432	93214	130394	148640	138666	85174	80477	39940
5	68376	57160	103648	91242	60639	76017	85653	90263	53278	29226
6	39092	38532	29117	48957	65695	40722	35685	45521	45966	15647
7	18307	13842	17452	14876	31231	32418	18092	17975	22032	12709
8	6687	8329	8819	11013	12620	17312	14759	17410	12529	11262

TABLE 3.6.18 WBSS HERRING/FINAL RUN. CATCH RESIDUALS

Units : thousands NA

age	2006	2007	2008	2009	2010
0	-0.2008	0.1213	0.01737	0.3209	-0.2627
1	-0.0809	0.2958	0.05284	0.2560	-0.4961
2	-0.1812	-0.0531	-0.23999	0.2527	0.2429
3	-0.0779	0.0503	0.01258	-0.1349	0.1424
4	0.0135	-0.0890	0.08040	-0.1404	0.1592
5	0.2616	-0.2760	-0.00920	-0.1024	0.0255
6	0.0418	-0.1669	0.00895	-0.1453	0.1723
7	0.0000	0.1611	-0.04317	-0.0524	-0.1448
8	0.0000	0.0000	0.00000	0.0000	0.0000

TABLE 3.6.19 WBSS HERRING/FINAL RUN. PREDICTED INDEX VALUES

HERAS 3-6 wr
Units : NA NA

year

age	1993	1994	1995	1996	1997	1998	1999
3	1163353970	1005298084	592580291	464904893	747440260	609038604	NA
4	567841298	433731670	400481165	209379006	192245544	298151736	NA
5	286110820	203595221	173961493	132381629	79439261	80282328	NA
6	129125424	84300279	72298272	63205300	43556077	31653612	NA

year

age	2000	2001	2002	2003	2004	2005	2006
3	628350691	1059330606	1141019004	644898716	718808505	826213065	833380953
4	339409443	276118178	489934088	512067734	306680489	324071297	376971573
5	116769000	150810694	120863067	217304935	236668105	142331078	134830510
6	53546014	42610866	66277758	53675131	98231050	104062365	60795332

year

age	2007	2008	2009	2010
3	474442106	423901566	333748550	367062832
4	368912847	206594859	177582167	156565333
5	159468521	153021898	82052220	80494678
6	55913304	64964685	59612015	36238548

GerAS 1-3 wr
Units : NA NA

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	885868	1235737	886992	1179128	941276	1446740	1576731	NA	934618	912546
2	428336	358684	530736	407925	530483	422832	679400	NA	413965	449874
3	498022	293431	227965	371079	307004	388581	316965	NA	577540	328736

year

age	2004	2005	2006	2007	2008	2009	2010
1	1110890	668842	589907	490108	495736	446978	691939
2	501744	552476	314972	286730	232712	228406	235436
3	368143	424503	419880	239780	212931	166515	189430

N20
Units : NA NA

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	6218	5220	10497	6561	7647	6603	9277	10722	5798	7083	4991	6656	4327	3429

year

age	2006	2007	2008	2009	2010
0	2740	2801	2557	3732	6855

TABLE 3.6.20 WBSS HERRING/FINAL RUN. INDEX RESIDUALS

HERAS 3-6 wr
Units : NA

year

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	0.0909	-0.0725	0.545	-0.632	0.0516	0.3916	NA	0.0695	-0.851	0.1994
4	0.0517	0.1442	1.154	-0.395	-0.1468	-0.0557	NA	0.0697	-0.590	0.0678
5	0.4167	0.1603	0.382	-0.107	-0.1703	0.3240	NA	0.4639	-0.448	-0.3230
6	0.1762	0.7914	0.878	-0.535	0.4601	0.4770	NA	0.0376	-0.125	-0.5176

year

age	2003	2004	2005	2006	2007	2008	2009	2010
3	-0.491	0.009955	-0.578	0.759	0.6763	0.687	-0.487378	-0.368
4	-0.460	0.000716	-0.476	0.262	0.3020	0.477	-0.098029	-0.309
5	-0.743	-0.253355	-0.328	0.291	-0.0349	0.583	-0.000637	-0.214
6	-0.756	-0.309268	-0.219	-0.812	-0.4974	0.997	0.366490	-0.412

GerAS 1-3 wr
Units : NA

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.757	0.3043	0.484	0.5058	-0.161	-0.0776	-0.0978	NA	-0.10966	0.305
2	0.724	-0.0876	0.106	0.5931	0.246	-0.3867	-0.4032	NA	0.01778	-0.704
3	0.117	0.1988	0.644	0.0613	0.250	-0.5136	0.0371	NA	-0.00379	-0.414

year

age	2004	2005	2006	2007	2008	2009	2010
1	-0.1368	0.1185	0.477	0.1333	-0.2328	-0.501	-0.256
2	0.1660	0.1472	-0.138	-0.0309	-0.0862	-0.528	0.364
3	-0.0614	-0.0568	-0.109	-0.4758	-0.0186	-0.590	0.936

N20
Units : NA

year

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	-1.77	-0.539	0.176	0.190	1.01	-0.304	0.59	0.641	-0.65	-0.38	0.82	-0.189

year

age	2004	2005	2006	2007	2008	2009	2010
0	0.265	0.125	0.32	-0.426	-0.455	0.549	0.0263

TABLE 3.6.21 WBSS HERRING/FINAL RUN. FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2006	0.43099	0.188	0.29834	0.62262
F, 2007	0.41222	0.186	0.28602	0.59410
F, 2008	0.44918	0.190	0.30968	0.65153
F, 2009	0.49012	0.206	0.32740	0.73371
F, 2010	0.28586	0.228	0.18279	0.44702
Selectivity at age 0	0.01651	0.481	0.00643	0.04239
Selectivity at age 1	0.36202	0.215	0.23737	0.55214
Selectivity at age 2	0.83723	0.203	0.56255	1.24602
Selectivity at age 3	0.94526	0.197	0.64224	1.39126
Selectivity at age 5	1.15547	0.178	0.81587	1.63642
Selectivity at age 6	1.12192	0.170	0.80428	1.56501
Terminal year pop, age 0	3961258.62804	0.314	2141321.52350	7327984.02575
Terminal year pop, age 1	1587034.03348	0.231	1009356.89346	2495328.50050
Terminal year pop, age 2	552445.87095	0.196	376007.72827	811675.97734
Terminal year pop, age 3	333789.22231	0.182	233814.00028	476512.29094
Terminal year pop, age 4	176398.62274	0.182	123378.58921	252203.19267
Terminal year pop, age 5	114005.70608	0.194	77888.92005	166869.70382
Terminal year pop, age 6	62589.61675	0.220	40676.41169	96307.90827
Terminal year pop, age 7	56130.85533	0.258	33853.18181	93068.73836
Last true age pop, 2006	101426.69483	0.351	51022.27260	201625.17076
Last true age pop, 2007	58687.06584	0.265	34885.89180	98726.77804
Last true age pop, 2008	54402.21078	0.236	34273.64567	86352.07841
Last true age pop, 2009	62233.68717	0.242	38698.42623	100082.41151
Index 1, age 3 numbers, Q	1475.35918	0.156	1087.04050	2002.39524
Index 1, age 4 numbers, Q	1202.47464	0.156	884.83566	1634.13990
Index 1, age 5 numbers, Q	983.50840	0.158	721.46571	1340.72730
Index 1, age 6 numbers, Q	801.67719	0.161	584.35473	1099.82220
Index 2, age 1 numbers, Q	0.70657	0.140	0.53666	0.93027
Index 2, age 2 numbers, Q	0.60565	0.140	0.46013	0.79719
Index 2, age 3 numbers, Q	0.82669	0.140	0.62779	1.08860
Index 3, age 0 numbers, Q	0.00195	0.078	0.00168	0.00228

Table 3.7.1 WESTERN BALTIC HERRING. Input table for short term predictions

MFDP version 1a
Run: WBSS_MFDP_1
Time and date: 18:03 21/03/2011
Fbar age range: 3-6

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1754829	0.3	0.00	0.1	0.25	0.000	0.007	0.013
1	1293888	0.5	0.00	0.1	0.25	0.018	0.148	0.053
2	867951	0.2	0.20	0.1	0.25	0.061	0.342	0.076
3	356035	0.2	0.75	0.1	0.25	0.091	0.386	0.103
4	208576	0.2	0.90	0.1	0.25	0.123	0.408	0.130
5	108516	0.2	1.00	0.1	0.25	0.152	0.472	0.153
6	67085	0.2	1.00	0.1	0.25	0.166	0.458	0.167
7	37185	0.2	1.00	0.1	0.25	0.176	0.408	0.186
8	65129	0.2	1.00	0.1	0.25	0.187	0.408	0.197

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1754829	0.3	0.00	0.1	0.25	0.000	0.007	0.013
1		0.5	0.00	0.1	0.25	0.018	0.148	0.053
2		0.2	0.20	0.1	0.25	0.061	0.342	0.076
3		0.2	0.75	0.1	0.25	0.091	0.386	0.103
4		0.2	0.90	0.1	0.25	0.123	0.408	0.130
5		0.2	1.00	0.1	0.25	0.152	0.472	0.153
6		0.2	1.00	0.1	0.25	0.166	0.458	0.167
7		0.2	1.00	0.1	0.25	0.176	0.408	0.186
8		0.2	1.00	0.1	0.25	0.187	0.408	0.197

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1754829	0.3	0.00	0.1	0.25	0.000	0.007	0.013
1		0.5	0.00	0.1	0.25	0.018	0.148	0.053
2		0.2	0.20	0.1	0.25	0.061	0.342	0.076
3		0.2	0.75	0.1	0.25	0.091	0.386	0.103
4		0.2	0.90	0.1	0.25	0.123	0.408	0.130
5		0.2	1.00	0.1	0.25	0.152	0.472	0.153
6		0.2	1.00	0.1	0.25	0.166	0.458	0.167
7		0.2	1.00	0.1	0.25	0.176	0.408	0.186
8		0.2	1.00	0.1	0.25	0.187	0.408	0.197

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)

$N_{2010/2011/2012/2013}$ Age 0:	Geometric Mean from ICA of age 0 (Table 3.6.14) for the years 2005-2009
N_{2011} Age 1	= N_{2010} Age 0 * EXP(-(F_{2010} Age 0+ M_{2010} Age 0))
N_{2011} Age 2-8+	Output from ICA (Table 3.6.15)
Natural Mortality (M):	Average for 2008-2010
Weight in the Catch/Stock (CWt/SWt):	Average for 2008-2010
Expoitation pattern (Sel):	Average for 2008-2010

Table 3.7.2 WESTERN BALTIC HERRING.
Short-term prediction multiple option table, Catch constraint

MFDP version 1a
Run: WBSS_MFDP_1
Western Baltic Herring (combined sex; plus group)
Time and date: 18:03 21/03/2011
Fbar age range: 3-6

2011				
Biomass	SSB	FMult	FBar	Landings
181209	97452	0.4464	0.1925	29041

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
208961	125861	0.0000	0.0000	0	265885	174775
	125344	0.1000	0.0431	8002	257720	167518
	124829	0.2000	0.0862	15721	249853	160571
	124316	0.3000	0.1293	23170	242274	153920
	123806	0.4000	0.1725	30358	234972	147552
	123297	0.5000	0.2156	37295	227936	141455
	122790	0.6000	0.2587	43991	221155	135617
	122286	0.7000	0.3018	50454	214621	130026
	121784	0.8000	0.3449	56693	208324	124673
	121283	0.9000	0.3880	62717	202255	119547
	120785	1.0000	0.4311	68534	196404	114638
	120289	1.1000	0.4742	74151	190764	109937
	119795	1.2000	0.5174	79576	185327	105435
	119303	1.3000	0.5605	84816	180085	101123
	118813	1.4000	0.6036	89878	175031	96993
	118325	1.5000	0.6467	94768	170157	93037
	117839	1.6000	0.6898	99493	165456	89248
	117355	1.7000	0.7329	104060	160923	85619
	116873	1.8000	0.7760	108473	156551	82142
	116393	1.9000	0.8191	112739	152333	78811
	115915	2.0000	0.8623	116862	148265	75620

Input units are thousands and kg - output in tonnes

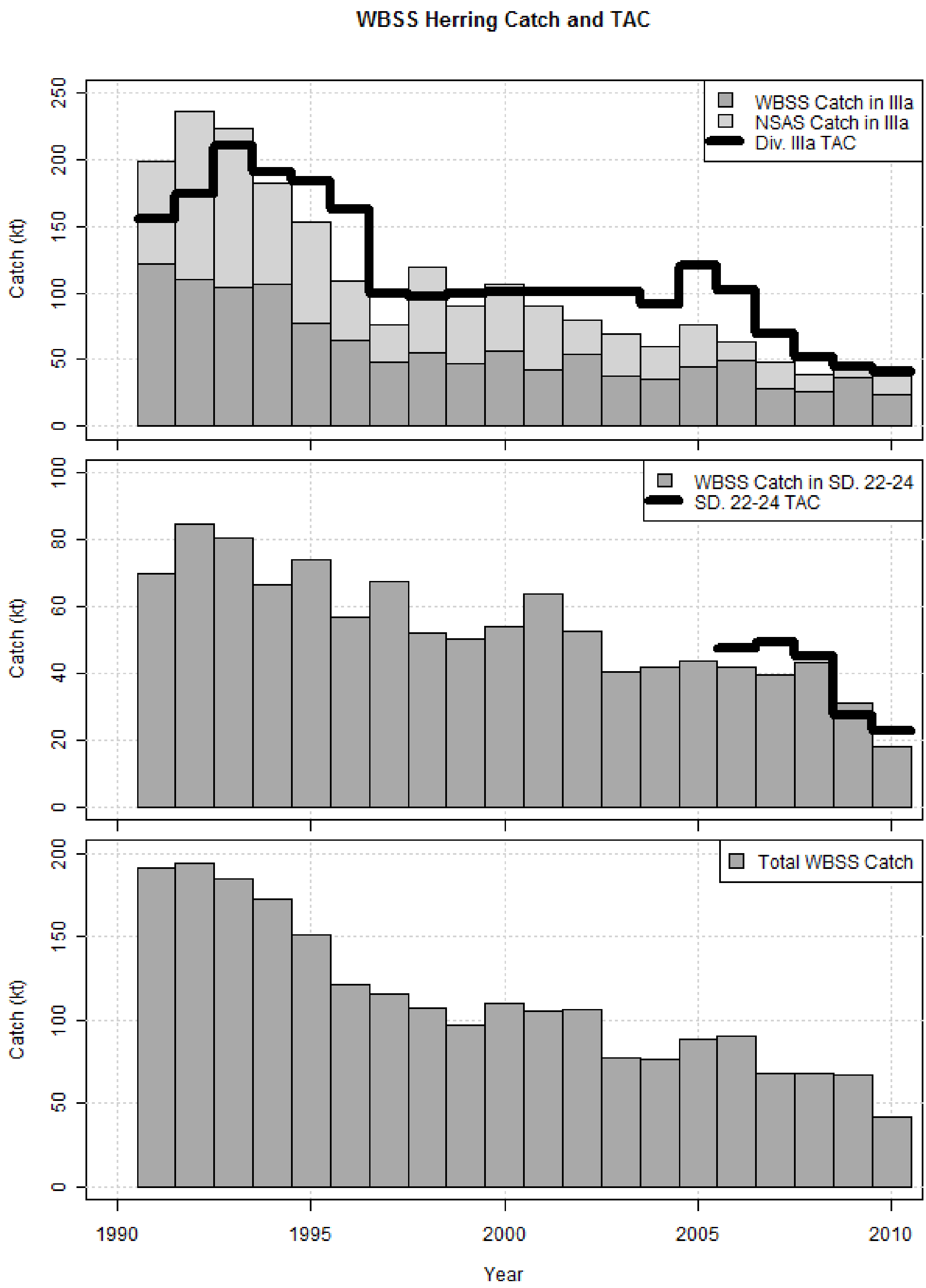


Figure 3.1.1 Western Baltic Spring Spawning Herring. Catches and TACs by area. Top panel) Catches of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in division IIIa, and the total TAC for both stocks. Middle panel) Catches and TACs of WBSS herring in subdivisions 22-24.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

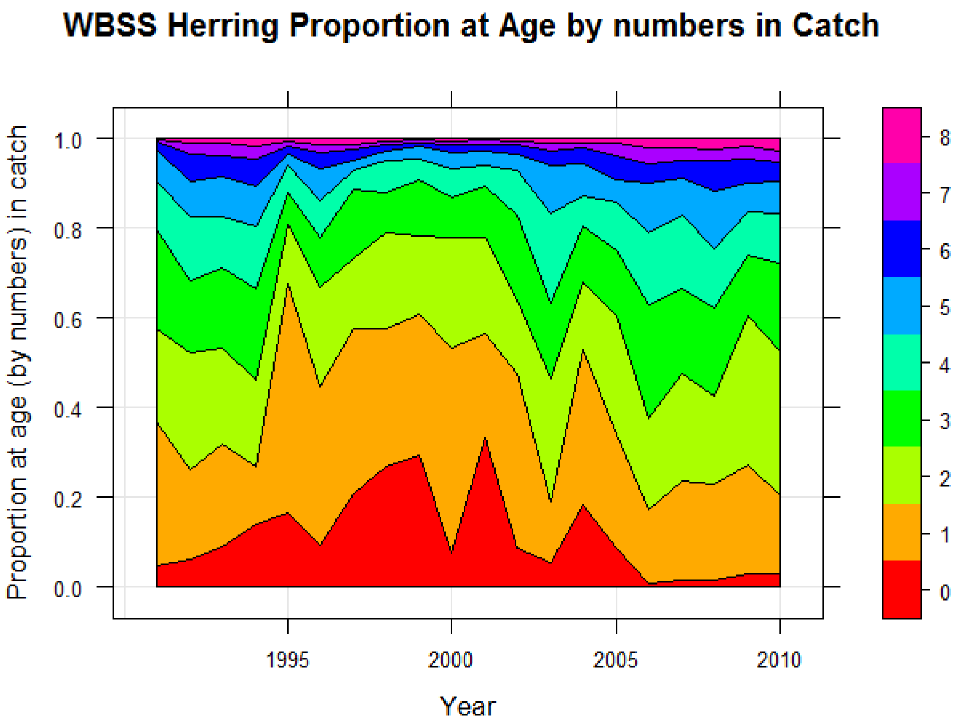


Figure 3.6.1.1 Western Baltic Spring Spawning Herring. Proportion (by numbers) of a given age (in winter rings) in the catch.

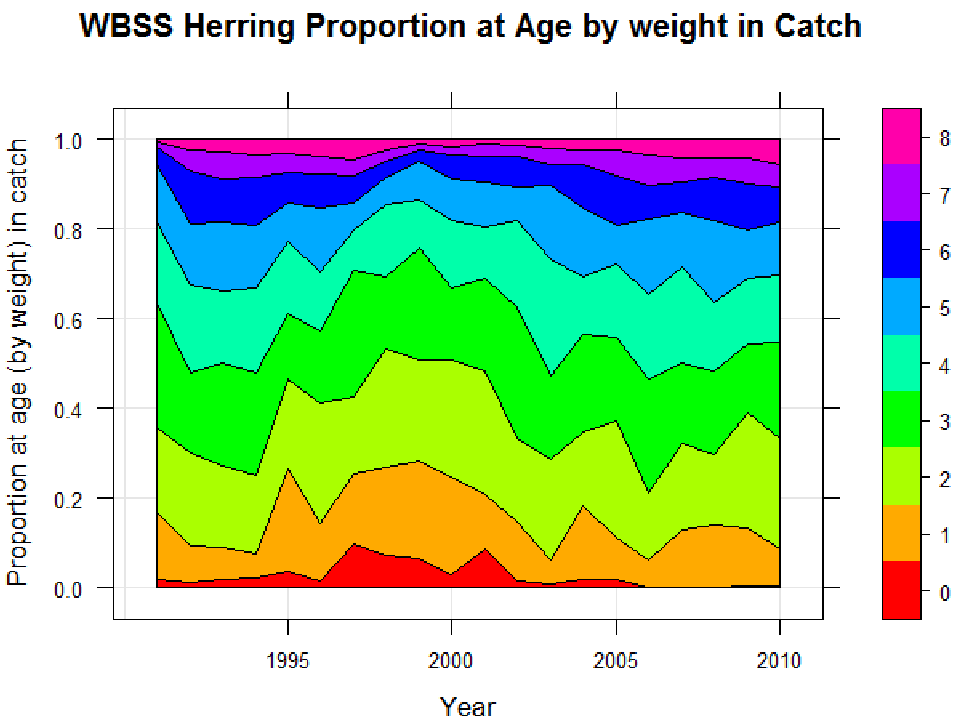


Figure 3.6.1.2 Western Baltic Spring Spawning Herring. Proportion (by weight) of a given age (in winter rings) in the catch.

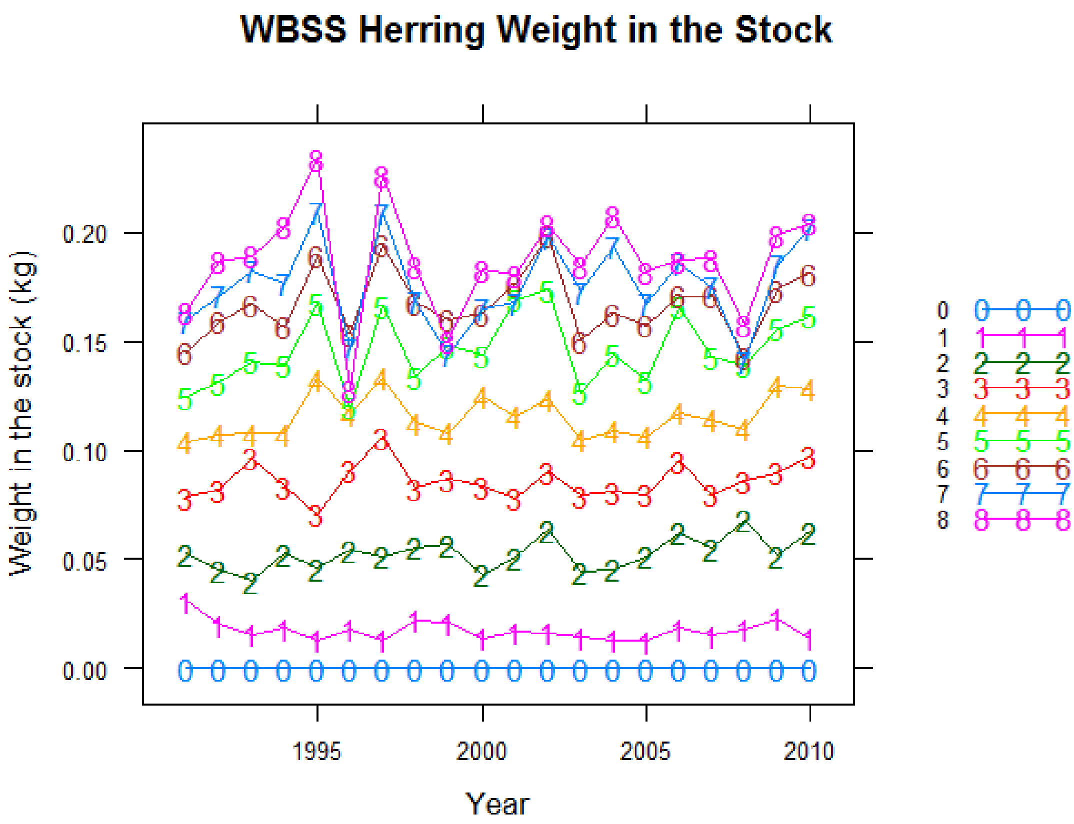


Figure 3.6.1.3 Western Baltic Spring Spawning Herring. Weight at age (in winter rings) in the stock.

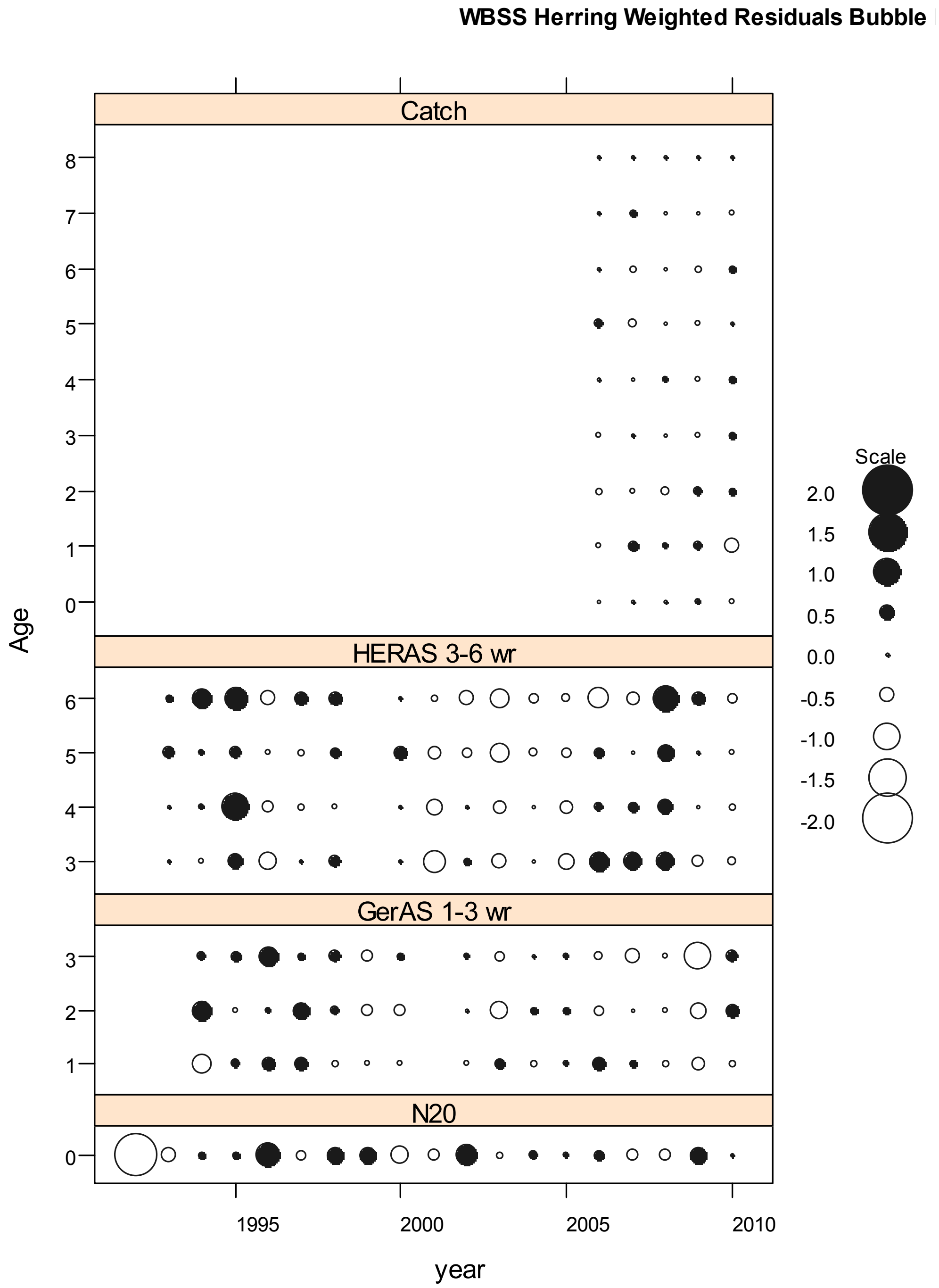


Figure 3.6.4.1 Western Baltic Spring Spawning Herring – GERAS data exploration run. Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with FLICA in calculating the objective function. The bubble scale is consistent between all panels.

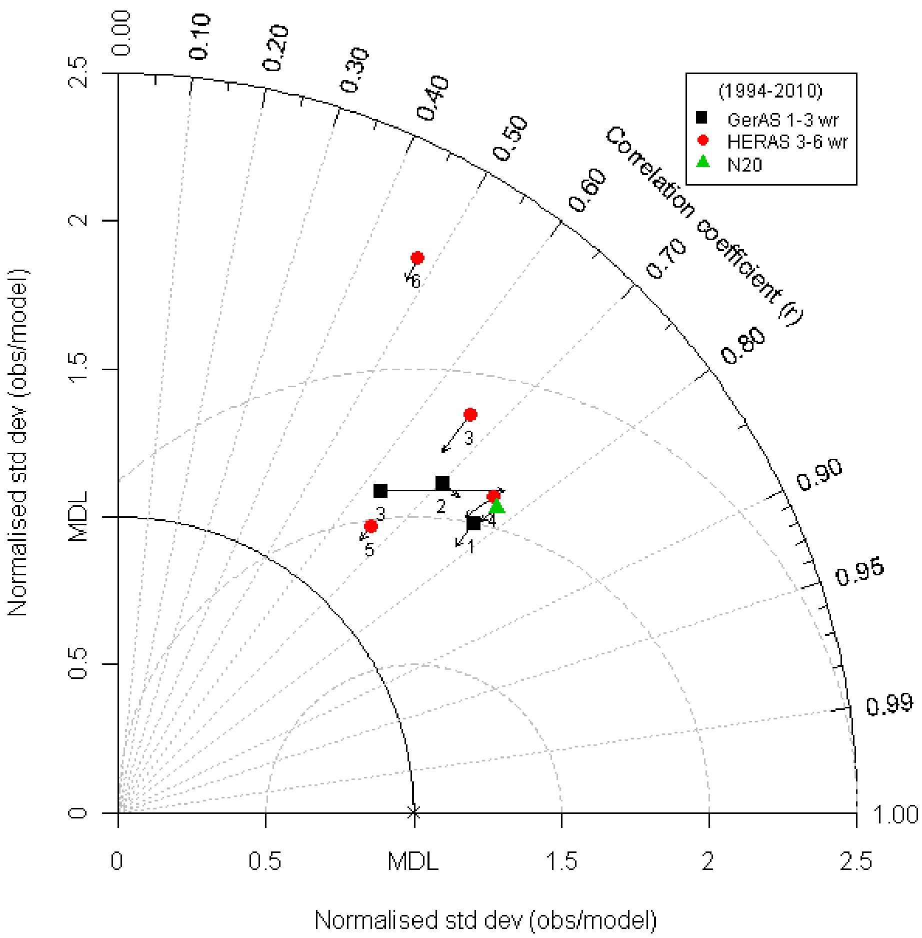


Figure 3.6.4.2 Western Baltic Spring Spawning Herring. Data exploration. Comparative Taylor diagram (Taylor 2001, Payne 2011). Solid points show the default (final) run using the unrevised GERAS time series. Arrows link these points to the point for the assessment performed using the revised GERAS values. The Taylor plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modeled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labeled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.

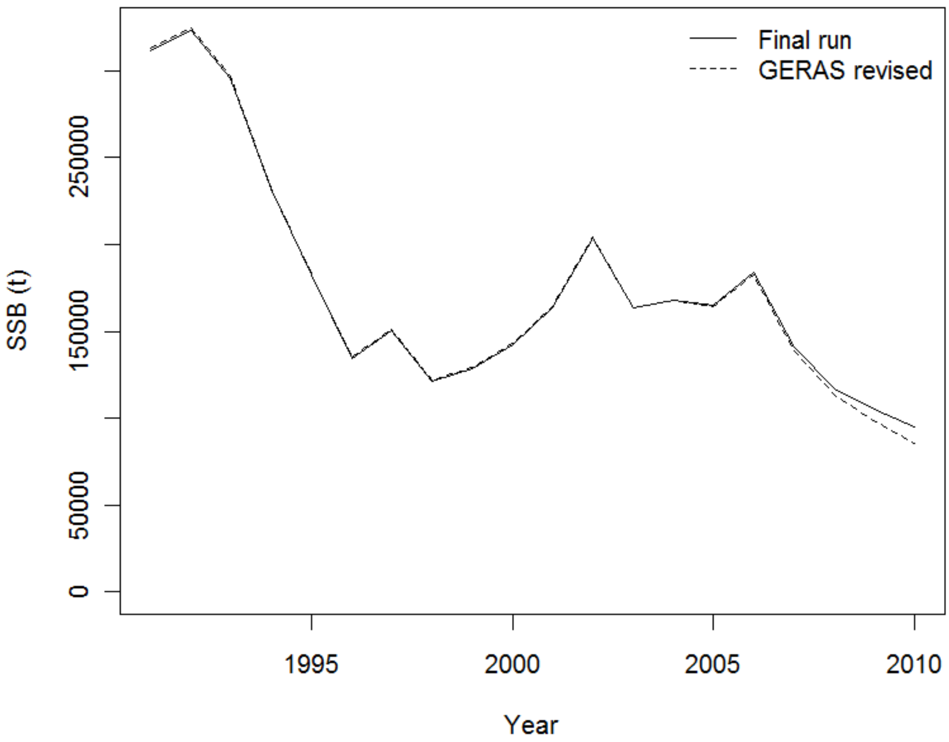


Figure 3.6.4.3 Western Baltic Spring Spawning Herring. Comparison of the perception of the stock (SSB) based on assessments using the standard (final) run (line) and the assessment based on the revised GERAS time series (dotted line).

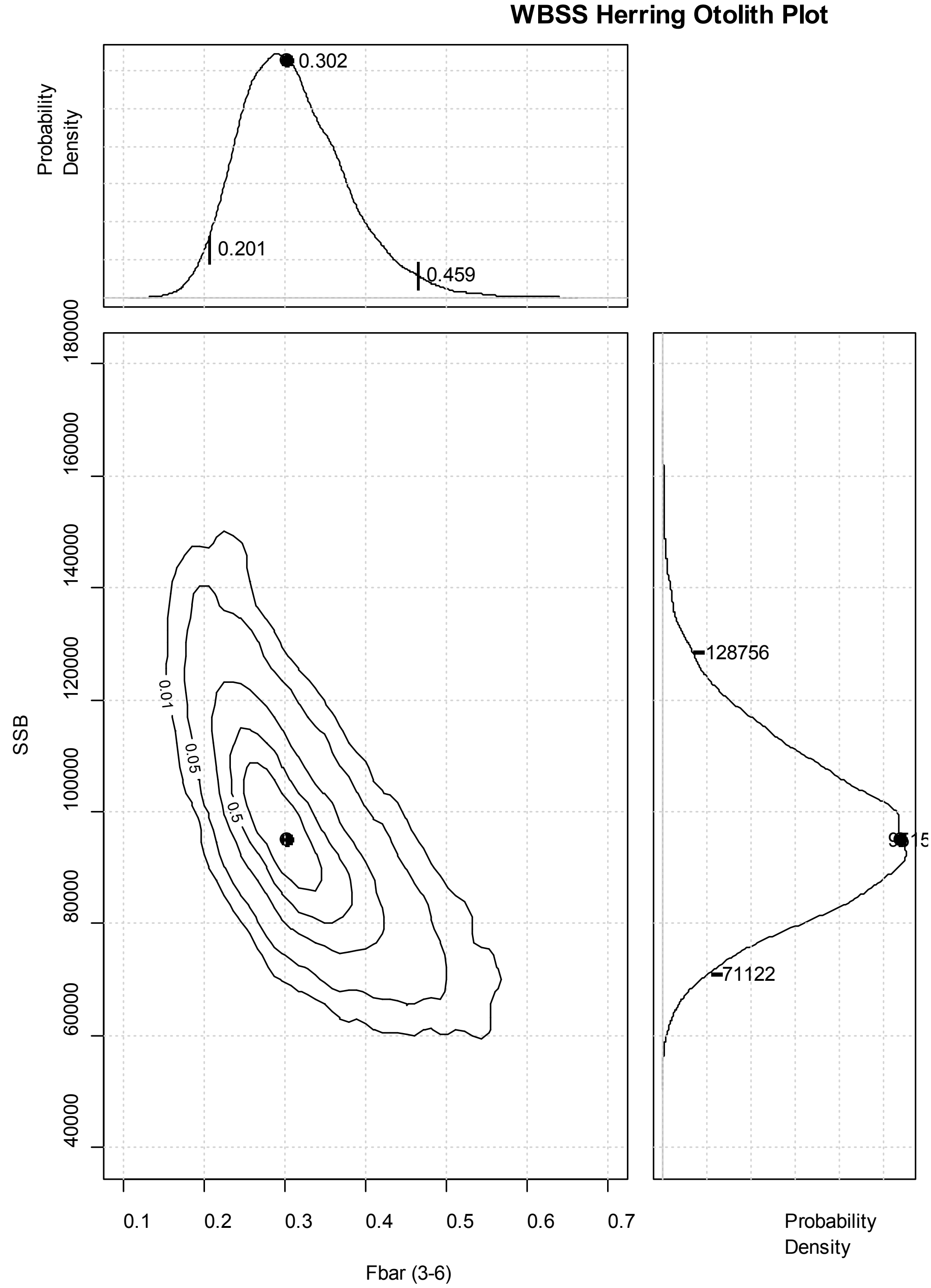


Figure 3.6.5.1 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. "Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance covariance matrix in the parameters returned by FLICA. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.

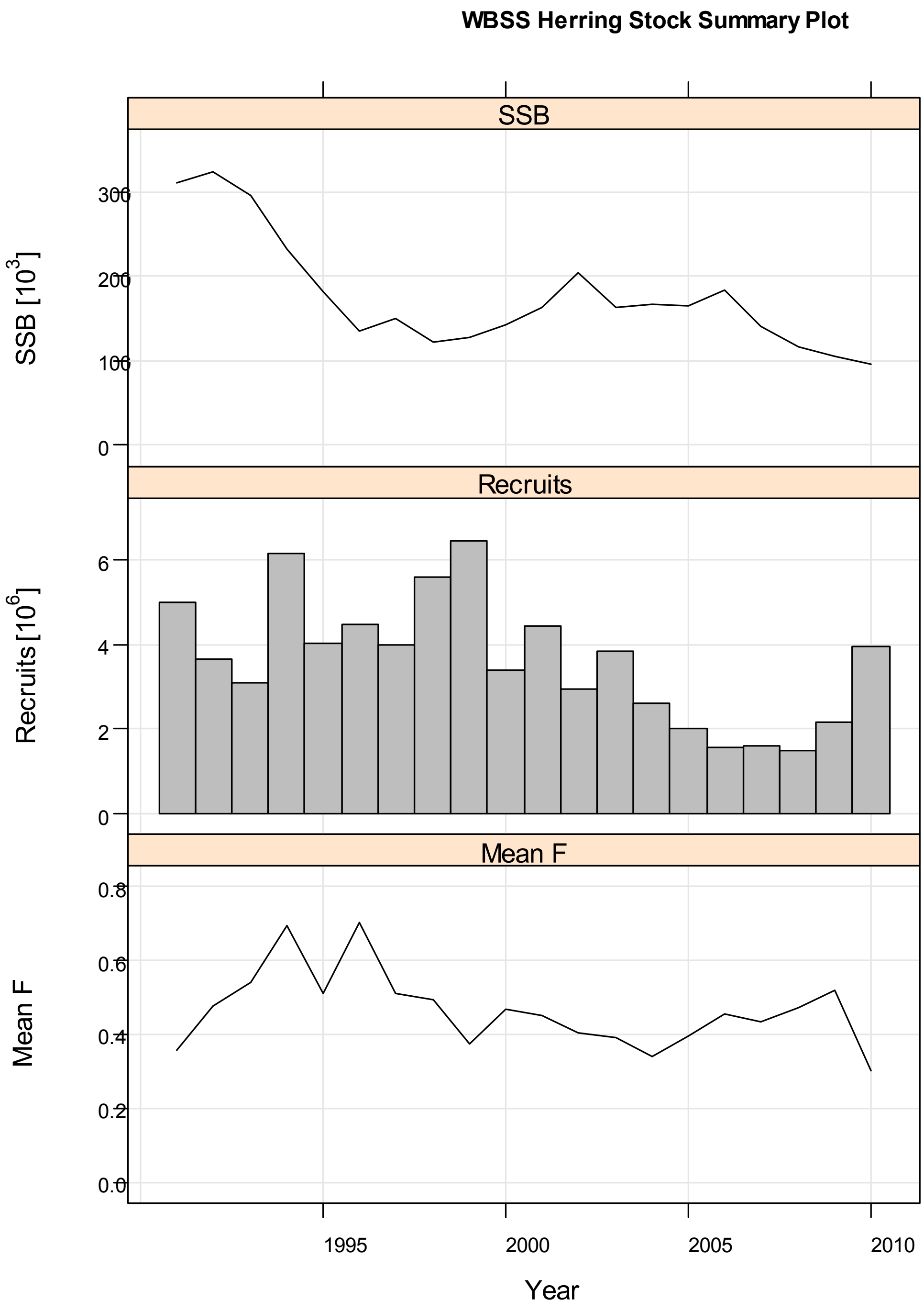


Figure 3.6.5.2 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age 0-wr) as a function of time. Bottom panel:: Mean annual fishing mortality on ages 3-6 ringers as a function of time.

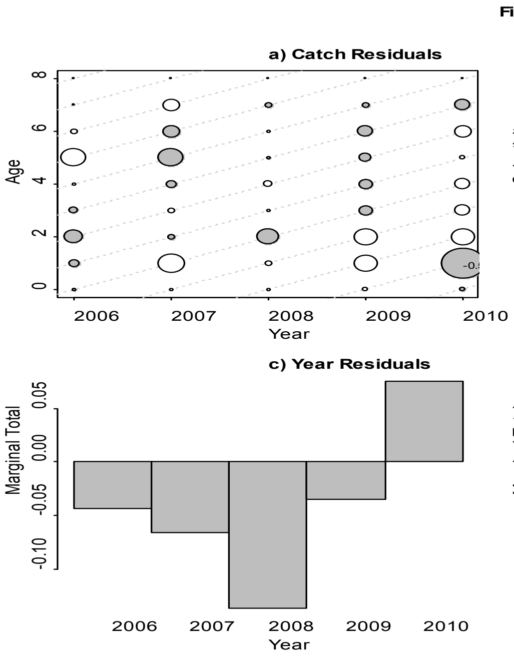


Figure 3.6.5.3 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of selection pattern. a) Bubbles plot of log catch residuals by age (weighting applied) and year. Grey bubbles correspond to negative log residuals. The largest residual is given. b) Estimated selection parameters (relative to 4 wr) with 95% confidence intervals. c): Marginal totals of residuals by year. d). Marginal totals of residuals by age (wr).

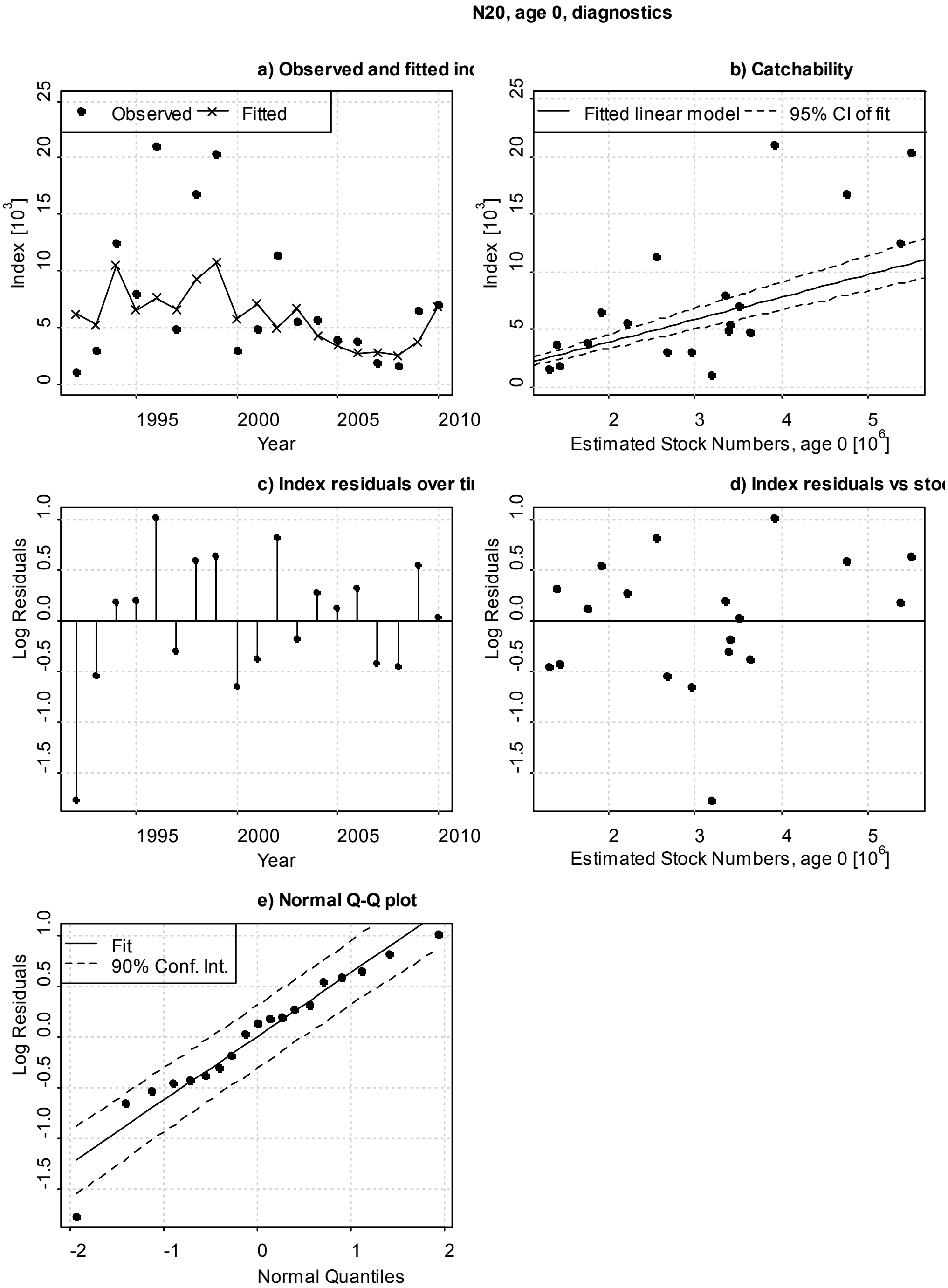


Figure 3.6.5.4 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the N20 larval index. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals of catchability model fitted by 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).

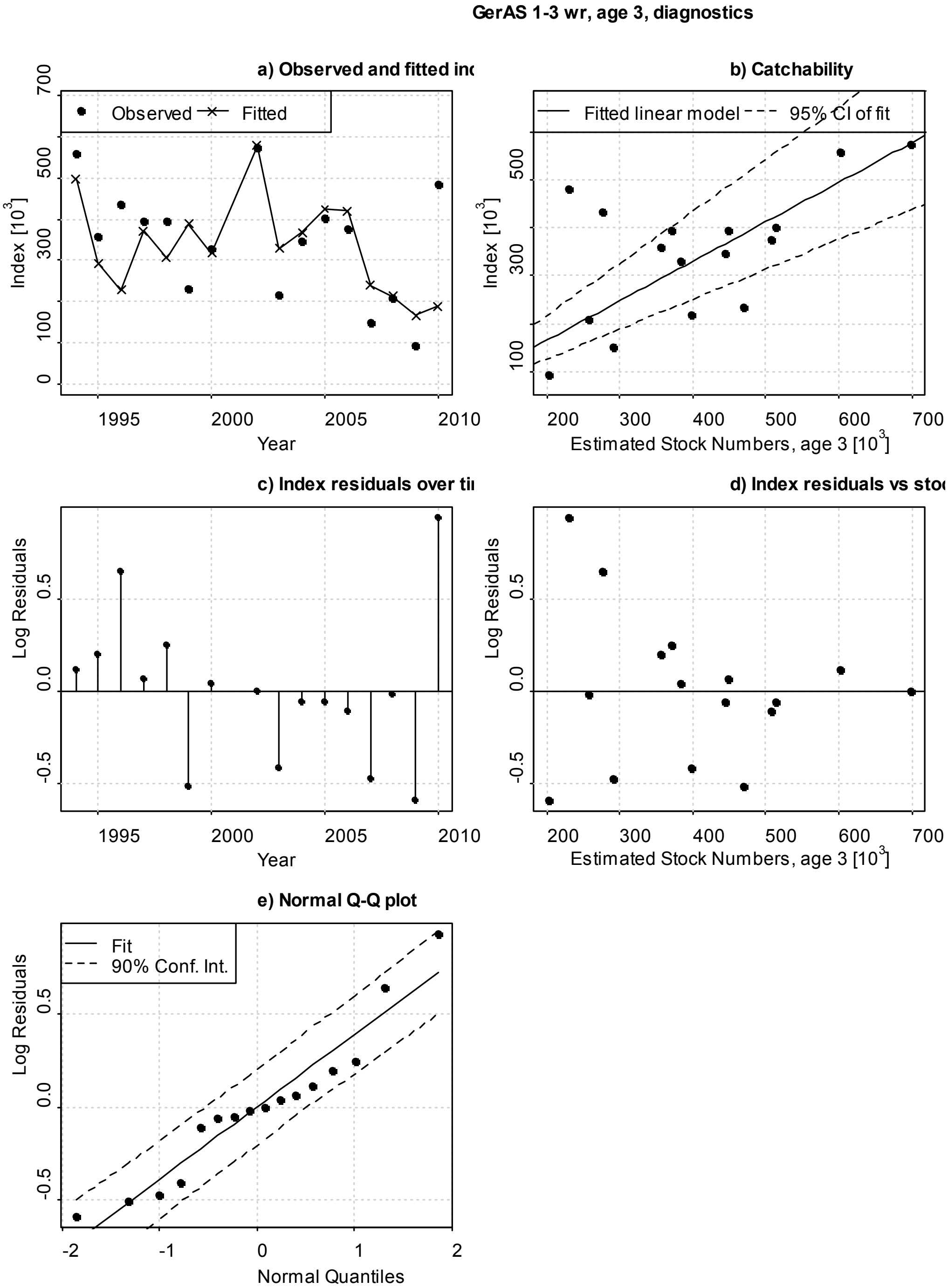


Figure 3.6.5.5 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

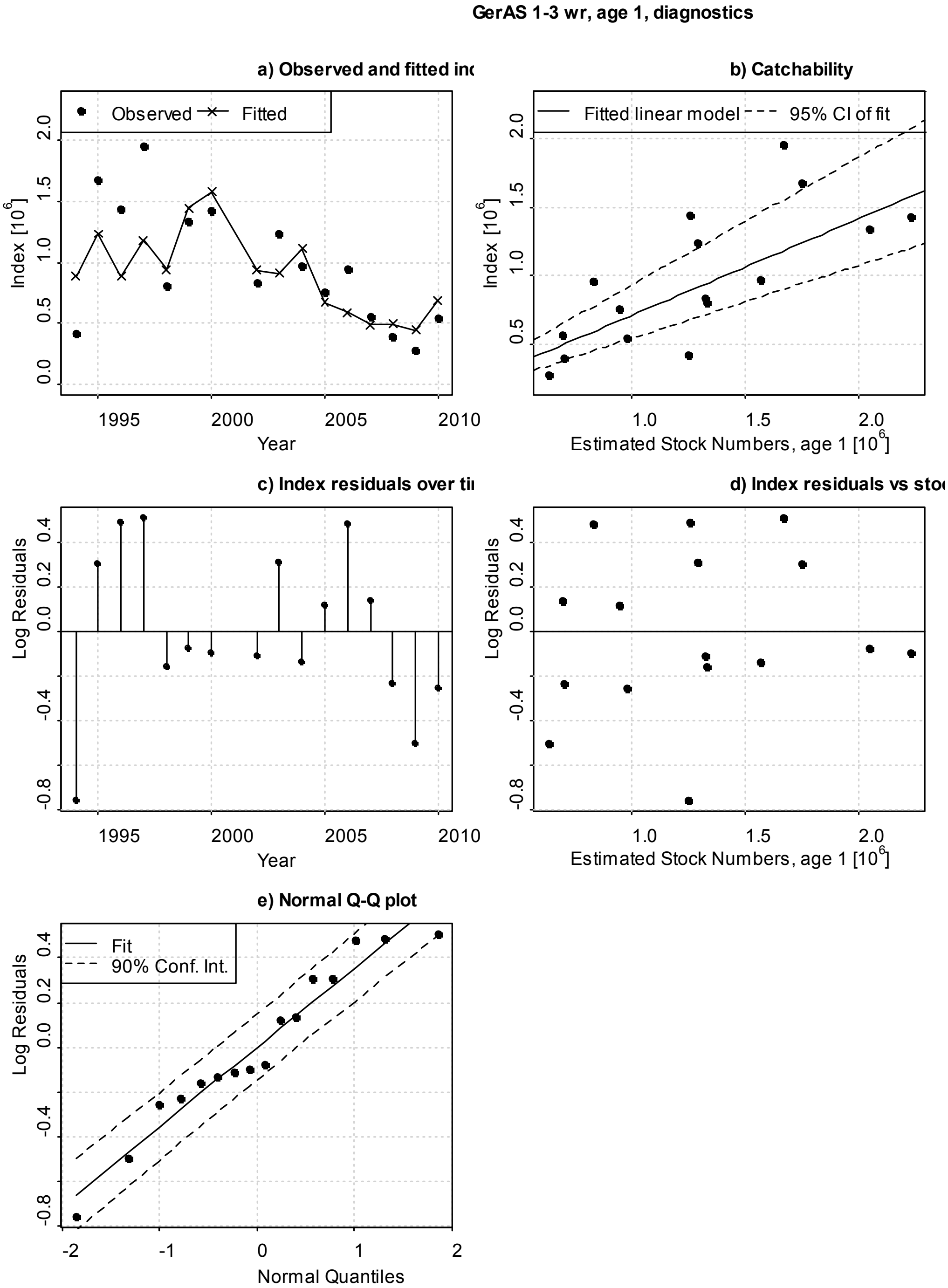


Figure 3.6.5.6 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

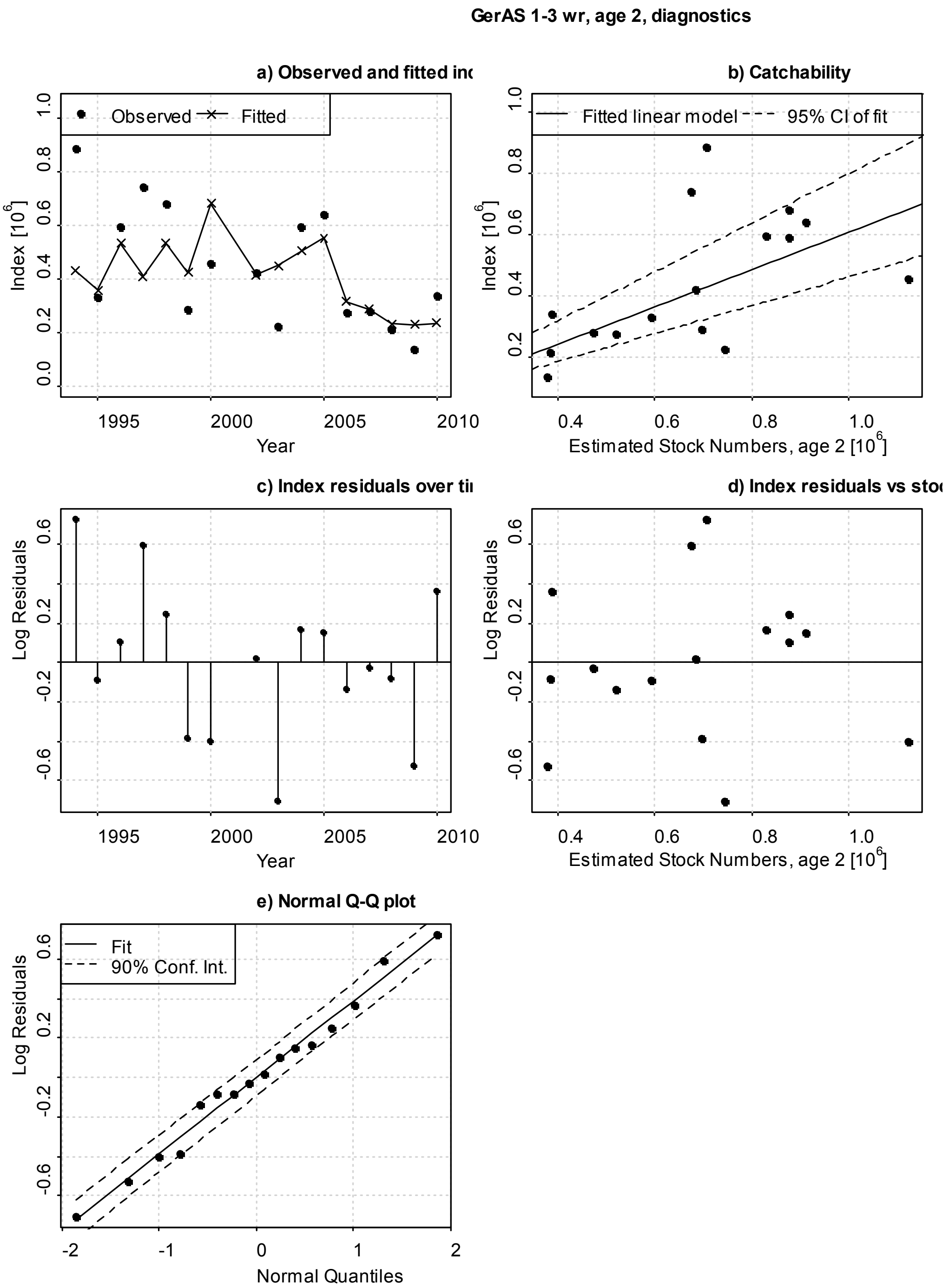


Figure 3.6.5.7 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

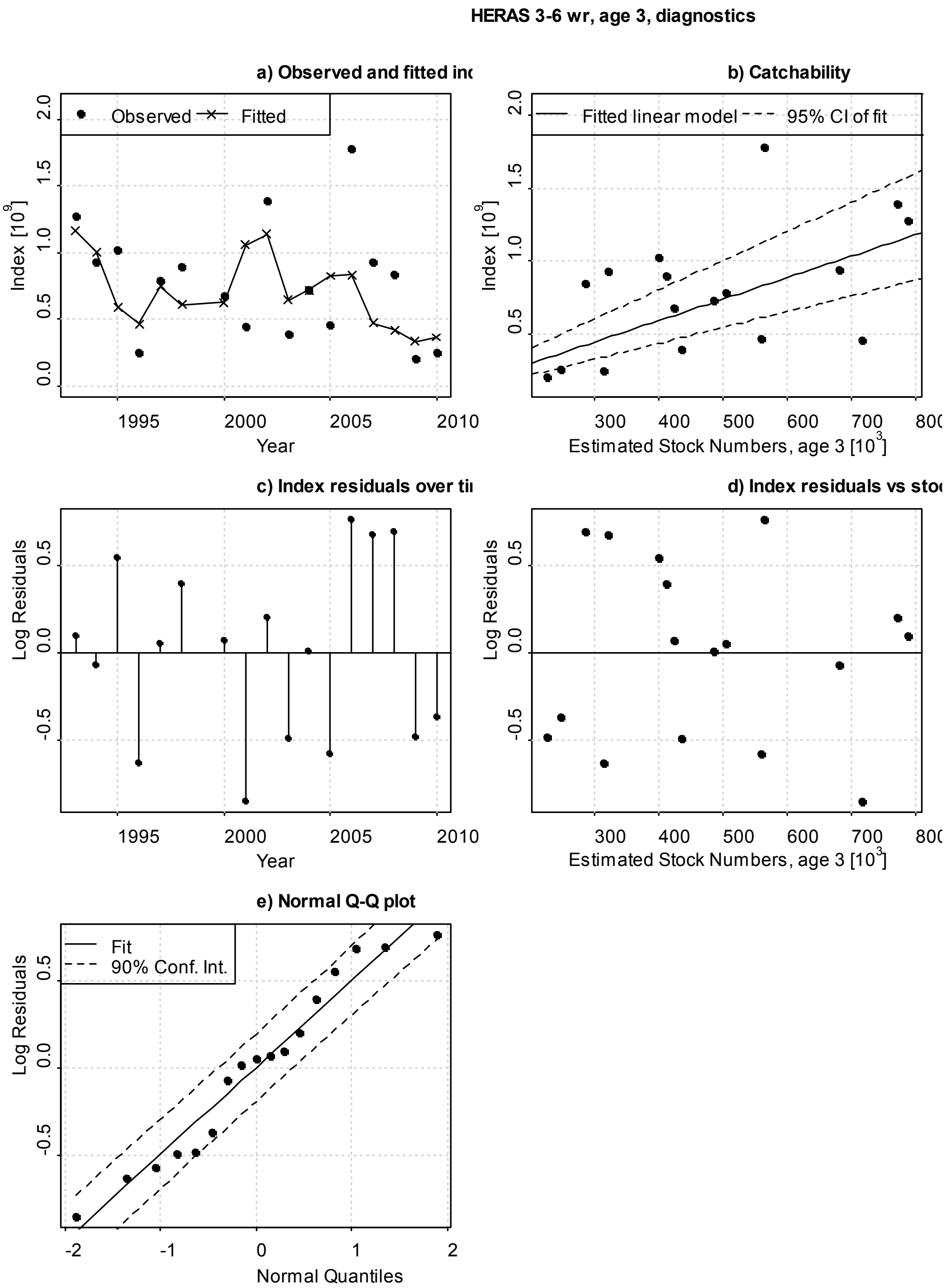


Figure 3.6.5.8 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

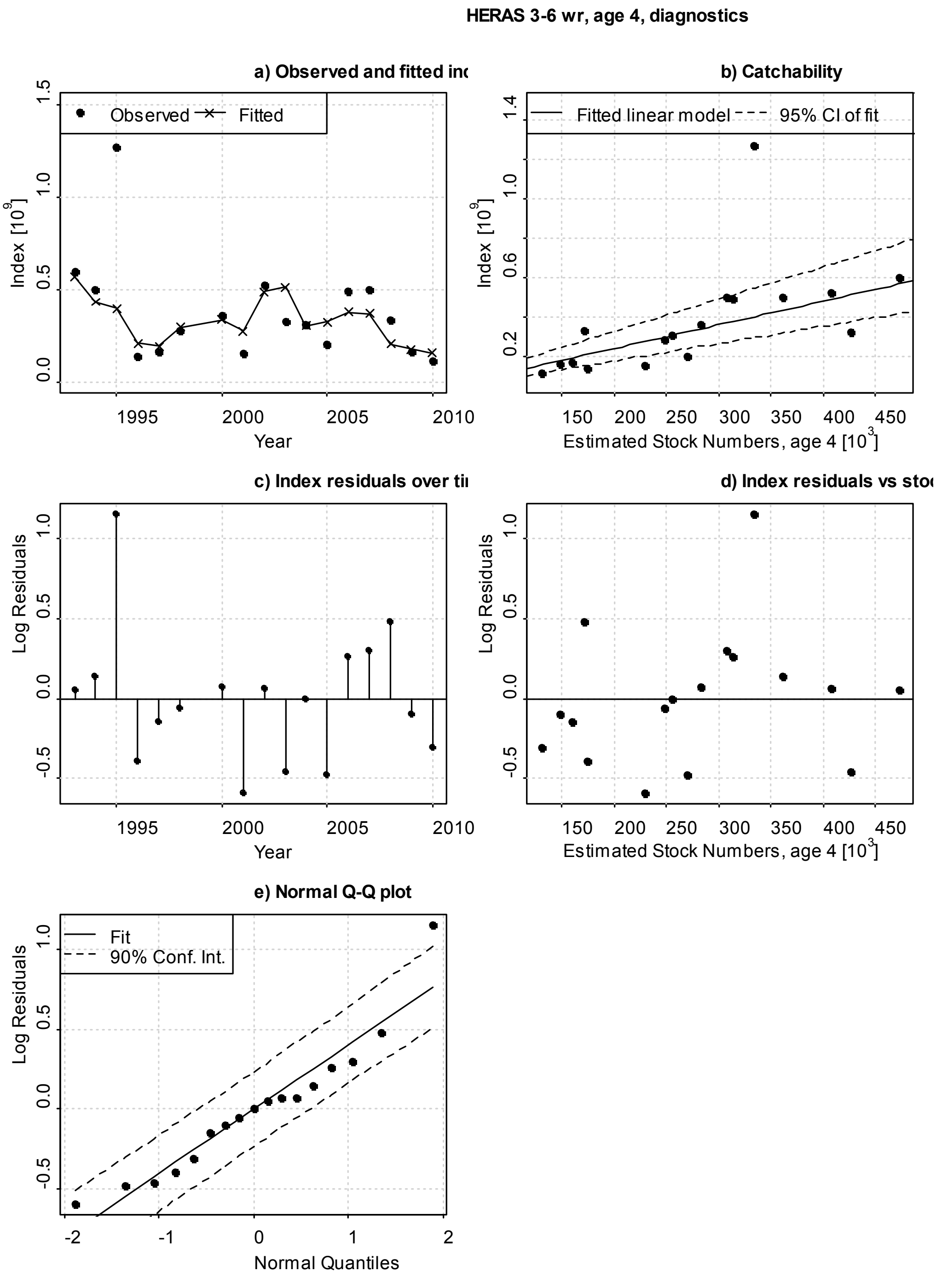


Figure 3.6.5.9 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

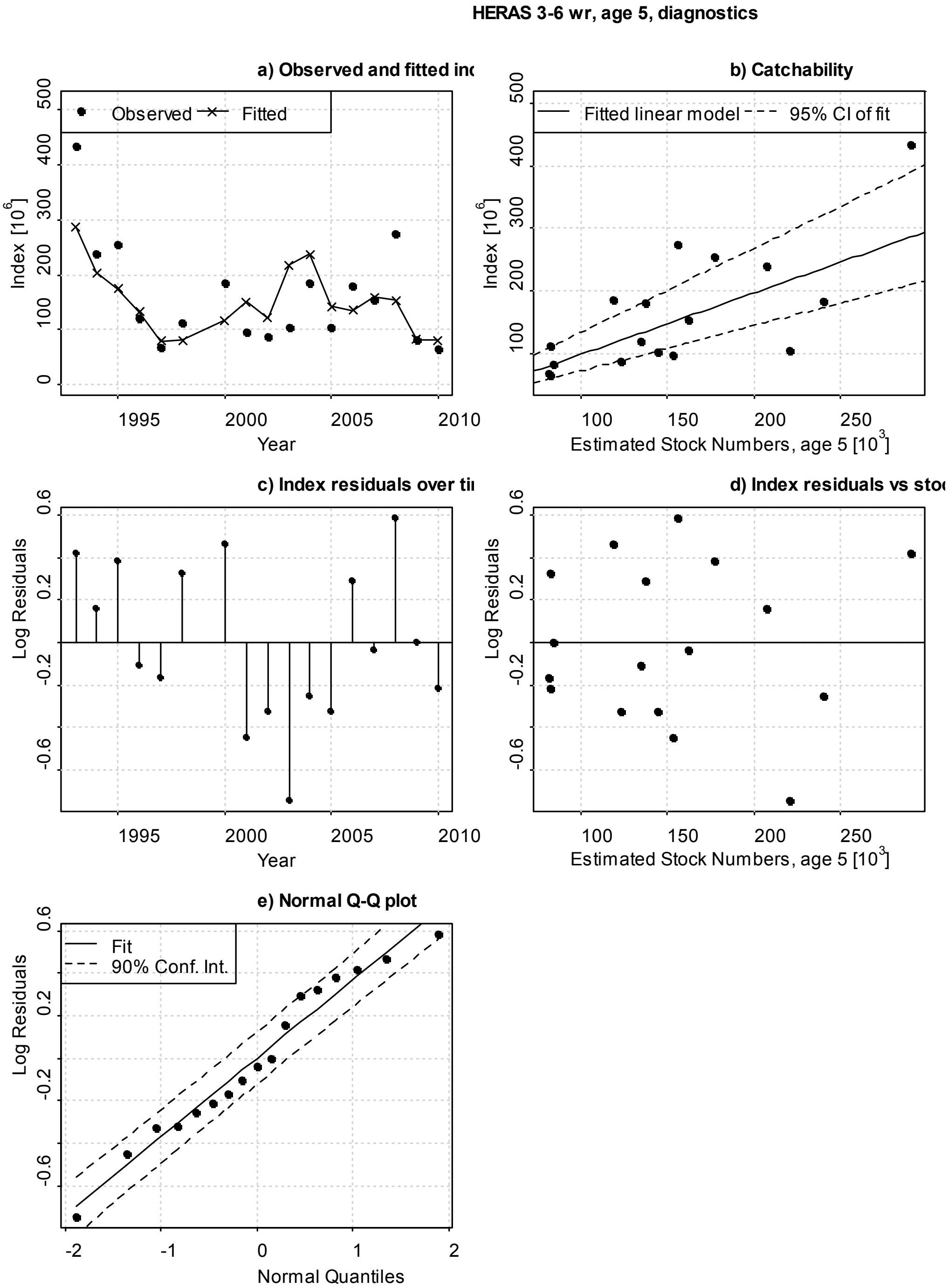


Figure 3.6.5.10 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

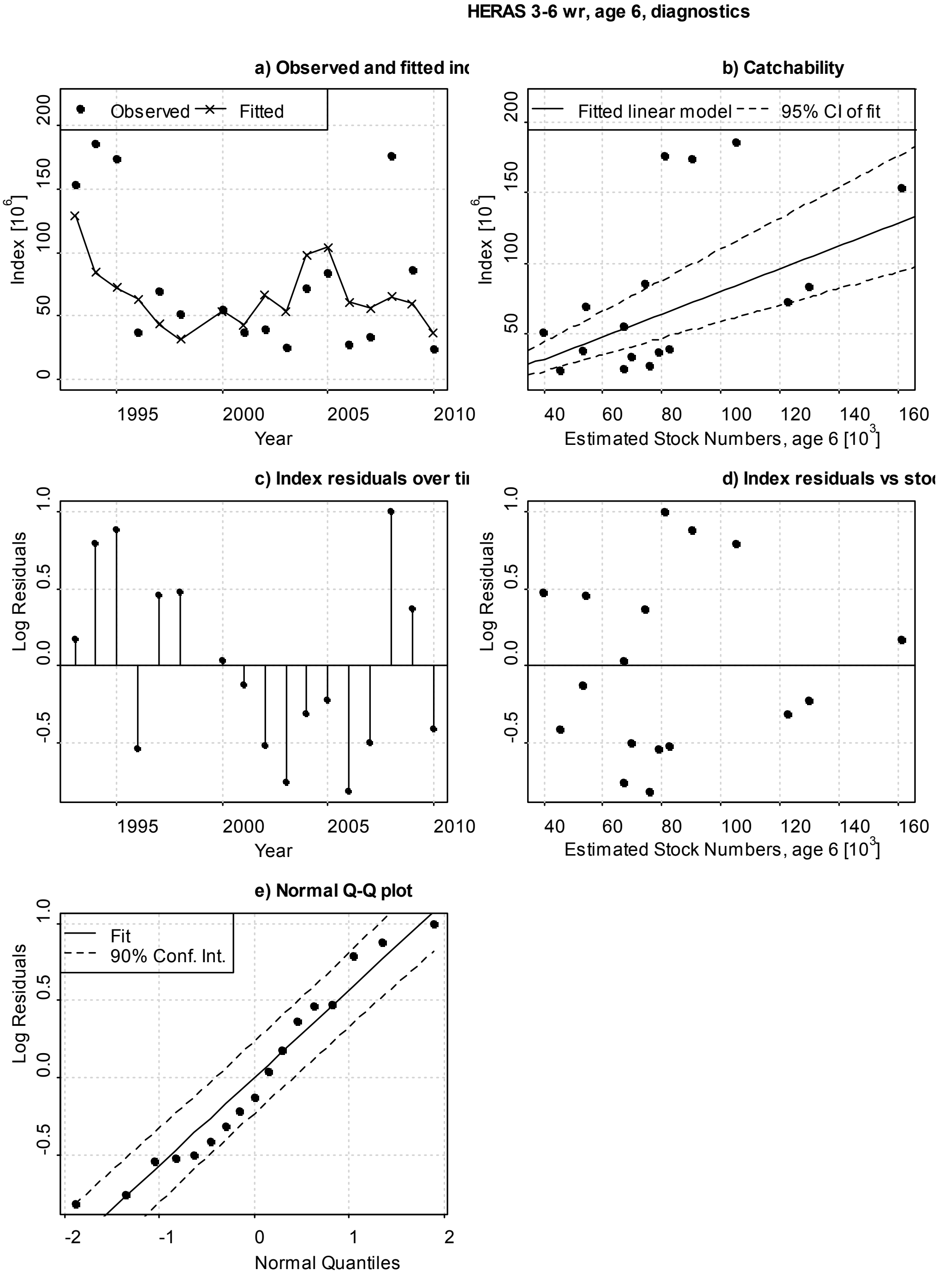


Figure 3.6.5.11 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log siduals 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).

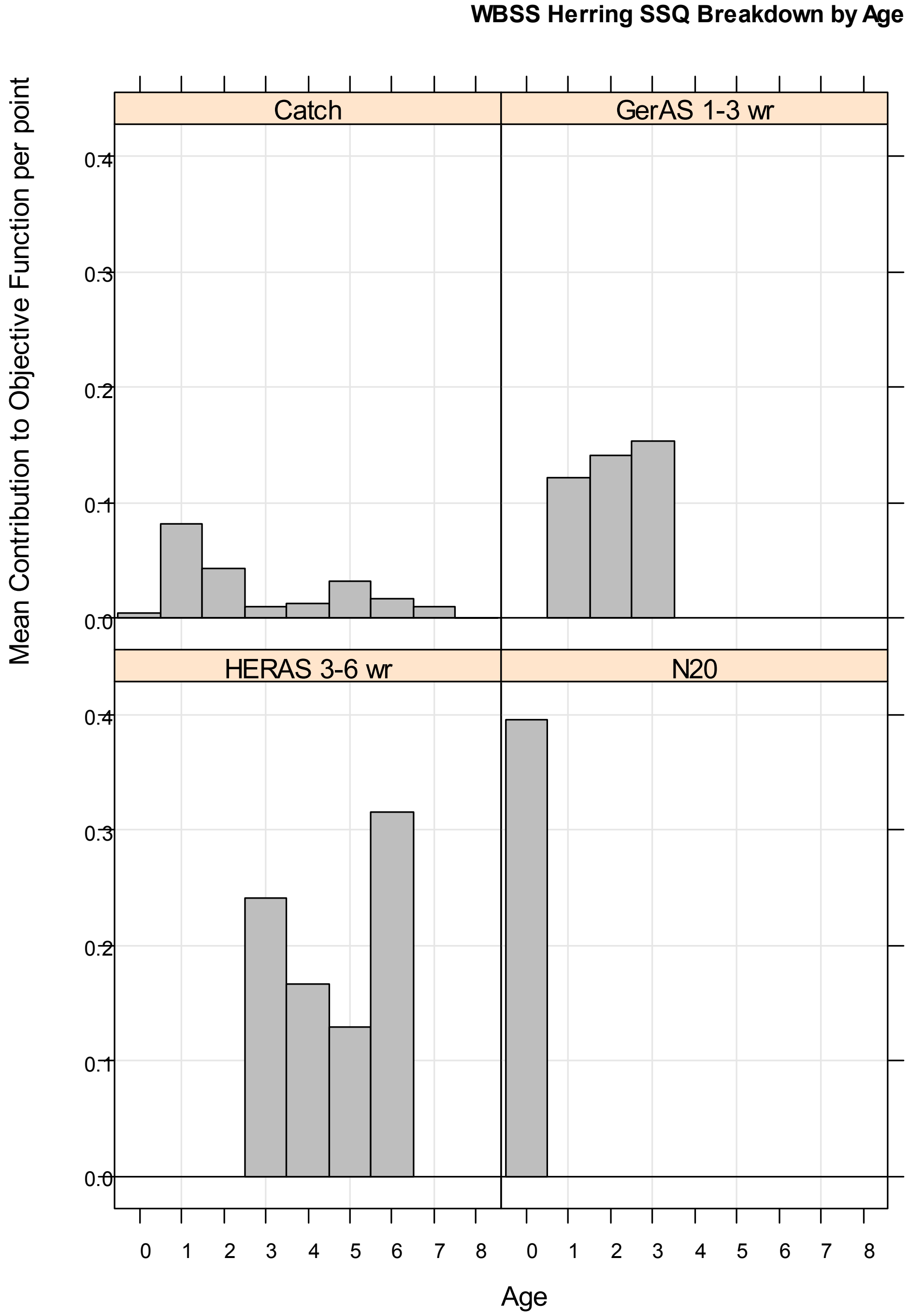


Figure 3.6.5.12 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Mean contribution of a data point individual information groups (ages in each survey) to the FLICA objective function. The contribution is calculated from the mean of the squared residuals in the corresponding class, and weighted according to the appropriate value employed by the optimiser.

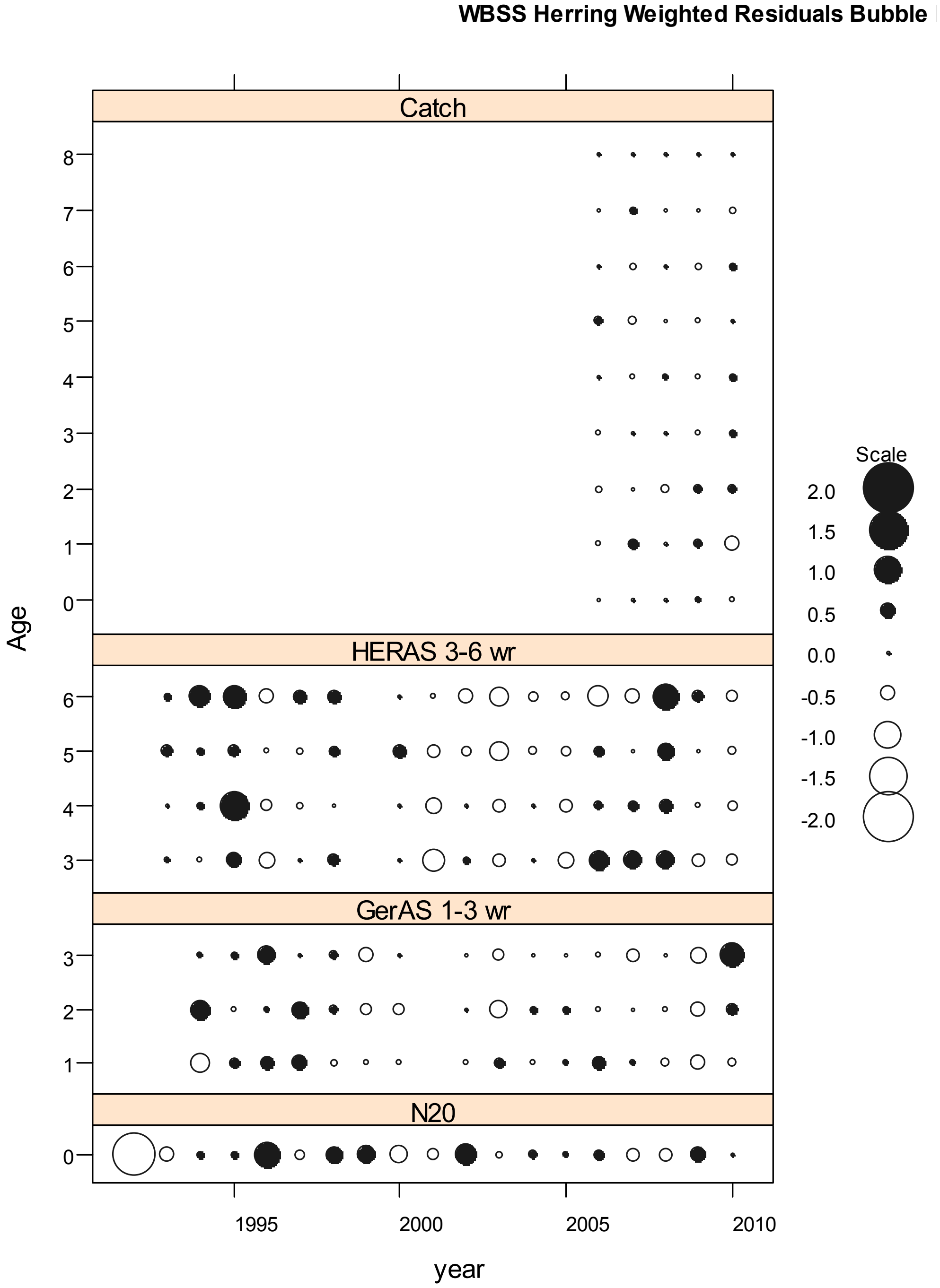


Figure 3.6.5.13 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with FLICA in calculating the objective function. The bubble scale is consistent between all panels.

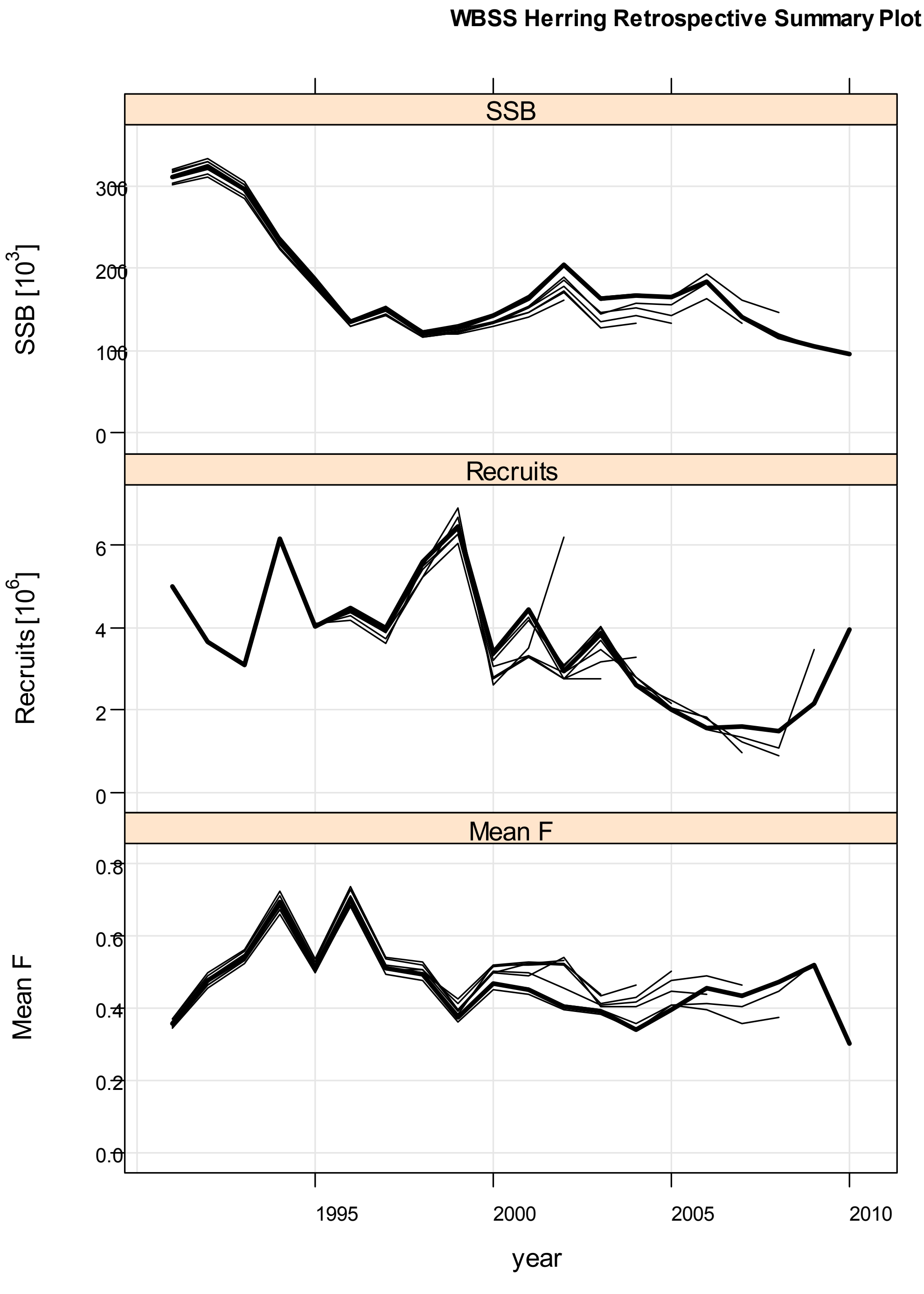


Figure 3.6.5.14 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Analytical retrospective pattern in the assessment. Top panel: Spawning stock biomass. Middle panel: Recruitment at age 0 wr. Bottom panel: Mean fishing mortality in the ages 3-6 ringer. The heavy black line shows the current assessment

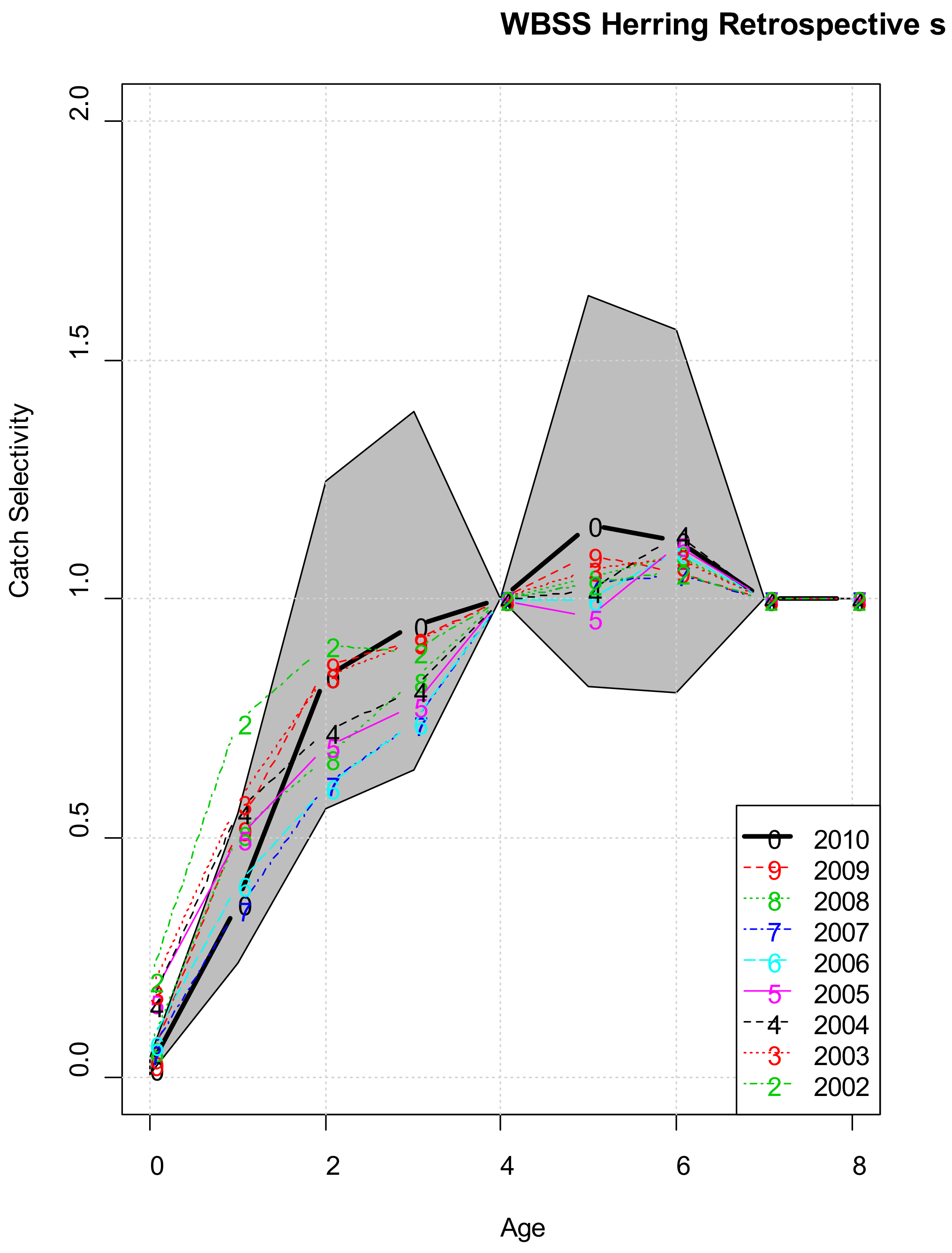


Figure 3.6.5.15 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Retrospective selectivity pattern

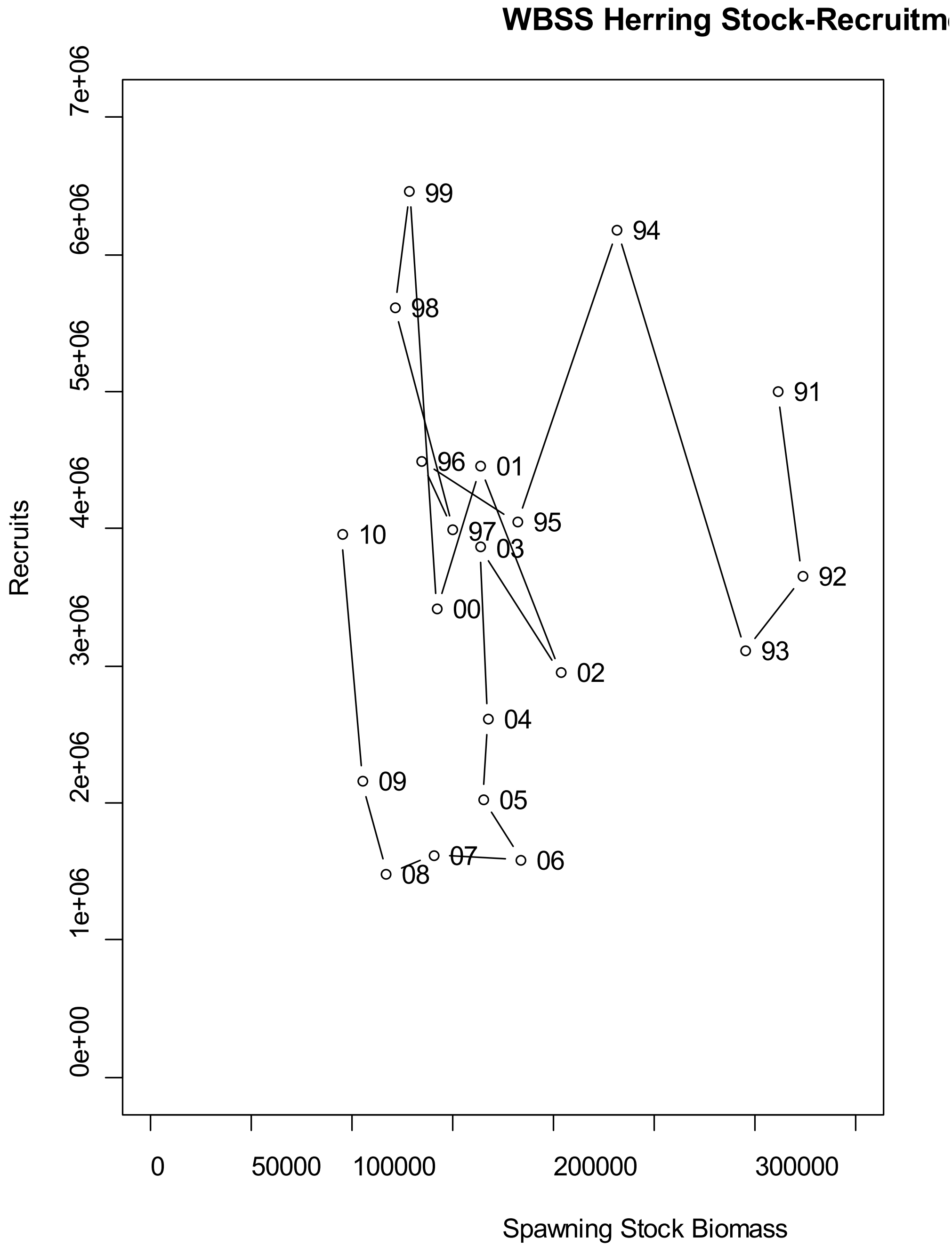


Figure 3.6.5.16 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Stock-recruitment relationship. Recruitment at age 0-wr (in thousands) is plotted as a function of spawning stock biomass (tonnes) estimated by the assessment. Successive years are joined by the line. Individual data points are labelled with the two-digit year.

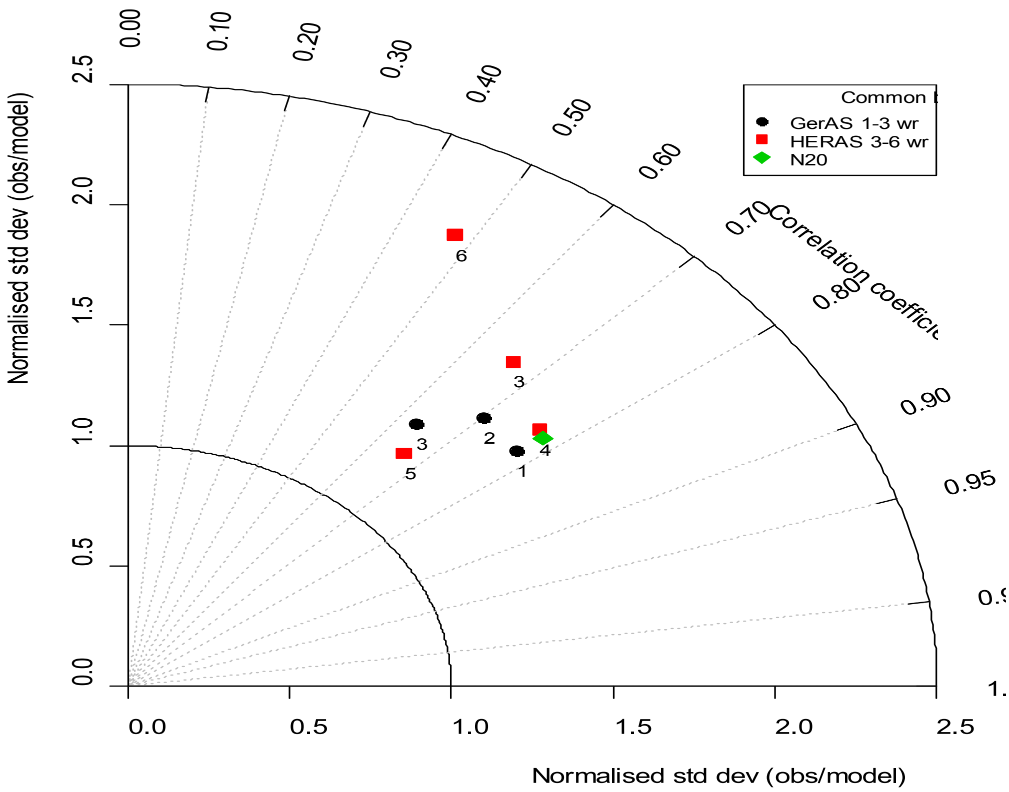
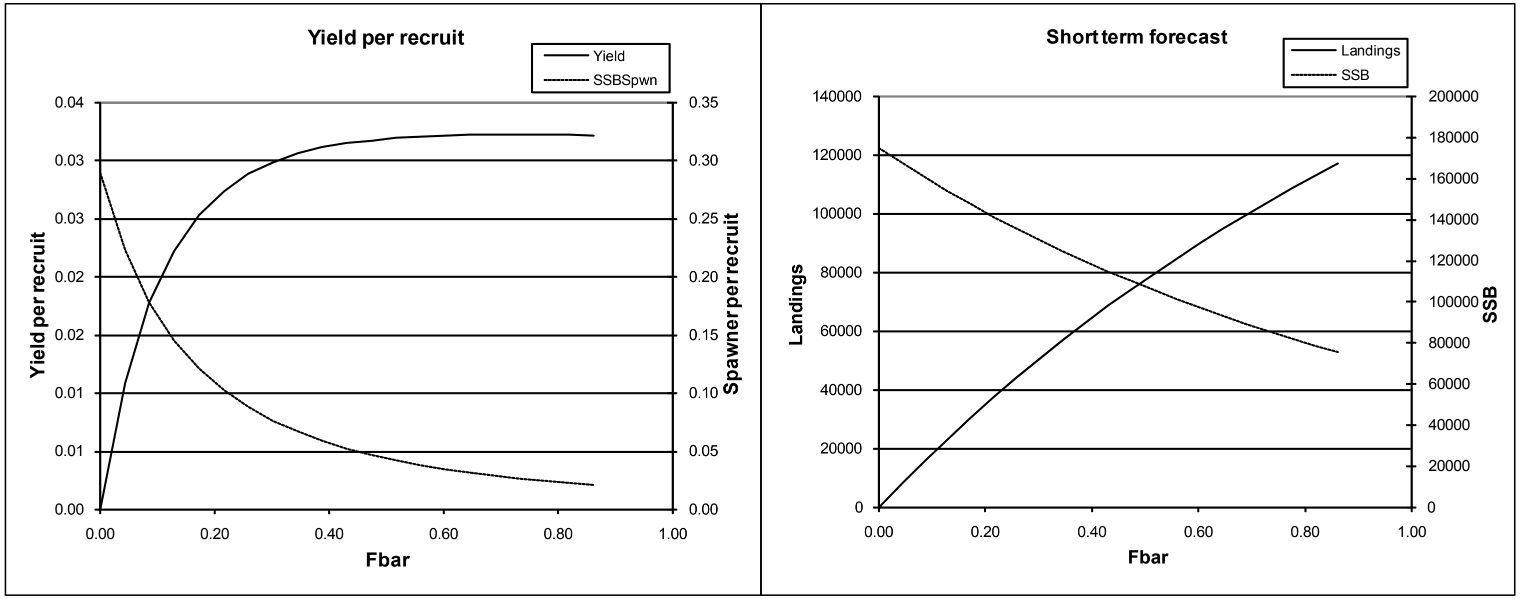


Figure 3.6.5.17 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN Taylor diagram (Taylor 2001, Payne 2011). The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modelled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labeled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.



MFYPR version 2a
Run: WBSS_MYPR2_Final_1
Time and date: 10:32 22/03/2011

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.4311
FMax	1.6847	0.7263
F0.1	0.5629	0.2427
F35%SPR	0.5065	0.2184

Weights in kilograms

MFDP version 1a
Run: WBSS_MFDP_1
Western Baltic Herring (combined sex; plus group)
Time and date: 18:03 21/03/2011
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 Herring in the Celtic Sea (Division VIIa South of 52° 30' N and VIIg,h,j,)

The assessment year for this stock runs from the 1st April – 31st March. Unless otherwise stated, year and year class are referred to by the first year in the season i.e. 2010 refers to the 2010/2011 season.

4.1 The Fishery

4.1.1 Advice and management applicable to 2010 – 2011

The TAC is set by calendar year and in 2010 was 10 150 t, and in 2011 is 13 200 t. In 2010 ICES advised that the TAC for 2011 should be 13 200 (following rebuilding plan) or 16 800 t (MSY approach).

Rebuilding Plan

In 2008, the Irish local fishery management committee developed a rebuilding plan for this stock. The text of this plan is presented in the Stock Annex. The plan was adopted by the Pelagic RAC and it was used as a basis for the 2010 and 2011 TACs. In 2009, the plan was evaluated by ICES and found to be in accordance with the precautionary approach, within the estimated stock dynamics. The plan will come to an end at the end of 2011 and is expected to be replaced by a long term management plan.

4.1.2 The fishery in 2010/2011

In 2010/2011, 35 vessels took part in the Irish fishery. These are categorised as follows:

- 2 Pelagic segment vessels with refrigerated seawater (RSW) storage.
- 4 Polyvalent segment boats with RSW storage.
- 29 Polyvalent vessels with bulk storage.

The fishery took place in the third and fourth quarter of 2010 and in the first quarter of 2011. In quarter 3, fishing only took place in VIIg. In the fourth quarter, the fishery was in VIIj, VIIg and VIIaS and in quarter 1 2011 was in VIIaS only. Most vessels under 20 m reported landings of about 100 t for the season while the four Polyvalent boats with RSW storage reported combined landings of around 1 800 t. The term "Polyvalent" refers to a segment of the Irish fleet, entitled to catch a variety of species, both demersal and pelagic.

The third quarter fishery took place in VIIg, landing a total of 1 890 t, from mid-September. The quarter 4 fishery took place mainly in VIIg, with smaller catches in VIIj, off the south Irish coast, and further east in VIIaS. This fishery began on the 4th October, and lasted until the 2nd week of December.

The fishery was closed in quarter 1 2011, except for the sentinel fishery that took place in Subdivision VIIaS, where around 154 t were caught. The sentinel fishery took place from the 30th January until the 18th February 2011.

The distribution of the total landings is presented in Figure 4.1.2.1.

4.1.3 The catches in 2010/2011

The estimated national catches from 1988–2010 for the combined areas by year and by season (1st April–31st March) are given in Table 4.1.3.1 and Table 4.1.3.2 respectively. The catch taken during the 2010 season has increased to around 8 400 t and is higher than the 2009 catch which was the lowest estimate in the series, being about 5 700 t (Figure 4.1.3.1.). The catch data include discards, until 1997. Catches considered to be area-misreported are subtracted as unallocated catches.

There are no recent estimates of discards for this fishery. Statements from fishermen suggest that discarding is not a feature of this fishery at present.

4.1.4 Regulations and their effects

The closure of Subdivision VIIaS from the 2007 -2011, except for a sentinel fishery, means that only small dry hold vessels, no more than 50 feet total length, can fish in that area. This closure has meant that the majority of the quota was taken by the larger bulk storage vessels further west, including VIIj.

There is evidence that closure of Subdivision VIIaS, under the rebuilding plan, has helped to reduce fishing mortality substantially (see text table). This area has been the dominant spawning area, and before the closure a large proportion of the catch was taken from it. Closing this area seems to have had a positive effect of keeping fishing mortality down. There is no evidence that this closure has led to improved recruitment. However, this area, particularly the area off Dunmore East, is important for recruit spawners. It can be expected that the closure allows these fish to spawn at least once, and contribute to SSB through further growth and spawning potential.

Season	Open or Closed	F estimates (HAWG)
1999 / 2000	Open	0.84
2000 / 2001	Open	0.84
2001 / 2002	Partial closure (16/1/02-23/2/02)	0.73
2002 / 2003	Closed	0.29
2003 / 2004	Partial closure (1/4/02-1/12/03)	0.38
2004 / 2005	Open	0.51
2005 / 2006	Open	0.39
2006 / 2007	Open	0.20
2007 / 2008	Closed	0.16
2008 / 2009	Closed	0.09
2009 / 2010	Closed	0.07
2010 / 2011	Closed	0.08
2011 / 2012	Open 1st January	-

The spawning area closures instituted under EU legislation (see Stock Annex) do not appear to have been beneficial to the stock in terms of either SSB, F or recruitment.

4.1.5 Changes in fishing technology and fishing patterns

The stock is exploited by three types of vessels, larger boats with RSW or bulk storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). These boats are excluded from VIIaS under the terms of the rebuilding plan, as they are over 65 feet. The fleet involved in the sentinel fishery is increasing, both in number of vessels and fishing efficiency.

4.2 Biological composition of the catch

4.2.1 Catches in numbers-at-age

Catch numbers-at-age are available for the period 1958 to 2010. In 2010, the most abundant age classes were 2-ringers (2007 year class), 4-ringers (2005 year class) and 6-ringers (2003 year class). These cohorts were also strong in the previous season as 1-, 3- and 5-ringers respectively. The weak 2001/2002 year class has now almost disappeared from the catches (Table 4.2.1.1). The strong 2003 year class is now 6-ringer and the currently used plus group is 6. This year class is a significant component of the plus group. The yearly mean standardised catch numbers-at-age for 6+ and 7+ are shown in Figure 4.2.1.1 and 4.2.1.2 and clearly show this strong cohort.

The overall proportions-at-age were similar in all sampled metiers (division*quarter). A slightly different age profile can be seen in quarter 4 from Division VIIj with lower amounts of 4-ringers and higher amounts of 5-ringers. However, as in 2009 the survey and the commercial fishery did not agree as well as in terms of proportions-at-age (Figure 4.2.1.3). The 4- and 6-ringers that were dominant in the commercial catch were less dominant in the survey. As expected the survey caught greater amounts of 1-ring fish.

Table 4.2.1.2 and Figure 4.2.1.4 show the length frequency data by area and quarter. A similar length range was found in all areas with the exception of 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 4.2.2.1). Under the Data Collection Framework the sampling of this stock is well above that required by the Minimum Programme (Section 1.5).

The quality of catch data has varied over time. A rudimentary history of the Irish fishery since 1958 is presented in the Stock Annex. In 2010/2011 only preliminary data were available at the time of the Working Group. Best estimates of small boat catches were used for the VIIaS sentinel fishery. This is because not all the vessels are required to make logbook returns, being less than 10 m in total length.

4.3 Fishery Independent Information

4.3.1 Acoustic Surveys

The Celtic Sea herring acoustic survey (CSHAS) time series currently used in the assessment runs from 2002 -2010 and is presented in Table 4.3.1.1.

The acoustic survey of the 2010/2011 season was carried out in October 2010, on the *Celtic Explorer* (Saunders, *et al* 2010). The survey track began at the northern boundary of VIIj, covering the SW bays in zig-zags and parallel transects (Figure 4.3.1.1a). As in previous seasons, very little herring was registered in the bays of VIIj Figure 4.3.1.1b. The main broad scale survey in VIIg and VIIaS had a parallel transect design and showed the greatest concentrations of herring close inshore on the spawning grounds.

Difficulties were encountered when calibrating the 38kHz echosounder. Problems with the 38kHz transducer cable led to distortion of the acoustic beam and resulted in a complete loss of 38kHz data. The abundance estimate was calculated using the fully calibrated 18kHz data. Full details of this work including comparisons between 38kHz and 18kHz estimates are presented in Saunders *et al,* 2010 WD 08. Based on this work and discussions at WGIPS in 2011 it was agreed to use the 18kHz abundance estimates for 2010 in the 2011 assessment.

In 2010/2011 the SSB estimate was almost 122 000 t. This is an increase of 34% on the 2009 SSB estimate of 91 000 t. The distribution of herring encountered on the 2010 survey was more concentrated than in 2009 with more 'definitely herring' marks encountered and less herring in mixed schools.

This survey shows quite good internal consistency for the age groups used in the assessment (Figure 4.3.1.2). The worst coherence is shown by 2-ringers. This may be due to the variation in immigration from the Irish Sea.

4.4 Mean weights-at-age and maturity-at-age

The mean weights in the catch and mean weight in the stock at spawning time are presented in Figure 4.4.1.1 and 4.4.1.2 respectively. There has been an overall downward trend in mean weights-at-age since the mid-1980s. However, around 2008 the main age groups 2-8 have shown an increase. For 2010/2011 the mean weights-at-age have decreased slightly for all ages.

Mean weights in the stock at spawning time were calculated from biological samples, for quarters 4 and 1 (Figure 4.4.1.2). Decreases in mean weight can be seen across all ages with the exception of 8-ringers where a very small increase was seen.

In the assessment, 50% of 1-ringers are considered mature. Sampling data from the Celtic Sea catches suggest that greater than 50% of 1-ringers are mature (Lynch, 2011). The Celtic Sea 1-ringers that are present in the Irish Sea have less than 50% maturity (Beggs *et al*., 2008, WD 04).

4.5 Recruitment

At present there are no recruitment estimates for this stock.

4.6 Assessment

4.6.1 Data Exploration

An additional exploratory assessment was run to explore the effect of increasing the plus group to 7. The fitted catch diagnostics from the spaly 6+ run and the 7+ run are presented in Figures 4.6.1.1 and 4.6.1.2. A change in selection can be seen, as well as an increase in the size of the residuals for the 7+ run. The retrospective selection patterns from both runs are presented in Figures 4.6.1.3 and 4.6.1.4. The 6+ run shows a more stable selection pattern over time. The separable model diagnostics show that the total residuals by age and year between the catch and separable model do not show any clear trends. A flat topped selection pattern is considered appropriate for this stock.

The stock summary for each run is also presented (Figures 4.6.1.5. and 4.6.1.6). The SSB estimate is significantly higher (+26%) when the 6+ data is used. Overall, the diagnostics were not improved significantly when the plus group was extended. It was decided to use the 6+ data in the 2011 assessment and the results of this run are presented in detail. The plus group is an issue that may have to be reinvestigated as several strong year classes are entering this fishery. The plus group was reduced at a time when there was significant truncation at older ages and poor incoming recruitment.

4.6.2 Stock Assessment

This update assessment was carried out using FLICA. The same settings as the 2010 assessment were used (Table 4.6.1.10) and the assessment was tuned using the Celtic Sea herring acoustic survey (CSHAS). The input and output data are presented in Tables 4.6.1.1 to 4.6.1.21.

The fitted catch diagnostics show a reasonable residual pattern (Figure 4.6.1.1). The survey diagnostics at-age are presented in Figures 4.6.1.7 – 4.6.1.10 and are similar to last year. The fit between the observed and expected time series is relatively good, with the fit improving as the age increases. High estimates of the 2005 and 2007 year classes can be seen in 2010.

The catch and survey residual patterns are shown in Figure 4.6.1.11. Year effects can be seen in the acoustic surveys in 2002, 2003 and 2005 and also in 2010. It is not clear what is causing the year effects in 2010 but it may be due to the significant increase in the survey abundance. In more recent years the survey is performing better in the assessment with smaller residuals. No age effects are seen in the time series.

An "otolith" plot which depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality is presented in Figure 4.6.1.12. This figure shows that there is considerable uncertainty in the estimates of SSB with a wide range of values shown. The incoming recruitment of 1-ringers is poorly estimated in the assessment and leads to greater uncertainty of the estimation of SSB.

A Taylor diagram is presented in Figure 4.6.1.13 to shows the statistical comparison of observations from the acoustic survey data and the model estimates. The agreement between the model and the observations is best for 4-ringers and the 3- and 5-ringers are comparable. The worst correlation is seen for the 2-ringers.

Retrospective plots by cohort are shown in Figure 4.6.1.14. The strong year classes (2003, 2005 and 2007) tend to be underestimated. The analytical retrospective pattern is displayed in Figure 4.6.2.15. The retrospective pattern was investigated as far back as 2003 but excludes the 2004 estimates. A retrospective analysis cannot be extended into earlier years because of the lack of reliable survey data. An upward revision can be seen in SSB with estimates of F showing a more stable pattern over time. In 2009, the 2007 year class was underestimated. A historical retrospective is presented in Figure 4.6.2.16. This compares the final assessments in 2009, 2010 and 2011. The upward revision in SSB can be seen here also.

4.6.3 State of the stock

The stock has increased considerably in size and is well above B_{pa} (44 000 t). F has declined from the peak in 2003, and is estimated to be below $F_{0.1}$, and has increased slightly since last year. The stock continues to be in a state of recovery with evidence of three strong cohorts recruited to this stock.

4.7 Short term projections

4.7.1 Deterministic Short Term Projections

A deterministic short term forecast was performed, using FLR. The input data are presented in Table 4.7.1.1. Mean weights in the catch and in the stock were calculated as means over the last three years. Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. The population numbers at 1-ring are replaced by geometric mean from 1995-2008. This time period was used because this represents the current perceived recruitment regime where recruitment has been fluctuating around the mean. Population numbers of 2-ringers in the intermediate season (2011) were calculated by the degradation of geometric mean recruitment (1995-2008) using the equation below.

$$N_{t+1} = N_t * e^{-Ft+Mt}$$

The short term forecast was performed using the predicted catch in the interim season 2011/2012. This was calculated as the remaining Irish quota for 2011 plus the likely Irish catch in quarter 1 of 2012.

The 2012 quarter 1 catch was estimated assuming that the quota would be increased by 30% and divided into 3 equal parts for quarters 1, 3 and 4. This 30% increase in TAC is the maximum allowed according to the proposed management plan. The use of Irish catch estimates in the interim year assumes that other countries' catches are unallocated.

The results of the short term projection are presented in Table 4.7.1.2 and 4.7.1.3. Fishing according to the proposed rebuilding plan implies catches of 21 054 t in 2012. All scenarios show SSB will be well above B_{pa} in 2013.

4.7.2 Yield Per Recruit

A yield per recruit analysis was conducted using FLR in 2011 and $F_{0.1}$ was estimated to be 0.17 (Figure 4.7.2.1).

4.8 Long term simulations

A long term plan has been proposed for Celtic Sea herring and simulations have been carried out in conjunction with this work. HCS10 (Skagen, 2010) was used to project the stock forward twenty years and screen over a range of possible trigger points, F values and % constraints on TAC change. It was agreed by the Irish industry that a target F of 0.23 would be proposed and that 61 000 t would be used as a trigger biomass. Once the stock falls to this level, reductions in F would be implemented. A 30% constraint in TAC change would also apply. Simulations have shown that this combination of options shows that the risk of falling below the breakpoint, which is 41 000 t, is less than 5% over the simulation period (Egan and Clarke, 2011 WD 11).

4.9 Precautionary and yield based reference points

Reference points are defined for this stock, $\mathbf{B_{pa}}$ is currently at 44 000t (low probability of low recruitment) and $\mathbf{B_{lim}}$ at 26 000 t **($\mathbf{B_{loss}}$)** for this stock. $\mathbf{F_{pa}}$ and $\mathbf{F_{lim}}$ are not defined. 0.25 is suggested as a possible option for $\mathbf{F_{MSY}}$.

Simulations carried out by Egan and Clarke, 2011 (WD 11) show that the breakpoint in the stock recruit relationship is 41 000 t. This could be considered as a possible alternative to the current $\mathbf{B_{lim}}$. Based on this, a possible new option for $\mathbf{B_{pa}}$ based on the equation $\mathbf{B}_{pa} = \mathbf{B}_{lim} \exp(1.645\sigma)$, where σ is the CV from the assessment (ICES:CM 1998/ACFM 10), was calculated as 67 000 t.

HAWG has not considered candidate values for a $B_{MSYtrigger}$ in great detail. HAWG considered that there is a range of biologically appropriate biomass triggers that may be appropriate, suggesting 50 000 t as one possible value. The proposed management plan has a trigger biomass of 61 000 t. In 2010 ACOM endorsed the approach taken by HAWG, and ICES WKFRAME II also endorsed the approach in 2011.

4.10 Quality of the Assessment

This assessment is an update of the 2010 assessment. A significant upward revision of the perception of SSB is a feature of the 2011 assessment. The underestimation of strong incoming year classes is likely to be a factor influencing this revision. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below and are shown in the historical retrospective in Figure 4.6.1.16.

2010 Report				2011 Assessment				Percentage change in Estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2008	70958	5872**	0.09	2008	78351	5872	0.09	10	0
2009	74689	5745	0.07	2009	105903	5745	0.07	42	0
2010*	74804	12150	0.17	2010	114319	8370	0.08	52	-50

* From Intermediate year in STF

** Revision due to area misreporting

4.11 Management Considerations

Fishing mortality on this stock was high for many years, well above $\mathbf{F}_{MSY} = 0.25$. In the past three years F has been substantially reduced and is now below $\mathbf{F}_{MSY}$ and $F_{0.1}$. The current estimate of F is 0.08. SSB is well above $\mathbf{B}_{pa}$ (44 000t).

The advice for 2011 was based on the rebuilding plan and led to a 30% increase in TAC. There is good evidence to show that the stock has increased substantially. The rebuilding plan can be considered to be successful because the stock has been shown to be above $\mathbf{B}_{pa}$ for three consecutive years. This was the criterion for recovery used in the rebuilding plan. The stock should now be managed according to a long term management plan.

A long term management plan has been proposed by the Irish industry. The proposed target F is 0.23 and the trigger biomass point is 61 000 t. The plan will be forwarded to the Pelagic RAC for review. It will be fully evaluated before it is deemed precautionary.

The closure of the Subdivision VIIaS as a measure to protect first time spawners has been in place since 2007/2008. Under the terms of the rebuilding plan the stock is considered to have recovered and this area will be reopened in January 2012.

4.12 Ecosystem considerations

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

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging, sand and gravel extraction, dumping of dredge spoil and waste from fish cages. There have been several proposals for extraction of gravel and to dump dredge spoil in recent years. Many of these proposals relate to known herring spawning grounds. ICES have consistently advised that activities that perturb herring spawning grounds should be avoided.

Herring fisheries tend to be clean with little bycatch of other fish. Mega-fauna by catch is unquantified. Anecdotal reports suggest that seals are caught from time to time.

4.13 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 could have implications for herring that is at the southern edge of its distribution in this area. It is known that similar environmental changes have affected the North Sea herring. However, there is no evidence that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Table 4.1.3.1. Herring in the Celtic Sea. Landings by quota year (t), 1988–2010. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988	-	-	16,800	-	-	-	2,400	19,200
1989	+	-	16,000	1,900	-	1,300	3,500	22,700
1990	+	-	15,800	1,000	200	700	2,500	20,200
1991	+	100	19,400	1,600	-	600	1,900	23,600
1992	500	-	18,000	100	+	2,300	2,100	23,000
1993	-	-	19,000	1,300	+	-1,100	1,900	21,100
1994	+	200	17,400	1,300	+	-1,500	1,700	19,100
1995	200	200	18,000	100	+	-200	700	19,000
1996	1,000	0	18,600	1,000	-	-1,800	3,000	21,800
1997	1,300	0	18,000	1,400	-	-2,600	700	18,800
1998	+	-	19,300	1,200	-	-200	-	20,300
1999		200	17,900	1300	+	-1300	-	18,100
2000	573	228	18,038	44	1	-617	-	18,267
2001	1,359	219	17,729	-	-	-1578	-	17,729
2002	734	-	10,550	257	-	-991	-	10,550
2003	800	-	10,875	692	14	-1,506	-	10,875
2004	801	41	11,024	-	-	-801	-	11,065
2005	821	150	8452	799	-	-1770	-	8,452
2006	-	-	8,530	518	5	-523	-	8,530
2007	581	248	8,268	463	63	-1355	-	8,268
2008	503	191	6,853	291		-985	-	6,853
2009	364	135	5,760			-499	-	5,760
2010	636	278	8406	325		-1239	-	8,406

Table 4.1.3.2. Herring in the Celtic Sea. Landings (t) by assessment year (1st April–31st March) 1988/1989-2010/2011. (Data provided by Working Group members). These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988/1989	-	-	17,000	-	-	-	3,400	20,400
1989/1990	+	-	15,000	1,900	-	2,600	3,600	23,100
1990/1991	+	-	15,000	1,000	200	700	1,700	18,600
1991/1992	500	100	21,400	1,600	-	-100	2,100	25,600
1992/1993	-	-	18,000	1,300	-	-100	2,000	21,200
1993/1994	-	-	16,600	1,300	+	-1,100	1,800	18,600
1994/1995	+	200	17,400	1,300	+	-1,500	1,900	19,300
1995/1996	200	200	20,000	100	+	-200	3,000	23,300
1996/1997	1,000	-	17,900	1,000	-	-1,800	750	18,800
1997/1998	1,300	-	19,900	1,400	-	-2100	-	20,500
1998/1999	+	-	17,700	1,200	-	-700	-	18,200
1999/2000		200	18,300	1300	+	-1300	-	18,500
2000/2001	573	228	16,962	44	1	-617	-	17,191
2001/2002	-	-	15,236	-	-	-	-	15,236
2002/2003	734	-	7,465	257	-	-991	-	7,465
2003/2004	800	-	11,536	610	14	-1,424	-	11,536
2004/2005	801	41	12,702	-	-	-801	-	12,743
2005/2006	821	150	9,494	799	-	-1770	-	9,494
2006/2007	-	-	6,944	518	5	-523	-	6,944
2007/2008	379	248	7,636	327	-	-954	-	7,636
2008/2009	503	191	5,872	150		-844	-	5,872
2009/2010	364	135	5,745		-	-499	-	5,745
2010/2011	636	278	8,370	325	-	-1239	-	8,370

Table 4.2.1.1. Herring in the Celtic Sea. Comparison of age distributions (percentages) in the catches of Celtic Sea and VIIj herring from 1966-2010

	1	2	3	4	5	6	7	8	9
1966	5%	15%	46%	8%	10%	4%	3%	7%	3%
1967	5%	26%	13%	32%	6%	6%	3%	4%	4%
1968	8%	35%	25%	7%	14%	3%	3%	1%	3%
1969	4%	40%	24%	14%	5%	8%	2%	1%	1%
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
1998	5%	34%	22%	23%	11%	3%	2%	0%	0%
1999	11%	27%	28%	11%	12%	7%	1%	2%	0%
2000	7%	58%	14%	9%	4%	5%	2%	0%	0%
2001	12%	49%	28%	5%	3%	1%	1%	0%	0%
2002	6%	46%	32%	9%	2%	2%	1%	0%	0%
2003	3%	41%	27%	16%	6%	4%	3%	0%	1%
2004	5%	10%	50%	24%	9%	2%	1%	0%	0%
2005	19%	38%	7%	23%	9%	2%	1%	0%	0%
2006	3%	58%	19%	4%	11%	4%	1%	0%	0%
2007	12%	17%	56%	9%	2%	3%	1%	0%	0%
2008	3%	31%	20%	38%	6%	1%	1%	0%	0%
2009	24%	11%	30%	12%	20%	2%	1%	1%	0%
2010	24%	11%	30%	12%	20%	2%	1%	1%	0%

Table 4.2.1.2. Herring in the Celtic Sea. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2010/2011 season in the Celtic Sea and VIIj fishery.

	VIIg Q3	VIIg Q4	VIIj Q4	VIIas Q4	VIIaS Q1	Total
18	26					26
18.5	26	57				83
19	43	85		10		138
19.5	60	227		6		294
20	69	270		3		342
20.5	138	270	18	10	8	443
21	232	553	18	29	18	851
21.5	275	596	88	55	25	1039
22	448	1107	176	103	74	1907
22.5	508	1532	123	100	74	2337
23	947	2086	123	154	82	3392
23.5	947	2852	88	145	104	4136
24	1369	3406	132	244	109	5259
24.5	1429	3590	194	241	125	5579
25	1575	4839	167	450	111	7142
25.5	1575	4881	123	552	156	7288
26	1584	6527	185	623	176	9096
26.5	1464	4981	203	379	145	7171
27	1085	2441	238	202	94	4060
27.5	465	1022	264	71	39	1860
28	155	511	308	19	2	995
28.5	26	85	229	6	4	351
29	9	14	44			67
29.5	9		18			26
30			18			18
30.5						
31						
31.5		14	9			23
32		14				14

Table 4.2.2.1 Herring in the Celtic Sea. Sampling intensity of Irish commercial catches (2010/2011). Only Ireland provides samples of this stock.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIIg	2010	3	1890	7	488	1680	0.49
VIIg	2010	4	5476	16	1090	2957	1.09
Sub-total			**7366**	**23**	**1578**	**4637**	
VIIaS	2010	4	430	10	500	1059	0.50
VIIaS	2011	1	154	6	300	656	0.30
Sub-total			**584**	**16**	**800**	**1715**	
VIIj	2010	4	420	3	150	314	0.15
Sub-total			**420**	**3**	**150**	**314**	
Total Celtic Sea			**8370**	**42**	**2528**	**6666**	

Table 4.3.1.1. Herring in the Celtic Sea. Revised acoustic index of abundance used in the assessment. Total stock numbers-at-age (10^6) estimated using combined acoustic surveys (age refers in winter rings, biomass and SSB in 000's tonnes). Only 2-5 ring abundance is used in tuning.

	2002 2003	**2003 2004**	**2004 2005**	**2005 2006**	**2006 2007**	**2007 2008**	**2008 2009**	**2009 2010**	**2010 2011**
0	0	24	-	2	-	1	99	239	5
1	42	13	-	65	21	106	64	381	346
2	185	62	-	137	211	70	295	112	549
3	151	60	-	28	48	220	111	210	156
4	30	17	-	54	14	31	162	57	193
5	7	5	-	22	11	9	27	125	65
6	7	1	-	5	1	13	6	12	91
7	3	0	-	1	-	4	5	4	7
8	0	0	-	0	-	1		6	3
9	0	0	-	0	-	0		1	
							-		
Abundance	423	183	-	312	305	454	769	1,147	1,414
SSB	41	20	-	33	36	46	90	91	122
CV	49	34	-	48	35	25	20	24	20
Design	AR	AR		R	R	R	R	R	R

*AR Adaptive random; R random

TABLE 4.6.1.1 Herring in the Celtic Sea. CATCH IN NUMBER

Units : thousands

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	4276	15419
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	9470	30710
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	46243	5766
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21863	18666
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	7349
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

age \ year	2006	2007	2008	2009	2010
1	1460	8043	1306	10171	2468
2	33894	11028	12638	4465	20929
3	10914	36223	8255	12859	8183
4	2469	5509	15777	4887	15917
5	6261	1365	2360	8458	4846
6	2997	2509	921	1578	11592

TABLE 4.6.1.2 Herring in the Celtic Sea. WEIGHTS AT AGE IN THE CATCH

Units : kg

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.214	0.219	0.205	0.211

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.089	0.080	0.077
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.102	0.130	0.102
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.128	0.134	0.142
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.146	0.151	0.147
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.185	0.165	0.159	0.158
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.191	0.186	0.174

age \ year	2006	2007	2008	2009	2010
1	0.093	0.074	0.091	0.078	0.075
2	0.105	0.106	0.120	0.122	0.108
3	0.127	0.123	0.144	0.146	0.129
4	0.151	0.141	0.156	0.160	0.142
5	0.155	0.166	0.172	0.169	0.155
6	0.168	0.164	0.193	0.188	0.159

TABLE 4.6.1.3 Herring in the Celtic Sea. WEIGHTS AT AGE IN THE STOCK

Units : kg

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age \ year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.213	0.219	0.205	0.211

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.078	0.077	0.074
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.100	0.127	0.103
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.130	0.133	0.145
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.141	0.151	0.143
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.184	0.156	0.156	0.155
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.168	0.187	0.167

age \ year	2006	2007	2008	2009	2010
1	0.085	0.066	0.083	0.076	0.076
2	0.104	0.102	0.117	0.117	0.106
3	0.123	0.116	0.140	0.142	0.127
4	0.153	0.135	0.156	0.158	0.139
5	0.150	0.151	0.170	0.168	0.152
6	0.159	0.160	0.180	0.178	0.159

TABLE 4.6.1.4 Herring in the Celtic Sea. NATURAL MORTALITY

Units : NA

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
1	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
3	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
5	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

TABLE 4.6.1.5 Herring in the Celtic Sea. PROPORTION MATURE

Units : NA

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

TABLE 4.6.1.6 Herring in the Celtic Sea. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
6	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

age	2003	2004	2005	2006	2007	2008	2009	2010
1	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
2	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
3	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
4	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
5	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551
6	0.551	0.551	0.551	0.551	0.551	0.551	0.551	0.551

TABLE 4.6.1.7 Herring in the Celtic Sea. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	2003	2004	2005	2006	2007	2008	2009	2010
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

TABLE 4.6.1.8 Herring in the Celtic Sea. SURVEY INDICES

Celtic Sea Herring Acoustic Survey - Configuration

```
"Celtic Sea   and   Division  VIIj herring . Imported from VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
        2         5        NA      2002      2010         1         1
Index type : number
```

Celtic Sea Herring Acoustic Survey - Index Values

```
Units  :  NA
   year
age  2002 2003 2004  2005  2006 2007 2008 2009 2010
  2 185.2 61.7   -1 137.1 210.5   70  295  112  549
  3 150.6 60.4   -1  28.2  47.8  220  111  210  156
  4  29.7 17.2   -1  54.2  13.5   31  162   57  193
  5   6.6  5.4   -1  21.6  11.0    9   27  125   65
```

Celtic Sea Herring Acoustic Survey - Index Variance (Inverse Weights)

```
Units  :  NA
   year
age 2002 2003 2004 2005 2006 2007 2008 2009 2010
  2    1    1    1    1    1    1    1    1    1
  3    1    1    1    1    1    1    1    1    1
  4    1    1    1    1    1    1    1    1    1
  5    1    1    1    1    1    1    1    1    1
```

TABLE 4.6.1.9 Herring in the Celtic Sea. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        1         6         6      1958      2010         2         5
```

TABLE 4.6.1.10 Herring in the Celtic Sea. FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1
lambda.sr   : 0
index.model : linear
index.cor   : 1
sep.nyr     : 6
sep.age     : 3
sep.sel     : 1
```

TABLE 4.6.1.11 Herring in the Celtic Sea. FLR, R SOFTWARE VERSIONS

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

Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

TABLE 4.6.1.12 Herring in the Celtic Sea. STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 2-5)	Landings tonnes	Landings SOP
1958	296749	112164	81192	0.3578	22978	1.1144
1959	877840	137942	76574	0.3078	15086	1.1238
1960	191417	87465	62882	0.4498	18283	1.1314
1961	221309	76365	53899	0.2815	15372	0.7759
1962	569088	116616	63954	0.5958	21552	1.0137
1963	286381	89078	58590	0.4008	17349	1.0017
1964	1086254	168997	82323	0.2453	10599	1.0234
1965	341357	151680	110992	0.2282	19126	1.1620
1966	701444	193253	118863	0.2742	27030	0.9617
1967	715913	199852	123705	0.3455	27658	1.1093
1968	840789	214451	127286	0.3235	30236	0.9937
1969	445612	176603	116398	0.5068	44389	1.0062
1970	215682	123926	88822	0.4478	31727	1.0041
1971	858507	168019	84550	0.6735	31396	1.0385
1972	265141	115031	72075	0.7100	38203	0.9936
1973	291594	89570	52212	0.7155	26936	1.0461
1974	130011	58047	36224	0.7920	19940	1.0226
1975	145243	46988	27215	0.7308	15588	0.9298
1976	175521	46334	25252	0.6265	9771	1.0604
1977	170146	44122	24284	0.5420	7833	0.9983
1978	134982	41415	25071	0.5050	7559	1.0882
1979	238310	52522	26929	0.6422	10321	0.9954
1980	148348	44083	26233	0.6795	13130	0.9302
1981	405412	69129	30520	0.9710	17103	0.9861
1982	672638	105980	45850	0.6842	13000	0.9865
1983	744616	131762	63199	0.6792	24981	0.9551
1984	573187	114355	63446	0.8508	26779	1.0089
1985	517083	111009	62863	0.4892	20426	0.9760
1986	539118	121991	67457	0.6370	25024	0.9992
1987	979144	152842	74656	0.7280	26200	1.0043
1988	394043	112886	73026	0.4050	20447	0.9962
1989	476177	113542	66817	0.5245	23254	0.9984
1990	430086	100951	61509	0.4448	18404	1.0102
1991	181263	72762	49500	0.6752	25562	0.9873
1992	962532	129137	55704	0.9740	21127	1.0467
1993	331174	89834	57086	0.5670	18618	0.9993
1994	704501	123430	65853	0.4230	19300	1.0049
1995	685674	122999	69150	0.5340	23305	0.9979
1996	343402	93948	62043	0.3908	18816	0.9981
1997	374906	85469	51419	0.5990	20496	1.0037
1998	244778	67378	42061	0.6198	18041	1.0016
1999	517528	80110	39862	0.8435	18485	1.0024
2000	457689	76047	38625	0.8402	17191	1.0001
2001	427987	66907	35157	0.7330	15269	1.0064
2002	543683	85152	43584	0.2905	7465	0.9994
2003	117836	52029	34682	0.3820	11536	0.9977
2004	305664	55944	29076	0.5130	12743	1.0080
2005	982324	99896	41875	0.3932	9494	0.9983
2006	369330	84614	52471	0.2005	6944	0.9976
2007	827993	104459	57743	0.1562	7636	0.9998
2008	373767	110744	78351	0.0855	5872	0.9995
2009	1432574	191440	105903	0.0652	5745	0.9963
2010	**417056***	168141	114319	0.0845	8370	0.9983

***Geometric Mean 1995 - 2008**

TABLE 4.6.1.13 Herring in the Celtic Sea. ESTIMATED FISHING MORTALITY

Units : f

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.009	0.002	0.024	0.015	0.002	0.002	0.011	0.000	0.016	0.017	0.023	0.034
2	0.167	0.319	0.298	0.312	0.309	0.336	0.180	0.229	0.198	0.200	0.279	0.436
3	0.398	0.154	0.620	0.222	0.870	0.397	0.188	0.172	0.332	0.340	0.332	0.535
4	0.489	0.403	0.387	0.261	0.566	0.419	0.343	0.249	0.264	0.471	0.318	0.483
5	0.377	0.355	0.494	0.331	0.638	0.451	0.270	0.263	0.303	0.371	0.365	0.573
6	0.377	0.355	0.494	0.331	0.638	0.451	0.270	0.263	0.303	0.371	0.365	0.573

year

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.010	0.024	0.051	0.135	0.069	0.148	0.126	0.078	0.033	0.078	0.079	0.164
2	0.315	0.415	0.709	0.633	0.732	0.503	0.324	0.291	0.309	0.403	0.551	0.655
3	0.476	0.651	0.707	0.777	0.722	0.866	0.508	0.481	0.536	0.563	0.771	1.150
4	0.508	0.900	0.603	0.639	0.811	0.751	1.011	0.820	0.629	0.909	0.633	1.014
5	0.492	0.728	0.821	0.813	0.903	0.803	0.663	0.576	0.546	0.694	0.763	1.065
6	0.492	0.728	0.821	0.813	0.903	0.803	0.663	0.576	0.546	0.694	0.763	1.065

year

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.037	0.029	0.055	0.056	0.012	0.010	0.009	0.028	0.010	0.017	0.017	0.008
2	0.488	0.675	0.509	0.397	0.448	0.496	0.307	0.413	0.330	0.625	0.625	0.371
3	0.675	0.716	0.690	0.409	0.637	0.801	0.484	0.486	0.483	0.619	0.948	0.502
4	0.821	0.540	1.290	0.605	0.763	0.817	0.378	0.615	0.473	0.687	1.265	0.779
5	0.753	0.786	0.914	0.546	0.700	0.798	0.451	0.584	0.493	0.770	1.058	0.616
6	0.753	0.786	0.914	0.546	0.700	0.798	0.451	0.584	0.493	0.770	1.058	0.616

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.028	0.022	0.016	0.016	0.038	0.044	0.035	0.060	0.010	0.037	0.022	0.029
2	0.414	0.445	0.340	0.423	0.431	0.595	0.661	0.573	0.230	0.242	0.302	0.252
3	0.478	0.540	0.431	0.589	0.674	0.918	0.872	0.821	0.356	0.367	0.578	0.428
4	0.311	0.550	0.349	0.726	0.693	0.933	0.890	0.720	0.251	0.505	0.619	0.465
5	0.489	0.601	0.443	0.658	0.681	0.928	0.938	0.818	0.325	0.414	0.553	0.428
6	0.489	0.601	0.443	0.658	0.681	0.928	0.938	0.818	0.325	0.414	0.553	0.428

year

age	2006	2007	2008	2009	2010
1	0.015	0.012	0.006	0.005	0.006
2	0.129	0.100	0.055	0.042	0.054
3	0.218	0.170	0.093	0.071	0.092
4	0.237	0.185	0.101	0.077	0.100
5	0.218	0.170	0.093	0.071	0.092
6	0.218	0.170	0.093	0.071	0.092

TABLE 4.6.1.14 Herring in the Celtic Sea. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	296749	877840	191417	221309	569088	286381	1086254	341357	701444	715913
2	28016	108213	322239	68769	80178	208907	105181	395233	125545	253924
3	110569	17560	58288	177228	37282	43598	110599	65066	232901	76317
4	69625	60828	12328	25675	116262	12794	23999	75017	44836	136877
5	41845	38618	36785	7573	17889	59714	7617	15403	52927	31154
6	183405	121825	51177	53476	47196	26989	56671	115717	87240	90068

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	840789	445612	215682	858507	265141	291594	130011	145243	175521	170146
2	258953	302224	158434	78578	308475	92659	93718	44641	46091	56900
3	153990	145180	144768	85670	38426	112499	36452	33376	20005	24692
4	44462	90498	69583	73636	36571	15518	42335	14504	11489	9852
5	77335	29284	50496	37888	27078	18103	7410	17027	6195	3784
6	52511	67695	53142	44232	20593	22914	14810	14168	21088	9058

age \ year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	134982	238310	148348	405412	672638	744616	573187	517083	539118	979144
2	57875	48032	81114	50433	126541	238549	266068	199556	179845	195912
3	31498	31485	23772	34636	19403	57548	89967	118452	99392	85110
4	12500	15090	14681	9003	8975	8088	23018	36933	64449	43044
5	3928	6029	5504	7056	2956	3571	4266	5732	18251	27201
6	8343	7899	10207	8601	8868	3719	3260	1536	2629	8833

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	394043	476177	430086	181263	962532	331174	704501	685674	343402	374906
2	356732	143619	170380	156648	65572	348046	120897	252128	246755	124310
3	88385	194471	70398	90708	62132	25989	177922	59205	119649	130149
4	31280	44618	97927	35561	39982	19721	12882	90341	28247	63659
5	17212	19395	21829	55215	16184	10210	8188	8537	47157	18029
6	12409	18615	17848	17502	44783	22927	23455	20316	18130	18900

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	244778	517528	457689	427987	543683	117836	305664	982324	369330	827993
2	135683	86673	182111	162598	148341	197978	41777	109964	351029	133867
3	60322	65301	35419	69634	67910	87324	115124	22889	63312	228622
4	59108	25176	21352	12122	25090	38958	49548	52880	12221	41664
5	27883	26753	8964	7936	5341	17665	21272	24151	30067	8721
6	15668	22942	16774	7044	7774	20473	5297	7510	16020	16843

age \ year	2008	2009	2010
1	373767	1432574	417056
2	301104	136639	524474
3	89714	211214	97068
4	157922	66957	161057
5	31341	129217	56080
6	10937	24143	137905

TABLE 4.6.1.15 Herring in the Celtic Sea. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2011
1	NA
2	152466
3	367938
4	72458
5	131807
6	160032

TABLE 4.6.1.16 Herring in the Celtic Sea. FITTED SELECTION PATTERN

Units : NA

age	2005	2006	2007	2008	2009	2010
1	0.068	0.068	0.068	0.068	0.068	0.068
2	0.590	0.590	0.590	0.590	0.590	0.590
3	1.000	1.000	1.000	1.000	1.000	1.000
4	1.087	1.087	1.087	1.087	1.087	1.087
5	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 4.6.1.17 Herring in the Celtic Sea. PREDICTED CATCH IN NUMBERS

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	4276	17822
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	9470	21300
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	46243	7268
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21863	18772
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	8023
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

age	2006	2007	2008	2009	2010
1	3444	6016	1482	4367	2468
2	36768	11056	13838	4852	24059
3	11302	32481	7201	13156	7777
4	2462	6697	14396	4742	14655
5	5625	1299	2639	8446	4714
6	2997	2509	921	1578	11592

TABLE 4.6.1.18 Herring in the Celtic Sea. CATCH RESIDUALS

Units : thousands NA

age \ year	2005	2006	2007	2008	2009	2010
1	-0.145	-0.858	0.290	-0.127	0.845	0.000
2	0.366	-0.081	-0.003	-0.091	-0.083	-0.139
3	-0.232	-0.035	0.109	0.137	-0.023	0.051
4	-0.006	0.003	-0.195	0.092	0.030	0.083
5	-0.088	0.107	0.049	-0.112	0.001	0.028
6	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 4.6.1.19 Herring in the Celtic Sea. PREDICTED INDEX VALUES

Celtic Sea Herring Acoustic

Units : NA NA

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	105	138	NA	76	274	108	253	116	441
3	67	86	NA	21	72	273	116	279	125
4	23	27	NA	38	11	40	165	72	168
5	4	11	NA	15	23	7	28	116	49

TABLE 4.6.1.20 Herring in the Celtic Sea. INDEX RESIDUALS

Celtic Sea Herring Acoustic

Units : NA

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010
2	0.571	-0.805	NA	0.592	-0.264	-0.429	0.153	-0.038	0.219
3	0.803	-0.351	NA	0.287	-0.412	-0.218	-0.044	-0.284	0.218
4	0.276	-0.456	NA	0.346	0.194	-0.254	-0.017	-0.227	0.138
5	0.572	-0.736	NA	0.351	-0.752	0.237	-0.021	0.073	0.275

TABLE 4.6.1.21 Herring in the Celtic Sea FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2005	0.43	0.18	0.30	0.60
F, 2006	0.22	0.20	0.15	0.32
F, 2007	0.17	0.20	0.11	0.25
F, 2008	0.09	0.21	0.06	0.14
F, 2009	0.07	0.22	0.05	0.11
F, 2010	0.09	0.23	0.06	0.15
Selectivity at age 1	0.07	0.33	0.04	0.13
Selectivity at age 2	0.59	0.13	0.46	0.76
Selectivity at age 4	1.09	0.11	0.88	1.34
Terminal year pop, age 1	623430.83	0.79	131338.44	2959270.72
Terminal year pop, age 2	524473.09	0.29	296064.00	929096.48
Terminal year pop, age 3	97067.21	0.23	61606.78	152938.42
Terminal year pop, age 4	161055.88	0.21	106256.66	244116.43
Terminal year pop, age 5	56078.64	0.21	37453.00	83966.94
Last true age pop, 2005	24149.63	0.23	15405.63	37856.59
Last true age pop, 2006	30066.06	0.21	19834.30	45576.00
Last true age pop, 2007	8720.16	0.21	5772.84	13172.22
Last true age pop, 2008	31339.84	0.20	20970.64	46836.20
Last true age pop, 2009	129216.04	0.20	86656.16	192678.58
Index 1, age 2 numbers, Q	0.00	0.20	0.00	0.00
Index 1, age 3 numbers, Q	0.00	0.20	0.00	0.00
Index 1, age 4 numbers, Q	0.00	0.20	0.00	0.00
Index 1, age 5 numbers, Q	0.00	0.21	0.00	0.00

Table 4.7.1.1. Herring in the Celtic Sea. Inputs to the Short Term Forecast.

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	417056	1	0.5	0.55	0.5	0.078	0.006	0.08
2	152466	0.3	1	0.55	0.5	0.113	0.050	0.12
3	367938	0.2	1	0.55	0.5	0.136	0.085	0.14
4	72458	0.1	1	0.55	0.5	0.151	0.093	0.15
5	131807	0.1	1	0.55	0.5	0.163	0.085	0.17
6	160032	0.1	1	0.55	0.5	0.172	0.085	0.18

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	417056	1	0.5	0.55	0.5	0.078	0.006	0.081
2	-	0.3	1	0.55	0.5	0.113	0.050	0.117
3	-	0.2	1	0.55	0.5	0.136	0.085	0.140
4	-	0.1	1	0.55	0.5	0.151	0.093	0.153
5	-	0.1	1	0.55	0.5	0.163	0.085	0.165
6	-	0.1	1	0.55	0.5	0.172	0.085	0.180

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	417056	1	0.5	0.55	0.5	0.078	0.006	0.081
2	-	0.3	1	0.55	0.5	0.113	0.050	0.117
3	-	0.2	1	0.55	0.5	0.136	0.085	0.140
4	-	0.1	1	0.55	0.5	0.151	0.093	0.153
5	-	0.1	1	0.55	0.5	0.163	0.085	0.165
6	-	0.1	1	0.55	0.5	0.172	0.085	0.180

Table 4.7.1.2. Herring in the Celtic Sea. Single Option Tables from the Short Term Forecast.

a). Catch(2012) = Zero

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0	0.00
2	152465.9	151883.5	153426.2	0.088	0	0.00
3	367937.9	103467.3	112518.1	0.149	0	0.00
4	72458.24	259614	84711.82	0.162	0	0.00
5	131807.5	55778.99	234908.4	0.149	0	0.00
6	160032.2	227576.4	256390.6	0.149	0	0.00

b). Catch(2012) = 2011 TAC -15% (11220 t)

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.007	0.007
2	152465.9	151883.5	152335	0.088	0.062	0.062
3	367937.9	103467.3	105761.2	0.149	0.105	0.105
4	72458.24	259614	76265.36	0.162	0.114	0.114
5	131807.5	55778.99	209568.9	0.149	0.105	0.105
6	160032.2	227576.4	230826.4	0.149	0.105	0.105

c). Catch(2012) = 2011 TAC sq (13200 t)

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.008	0.008
2	152465.9	151883.5	152131.3	0.088	0.074	0.074
3	367937.9	103467.3	104540.4	0.149	0.125	0.125
4	72458.24	259614	74778.24	0.162	0.136	0.136
5	131807.5	55778.99	205131.9	0.149	0.125	0.125
6	160032.2	227576.4	226325.4	0.149	0.125	0.125

d). Catch(2012) = 2011 TAC +15% (15180 t)

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.010	0.010
2	152465.9	151883.5	151924	0.088	0.085	0.085
3	367937.9	103467.3	103310.5	0.149	0.145	0.145
4	72458.24	259614	73292.25	0.162	0.157	0.157
5	131807.5	55778.99	200705.9	0.149	0.145	0.145
6	160032.2	227576.4	221827.9	0.149	0.145	0.145

e). Catch(2012) = 2011 TAC + 25% (16500 t)

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.011	0.011
2	152465.9	151883.5	151783.6	0.088	0.093	0.093
3	367937.9	103467.3	102485.4	0.149	0.158	0.158
4	72458.24	259614	72302.25	0.162	0.172	0.172
5	131807.5	55778.99	197761.5	0.149	0.158	0.158
6	160032.2	227576.4	218831.5	0.149	0.158	0.158

f). Catch(2012) = 2011 TAC + 30% (17160 t)

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.011	0.011
2	152465.9	151883.5	151712.8	0.088	0.097	0.097
3	367937.9	103467.3	102071.3	0.149	0.165	0.165
4	72458.24	259614	71807.44	0.162	0.180	0.180
5	131807.5	55778.99	196291.2	0.149	0.165	0.165
6	160032.2	227576.4	217333.9	0.149	0.165	0.165

g). Fbar(2012) = 0.25

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.018	0.018
2	152465.9	151883.5	150616.3	0.088	0.160	0.160
3	367937.9	103467.3	95845.15	0.149	0.272	0.272
4	72458.24	259614	64537.3	0.162	0.296	0.296
5	131807.5	55778.99	174792.5	0.149	0.272	0.272
6	160032.2	227576.4	195330	0.149	0.272	0.272

h). Fbar(2012) = 0.19

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.014	0.014
2	152465.9	151883.5	151286	0.088	0.122	0.122
3	367937.9	103467.3	99606.27	0.149	0.207	0.207
4	72458.24	259614	68891.05	0.162	0.225	0.225
5	131807.5	55778.99	187643.2	0.149	0.207	0.207
6	160032.2	227576.4	208507.1	0.149	0.207	0.207

i). Fbar(2012) = 0.14

Age	N(2011)	N(2012)	N(2013)	F(2011)	F(2012)	F(2013)
1	417055.7	417055.7	417055.7	0.010	0.010	0.010
2	152465.9	151883.5	151846.3	0.088	0.090	0.090
3	367937.9	103467.3	102853	0.149	0.152	0.152
4	72458.24	259614	72742.7	0.162	0.166	0.166
5	131807.5	55778.99	199071	0.149	0.152	0.152
6	160032.2	227576.4	220164.6	0.149	0.152	0.152

Table 4.7.1.3. Herring in the Celtic Sea. Catch option table from the Short Term Forecast.

Rationale	Fbar (2011)	Catch (2011)	SSB (2011)	Fbar (2012)	Catch (2012)	SSB (2012)	SSB (2013)
Catch(2012) = Zero	0.1367	16196	118399	0	0	120749	129448
Catch(2012) = 2011 TAC -15% (11220 t)	0.1367	16196	118399	0.097	11220	114637	113270
Catch(2012) = 2011 TAC sq (13200 t)	0.1367	16196	118399	0.115	13200	113530	110510
Catch(2012) = 2011 TAC +15% (15180 t)	0.1367	16196	118399	0.133	15180	112414	107780
Catch(2012) = 2011 TAC + 25% (16500 t)	0.1367	16196	118399	0.146	16500	111664	105976
Catch(2012) = 2011 TAC + 30% (17160 t)	0.1367	16196	118399	0.152	17160	111288	105079
Fbar(2012) = 0.25	0.1367	16196	118399	0.25	26880	105616	92251
Fbar(2012) = 0.19	0.1367	16196	118399	0.19	21054	109045	99853
Fbar(2012) = 0.14	0.1367	16196	118399	0.14	15913	111998	106777

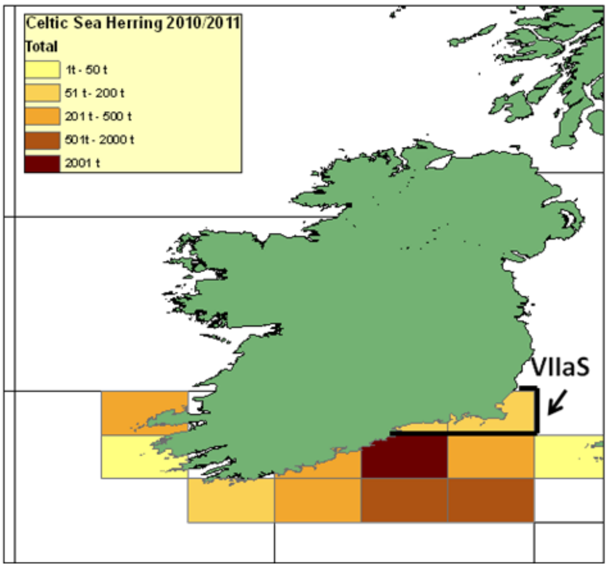


Figure 4.1.2.1. Herring in the Celtic Sea. Irish official herring catches by statistical rectangle in 2010/2011 with Subdivision **VIIaS highlighted.**

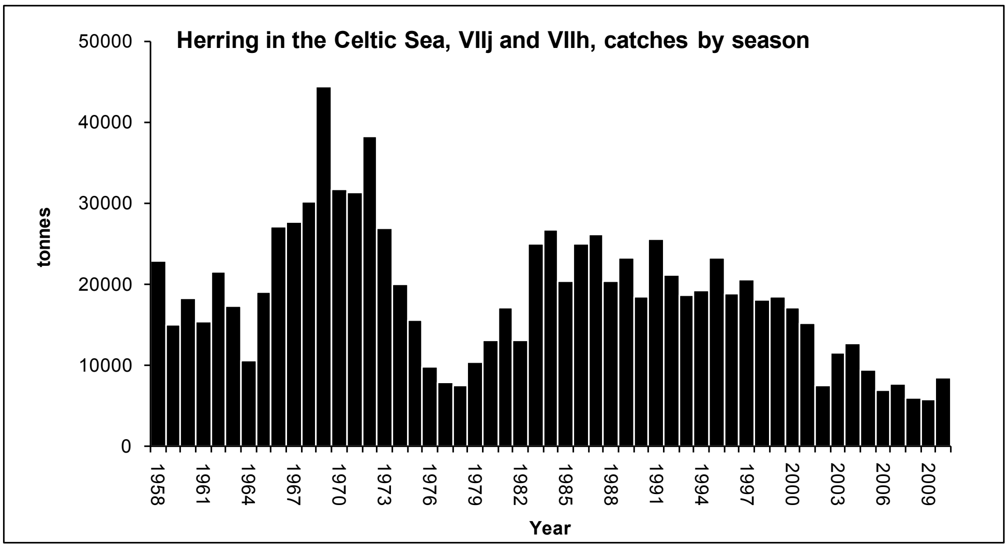


Figure 4.1.3.1. Herring in the Celtic Sea. Working Group estimates of herring landings per season.

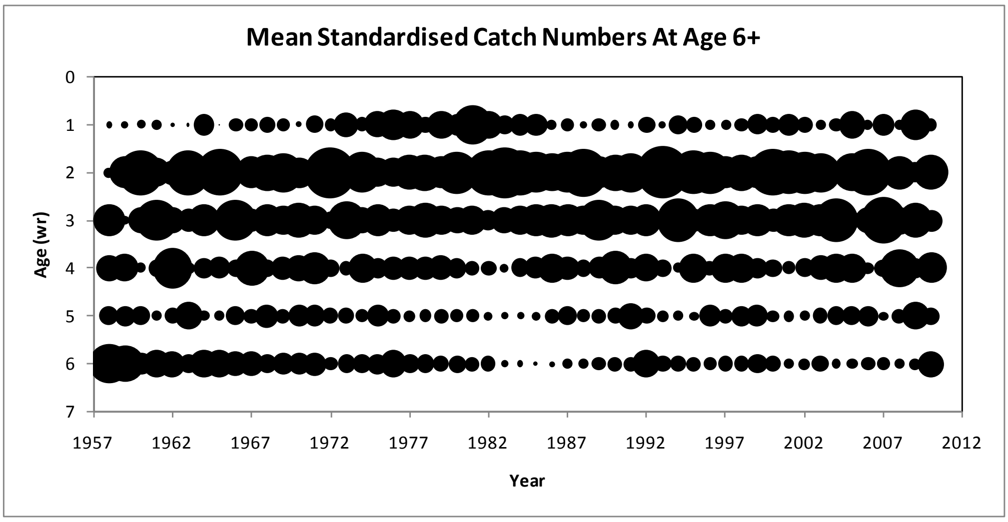


Figure 4.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 6-ringer is the plus group.

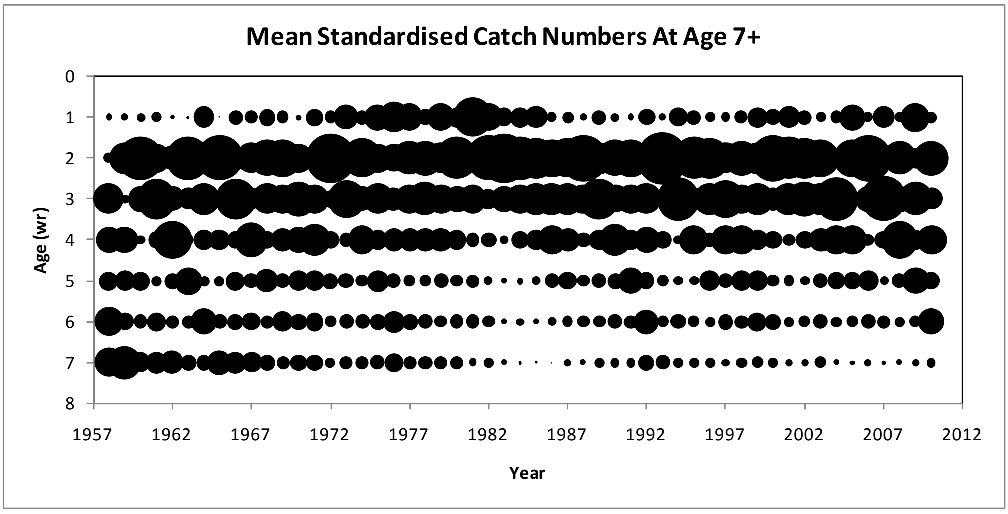


Figure 4.2.1.2. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 7-ringer is the plus group.

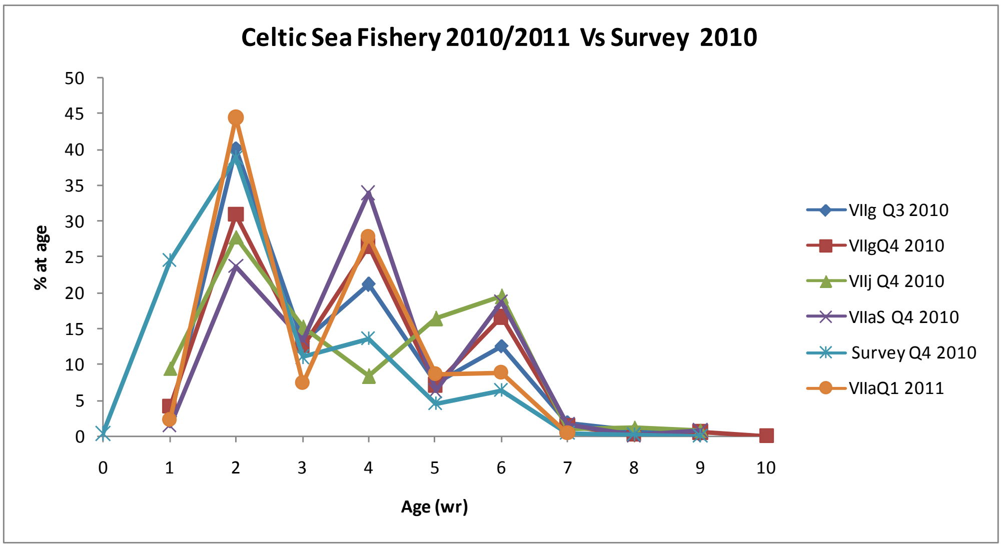


Figure 4.2.1.3. Herring in the Celtic Sea. The percentage age composition in the survey and the commercial fishery 2010/2011.

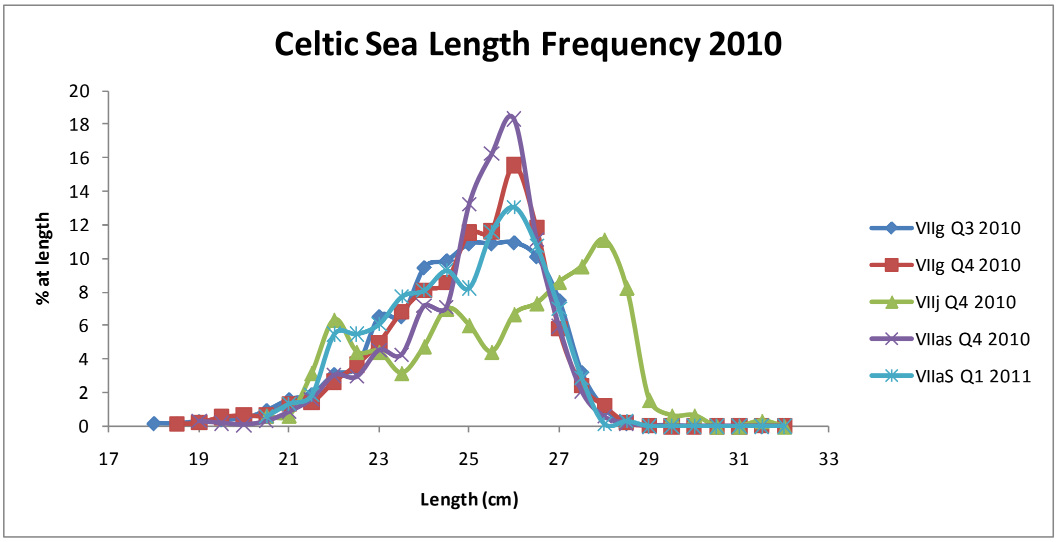


Figure 4.2.1.4. Herring in the Celtic Sea. Length-frequency data from sampling in 2010/2011.

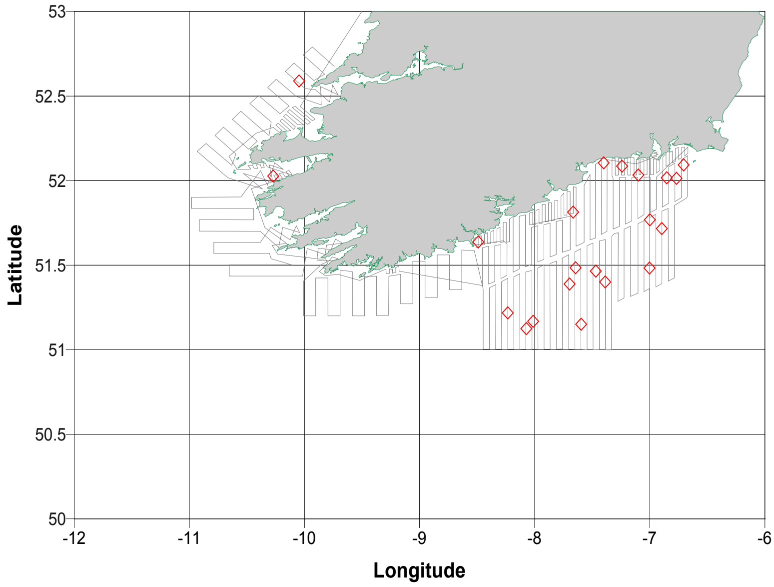


Figure 4.3.1.1a. Herring in the Celtic Sea. Acoustic survey track and haul positions from acoustic survey, October 2010.

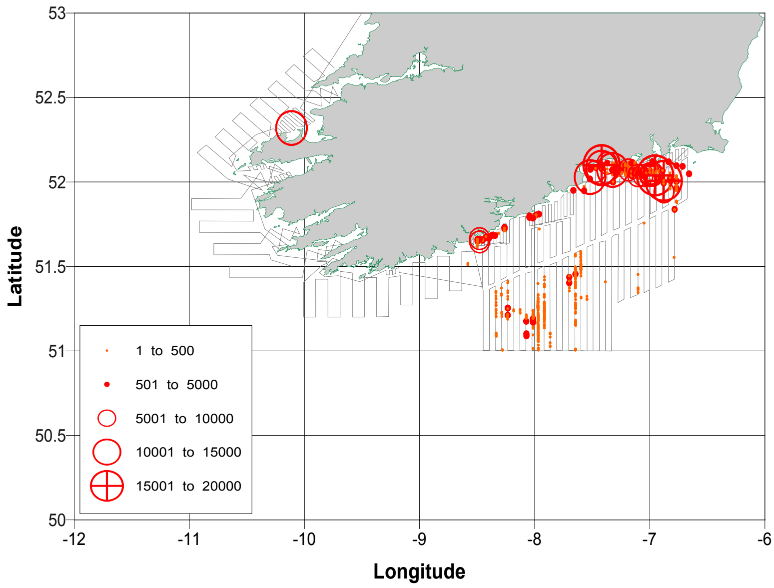


Figure 4.3.1.1b. Herring in the Celtic Sea. Acoustic survey total Sa values attributed to herring in the acoustic survey, October 2010.

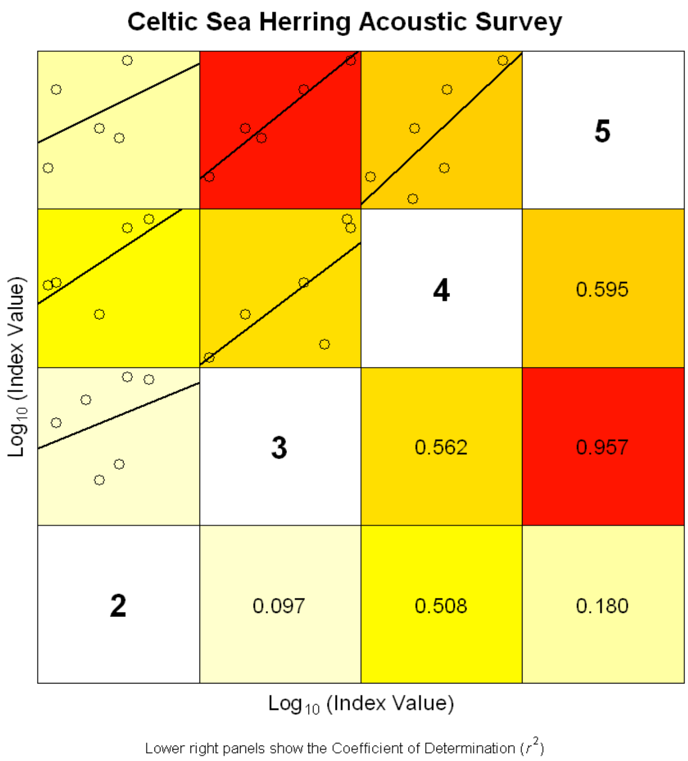


Figure 4.3.1.2. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring Acoustic survey time series.

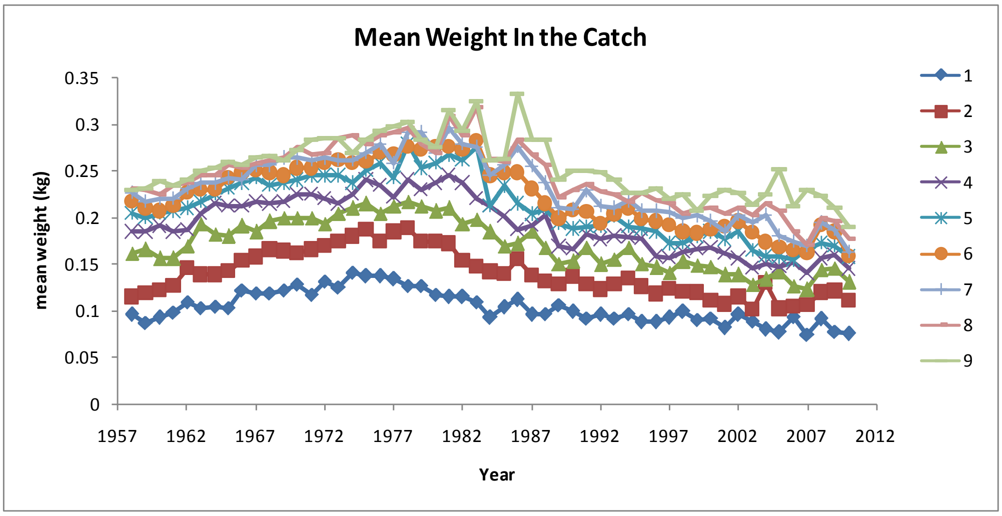


Figure 4.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1-9+.

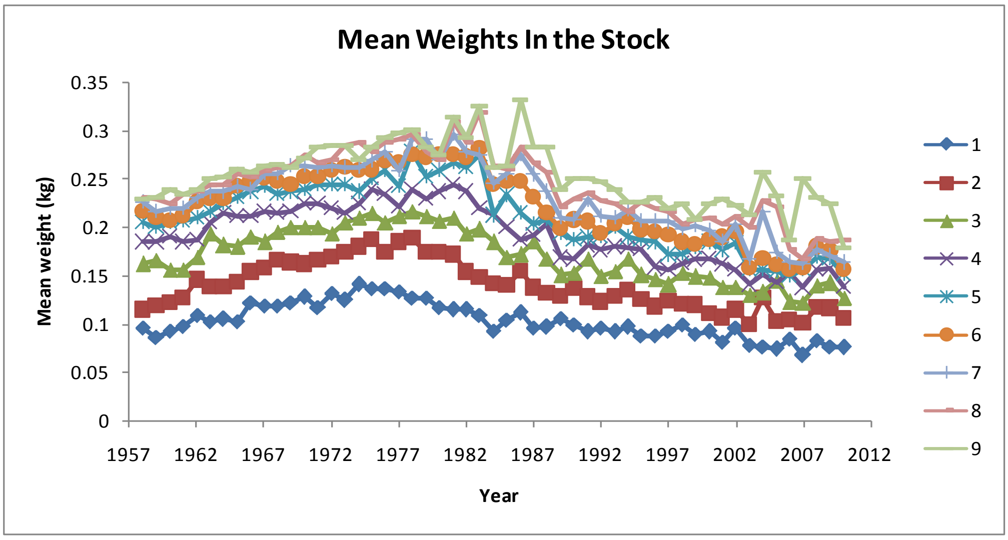


Figure 4.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1-9+.

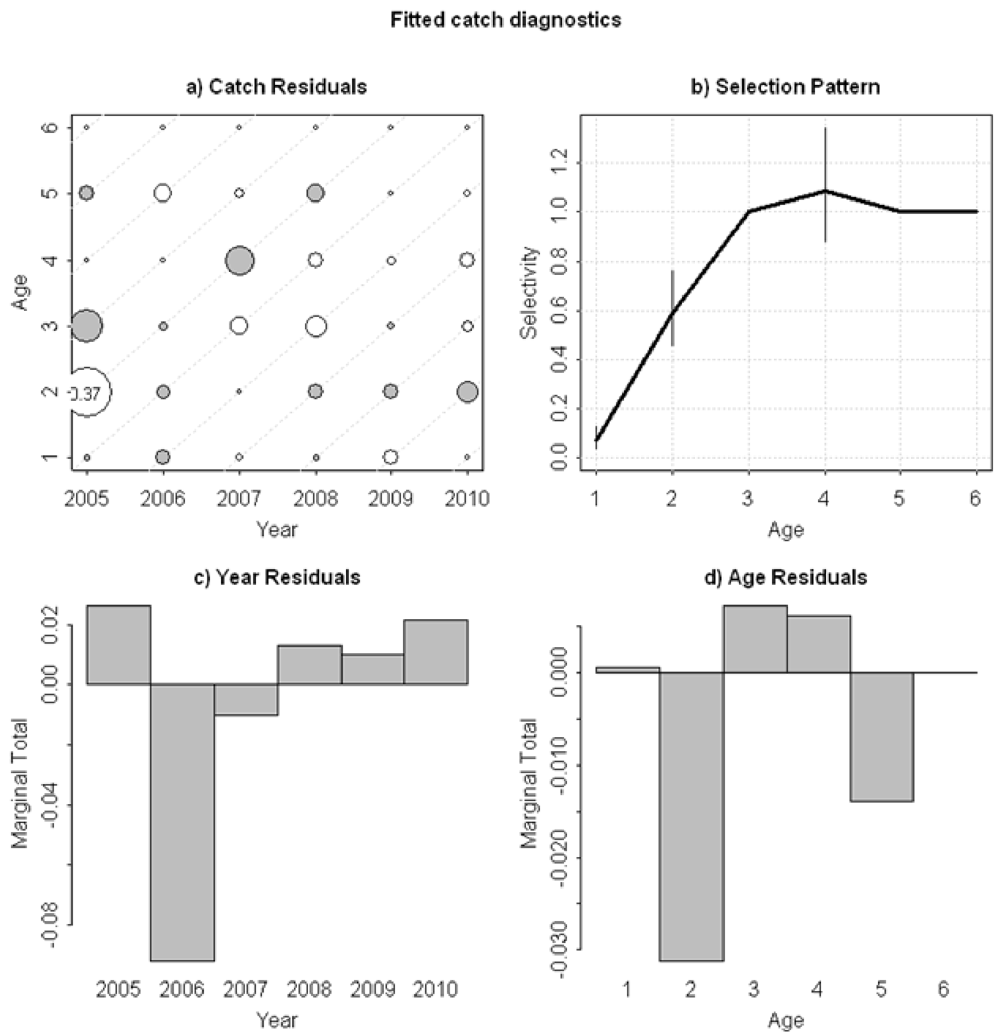


Figure 4.6.1.1. Herring in the Celtic Sea. Illustration of selection patterns diagnostics, from deterministic calculation (6-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 3-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring from the 6+ run.

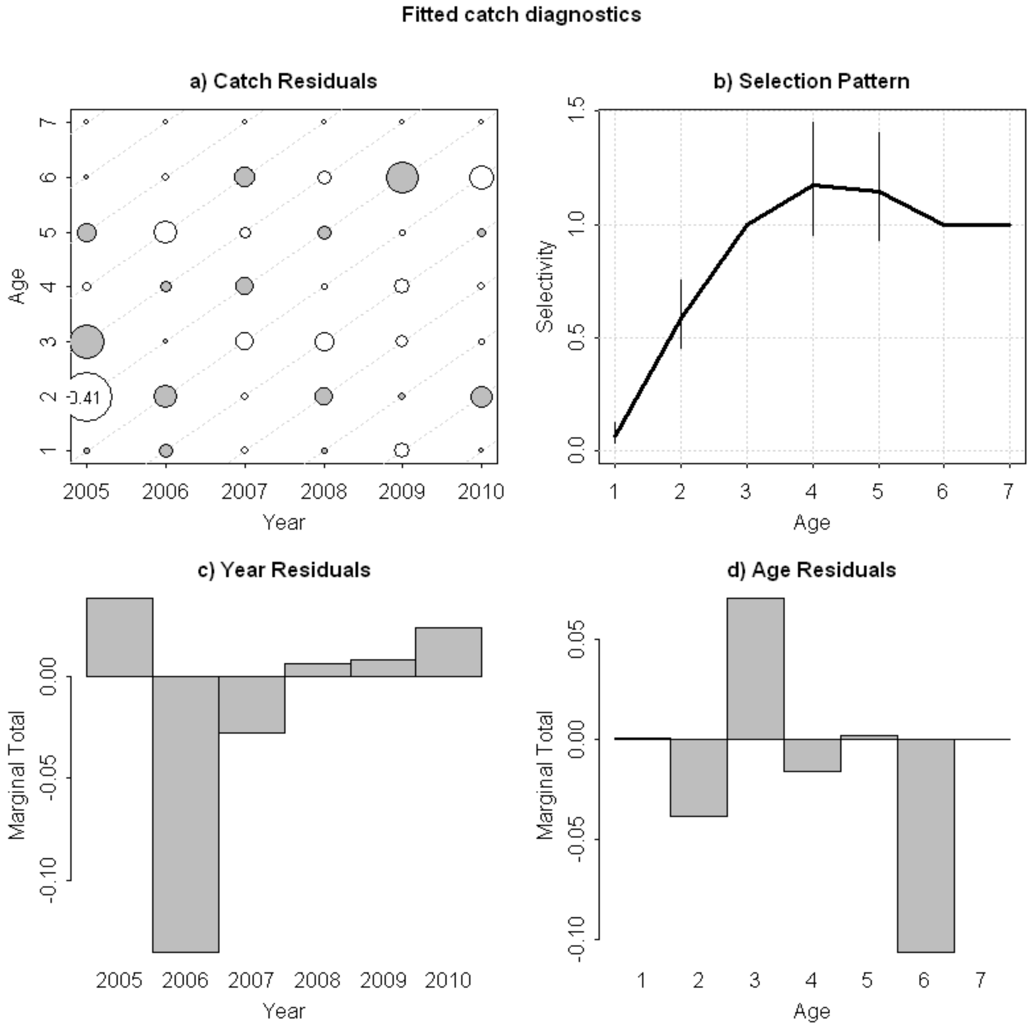


Figure 4.6.1.2. Herring in the Celtic Sea. Illustration of selection patterns diagnostics, from deterministic calculation (6-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 3-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring from the 7+ run.

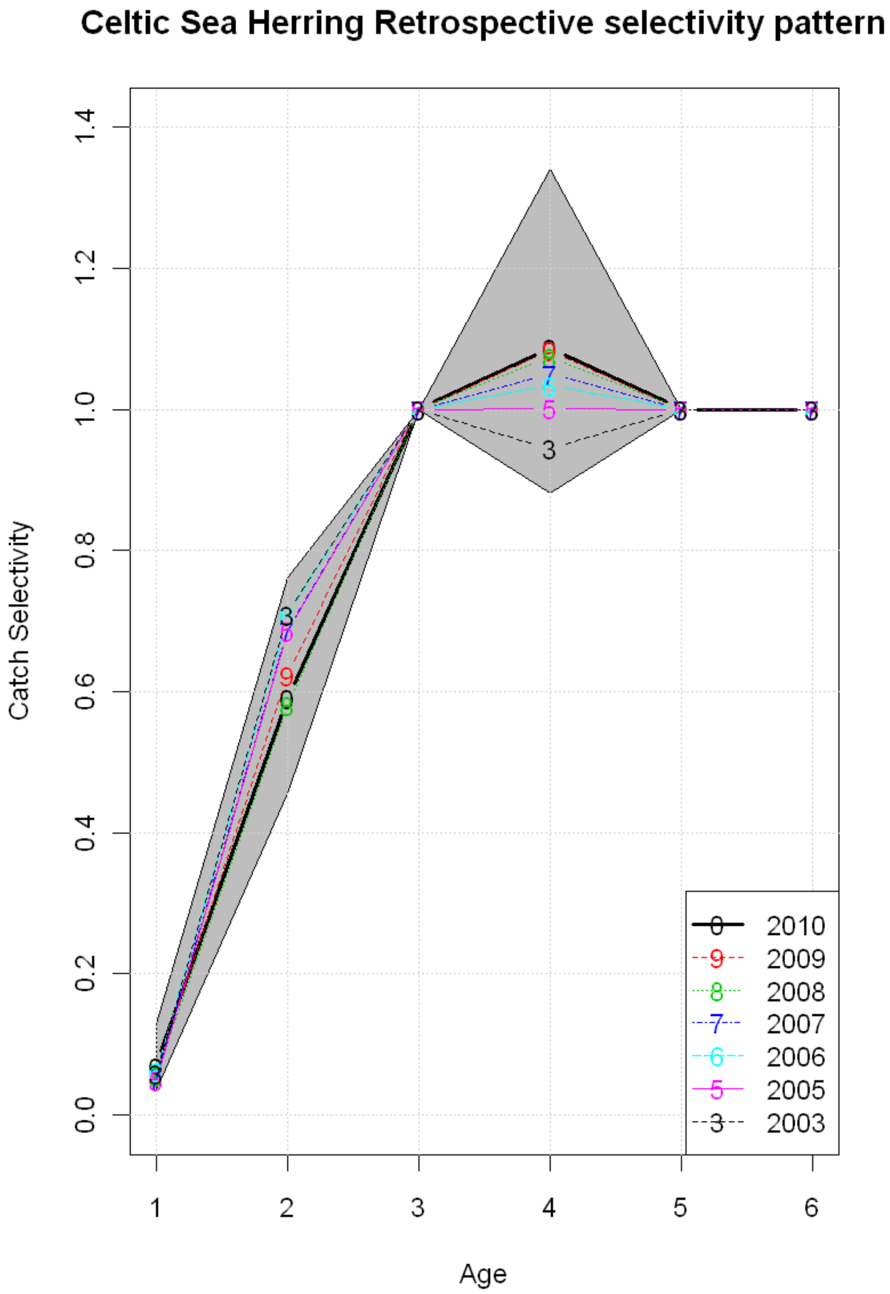


Figure 4.6.1.3. Herring in the Celtic Sea. Retrospective Selection pattern from the 6+ run.

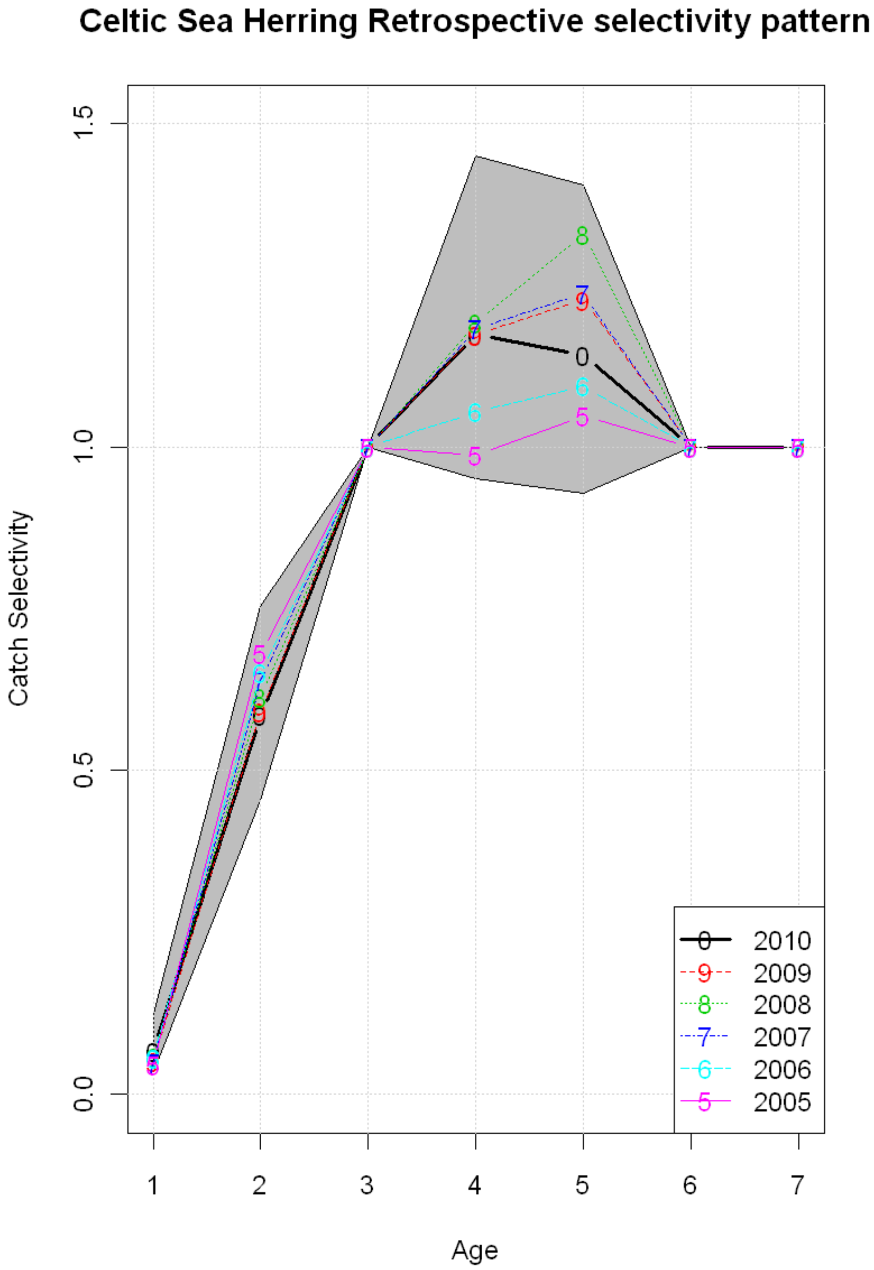


Figure 4.6.1.4. Herring in the Celtic Sea. Retrospective Selection pattern from the 7+ run.

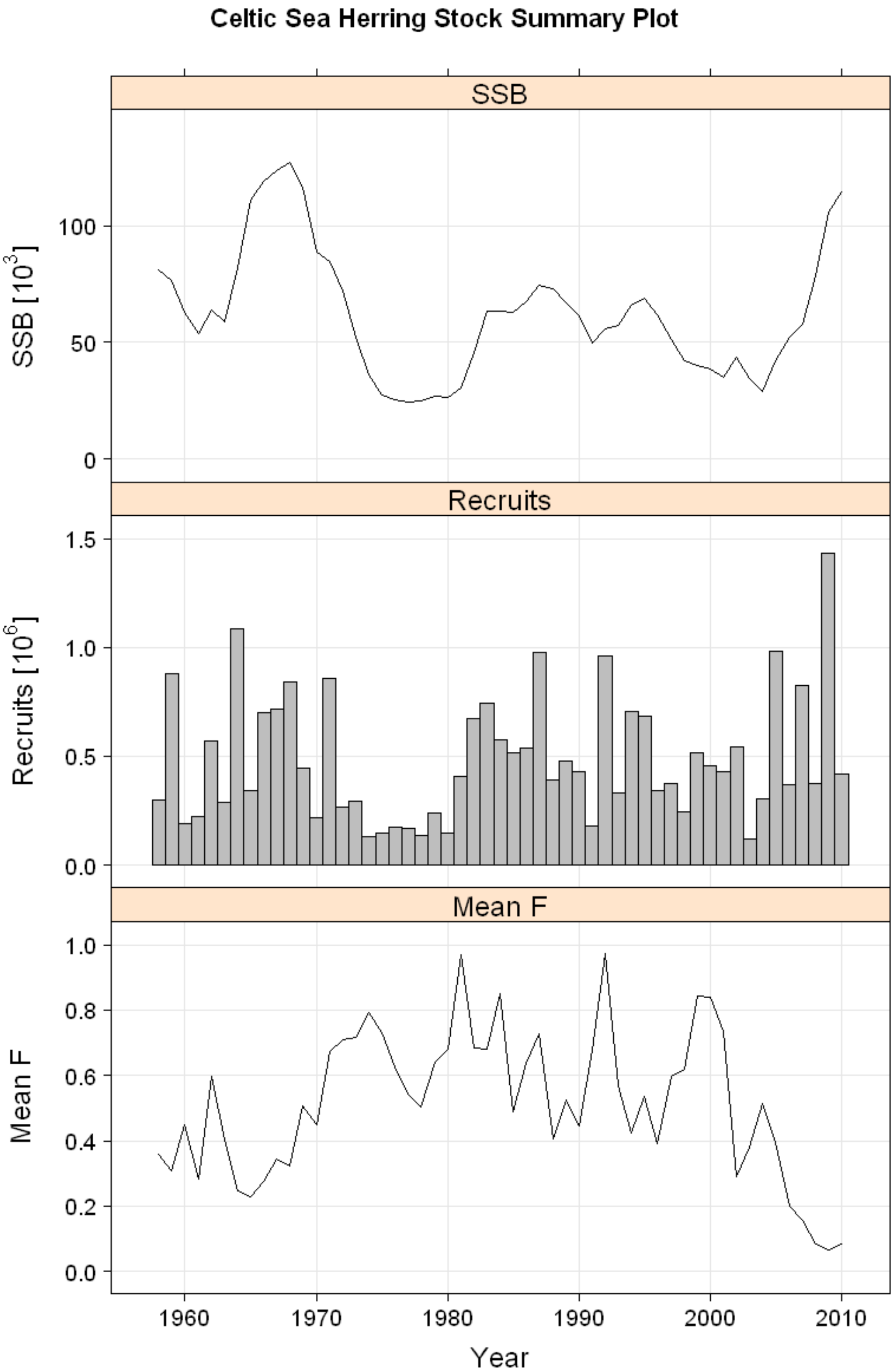


Figure 4.6.1.5. Herring in the Celtic Sea. Stock Summary from the spaly 6+ Run

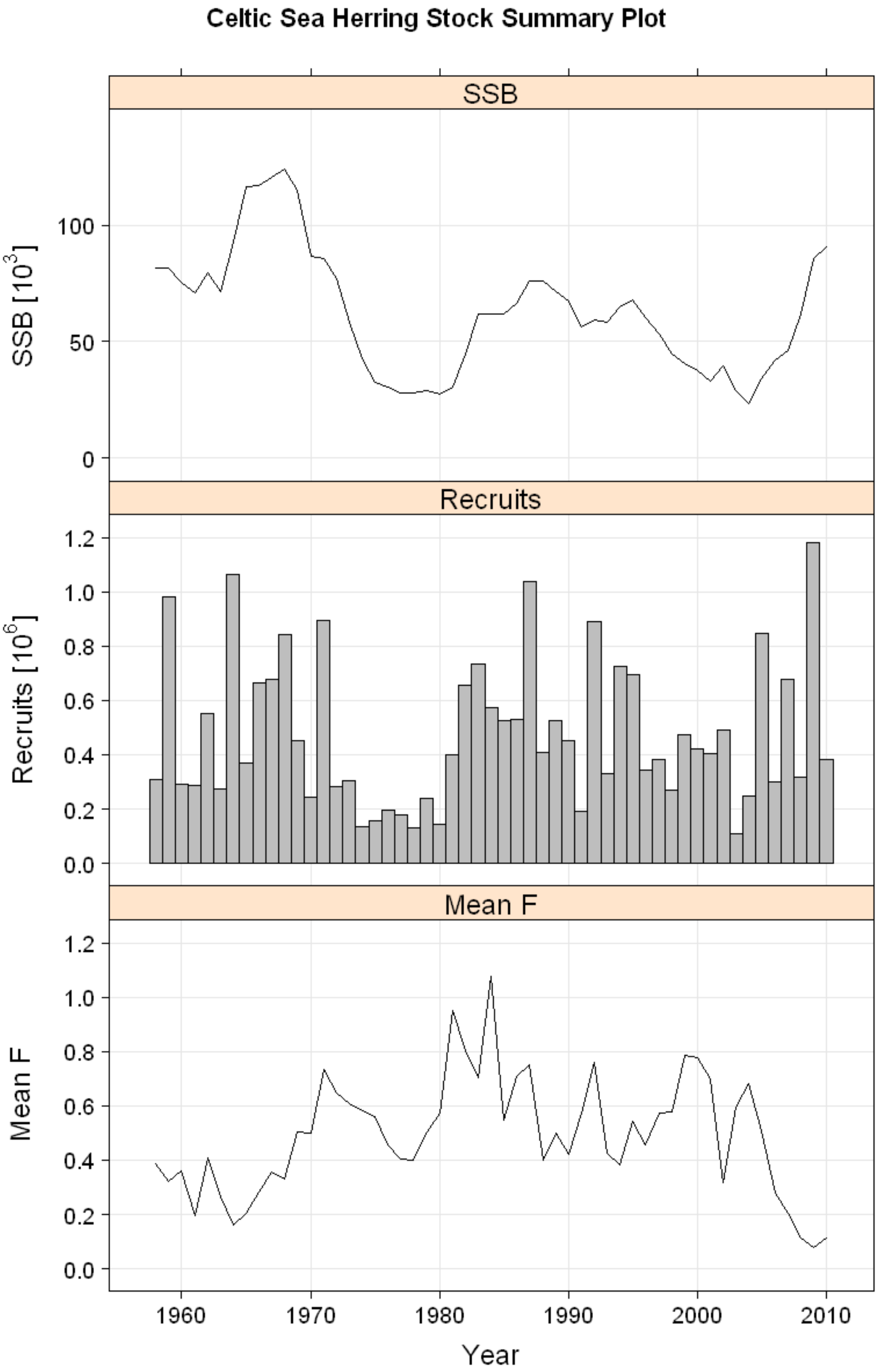


Figure 4.6.1.6. Herring in the Celtic Sea. Stock Summary from the 7+ Run.

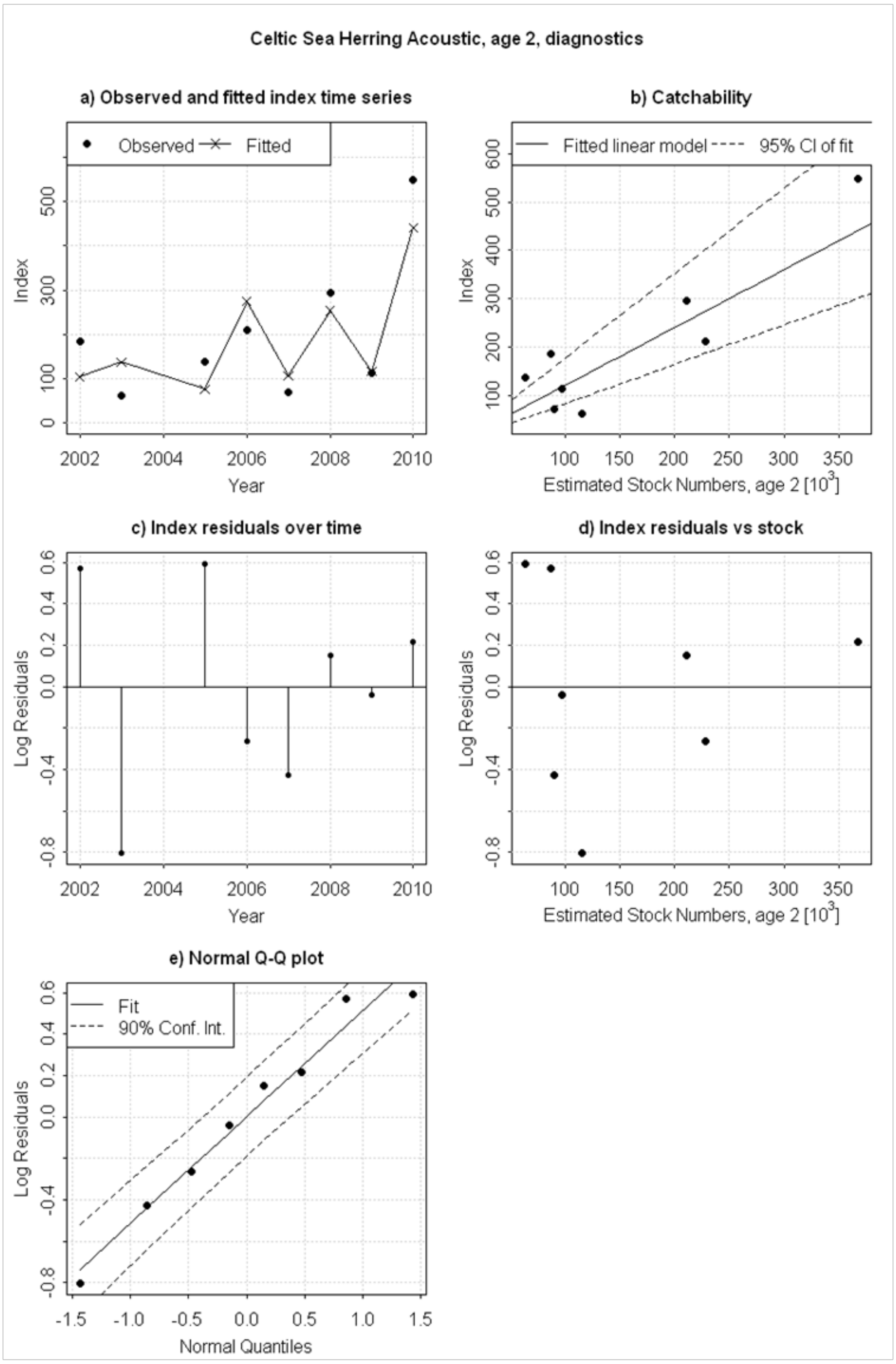


Figure 4.6.1.7. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 2 from the 6+ run.

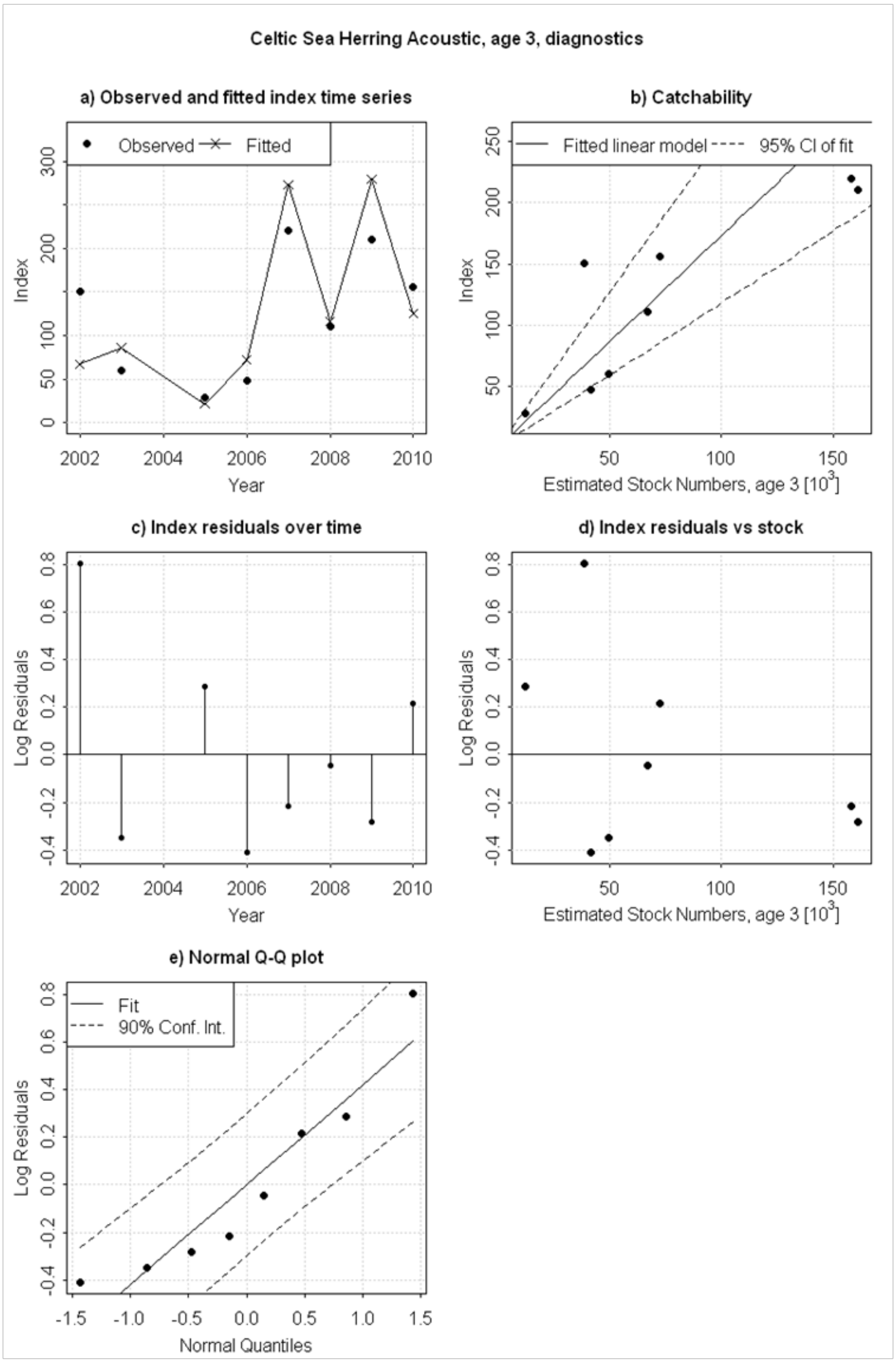


Figure 4.6.1.8. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 3 from the 6+ run.

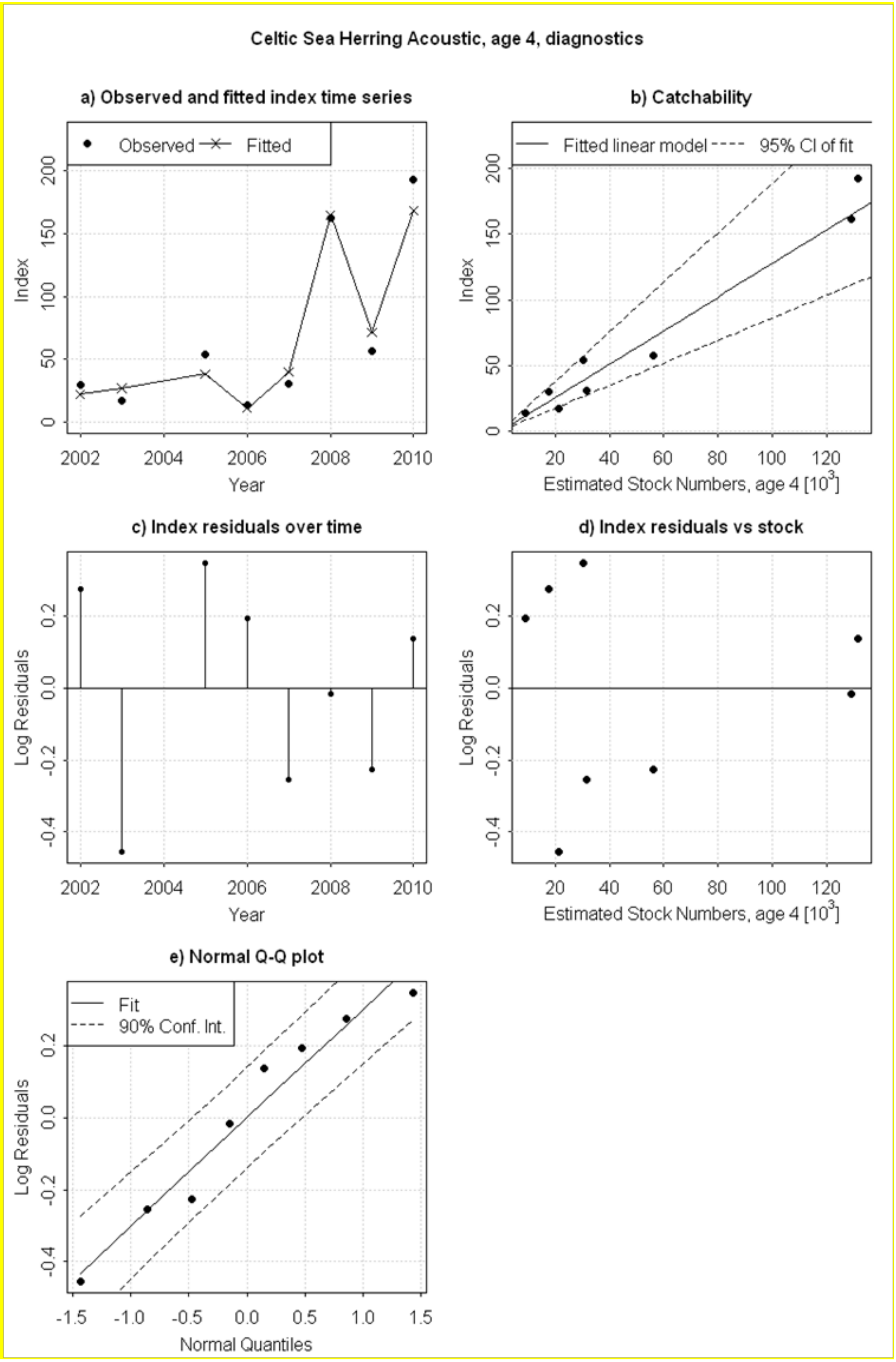


Figure 4.6.1.9. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 4 from the 6+ run.

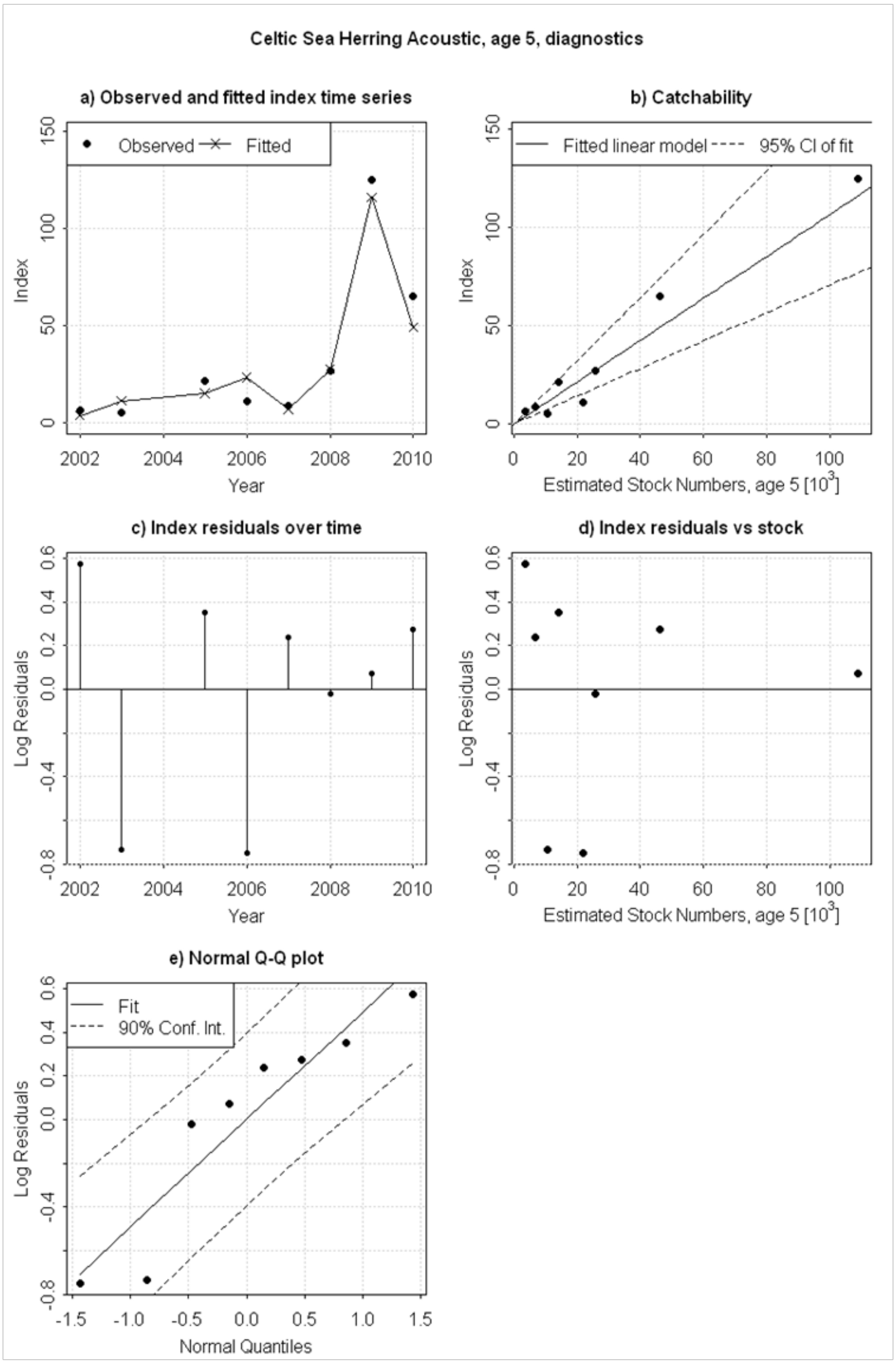


Figure 4.6.1.10. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 5 from the 6+ run.

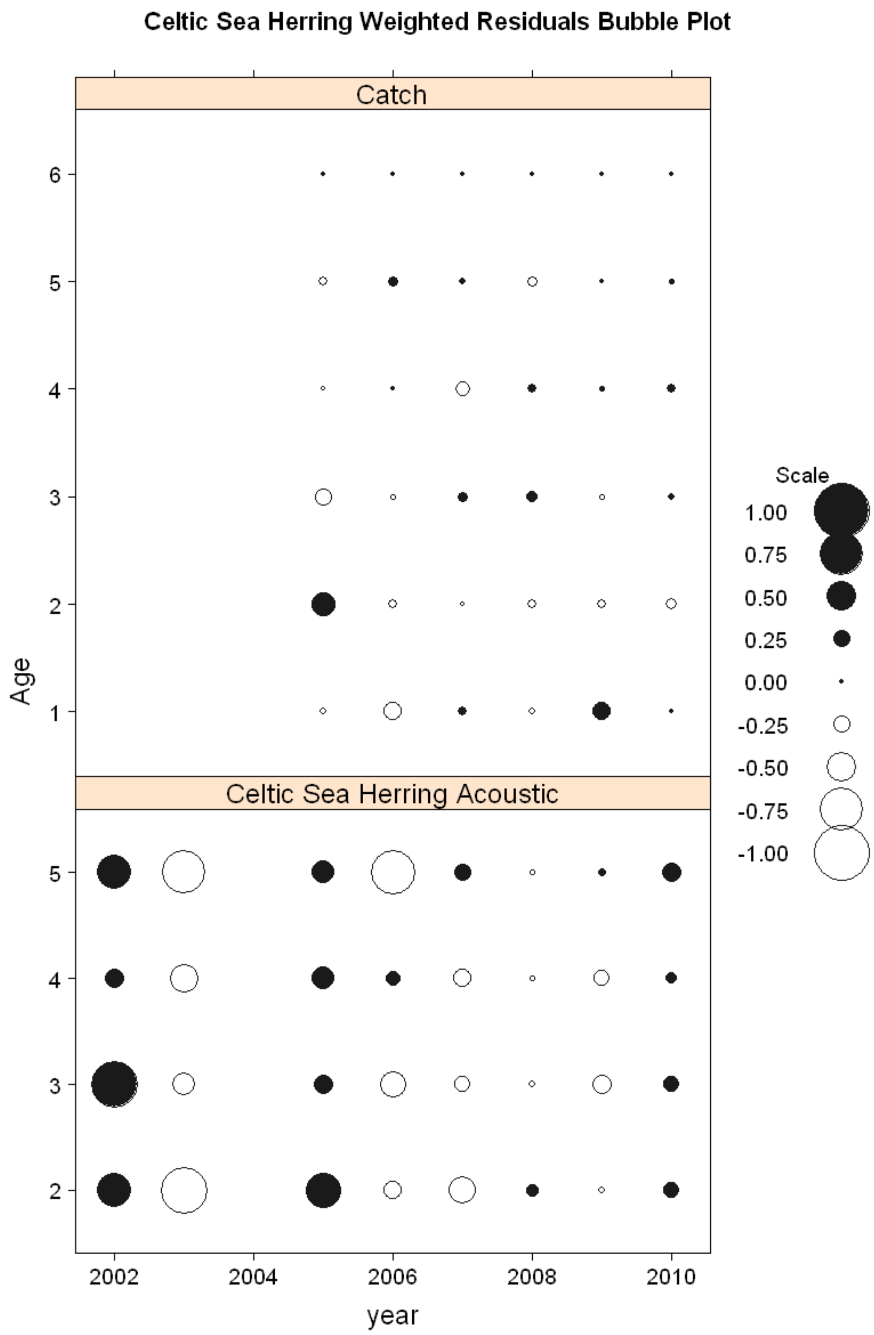


Figure 4.6.1.11. Herring in the Celtic Sea. Weighted catch and survey residuals from the 6+ run.

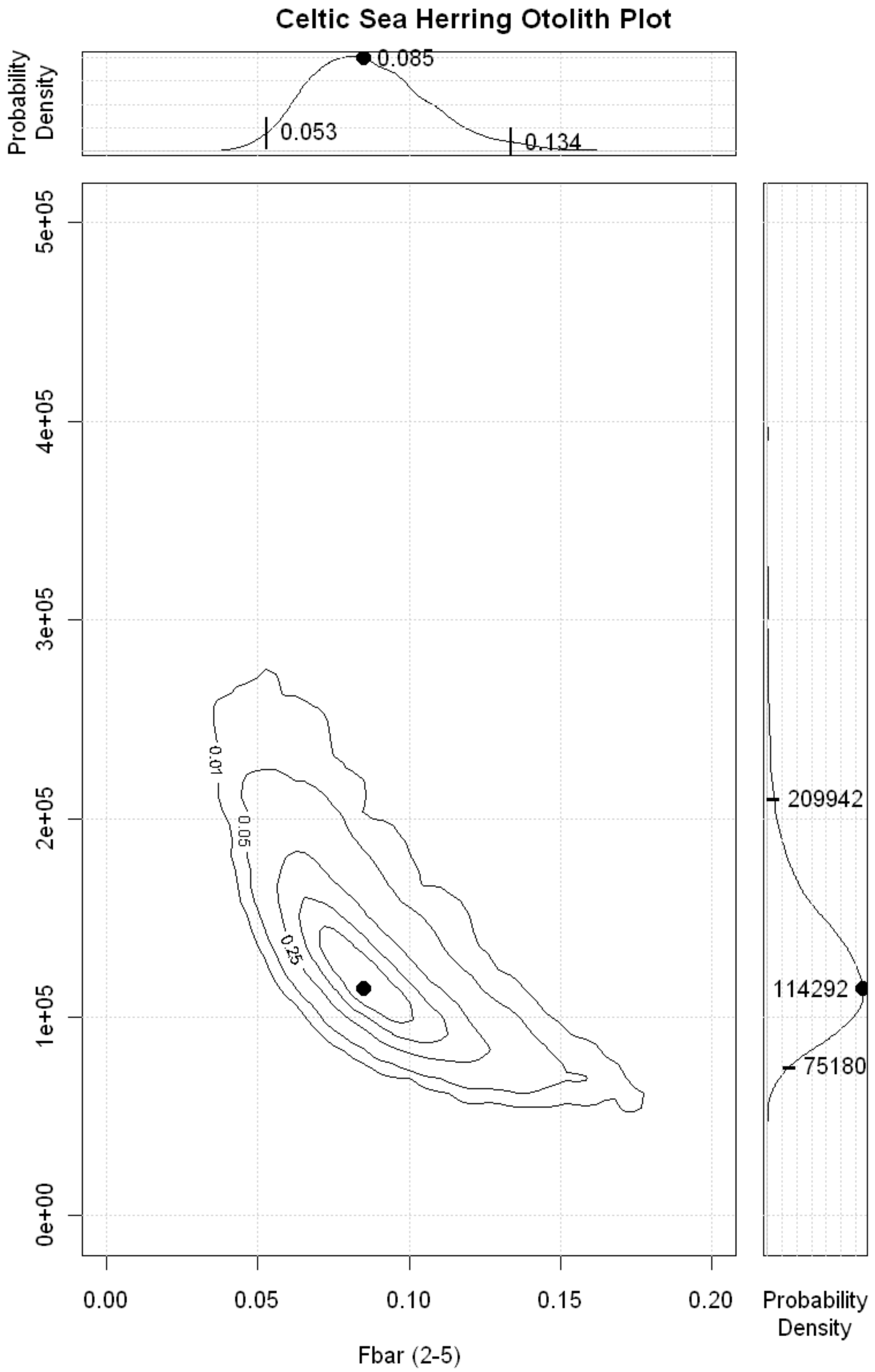


Figure 4.6.1.12. Herring in the Celtic Sea. Otolith plot showing the results of parametric bootstrapping from FLICA.

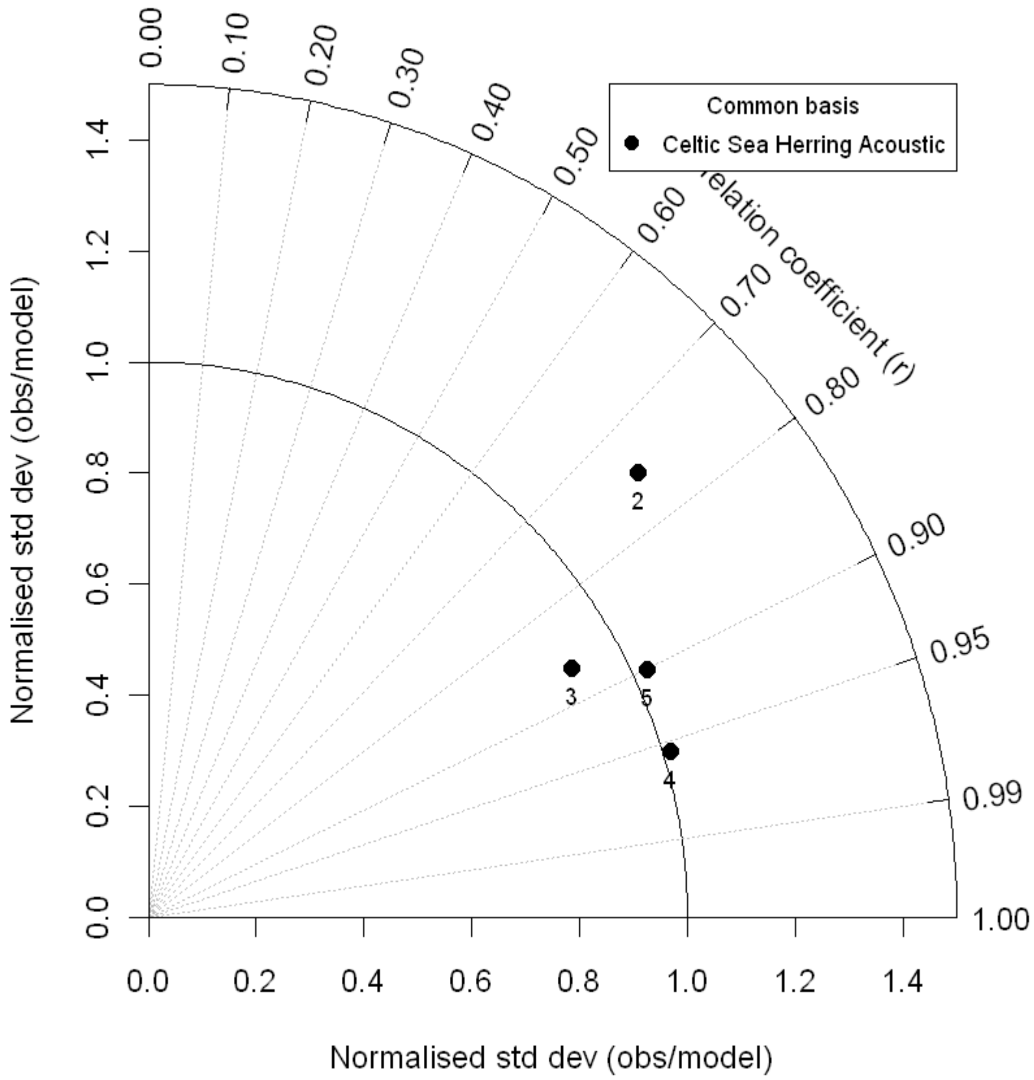


Figure 4.6.1.13. Herring in the Celtic Sea. Taylor Diagram. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modeled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labeled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.

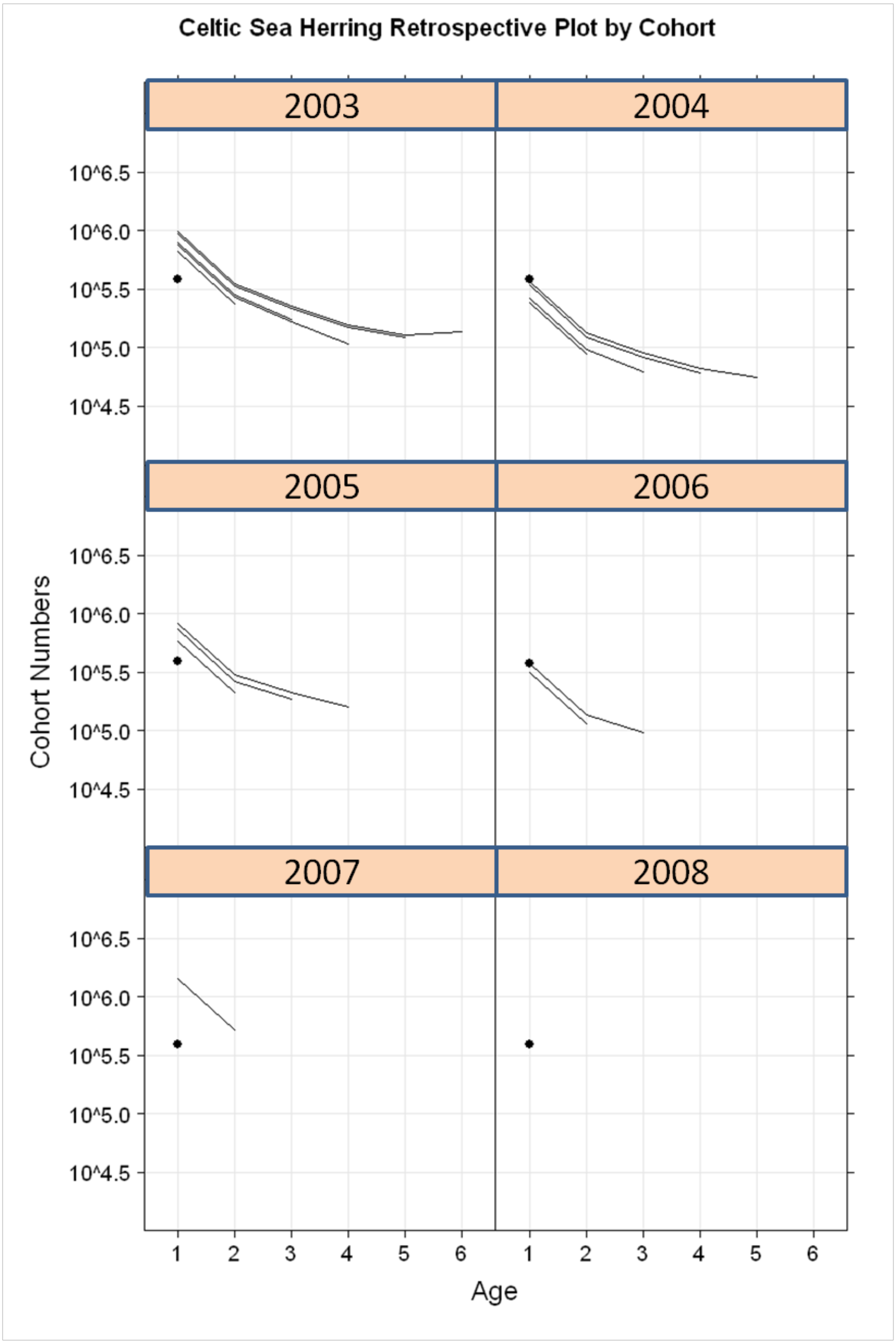


Figure 4.6.1.14. Herring in the Celtic Sea. Retrospectives by cohort.

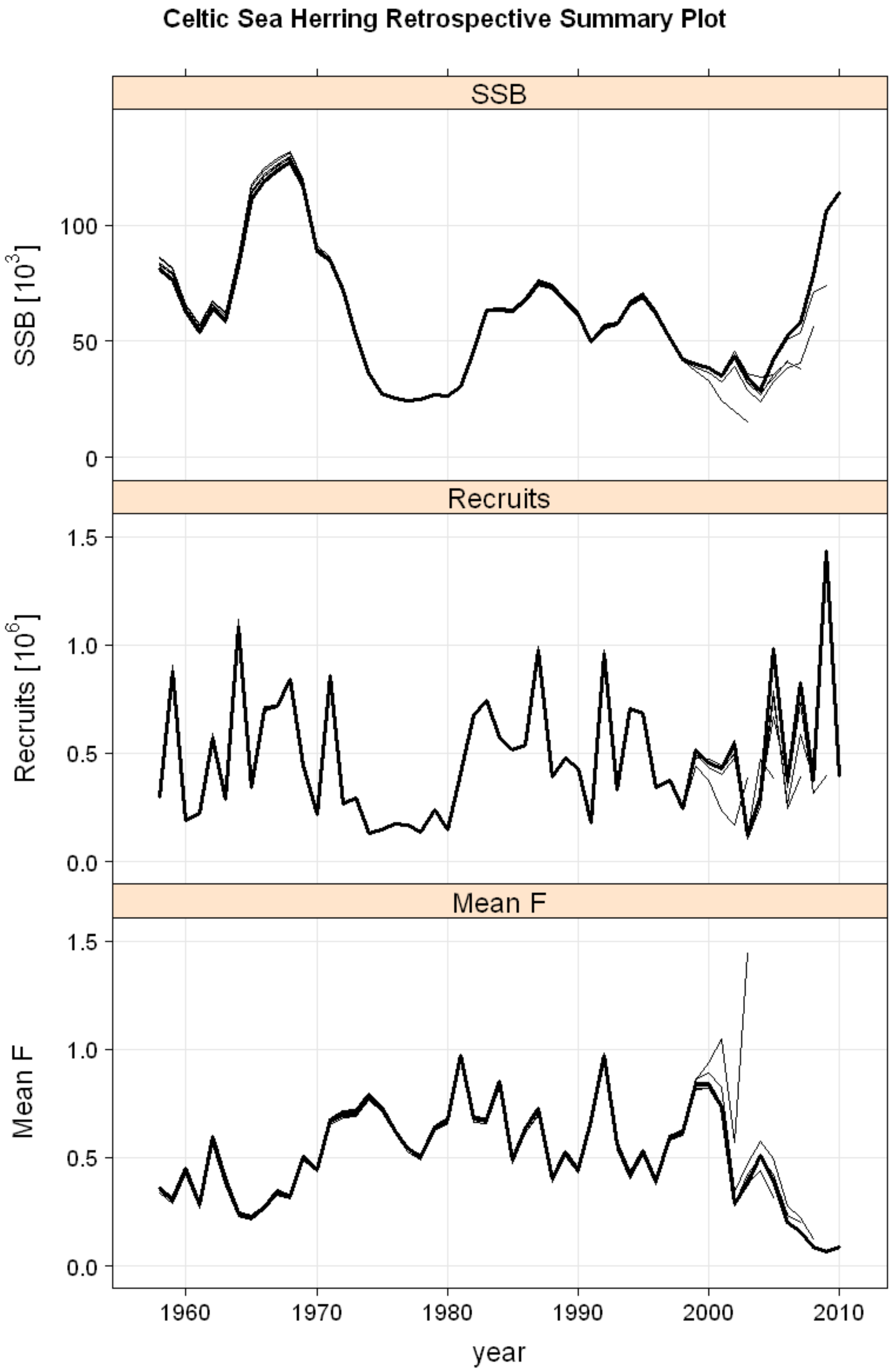


Figure 4.6.1.15. Herring in Celtic Sea. Analytical retrospective pattern. This retrospective includes 2003 and 2005-2010. 2004 data are excluded.

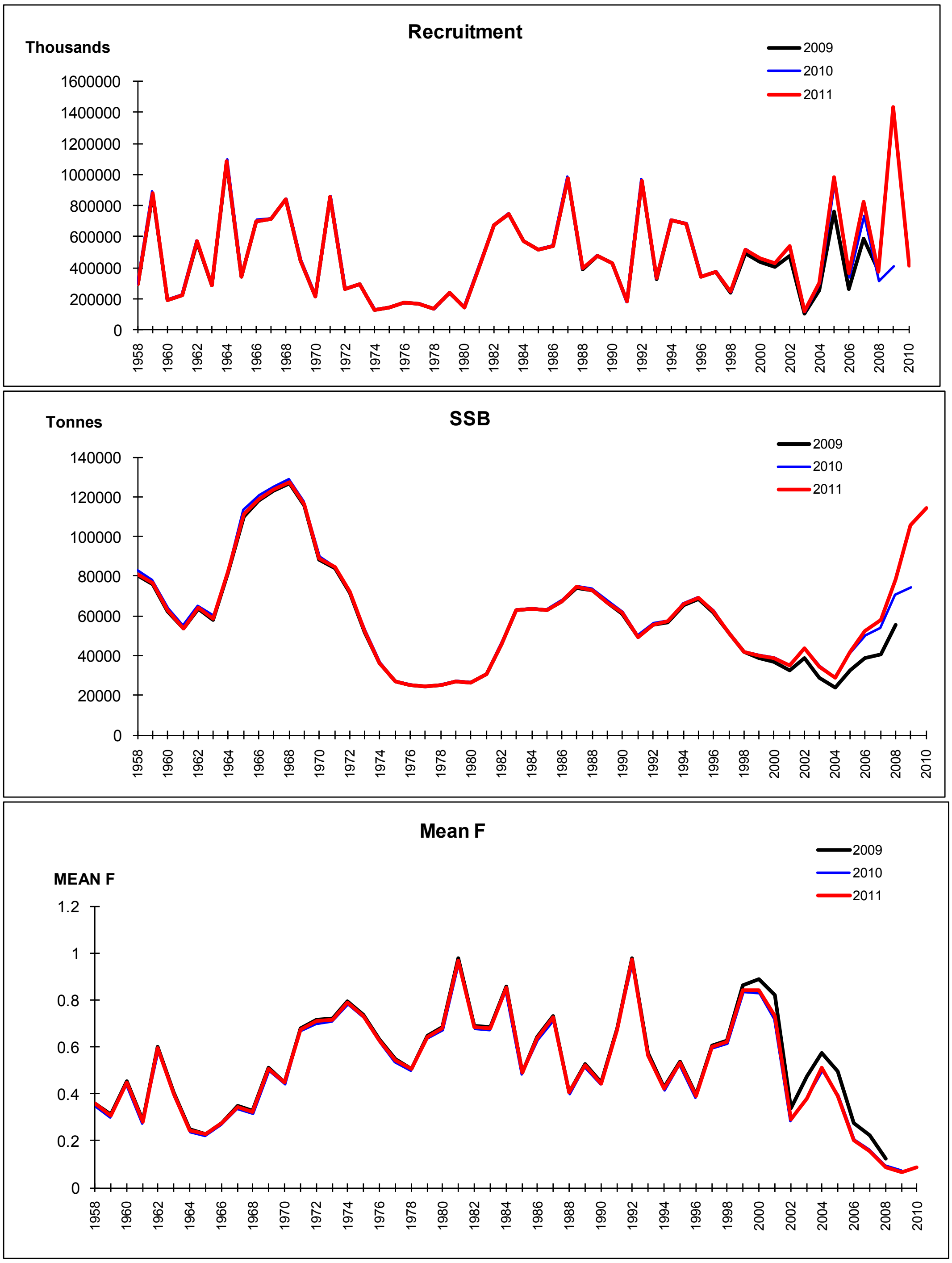


Figure 4.6.1.16. Herring in the Celtic Sea. Historical Retrospective based on the final assessments in 2009, 2010 and 2011

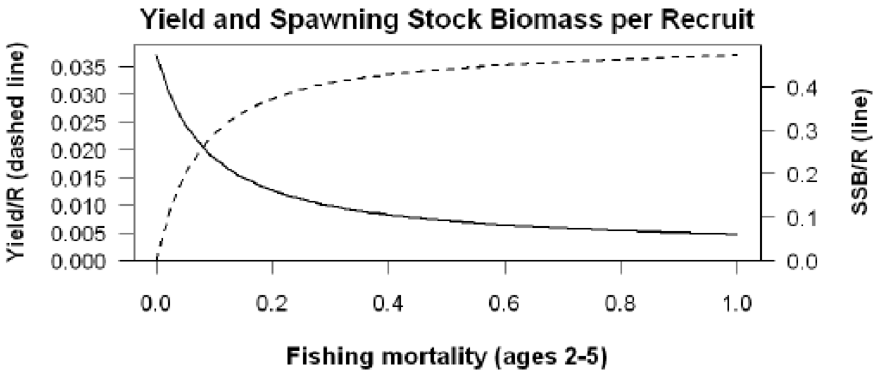


Figure 4.7.2.1. Herring in the Celtic Sea. Yield Per Recruit Plot.

5 Herring in Division VIa (North)

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 Advice applicable to 2010 and 2011

ACOM reported in 2010 that the stock over recent years had been fluctuating at a low level and was being exploited close to F_{MSY}.

The basis for the advice was the management plan accepted by the European Commission on 18 December 2008 (Council Regulation (EC) 1300/2008).

The International TAC for 2011 is 22 481 t, which is in accordance with the agreed plan (see Section I.1 in the Stock Annex). The International TAC in 2010 was 24 420 t.

5.1.2 Changes in the VIa (North) fishery.

Historically, catches have been taken from this area by three fisheries: (i) a Scottish domestic pair trawl fleet and the Northern Irish fleet; (ii) the Scottish single boat trawl and purse seine fleets and (iii) an international freezer-trawler fishery. The details of these fleets are described in the Stock Annex. In recent years the catch of the last two fleets has become more similar.

In 2010, 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). Recently (since 2006) the majority of the fishery has been prosecuted in quarter 3. This pattern has continued in 2010, with 86% of catches taken in quarter 3. Since 2006, the quarter 3 fishery has concentrated in the northern part of the area. This trend has continued in 2010, with over 99% of the quarter 3 catches taken north of the Hebrides and to the north of Scotland. Prior to 2006 there was a much more even distribution of effort, both temporally and spatially.

5.1.3 Regulations and their affects

New sources of information on catch misreporting from the UK became available in 2006 (see the 2007 HAWG report). This information was associated with a stricter enforcement regime that may have been responsible for the lack of that area misreporting since 2006. In 2010 there was little evidence of misreporting of catch from IVa into VIa (North).

There are no new changes to the regulations relevant to the fishery in VIa (North).

5.1.4 Catches in 2010 and allocation of catches to area for VIa (N)

For 2010 the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 22 510 t, compared with the TAC of 22 481 t. The Working Group's estimates of area misreported and unallocated catches are 2 728 t. Various observer programs suggest that discarding is not perceived to be a problem. In 2010, there were 95 t of discards, in the quarter 3 fishery.

The Working Group’s best estimate of removals from the stock in 2010 is 19 877 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 increased markedly from the low level seen over the last few years (except in 2006). There were 31 samples available in 2010, obtained from the German (10), Scottish (8) and English (13) fleets. The English fleet catch was sampled by the Dutch. However, the samples were raised to the English reported catch. The English and German fleets each took a similar magnitude of catches in the area; both around 40% of the Scottish UK catch. The available samples were used to allocate a mean age-structure (using the sample number weighting) to unsampled catches, in the same or adjacent quarters, as no sampling data were available for other quarters. The allocation of age structures to unsampled catches, and the calculation of total international catch-at-age and mean weight-at-age in the catches were made using the 'sallocl' programme (Patterson, 1998a). As 26 of the 31 samples obtained came from three of the major fisheries in one quarter (English flagged vessels, Germany and Scotland 3rd quarter) it is likely that they are reasonably representative of these catches, and reflect a large proportion of the fishery.

Catch number- and weight-at-age information is given in the ICA stock report section 5.6 (cf Table 5.6.1 and 5.6.2 respectively). Three larger year classes can be seen clearly in the catch-at-age bubble plot (Figure 5.2.1): 2004, 2006 and 2007 at 5-, 3- and 2-ringers respectively in 2010. The plus group is also large; this group now contains the large 2000 year class, at 9-ringer in 2010. The 2001, 2002 and 2003 year classes still all appear relatively weak, with the 2002 year class the weakest. 1-ring herring in the catch are observed intermittently and are rarely representative of year class strength and are down-weighted in the assessment, (see Section 5.6).

5.3 Fishery Independent Information

5.3.1 Acoustic survey – MSHAS_N

The survey values for number-, weight- and proportion mature-at-age in the stock were revised in 2009 and reported in the 2010 HAWG (see Section 5.6.1 in Anon (2010). The 2010 survey values are in Table 5.3.1.

The 2010 acoustic survey was carried out from the 28th June to the 17th July 2010 using a chartered commercial fishing vessel (MFV *Prowess*). Further details are available in the Report of the Working Group for International Pelagic Surveys (ICES 2011/ SSGESST:02). The commercial vessel changes through the time series, though year effects seen in the series are not thought to be linked to vessel effects. The spawning stock biomass estimate for VIa (North) from the acoustic survey (Table 5.3.2) has decreased by approximately 47% from 2009 (from 578 800 tonnes to 308 055 tonnes), to give the fourth lowest estimate in the time series. The 2009 value was the fourth highest in the time series.

In 2010 reasonably similar patterns in year class proportions were seen in the catch and the survey (Figure 5.3.1). However, the catch showed higher proportions of 5-ringers, whereas the survey showed higher proportions of 2- and 3-ring fish. There is no basis for concluding which of these data sources are more reliable (ICES 2011/SSGESST:02).

The survey shows reasonable internal consistency (Figure 5.3.2) for the older ages (5- to 9-ringers), but not for the 1- to 4-ringers. The 1-ringers are down weighted in the assessment. The 2-, 3- and 4-ringers are not because there is no other fishery-independent information available for this stock.

5.4 Mean Weights-At-Age and Maturity-At-Age

5.4.1 Mean weight-at-age

Weights-at-age in the stock are obtained from the acoustic surveys and are given in Tables 5.3.1 (for the current year) and 5.6.3 (for the time series); weights-at-age in the catches are given in Section 5.6.1 (cf. Table 5.6.2) and are used in the assessment. The weights-at-age in the catch have decreased for all ages in 2010. 1- to 7- ringer weights were increasing until 2009. The weights-at-age in the stock have also decreased for all ages in 2010, reversing the gradual increase from 2007 seen up until 2009 (cf. Table 5.6.3).

5.4.2 Maturity ogive

The maturity ogive is obtained from the acoustic survey (Table 5.3.1). The survey provides estimated values for the period 1991 to 2010 (cf. Table 5.6.5). In 2010, 79% of the 2-ring fish were mature. This is an increase from 2009 where 70% of the fish were mature, but a reduction from 2008 where 98% of the 2-ring fish caught was mature. The 2008 value was the second highest proportion mature at this age since 1992 when measurements began, with the highest value (virtually 100% mature) seen in 2007. The sensitivity of the assessed SSB to the estimated maturity was investigated in 2008 (ICES 2008/ACOM:02) where the assessment was re-run with fraction mature at 2-ring taken from average maturity for the years 2004-2006. This resulted in a 4% reduction of SSB in 2007. This was considered to be negligible in the context of the precision of the estimate of SSB.

5.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey generally have some catches at 1-ring, both the fishery and survey encounter this age group only incidentally. The first reliable appearance of a cohort appears at 2-ring in both the catch and the stock.

5.6 Assessment of VIa (North) herring

5.6.1 Stock assessment

This is an update assessment using FLICA (Kell, 2007; Patterson, 1998b) with the same settings as in 2010, using the revised catch data, post HAWG 2010, with the 8 year separable period moved forward one year to 2003 – 2010. However, it is tuned using the revised survey time series (1991-2010) – see Stock Annex. The assessment uses catch data from 1957 to 2010 giving an assessment of F from 1957 to 2010 and numbers-at-age from 1 Jan 1957 to 2011. The input data are given in Tables 5.6.1-8, the run settings are presented in Tables 5.6.9-11.

The results of the assessment are given as the stock summary in Table 5.6.12 and Figure 5.6.1. The output values are in Tables 5.6.13-17. Run diagnostics are given in Tables 5.6.18–20 and Figures 5.6.2-12. The parameter estimates are given in Table 5.6.21.

The 2000 year class is still reasonably abundant in the catch and survey data in 2010 (9-ringers). Three additional year classes (2004, 5-ringers, 2006, 3-ringers and 2007, 2-ringers in 2010) are also reasonably abundant in the catch and survey data in 2010 (Figure 5.3.1). The 2000 and 2004 year classes were both also well represented in the 2009 catch and survey.

The separable model diagnostics (Table 5.6.18 and Figure 5.6.2) show that the total residuals by age and year between the catch and separable model are reasonably trend-free. The fits between survey and assessment are illustrated in Figures 5.6.3-11 for ages 1 to 9+ winter rings. The poor fit at age 1 supports the down weighting of this index. The best fits are to middle ages 3-5.

The assessment shows continuing low levels of recruitment (the 2001, 2002 and 2003 year classes are all weak). The tuning diagnostics (Figures 5.6.3 to 5.6.12 and Table 5.6.17-21) show year effects in the survey that the assessment is sensitive to, especially around 2004 to 2005. The assessment fits between negative and positive residuals in the last two years of the assessment but these residuals are small and more balanced than in the past. The analytical retrospective (Figure 5.6.13) plots show that the assessment is noisy. However, it now shows a reasonably stable but historically low stock level. Although the assessment is noisy, it gives a clear indication of the state of the stock in its historical context. The Taylor diagram (Figure 5.6.14) shows a clear indication that there is no signal in the 1-ring data in the survey. It also reflects the patterns of internal consistency seen in Figure 5.3.1, showing no signal for the 1-ringers but a good agreement between the observations and model for the older age classes.

In conclusion, this assessment is driven by a noisy survey, giving the third lowest survey SSB estimate in 2007 to the second highest survey estimate in 2008. Point estimates of SSB and F from the survey are therefore not that informative and should only be used to indicate medium term trends and for guidance. The current management agreement that restricts large inter-annual changes in TACs is appropriate for such a noisy assessment.

5.6.1.1 State of the stock

The assessment gives an SSB for 2010 of around 62 000 t and a mean fishing mortality (3 to 6-ringers) of 0.27. SSB was fairly stable from 2005 to 2007 and decreased in 2009 to around 20% below the average of the previous 20 years. However, the outcome of the assessment this year suggests a lower position again from last year's assessment, with SSB now around 34% below the average of the last 20 years. F has increased again in 2010, to F=0.27 (compared to F=0.22 in 2009 and F=0.16 in 2008). Catch in 2010 increased by 7%, compared to 2009 (which had already increased by 15% compared to 2008). Recruitment is low for the 2001, 2002 and 2003 year classes (Table 5.6.12). The 2004 recruitment currently appears to be around half the level of the last reasonable year class (2000); the 2005 and 2006 year classes appear to be around the same level as the poor 2001 – 2003 year classes. The 2007 year class appears to be slightly bigger than the 2004 year class. There is insufficient data to evaluate later year classes.

5.7 Short Term Projections

5.7.1 Deterministic short-term projections

Deterministic short-term projections are presented, which provide options including those based on the management agreement, the target F of which is considered to be F_{MSY}.

The Advice Drafting Group in 2010 recommended that the basis for the projection should be an average F of the last three years and not a TAC constraint. This is because the WG catch for this stock is consistently below the TAC. This continues to be the case (see text table below) so the average $F_{3\text{-}6}$ for the years 2008 to 2010 was considered to be appropriate again.

HAWG YEAR	TAC	CATON	% BELOW TAC
2008	27200	16054	41
2009	21760	18508	15
2010	24420	19877	19

Short-term projections were carried out using MFDP (Smith, 2000), with the same settings as in the advice last year (F constraint of average $F_{3\text{-}6}$ 2008 to 2010). Input data are stock numbers on 1st January in 2011 from the 2010 ICA assessments (Section 5.6.1, Table 5.7.1.1). Geometric mean recruitment of 1-ringers (1989-2009) replaced recruitment for 1-ringers in both 2010 and 2011. Geometric mean recruitment (1989-2009) of 2-ringers from the "estimated population abundance" table in the assessment output replaced recruitment for 2-ringers in 2011. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period. The retrospective assessment of recruitment estimates in the 2003 Working Group (ICES 2003/ACFM:17) showed the substantial revision of 1- and 2-ring herring abundance (1st January survivors) in subsequent assessments, justifying the use of geometric means for these ages. The selection pattern used is taken from the final year of the ICA assessment (Table 5.6.16, and Figure 5.6.2), and is therefore effectively the mean of last 8 years and is scaled by the Fbar (3-6) to the level of the last year. For the projections, data for maturity, natural mortality, mean weights-at-age in the catch and in the stock are means of the three previous years (i.e., 2008 - 2010). An F constraint of 0.2185 in 2010 is used for the basis for the intermediate year in the projection, this implies an SSB in 2011 at 81 000 t. All the input values are summarised in Table 5.7.1.1.

The results of the short-term projection using the F constraint are given in Tables 5.7.1.2 – 5.7.1.3. HAWG considers that, as the management plan was based on extensive investigation of maximum yield in the long-term (considering different productivity regimes: Simmonds and Keltz, 2007; ICES 2009/ACOM:27), the F target in the accepted management plan is consistent with the MSY approach.

The catch option consistent with the management plan (F=0.25 in 2012) implies an SSB in 2012 of ~ 85 000 t and a catch of ~ 23 000 t. This is coherent with a biomass in 2012 above $B_{trigger}$. The 2012 catch is a 2% increase on the 2011 TAC. The SSB is expected to rise to ~ 88 000 t in 2013.

5.7.2 Yield-per-recruit

Yield-per-recruit analyses were carried out using MFYPR (Smith, 2000) to provide yield-per-recruit (Figure 5.7.2.1). The value for $\mathbf{F_{0.1}}$ is 0.15.

5.8 Precautionary and Yield Based Reference Points

B_{lim} is agreed at 50 000t (based on B_{loss}). There are no other agreed precautionary reference points for this stock. The agreed management rule has a $B_{trigger}$ at 75 000 t.

In 2010, HAWG defined F_{MSY} as 0.25. HAWG has not considered candidate values for a $B_{MSYtrigger}$ in great detail. HAWG considered that the values of 50 000 t, the B_{lim} for the stock, and 75 000 t, the $B_{trigger}$ for the stock, are appropriate. In 2010 ACOM endorsed the approach taken by HAWG, and ICES WKFRAME II also endorsed the approach in 2011.

5.9 Quality of the Assessment

This year's estimate of SSB for 2009 is around 75 000 t, compared with some 80 000 t in last year's final assessment run, a decrease of 6%.

The HAWG accepted this year's assessment. The quality of the assessment is the same as last year's. The precision of the assessment estimated through parametric bootstrap is shown in Figure 5.9.1. The assessment outcomes were revised downwards from those made last year. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below and in Figure 5.9.2.

	2010 Assessment		**2011 Assessment**		**Percentage change in estimate 2010-2011**	
Year	SSB	F_{3-6}	SSB	F_{3-6}	SSB	F_{3-6}
2008	99141	0.143	90128	0.152	-9.09	6.29
2009	79755	0.224	74800	0.238	-6.21	6.25
2010*	83019	0.294	61649	0.266	-25.74	-9.52

*projected values from the intermediate year in the deterministic short term projection, assuming catch constraint with small overshoot. (Recruits are defined as age 1).

Retrospective analyses of the assessment from 2010 to 2006 (Figure 5.6.13) support the perception of a noisy but fairly well balanced assessment.

5.10 Management Considerations

The forecast shows that SSB (in 2011) is approx. 1.6 times B_{lim}. ICES considers that the stock is currently fluctuating at a low level and is being exploited slightly above, but close to, F_{MSY}. Recruitment has been low since 1998, and the 2001 - 2003 and 2005 and 2006 year classes are all weak.

There has been considerable uncertainty in the amount of landings from this stock in the past. Area misreporting is less of a problem than in the past, but almost all countries still take catches of herring in other areas and report it into VIa (N). Increased observer coverage and use of VMS and electronic log books is helping to reduce these problems.

The assessment is noisy, leading to annual revisions of SSB and F. The management plan has been designed to cope with this by applying a constraint on year-on-year change in TAC. Revisions in SSB can be upwards or downwards, so it is important to maintain the restrictions on change in TAC both when the stock is revised upwards or downwards. Asymmetrical changes in TAC have not been tested.

The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER. This identified Division VIa (N) as an area where catches comprise a mixture of fish from Divisions VIa (N), VIa (S), and VIIa (N). Concerning the management plan for Division VIa (N), ICES has advised that herring components should be managed separately to afford maximum protection. If there is an increasing catch on the mixed fishery in Division VIa (N), this should be considered in the management of the Division VIa (S) component which is in a depleted state. In 2008 ICES began to evaluate management for this Division VIa (S) and VIIa (N). It will be a number of years before ICES can provide a fully operational integrated strategy for these units. In this context HAWG recommends that the management plan for Division VIa (N) should be continued.

5.11 Ecosystem Considerations

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

Observers monitor the fisheries. Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

5.12 Changes in the Environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006/LRC:03). It is considered that this may have implications for herring. It is known that similar environmental changes have affected the North Sea herring. There is evidence that there have been recent changes of the productivity of this stock (ICES 2007/ACFM:11).

Herring are thought to be a source of food for seals. Grey seals (*Halichoerus grypus*) are common in many parts of the Celtic Seas area. The majority of individuals are found in the Hebrides and in Orkney (SCOS 2005). A recent study (Hammond & Harris, 2006) of seal diets off western Scotland revealed that grey seals may be an important predator for cod, herring and sandeels in this area. Common seals (*Phoca vitulina*) are also widespread in the northern part of the ecoregion with around 15,000 animals estimated (SCOS 2005). The numbers of seals in VIa (N) is thought to have increased over the last decades. The seal consumption of herring is estimated with great uncertainty and the impact of increased predation is not known, but there is a possibility that seal predation could influence natural mortality.

Table 5.1.1. Herring in VIa (North). Catch in tonnes by country, 1987-2010. These figures do 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**
Denmark								
Faroes				326	482			274
France	136	44	1342	1287	1168	119	818	5087
Germany	1711	1860	4290	7096	6450	5640	4693	7938
Ireland	6800	6740	8000	10000	8000	7985	8236	6093
Netherlands	5212	6131	5860	7693	7979	8000	6132	8183
Norway	4300	456		1607	3318	2389	7447	30676
UK	26810	26894	29874	38253	32628	32730	32602	-4287
Unallocated	18038	5229	2123	2397	-10597	-5485	-3753	700
Discards			1550	1300	1180	200		
Total	63007	47354	53039	69959	50608	51578	56175	54664
Area-Misreported	-18647	-11763	-19013	-25266	-22079	-22593	-24397	-30234
WG Estimate	44360	35591	34026	44693	28529	28985	31778	24430
Source (WG)	1989	1990	1991	1993	1993	1994	1995	1996

Country	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Faroes								800
France	3672	2297	3093	1903	463	870	760	1340
Germany	3733	7836	8873	8253	6752	4615	3944	3810
Ireland	3548	9721	1875	11199	7915	4841	4311	4239
Netherlands	7808	9396	9873	8483	7244	4647	4534	4612
Norway	4840	6223	4962	5317	2695			
UK	42661	46639	44273	42302	36446	22816	21862	20604
Unallocated	-4541	-17753	-8015	-11748	-8155			878
Discards			62	90				
Total	61271	64359	64995	65799	61514	37789	35411	36283
Area-Misreported	-32146	-38254	-29766	-32446	-23623	-19467	-11132	-8735
WG Estimate	29575	26105	35233*	33353	29736	18322$	24556$	32914$
Source (WG)	1997	1997	1998	1999	2000	2001	2002	2003

Country	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Faroes	400	228	1810	570	484	927	1544	70
France	1370	625	613	701	703	564	1049	511
Germany	2935	1046	2691	3152	1749	2526	27	3583
Ireland	3581	1894	2880	4352	5129	3103	1935	2728
Netherlands	3609	8232	5132	7008	8052	4133	5675	3600
Norway								
UK	16947	17706	17494	18284	17618	13963	11076	12018
Unallocated	-7							
Discards		123	772	163				95
Total	28835	29854	31392	34230	33735	25216	21306	22510
Area-Misreported	-3581	-7218	-17263	-6884	-4119	-9162	-2798	-2728
WG Estimate	28081$	25021$	14129$	27346	29616	16054	18508	19877
Source (WG)	2004	2005	2006	2007	2008	2009	2010	2011

$Revised at HAWG 2007

Table 5.2.1. Herring in VIa (North). Catch and sampling effort by nations participating in the fishery in 2010.

Summary of Sampling by Country
AREA : VIa(N)

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	3336.00	3336.00	13	1954	325	101.31
Faroes	0.00	70.00	0	0	0	0.00
France	0.00	511.00	0	0	0	0.00
Germany	3583.00	3583.00	10	1056	973	96.27
Ireland	0.00	2728.00	0	0	0	0.00
Netherlands	0.00	3600.00	0	0	0	0.00
Northern Ireland	0.00	321.00	0	0	0	0.00
Scotland	7375.00	8361.00	8	2066	611	100.00
Total VIa(N)	14294.00	22510.00	31	5076	1909	99.37

Sum of Offical Catches : 22510.00
Unallocated Catch : -2633.00
Working Group Catch : 19877.00

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	0.00	478.00	0	0	0	0.00
Scotland	0.00	306.00	0	0	0	0.00
Period Total	0.00	784.00	0	0	0	0.00

Sum of Offical Catches : 784.00
Unallocated Catch : -478.00
Working Group Catch : 306.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	497.00	497.00	2	255	254	99.33
Netherlands	0.00	261.00	0	0	0	0.00
Period Total	497.00	758.00	2	255	254	99.33

Sum of Offical Catches : 758.00
Unallocated Catch : 0.00
Working Group Catch : 758.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	2048.00	2048.00	10	1475	250	101.90
France	0.00	511.00	0	0	0	0.00
Germany	3086.00	3086.00	8	801	719	95.77
Netherlands	0.00	3322.00	0	0	0	0.00
Scotland	7375.00	8030.00	8	2066	611	100.00
Period Total	12509.00	16997.00	26	4342	1580	99.27

Sum of Offical Catches : 16997.00
Unallocated Catch : 95.00
Working Group Catch : 17092.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	1288.00	1288.00	3	479	75	100.38
Faroes	0.00	70.00	0	0	0	0.00
Ireland	0.00	2250.00	0	0	0	0.00
Netherlands	0.00	17.00	0	0	0	0.00
Northern Ireland	0.00	321.00	0	0	0	0.00
Scotland	0.00	25.00	0	0	0	0.00
Period Total	1288.00	3971.00	3	479	75	100.38

Sum of Offical Catches : 3971.00
Unallocated Catch : -2250.00
Working Group Catch : 1721.00

Table 5.3.1. Herring in VIa (North). Estimates of abundance, biomass, maturity, weight- and length-at-age from the 2010 Scottish acoustic survey. Thousands of fish at age and spawning biomass (SSB, thousand tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith). N.B. these results are from the Scottish survey alone and not the coordinated survey in VIaN, to retain consistency with previous year's survey results.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	120	7.7	0.00	64.2	19.5
2	494	66.5	0.79	92.3	24.6
3	483	89.4	1.00	167.7	27.4
4	171	34	1.00	198.3	28.0
5	163	34.6	1.00	211.4	28.6
6	93	20	1.00	214.8	28.7
7	64	13.4	1.00	209.1	28.5
8	53	11.6	1.00	219.3	28.9
9+	223	48.1	1.00	215.3	28.8
Immature	224.37	17.34		77.2	20.6
Mature	1641.15	308.06		187.7	27.4
Total	1865.53	325.39	0.87	174.4	26.6

Table 5.3.2. Herring in VIa (North). Estimates of abundance and SSB for the time series of Scottish acoustic surveys of VIa (N). Thousands of fish at age and spawning biomass (SSB, tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year/Age	1	2	3	4	5	6	7	8	9+	SSB
1991	338312	294484	327902	367830	488288	176348	98741	89830	58043	410 000
1992	74310	503430	210980	258090	414750	240110	105670	56710	63440	351 460
1993	2357	579320	689510	688740	564850	900410	295610	157870	161450	845 452
1994	494150	542080	607720	285610	306760	268130	406840	173740	131880	533 740
1995	441200	1103400	473300	450300	153000	187200	169200	236700	201700	452 300
1996	41220	576460	802530	329110	95360	60600	77380	78190	114810	370 300
1997	792320	641860	286170	167040	66100	49520	16280	28990	24440	175 000
1998	1221700	794630	666780	471070	179050	79270	28050	13850	36770	375 890
1999	534200	322400	1388000	432000	308000	138700	86500	27600	35400	460 200
2000	447600	316200	337100	899500	393400	247600	199500	95000	65000	444 900
2001	313100	1062000	217700	172800	437500	132600	102800	52400	34700	359 200
2002	424700	436000	1436900	199800	161700	424300	152300	67500	59500	548 800
2003	438800	1039400	932500	1471800	181300	129200	346700	114300	75200	739 200
2004	564000	274500	760200	442300	577200	55700	61800	82200	76300	395 900
2005	50200	243400	230300	423100	245100	152800	12600	39000	26800	222 960
2006	112300	835200	387900	284500	582200	414700	227000	21700	59300	471 700
2007	-1	126000	294400	202500	145300	346900	242900	163500	32100	298 860
2008	47840	232570	911950	668870	339920	272230	720860	365890	263740	788 200
2009	345821	186741	264040	430293	373499	219033	186558	499695	456039	578 800
2010	119788	493908	483152	171452	163436	93289	64076	53116	223311	308 055

Tables 5.6.1. – 5.6.21. Herring in VIa (North). Input data, FLICA run settings and results for the maximum-likelihood ICA calculation for the 8 year separable period. N.B. In these tables "age" refers to number of rings (winter rings in the otolith).

TABLE 5.6.1 Herring in VIa (North). CATCH IN NUMBER
Units : Thousands

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	3568.58
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	18161.91
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	17263.76
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	40673.54
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	12264.30
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	7120.78
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3083.08
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1451.93
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	455.93

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
1	142.98	992.20	56.12	0.00	182.500	132.46	130.75	0.00
2	81030.48	38481.61	33331.97	6843.91	9632.710	6691.49	34326.00	7898.43
3	14942.91	93975.06	46865.58	22223.20	23236.710	9186.07	17754.83	13039.08
4	9305.89	9014.41	53766.66	27815.23	20602.390	13644.88	6555.14	5427.59
5	24482.25	18113.71	7462.99	45782.43	10237.930	41067.79	14264.99	3219.52
6	9280.71	28016.08	4344.55	3916.10	9783.180	27781.86	30566.16	5688.56
7	6624.96	9040.10	12818.38	7641.76	1014.997	20972.98	21517.07	14832.27
8	4610.61	1547.86	9187.62	8481.01	1194.960	3041.71	13585.45	8142.31
9	1000.53	1422.68	1407.96	4008.01	1430.760	5088.99	4242.60	8968.60

age \ year	2009	2010
1	1923.62	10074.12
2	11508.54	20339.85
3	10475.63	16331.31
4	16586.96	9957.96
5	8332.17	14608.15
6	5688.68	6322.33
7	7514.70	4322.24
8	11793.98	5388.91
9	9443.85	13199.28

TABLE 5.6.2 Herring in VIa (North). WEIGHTS AT AGE IN THE CATCH
Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082	0.079	0.084	0.091
2	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142	0.129	0.118	0.119
3	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145	0.173	0.160	0.183
4	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191	0.182	0.203	0.196
5	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190	0.209	0.211	0.227
6	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213	0.224	0.229	0.219
7	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216	0.228	0.236	0.244
8	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204	0.237	0.261	0.256
9	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243	0.247	0.271	0.256

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834	0.049	0.107	0.060	NaN
2	0.128	0.142	0.142	0.134	0.136	0.138	0.130	0.1373	0.140	0.146	0.145	0.154
3	0.158	0.167	0.181	0.178	0.177	0.159	0.158	0.1637	0.163	0.163	0.160	0.173
4	0.197	0.190	0.191	0.210	0.205	0.182	0.175	0.1829	0.183	0.173	0.169	0.195
5	0.206	0.195	0.198	0.230	0.222	0.199	0.191	0.2014	0.192	0.160	0.186	0.216
6	0.228	0.201	0.214	0.233	0.223	0.218	0.210	0.2147	0.196	0.179	0.200	0.220
7	0.223	0.244	0.208	0.262	0.219	0.227	0.225	0.2394	0.205	0.187	0.194	0.199
8	0.262	0.234	0.227	0.247	0.238	0.212	0.223	0.2812	0.225	0.245	0.186	0.190
9	0.263	0.266	0.277	0.291	0.263	0.199	0.226	0.2526	0.272	0.281	0.294	0.311

age \ year	2005	2006	2007	2008	2009	2010
1	0.1084	0.0908	0.1152	NaN	0.1121	0.0818
2	0.1327	0.1580	0.1667	0.1705	0.1726	0.1549
3	0.1632	0.1676	0.1881	0.2060	0.2141	0.1883
4	0.1845	0.1929	0.1968	0.2310	0.2379	0.2129
5	0.2108	0.2076	0.2105	0.2309	0.2457	0.2337
6	0.2258	0.2251	0.2214	0.2489	0.2535	0.2394
7	0.2341	0.2443	0.2161	0.2529	0.2599	0.2369
8	0.2556	0.2615	0.2618	0.2840	0.2549	0.2400
9	0.2496	0.2750	0.3030	0.2877	0.2730	0.2549

TABLE 5.6.3 Herring in VIa (North). WEIGHTS AT AGE IN THE STOCK
Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

TABLE 5.6.3 continued. Herring in VIa (North). WEIGHTS AT AGE IN THE STOCK

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.253
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.273
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.299
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.302

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.073	0.052	0.042	0.045	0.054	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.164	0.150	0.144	0.140	0.142	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.180	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.199	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.225	0.221	0.225	0.219	0.213	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.222	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.253	0.241	0.247	0.229	0.231	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.259	0.270	0.260	0.242	0.242	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.263	0.249	0.245	0.230	0.254	0.259	0.228	0.206

age \ year	2005	2006	2007	2008	2009	2010
1	0.0751	0.075	0.0750	0.0546	0.1013	0.0642
2	0.1296	0.135	0.1675	0.1721	0.1734	0.0923
3	0.1538	0.166	0.1830	0.1913	0.2064	0.1677
4	0.1665	0.185	0.1914	0.2083	0.2233	0.1983
5	0.1802	0.192	0.1951	0.2143	0.2331	0.2114
6	0.1911	0.204	0.1951	0.2139	0.2313	0.2148
7	0.2125	0.211	0.2021	0.2206	0.2318	0.2091
8	0.2030	0.224	0.2034	0.2242	0.2323	0.2193
9	0.2284	0.231	0.2138	0.2385	0.2382	0.2153

TABLE 5.6.4 Herring in VIa (North). NATURAL MORTALITY

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

TABLE 5.6.4 continued. Herring in VIa (North). NATURAL MORTALITY

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	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
3	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
5	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
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 5.6.5 Herring in VIa (North). PROPORTION MATURE

Units : NA

year

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	0.21	0.76	0.55	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.93	0.98	0.94	0.95	0.97	0.98	0.92	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.0	0.00
2	0.92	0.76	0.83	0.84	0.81	1	0.98	0.7	0.79
3	1.00	1.00	0.97	1.00	0.97	1	1.00	1.0	1.00
4	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00
5	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00
6	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00
7	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00
8	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00
9	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00

TABLE 5.6.6 Herring in VIa (North). FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.7 Herring in VIa (North). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

TABLE 5.6.7 continued. Herring in VIa (North). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

year

age	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.8 Herring in VIa (North). SURVEY INDICES

West of Scotland Summer Acoustic Survey - Configuration

"Herring in Division VIa (North)(runname:ICAPGF08) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1991.00	2010.00	0.52	0.57

Index type : number

West of Scotland Summer Acoustic Survey - Index Values

Units : number

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	338312	74310	2357	494150	441200	41220	792320	1221700	534200	447600
2	294484	503430	579320	542080	1103400	576460	641860	794630	322400	316200
3	327902	210980	689510	607720	473300	802530	286170	666780	1388000	337100
4	367830	258090	688740	285610	450300	329110	167040	471070	432000	899500
5	488288	414750	564850	306760	153000	95360	66100	179050	308000	393400
6	176348	240110	900410	268130	187200	60600	49520	79270	138700	247600
7	98741	105670	295610	406840	169200	77380	16280	28050	86500	199500
8	89830	56710	157870	173740	236700	78190	28990	13850	27600	95000
9	58043	63440	161450	131880	201700	114810	24440	36770	35400	65000

year

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	313100	424700	438800	564000	50200	112300	-1	47840	345821	119788
2	1062000	436000	1039400	274500	243400	835200	126000	232570	186741	493908
3	217700	1436900	932500	760200	230300	387900	294400	911950	264040	483152
4	172800	199800	1471800	442300	423100	284500	202500	668870	430293	171452
5	437500	161700	181300	577200	245100	582200	145300	339920	373499	163436
6	132600	424300	129200	55700	152800	414700	346900	272230	219033	93289
7	102800	152300	346700	61800	12600	227000	242900	720860	186558	64076
8	52400	67500	114300	82200	39000	21700	163500	365890	499695	53116
9	34700	59500	75200	76300	26800	59300	32100	263740	456039	223311

West of Scotland Summer Acoustic Survey - Index Variance (Inverse Weights)

Units : NA

year

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

year

West of Scotland Summer Acoustic Survey - Index Variance (Inverse Weights) continued.

age	2006	2007	2008	2009	2010
1	10	10	10	10	10
2	1	1	1	1	1
3	1	1	1	1	1
4	1	1	1	1	1
5	1	1	1	1	1
6	1	1	1	1	1
7	1	1	1	1	1
8	1	1	1	1	1
9	1	1	1	1	1

TABLE 5.6.9 Herring in VIa (North). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2010	3	6

TABLE 5.6.10 Herring in VIa (North). FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1 1 1
lambda.sr   : 0.01
index.model : linear
index.cor   : 1
sep.nyr     : 8
sep.age     : 4
sep.sel     : 1
```

TABLE 5.6.11 Herring in VIa (North). FLR, R SOFTWARE VERSIONS

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

Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

TABLE 5.6.12 Herring in VIa (North). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings Tonnes	Landings SOP
1957	1030679	386792	174398	0.2993	43438	0.7258
1958	2009074	471412	187830	0.3536	59669	0.7470
1959	2051919	505691	197825	0.3288	65221	0.7248
1960	605231	403413	229110	0.2128	63759	0.5679
1961	1249162	411009	229080	0.1397	46353	0.5846
1962	2240089	514435	218288	0.2217	58195	0.7727
1963	2071905	546736	240738	0.1956	49030	0.6970
1964	963114	498947	285512	0.1635	64234	0.5774
1965	7747943	1087101	294012	0.1672	68669	0.8586
1966	1058405	825253	407680	0.2022	100619	1.0136
1967	2485734	810936	441171	0.1960	90400	0.8072
1968	4091826	936932	421337	0.1471	84614	0.7964
1969	2996445	966910	460042	0.2476	107170	0.7573
1970	3438117	990440	433059	0.3647	165930	0.7343
1971	9564545	1506916	308128	0.7983	207167	1.0162
1972	2674778	1108577	436835	0.3688	164756	1.0239
1973	1073108	798369	382076	0.6093	210270	1.0438
1974	1669559	574028	201883	0.9622	178160	1.1255
1975	2087623	431810	105647	0.9153	114001	1.0108
1976	599081	260989	71891	1.0802	93642	0.9984
1977	615080	160357	50275	1.0181	41341	0.9154
1978	906923	167881	46608	0.7166	22156	1.0056
1979	1214030	213564	70607	0.0008	60	1.0011
1980	877303	249380	120278	0.0004	306	1.0007
1981	1653290	361284	129730	0.3680	51420	0.9698
1982	763072	302177	107109	0.6861	92360	1.0347
1983	2915059	418529	78734	0.7292	63523	1.0277
1984	1110270	345656	116420	0.5328	56012	0.9494
1985	1185789	340823	142534	0.3290	39142	1.0058
1986	875469	306436	127401	0.5501	70764	1.0479
1987	2051745	368800	116879	0.3637	44360	0.9725
1988	876338	323143	140689	0.2999	35591	1.0236
1989	806790	304884	155587	0.2591	34026	1.0199
1990	426677	258048	145013	0.3676	44693	0.9889
1991	376175	199166	118059	0.2765	28529	1.0693
1992	788857	184941	91153	0.3018	28985	1.0018
1993	574682	176090	92859	0.2601	31778	0.9912
1994	842040	170142	85041	0.2358	24430	0.9984
1995	603039	151836	67752	0.2723	29575	1.0001
1996	914121	186061	105933	0.1760	26105	1.0477
1997	1463902	203675	68773	0.5293	35233	1.0079
1998	486706	182886	97683	0.5206	33353	0.9992
1999	303901	140855	81518	0.3214	29736	1.0015
2000	1641178	199263	69353	0.2519	18322	0.9997
2001	1093739	221656	113311	0.2023	24556	1.0049
2002	1142677	254838	132036	0.3575	32914	1.0021
2003	446257	212373	132540	0.2247	28081	1.0074
2004	266886	167365	116523	0.2022	25021	1.0172
2005	312348	140041	96873	0.1219	14129	1.0021
2006	535371	161136	92837	0.2244	27346	0.9997
2007	277382	141374	91319	0.2807	29616	1.0004
2008	342339	128845	90128	0.1522	16054	1.0022
2009	630167	165976	74800	0.2376	18508	1.0492
2010	588137	774993	61649	0.2656	19877	0.9951

N.B. The recruitment in 2010 is replaced with geometric mean (1989-2009) because it is not well estimated in the assessment.

TABLE 5.6.13 Herring in VIa (North). ESTIMATED FISHING MORTALITY

Units : f

age \ year	1957	1958	1959	1960	1961	1962
1	0.01001241	0.01235991	0.04164859	0.009344276	0.01668192	0.03952066
2	0.10296885	0.10013734	0.11369370	0.177375988	0.26863585	0.26932013
3	0.33244314	0.31632080	0.16748396	0.147887537	0.16361642	0.21823300
4	0.22795384	0.37009587	0.42629562	0.147613295	0.10761587	0.25683366
5	0.31730137	0.31933377	0.37981894	0.283714190	0.19064103	0.18397167
6	0.31940405	0.40845723	0.34145088	0.272180149	0.09673569	0.22786077
7	0.20710579	0.45181333	0.42006291	0.312772213	0.17317202	0.24594791
8	0.26359732	0.33107049	0.31152469	0.242970232	0.20945821	0.27457663
9	0.26359732	0.33107049	0.31152469	0.242970232	0.20945821	0.27457663

age \ year	1963	1964	1965	1966	1967	1968	1969
1	0.009040758	0.0444172	0.06276430	0.3668898	0.1402225	0.08833049	0.02007436
2	0.121027016	0.1348659	0.06977034	0.2424087	0.1247249	0.14737179	0.08076601
3	0.260854511	0.1605276	0.15197318	0.1710204	0.1679628	0.14042404	0.16924511
4	0.164120375	0.1905800	0.18852469	0.2040271	0.2751417	0.16844353	0.21669760
5	0.216237251	0.1290722	0.21517021	0.1719690	0.1770857	0.14182743	0.31313226
6	0.141270954	0.1738526	0.11323059	0.2619156	0.1637436	0.13776300	0.29120937
7	0.132893265	0.1271951	0.22089652	0.1553832	0.2249008	0.10926776	0.35024248
8	0.191750712	0.1731773	0.16507792	0.2389339	0.2042094	0.16380073	0.23781949
9	0.191750712	0.1731773	0.16507792	0.2389339	0.2042094	0.16380073	0.23781949

age \ year	1970	1971	1972	1973	1974	1975	1976
1	0.1149504	0.03485802	0.3669080	0.0779135	0.3353922	0.1387218	0.1977559
2	0.1118049	0.41622896	0.2363045	0.5026638	0.4962415	0.7402282	0.7827046
3	0.3503443	0.98413987	0.4281704	0.5876248	0.7732648	0.8868223	1.2300598
4	0.4059260	0.86886306	0.3003230	0.6304226	0.9134984	0.8574821	1.0953710
5	0.3823721	0.69913836	0.4139373	0.5966747	0.9349166	0.9116825	0.8991035
6	0.3200966	0.64095765	0.3326091	0.6224164	1.2272396	1.0053192	1.0962069
7	0.4838912	0.59985242	0.5144238	0.3699916	0.9244961	1.0802126	1.1472524
8	0.3473847	0.76380707	0.3982823	0.6296737	0.9332119	1.0114653	1.1517178
9	0.3473847	0.76380707	0.3982823	0.6296737	0.9332119	1.0114653	1.1517178

age \ year	1977	1978	1979	1980	1981	1982
1	0.09312234	0.03995029	0.0003219039	0.0048641637	0.03568175	0.02790417
2	0.36071856	0.29833491	0.0005128441	0.0007235612	0.32668926	0.66373118
3	0.62037033	0.27716271	0.0007499168	0.0004416799	0.43079460	0.61496539
4	0.96986131	0.55686352	0.0003445320	0.0005781906	0.40156716	0.81002899
5	0.98156528	0.82903886	0.0002643560	0.0002606036	0.31255509	0.73191163
6	1.50065609	1.20336992	0.0016721541	0.0002023110	0.32702899	0.58749944
7	0.93341899	1.09173872	0.0027187809	0.0018512718	0.33824566	0.49347456
8	0.91923763	0.71528525	0.0010515820	0.0007524969	0.40640387	0.75225294
9	0.91923763	0.71528525	0.0010515820	0.0007524969	0.40640387	0.75225294

age \ year	1983	1984	1985	1986	1987	1988
1	0.04530522	0.003148802	0.0556990	0.06262778	0.01510164	0.003087283
2	0.39554873	0.238182939	0.2164933	0.55993443	0.28841603	0.204452256
3	0.60245865	0.511387937	0.3177382	0.49066297	0.33642494	0.318436758
4	0.51589503	0.454359465	0.3145309	0.42936972	0.32247687	0.344793210
5	0.98422375	0.480080014	0.3237178	0.59052944	0.28796038	0.300505949
6	0.81412217	0.685302470	0.3601067	0.68999171	0.50809552	0.235991272
7	0.79898861	0.641816070	1.0760108	0.20639832	0.59089889	0.332302630
8	0.72485095	0.523925012	0.4399959	0.58535426	0.42179863	0.316570209
9	0.72485095	0.523925012	0.4399959	0.58535426	0.42179863	0.316570209

age \ year	1989	1990	1991	1992	1993	1994
1	0.01225101	0.05420575	0.1164830	0.01058104	0.04979776	0.003250879
2	0.14148847	0.17511346	0.1963556	0.25937511	0.47736692	0.234617171
3	0.31159800	0.24437918	0.1651896	0.35952904	0.34468414	0.406100992
4	0.22122274	0.34133089	0.2526067	0.21907425	0.25175031	0.167674165
5	0.34237181	0.48235763	0.2577922	0.28176430	0.16417476	0.241098434
6	0.16128696	0.40250520	0.4303883	0.34697848	0.27975023	0.128312306
7	0.16810100	0.28968868	0.3741651	0.32739028	0.30080471	0.292248198
8	0.24517992	0.34071272	0.2998541	0.33640885	0.38183937	0.282121826
9	0.24517992	0.34071272	0.2998541	0.33640885	0.38183937	0.282121826

year

TABLE 5.6.13 continued. Herring in VIa (North). ESTIMATED FISHING MORTALITY

age	1995	1996	1997	1998	1999	2000
1	0.0006980127	0.003382908	0.001289920	0.02992335	0.04041913	0.003444809
2	0.3642537212	0.218863470	0.212857243	0.17307658	0.26561699	0.216588416
3	0.3327170925	0.240395431	0.343498697	0.20998741	0.36716566	0.213558062
4	0.3704110727	0.150664107	0.391741463	0.57177944	0.22002957	0.254131002
5	0.1990737187	0.192540535	0.596002234	0.48228612	0.44236427	0.142837111
6	0.1869803147	0.120277302	0.785903462	0.81835935	0.25604789	0.397139854
7	0.1795880559	0.292698448	0.867295001	1.05098609	0.38245317	0.141781628
8	0.3344590053	0.234142803	0.537816421	0.54177929	0.35779877	0.261595432
9	0.3344590053	0.234142803	0.537816421	0.54177929	0.35779877	0.261595432

year

age	2001	2002	2003	2004	2005
1	0.0002068232	0.001374439	0.0008772789	0.0007892546	0.0004757894
2	0.1686904039	0.116984690	0.1080984791	0.0972521054	0.0586268607
3	0.2959003327	0.320070553	0.1990297855	0.1790595560	0.1079431607
4	0.1620679861	0.277431203	0.2236395210	0.2012000025	0.1212901712
5	0.2138631357	0.474020219	0.2426488965	0.2183020173	0.1315998446
6	0.1374413746	0.358404069	0.2336548107	0.2102103792	0.1267219312
7	0.6933631897	0.172642738	0.2742326096	0.2467166872	0.1487291693
8	0.2896091511	0.299970038	0.2236395210	0.2012000025	0.1212901712
9	0.2896091511	0.299970038	0.2236395210	0.2012000025	0.1212901712

year

age	2006	2007	2008	2009	2010
1	0.0008757594	0.001095821	0.0005942816	0.0009273655	0.001036623
2	0.1079112505	0.135027225	0.0732274978	0.1142701637	0.127732896
3	0.1986850622	0.248610711	0.1348257006	0.2103930264	0.235180467
4	0.2232521731	0.279351053	0.1514966969	0.2364078097	0.264260181
5	0.2422286240	0.303095913	0.1643739272	0.2565024906	0.286722315
6	0.2332501162	0.291861283	0.1582812014	0.2469949040	0.276094593
7	0.2737576336	0.342547543	0.1857691984	0.2898894180	0.324042721
8	0.2232521731	0.279351053	0.1514966969	0.2364078097	0.264260181
9	0.2232521731	0.279351053	0.1514966969	0.2364078097	0.264260181

TABLE 5.6.14 Herring in VIa (North). ESTIMATED POPULATION ABUNDANCE

Units : NA

year

age	1957	1958	1959	1960	1961	1962
1	1030679.055	2009073.88	2051918.64	605231.21	1249161.86	2240089.35
2	880501.568	375388.21	730018.03	724065.58	220581.29	451938.53
3	225348.514	588468.18	251595.69	482690.44	449216.96	124914.62
4	132556.926	132317.59	351145.99	174223.58	340865.51	312276.67
5	130980.869	95493.52	82690.87	207453.34	136009.69	276959.73
6	76240.974	86293.12	62785.53	51177.00	141343.38	101705.88
7	49824.969	50123.75	51898.64	40377.54	35272.73	116100.54
8	6457.248	36649.89	28866.50	30852.87	26722.38	26841.20
9	20014.301	26618.30	33655.39	22446.85	14332.61	30923.93

year

age	1963	1964	1965	1966	1967	1968	1969
1	2071905.27	963114.17	7747943.17	1058405.20	2485733.99	4091826.50	2996444.93
2	792149.69	755351.44	338916.84	2676909.92	269785.90	794808.15	1378038.29
3	255756.56	519945.17	488977.87	234155.26	1556211.60	176426.39	508125.76
4	82219.90	161317.03	362562.08	343897.64	161574.12	1077120.87	125521.83
5	218558.98	63135.11	120637.66	271692.53	253741.74	111032.42	823532.79
6	208491.96	159304.69	50209.53	88025.04	206996.53	192333.59	87181.73
7	73275.36	163797.27	121142.32	40567.79	61295.45	159008.62	151633.78
8	82146.86	58051.53	130507.98	87888.55	31424.60	44292.03	128984.29
9	36605.92	99664.92	134686.99	133641.32	146525.09	75109.62	129856.38

year

age	1970	1971	1972	1973	1974	1975
1	3438117.09	9564544.68	2674778.12	1073107.61	1669558.77	2087623.04
2	1080422.54	1127467.03	3398061.02	681784.59	365183.70	439185.74
3	941665.60	715729.69	550870.56	1987545.63	305530.60	164705.50
4	351244.96	543106.78	219019.92	293926.42	904182.33	115443.95
5	91449.06	211782.09	206116.78	146766.03	141585.93	328170.29
6	544828.52	56453.09	95241.86	123285.84	73124.61	50299.25
7	58955.65	357943.27	26908.77	61794.26	59864.83	19393.26
8	96662.53	32880.98	177775.60	14556.37	38621.88	21490.12
9	85983.34	62561.44	53020.57	72094.96	36167.40	22435.15

year

TABLE 5.6.14 continued. Herring in VIa (North). ESTIMATED POPULATION ABUNDANCE

age	1976	1977	1978	1979	1980	1981
1	599081.247	615079.832	906922.648	1214029.6560	877302.997	1653289.851
2	668515.543	180845.189	206155.292	320571.9905	446472.807	321175.679
3	155196.833	226411.695	93402.937	113328.9685	237363.810	330515.955
4	55552.956	37137.766	99681.955	57960.4034	92716.356	194251.235
5	44314.105	16809.862	12740.337	51682.5993	52426.676	83844.736
6	119324.921	16316.869	5699.626	5031.5810	46751.989	47425.257
7	16654.343	36076.559	3292.158	1548.1034	4545.156	42294.391
8	5957.868	4784.678	12835.623	999.8047	1396.979	4105.021
9	18287.642	2577.966	3156.770	7076.8430	7300.372	4158.333

year age	1982	1983	1984	1985	1986	1987
1	763072.16	2915058.85	1110269.743	1185789.281	875468.904	2051745.42
2	586891.92	272993.62	1024889.485	407161.321	412594.344	302515.30
3	171622.79	223879.84	136169.400	598338.787	242916.123	174605.73
4	175890.27	75969.63	100348.673	66854.042	356530.186	121760.16
5	117634.83	70798.04	41035.543	57644.301	44167.130	209987.75
6	55501.59	51196.62	23941.362	22973.895	37734.455	22141.45
7	30942.35	27907.97	20523.106	10916.824	14501.496	17125.73
8	27286.96	17092.70	11358.014	9774.093	3367.916	10674.46
9	7954.58	17187.92	5026.056	6438.607	4651.831	18205.61

year age	1988	1989	1990	1991	1992	1993	1994
1	876338.376	806790.382	426676.59	376174.78	788856.71	574681.73	842040.46
2	743481.953	321393.107	293187.66	148683.60	123170.66	287149.69	201143.51
3	167958.314	448941.342	206681.00	182308.34	90510.42	70400.17	131978.20
4	102115.602	100010.888	269156.83	132528.45	126533.84	51724.73	40833.86
5	79804.219	65451.690	72534.07	173116.25	93148.10	91967.52	36386.06
6	142463.925	53467.309	42053.41	40516.07	121046.06	63588.10	70616.28
7	12053.510	101808.901	41173.03	25442.86	23838.70	77415.94	43496.31
8	8582.137	7822.884	77866.56	27885.16	15835.75	15547.81	51851.71
9	9115.142	16904.567	20040.04	18029.06	20215.62	12343.20	43526.78

year age	1995	1996	1997	1998	1999	2000
1	603038.57	914120.87	1463902.21	486705.529	303900.886	1641177.607
2	308763.99	221690.70	335150.57	537845.302	173770.580	107370.180
3	117848.68	158907.69	131949.55	200682.218	335121.916	98703.355
4	71990.61	69178.10	102301.88	76624.815	133184.482	190057.895
5	31244.31	44975.80	53840.19	62563.784	39139.866	96708.923
6	25870.08	23167.81	33568.37	26843.347	34949.370	22754.826
7	56201.78	19416.18	18587.45	13841.629	10715.150	24479.905
8	29383.34	42493.89	13110.43	7065.271	4378.449	6614.112
9	36077.63	156289.91	24855.25	8320.764	3793.263	2076.940

year age	2001	2002	2003	2004	2005	2006	2007
1	1093739.096	1142676.895	446256.723	266886.33	312347.74	535371.42	277381.86
2	601679.257	402280.918	419789.966	164024.72	98104.54	114851.65	196779.73
3	64051.924	376543.698	265115.599	279123.97	110251.60	68539.26	76380.70
4	65271.851	39009.053	223847.172	177884.80	191061.71	81030.19	46003.69
5	133379.404	50223.994	26745.401	161955.89	131622.26	153132.92	58648.95
6	75858.409	97449.529	28288.990	18986.22	117803.97	104411.13	108752.83
7	13841.031	59825.213	61616.552	20263.43	13922.46	93906.54	74820.07
8	19222.298	6260.589	45548.808	42380.91	14326.36	10856.61	64621.19
9	4171.354	5754.276	7369.287	23070.93	13149.46	26677.19	18249.70

year age	2008	2009	2010
1	342338.91	630166.54	588137.34
2	101931.32	125864.63	231610.43
3	127365.10	70180.59	83174.16
4	48770.19	91124.99	46557.06
5	31480.57	37925.46	65093.47
6	39192.04	24167.21	26552.40
7	73494.93	30271.07	17081.60
8	48064.25	55226.74	20497.50
9	66955.98	47042.60	59596.15

TABLE 5.6.15 Herring in VIa (North). SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2011
1	NA
2	3950163.36
3	151006.65
4	53825.98
5	32343.68
6	44216.67
7	18229.22
8	11178.13
9	55641.90

TABLE 5.6.16 Herring in VIa (North). FITTED SELECTION PATTERN

Units : NA

age	2003	2004	2005	2006	2007	2008
1	0.003922736	0.003922736	0.003922736	0.003922736	0.003922736	0.003922736
2	0.483360359	0.483360359	0.483360359	0.483360359	0.483360359	0.483360359
3	0.889958021	0.889958021	0.889958021	0.889958021	0.889958021	0.889958021
4	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000
5	1.085000073	1.085000073	1.085000073	1.085000073	1.085000073	1.085000073
6	1.044783184	1.044783184	1.044783184	1.044783184	1.044783184	1.044783184
7	1.226226064	1.226226064	1.226226064	1.226226064	1.226226064	1.226226064
8	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000
9	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000

age	2009	2010
1	0.003922736	0.003922736
2	0.483360359	0.483360359
3	0.889958021	0.889958021
4	1.000000000	1.000000000
5	1.085000073	1.085000073
6	1.044783184	1.044783184
7	1.226226064	1.226226064
8	1.000000000	1.000000000
9	1.000000000	1.000000000

TABLE 5.6.17 Herring in VIa (North). PREDICTED CATCH IN NUMBERS

Units : NA

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

year

TABLE 5.6.17 continued. Herring in VIa (North). PREDICTED CATCH IN NUMBERS

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	14294	26396	5253	17719	1728	266	1952	1193	9092	7635	3568.58
2	40867	23013	24469	95288	36554	82176	37854	55810	74167	35252	18161.91
3	40779	25229	24922	18710	40193	30398	30899	34966	34571	93910	17263.76
4	74279	28212	23733	10978	6007	21272	9219	31657	31905	25078	40673.54
5	26520	37517	21817	13269	7433	5376	7508	23118	22872	13364	12264.30
6	13305	13533	33869	14801	8101	4205	2501	17500	14372	7529	7120.78
7	9878	7581	6351	19186	10515	8805	4700	10331	8641	3251	3083.08
8	21456	6892	4317	4711	12158	7971	8458	5213	2825	1257	1451.93
9	5522	4456	5511	3740	10206	9787	31108	9883	3327	1089	455.93

age \ year	2001	2002	2003	2004	2005	2006	2007
1	142.98	992.20	247.3792	133.1068	93.92185	296.2654	192.0518
2	81030.48	38481.61	37260.0752	13164.3074	4833.21079	10177.3325	21545.4679
3	14942.91	93975.06	43509.3500	41598.7120	10242.96414	11230.6209	15301.1679
4	9305.89	9014.41	42767.7560	30903.1323	20788.94688	15457.4717	10694.7084
5	24482.25	18113.71	5494.7087	30280.8408	15461.92797	31412.1254	14630.0388
6	9280.71	28016.08	5620.2105	3431.4002	13357.01619	20711.5262	26260.3541
7	6624.96	9040.10	14095.6220	4224.7021	1833.24354	21449.9648	20709.9588
8	4610.61	1547.86	8702.4566	7362.6454	1558.81536	2071.0272	15022.8120
9	1000.53	1422.68	1407.9600	4008.0100	1430.76000	5088.9900	4242.6000

age \ year	2008	2009	2010
1	128.5703	369.2648	7040.319
2	6229.5161	11775.5188	24070.522
3	14592.9611	12110.8907	15860.360
4	6532.6560	18293.4338	10311.399
5	4547.0687	8182.8827	15478.403
6	5466.9950	5043.6173	6110.129
7	11875.5528	7266.8144	4511.283
8	6438.0964	11086.8233	4539.761
9	8968.6000	9443.8500	13199.280

TABLE 5.6.18 Herring in VIa (North). CATCH RESIDUALS

Units : Thousands NA

age \ year	2003	2004	2005
1	-1.48342998	-Inf	0.6642871150873095320577
2	-0.11140539	-0.6541499735591980169147	0.6896535913206351953164
3	0.07430765	-0.6269324159248597094773	0.8191423112496212244338
4	0.22886912	-0.1052738338207073603980	-0.0090143569292715983177
5	0.30617057	0.4133851978004446925397	-0.4122812915023512103652
6	-0.25744693	0.1321278628739084859411	-0.3113772193234328744538
7	-0.09498418	0.5926791989560888929134	-0.5912011657362400418592
8	0.05425157	0.1414102511389307426093	-0.2658134368284216231260
9	0.00000000	-0.0000000000000001110223	-0.0000000000000001110223

age \ year	2006	2007	2008	2009	2010
1	-0.8049749842408561173457	-0.38447827	-Inf	1.65045022	0.35831629
2	-0.4193263716996037948626	0.46573759	0.23736535	-0.02293333	-0.16840592
3	-0.2009558478696570893440	0.14872844	-0.11258829	-0.14505350	0.02926120
4	-0.1247281294932872514059	-0.48949960	-0.18531840	-0.09792534	-0.03487777
5	0.2680301377254705186282	-0.02526858	-0.34525051	0.01807943	-0.05786611
6	0.2936929230354884401422	0.15183316	0.03972804	0.12035470	0.03413999
7	-0.0224880631512752657275	0.03823189	0.22232331	0.03354309	-0.04280771
8	0.3843751317664331756951	-0.10057048	0.23484101	0.06183192	0.17146875
9	-0.0000000000000002220446	0.00000000	0.00000000	0.00000000	0.00000000

TABLE 5.6.19 Herring in VIa (North). PREDICTED INDEX VALUES

WoS Summer Acoustic Survey

Units : NA NA

age	1991	1992	1993	1994	1995	1996	1997
1	99003.68	219950.92	156845.78	235719.6	169048.8	255879.22	410240.80
2	316920.75	253675.63	525149.86	419891.9	600584.8	466775.09	707981.30
3	723078.00	322908.07	253202.34	459049.4	426629.8	604954.96	474878.48
4	567052.56	551388.46	221419.09	182994.2	288872.9	312904.39	405756.90
5	692934.23	368005.42	387388.78	146974.0	129128.9	186542.40	179229.57
6	146689.01	458630.83	249919.85	301421.1	106949.9	99324.31	100127.51
7	96472.39	92723.71	305514.00	172456.1	236941.8	76963.23	53868.84
8	109383.99	60892.96	58323.66	205371.7	113107.4	172766.81	45172.51
9	78758.03	86567.85	51563.74	191988.5	154656.8	707629.48	95371.03

age	1998	1999	2000	2001	2002	2003
1	134281.38	83367.59	459380.255	306688.07	320206.56	125086.15
2	1161060.65	356673.09	226350.976	1301969.27	895371.73	938878.26
3	776755.45	1190626.78	381295.948	236577.17	1372572.09	1032296.04
4	275510.69	580067.45	812529.809	293406.52	164665.97	973020.62
5	221585.64	141672.99	412125.513	546815.16	178684.27	107941.28
6	78664.34	139147.16	83890.619	322189.78	366934.05	114012.55
7	36293.36	40445.82	105353.685	44101.60	253174.36	246710.43
8	24291.14	16641.25	26491.559	75824.70	24556.60	186250.23
9	31858.37	16055.35	9264.057	18324.14	25135.35	33557.26

age	2004	2005	2006	2007	2008	2009	2010
1	74812.06	87570.50	150065.20	NA	95972.7	176631.41	3012634.70
2	369023.27	225411.35	256896.86	433694.4	232347.8	280556.37	512493.14
3	1098734.80	451141.95	266925.46	289479.2	513589.2	271579.15	317541.80
4	782745.36	878151.02	352297.04	193988.8	220495.9	393356.01	197943.62
5	662365.77	564354.58	618167.96	229029.5	132589.2	151911.38	256474.46
6	77503.78	503274.78	420898.94	424618.5	164578.6	96695.05	104566.83
7	82359.91	59691.37	376095.73	288628.2	308806.1	120174.44	66562.41
8	175428.95	61941.36	44402.33	256335.3	204417.2	224257.54	81979.69
9	106349.97	63313.17	121504.59	80617.7	317121.6	212730.72	265438.99

TABLE 5.6.20 Herring in VIa (North). INDEX RESIDUALS
WoS Summer Acoustic Survey

Units : NA

age	1991	1992	1993	1994	1995	1996
1	1.22881151	-1.0851589	-4.19787339	0.7401964	0.9593111	-1.825781958
2	-0.07342707	0.6853883	0.09817133	0.2554164	0.6082477	0.211058414
3	-0.79080232	-0.4256043	1.00179227	0.2805565	0.1038128	0.282615233
4	-0.43283112	-0.7591312	1.13480659	0.4451728	0.4439271	0.050494365
5	-0.35002970	0.1195783	0.37713143	0.7358102	0.1696272	-0.670999373
6	0.18414452	-0.6471485	1.28170994	-0.1170364	0.5598169	-0.494095438
7	0.02324341	0.1306968	-0.03295460	0.8582775	-0.3367331	0.005400617
8	-0.19694550	-0.0711670	0.99576411	-0.1672618	0.7384555	-0.792800989
9	-0.30519615	-0.3108339	1.14137670	-0.3755433	0.2655728	-1.818642031

age	1997	1998	1999	2000	2001	2002
1	0.65822105	2.208061148	1.857510696	-0.02597833	0.02069146	0.28241675
2	-0.09804747	-0.379212626	-0.101026640	0.33428814	-0.20372402	-0.71959673
3	-0.50647289	-0.152665407	0.153383985	-0.12319622	-0.08315647	0.04580160
4	-0.88752090	0.536380256	-0.294718803	0.10168645	-0.52942423	0.19339787
5	-0.99749878	-0.213144041	0.776578271	-0.04650104	-0.22303412	-0.09987760
6	-0.70406786	0.007669834	-0.003218775	1.08230074	-0.88780368	0.14525863
7	-1.19661481	-0.257646154	0.760181191	0.63849112	0.84628934	-0.50822617
8	-0.44353769	-0.561826645	0.505931342	1.27705072	-0.36951754	1.01114686
9	-1.36155369	0.143382199	0.790669888	1.94824521	0.63852028	0.86170091

age	2003	2004	2005	2006	2007	2008
1	1.2550410	2.0200751	-0.55642919	-0.28989601	NA	-0.6962016375
2	0.1017131	-0.2959084	0.07677924	1.17899655	-1.23605823	0.0009559723
3	-0.1016716	-0.3683331	-0.67239923	0.37377815	0.01685611	0.5741613586
4	0.4138361	-0.5708190	-0.73021003	-0.21374143	0.04293927	1.1097108033
5	0.5185657	-0.1376291	-0.83401646	-0.05994616	-0.45505034	0.9414549651
6	0.1250530	-0.3303466	-1.19200643	-0.01483739	-0.20215447	0.5032590394
7	0.3402446	-0.2871954	-1.55549058	-0.50489369	-0.17248949	0.8477312328
8	-0.4882645	-0.7580788	-0.46262656	-0.71597957	-0.44967331	0.5821696006
9	0.8068981	-0.3320623	-0.85969153	-0.71734277	-0.92086230	-0.1843216349

year

TABLE 5.6.20 continued. Herring in VIa (North). INDEX RESIDUALS

age	2009	2010
1	0.67185616	-3.22484678
2	-0.40705205	-0.03693806
3	-0.02815303	0.41972184
4	0.08975130	-0.14367888
5	0.89961803	-0.45060762
6	0.81766019	-0.11412416
7	0.43979782	-0.03807016
8	0.80120280	-0.43399333
9	0.76255121	-0.17281959

TABLE 5.6.21 Herring in VIa (North). FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL
F, 2003	0.223638521	0.1470826	0.167628308
F, 2004	0.201199003	0.1458762	0.151165782
F, 2005	0.121289171	0.1446341	0.091349680
F, 2006	0.223251173	0.1433777	0.168557556
F, 2007	0.279350053	0.1519248	0.207409064
F, 2008	0.151495697	0.1664625	0.109321242
F, 2009	0.236406810	0.1838297	0.164884949
F, 2010	0.264259181	0.2236472	0.170473831
Selectivity at age 1	0.003921736	0.3770853	0.001872824
Selectivity at age 2	0.483359359	0.1394528	0.367760893
Selectivity at age 3	0.889957021	0.1277594	0.692816164
Selectivity at age 5	1.084999073	0.1148603	0.866280111
Selectivity at age 6	1.044782184	0.1116173	0.839489368
Selectivity at age 7	1.226225064	0.1118462	0.984838050
Terminal year pop, age 1	10748792.954324342	0.8625282	1982261.299407002
Terminal year pop, age 2	231609.428459009	0.3180442	124174.251014013
Terminal year pop, age 3	83173.164007027	0.2524731	50707.682774775
Terminal year pop, age 4	46556.064787960	0.2206020	30213.154435798
Terminal year pop, age 5	65092.471181141	0.2042163	43621.269390660
Terminal year pop, age 6	26551.400749794	0.1994455	17960.400688385
Terminal year pop, age 7	17080.598817369	0.1951210	11652.328868806
Terminal year pop, age 8	20496.504525047	0.2007944	13828.026088680
Last true age pop, 2003	45547.807753170	0.2690027	26883.620661267
Last true age pop, 2004	42379.905486501	0.2128030	27926.621752496
Last true age pop, 2005	14325.359646585	0.1900915	9869.528621441
Last true age pop, 2006	10855.609772853	0.1693040	7790.041135365
Last true age pop, 2007	64620.194647729	0.1708038	46235.667534984
Last true age pop, 2008	48063.250284777	0.1787467	33857.964108400
Last true age pop, 2009	55225.736469364	0.1751838	39176.179772591
Index 1, age 1 numbers, Q	0.483640418	0.5544866	0.163130072
Index 1, age 2 numbers, Q	2.793638826	0.1760179	1.978521740
Index 1, age 3 numbers, Q	4.839667630	0.1749366	3.434839822
Index 1, age 4 numbers, Q	5.185287368	0.1746270	3.682368997
Index 1, age 5 numbers, Q	4.864522196	0.1749093	3.452664404
Index 1, age 6 numbers, Q	4.834016739	0.1756437	3.426077747
Index 1, age 7 numbers, Q	4.909840876	0.1772991	3.468545524
Index 1, age 8 numbers, Q	4.877779899	0.1793299	3.432207542
Index 1, age 9 numbers, Q	5.432045488	0.1770019	3.839691562

	Upper.95.pct.CL
F, 2003	0.298363616
F, 2004	0.267792342
F, 2005	0.161041210
F, 2006	0.295691795
F, 2007	0.376244175
F, 2008	0.209940409
F, 2009	0.338952585
F, 2010	0.409640084
Selectivity at age 1	0.008212207
Selectivity at age 2	0.635293948
Selectivity at age 3	1.143194314
Selectivity at age 5	1.358940339
Selectivity at age 6	1.300278304
Selectivity at age 7	1.526776822

Terminal year pop, age 1	58285227.083581589
Terminal year pop, age 2	431997.188733237
Terminal year pop, age 3	136424.597465163
Terminal year pop, age 4	71739.188079370
Terminal year pop, age 5	97132.198664875
Terminal year pop, age 6	39251.734635968
Terminal year pop, age 7	25037.643482665
Terminal year pop, age 8	30380.814662275
Last true age pop, 2003	77169.768806802
Last true age pop, 2004	64313.414095073
Last true age pop, 2005	20792.880478425
Last true age pop, 2006	15127.553435562
Last true age pop, 2007	90314.897111647
Last true age pop, 2008	68228.438678154
Last true age pop, 2009	77850.417939868
Index 1, age 1 numbers, Q	1.433874527
Index 1, age 2 numbers, Q	3.944570198
Index 1, age 3 numbers, Q	6.819061146
Index 1, age 4 numbers, Q	7.301605328
Index 1, age 5 numbers, Q	6.853714530
Index 1, age 6 numbers, Q	6.820545113
Index 1, age 7 numbers, Q	6.950042104
Index 1, age 8 numbers, Q	6.932196391
Index 1, age 9 numbers, Q	7.684762620

Table 5.7.1.1. Herring in VIa (North). Input data for short-term predictions, numbers at age from the assessment with ages 1- and 2-ring in 2010 and 2-ring in 2011 replaced by geometric mean values (1989-2009) - natural mortality (M), proportion mature (Mat), proportion of fishing mortality prior to spawning (PF), proportion of natural mortality prior to spawning (PM), mean weights at age in the stock (SWt), selection pattern (Sel), mean weights at age in the catch (CWt). All biological data are taken as mean of the last 3 years. VIa (N) herring appears to have considerable annual variability in mean weights and in fraction mature. Last year's values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	588137.3	1	0	0.67	0.67	7.34E-02	1.04E-03	6.46E-02
2	228795	0.3	0.823333	0.67	0.67	0.145933	0.127733	0.166
3	151006.7	0.2	1	0.67	0.67	0.188467	0.23518	0.2028
4	53825.98	0.1	1	0.67	0.67	0.209967	0.26426	0.227267
5	32343.68	0.1	1	0.67	0.67	0.2196	0.286722	0.236767
6	44216.67	0.1	1	0.67	0.67	0.22	0.276095	0.247267
7	18229.22	0.1	1	0.67	0.67	0.2205	0.324043	0.2499
8	11178.13	0.1	1	0.67	0.67	0.225267	0.26426	0.259633
9	55641.9	0.1	1	0.67	0.67	0.230667	0.26426	0.271867

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	588137.3	1	0	0.67	0.67	7.34E-02	1.04E-03	6.46E-02
2	.	0.3	0.823333	0.67	0.67	0.145933	0.127733	0.166
3	.	0.2	1	0.67	0.67	0.188467	0.23518	0.2028
4	.	0.1	1	0.67	0.67	0.209967	0.26426	0.227267
5	.	0.1	1	0.67	0.67	0.2196	0.286722	0.236767
6	.	0.1	1	0.67	0.67	0.22	0.276095	0.247267
7	.	0.1	1	0.67	0.67	0.2205	0.324043	0.2499
8	.	0.1	1	0.67	0.67	0.225267	0.26426	0.259633
9	.	0.1	1	0.67	0.67	0.230667	0.26426	0.271867

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	588137.3	1	0	0.67	0.67	7.34E-02	1.04E-03	6.46E-02
2	.	0.3	0.823333	0.67	0.67	0.145933	0.127733	0.166
3	.	0.2	1	0.67	0.67	0.188467	0.23518	0.2028
4	.	0.1	1	0.67	0.67	0.209967	0.26426	0.227267
5	.	0.1	1	0.67	0.67	0.2196	0.286722	0.236767
6	.	0.1	1	0.67	0.67	0.22	0.276095	0.247267
7	.	0.1	1	0.67	0.67	0.2205	0.324043	0.2499
8	.	0.1	1	0.67	0.67	0.225267	0.26426	0.259633
9	.	0.1	1	0.67	0.67	0.230667	0.26426	0.271867

Table 5.7.1.2. Herring in VIa (North). Short-term prediction single option table, with F constraint (Fsq (avg 2008-2010)). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year:	2011	F multiplier:	0.8226	Fbar:	0.2185				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0009	317	20	588137	43150	0	0	0	0
2	0.1051	19768	3281	228795	33389	188375	27490	143600	20956
3	0.1935	24152	4898	151007	28460	151007	28460	116013	21865
4	0.2174	10026	2279	53826	11302	53826	11302	43515	9137
5	0.2359	6480	1534	32344	7103	32344	7103	25826	5671
6	0.2271	8565	2118	44217	9728	44217	9728	35514	7813
7	0.2666	4068	1017	18229	4020	18229	4020	14260	3144
8	0.2174	2082	541	11178	2518	11178	2518	9037	2036
9	0.2174	10364	2818	55642	12835	55642	12835	44983	10376
Total		85823	18506	1183375	152503	554817	103454	432747	80998

Year:	2012	F multiplier:	1	Fbar:	0.2656				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.001	385	25	588137	43150	0	0	0	0
2	0.1277	22467	3729	216179	31548	177988	25974	133638	19502
3	0.2352	29097	5901	152589	28758	152589	28758	113998	21485
4	0.2643	22566	5128	101886	21393	101886	21393	79822	16760
5	0.2867	9318	2206	39188	8606	39188	8606	30243	6641
6	0.2761	5320	1315	23117	5086	23117	5086	17968	3953
7	0.324	8420	2104	31880	7030	31880	7030	23996	5291
8	0.2643	2798	727	12635	2846	12635	2846	9899	2230
9	0.2643	10775	2929	48648	11222	48648	11222	38113	8791
Total		111145	24065	1214260	159637	587931	110914	447676	84654

Year:	2013	F multiplier:	1	Fbar:	0.2656				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.001	385	25	588137	43150	0	0	0	0
2	0.1277	22463	3729	216139	31542	177955	25970	133613	19499
3	0.2352	26877	5451	140946	26564	140946	26564	105299	19845
4	0.2643	21871	4970	98748	20734	98748	20734	77363	16244
5	0.2867	16831	3985	70781	15544	70781	15544	54625	11996
6	0.2761	6126	1515	26620	5856	26620	5856	20690	4552
7	0.324	4191	1047	15870	3499	15870	3499	11945	2634
8	0.2643	4621	1200	20862	4700	20862	4700	16344	3682
9	0.2643	9429	2563	42574	9820	42574	9820	33354	7694
Total		112793	24485	1220678	161408	594356	112686	453235	86145

Table 5.7.1.3. Herring in VIa (North). Short-term prediction multiple option table, with F constraint (Fsq (avg 2008-2010)).

2011				
Biomass	SSB	FMult	FBar	Landings
152503	80998	0.8226	0.2185	18506

2012					2013	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
159637	98937	0	0	0	183085	120772
.	97399	0.1	0.0266	2672	180674	116654
.	95887	0.2	0.0531	5282	178321	112698
.	94399	0.3	0.0797	7829	176024	108898
.	92937	0.4	0.1062	10317	173782	105247
.	91498	0.5	0.1328	12746	171594	101739
.	90083	0.6	0.1593	15119	169458	98368
.	88692	0.7	0.1859	17435	167372	95128
	88348	0.725	0.1925	18006	166859	94338
.	87323	0.8	0.2125	19698	165336	92015
.	85977	0.9	0.239	21907	163349	89022
	85644	0.925	0.2456	22451	162859	88292
	85379	0.945	0.251	22885	162470	87713
.	84654	1	0.2656	24065	161408	86145
.	83351	1.1	0.2921	26173	159514	83379
	82837	1.14	0.3027	27002	158769	82302
.	82071	1.2	0.3187	28232	157664	80719
.	80811	1.3	0.3452	30243	155858	78161
.	79572	1.4	0.3718	32207	154094	75702
.	78353	1.5	0.3983	34126	152372	73336
.	77155	1.6	0.4249	36001	150691	71060
.	75976	1.7	0.4515	37832	149049	68870
.	74816	1.8	0.478	39622	147445	66763
.	73675	1.9	0.5046	41370	145879	64736
.	72553	2	0.5311	43078	144350	62784

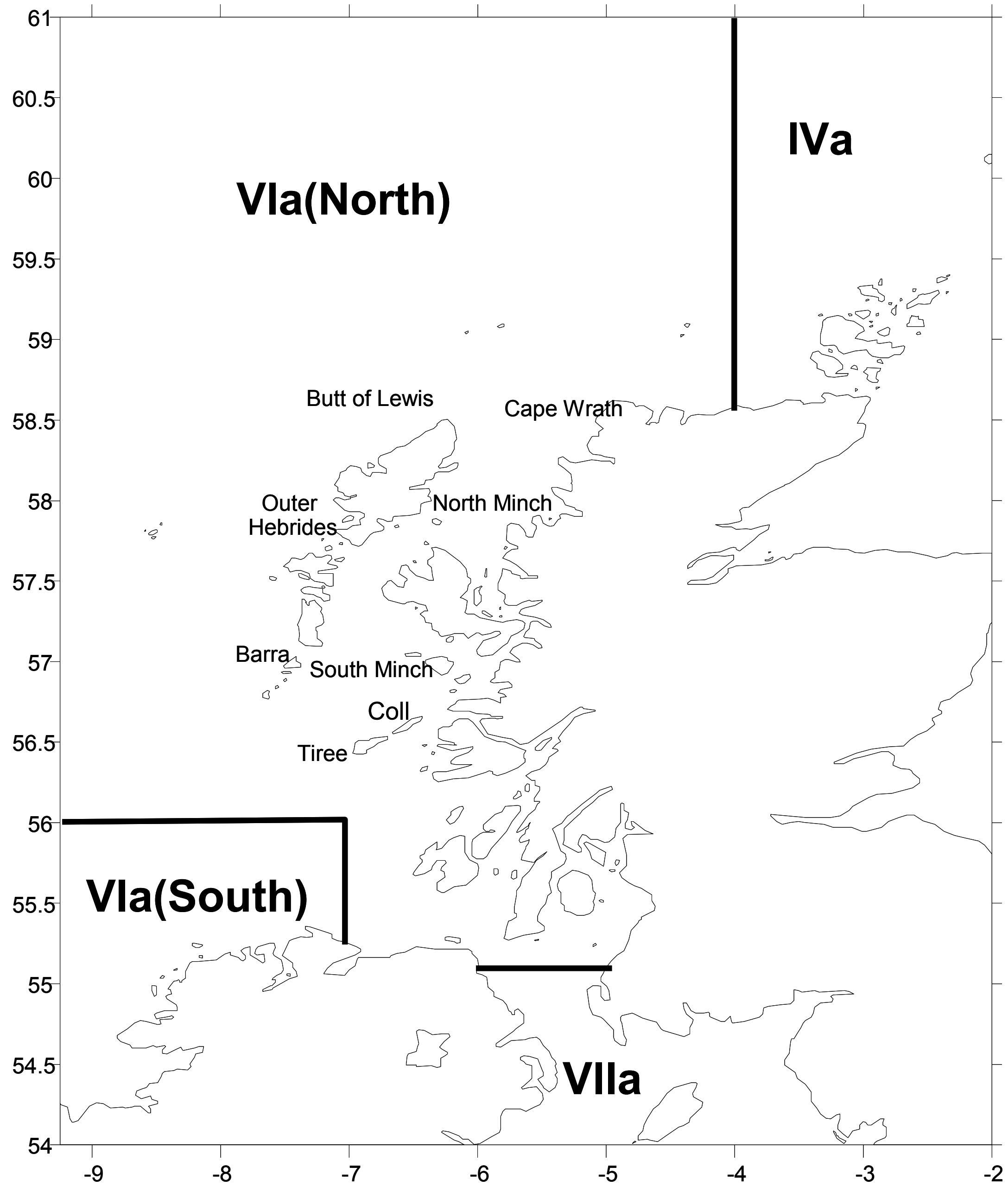


Figure 5.1. Location of ICES area VIa (North) and adjacent areas, with place names.

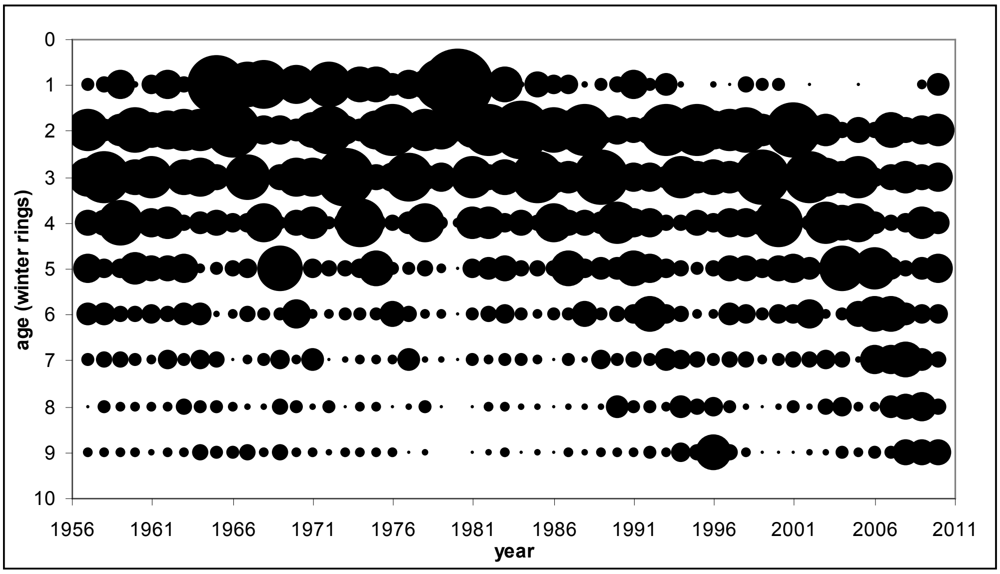


Figure 5.2.1. Herring in VIa (North). Mean standardised catch numbers-at-age standardised by year for the fishery, 1957 to 2010.

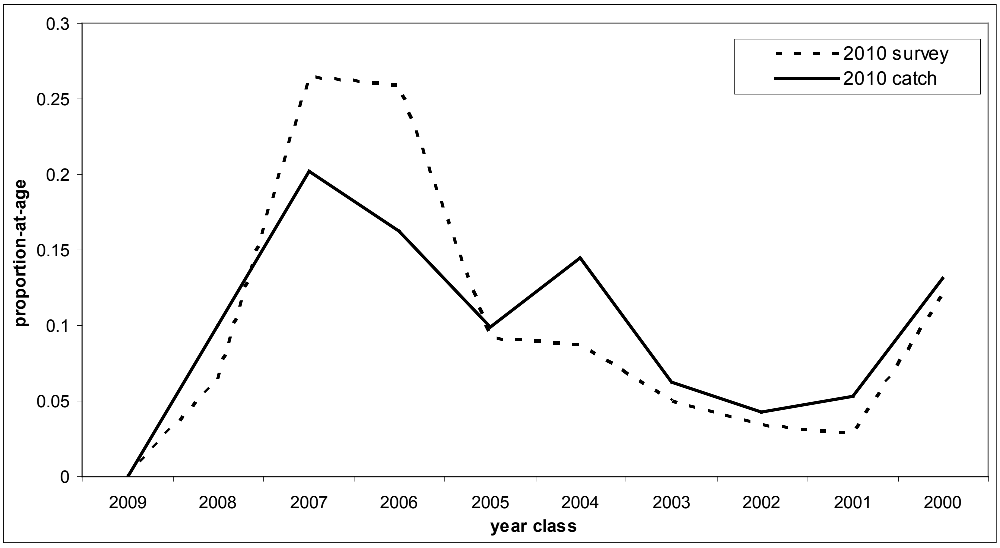


Figure 5.3.1. Herring in VIa (North). Comparison of the proportions-at-age, by year class, in the 2010 acoustic survey (MSHAS_N) and the catch.

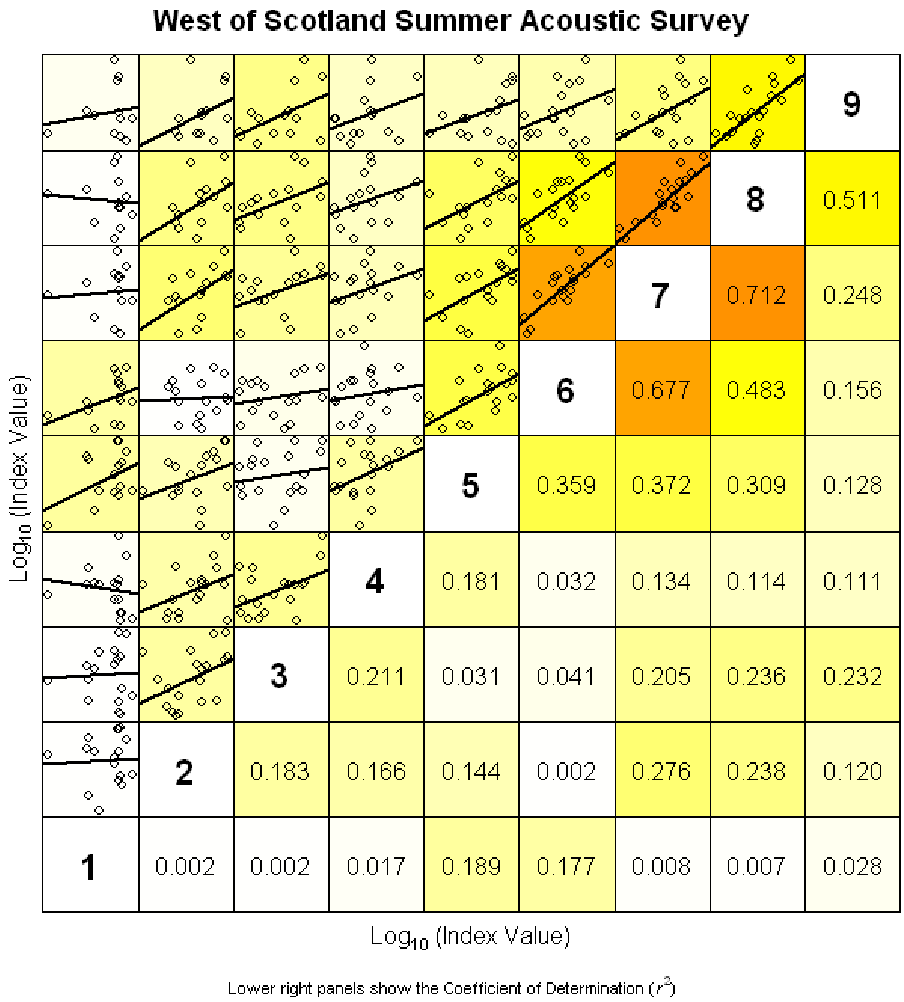


Figure 5.3.2. Herring in VIa (North). Internal consistency between ages in the West of Scotland acoustic survey time series.

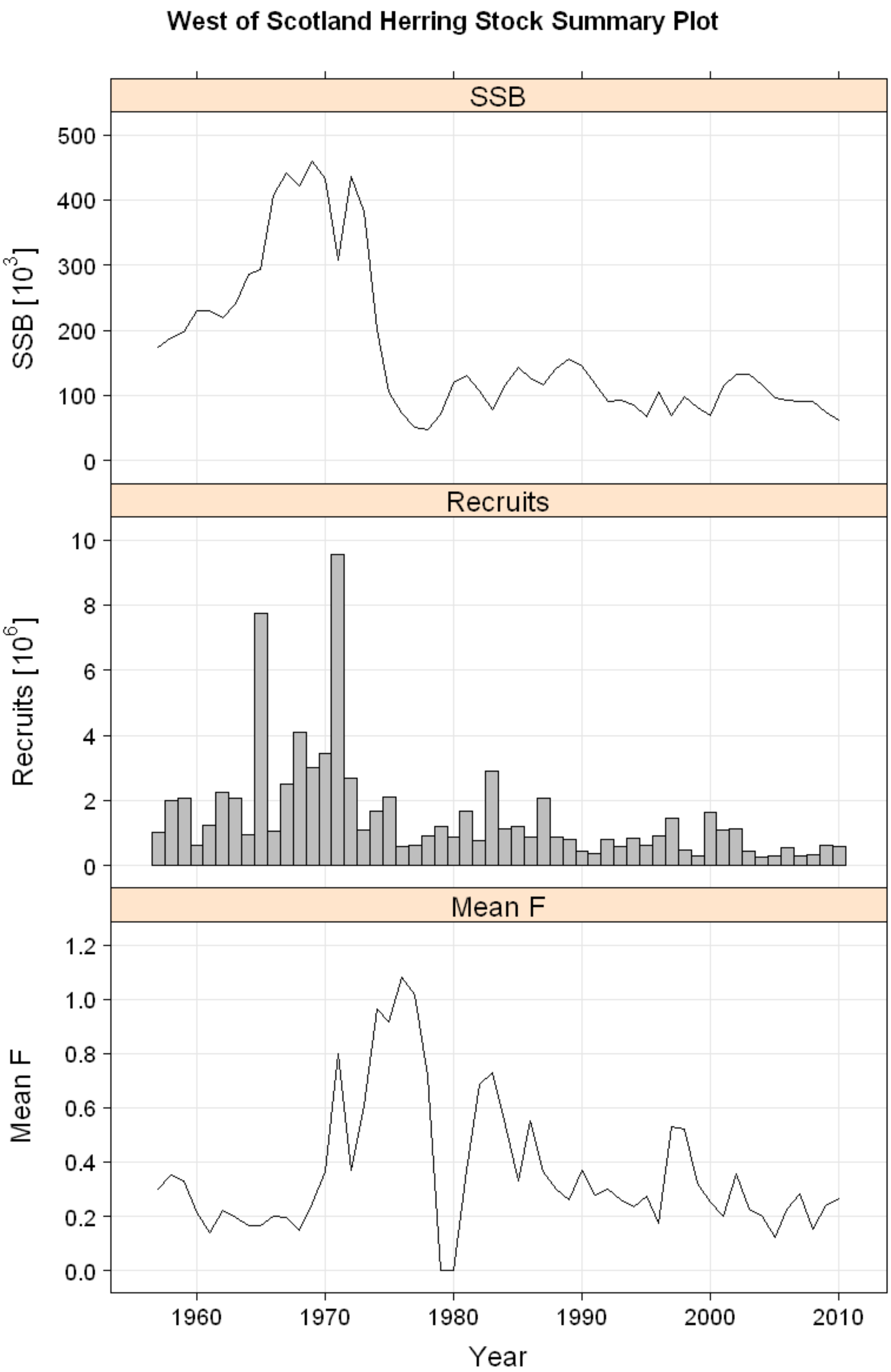


Figure 5.6.1. Herring in VIa (North). Illustration of stock trends from the assessment (8 year separable period) 1957-2010. Summary of estimates of landings, spawning stock biomass at spawning time, fishing mortality at F_{3-6}, recruitment at 1-ring, in the final assessment run. The 2010 estimate for recruitment is given as geometric mean (1989-2007) because there are no data to support its estimation.

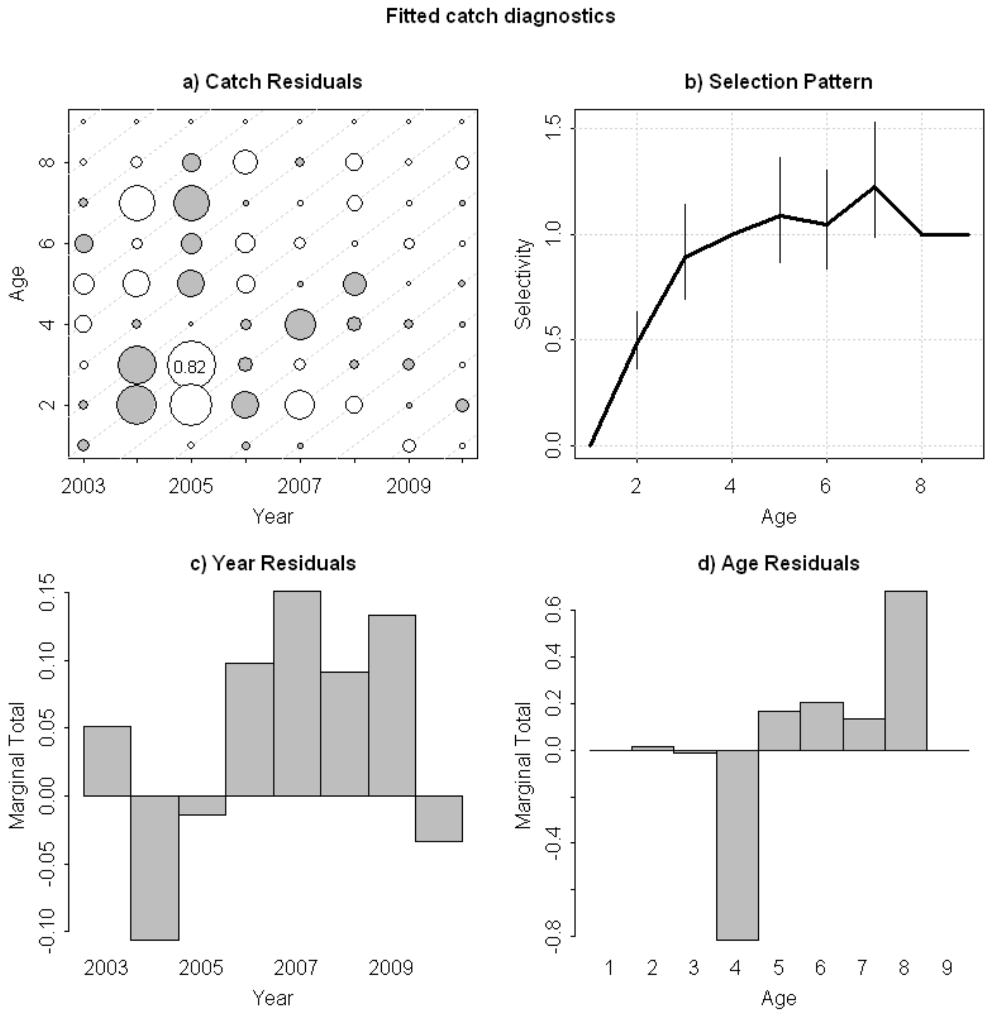


Figure 5.6.2. Herring in VIa (North). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring.

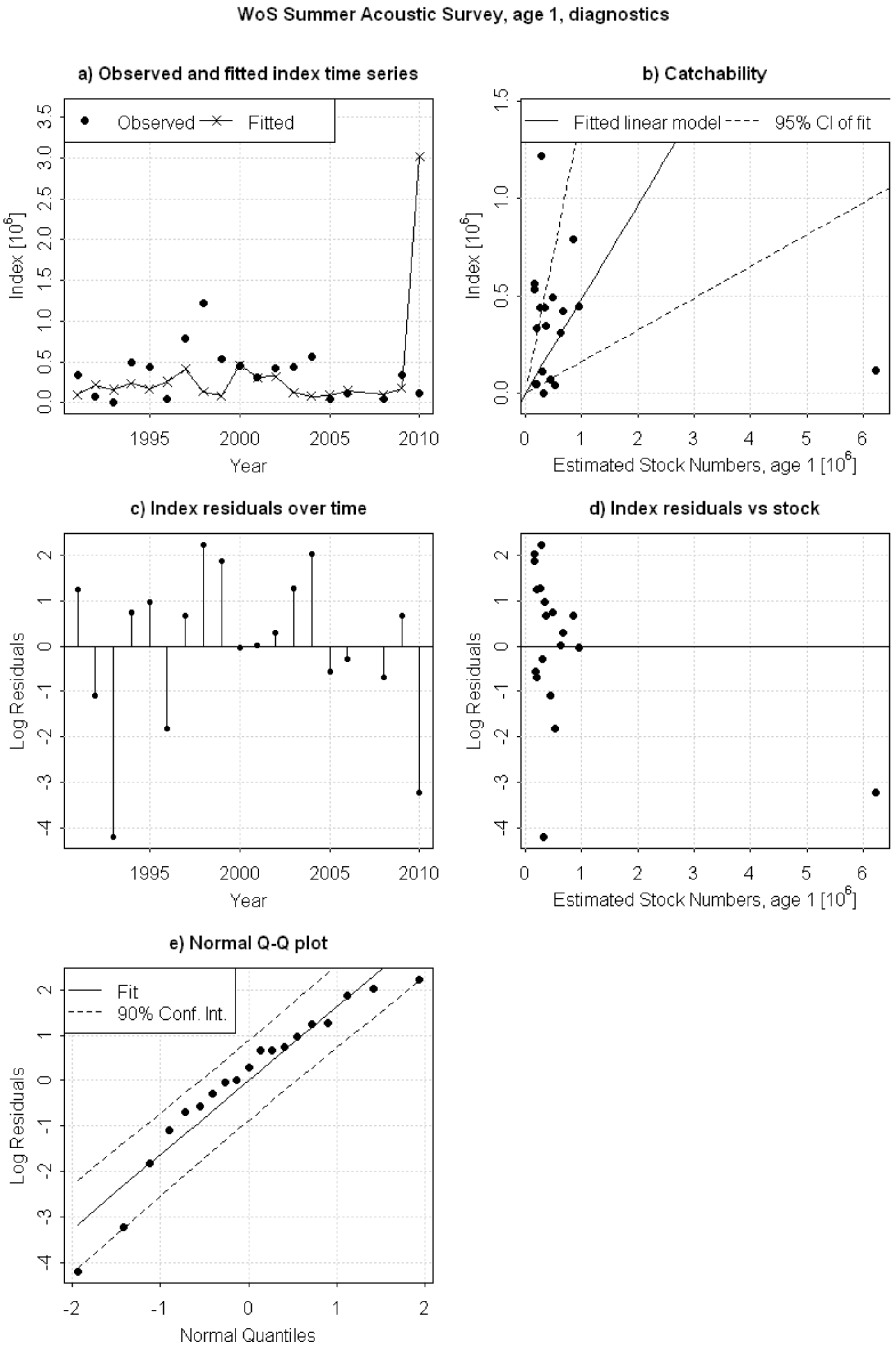


Figure 5.6.3. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 1 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

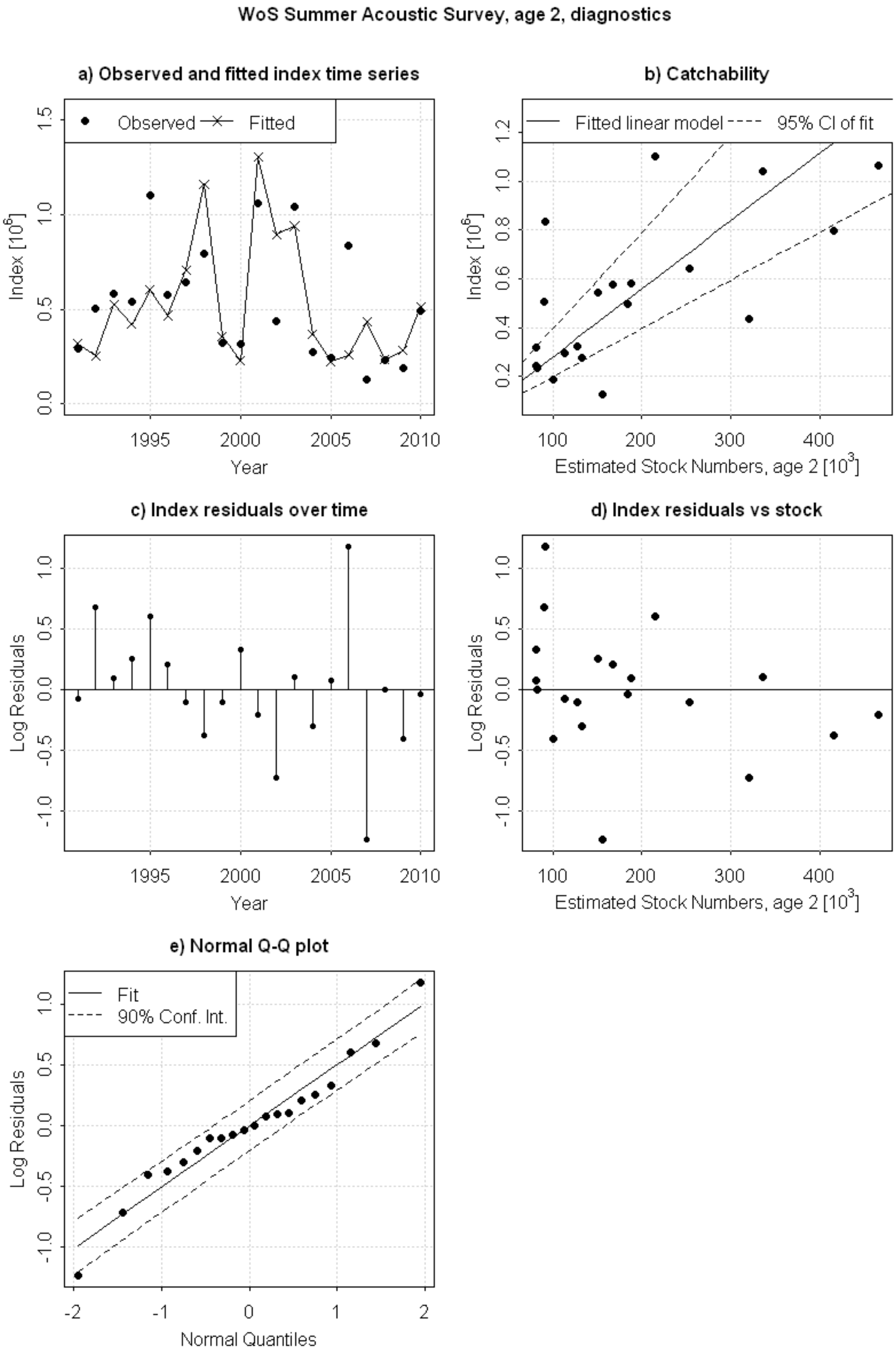


Figure 5.6.4. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 2 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

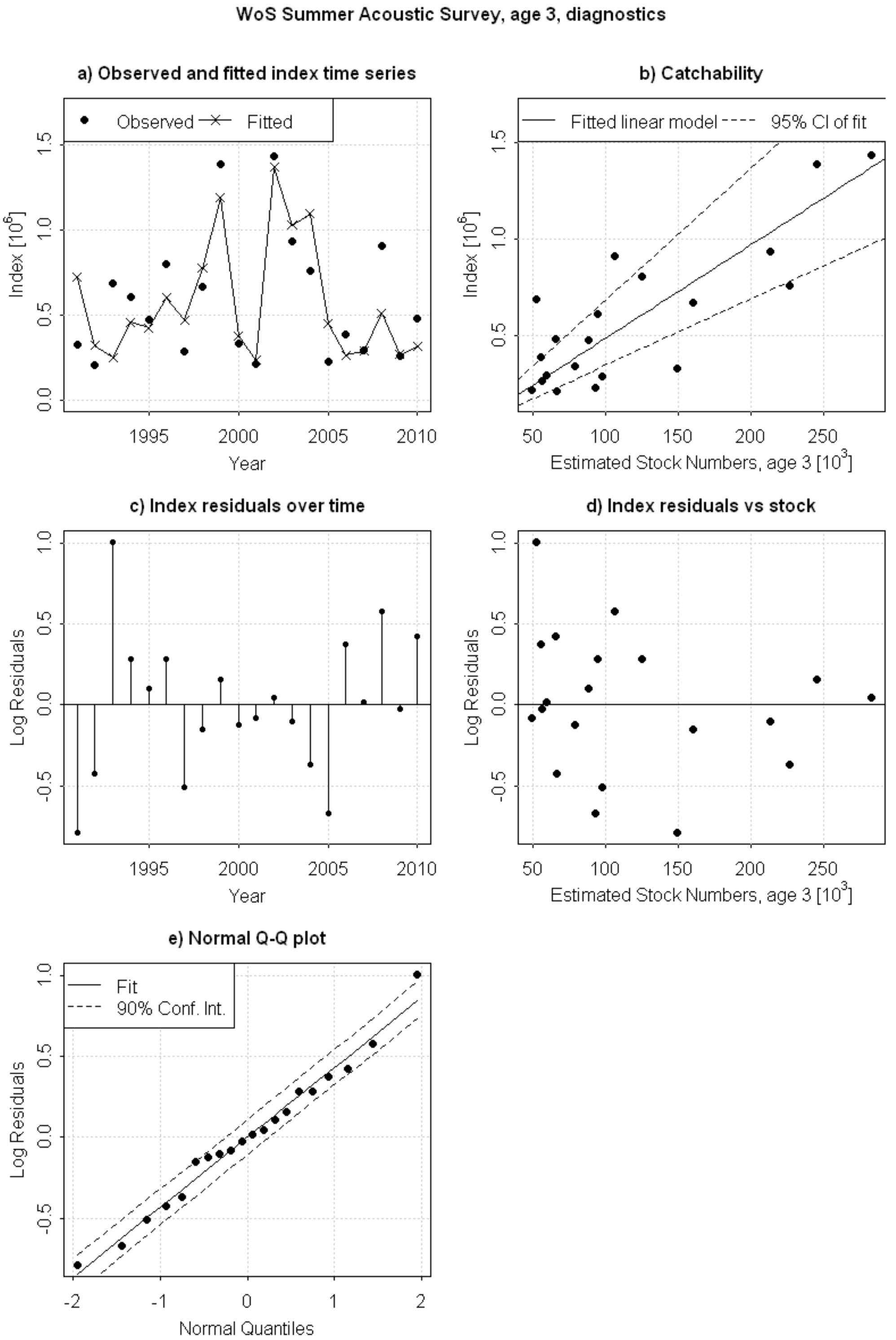


Figure 5.6.5. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 3 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

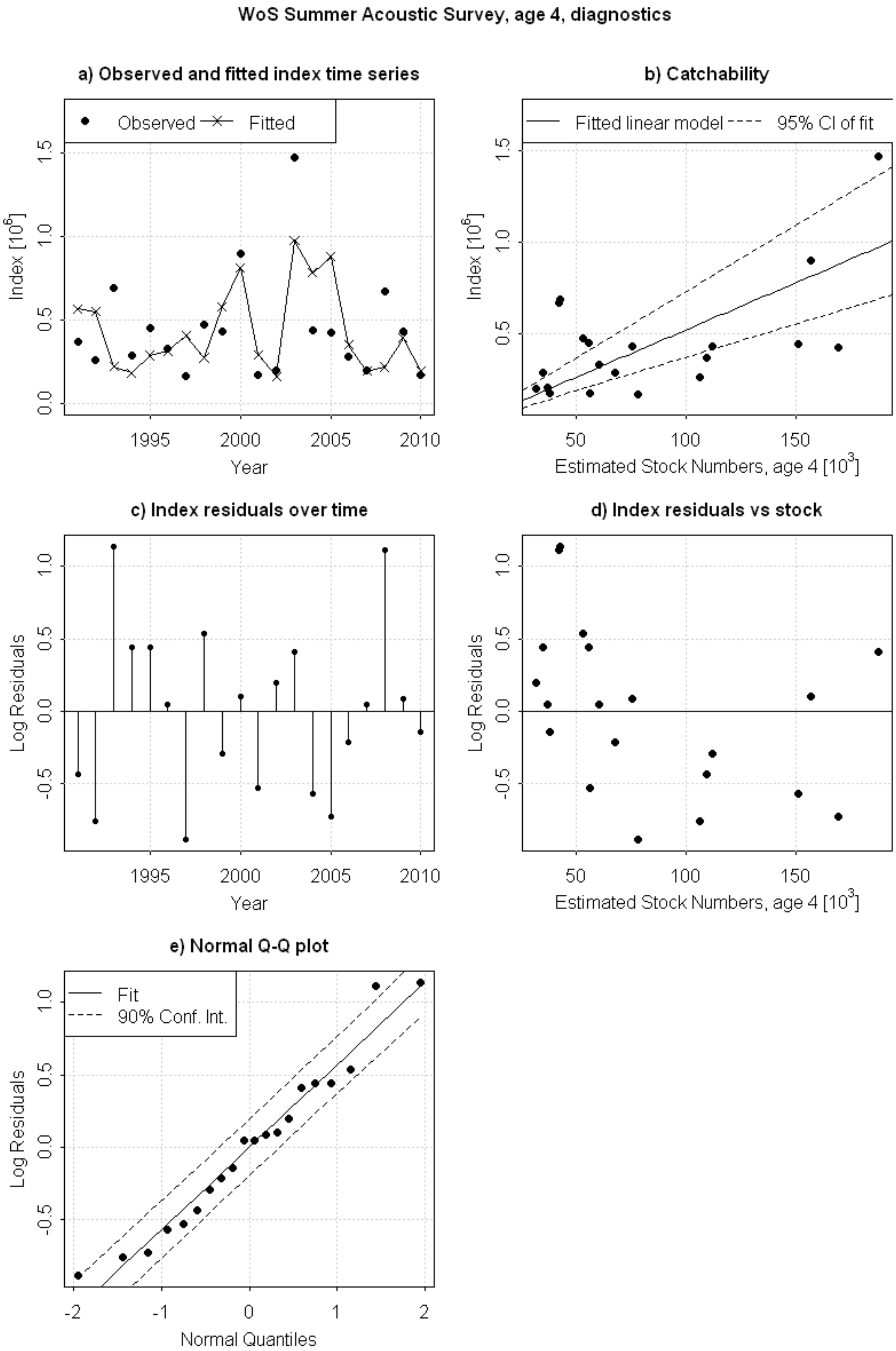


Figure 5.6.6. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 4 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

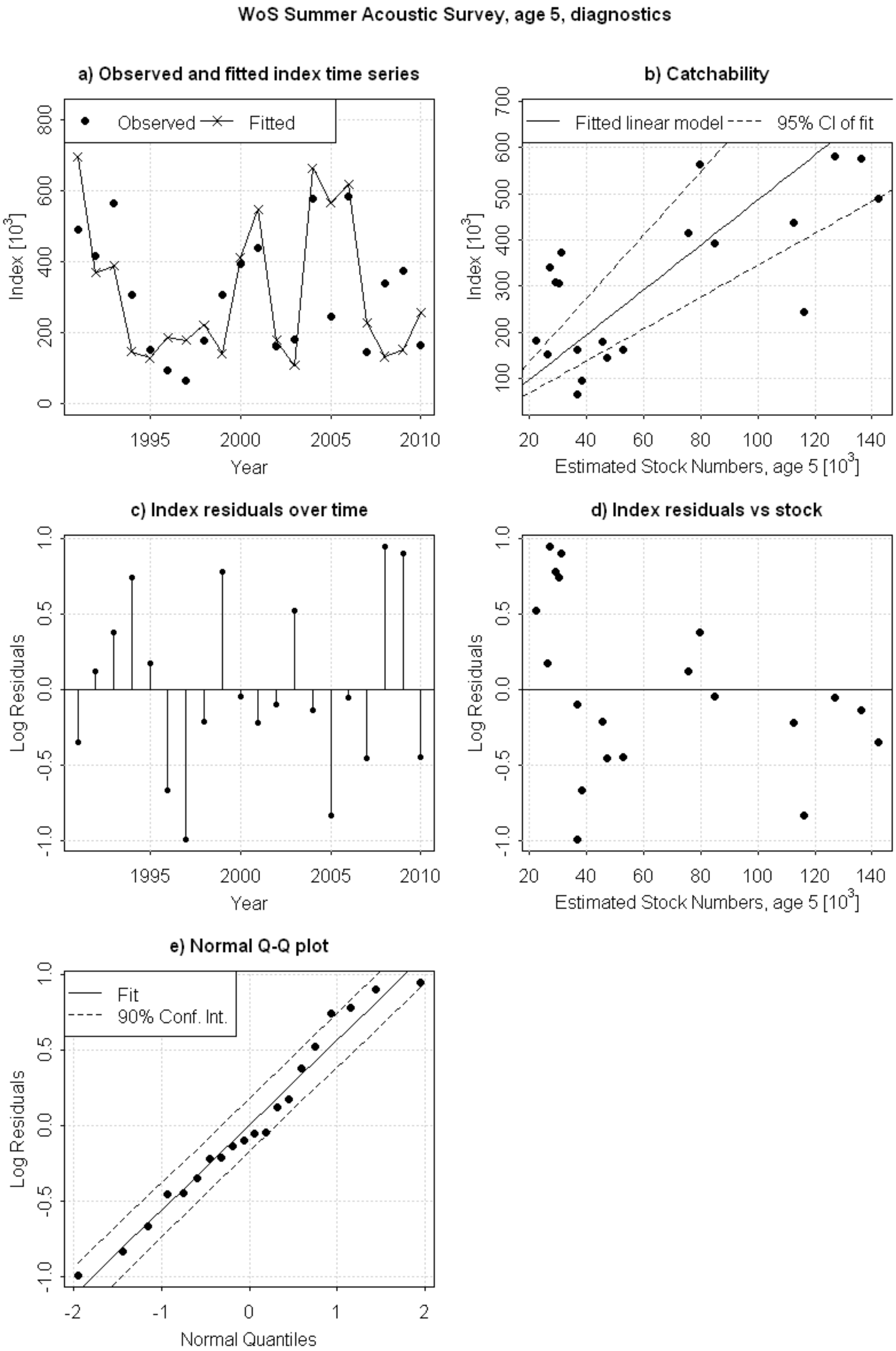


Figure 5.6.7. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 5 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

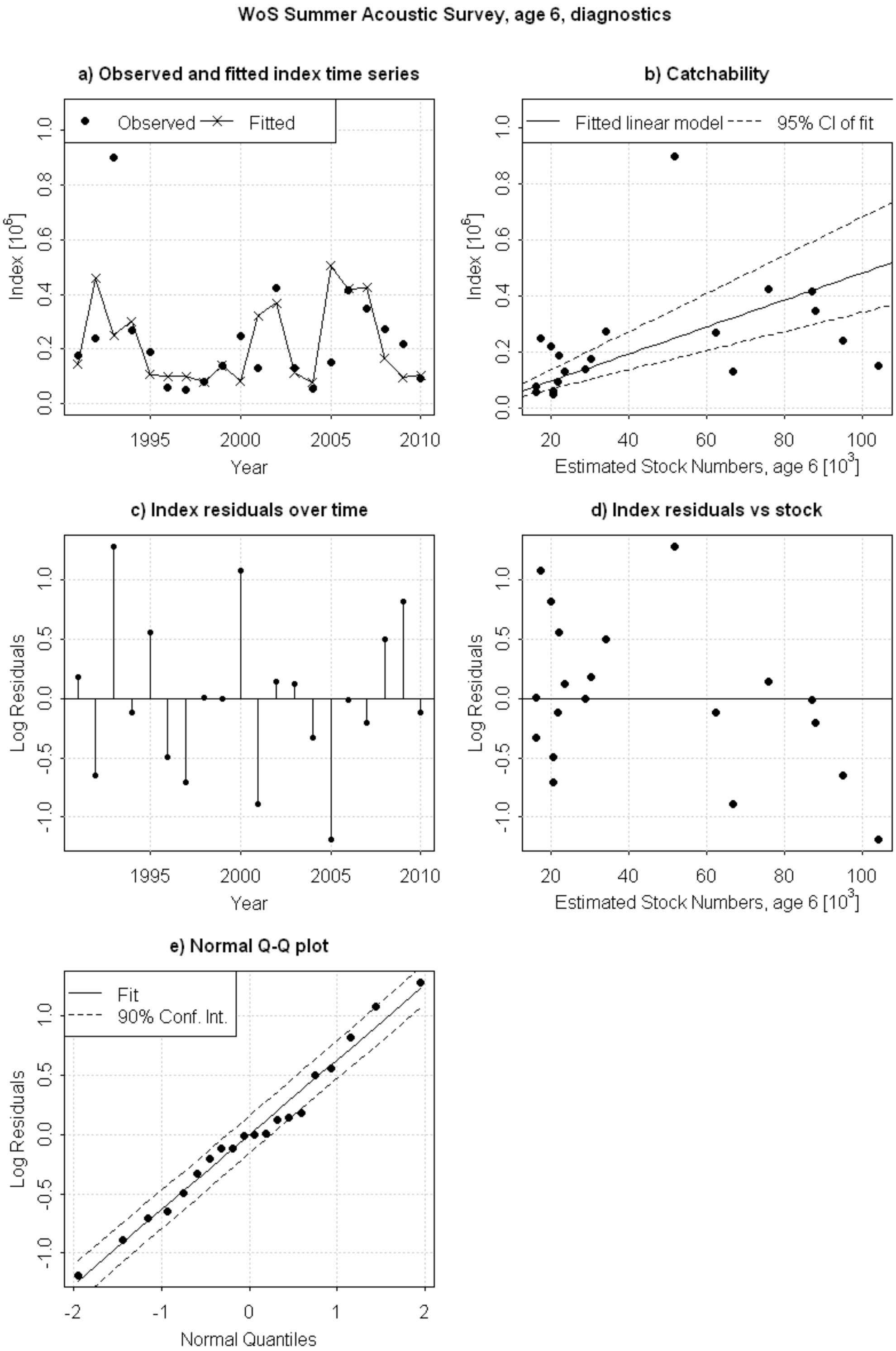


Figure 5.6.8. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 6 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

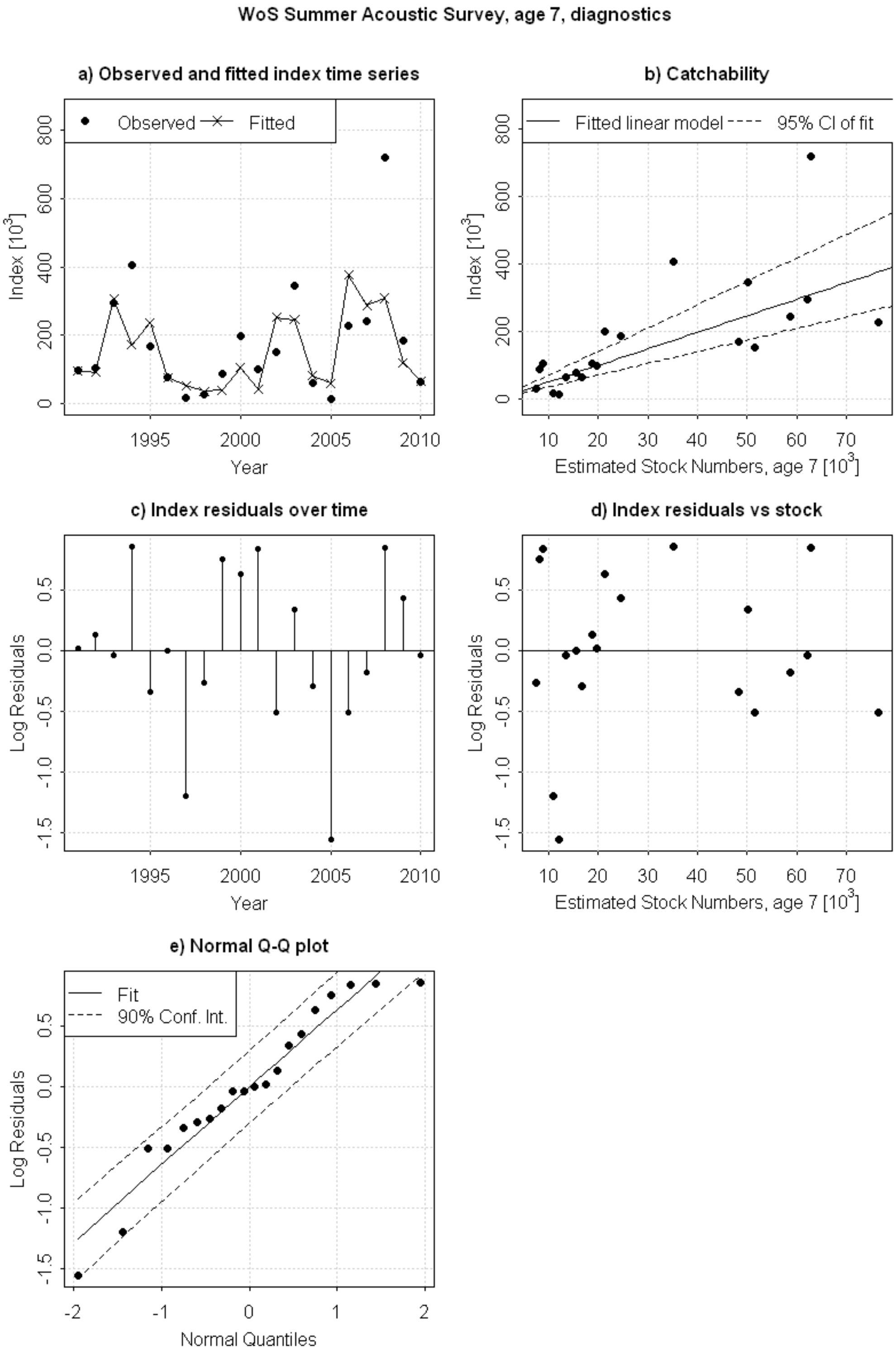


Figure 5.6.9. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 7 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

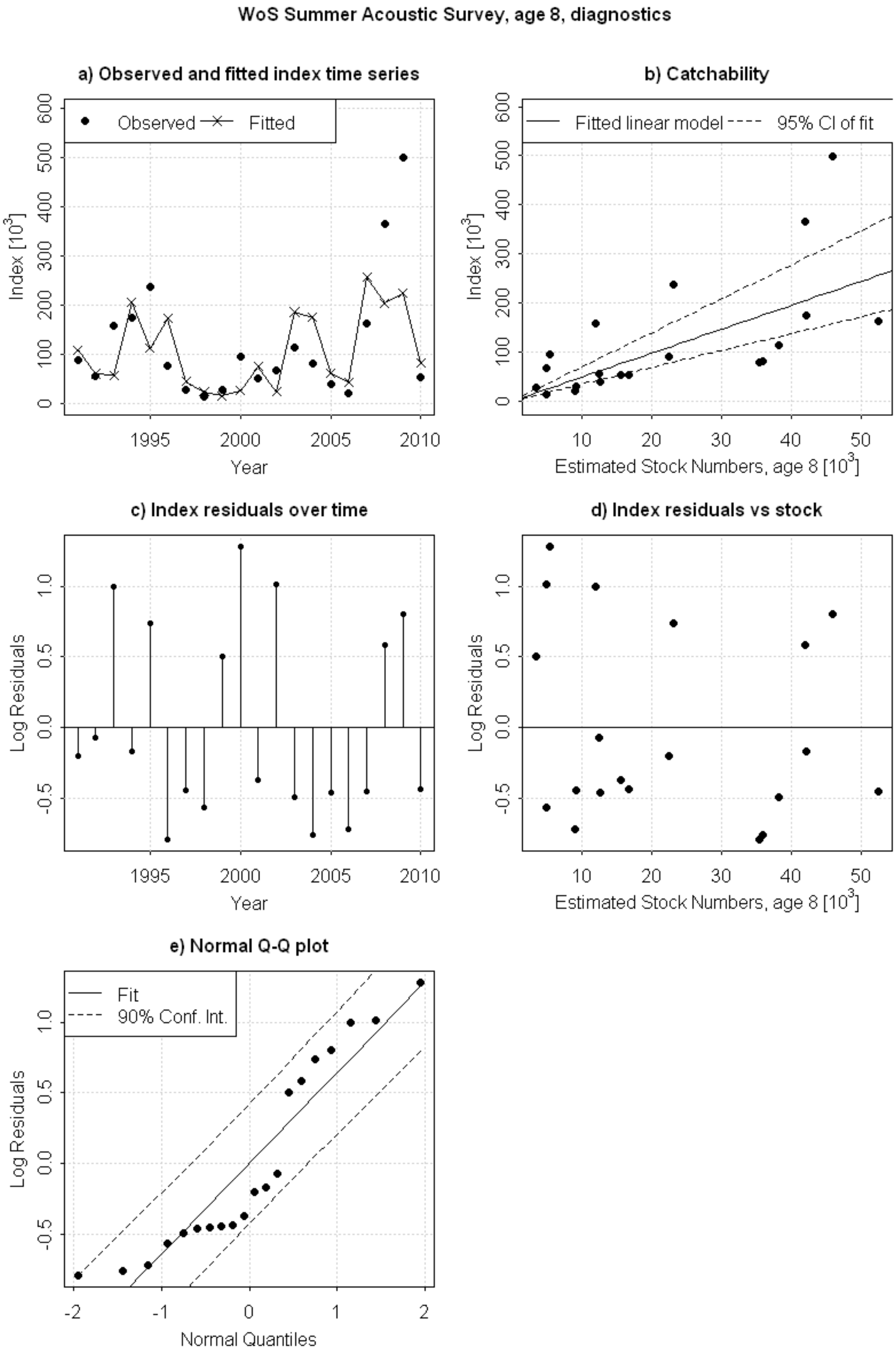


Figure 5.6.10. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 8 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

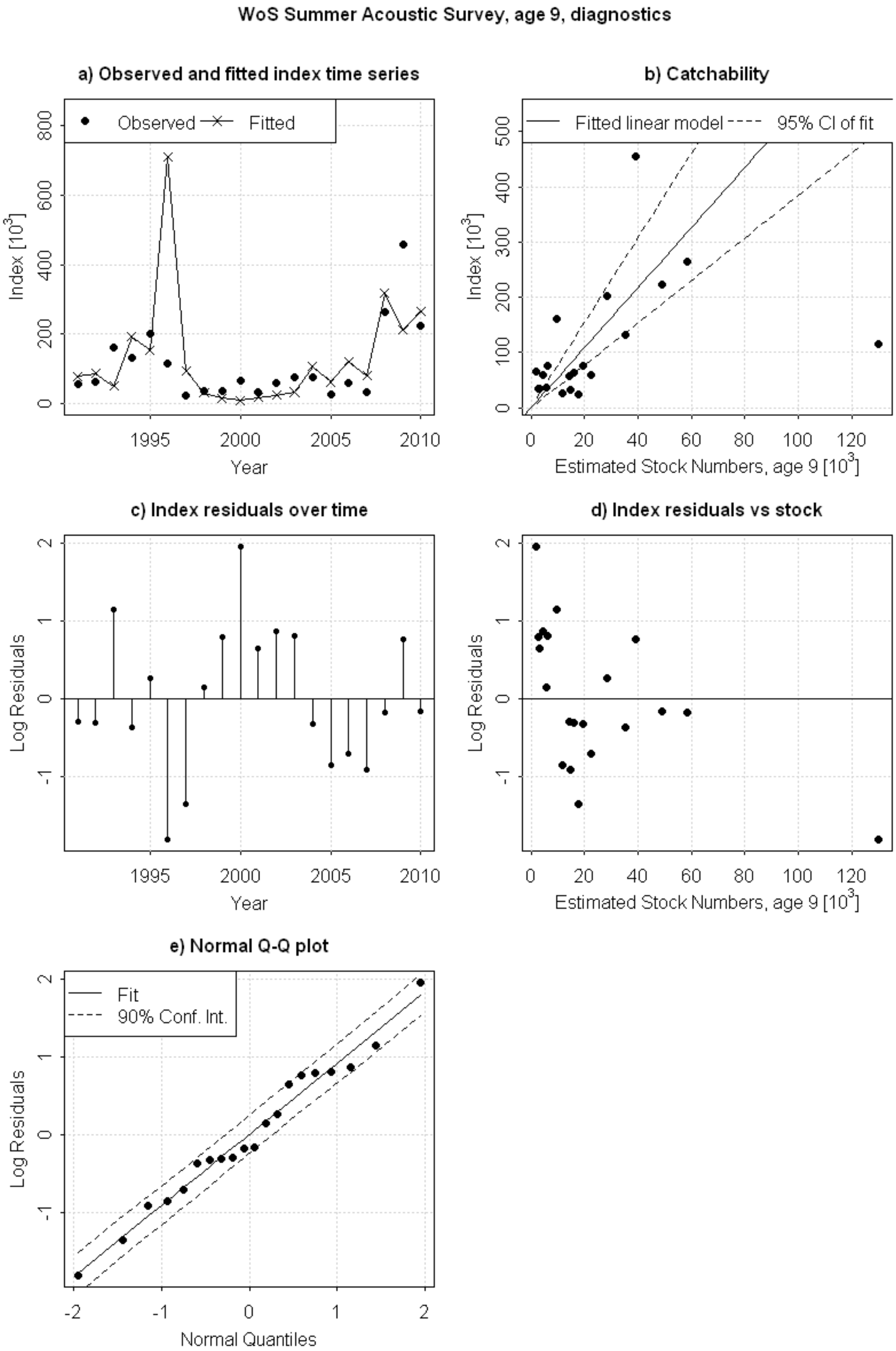


Figure 5.6.11. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 9 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d) Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e) Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

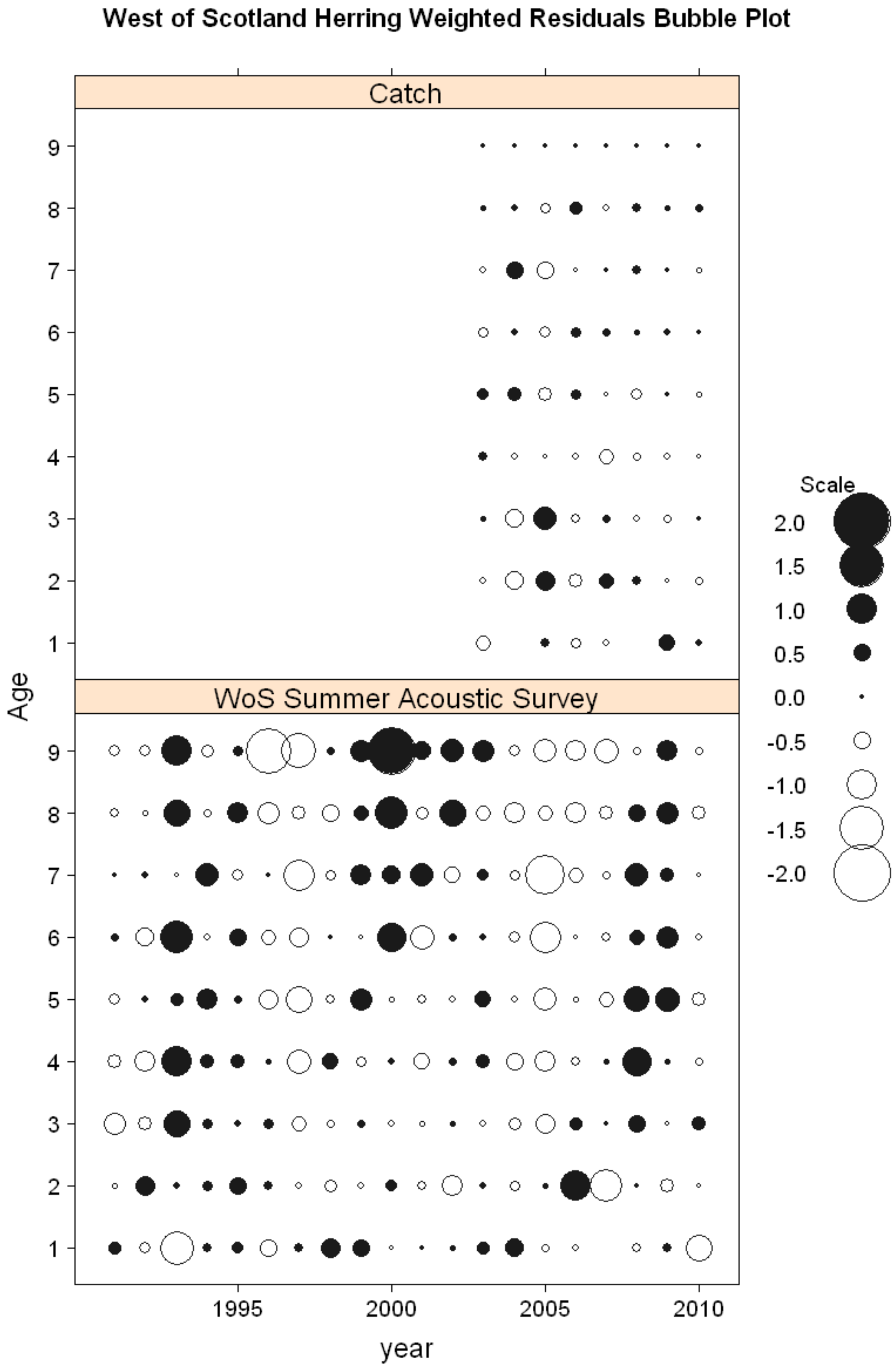


Figure 5.6.12. Herring in VIa (North). Comparison of residuals in the catch (top) and survey (bottom) Note the year effects in the survey, particularly in 2005, 2008 and 2009. The assessment effectively smoothes an otherwise noisy survey.

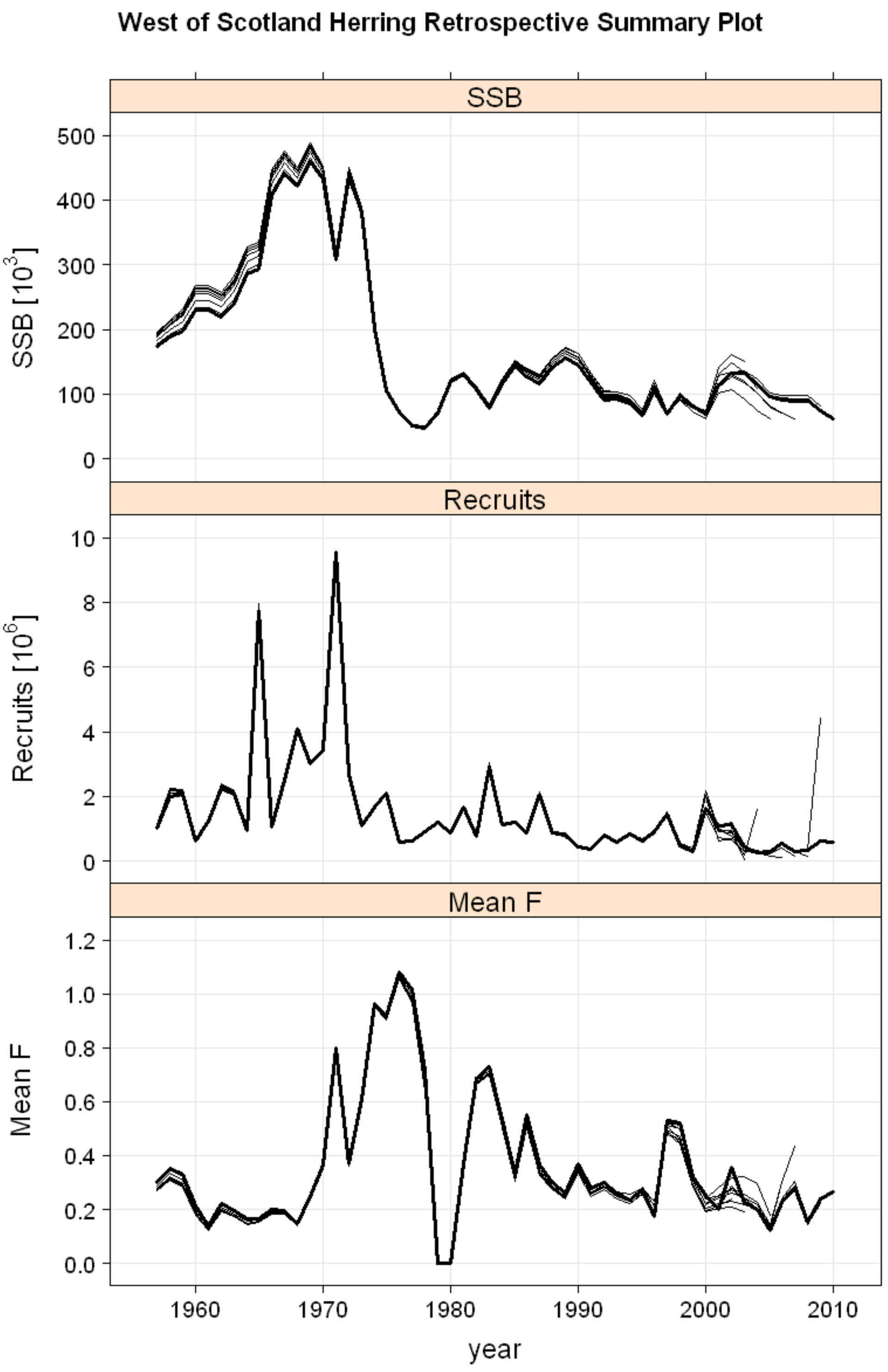


Figure 5.6.13. Herring in VIa (North). Analytical retrospective patterns (2010 to 2006) of SSB, recruitment and mean $F_{3\text{-}6}$ from the final assessment. The 2010 estimate for recruitment is given as geometric mean (1989 to 2009) because there are no data to support its estimation.

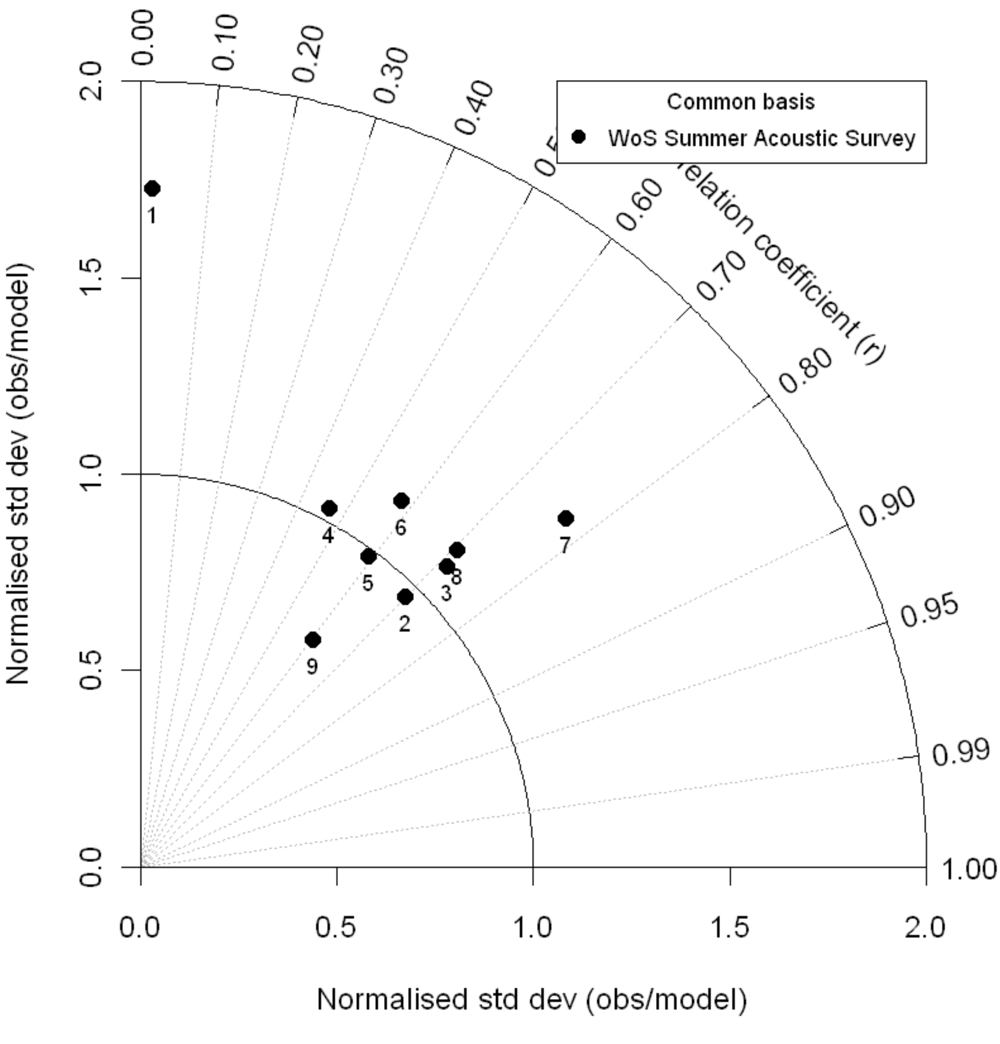
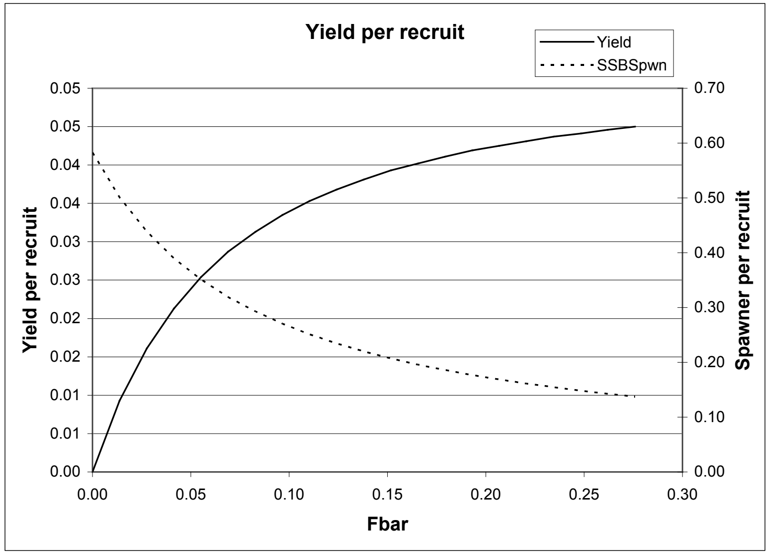
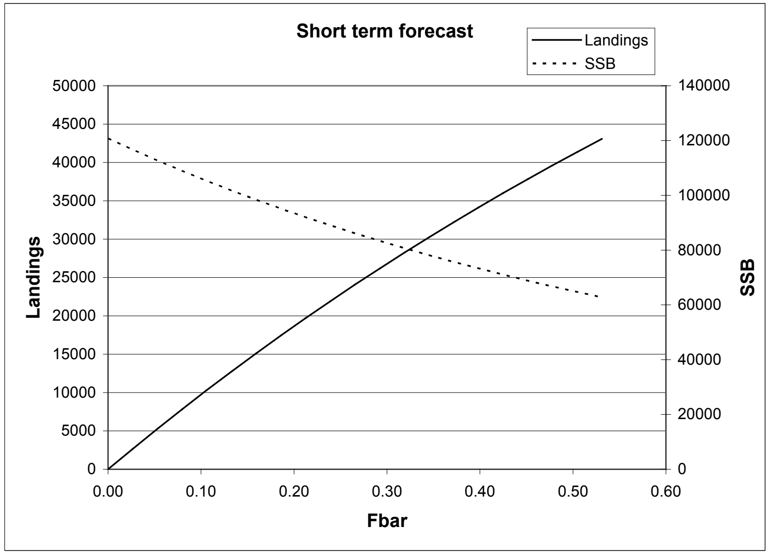


Figure 5.6.14. Herring in VIa (North). Taylor diagram. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the modeled values. The point corresponding to 1.0 on the horizontal axis represents a perfect fit between the model and the observations – the closer to this point the better. Points are labeled according to the survey and the age of the time series. All time series are truncated to allow comparison on a common basis.





MFYPR version 2a"
Run: Test
Time and date: 13:31 21/03/2011

Reference point	F multiplier	Absolute F
Fbar(1-9)	1.0000	0.1379
FMax	200.4630	27.6529
F0.1	1.0710	0.1477
F35%SPR	1.1278	0.1556
Flow		
Fmed		
Fhigh		

Weights in kilograms

MFDP version 1a
Run: Baseline
Herring VIaN
Time and date: 07:57 21/03/2011
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 5.7.2.1. Herring in VIa (North). Yield-per-recruit and short-term forecast.

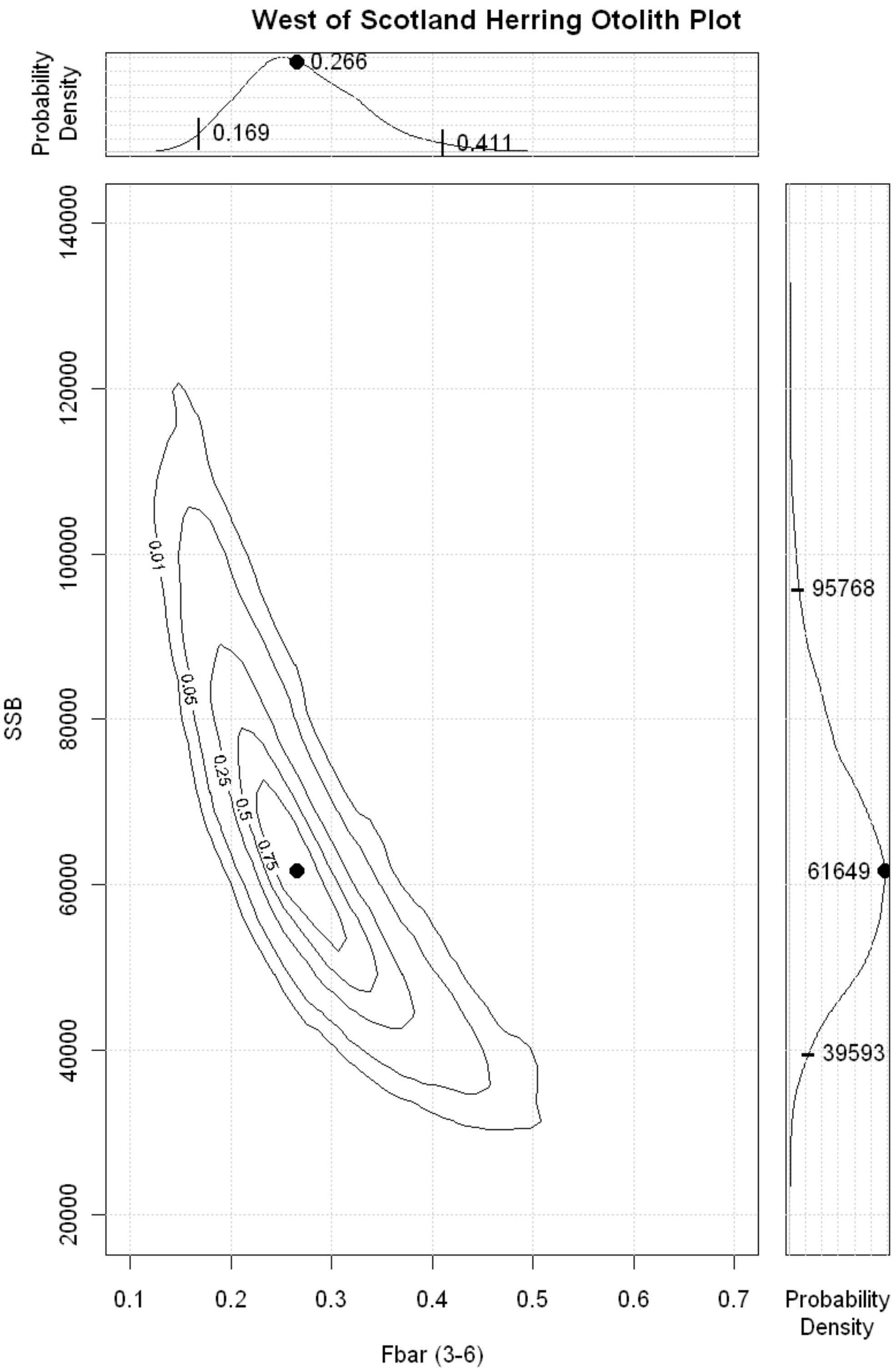


Figure 5.9.1. Herring in VIa (North). Results of parametric bootstrapping from FLICA. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance covariance matrix in the parameters returned by FLICA. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.

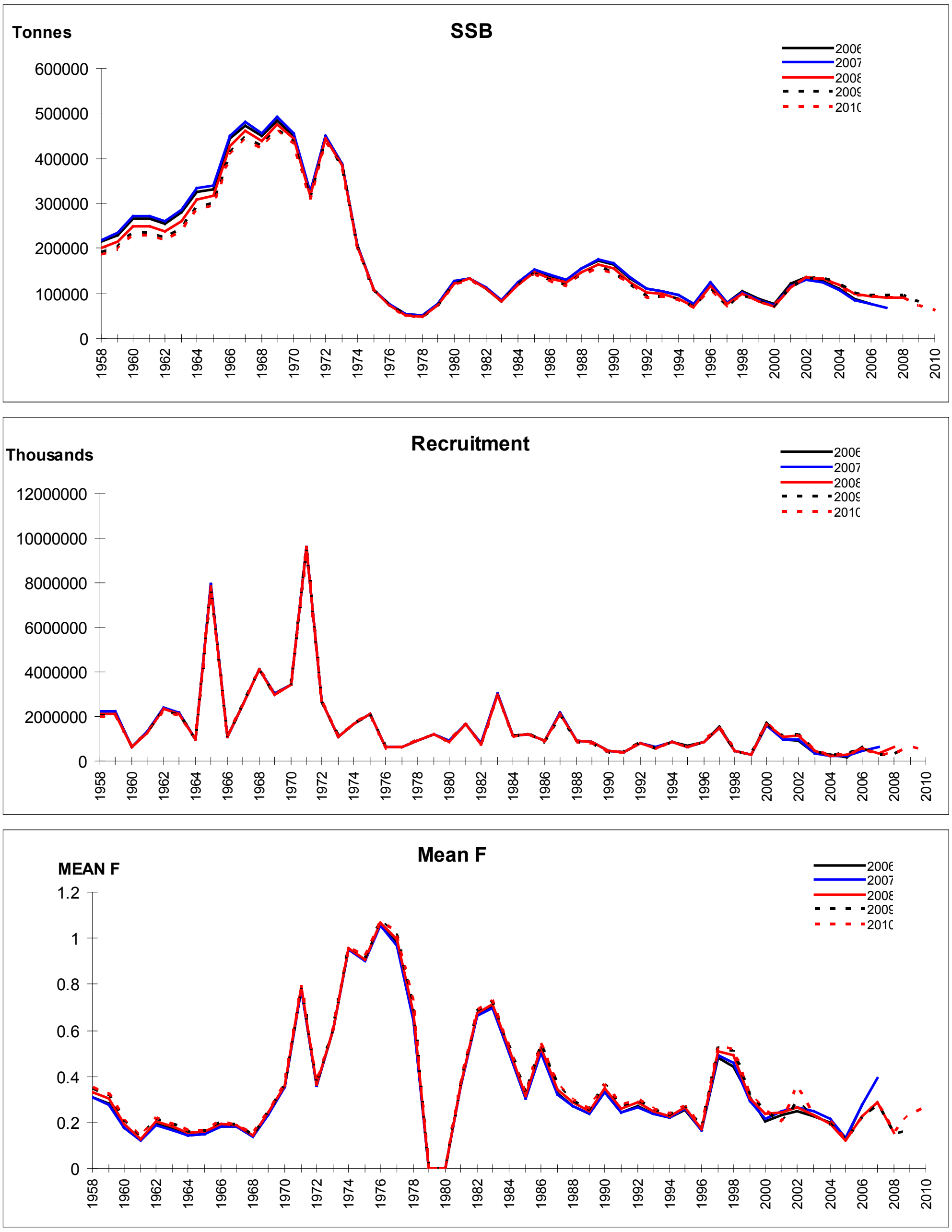


Figure 5.9.2. Herring in VIa (North). Historical retrospective patterns (2010 to 2006 assessments) of SSB, recruitment and mean $F_{3\text{-}6}$ from the final assessment. The final estimate for recruitment in each year is given as geometric mean (1989 to one year prior to the last data year) because there are no data to support its estimation.

6 Herring in Divisions VIa (South) and VIIb,c

This management unit has existed since 1982 when it was separated from VIaN. Until that time, VIIb,c was a separate management unit. The stock comprises autumn and winter, and spring spawning components. This stock is classified as "SALY" in 2011.

6.1 The Fishery

6.1.1 Advice and management applicable to 2010–2011

The TAC for this area in 2010 was 7 451 t with a decrease of 40% to 4 471 t in 2011. For 2011, ICES advised that there should be no fishing without a rebuilding plan (Precautionary Approach) and zero-catch (MSY Approach). The advice for the fishery in 2011 is therefore the same as the advice given in recent years. STECF followed the European Commission's policy statement on fishing opportunities for 2011 and stated that the TAC should be reduced by at least 25% and that recovery measures should be implemented.

Rebuilding plan

A rebuilding plan was developed by the Federation of Irish Fishermens' Organisations and the Pelagic RAC in 2009. The plan was for *status quo* TAC in 2010, and, in subsequent years a TAC set at $F_{0.1}$. This plan was not adopted. However this plan is still the stated policy of the Pelagic RAC for management of this stock.

6.1.2 Catches in 2010

The working group estimates of landings recorded by each country from this fishery from 1988 – 2010 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 2010 was over 7 513 t, compared with 8 533 t in 2009. The total working group estimates of catches in these areas from 1970 –2010 are shown in Figure 6.1.2.1. The working group estimates of catch have declined from about 19 000 t in 2006 to 10 000 t in 2010. The Irish official catch was close to the quota.

There were no estimates of discards reported for 2010.

The assessment period runs concurrently with the annual quota. In recent years Ireland has been the only country participating in this fishery. In 2010 all of the catches were reported from quarters 1 and 4 in VIaS. Small landings were reported in VIIb in quarter 1 and 4. In the first quarter, fishing began in the middle of January and continued until the middle of February. Fishing reopened in the fourth quarter in mid October and closed in mid December when the quota was exhausted. The distribution of the landings from this area is presented in Figure 6.1.3.1. The main fishing took place throughout VIaS with a very small proportion in VIIb.

A total of 50 boats categorised as follows caught herring in VIaS, VIIb,c in 2010:

- 23 pelagic segment boats with refrigerated seawater (RSW) storage
- 3 polyvalent segment boats with refrigerated seawater storage
- 24 polyvalent segment vessels with bulk storage.

"Polyvalent" is a term used to define part of the Irish fleet allowed to catch both pelagic and demersal fish.

6.1.3 Regulations and their effects

The reduction in quotas in the recent past has meant that searching and fishing times have been reduced.

In effect, the boat-quotas were taken in one or two hauls in many cases. Quota is often taken on an opportunistic basis, and only in two main areas.

Pelagic segment vessels are not allowed to fish within the Irish 12 mile limit. The strict enforcement of this in recent years has meant that these vessels fish offshore. However, they still operate in proximity to the spawning grounds.

6.1.4 Changes in fishing technology and fishing pattern

There have been no significant changes in the fishing technology of the fleets in this area in recent years. The pattern of this fishery has changed over time. In the early part of the 20th century the main spawning components were the winter spawners off the north coast, and this was where the main fishery took place. In the 1970s and 1980s the west of Ireland autumn-spawning components were dominant and the fishery was mainly distributed along the coasts of VIIb,c and VIaS. More recently the northern grounds are more important again.

Only two main areas have been fished in the past two seasons. This is due to restrictive quotas, fuel prices and other factors that led to decisions to avoid long distances from the main fishing port (Figure 6.1.4.1).

6.2 Biological composition of the catch

6.2.1 Catch in numbers-at-age

The time series has been extended to include data from 1957 (WD 09, Clarke 2011), with details of the extension included in an adjunct to the stock annex. Catch-at-age data for this fishery are shown in Table 6.2.1.1 with percentages since 1994 shown in Table 6.2.1.2. In 2010 the fishery has been dominated by 2- and 3-ringers accounting for 23% and 34% respectively. 1-ringers are never well represented in the catch and normally do not show up in the catch until quarter 3. The abundance of 1-ringer in the catches has been very low in the past five years of the time in the series. A slight increase in the abundance of 1-ringers was seen in 2010 where they accounted for 2% of the total canum. The catch numbers at age have been mean standardised and are presented in Figure 6.2.1.1. The slightly higher numbers of 1-ringers and the attenuation of older ages can be clearly seen.

Sampling data indicates that herring are fully recruited to the fishery at 3-ring 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 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 and Figure 6.2.2.2. No samples were collected from VIIb in 2010, and overall landings from this area were very small.

Mixing of autumn, winter and spring spawners takes place in this area which may lead to ageing difficulties regarding counting of winter rings. This issue will be investigated further.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

The only survey that could be used to tune this assessment is the northwest of Ireland herring acoustic survey, a constituent survey of the Malin Shelf survey (MSHAS_S). In 2010, the Irish survey of VIaS, VIIb, c was conducted in July with effort concentrating on summer feeding aggregations. This is the third acoustic survey that has been carried out at this time of year. The July 2010 survey track and NASC values attributed to herring are shown in Figures 6.3.1.1 and 6.3.1.2 respectively. The survey was carried out on the Celtic Explorer and commenced in the south and worked progressively northwards. Existing survey methods were followed with acoustic surveying undertaken between 04:00 and 23:00 (daylight hours).

The results of this acoustic survey are not directly comparable with the winter surveys conducted from 2004-2007 (Table 6.3.1.1) because of the timing and coverage. It is comparable in time and area with those conducted from 1994-1996 (Table 6.3.1.2) and the 2008 and 2009 surveys which had the same timing. Two estimates for SSB and total biomass were calculated because the 2010 survey extended further north into ICES division VIaN than in previous years. The SSB estimate from the total area (VIaS, VIIb,c and VIaN) was 170 154 t which is the highest ever estimate from this survey. The SSB estimate from divisions VIaS and VIIb only, is 81 400 t which is a significant increase on the 2009 estimate of 21 000 t.

The 2010 age structure shows high numbers of 2-ringers. This follows on from the high proportions of 1-ringers in 2009 (2007 year class) Figure 6.3.1.3. This suggests that there may be a strong year class entering the fishery. The proportions-at-age in the catch and survey data from 2008-2010 are presented in Figure 6.3.1.4 and show that there is little agreement between the data sources within years. Nor is there good representation of particular cohorts between years for the commercial catch-at-age. There may be two stocks mixing in the survey area at this time and it may explain why the age compositions vary between the survey and the catch.

The estimate of abundance should be considered as robust due to the high level of ground coverage and trawling achieved in areas of high herring abundance especially regarding mixed species layers. It is not known whether the stock was fully contained within the southern limit of the survey and therefore the estimate from VIIb may be an underestimate. In 2010 area coverage increased by approximately 5 000nmi^2 (to 14 600nmi^2) from previous years due to extension into VIaN. Over 57% of the TSB for the survey was located within VIaN in an area co-surveyed with the Scottish vessel (O'Donnell et al, 2010).

6.4 Mean weights-at-age and maturity-at-age

6.4.1 Mean Weights-at-Age

The mean weights-at-age (kg) in the catches in 2010 are based on Irish catches (Figure 6.4.1.1). In 2010 there is an increase in the mean weight of 1-ringers. The overall trend over the past three years has been upwards for most of the older age groups. Generally the oldest and youngest ages are poorly represented in the catch data.

The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period that extends from October to February (Figure 6.4.1.2). The mean weights in the stock show the same overall trends as the mean weights in the catch.

6.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

6.5 Recruitment

There is little information on terminal year recruitment in the catch-at-age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely but have been consistently low in the most recent years. Numbers of 1-ringers in 2010 (2008 year class) are slightly higher than in previous years. This year class was also evident in the Irish groundfish survey data. The length frequency data from the 2009 and 2010 Irish groundfish surveys are presented in Figure 6.5.1.1. A small peak in 0 group fish at ~15cm can be seen in 2009. In 2010 the 1-ringers would be 21cm – 24cm. There is some evidence to suggest a stronger cohort (2007) in the acoustic survey (Figure 6.3.1.3).

6.6 Stock Assessment

6.6.1 Data Exploration

Data extension

The time series of catch at age data was extended from 1970 back to 1957. This was done to improve the understanding of long term stock dynamics and productivity of this stock. A similar exercise had been conducted by HAWG (2004) for VIaN. That exercise de-segregated VIaN data from the combined VIa time series, presented in HAWG (1974). The broad approach of the current exercise was to use the remainder of the 1974 VIa time series, and combine it with data from VIIb,c. Full details are presented by Clarke (2011 WD 09). A comparison of separable VPA stock trajectories from the extended time series, and the previous (1970-2010) time series showed little difference in perceptions of stock development over time (Figure 6.2.2.1).

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 attenuation in older age groups in recent years, and in most recent years, 1-ringers also. However 1-ringers were never well represented in assessment. Log catch ratios show an upward trend in cohort total mortality on fully recruited year classes, since the mid 1990s. Catch curves show low mortality on the very large 1963, 1981 and 1985 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 onwards.

6.6.2 Assessment

Following the procedure of recent years, a separable VPA was used to screen over four terminal fishing mortalities, 0.2, 0.4, 0.5 and 0.6. This was achieved using the

Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to 3 winter rings. This assessment is still exploratory, and no assessment has been accepted in recent years.

Four exploratory assessments using the separable VPA were performed, based on the four choices of terminal F. Recruitment, SSB and mean F from each run and for the two times series, the extended 1957-2010 and original 1970-2010 series, are plotted in Figure 6.6.2.1. The two time series are compared and show the same overall trends. All other results presented, represent the extended time series. Figure 6.6.2.2 shows the exploratory assessment 2011 and is more informative for the converged part of the VPA, but in most recent years has little information on the current stock dynamics. Outputs from separable VPAs with terminal Fs of 0.2, 0.4, 0.5 and 0.6 are presented in Tables 6.6.2.1, 6.6.2.2, 6.6.2.3 and 6.6.2.4 respectively. Residual plots for the four trial assessments are presented in Figure 6.6.2.3. Large residuals can be seen in 1-ringers, reflecting the poor estimation of this age group. These residuals are also, this year, presented in Tables 6.6.2.5 – 6.6.2.8 to address the review group suggestion.

Fishing mortality was estimated to be highest 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 has been stable at a low level or declining in recent years. In 2010 there appears to be an increase in recruitment irrespective of the terminal F values used. Recruitment in the last year is replaced with the geometric mean recruitment, in Figures 6.6.2.1 and 6.6.2.2. Using terminal F =0.2 produces a recruitment in 2010 that is highest in the series (Figure 6.6.2.8) when the final year is not adjusted. There is no evidence from the catch at age data or the survey data for such a strong cohort.

All of the F values greater than 0.2, show that SSB is at the lowest level in the series and is considerably lower than B_{pa} (110 000 t) and B_{lim} (81 000). There is some evidence, of a small increase in recruitment, from the raw catch numbers-at-age. However, 1-ringer numbers in the catch are not themselves enough evidence that a strong cohort is recruiting to the fishery.

A retrospective assessment was conducted for each of the F scenarios. Using, a terminal F = 0.2, as a starting value, (Figure 6.6.2.4) shows a bias towards overestimation of SSB and underestimation of F. Using a terminal F = 0.4 (Figure 6.6.2.5) displays a much more stable estimation of SSB and the underestimation of F is not as pronounced. The retrospective assessment using F=0.5 and F=0.6 (Figures 6.6.2.6 and 6.6.2.7) show a bias towards an underestimation of SSB and an overestimation of F.

The results of the retrospective analysis suggest that using an initial terminal F of 0.4 produces more stable estimates of SSB and F than smaller or larger values. The mean F generated by this run is 0.55 in 2010, and mean F in the non converged VPA (2005-2010) is 0.64. This suggests that recent F has been about 0.55, which is above $F_{0.1}$ and F_{msy}, estimated to be around 0.2 and 0.25 respectively (ICES, 2010 ACFM:06).

These explorations are indicators of trends only. Most of the assessment runs suggest that SSB has declined to the lowest level in the series and that there is no evidence of stock recovery. The run using F=0.2 suggests a slight increase in SSB but suggests a record high recruitment for which there is no other evidence.

6.6.3 Pseudo-cohort analysis

In 2011, WKFRAME presented a protocol for advice provision for stocks without population size estimates. An attempt was made by HAWG to apply this approach to this stock. Exploratory analyses set out to estimate the relationship between F in the terminal year and F_{msy} (0.25). F_{msy} estimates are available for this stock, but the separable VPA does not provide robust estimates of current F. Pseudo-cohort mortality in the terminal year was examined to see if it could provide an estimate of current F. An analysis of pseudo-cohort mortality over time was conducted to determine if these estimates were in agreement with those from the converged VPA. A very poor agreement was found between pseudo-cohort Z and the mortality from the converged part of the separable VPA estimates of F. When natural mortality was subtracted, negative mortality was found in many years, and the relationship with the VPA was even poorer. It was concluded that pseudo-cohort catch curves are not a robust estimate of fishing mortality for this stock.

A second approach was to use the VIT software (Lleonart and Salat, 1997) a program often applied by STECF-SGMED to stocks with only one year of catch at age. The model fits a VPA-type model to pseudo-cohort derived mortality estimates from a single year. VIT produced F estimates that were in broad agreement with separable VPA estimates over time (correlation coefficient 0.7). However VIT produced unrealistic estimates of F for some of the age groups in recent years. This is probably due to the lack of coherence within the catch at age matrix.

Both of these approaches showed that mortality in the last 12 years has been increasing above any previously observed rates. This agrees with the separable VPA analyses conducted above and also with log catch ratios and cohort catch curves (see Stock Annex).

6.6.4 State of the Stock

The results of the exploratory assessment continue to suggest a strong decline in SSB since the mid 1990s. The current level of SSB is uncertain but is very likely to be below B_{pa} and B_{lim}. Though current SSB is uncertain, there is little doubt that it is much lower than in the 1990s. Over the period of stock decline, F has increased, and recent F remains well above sustainable rates. There is some evidence of a stronger (2008) cohort recruiting to the stock, but it is premature to make any conclusions on this as it is only entering the fishery. The perception of stock trends is consistent, even though the most recent estimates of SSB and F are uncertain.

The pelagic RAC disagrees with the HAWG perception that the stock has decreased to a low level. The RAC noted that the industry does not share the perception that the stock is at a low level, and that experience from the fishing grounds suggests that herring abundance is high.

6.7 Short term projections

In 2011, the working group conducted a series of exploratory short term deterministic forecasts. These forecasts were used to explore possible reactions of the stock in the short term.

The terminal populations from each sVPA were used as inputs and F-at-age was taken as the average over 2005-2010, the non-converged VPA. Recruitment (1-ring) was taken to be geometric mean 1957-2004, but excluding the very strong 1963, 1981, 1983 and 1985 year classes. Thus the forecasts are based on a low recruitment regime.

The interim catch was taken to be the TAC in VIaS/VIIbc + Irish quota in VIaN. These inputs are summarised in Table 6.7.1.

Results of these forecasts are shown in Table 6.7.2. Assuming the terminal populations from the sVPAs are indicative of stock status, fishing at F0.1 (F= 0.2) implies catches in 2012 of between about 5 000 t and 10 000 t. Fishing at F_{msy} (0.25) implies catches in 2012 of between 6 300 t and 13 000 t.

The most plausible assessment run (terminal F = 0.4) is associated with small recovery from current SSB levels, for F < 0.7, the likely range of recent F (0.55-0.64). Only the most optimistic assessment (terminal F = 0.2) is associated with recovery to above B_{lim} in 2013, fishing at F=0.1. None of the scenarios imply recovery to B_{pa} in 2013.

6.8 Medium term simulations

No yield per recruit was performed in 2011.

6.9 Long term simulations

Work has been conducted on simulating the long term dynamics of this stock. This work focuses on using the converged sVPA assessment and projecting forward. The analysis aims to define a range of target F, B trigger and percentage TAC constraints that would be appropriate for this stock. Preliminary results are in broad agreement with the work conducted by HAWG in 2010, in developing the MSY approach for this stock (ICES 2010, ACOM:06).

6.10 Precautionary and yield based reference points

Analysis of stock recruit data for the period (1957-2007), excluding periods of high productivity (1981-1985) found a breakpoint in the segmented regression of 70 000 t. When all of the data, including the periods of low and high productivity are used the breakpoint is 83 000 t which is in close agreement with the existing B_{lim} (81 000 t). HAWG considers that the current reference points are appropriate for this stock.

In 2010, HAWG estimated $F_{0.1}$ as 0.2.

In 2010, HAWG defined F_{MSY} as 0.25. Further analysis using the plotMSY program estimated F_{MSY} around 0.25.

HAWG has not considered candidate values for a $B_{trigger}$ in great detail. HAWG considered that there is a range of biologically appropriate biomass triggers that may be appropriate, suggesting 95 000 t as one possible value. The final choice should be made based on management plan development. As such the trigger biomass will be subject to evaluation by ICES. In 2010 ACOM endorsed the approach taken by HAWG, and ICES WKFRAME II also endorsed the approach in 2011.

6.11 Quality of the Assessment

The assessment presented was based on the results from a separable VPA without a tuning index, therefore the estimates of SSB and F for recent years depend on the choice of terminal F. The VPA was run for a range of terminal F values and the current perception of the stock is highly influenced by that choice. There is no information on recent recruitment levels both because the selectivity of the fishery appears to be low for the juveniles and also due to the lack of a recruitment index.

However, in the 2009 acoustic survey, 1-ringer abundance was high and the abundance of 2-ringers was high in the 2010 acoustic survey. Examination of the survey data alone suggests that there may be a strong year class entering the fishery. Comparisons of the age structures from the catch and survey data each year show a mismatch between the data sources regarding the main ages present. This (2008) cohort is not well represented in the catch at age data in either 2009 or 2010. This underlies the lack of coherence in the catch-at-age matrix from year to year, which has been an ongoing feature of this assessment.

Further work will be conducted to examine the mixing of components of this fishery. The mixture of spawning components may affect the ageing procedure with possible difficulties in interpreting the winter ring. This will also be investigated in greater detail. It is unlikely that a strong cohort entering the fishery would be missed due to difficulties of this kind. The significant decline in SSB is clear and is unlikely due to such methodological issues.

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 0.5 and 0.6 used show an overestimation of F. Based on this information we can infer that recent F may have been in the region of 0.4. In the last two years HAWG has estimated recent F at about 0.5, slightly higher than this year's estimate from this analysis.

There are concerns about the underlying assumptions of the separable VPA. The assumption of a constant selection pattern throughout the series is invalid. However in the absence of a tuning index there is little alternative. In the past, traditional VPA runs using the same terminal Fs as inputs have not produced different stock trajectories.

6.12 Management Considerations

Since 2000, reported landings have been much lower than previously. In recent years landings have been reduced each year, with a stabilisation in 2009 and 2010. There is no evidence available to alter stock perception. Evidence from the survey of a good incoming year class needs to be further corroborated in the next years. Recent F has been well above the range of potential estimates of F_{MSY}.

The catch target (20 000 – 25 000 t) of the local management plan is not likely to be achievable at current stock productivity. A rebuilding plan is urgently required and should aim to keep catches at a low level until stock recovery can be confirmed.

6.13 Environment

6.13.1 Ecosystem Considerations

No new information.

6.13.2 Changes in the Environment

No new information.

Table 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Estimated Herring catches in tonnes, 1988–2010. 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
France	-	-	+	-	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	250	-	-	11	-	-	-
Ireland	15000	18200	25000	22500	26000	27600	24400	25450	23800	24400	25200
Netherlands	300	2900	2533	600	900	2500	2500	1207	1800	3400	2500
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
Unallocated/ area misreported	13800	7100	13826	11200	4600	6250	6250	1100	6900	-700	11200
Discards	-	1000	2530	3400	100	250	700	-	-	50	
WG catch	29100	29200	43969	37700	31850	36800	33900	27792	32500	27150	38900

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
France	-	-	-	515	-	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	16325	10164	11278	13072	12921	10950	13351	14840	12662	10237	8533	7513
Netherlands	1868	1234	2088	366	-	64	-	353	13			
UK (N.Ireland)	-	-	-	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	-	6	-	-		
Total landings	18193	11398	13366	13953	12921	11014	13351	15199	12675	10237	8533	7513
Area misreported	7916	8448	1390	3873	3581	2813	2880	4353	5129	3103	1935	2728
Unallocated								-353	-13			
Discards	-	-	-	-	-	-	-	-	-	-	-	-
WG catch	26109	19846	14756	17826	16502	13827	16231	19193	17791	13340	10468	10241

Table 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Catch in numbers-at-age (winter rings) from 1957 to 2010.

	1	2	3	4	5	6	7	8	9+
1957	0	7709	9965	1394	6235	2062	943	287	490
1958	100	3349	9410	6130	4065	5584	3279	1192	2195
1959	1060	7251	3585	8642	3222	1757	2002	858	839
1960	516	18221	7373	3551	2284	770	1020	578	326
1961	1768	7129	14342	6598	2481	2392	566	706	387
1962	259	7170	5535	10427	5235	3322	4111	1653	1525
1963	132	6446	5929	2032	3192	3541	2079	1293	2517
1964	88	7030	5903	4048	2195	3972	3779	1830	3559
1965	234	3847	10135	9008	2426	2019	6349	2737	4276
1966	0	16809	11894	10319	7392	3356	7112	2987	6109
1967	0	1232	55013	12681	9071	6348	3455	4862	8165
1968	574	10192	4702	78638	5316	4534	1889	839	3340
1969	1495	15038	13013	4410	54809	4918	3234	1954	3136
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17
2010	1271	13507	20127	6541	7588	6780	2563	661	189

Table 6.2.1.2. Herring in Divisions VIa(S) and VIIb,c. Percentage age composition (winter rings).

	1	2	3	4	5	6	7	8	9
1994	6	28	15	8	11	7	4	16	5
1995	0	23	23	12	13	11	4	6	9
1996	3	13	38	17	5	8	4	7	4
1997	5	34	16	23	9	4	5	2	3
1998	3	29	32	15	12	4	2	1	1
1999	1	30	36	21	6	3	1	1	1
2000	3	27	30	24	10	2	1	1	1
2001	2	23	23	18	19	10	2	1	1
2002	3	27	31	16	10	9	2	1	1
2003	2	31	27	23	9	5	2	1	0
2004	2	18	38	23	10	6	2	1	0
2005	0	27	29	26	10	5	1	1	0
2006	0	18	29	25	18	7	2	1	0
2007	0	22	39	21	12	5	2	0	0
2008	1	15	24	35	14	7	3	1	0
2009	0	22	21	21	22	9	4	1	0
2010	2	23	34	11	13	11	4	1	0

Table 6.2.2.1. Herring in Divisions VIa(S) and VIIb,c. Sampling intensity of catches in 2010.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIaS	2010	1	1941	12	798	2612	0.80
VIaS	2010	4	5482	21	1208	4960	1.21
Total North West			7423	33	2006	7572	2

Table 6.2.2.2. Herring in Divisions VIa(S) and VIIb,c. Length distribution of Irish catches/quarter (thousands) 2010.

Length cm	Quarter 1 VIa South	Quarter 4 VIa South
21		
21.5		7
22	4	85
22.5	16	164
23	31	381
23.5	27	742
24	31	1156
24.5	55	1820
25	106	2247
25.5	341	1977
26	659	1912
26.5	781	2371
27	863	2943
27.5	887	3751
28	930	4027
28.5	1205	3738
29	1511	3133
29.5	1201	1485
30	777	486
30.5	420	112
31	247	26
31.5	94	7
32	43	
32.5		7
33	4	7
33.5	8	
34	8	
Total	10250	32575

Table 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Time series of acoustic surveys since 1999-2007 (upper table). The 2008-2010 surveys are part of a new summer survey of the Malin Shelf stock complex (lower table).

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007
0	-	-	5	0	-	0	1	0	-
1	19	11	23	36	10		8	2	0
2	105	61	52	14	26	4	57	7	4
3	33	49	6	24	30	62	94	87	60
4	11	26	6	14	11	55	110	58	22
5	2	9	3	6	3	80	101	28	12
6	1	2	2	6	1	47	57	16	6
7	0	1	0	5	1	14	21	5	2
8	0	0	0	3	0	12	25	5	-
9+	0	1	0	4	0	-	13	1	-
Abundance (millions)	171	160	98	111	83	274	485	203	105
Total Biomass (t)	23762	21048	11062	8867	10300	41700	71253	27770	14222
SSB (t)	22788	20500	9800	6978	9500	41300	66138	27200	13974
CV	-	-	-	-	-	-	-	49%	44%

Winter rings	2008^	2009^	2010^	2010*
0	-	-		
1	12	416	17	525
2	83	81	293	504
3	65	11	85	133
4	38	15	63	107
5	22	8	43	103
6	29	7	27	84
7	9	7	19	58
8	5	0	13	35
9	2	1	6	18
10	2	0	0	0
Abundance (millions)	267	548	565	1567
Total Biomass (t)	44,611	46,460	82,100	192,979
SSB (t)	43,006	20,906	81,400	170,154
CV	34%	38%	-	24.70%

^ Survey coverage: VIaS & VIIb

* Survey coverage: VIaS, VIaN & VIIb

Table 6.3.1.2. Herring in Divisions VIa(S) and VIIb,c. Details of all acoustic surveys conducted on this stock.

Year	Type	Biomass	SSB
1994	Feeding phase	-	353,772
1995	Feeding phase	137,670	125,800
1996	Feeding phase	34,290	12,550
1997	-	-	-
1998	-	-	-
1999	Autumn spawners	23,762	22,788
2000	Autumn spawners	21,000	20,500
2001	Autumn spawners	11,100	9,800
2002	Winter spawners	8,900	7,200
2003	Winter spawners	10,300	9,500
2004	Winter spawners	41,700	41,399
2005	Winter spawners	71,253	66,138
2006	Winter spawners	27,770	27,200
2007	Winter spawners	14,222	13,974
2008	Feeding phase	44,611	43,006
2009	Feeding Phase	46,460	20,906
2010	Feeding Phase	192,979	170,154

Table 6.6.2.1. Herring in Divisions VIa(S) and VIIb,c. VPA run with a terminal F value of 0.2.

	Recruitment	SSB	Landings	Mean F 3-6
1957	159900	27065	5070	0.2448
1958	304915	26132	6825	0.3603
1959	445905	34084	5226	0.2316
1960	245598	45857	5401	0.1076
1961	194472	46751	6182	0.1336
1962	270321	50182	7399	0.1496
1963	296450	60470	5059	0.0934
1964	282964	62668	6169	0.0983
1965	2307557	68111	8016	0.1354
1966	161293	173753	12215	0.2123
1967	457220	104421	18881	0.2496
1968	535394	144842	20731	0.1811
1969	346767	133742	19607	0.179
1970	401853	123869	20306	0.1993
1971	810436	108997	15044	0.174
1972	728328	112565	23474	0.2086
1973	529683	128810	36719	0.2905
1974	583378	90137	36589	0.4572
1975	402311	84837	38764	0.4473
1976	678477	63046	32767	0.512
1977	568435	69389	20567	0.3273
1978	1032366	69149	19715	0.2696
1979	956146	95439	22608	0.2804
1980	522318	100758	30124	0.406
1981	662914	94513	24922	0.3266
1982	685257	104692	19209	0.2358
1983	2264193	102249	32988	0.3771
1984	940818	181253	27450	0.2143
1985	1207174	183116	23343	0.1789
1986	931059	217741	28785	0.1888
1987	3182874	196244	48600	0.3583
1988	474037	291336	29100	0.2815
1989	708802	217091	29210	0.1884
1990	805441	187404	43969	0.268
1991	501374	162794	37700	0.251
1992	414880	130415	31856	0.28
1993	615083	110763	36763	0.3608
1994	801383	93030	33908	0.3668
1995	457012	78626	27792	0.4725
1996	830940	62083	32534	0.5864
1997	819584	63384	27225	0.5398
1998	528247	51980	38895	1.0447
1999	386070	44293	26109	0.7138
2000	439291	36786	19846	0.5334
2001	448628	34284	14756	0.6418
2002	553184	32958	17826	0.7087
2003	461853	38033	16502	0.6406
2004	488975	40464	13727	0.5858
2005	573437	41185	16231	0.5715
2006	362909	41231	19193	0.7902
2007	234273	36168	17791	0.5647
2008	472847	30912	13340	0.5013
2009	519810	41931	10468	0.3653
2010	3739085	49139	10241	0.2774
Mean	541828*	92985	22106	0.3586

***Geometric Mean recruitment 1957- 2009**

Table 6.6.2.2. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.4.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	164914	27919	5070	0.2376
1958	314960	27184	6825	0.3459
1959	458798	35590	5226	0.2207
1960	251699	47791	5401	0.1027
1961	198999	48742	6182	0.1279
1962	275968	52485	7399	0.1432
1963	301699	63261	5059	0.0898
1964	287407	65273	6169	0.095
1965	2339280	70898	8016	0.1317
1966	163047	178130	12215	0.2061
1967	460967	107039	18881	0.242
1968	538784	148288	20731	0.1765
1969	348247	136716	19607	0.1751
1970	403439	113464	20306	0.1965
1971	814028	96914	15044	0.1716
1972	732031	102957	23474	0.2065
1973	532671	133671	36719	0.288
1974	586882	89334	36589	0.4527
1975	405601	96916	38764	0.4413
1976	684093	67267	32767	0.5039
1977	573730	76190	20567	0.3212
1978	1044225	71640	19715	0.265
1979	969039	103681	22608	0.2749
1980	529029	99142	30124	0.3973
1981	670425	99926	24922	0.3179
1982	693875	110461	19209	0.2295
1983	2290963	105641	32988	0.3676
1984	951764	179556	27450	0.2088
1985	1218518	184105	23343	0.1745
1986	938418	218303	28785	0.1846
1987	3204266	190250	48600	0.3506
1988	476606	295807	29100	0.2756
1989	711532	220845	29210	0.185
1990	807197	190650	43969	0.2639
1991	502008	164695	37700	0.2476
1992	415158	131673	31856	0.2776
1993	615417	113009	36763	0.3582
1994	801863	94100	33908	0.3649
1995	457265	83260	27792	0.4704
1996	831214	62106	32534	0.5849
1997	819740	63708	27225	0.5384
1998	527646	52021	38895	1.0404
1999	385340	44422	26109	0.7103
2000	438286	36853	19846	0.5325
2001	445535	34200	14756	0.6413
2002	545980	32751	17826	0.7107
2003	449948	37634	16502	0.6475
2004	466149	39554	13727	0.5969
2005	519939	39363	16231	0.5895
2006	300321	37579	19193	0.8456
2007	170088	30246	17791	0.6456
2008	282728	22584	13340	0.6461
2009	260624	24968	10468	0.5634
2010	1599679	23498	10241	0.5474
Mean	526707*	93042	22106	0.3691

***Geometric mean recruitment: 1957-2009**

Table 6.6.2.3. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.5.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	166529	28196	5070	0.2353
1958	318181	27525	6825	0.3414
1959	462921	36075	5226	0.2174
1960	253647	48416	5401	0.1013
1961	200443	49381	6182	0.1262
1962	277768	53224	7399	0.1413
1963	303367	64156	5059	0.0887
1964	288814	66106	6169	0.094
1965	2349306	71788	8016	0.1305
1966	163599	179521	12215	0.2042
1967	462149	107871	18881	0.2397
1968	539859	149382	20731	0.175
1969	348719	137657	19607	0.1739
1970	403948	114218	20306	0.1956
1971	815185	97549	15044	0.1709
1972	733219	103569	23474	0.2059
1973	533628	134550	36719	0.2872
1974	588005	89761	36589	0.4513
1975	406658	97422	38764	0.4394
1976	685896	67666	32767	0.5013
1977	575425	76640	20567	0.3193
1978	1048024	72081	19715	0.2635
1979	973145	104292	22608	0.2732
1980	531161	99800	30124	0.3946
1981	672807	100714	24922	0.3152
1982	696612	111298	19209	0.2276
1983	2299426	106585	32988	0.3646
1984	955209	180814	27450	0.2071
1985	1222086	185312	23343	0.1732
1986	940726	219628	28785	0.1833
1987	3210953	191532	48600	0.3482
1988	477409	297284	29100	0.2738
1989	712384	221959	29210	0.1839
1990	807742	191633	43969	0.2626
1991	502207	165436	37700	0.2465
1992	415245	132267	31856	0.2768
1993	615525	113504	36763	0.3575
1994	802020	94492	33908	0.3642
1995	457350	83419	27792	0.4697
1996	831319	62201	32534	0.5844
1997	819831	63778	27225	0.5379
1998	527525	52057	38895	1.039
1999	385190	44443	26109	0.7092
2000	438082	36870	19846	0.5322
2001	444916	34199	14756	0.6409
2002	544547	32720	17826	0.7109
2003	447606	37544	16502	0.6489
2004	461794	39371	13727	0.5992
2005	509581	39019	16231	0.5932
2006	287829	36859	19193	0.8576
2007	157100	29079	17791	0.6643
2008	244763	20925	13340	0.6852
2009	211003	21586	10468	0.6314
2010	1219432	18412	10241	0.6811
Mean	522869*	93366	22106	0.373

*** Geometric mean recruitment 1957-2009**

Table 6.6.2.4. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.6.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	167833	28421	5070	0.2335
1958	320778	27800	6825	0.3379
1959	466243	36469	5226	0.2148
1960	255215	48920	5401	0.1001
1961	201604	49897	6182	0.1248
1962	279214	53820	7399	0.1398
1963	304706	64878	5059	0.0879
1964	289942	66776	6169	0.0932
1965	2357344	72505	8016	0.1296
1966	164042	180639	12215	0.2027
1967	463096	108538	18881	0.2379
1968	540721	150259	20731	0.1739
1969	349100	138412	19607	0.1729
1970	404358	114823	20306	0.1949
1971	816119	98059	15044	0.1703
1972	734177	104060	23474	0.2054
1973	534400	135254	36719	0.2865
1974	588910	90105	36589	0.4502
1975	407511	97829	38764	0.4379
1976	687352	67987	32767	0.4992
1977	576791	77002	20567	0.3178
1978	1051085	72436	19715	0.2623
1979	976447	104785	22608	0.2719
1980	532873	100329	30124	0.3924
1981	674718	101349	24922	0.3131
1982	698810	111972	19209	0.2261
1983	2306210	107346	32988	0.3623
1984	957965	181824	27450	0.2058
1985	1224938	186282	23343	0.1722
1986	942570	220691	28785	0.1823
1987	3216284	192559	48600	0.3464
1988	478050	298466	29100	0.2723
1989	713062	222851	29210	0.1831
1990	808175	192419	43969	0.2616
1991	502365	166028	37700	0.2457
1992	415315	132742	31856	0.2762
1993	615612	113899	36763	0.3569
1994	802146	94805	33908	0.3638
1995	457419	83545	27792	0.4692
1996	831407	62277	32534	0.584
1997	819915	63834	27225	0.5376
1998	527446	52087	38895	1.0379
1999	385090	44461	26109	0.7082
2000	437947	36886	19846	0.5319
2001	444506	34201	14756	0.6405
2002	543598	32702	17826	0.7109
2003	446060	37486	16502	0.6499
2004	458992	39251	13727	0.6007
2005	502883	38794	16231	0.5957
2006	279603	36392	19193	0.8657
2007	148446	28316	17791	0.6771
2008	219485	19832	13340	0.7135
2009	178467	19344	10468	0.6859
2010	977891	15031	10241	0.8139
Mean	520069*	93661	22106	0.3764

*** Geometric mean recruitment 1957-2009**

Table 6.6.2.5 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.2 VPA

Years	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
1/ 2	-1.247	-0.287	0.926	1.601	3.213	0.522	0.415	0.711	0.488
2/ 3	0.782	0.064	-0.07	0.665	1.06	0.129	0.694	0.335	-0.171
3/ 4	0.914	-0.357	-0.579	0.031	0.617	0.434	0.498	-0.215	0.436
4/ 5	-0.798	0.031	0.597	0.151	0.401	0.488	-0.077	0.602	0.526
5/ 6	0.276	0.11	0.598	-0.34	-0.209	-0.391	-0.297	0.093	-0.082
6/ 7	-0.507	0.07	-0.515	-0.204	-0.674	-0.537	-0.361	-0.676	-1.23
7/ 8	-0.542	0.113	-0.122	-0.462	-1.514	-0.173	-0.497	-0.21	0.472
TOT	0.001	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75
1/ 2	-0.451	-3.018	1.16	1.203	0.184	1.267	0.842	3.135	1.865
2/ 3	-0.375	-0.987	0.351	-0.023	1.792	-0.28	0.183	0.742	0.599
3/ 4	0.22	-0.542	0.128	-0.03	0.528	0.522	0.322	0.231	0.155
4/ 5	0.273	0.539	0.282	-0.035	-0.082	0.228	-0.216	-0.067	0.241
5/ 6	0.201	0.263	-0.099	0.051	-0.596	0.028	-0.247	-0.311	-0.019
6/ 7	-0.194	0.561	-0.056	0.023	-0.816	-0.128	-0.267	-0.216	-0.344
7/ 8	-0.078	0.469	-0.721	-0.105	-0.845	-0.495	0.141	-0.692	-0.818
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/ 2	3.089	2.837	1.915	2.712	2.697	1.979	1.677	0.724	-0.337
2/ 3	0.602	0.668	0.734	1.188	0.467	0.11	0.512	-0.084	0.212
3/ 4	-0.2	0.029	-0.338	0.184	-0.122	0.287	0.077	-0.04	0.238
4/ 5	-0.219	-0.192	-0.044	0.069	-0.125	0.056	0.068	0.077	0.307
5/ 6	-0.054	-0.182	0.185	-0.158	0.048	-0.19	-0.128	0.082	-0.161
6/ 7	-0.009	-0.361	-0.02	-0.632	-0.16	-0.163	0.33	0.069	-0.18
7/ 8	-0.428	-0.245	-0.708	-0.921	-0.377	-0.297	-1.026	-0.175	-0.38
TOT	0	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
1/ 2	2.537	3.346	1.092	2.963	-2.526	2.202	0.627	1.194	2.532
2/ 3	0.598	-0.042	0.026	-0.064	-0.537	-0.266	0.336	0.266	0.352
3/ 4	0.693	0.06	0.166	0.087	0.497	-0.427	0.338	-0.043	0.176
4/ 5	0.208	-0.228	0.012	-0.176	0.428	0.152	0.143	-0.247	0.135
5/ 6	-0.409	0.159	0.272	-0.088	0.126	0.042	-0.073	-0.029	-0.192
6/ 7	-0.233	-0.107	-0.355	-0.308	0.07	-0.318	-0.295	0.179	-0.244
7/ 8	-1.111	-0.177	-0.23	0.253	-0.331	0.597	-0.51	-0.245	-0.481
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/**	2001/**
1/ 2	-1.361	3.211	0.252	1.812	2.5	1.996	1.293	2.625	1.859
2/ 3	0.016	0.862	0.08	0.257	0.377	0.031	0.26	0.808	-0.023
3/ 4	0.137	0.326	0.292	0.235	-0.367	-0.096	-0.02	0.496	0.006
4/ 5	0.318	-0.497	0.605	0.186	0.018	0.091	0.001	-0.009	0.047
5/ 6	0.075	-0.194	0.056	-0.231	0.059	0.172	0.173	-0.375	0.07
6/ 7	-0.228	0.147	0.303	-0.349	-0.49	-0.137	0.017	-0.44	0.549
7/ 8	-0.18	-0.965	-1.361	-0.279	0.154	-0.261	-0.56	-0.743	-0.836
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	2002/**	2003/**	2004/**	2005/**	2006/**	2007/**	2008/**	2009/**
1/ 2	2.028	1.931	1.343	-0.028	0.224	-0.919	0.718	-0.096
2/ 3	0.266	0.149	-0.304	0.383	-0.73	0.458	0.099	-0.222
3/ 4	-0.109	-0.124	-0.018	-0.007	-0.289	0.031	-0.036	0.295
4/ 5	-0.103	0.268	0.175	-0.042	-0.187	0.132	0.107	-0.016
5/ 6	-0.159	-0.224	-0.07	-0.23	0.227	0.073	-0.09	0.023
6/ 7	0.196	0.103	0.502	0.2	0.201	-0.292	0.005	-0.103
7/ 8	-0.294	-0.364	-0.419	-0.302	0.756	-0.309	-0.157	0.033
TOT	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	1	1	1	1	1

Table 6.6.2.6 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.4 VPA

Years	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
1/ 2	-1.354	-0.396	0.822	1.501	3.113	0.422	0.319	0.615	0.389
2/ 3	0.728	0.006	-0.124	0.615	1.009	0.078	0.646	0.287	-0.219
3/ 4	0.902	-0.372	-0.594	0.018	0.604	0.42	0.485	-0.227	0.423
4/ 5	-0.787	0.042	0.605	0.159	0.409	0.495	-0.071	0.608	0.533
5/ 6	0.306	0.142	0.628	-0.313	-0.183	-0.365	-0.272	0.119	-0.056
6/ 7	-0.471	0.109	-0.477	-0.168	-0.638	-0.5	-0.326	-0.641	-1.195
7/ 8	-0.541	0.114	-0.118	-0.458	-1.511	-0.169	-0.493	-0.206	0.475
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75
1/ 2	-0.552	-3.119	1.059	1.103	0.085	1.168	0.741	3.032	1.759
2/ 3	-0.426	-1.039	0.3	-0.074	1.742	-0.329	0.132	0.688	0.542
3/ 4	0.207	-0.555	0.115	-0.043	0.515	0.51	0.309	0.219	0.142
4/ 5	0.281	0.547	0.29	-0.026	-0.074	0.236	-0.206	-0.055	0.254
5/ 6	0.229	0.291	-0.071	0.079	-0.568	0.054	-0.219	-0.28	0.014
6/ 7	-0.159	0.597	-0.021	0.058	-0.781	-0.094	-0.232	-0.182	-0.308
7/ 8	-0.076	0.472	-0.719	-0.103	-0.842	-0.493	0.143	-0.692	-0.82
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/ 2	2.98	2.728	1.811	2.609	2.592	1.873	1.574	0.619	-0.442
2/ 3	0.544	0.607	0.679	1.135	0.413	0.054	0.458	-0.137	0.156
3/ 4	-0.213	0.013	-0.352	0.171	-0.135	0.273	0.064	-0.052	0.223
4/ 5	-0.205	-0.178	-0.033	0.079	-0.113	0.068	0.078	0.088	0.317
5/ 6	-0.019	-0.146	0.216	-0.128	0.078	-0.158	-0.098	0.112	-0.13
6/ 7	0.026	-0.322	0.016	-0.596	-0.125	-0.126	0.366	0.103	-0.142
7/ 8	-0.431	-0.246	-0.707	-0.92	-0.376	-0.297	-1.024	-0.175	-0.378
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
1/ 2	2.437	3.247	0.989	2.861	-2.626	2.101	0.526	1.094	2.43
2/ 3	0.548	-0.092	-0.025	-0.118	-0.588	-0.317	0.284	0.214	0.3
3/ 4	0.68	0.047	0.154	0.072	0.484	-0.44	0.325	-0.056	0.164
4/ 5	0.216	-0.22	0.022	-0.166	0.436	0.161	0.152	-0.238	0.146
5/ 6	-0.381	0.186	0.3	-0.058	0.154	0.07	-0.044	0	-0.163
6/ 7	-0.198	-0.071	-0.321	-0.27	0.106	-0.283	-0.26	0.214	-0.21
7/ 8	-1.108	-0.174	-0.228	0.255	-0.329	0.599	-0.509	-0.244	-0.48
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/**	2000/**	2001/**
1/ 2	-1.463	3.109	0.148	1.708	2.391	1.886	1.188	2.522	1.756
2/ 3	-0.038	0.809	0.026	0.201	0.319	-0.034	0.2	0.752	-0.079
3/ 4	0.124	0.313	0.28	0.222	-0.378	-0.111	-0.035	0.483	-0.006
4/ 5	0.329	-0.486	0.618	0.2	0.036	0.111	0.017	0.005	0.062
5/ 6	0.106	-0.163	0.087	-0.197	0.094	0.215	0.209	-0.342	0.103
6/ 7	-0.193	0.182	0.336	-0.314	-0.458	-0.099	0.054	-0.405	0.583
7/ 8	-0.18	-0.965	-1.362	-0.282	0.149	-0.269	-0.564	-0.745	-0.838
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	2002/**	2003/**	2004/**	2005/**	2006/**	2007/**	2008/**	2009/**
1/2	1.927	1.835	1.253	-0.103	0.183	-0.925	0.76	-0.009
2/3	0.209	0.096	-0.353	0.342	-0.755	0.454	0.124	-0.174
3/4	-0.122	-0.137	-0.029	-0.016	-0.294	0.03	-0.03	0.306
4/5	-0.089	0.28	0.187	-0.031	-0.18	0.133	0.101	-0.029
5/6	-0.124	-0.192	-0.042	-0.207	0.244	0.074	-0.104	-0.007
6/7	0.23	0.136	0.532	0.224	0.215	-0.29	-0.009	-0.132
7/8	-0.298	-0.367	-0.42	-0.301	0.752	-0.308	-0.158	0.037
TOT	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	1	1	1	1	1

Table 6.6.2.7 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.5 VPA

Years	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
1/ 2	-1.388	-0.43	0.789	1.47	3.081	0.391	0.288	0.584	0.358
2/ 3	0.712	-0.011	-0.14	0.6	0.994	0.063	0.632	0.272	-0.234
3/ 4	0.898	-0.377	-0.598	0.013	0.6	0.416	0.481	-0.231	0.42
4/ 5	-0.784	0.045	0.608	0.16	0.411	0.496	-0.069	0.61	0.535
5/ 6	0.315	0.152	0.637	-0.305	-0.175	-0.357	-0.265	0.126	-0.048
6/ 7	-0.46	0.121	-0.465	-0.157	-0.627	-0.489	-0.315	-0.63	-1.184
7/ 8	-0.541	0.114	-0.118	-0.457	-1.51	-0.167	-0.492	-0.204	0.476
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75
1/ 2	-0.583	-3.151	1.028	1.071	0.054	1.137	0.71	2.999	1.725
2/ 3	-0.441	-1.054	0.285	-0.089	1.727	-0.344	0.116	0.672	0.525
3/ 4	0.203	-0.559	0.111	-0.047	0.511	0.506	0.306	0.215	0.138
4/ 5	0.284	0.549	0.292	-0.024	-0.072	0.238	-0.204	-0.052	0.257
5/ 6	0.237	0.3	-0.063	0.087	-0.56	0.062	-0.21	-0.271	0.024
6/ 7	-0.148	0.608	-0.009	0.069	-0.769	-0.084	-0.221	-0.171	-0.297
7/ 8	-0.075	0.472	-0.718	-0.102	-0.841	-0.492	0.143	-0.692	-0.82
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/ 2	2.946	2.694	1.778	2.576	2.559	1.84	1.542	0.585	-0.475
2/ 3	0.526	0.589	0.663	1.119	0.396	0.037	0.442	-0.153	0.139
3/ 4	-0.217	0.009	-0.356	0.167	-0.139	0.268	0.059	-0.056	0.218
4/ 5	-0.201	-0.175	-0.031	0.082	-0.11	0.07	0.08	0.091	0.32
5/ 6	-0.009	-0.136	0.226	-0.12	0.088	-0.149	-0.089	0.121	-0.121
6/ 7	0.037	-0.31	0.028	-0.585	-0.114	-0.114	0.378	0.114	-0.13
7/ 8	-0.431	-0.247	-0.707	-0.92	-0.376	-0.296	-1.024	-0.175	-0.378
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
1/ 2	2.405	3.216	0.957	2.828	-2.657	2.069	0.494	1.062	2.398
2/ 3	0.532	-0.107	-0.04	-0.135	-0.603	-0.332	0.268	0.199	0.285
3/ 4	0.676	0.043	0.15	0.068	0.48	-0.443	0.321	-0.06	0.16
4/ 5	0.218	-0.218	0.025	-0.164	0.438	0.163	0.155	-0.235	0.148
5/ 6	-0.373	0.194	0.309	-0.049	0.162	0.079	-0.036	0.008	-0.154
6/ 7	-0.186	-0.06	-0.31	-0.259	0.117	-0.272	-0.248	0.225	-0.199
7/ 8	-1.107	-0.173	-0.228	0.255	-0.328	0.6	-0.508	-0.243	-0.48
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/**	2000/**	2001/**
1/ 2	-1.495	3.077	0.116	1.675	2.356	1.851	1.154	2.489	1.723
2/ 3	-0.054	0.793	0.01	0.183	0.301	-0.053	0.182	0.735	-0.095
3/ 4	0.12	0.309	0.277	0.218	-0.382	-0.116	-0.039	0.479	-0.01
4/ 5	0.332	-0.483	0.622	0.204	0.041	0.116	0.021	0.009	0.066
5/ 6	0.115	-0.154	0.096	-0.187	0.105	0.228	0.22	-0.332	0.113
6/ 7	-0.182	0.193	0.347	-0.303	-0.448	-0.087	0.066	-0.394	0.593
7/ 8	-0.18	-0.965	-1.363	-0.283	0.148	-0.272	-0.565	-0.746	-0.839
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	2002/**	2003/**	2004/**	2005/**	2006/**	2007/**	2008/**	2009/**
1/2	1.895	1.804	1.223	-0.13	0.164	-0.932	0.772	0.034
2/3	0.192	0.08	-0.368	0.328	-0.765	0.449	0.13	-0.151
3/4	-0.126	-0.141	-0.033	-0.019	-0.297	0.029	-0.028	0.311
4/5	-0.084	0.284	0.19	-0.027	-0.177	0.134	0.1	-0.035
5/6	-0.113	-0.182	-0.033	-0.199	0.251	0.077	-0.107	-0.021
6/7	0.242	0.147	0.542	0.232	0.221	-0.287	-0.013	-0.146
7/8	-0.299	-0.367	-0.42	-0.302	0.75	-0.309	-0.158	0.039
TOT	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	1	1	1	1	1

Table 6.6.2.8 Herring in Divisions VIa(S) and VIIb,c. Matrix of residuals from the 0.6 VPA

Years	1957/58	1958/59	1959/60	1960/61	1961/62	1962/63	1963/64	1964/65	1965/66
1/ 2	-1.415	-0.458	0.763	1.444	3.056	0.366	0.264	0.559	0.333
2/ 3	0.699	-0.024	-0.153	0.588	0.983	0.051	0.62	0.261	-0.245
3/ 4	0.895	-0.38	-0.602	0.01	0.597	0.412	0.478	-0.234	0.417
4/ 5	-0.782	0.047	0.609	0.162	0.412	0.498	-0.068	0.611	0.536
5/ 6	0.322	0.159	0.643	-0.299	-0.168	-0.351	-0.259	0.132	-0.042
6/ 7	-0.451	0.131	-0.455	-0.148	-0.618	-0.479	-0.306	-0.621	-1.175
7/ 8	-0.54	0.114	-0.117	-0.457	-1.509	-0.167	-0.491	-0.204	0.477
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74	1974/75
1/ 2	-0.609	-3.177	1.002	1.045	0.029	1.112	0.684	2.973	1.699
2/ 3	-0.453	-1.067	0.273	-0.101	1.715	-0.356	0.104	0.66	0.512
3/ 4	0.2	-0.563	0.108	-0.05	0.508	0.503	0.303	0.212	0.135
4/ 5	0.285	0.551	0.294	-0.023	-0.07	0.24	-0.202	-0.049	0.26
5/ 6	0.243	0.306	-0.057	0.094	-0.553	0.069	-0.204	-0.264	0.031
6/ 7	-0.139	0.618	0	0.079	-0.76	-0.075	-0.212	-0.163	-0.288
7/ 8	-0.074	0.473	-0.717	-0.102	-0.841	-0.492	0.143	-0.692	-0.821
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/ 2	2.918	2.667	1.751	2.55	2.532	1.813	1.516	0.559	-0.501
2/ 3	0.512	0.575	0.65	1.106	0.384	0.023	0.43	-0.166	0.126
3/ 4	-0.22	0.005	-0.359	0.164	-0.142	0.265	0.056	-0.059	0.215
4/ 5	-0.198	-0.172	-0.028	0.084	-0.108	0.073	0.082	0.093	0.321
5/ 6	-0.001	-0.127	0.233	-0.113	0.095	-0.141	-0.083	0.128	-0.113
6/ 7	0.047	-0.3	0.038	-0.575	-0.105	-0.104	0.387	0.123	-0.12
7/ 8	-0.432	-0.247	-0.707	-0.92	-0.376	-0.296	-1.023	-0.174	-0.378
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
1/ 2	2.38	3.19	0.931	2.802	-2.682	2.044	0.469	1.037	2.373
2/ 3	0.521	-0.119	-0.052	-0.147	-0.615	-0.344	0.256	0.187	0.272
3/ 4	0.673	0.04	0.147	0.065	0.476	-0.446	0.318	-0.063	0.157
4/ 5	0.22	-0.217	0.027	-0.162	0.44	0.165	0.156	-0.234	0.15
5/ 6	-0.367	0.2	0.315	-0.042	0.169	0.085	-0.029	0.015	-0.147
6/ 7	-0.177	-0.051	-0.301	-0.249	0.126	-0.263	-0.239	0.234	-0.19
7/ 8	-1.106	-0.172	-0.228	0.256	-0.328	0.6	-0.508	-0.243	-0.479
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/**	2000/**	2001/**
1/ 2	-1.521	3.052	0.09	1.648	2.328	1.824	1.128	2.463	1.696
2/ 3	-0.067	0.781	-0.002	0.17	0.287	-0.069	0.168	0.722	-0.109
3/ 4	0.117	0.306	0.274	0.215	-0.385	-0.12	-0.043	0.476	-0.013
4/ 5	0.334	-0.481	0.624	0.207	0.045	0.12	0.024	0.012	0.069
5/ 6	0.122	-0.147	0.104	-0.179	0.113	0.238	0.229	-0.324	0.121
6/ 7	-0.173	0.202	0.355	-0.294	-0.439	-0.077	0.076	-0.385	0.602
7/ 8	-0.18	-0.965	-1.363	-0.284	0.146	-0.274	-0.567	-0.746	-0.84
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Years	2002/**	2003/**	2004/**	2005/**	2006/**	2007/**	2008/**	2009/**
1/ 2	1.869	1.779	1.199	-0.153	0.148	-0.941	0.78	0.076
2/ 3	0.178	0.067	-0.38	0.316	-0.774	0.445	0.134	-0.13
3/ 4	-0.129	-0.144	-0.036	-0.021	-0.299	0.028	-0.027	0.316
4/ 5	-0.081	0.286	0.192	-0.025	-0.174	0.135	0.099	-0.04
5/ 6	-0.105	-0.175	-0.026	-0.192	0.257	0.08	-0.109	-0.035
6/ 7	0.251	0.156	0.551	0.239	0.227	-0.284	-0.016	-0.16
7/ 8	-0.3	-0.368	-0.421	-0.302	0.748	-0.309	-0.159	0.042
TOT	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	1	1	1	1	1

Table 6.7.1. Herring in Divisions VIa(S) and VIIb,c. Inputs to exploratory deterministic short term forecasts.

Run	0.2	0.4	0.5	0.6
GM Rec.	498 777	497 867	496 772	493 727
F (1 ring)	0.001	0.002	0.002	0.002
M 1 ring	1	1	1	1
2 ring 2011	183 294	182 862	182 420	181 260
F-at-age				
1	0.001	0.002	0.002	0.002
2	0.153	0.206	0.225	0.242
3	0.345	0.445	0.482	0.514
4	0.477	0.592	0.633	0.668
5	0.567	0.703	0.751	0.793
6	0.657	0.818	0.876	0.926
7	0.588	0.754	0.816	0.869
8	0.357	0.457	0.493	0.524
9	0.357	0.457	0.493	0.524
Interim catch (t)	7 757	7 757	7 757	7 757
Biomass (t)	117 319	90 251	84 833	80 947
SSB (t)	59 719	35 147	30 313	27 043
F Multiplier	0.347	0.537	0.611	0.674
F Bar (3-6)	0.177	0.344	0.419	0.489

Table 6.7.2. Herring in Divisions VIa(S) and VIIb,c. Results of exploratory short term deterministic forecasts, based on four separable VPA runs.

	2012				2013			2012				2013	
Run	SSB	FMult	FBar	Landings	Biomass	SSB	Run	SSB	FMult	FBar	Landings	Biomass	SSB
0.2	75864	0	0.00	0	148415	93895	0.5	46598	0	0	0	117777	65424
	73959	0.1	0.05	2879	145443	88671		45314	0.1	0.07	2018	115734	61538
	72111	0.2	0.10	5637	142600	83823		44073	0.2	0.14	3941	113791	57966
	70317	0.3	0.15	8279	139881	79322		42968	0.29	0.20	5632	112086	54933
	68577	0.4	0.20	10810	137278	75140		42873	0.30	0.21	5776	111941	54680
	67070	0.49	0.25	12975	135056	71666		42114	0.37	0.25	6923	110787	52685
	66887	0.5	0.26	13237	134788	71252		40590	0.5	0.34	9197	108504	48862
	65247	0.6	0.31	15563	132403	67635		39504	0.6	0.41	10793	106907	46285
	63654	0.7	0.36	17794	130120	64269		38452	0.7	0.48	12317	105385	43903
	62108	0.8	0.41	19934	127934	61133		37435	0.8	0.55	13774	103934	41699
	60607	0.9	0.46	21988	125839	58210		36451	0.9	0.62	15166	102551	39658
	59149	1	0.51	23958	123833	55483		35497	1	0.69	16498	101231	37765
	57734	1.1	0.56	25849	121910	52938		34574	1.1	0.75	17773	99971	36007
	56359	1.2	0.61	27665	120067	50561		33680	1.2	0.82	18992	98768	34373
	55023	1.3	0.67	29409	118300	48339		32814	1.3	0.89	20160	97620	32852
	53725	1.4	0.72	31084	116605	46261		31976	1.4	0.96	21279	96523	31434
	52465	1.5	0.77	32693	114980	44315		31163	1.5	1.03	22351	95474	30112
	46675	2	1.02	39855	107787	36260		27458	2	1.37	27089	90878	24678
0.4	51397	0	0	0	122930	70144	0.6	43282	0	0	0	113884	62058
	50012	0.1	0.06	2154	120738	66055		42064	0.1	0.07	1931	111938	58299
	48673	0.2	0.13	4210	118650	62288		40886	0.2	0.15	3770	110088	54851
	47377	0.3	0.19	6172	116661	58816		40018	0.276	0.20	5110	108743	52420
	47211	0.31	0.20	6421	116409	58385		39748	0.3	0.22	5523	108329	51684
	46233	0.39	0.25	7881	114932	55890		39249	0.345	0.25	6285	107566	50344
	44908	0.5	0.320	9836	112959	52652		37585	0.5	0.36	8788	105065	46091
	43733	0.6	0.38	11546	111236	49914		36557	0.6	0.44	10309	103550	43619
	42594	0.7	0.45	13181	109592	47380		35563	0.7	0.51	11761	102108	41338
	41492	0.8	0.51	14745	108024	45032		34601	0.8	0.58	13148	100734	39231
	40425	0.9	0.58	16241	106527	42854		33670	0.9	0.65	14473	99425	37281
	39391	1	0.64	17673	105098	40832		32770	1	0.73	15740	98177	35475
	38389	1.1	0.70	19044	103733	38952		31898	1.1	0.80	16951	96987	33800
	37418	1.2	0.77	20356	102429	37202		31055	1.2	0.87	18109	95852	32244
	36477	1.3	0.83	21614	101182	35572		30238	1.3	0.94	19218	94768	30798
	35566	1.4	0.90	22820	99991	34052		29447	1.4	1.02	20279	93734	29452
	34682	1.5	0.96	23976	98851	32633		28681	1.5	1.09	21295	92747	28197
	30647	2	1.28	29091	93844	26788		25195	2	1.45	25780	88427	23050

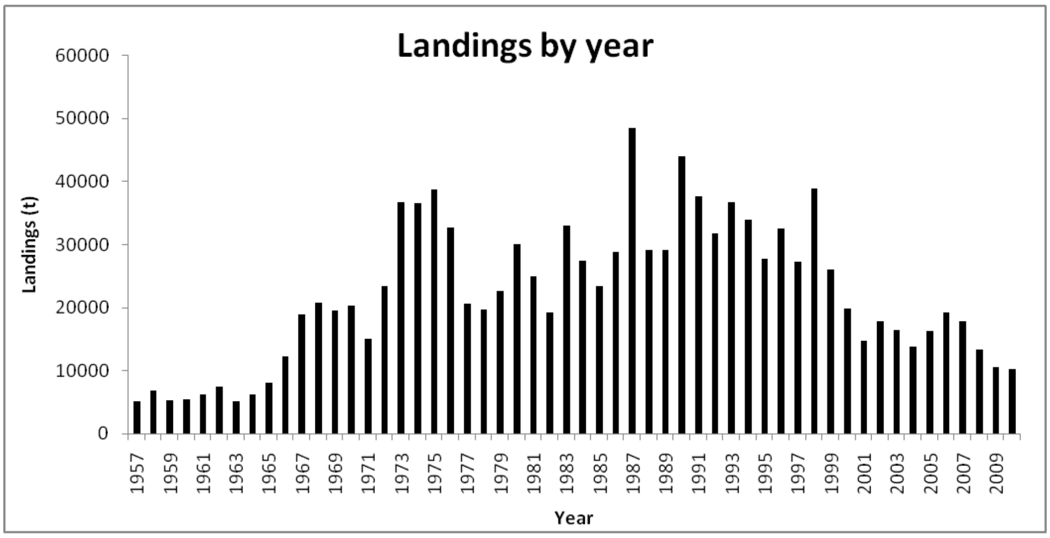


Figure 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Working group estimate of catches from 1957-2010.

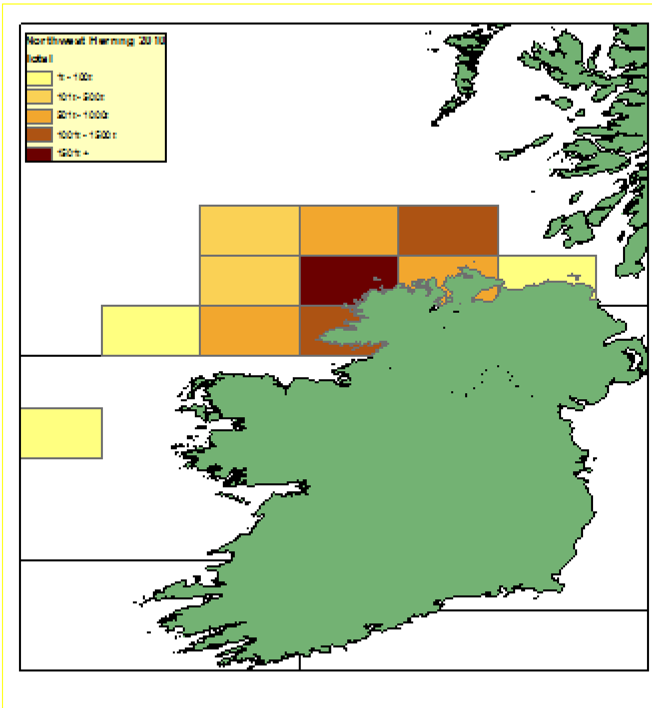


Figure 6.1.3.1. Herring in Divisions VIa(S) and VIIb,c. Herring landings by statistical rectangle in VIaS and VIIb,c in 2010.

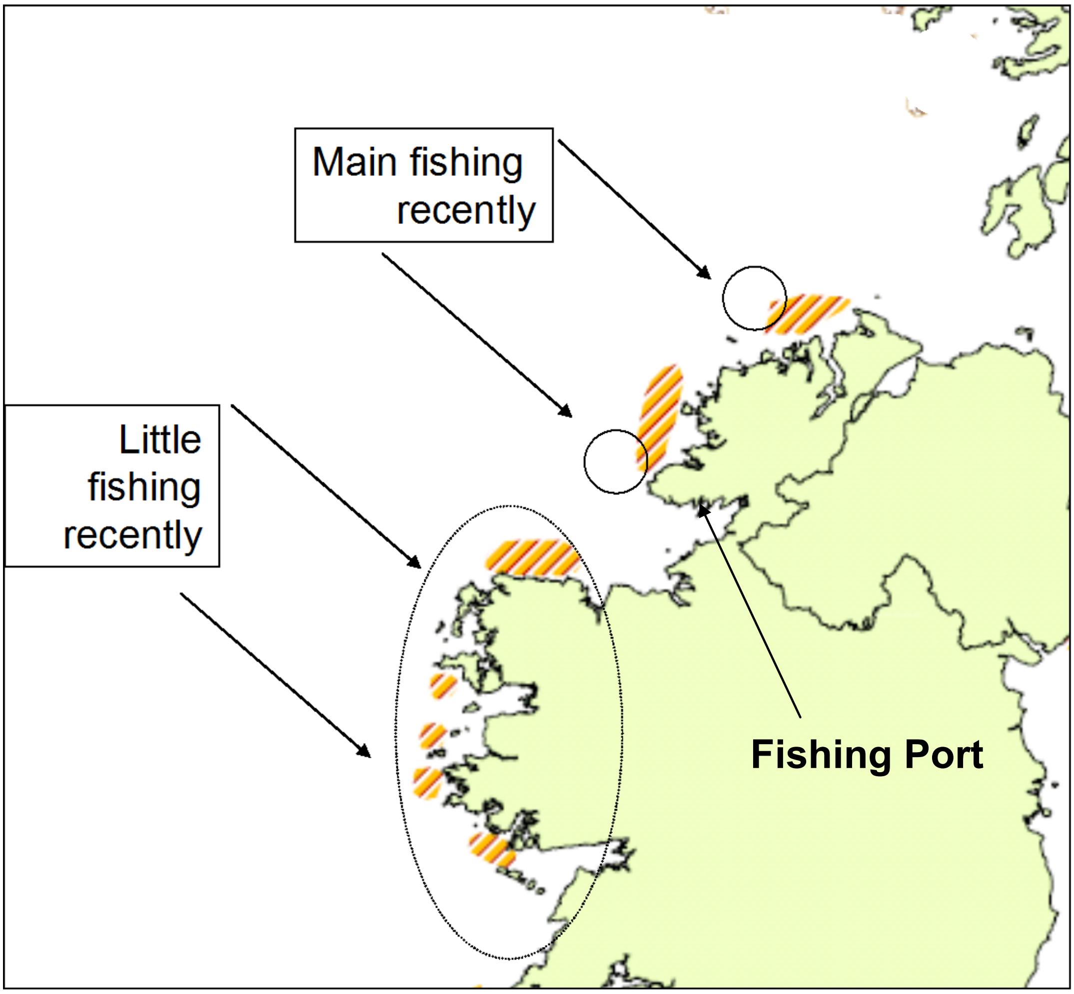


Figure 6.1.4.1. Herring in Divisions VIa(S) and VIIb,c. Main spawning grounds, and changes in recent fishing pattern. Fishing in recent years has been on or near the spawning grounds.

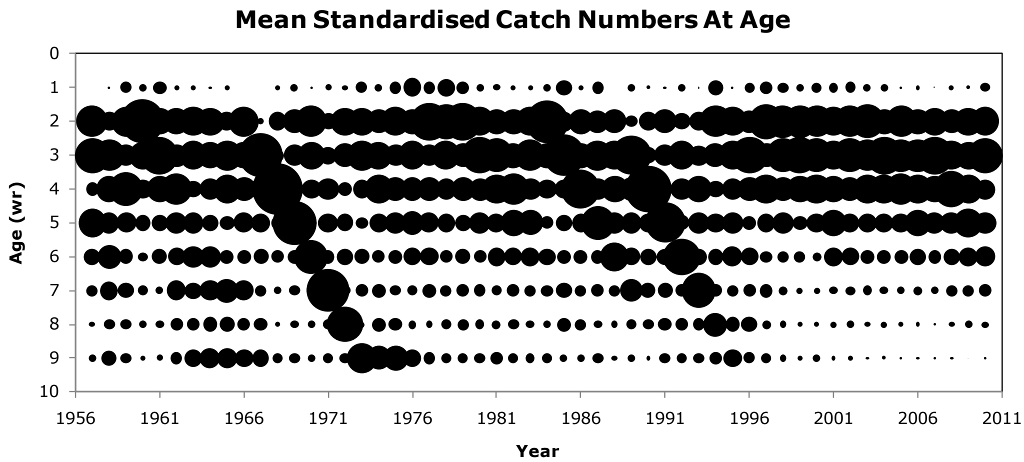


Figure 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean standardised catch numbers at age standardised by year for the fishery.

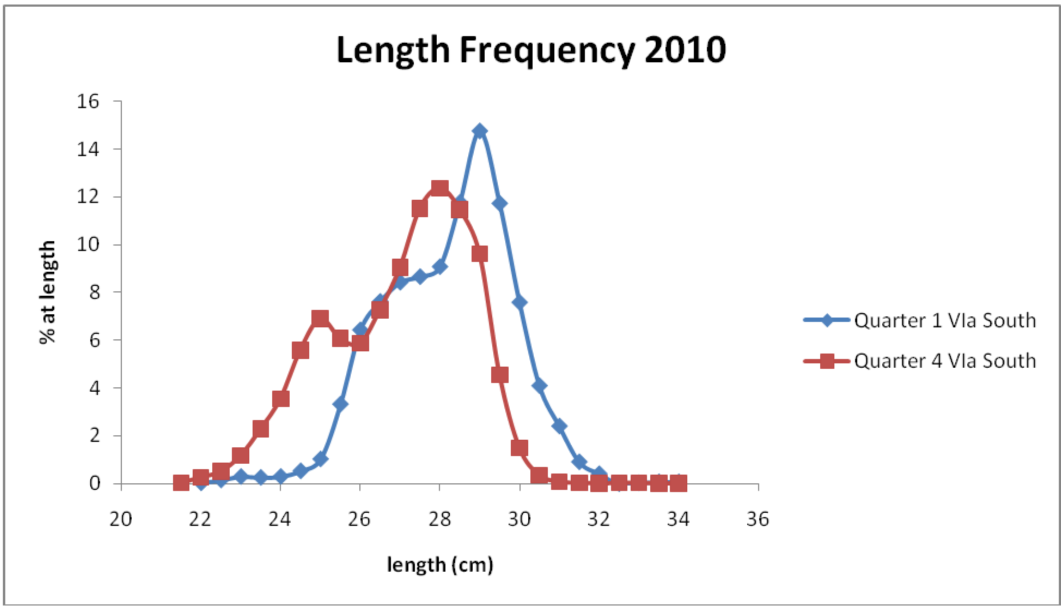


Figure 6.2.2.2. Herring in Divisions VIa(S) and VIIb,c. Length Frequency of herring samples.

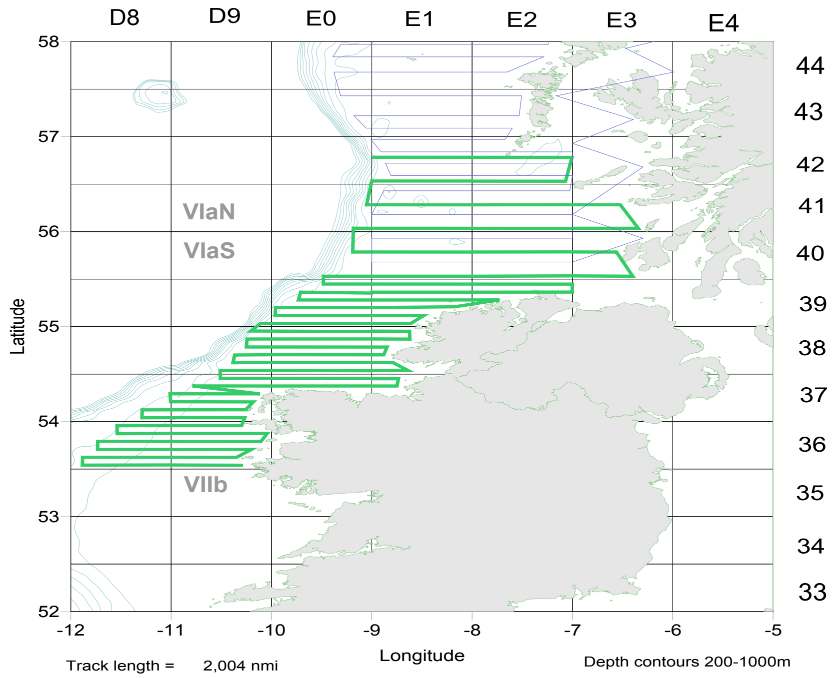


Figure 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Survey track for acoustic survey conducted in July 2010 as part of the Malin Shelf stock survey. The green track represents the RV Celtic Explorer track and the blue track shows the interlacing transects with the Scottish vessel.

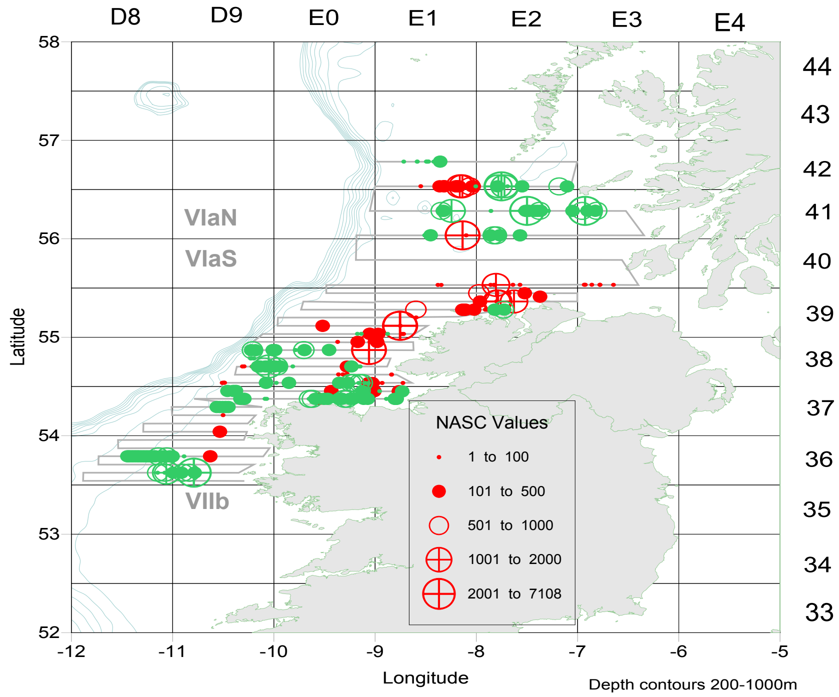


Figure 6.3.1.2. Herring in Divisions VIa(S) and VIIb,c. Total NASC (nautical area scattering coefficient) for herring in acoustic survey conducted in July 2010. The red marks represent definitely herring and the green marks represent herring in a mix.

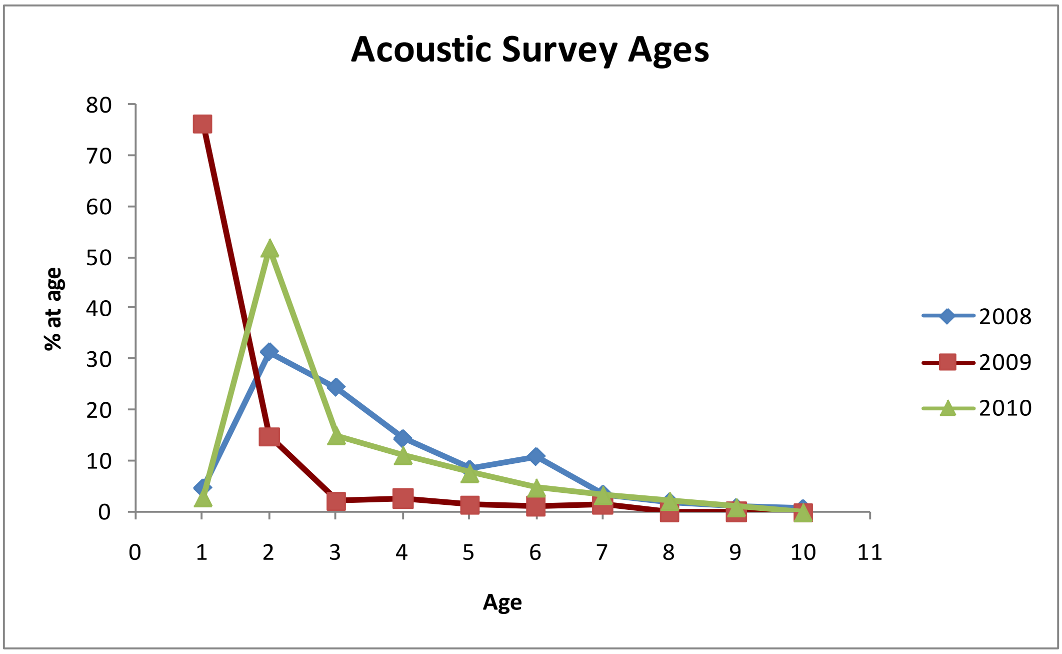
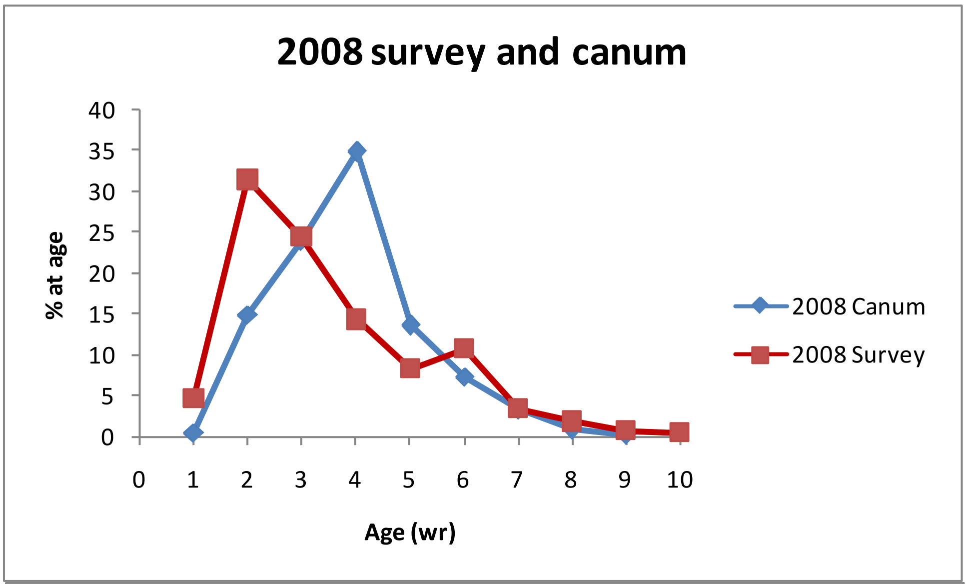
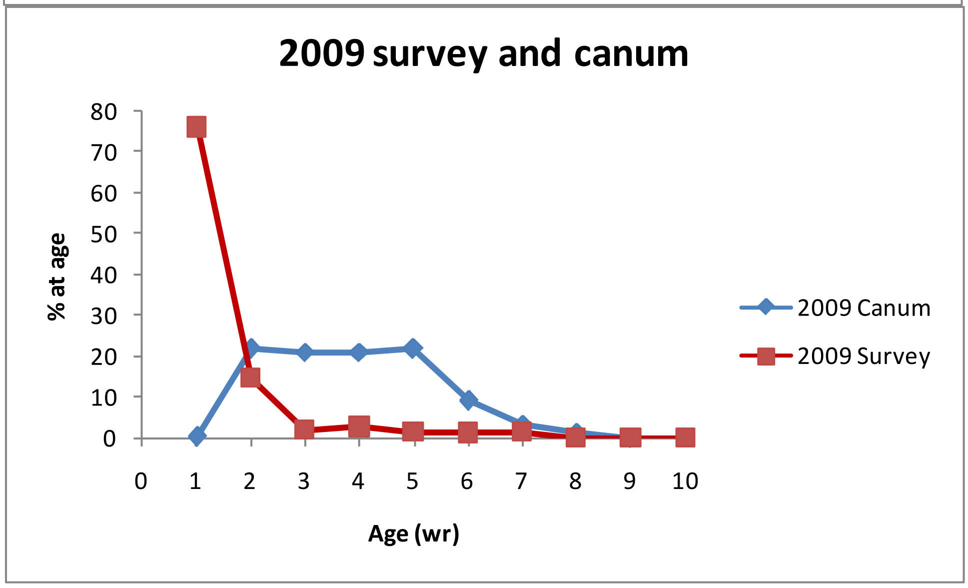


Figure 6.3.1.3. Herring in Divisions VIa(S) and VIIb,c. Age profiles from the acoustic surveys that were carried out in VIaS and VIIb in 2008, 2009 and 2010.





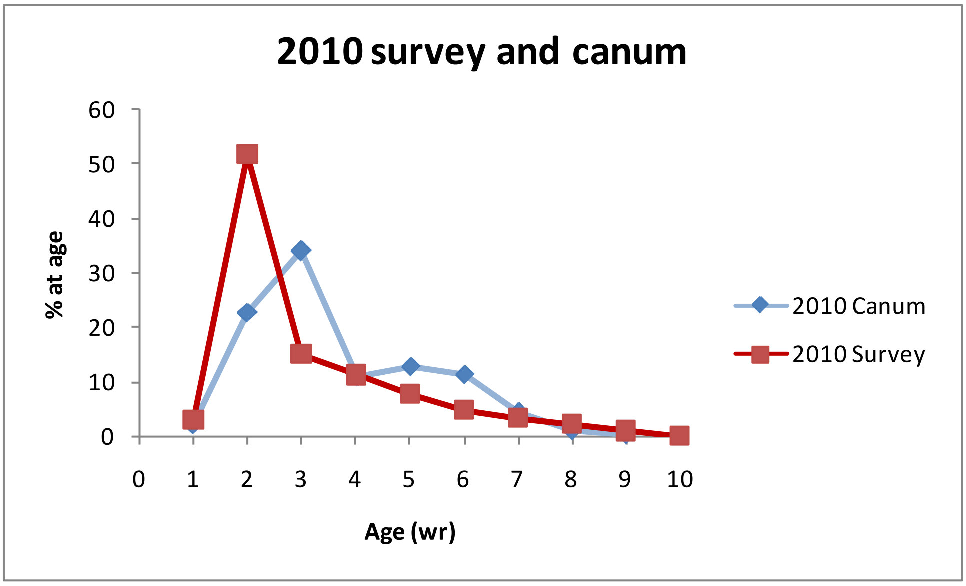


Figure 6.3.1.4. Herring in Divisions VIa(S) and VIIb,c. Proportions at age in the catch and survey data 2008-2010.

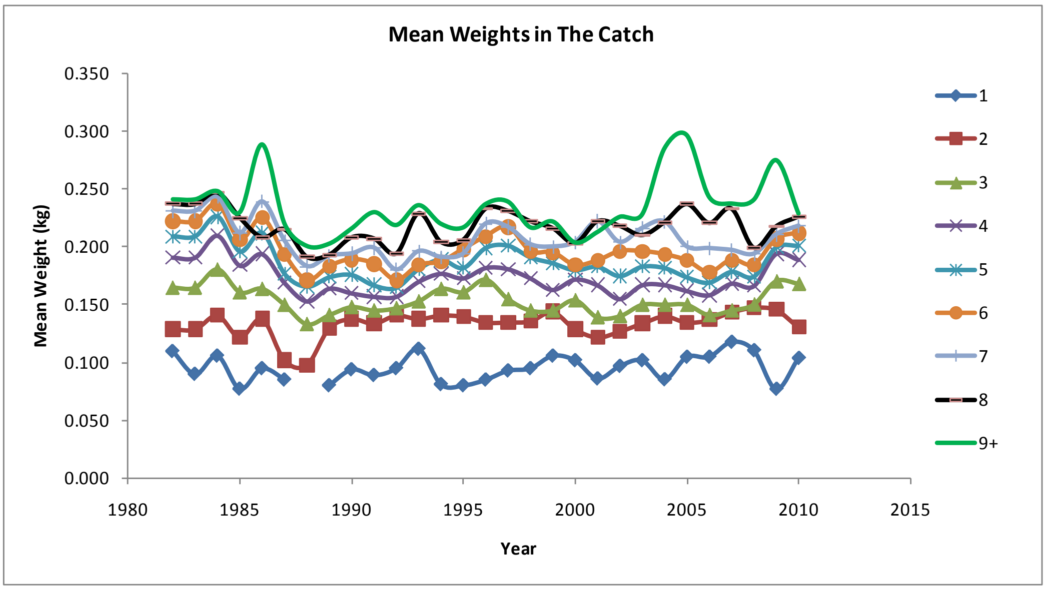


Figure 6.4.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean Weights in the Catch (kg) by age in winter rings.

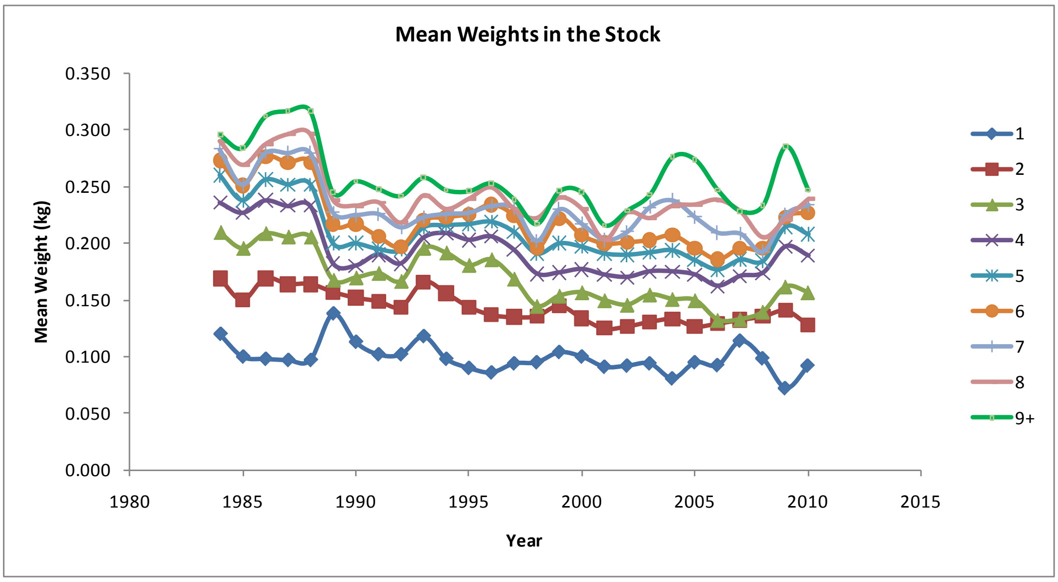
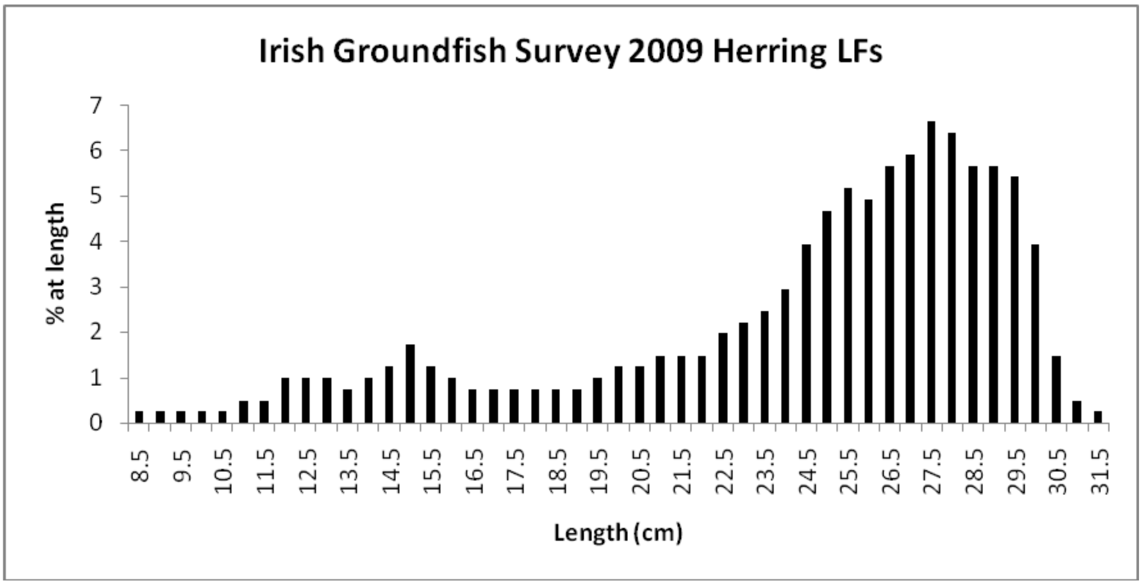


Figure 6.4.1.2. Herring in Divisions VIa(S) and VIIb,c. Mean weights in the stock (kg) by age in winter rings



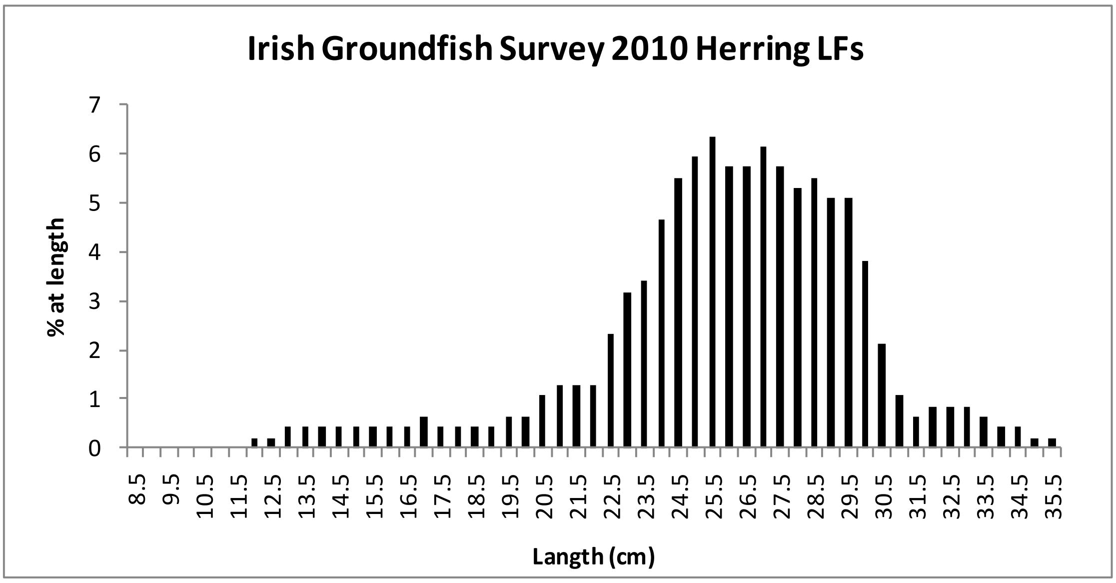


Figure 6.5.1.1. Herring in Divisions VIa(S) and VIIb,c. Irish Groundfish survey length frequency data 2009 (upper graph) and 2010 (lower graph).

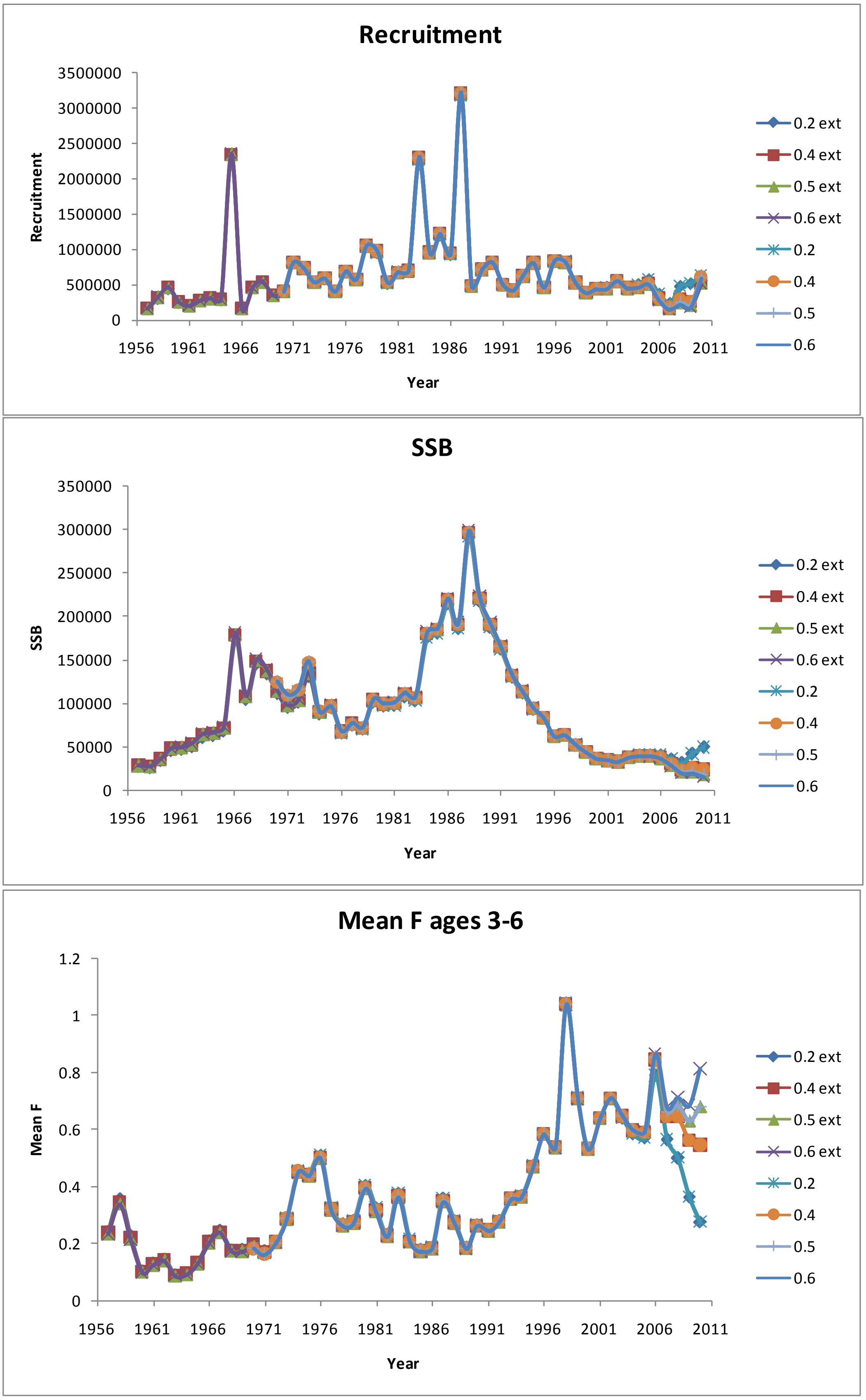


Figure 6.6.2.1. Herring in Divisions VIa(S) and VIIb,c. Four separable VPA runs using values of 0.2, 0.4, 0.5 and 0.6 for terminal F. The extended times series from 1957-2010 (0.2 ext, 0.4 ext, 0,5ext and 0.6ext) and the shorter time series 1970-2010 (0.2, 0.4, 0.5, 0.6) are presented.

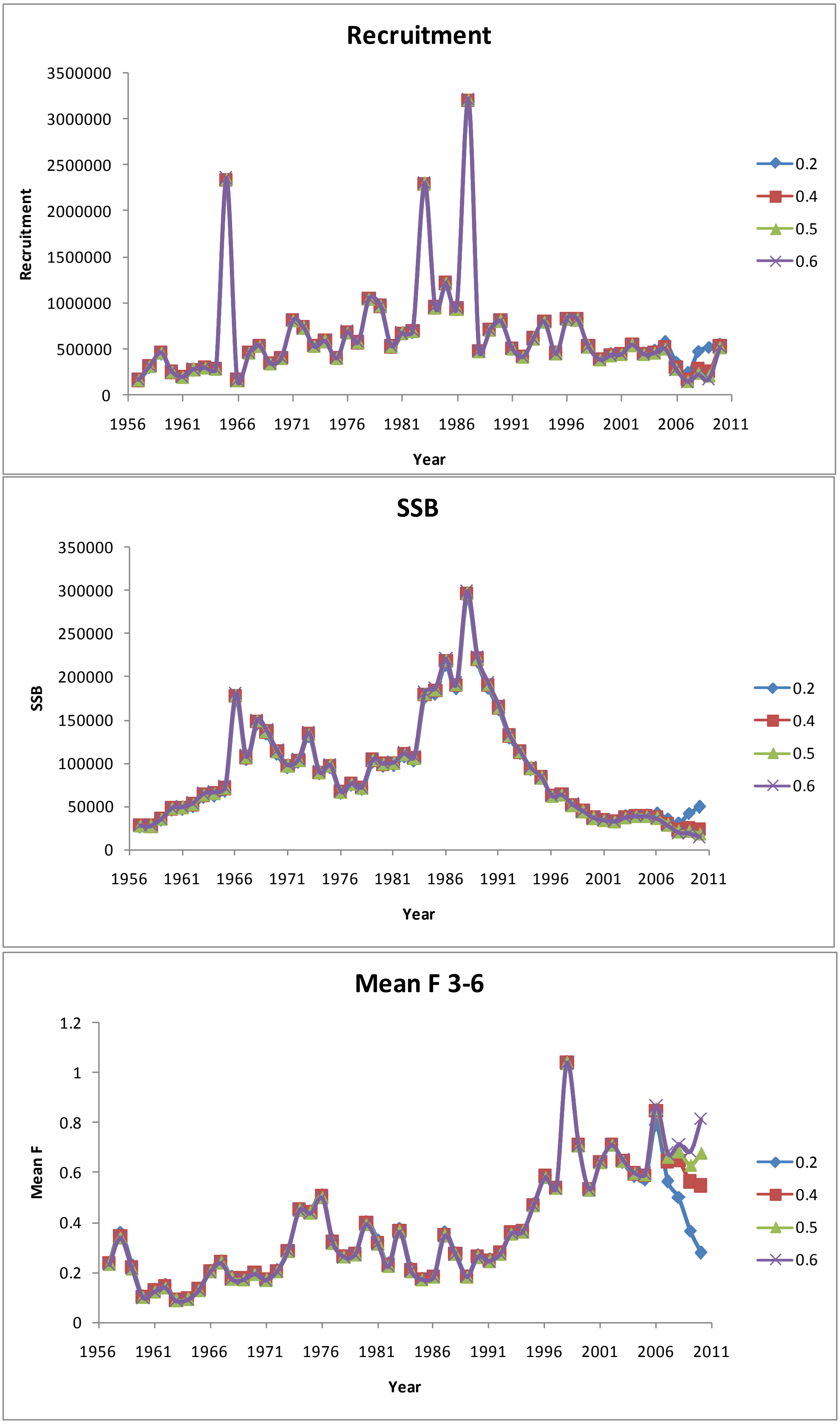


Figure 6.6.2.2. Herring in Divisions VIa(S) and VIIb,c. Results of the exploratory assessment showing the four separable VPAs with the time series 1957-2010.

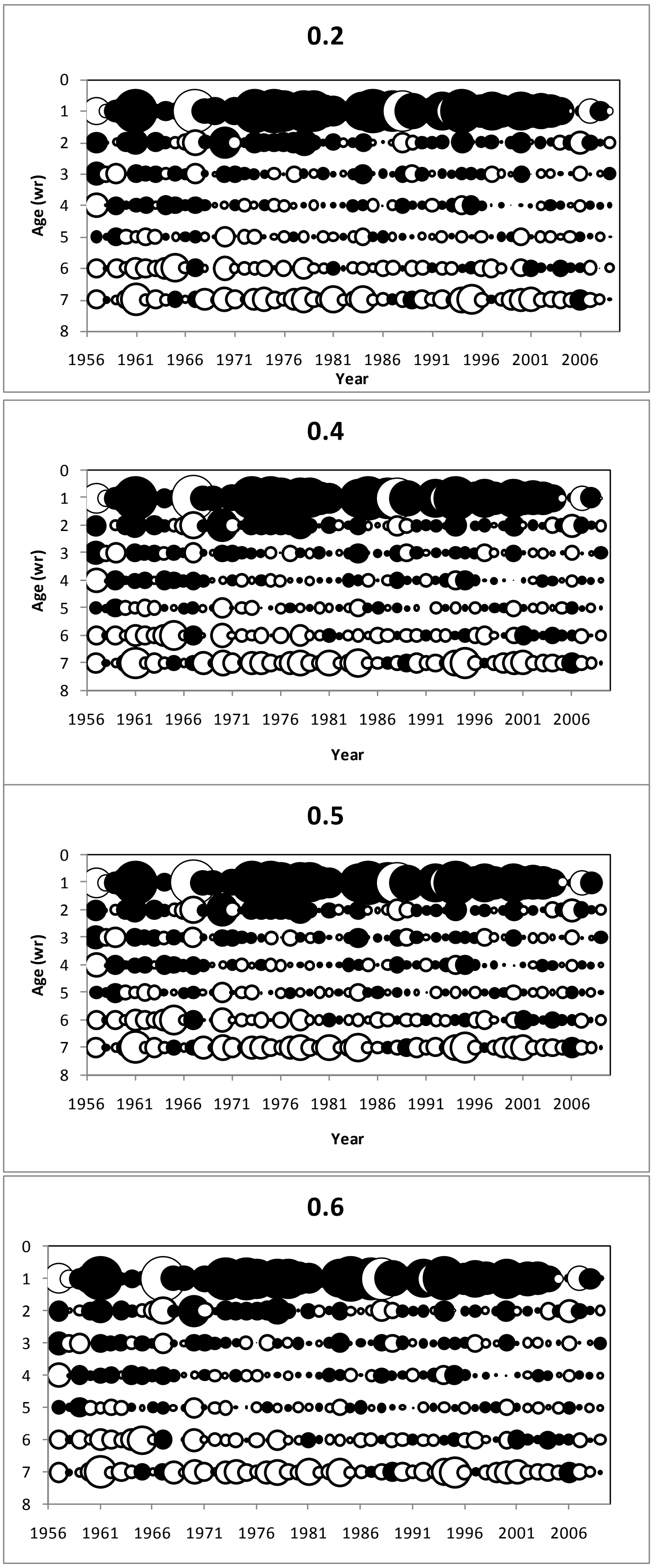


Figure 6.6.2.3. Herring in Divisions VIa(S) and VIIb,c. Residuals from the four separable VPA runs using terminal F values of 0.2 , 0.4, 0.5 and 0.6 . Black indicates positive residuals and white indicates negative.

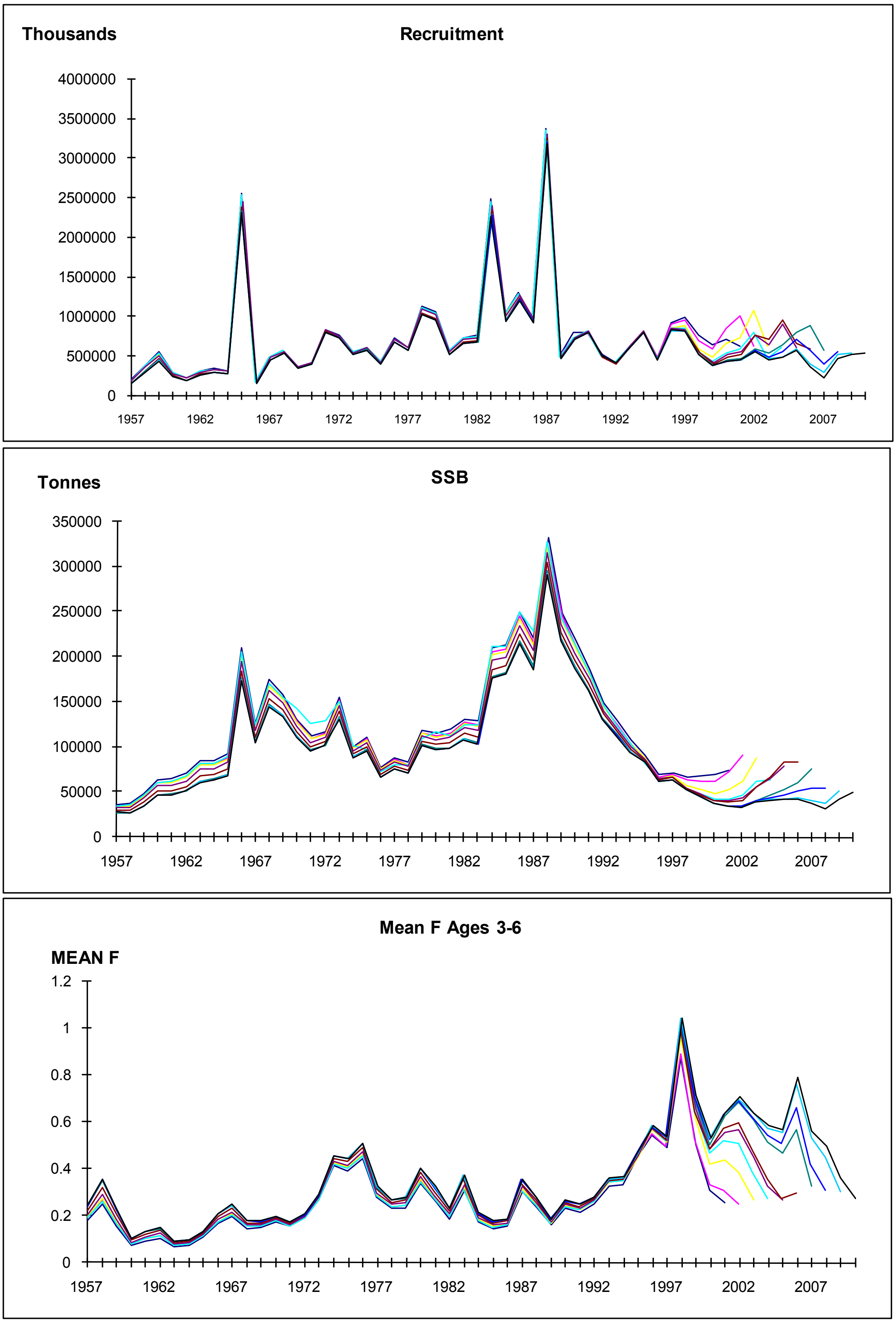


Figure 6.6.2.4. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.2

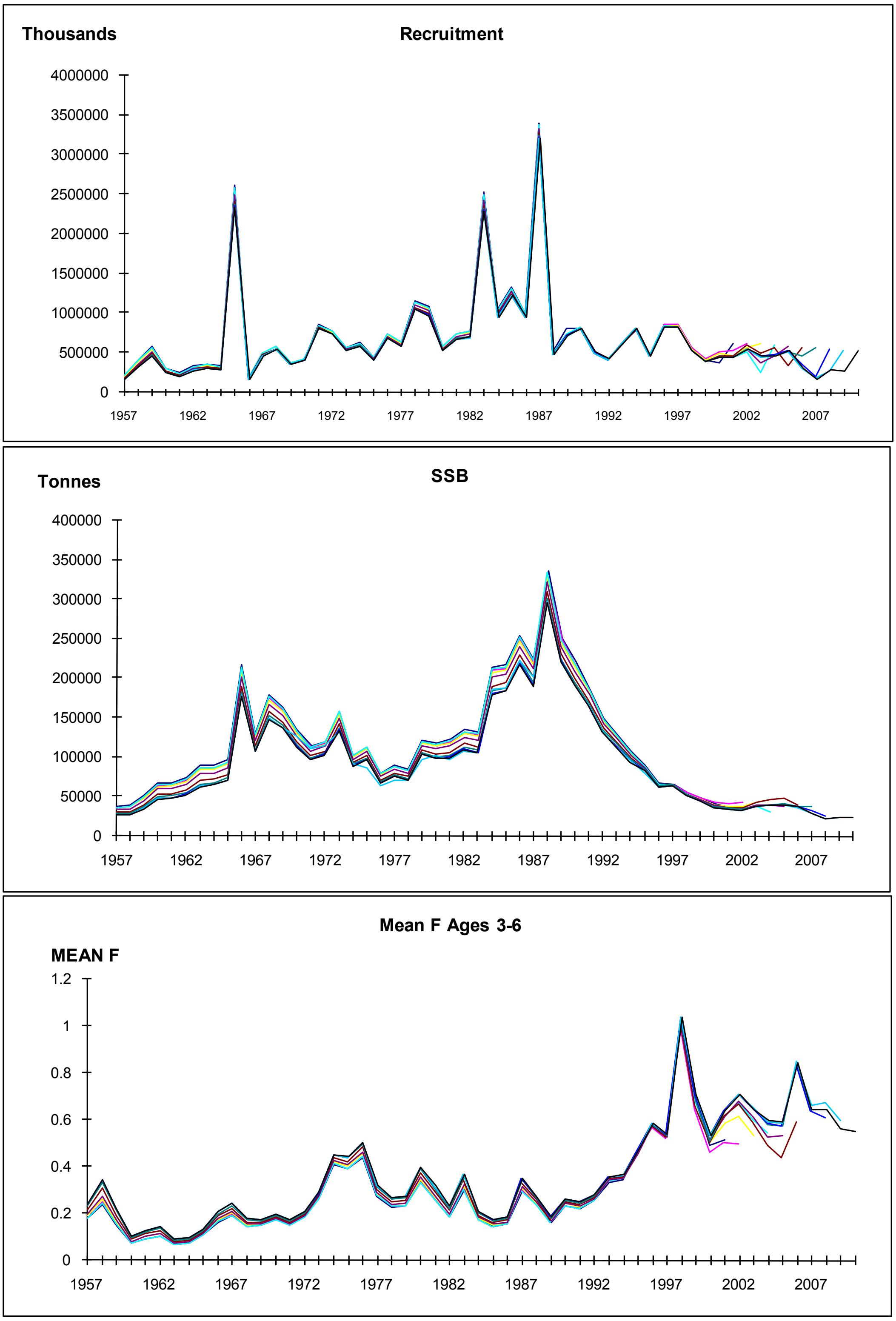
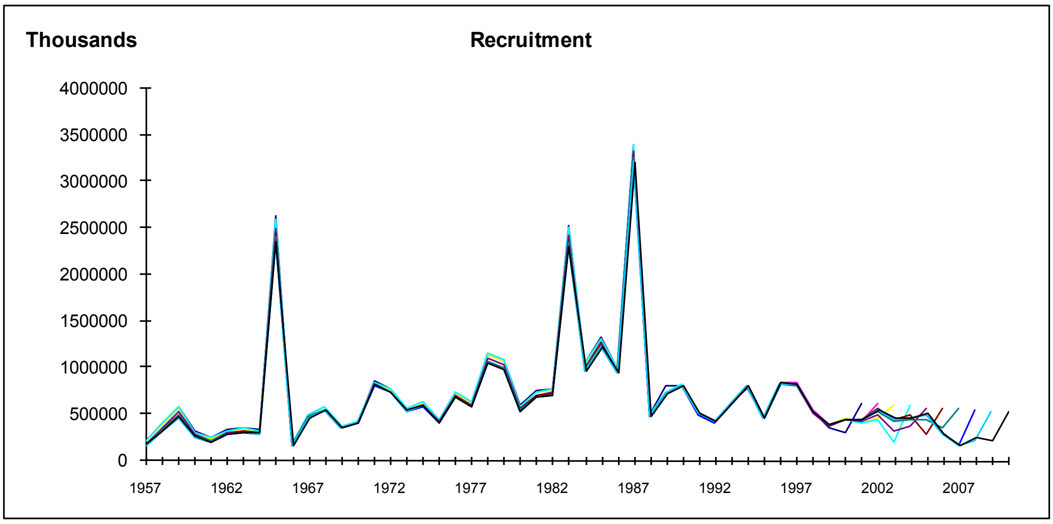
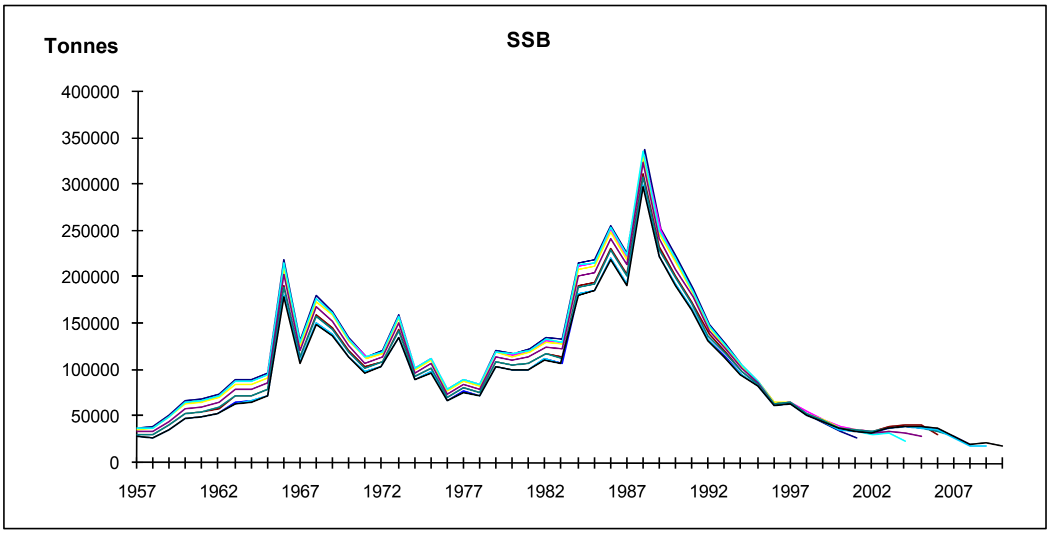


Figure 6.6.2.5. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.4.





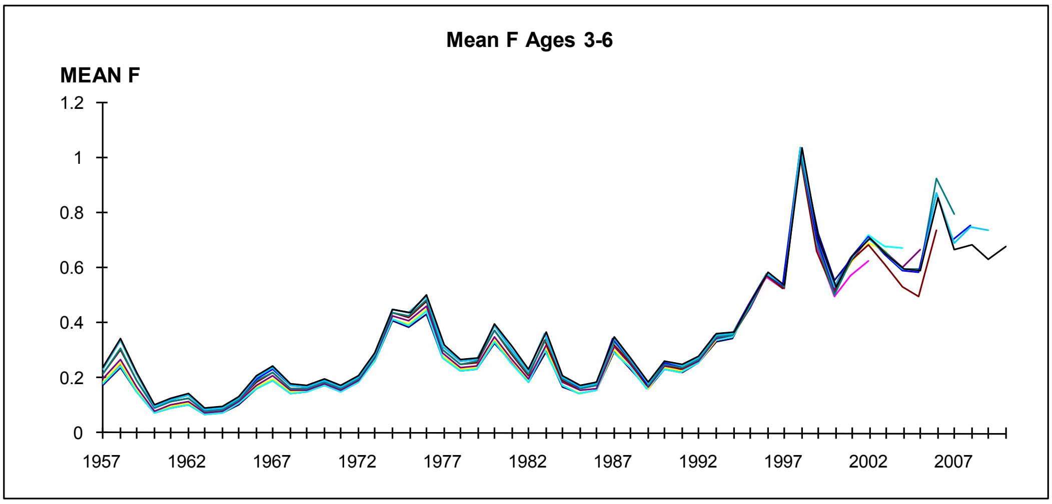


Figure 6.6.2.6. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.5

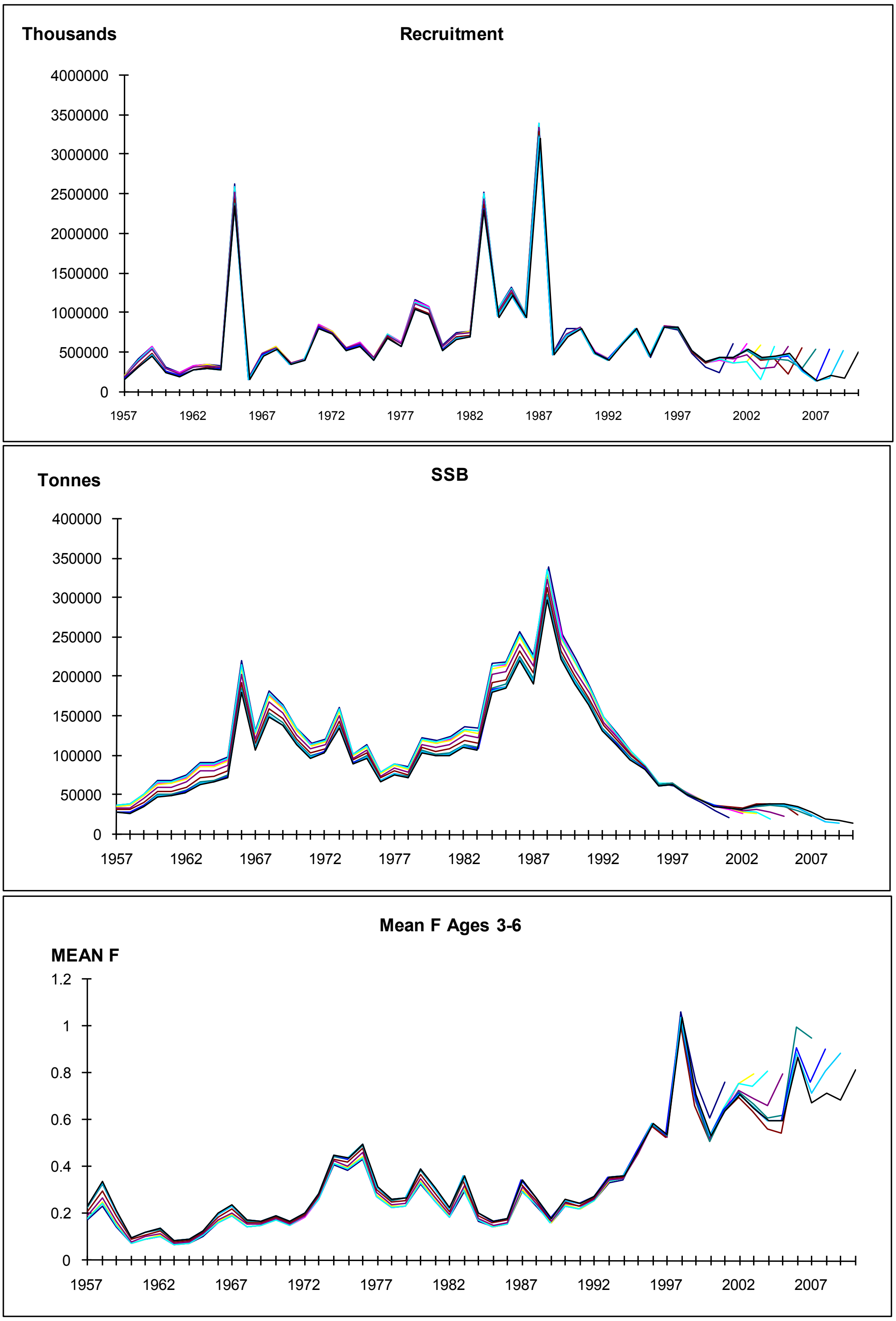


Figure 6.6.2.7. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.6.

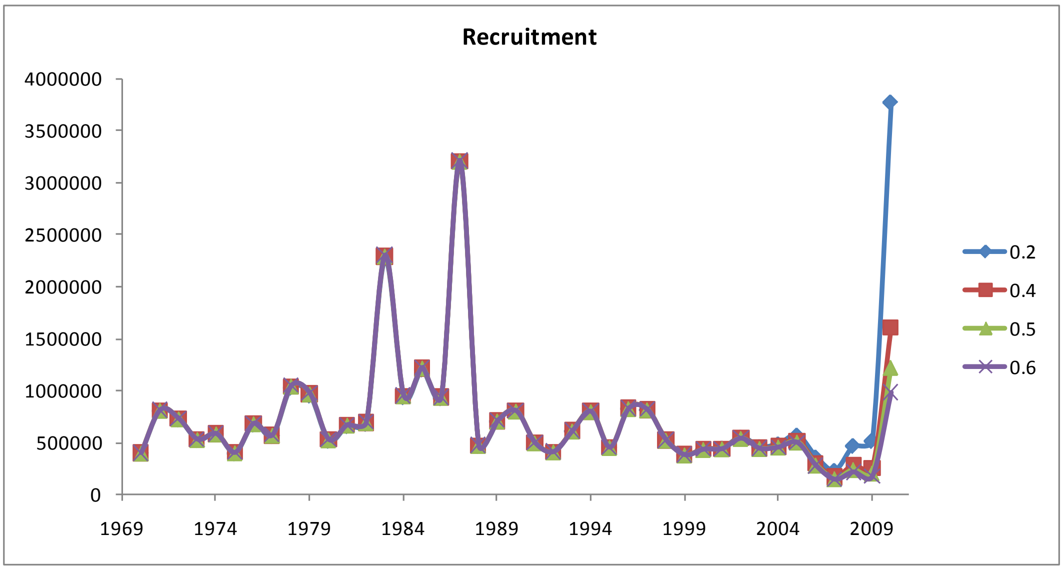


Figure 6.6.2.8. Herring in Divisions VIa(S) and VIIb,c. Recruitment over time, for each separable VPA run, using initial terminal F from 0.2 to 0.6.

7 Herring in Division VIIa North (Irish Sea)

This is an exploratory assessment, SALY status.

7.1 The Fishery

7.1.1 Advice and management applicable to 2010 and 2011

In 2010 a *status quo* TAC of 4 800 t was adopted and partitioned as 3 550 t to the UK and 1 250 t to the Republic of Ireland. In 2010 ACOM advised no increase in catch with a TAC of <4 800 t. A TAC of 5 280 t was subsequently adopted for 2011, partitioned as 3 906 t to the UK and 1 374 t to the Republic of Ireland.

7.1.2 The fishery in 2010

The catches reported from each country for the period 1987 to 2010 are given in Table 7.1.1, and total catches from 1961 to 2010 in Figure 7.1.1. Reported international landings in 2010 for the Irish Sea amounted to 4 894 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland. The majority of catches in 2010 were taken during the 3rd quarter.

The 2010 VIIa(N) herring fishery opened in August, with the majority of catches taken during August, September and October by a pair of UK pair trawlers. September and October saw activity of the Mourne fishery, limited to boats under 40ft. This was the 6th year of recorded landings for this fishery. In 2010 16 vessels recorded landings of ~129 t, taken during the months of September and October.

7.1.3 Regulations and their effects

Closed areas for herring fishing in the Irish Sea along the east coast of Ireland and within 12 nautical miles of the west coast of Britain were maintained throughout the year. The traditional gillnet fishery on the Mourne herring, which has a derogation to fish within the Irish closed box, operated successfully again in 2010. 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 to 15th November, and along the east coast of Ireland all year round. Any alterations to the present closures be considered carefully, in the context of this report, to ensure protection for all components of this stock.

7.1.4 Changes in fishing technology and fishing patterns

The fishery in area VIIa(N) has not changed in recent years. A pair of UK pair trawlers takes the majority of catches during the 3rd and 4th quarters. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 4th quarter. This fishery resumed in 2006 and has seen increasing catches of herring since, with 2006 landings of ~20 t, ~33.5 t in 2007, ~135 t in 2008, ~171 t in 2009 and ~129 t 2010.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Routine sampling of the main catch component recommenced in 2010. There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. In lieu of biological sampling 2009 data were estimated (see HAWG 2010 for methods). Catches in numbers-at-age are given in Table 7.6.1 for the years 1972 to 2010 and a graphical representation is given in Figure 7.2.1. The catch in numbers at length is given in Table 7.2.2 for 1995 to 2010, excluding 2009.

7.2.2 Quality of catch and biological data

27 samples from the main catch component were acquired in 2010, with a further 4 samples taken from the gillnet fishery operating on the Mourne ground. 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. Future monitoring in line with DCF requirements will take place. Details of sampling are given in Table 7.2.3.

7.3 Fishery Independent Information

7.3.1 Acoustic surveys AC(VIIaN)

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.3.1. As in the last year's assessment, the SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2010 was carried out over the period 28nd August - 11th September. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1.A). The ratio of sprat to 0-group herring continues to increase in favour of herring in 2010, with the biomass of sprat at its lowest level in 13 years. 0-group herring were found to be most abundant around the periphery of the Irish Sea (Figure 7.3.2.B), while sprat were also found to the west of the Isle of Man (Figure 7.3.1.B). The bulk of 1+ herring targets in 2010 were distributed to the east of the Isle of Man, in the region of the Douglas Bank spawning ground, to the north of the Isle of Man and in the North Channel (Figure 7.3.2.A). Further 1+ herring targets were found to the west of the Isle of Man and the western Northern Irish coastline. The survey followed the methods described in Armstrong *et al*., (ICES 2005 WD 23). Sampling intensity was high during the 2010 survey with 46 successful trawls completed. The length frequencies generated from these trawls highlights the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.3.3)

The estimate of herring SSB of 99 877 t for 2010 is the highest in the time series (Table 7.3.1). The biomass estimate of 131 849 t for 1+ ringers is also the highest in the time series and continues the increasing trend observed in recent years. The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2.

Results of a microstructure analysis of 1-ringer+ fish were presented Beggs *et al*., (HAWG 2008, WD08). The study shows that "winter" spawners, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these "winter" spawners has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods, such as ICA. However, removal of the "winter" spawning component, leaving just the "autumn" spawning component, from the 2006 to 2009 acoustic biomass estimates does not change the perception of a significant increase in 1-ringer+ biomass and SSB estimates (Figures 7.3.4-7.3.5).

7.3.2 Extended acoustic surveys

A series of additional acoustic surveys was conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The results of the first three years of the survey series were presented by Schön *et al*. (HAWG 2010, WD11). The enhanced survey programme was initiated to investigate the temporal and spatial variability in the population estimates from the routine acoustic survey and only concentrate on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (strata 2 and 5-9, Figure 7.3.1.A). Herring found in this area represents on average 86% of the total Irish Sea SSB estimate since 2001 and 81% of 1-ringer + biomass.

The surveys were roughly timed every fortnight, except for the last survey. The density distributions from the surveys highlight the temporal and spatial complexity of the herring distributions. Problems with timing of the survey are further exacerbated by the significant interannual variation in the migration patterns, evident from the changes in density distributions. The results confirm the high estimate of abundance observed during the routine annual acoustic survey estimates from 2007 to 2009 (HAWG 2010, WD11). Biomass estimates for the first three surveys in each year were above the previously observed maximum of the time series. The expected dissipation of herring off the spawning ground is evident from the marked decline in the survey estimates in late October/November.

The extended surveys were repeated again in 2010 but results were not available to the Working Group.

7.3.3 Larvae surveys (NINEL)

Northern Ireland undertook a herring larvae survey (NINEL) over the period 9th to 15th November 2010. The survey followed the methods and designs of previous surveys in the time-series (see Stock Annex 8). The production estimate of (2.04×10^{12} larvae) for 2010 in the NE Irish Sea was similar to the previous year and remains below the time-series average (Table 7.3.3). As in previous years herring larvae were found to be most abundant to the south east and north east of the Isle of Man and less abundant in the western Irish Sea. A difference in distribution pattern is, however, evident to the north of the Isle of Man with a westward expansion not routinely observed (Figure 7.3.6).

There was a continued low occurrence of larvae in the area of the traditional Mourne spawning ground, despite signs of the expansion of a spawning component in this area in recent years as evident from the fishery operating here. As such larvae would be expected in the area. The low occurrence of larvae caught during the survey may therefore suggest a timing mis-match between larvae emergence and sampling.

7.3.4 Groundfish surveys of Area VIIa(N) (NIGFS-WIBTS-1Q; NIGFS-WIBTS-4Q)

Groundfish surveys carried out by Northern Ireland since 1991 in the Irish Sea (NIGFS-WIBTS-1Q; NIGFS-WIBTS-4Q), were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring. These indices have performed poorly in the assessment and have not been used since. The time series was updated in 2010 (Figure 7.3.7). An increasing trend is evident for the 1-ring herring index from the spring groundfish survey over the time series. The indices of the groundfish do not take account of mixing between "winter" and "autumn" spawners.

7.4 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2010 with the mean weights-at-age in the 3rd quarter catches (for the whole time-series 1961 to present) used as estimates of stock weights at spawning time (Table 7.3.2). 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 (see Stock Annex 8). Mean weights-at-age have shown a general downward trend in the last 22 years, with a further pronounced reduction observed in 2010.

7.5 Recruitment

An estimate of total abundance of 0-ringers and 1-ringers is provided by the Northern Ireland acoustic survey, with trends also provided by the groundfish surveys. However, there is evidence that a proportion of these are of Celtic Sea origin (Brophy and Danilowicz, 2002). Separation of the trawl catches of 0-groups into autumn and winter spawning components, based on otolith microstructure and shape analysis was presented by Beggs *et al*. (HAWG 2008, WD08). 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.

7.6 Assessment

7.6.1 Data exploration and preliminary modelling

FLICA

2010 data were added to the Northern Irish larvae series (NINEL), the Northern Irish acoustic survey AC(VIIaN) (total biomass, SSB and age-structure indices) and the catch-at-age data derived from the landings. No biological sampling of the landings in 2009 meant that catch-at-age data were estimated (see HAWG 2010 for methods).

An exploratory FLICA run was conducted in 2010 with the updated survey indices; NINEL survey (SSB), acoustic survey and catch-at-age data. 2009 catch-at-age data remained downweighted (0.01) to eliminate the influence of this estimated data in the model fit. Results of the SPALY run as documented in the Stock Annex 8 are presented (Figures 7.6.1-7.6.14).

Residual patterns from the SPALY run highlighted a continued divergence in the signal from the acoustic and SSB indices (Figures 7.6.2-7.6.11). It has been observed that in recent years the abundance of larger herring larvae detected in the survey has declined. The abundance of these larger larvae has a significant influence on the SSB index. It is considered that the reduction in abundance of larger herring larvae is associated with a variation in the timing of spawning. In 2009 an exploratory FLICA run without the SSB index highlighted its effect on the catch at age residuals. A FLICA run with no SSB index was considered more reliable as an indicator of stock trends. Further investigation of the SSB index is required.

The catch residuals from the separable period (Figure 7.6.10) are generally small, however they exhibit patterns that are thought to originate from variation in the selectivity pattern originating from migration variation (HAWG 2007). Analysis of the retrospective patterns in the selectivity pattern at age and in the estimates of SSB, $F_{2\text{-}6}$ and recruitment was undertaken (Figures 7.6.13-7.6.14). There was evidence of variation in the selectivity pattern at age and a failure of the model to converge.

With all of the above considered the SPALY run although not considered reliable for absolute values of SSB and F, however is thought to be indicative of trends.

Two Stage Biomass

A two-stage biomass model was run with similar configurations as in previous years. A full description of this model can be found in Appendix 8. The model was run for two assumptions of recruitment variability: 0.4 and 0.8. The fit to the acoustics estimates is shown (Figures 7.6.15 – 7.6.16).

The model fits the data better when recruitment is allowed to vary more freely resulting in an additional variance close to zero. The additional variance estimates appear to be negatively correlated with recruitment variability suggesting that these two parameters are confounded and cannot be both estimated. Therefore, additional information on recruitment variability is required to resolve this issue. The difficulty of estimating both parameters provides support for fixing recruitment variability based on the dynamics of well-studied herring stocks, i.e. North Sea herring.

None of the recruitment variability scenarios fit the 2007 recruitment observation a year when the incidence of “winter” spawning herring (Figure 7.3.6) in the samples was particularly high, however the model supports the increasing trend in biomass estimated by the acoustic survey.

7.6.2 Conclusion to explorations

The exploratory FLICA runs conducted in 2011 did not improve the perception of the suitability of FLICA as an assessment method for the Irish Sea stock. However from the exploratory runs recent trends in SSB are thought to have increased while F has decreased. There is evidence from both the groundfish and acoustic surveys of increases in recent recruitment.

2011 acoustic survey estimates suggest that SSB is at higher levels than at any other period in the 18 year time-series, while 1-ringer+ biomass is also at its highest level. Numbers-at-age in the acoustic survey suggest the strong 2005 year class (1-ringers in 2007) is still present in the survey area as 4-ringers. The strong 2005 year class has now been tracked successfully over 5 years of the survey.

The two-stage biomass model supports the increasing trend in biomass estimated by the acoustic survey.

The acoustic estimates of population size for the last four years indicate a significant increase in herring abundance in the Irish Sea. Although the survey data are noisy, consecutive surveys indicate similar high abundance. The lack of an accepted assessment to form the basis of scientific advice is unsatisfactory, especially if management measures cannot be changed to reflect dramatic changes in stock abundances. A benchmark assessment is scheduled in 2012 for this stock.

7.6.3 Final assessment

No final assessment presented.

7.6.4 State of the stock

Trends from the September acoustic survey AC(VIIaN) and groundfish surveys indicate an increase in 1+ herring biomass in the Irish Sea since 2007. Recent catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data. Exploratory runs in FLICA show trends in F have decreased while SSB has increased. There is evidence from surveys of recent increases in recruitment.

7.7 Short term projections

7.7.1 Deterministic short term projections

The Working Group decided that there was no basis for undertaking short-term predictions of stock size.

7.7.2 Yield per recruit

The Working Group decided that there was no basis for yield-per-recruit analysis.

7.8 Medium term projections

The Working Group decided that there was no basis for undertaking medium-term projections of stock size.

7.9 Precautionary and yield based reference points

The estimation of $\mathbf{B}_{pa}$ (9 500 t) and $\mathbf{B}_{lim}$ (6 000 t) were not revisited this year. There are no precautionary F reference points for this stock. Fmsy advice is being developed for this stock.

7.10 Quality of the assessment

The exploratory FLICA runs conducted in 2011 did not improve the perception of the suitability of FLICA as an assessment method for the Irish Sea stock.

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 (HAWG 2008).

Again, in 2011, HAWG only received the acoustic data for the last year, towards the end of the meeting. Insufficient time was available to explore the data. This is the only instance of late arrival of data for any of the stocks dealt with by the group, and frustrates any attempts to explore model settings or alternative assessment methods. Given that a benchmark will be conducted in 2012, Irish Sea will be scheduled as "Update" for 2012, it is essential that these data are provided to WKBENCH, and through WGIPS well in advance of the HAWG. If the data arrive during the HAWG meeting there will be insufficient time to include them in the update assessment, and they will be excluded.

7.11 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is light and mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

In the absence of an accepted analytical assessment, the maintenance of catch levels at current TAC levels of 4 800 t, in the short-term, is considered precautionary.

In lieu of a current age based assessment method the use of a survey based approach should be considered. The Working Group recommends that a management plan should be developed for this stock. Such a plan should be developed with stake-holders and forwarded to ICES for evaluation.

7.12 Ecosystem Considerations

No additional information presented (see stock annex 8).

Table 7.1.1 Herring in Division VIIa North (Irish Sea). Working Group catch estimates in tonnes by country, 1987-2010. The total catch does not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1987	1988	1989	1990	1991	1992	1993	1994	1995
Ireland	1 200	2 579	1 430	1 699	80	406	0	0	0
UK	3 290	7 593	3 532	4 613	4 318	4 864	4 408	4 828	5 076
Unallocated	1 333	-	-	-	-	-	-	-	-
Total	5 823	10 172	4 962	6 312	4 398	5 270	4 408	4 828	5 076

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004
Ireland	100	0	0	0	0	862	286	0	749
UK	5 180	6 651	4 905	4 127	2 002	4 599	2 107	2 399	1 782
Unallocated	22	-	-	-	-	-		-	-
Total	5 302	6 651	4 905	4 127	2 002	5 461	2 393	2 399	2 531

Country	2005	2006	2007	2008	2009	2010
Ireland	1 153	581	0	0	0	0
UK	3 234	3821	4 629	4895	4594	4894
Unallocated	-	-				-
Total	4 387	4 402	4 629	4895	4594	4894

Table 7.2.2 Herring in Division VIIa North (Irish Sea). Catch at length data 1995-2010. Numbers of fish in thousands. Table amended with 1990-1994 year-classes removed (see Annex 8).

Length (cm)	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009*	2010
14															-	
14.5															-	
15															-	
15.5					10								16		-	93
16	21	21	17		19	12	9					2			-	107
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866
19.5	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108	-	673
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787
20.5	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133	-	888
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470
21.5	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217	-	1758
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363
22.5	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229	-	3362
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530
23.5	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264	-	5232
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559
24.5	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204	-	3616
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083
25.5	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114	-	2582
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777
26.5	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42	-	950
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460
27.5	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10	-	216
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-	
29	248	210	280	111	61	42	10	36	163		12	46			-	9
29.5	56	79	59	92		12	0	36	129				7		-	
30	40	32	8	84		6	9		43						-	
30.5	5	0	5	3					43						-	
31	1	2							43						-	
31.5															-	
32															-	
32.5															-	
33															-	
33.5															-	

Table 7.2.3 Herring in Division VIIa North (Irish Sea). Sampling intensity of commercial landings in 2010.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	3628	21	2190	1018
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	0	-	-	-
	UK (N. Ireland)	1266	10	1925	499
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

Table 7.3.1 Herring in Division VIIa North (Irish Sea). Summary of acoustic survey AC(VIIaN) information for the period 1989 - 2010. Small clupeoids include sprat and 0-ring herring unless otherwise stated. CVs are approximate. Biomass in t. All surveys carried out at 38kHz except December 1996, which was at 120kHz.

Year	Area	Dates	herring biomass (1+years)	CV	herring biomass (SSB)	CV	small clupeoids (biomass)	CV
1989	Douglas Bank	25/09-26/09			18,000	-	-	-
1990	Douglas Bank	26/09-27/09			26,600	-	-	-
1991	W. Irish Sea	26/07- 8/08	12,760	0.23			66,000[1]	0.20
1992	W. Irish Sea + IOM E. coast	20/07-31/07	17,490	0.19			43,200	0.25
1994	Area VIIa(N)	28/08 – 8/09	31,400	0.36	25,133	-	68,600	0.10
	Douglas Bank	22/09-26/09			28,200	-	-	-
1995	Area VIIa(N)	11/09-22/09	38,400	0.29	20,167	-	348,600	0.13
	Douglas Bank	10/10-11/10		-	9,840	-	-	-
	Douglas Bank	23/10-24/10			1,750	0.51	-	-
1996	Area VIIa(N)	2/09-12/09	24,500	0.25	21,426	0.25	-[2]	-
1997	Area VIIa(N)-reduced	8/09-12/09	20,100	0.28	10,702	0.35	46,600	0.20
1998	Area VIIa(N)	8/09-14/09	14,500	0.20	9,157	0.18	228,000	0.11
1999	Area VIIa(N)	6/09-17/09	31,600	0.59	21,040	0.75	272,200	0.10
2000	Area VIIa(N)	11/09-21/09	40,200	0.26	33,144	0.32	234,700	0.11
2001	Area VIIa(N)	10/09-18/09	35,400	0.40	13,647	0.42	299,700	0.08
2002	Area VIIa(N)	9/09-20/09	41,400	0.56	25,102	0.83	413,900	0.09
2003	Area VIIa(N)	7/09-20/09	49,500	0.22	24,390	0.24	265,900	0.10
2004	Area VIIa(N)	6/09-10/09, 15/09-16/09, 28/09-29/09	34,437	0.41	21,593	0.41	281,000	0.07
2005	Area VIIa(N)	29/08 -14/09	36,866	0.37	31,445	0.42	141,900	0.10
2006	Area VIIa(N)	30/08 – 9/09	33,136	0.24	16,332	0.22	143,200	0.09
2007	Area VIIa(N)	29/08 - 13/09	120,878	0.53	51,819	0.42	204,700	0.09
2008	Area VIIa(N)	27/08 – 14/09	106,921	0.22	77,172	0.23	252,300	0.12
2009	Area VIIa(N)	1/09 – 13/09	95,989	0.39	71,180	0.47	175,000	0.08
2010	Area VIIa(N)	28/08 – 11/09	131,849	0.22	99,877	0.22	107,400	0.10

[1] sprat only; [2]Data can be made available for the IoM waters only

Table 7.3.2 Herring in Division VIIa North (Irish Sea). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September AC(VIIaN).

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6
2009	371.2	182.6	177.8	92.7	32.5	15.1	13.9	6.9
2010	580.6	561.2	117.7	120.8	34.3	16.8	4.3	6.5

Table 7.3.3 Herring in Division VIIa North (Irish Sea). Larval production (10^{11}) indices for the Manx component. Table amended with Douglas Bank time series removed (see Stock Annex 8).

Year	Northeast Irish Sea				
		Isle of Man	NINEL	Northern Ireland	
	Date	Production	Date	Production	CV
1992	20 Nov	128.9	-	-	-
1993	22 Nov	1.1	17 Nov	38.3	0.48
1994	24 Nov	12.5	16 Nov	71.2	0.12
1995	-	-	28 Nov	15.1	0.62
1996	26 Nov	0.3	19 Nov	4.7	0.30
1997	1 Dec	35.9	4 Nov	29.1	0.11
1998	1 Dec	3.5	3 Nov	5.8	1.02
1999	-	-	9 Nov	16.7	0.57
2000	-	-	11 Nov	35.5	0.12
2001	11 Dec	198.6	7 Nov	55.3	0.55
2002	6 Dec	19.8	4 Nov	31.5	0.47
2003	-	-	9 Nov	15.8	0.58
2004	-	-	30 Oct	22.7	0.48
2005	-	-	6 Nov	26.4	0.57
2006	-	-	6 Nov	43.8	0.70
2007	-	-	6 Nov	12.6	0.67
2008	-	-	6 Nov	16.8	0.98
2009	-	-	8 Nov	16.9	0.89
2010	-	-	9 Nov	20.4	0.88

TABLE 7.6.1- 7.6.12 Herring in Division VIIa North (Irish Sea). Input data, FLICA run settings and results for the maximum-likelihood ICA calculation for the 8 year separable period. N.B. In these tables "age" refers to number of rings (winter rings in the otolith).

TABLE 7.6.1 Herring in Division VIIa North (Irish Sea). CATCH IN NUMBER

Units : Thousands

age \ year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	4541	381	4837	1508	846	940	4440	1020	1321	5605	12168	40640
2	11471	12296	9441	18095	27077	15048	40922	30181	42799	31177	66921	46660
3	2629	7340	2341	4346	8180	15635	5598	13459	16908	33630	31940	26950
4	12427	1811	2887	710	987	1999	4633	4079	12681	16465	29405	13180
5	239	5433	2263	532	705	118	1351	816	1321	12611	5070	13750
6	478	191	2263	710	987	353	0	612	2642	1752	3549	6760
7	1195	191	546	0	423	118	0	0	528	2102	1014	2660
8	2151	667	624	177	705	0	0	0	0	1051	1014	1670

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	42150	43250	33330	34740	30280	15540	11770	5840	5050	5100	1305	1168
2	32740	109550	48240	56160	39040	36950	38270	25760	15790	16030	12162	8424
3	38240	39750	39410	20780	22690	13410	23490	19510	3200	5670	5598	7237
4	11490	24510	10840	15220	6750	6780	4250	8520	2790	2150	2820	3841
5	6920	10650	7870	4580	4520	1740	2200	1980	2300	330	445	2221
6	5070	4990	4210	2810	1460	1340	1050	910	330	1110	484	380
7	2590	5150	2090	2420	910	670	400	360	290	140	255	229
8	2600	1630	1640	1270	1120	350	290	230	240	380	59	479

age \ year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	2429	4491	2225	2607	1156	2313	1999	12145	646	1970	3204	5335
2	10050	15266	12981	21250	6385	12835	9754	6885	14636	7002	21330	17529
3	17336	7462	6146	13343	12039	5726	6743	6744	3008	12165	3391	9761
4	13287	8550	2998	7159	4708	9697	2833	6690	3017	1826	5269	1160
5	7206	4528	4180	4610	1876	3598	5068	3256	2903	2566	1199	3603
6	2651	3198	2777	5084	1255	1661	1493	5122	1606	2104	1154	780
7	667	1464	2328	3232	1559	1042	719	1036	2181	1278	926	961
8	724	877	1671	4213	1956	1615	815	392	848	1991	1452	1364

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	9551	3069	1810	1221	2713	179	694	3225	8692	5669	20290	8939	3905
2	21387	11879	16929	3743	11473	9021	4694	8833	13980	15253	18291	18974	41005
3	7562	3875	5936	5873	7151	1894	3345	5405	10555	8198	4980	7487	22704
4	7341	4450	1566	2065	13050	1866	2559	2161	3287	6318	1655	2696	9251
5	1641	6674	1477	558	3386	2395	882	623	1422	1325	1062	2082	3278
6	2281	1030	1989	347	936	953	2945	213	415	605	325	1761	1496
7	840	2049	444	251	650	474	872	673	292	262	122	328	892
8	1432	451	622	147	803	337	605	127	368	246	111	216	215

age \ year	2010
1	9588
2	17627
3	6679
4	6201
5	3200
6	925
7	370
8	185

TABLE 7.6.2 Herring in Division VIIa North (Irish Sea). WEIGHTS AT AGE IN THE CATCH

Units : Kg

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.082	0.067	0.067	0.078	0.065	0.092	0.093	0.091	0.074	0.101	0.108	0.074
2	0.123	0.125	0.131	0.129	0.132	0.140	0.149	0.153	0.152	0.162	0.158	0.155
3	0.178	0.152	0.184	0.156	0.176	0.185	0.180	0.196	0.204	0.206	0.189	0.195
4	0.198	0.177	0.208	0.171	0.192	0.218	0.199	0.231	0.231	0.225	0.214	0.219
5	0.232	0.199	0.228	0.226	0.210	0.258	0.223	0.246	0.254	0.245	0.225	0.232
6	0.226	0.214	0.234	0.240	0.230	0.253	0.243	0.269	0.266	0.251	0.266	0.251
7	0.253	0.275	0.266	0.000	0.272	0.225	0.227	0.234	0.239	0.269	0.241	0.258
8	0.248	0.251	0.258	0.296	0.265	0.264	0.275	0.264	0.270	0.258	0.241	0.278

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.076
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.142
3	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.187
4	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.213
5	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.221
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.243
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.240
8	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.273

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.087	0.068	0.058	0.070	0.081	0.096	0.073	0.062	0.089	0.070	0.075	0.067
2	0.125	0.143	0.130	0.124	0.128	0.140	0.123	0.114	0.127	0.123	0.121	0.116
3	0.157	0.167	0.160	0.160	0.155	0.166	0.155	0.140	0.157	0.153	0.146	0.148
4	0.186	0.188	0.175	0.170	0.174	0.175	0.171	0.155	0.171	0.170	0.164	0.162
5	0.202	0.215	0.194	0.180	0.184	0.187	0.181	0.165	0.182	0.180	0.176	0.177
6	0.209	0.228	0.210	0.198	0.195	0.195	0.190	0.174	0.191	0.189	0.181	0.199
7	0.222	0.239	0.218	0.212	0.205	0.207	0.198	0.181	0.198	0.202	0.193	0.200
8	0.258	0.254	0.229	0.232	0.218	0.218	0.217	0.197	0.212	0.212	0.207	0.214

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.064	0.080	0.069	0.064	0.067	0.085	0.081	0.073	0.067	0.064	0.067	0.071
2	0.118	0.123	0.120	0.120	0.106	0.113	0.116	0.107	0.103	0.105	0.112	0.110
3	0.146	0.148	0.145	0.148	0.139	0.144	0.136	0.130	0.136	0.131	0.135	0.135
4	0.165	0.163	0.167	0.168	0.156	0.167	0.160	0.157	0.156	0.149	0.158	0.153
5	0.176	0.181	0.176	0.188	0.168	0.180	0.167	0.165	0.166	0.164	0.173	0.156
6	0.188	0.177	0.188	0.204	0.185	0.184	0.172	0.187	0.180	0.177	0.183	0.182
7	0.204	0.188	0.190	0.200	0.198	0.191	0.186	0.200	0.191	0.184	0.199	0.196
8	0.216	0.222	0.210	0.213	0.205	0.217	0.199	0.205	0.209	0.211	0.227	0.206

age	2009	2010
1	0.068	0.053
2	0.107	0.106
3	0.133	0.131
4	0.155	0.145
5	0.165	0.153
6	0.182	0.164
7	0.194	0.175
8	0.212	0.172

TABLE 7.6.3 Herring in Division VIIa North (Irish Sea). WEIGHTS AT AGE IN THE STOCK

Units : Kg

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.082	0.067	0.067	0.078	0.065	0.092	0.093	0.091	0.074	0.101	0.108	0.074
2	0.123	0.125	0.131	0.129	0.132	0.140	0.149	0.153	0.152	0.162	0.158	0.155
3	0.178	0.152	0.184	0.156	0.176	0.185	0.180	0.196	0.204	0.206	0.189	0.195
4	0.198	0.177	0.208	0.171	0.192	0.218	0.199	0.231	0.231	0.225	0.214	0.219
5	0.232	0.199	0.228	0.226	0.210	0.258	0.223	0.246	0.254	0.245	0.225	0.232
6	0.226	0.214	0.234	0.240	0.230	0.253	0.243	0.269	0.266	0.251	0.266	0.251
7	0.253	0.275	0.266	0.000	0.272	0.225	0.227	0.234	0.239	0.269	0.241	0.258
8	0.248	0.251	0.258	0.296	0.265	0.264	0.275	0.264	0.270	0.258	0.241	0.278

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.076
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.142
3	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.187
4	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.213
5	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.221
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.243
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.240
8	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.273

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.087	0.068	0.058	0.070	0.081	0.077	0.070	0.061	0.088	0.073	0.072	0.067
2	0.125	0.143	0.130	0.124	0.128	0.135	0.121	0.111	0.126	0.126	0.120	0.115
3	0.157	0.167	0.160	0.160	0.155	0.163	0.153	0.136	0.157	0.154	0.147	0.148
4	0.186	0.188	0.175	0.170	0.174	0.175	0.167	0.151	0.171	0.174	0.168	0.162
5	0.202	0.215	0.194	0.180	0.184	0.188	0.180	0.159	0.183	0.181	0.180	0.177
6	0.209	0.229	0.210	0.198	0.195	0.196	0.189	0.171	0.191	0.190	0.185	0.195
7	0.222	0.239	0.218	0.212	0.205	0.207	0.195	0.179	0.198	0.203	0.197	0.199
8	0.258	0.254	0.229	0.232	0.218	0.217	0.214	0.191	0.214	0.214	0.212	0.212

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.063	0.073	0.068	0.063	0.066	0.085	0.081	0.067	0.067	0.064	0.073	0.071
2	0.119	0.121	0.121	0.120	0.105	0.113	0.116	0.114	0.103	0.105	0.114	0.110
3	0.148	0.150	0.145	0.149	0.139	0.144	0.136	0.144	0.136	0.131	0.137	0.135
4	0.167	0.166	0.168	0.171	0.156	0.167	0.160	0.161	0.156	0.149	0.158	0.153
5	0.178	0.179	0.178	0.188	0.167	0.180	0.167	0.170	0.166	0.164	0.174	0.156
6	0.189	0.190	0.189	0.204	0.183	0.184	0.172	0.192	0.180	0.177	0.183	0.182
7	0.206	0.200	0.199	0.205	0.199	0.191	0.186	0.202	0.191	0.184	0.199	0.196
8	0.214	0.230	0.214	0.215	0.205	0.217	0.199	0.214	0.209	0.211	0.227	0.206

age	2009	2010
1	0.068	0.060
2	0.109	0.118
3	0.137	0.134
4	0.155	0.147
5	0.166	0.153
6	0.183	0.165
7	0.194	0.176
8	0.213	0.173

TABLE 7.6.4 Herring in Division VIIa North (Irish Sea). NATURAL MORTALITY

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	2006	2007	2008	2009	2010
1	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1

TABLE 7.6.5 Herring in Division VIIa North (Irish Sea). PROPORTION MATURE

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.15	0.11	0.12	0.36	0.40
2	0.22	0.24	0.34	0.53	0.61	0.47	0.37	0.88	0.71	0.92	0.87	0.88	0.77	0.99	0.99
3	0.63	0.83	0.88	0.81	0.90	0.91	0.75	0.94	0.92	0.94	0.97	0.90	0.89	0.96	1.00
4	1.00	0.92	0.89	1.00	1.00	1.00	0.83	0.94	0.94	0.96	0.98	1.00	0.97	1.00	0.94
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.07	0.03	0.04	0.00	0.20	0.19	0.10	0.02	0.00	0.14	0.31	0.00	0.00	0.07	0.06
2	0.96	0.92	0.81	0.84	0.88	0.89	0.80	0.73	0.69	0.62	0.73	0.85	0.90	0.63	0.66
3	0.98	0.96	0.88	0.81	0.95	0.90	0.89	0.88	0.83	0.71	0.66	0.91	0.96	0.93	0.90
4	1.00	1.00	0.91	0.78	0.95	0.94	0.91	0.90	0.93	0.88	0.81	0.87	0.99	0.95	0.95
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.04	0.28	0.00	0.19	0.10	0.02	0.04	0.30	0.02	0.14	0.15	0.02	0.11	0.11	0.20
2	0.30	0.48	0.46	0.68	0.86	0.60	0.82	0.83	0.84	0.79	0.54	0.92	0.76	1.00	0.97
3	0.74	0.72	0.99	0.99	0.94	0.96	0.95	0.97	0.95	0.99	0.88	0.95	0.95	0.97	0.99
4	0.82	0.81	1.00	0.97	0.99	0.83	1.00	0.99	0.97	1.00	0.97	0.98	0.97	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2006	2007	2008	2009	2010
1	0.19	0.16	0.16	0.13	0.11
2	0.89	0.94	0.84	0.82	0.92
3	1.00	0.98	1.00	0.97	1.00
4	1.00	1.00	1.00	0.98	0.98
5	1.00	1.00	1.00	1.00	0.97
6	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00

TABLE 7.6.6 Herring in Division VIIa North (Irish Sea). FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

age	2006	2007	2008	2009	2010
1	0.9	0.9	0.9	0.9	0.9
2	0.9	0.9	0.9	0.9	0.9
3	0.9	0.9	0.9	0.9	0.9
4	0.9	0.9	0.9	0.9	0.9
5	0.9	0.9	0.9	0.9	0.9
6	0.9	0.9	0.9	0.9	0.9
7	0.9	0.9	0.9	0.9	0.9
8	0.9	0.9	0.9	0.9	0.9

TABLE 7.6.7 Herring in Division VIIa North (Irish Sea). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

age	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

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

age	2006	2007	2008	2009	2010
1	0.75	0.75	0.75	0.75	0.75
2	0.75	0.75	0.75	0.75	0.75
3	0.75	0.75	0.75	0.75	0.75
4	0.75	0.75	0.75	0.75	0.75
5	0.75	0.75	0.75	0.75	0.75
6	0.75	0.75	0.75	0.75	0.75
7	0.75	0.75	0.75	0.75	0.75
8	0.75	0.75	0.75	0.75	0.75

TABLE 7.6.8 Herring in Division VIIa North (Irish Sea). SURVEY INDICES

NINEL - Configuration

"FLT04:" "Combined" "larvae" "(Catch:" "Unknown)" "(Effort:" "Unknown)"

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	1989	2010	NA	NA

Index type : biomass

NINEL - Index Values

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
all	-11	-11	-11	-11	38.3	71.2	15.1	4.7	29.1	5.8	16.7	35.5	55.3	31.5

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
all	15.8	22.7	26.4	43.8	12.6	16.8	16.9	20.4

NINEL - Index Variance (Inverse Weights)

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
all	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age \ year	2003	2004	2005	2006	2007	2008	2009	2010
all	1	1	1	1	1	1	1	1

FLT01: Northern Ireland acoustic surveys (age disaggregated) (Catch: Thousands) (Effort: Unknown) - Configuration

"Irish Sea herring (Division VIIa) (run name: ICAMDC20) . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
1.0	8.0	8.0	1994.0	2010.0	0.7	0.8

Index type : number

FLT01: Northern Ireland acoustic surveys (age disaggregated) (Catch: Thousands) (Effort: Unknown) - Index Values

Units : NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	66830	319116	11340	134146	110438	157756	78524	387559	390982	349216	241014
2	68290	82256	42372	49977	27312	77722	103439	93402	71935	220014	115529
3	73529	11935	67473	14812	8083	34017	105291	10194	31701	31984	29593
4	11860	29246	8954	10985	9266	5108	27543	17489	24804	4735	15398
5	9299	4574	26469	1751	6479	10260	8072	7704	31277	3921	2067
6	7550	3500	4171	4553	1778	13521	5432	1372	14830	4089	2299
7	3867	4887	5911	571	2254	1586	4899	626	2756	977	238
8	10118	6894	5815	1910	780	6289	2359	2263	4461	906	240

age \ year	2005	2006	2007	2008	2009	2010
1	94330	374731	1316673	475675	371230	580602
2	109938	96623	251276	452364	182643	561245
3	97111	15625	46570	114210	177813	117699
4	17023	9982	21101	39076	92741	120777
5	8029	530	20818	26370	32490	34325
6	810	369	1200	17063	15071	16759
7	607	478	718	4254	13940	4336
8	5804	469	556	599	6871	6453

FLT01: Northern Ireland acoustic surveys (age disaggregated) (Catch: Thousands) (Effort: Unknown) - Index Variance (Inverse Weights)

Units : NA

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
2	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
3	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
4	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8

age	2009	2010
1	80	80
2	8	8
3	8	8
4	8	8
5	8	8
6	8	8
7	8	8
8	8	8

TABLE 7.6.9 Herring in Division VIIa North (Irish Sea). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	8	8	1961	2010	2	6

TABLE 7.6.10 Herring in Division VIIa North (Irish Sea). FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 0.01 1
lambda.sr   : 0.01
index.model : linear linear
index.cor   : -925596313493178307362200866040864682646826004886202840426622244 0
sep.nyr     : 6
sep.age     : 4
sep.sel     : 1
```

TABLE 7.6.11 Herring in Division VIIa North (Irish Sea). FLR, R SOFTWARE VERSIONS

R version 2.8.1 (2008-12-22)

```
Package  : FLICA
Version  : 1.4-12
Packaged : 2009-10-08 15:16:26 UTC; mpa
Built    : R 2.9.1; ; 2009-10-08 15:16:27 UTC; windows

Package  : FLAssess
Version  : 1.99-102
Packaged : Mon Mar 23 08:18:19 2009; mpa
Built    : R 2.8.0; i386-pc-mingw32; 2009-03-23 08:18:21; windows

Package  : FLCore
Version  : 2.2
Packaged : Tue May 19 19:23:18 2009; Administrator
Built    : R 2.8.1; i386-pc-mingw32; 2009-05-19 19:23:22; windows
```

TABLE 7.6.12 Herring in Division VIIa North (Irish Sea). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 2-6) f	Landings Tonnes	Landings SOP
1961	67559	19666	5700	0.4676	5710	1.0002
1962	53462	12826	3381	0.5958	4343	0.9995
1963	130271	16298	2658	0.7282	3947	0.9992
1964	228981	26303	2723	0.6170	3593	1.0004
1965	124567	23921	5597	0.8122	5923	1.0021
1966	373283	50237	6498	0.4322	5666	1.0003
1967	360259	62713	9309	0.3522	8721	1.0023
1968	568489	91479	23956	0.2602	8660	0.9995
1969	379074	89071	32546	0.3004	14141	1.0004
1970	484293	115554	38070	0.4662	20622	0.9997
1971	499310	119945	36238	0.4886	26807	0.9994
1972	414813	94433	34732	0.5152	27350	0.8928
1973	667927	107649	32179	0.4546	22600	0.9927
1974	349430	93126	29413	0.8638	38640	1.0043
1975	369357	69354	21600	0.8106	24500	0.9747
1976	263290	54733	13659	0.9378	21250	1.0073
1977	324831	49535	9320	0.9164	15410	1.0484
1978	248671	43581	10156	0.7896	11080	1.0819
1979	139184	35321	8605	0.8196	12338	1.0757
1980	157428	29042	6319	0.9928	10613	1.0308
1981	223863	30690	8784	0.4652	4377	1.0999
1982	231879	38273	12513	0.3060	4855	1.0166
1983	232651	44616	16593	0.1756	3933	1.0165
1984	131707	43365	20939	0.1546	4066	1.0392
1985	148802	42403	15734	0.3818	9187	0.9802
1986	171166	39486	17011	0.3278	7440	1.0238
1987	275725	41549	16420	0.2650	5823	0.9632
1988	113260	37746	16514	0.5118	10172	0.9505
1989	149490	34638	14078	0.2814	4949	0.9966
1990	117269	31424	12680	0.3686	6312	0.9872
1991	69165	23355	9428	0.2886	4398	0.9994
1992	199305	25868	8210	0.4180	5270	0.9890
1993	64051	23707	9076	0.3132	4409	0.9869
1994	198166	29368	9753	0.4008	4828	0.9757
1995	128604	26484	10252	0.3450	5076	1.0007
1996	114486	23701	8427	0.3648	5301	0.9999
1997	121751	21931	6923	0.5772	6651	0.9996
1998	185521	25052	7255	0.6468	4905	0.9951
1999	62299	17960	7224	0.4956	4127	1.0001
2000	66186	15287	7827	0.2112	2002	0.9993
2001	69291	14826	4149	0.7422	5461	1.0004
2002	64754	12778	4168	0.4324	2393	0.9984
2003	144070	18580	4036	0.5812	2399	1.0010
2004	126908	18382	6549	0.4016	2531	0.9979
2005	143446	20484	6270	0.5478	4387	1.0062
2006	174895	21708	5775	0.6130	4402	1.0005
2007	205506	26935	8607	0.2774	4629	1.0012
2008	129694	25011	9351	0.3836	4895	1.0008
2009	204089	28788	11227	0.1624	4594	2.2069
2010	202813	31404	13143	0.2562	4894	0.9989

TABLE 7.6.13 Herring in Division VIIa North (Irish Sea). ESTIMATED FISHING MORTALITY

Units : f

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.111	0.011	0.060	0.010	0.011	0.004	0.020	0.003	0.006	0.018	0.039	0.166
2	0.510	0.981	0.801	0.611	0.465	0.478	0.420	0.310	0.269	0.299	0.574	0.361
3	0.309	0.794	0.535	1.295	0.677	0.580	0.349	0.251	0.305	0.375	0.612	0.517
4	0.723	0.343	0.816	0.289	1.230	0.325	0.319	0.439	0.376	0.518	0.621	0.524
5	0.141	0.718	0.827	0.298	0.459	0.389	0.338	0.076	0.220	0.693	0.263	0.589
6	0.655	0.143	0.662	0.592	1.230	0.389	0.335	0.225	0.332	0.446	0.373	0.585
7	0.435	0.525	0.662	0.289	0.757	0.389	0.319	0.439	0.275	0.424	0.446	0.469
8	0.435	0.525	0.662	0.289	0.757	0.389	0.319	0.439	0.275	0.424	0.446	0.469

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.104	0.214	0.152	0.229	0.157	0.103	0.142	0.060	0.036	0.035	0.009	0.014
2	0.343	0.824	0.751	0.790	0.855	0.533	0.749	1.061	0.403	0.264	0.187	0.122
3	0.612	1.008	0.905	0.972	0.988	0.918	0.858	1.306	0.368	0.262	0.147	0.171
4	0.412	0.998	0.815	1.094	0.983	0.895	0.818	0.861	0.607	0.429	0.191	0.135
5	0.510	0.736	0.936	0.887	1.055	0.650	0.734	1.052	0.525	0.116	0.131	0.203
6	0.396	0.753	0.646	0.946	0.701	0.952	0.939	0.684	0.423	0.459	0.222	0.142
7	0.411	0.786	0.733	0.856	0.830	0.724	0.746	0.893	0.425	0.284	0.161	0.139
8	0.411	0.786	0.733	0.856	0.830	0.724	0.746	0.893	0.425	0.284	0.161	0.139

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.026	0.042	0.013	0.037	0.012	0.032	0.047	0.100	0.016	0.016	0.040	0.076
2	0.277	0.398	0.284	0.280	0.202	0.317	0.312	0.393	0.293	0.424	0.416	0.580
3	0.418	0.364	0.293	0.568	0.269	0.299	0.291	0.395	0.317	0.452	0.402	0.364
4	0.508	0.355	0.231	0.619	0.379	0.342	0.225	0.495	0.292	0.307	0.341	0.220
5	0.355	0.287	0.262	0.579	0.287	0.493	0.269	0.386	0.367	0.383	0.302	0.367
6	0.351	0.235	0.255	0.513	0.270	0.392	0.346	0.421	0.297	0.438	0.264	0.293
7	0.350	0.296	0.239	0.468	0.258	0.334	0.261	0.381	0.283	0.362	0.312	0.325
8	0.350	0.296	0.239	0.468	0.258	0.334	0.261	0.381	0.283	0.362	0.312	0.325

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.131	0.026	0.047	0.030	0.064	0.004	0.008	0.041	0.132	0.148	0.067	0.092
2	0.966	0.425	0.346	0.219	0.800	0.563	0.258	0.215	0.580	0.649	0.294	0.406
3	0.577	0.487	0.418	0.205	0.910	0.307	0.451	0.571	0.567	0.635	0.287	0.397
4	0.487	0.768	0.351	0.237	0.881	0.607	0.829	0.561	0.495	0.554	0.251	0.347
5	0.485	0.987	0.552	0.182	0.661	0.340	0.574	0.429	0.577	0.645	0.292	0.404
6	0.371	0.567	0.811	0.213	0.459	0.345	0.794	0.232	0.520	0.582	0.263	0.364
7	0.517	0.589	0.452	0.193	0.673	0.395	0.539	0.367	0.495	0.554	0.251	0.347
8	0.517	0.589	0.452	0.193	0.673	0.395	0.539	0.367	0.495	0.554	0.251	0.347

age	2009	2010
1	0.039	0.062
2	0.172	0.271
3	0.168	0.265
4	0.147	0.232
5	0.171	0.270
6	0.154	0.243
7	0.147	0.232
8	0.147	0.232

TABLE 7.6.14 Herring in Division VIIa North (Irish Sea). ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	67559	53462	130271	228981	124567	373283	360259	568489	379074	484293	499310
2	32807	22235	19446	45123	83361	45334	136776	129952	208542	138685	174904
3	10871	14591	6178	6468	18144	38803	20832	66600	70590	118037	76204
4	25222	6538	5402	2962	1451	7548	17780	12028	42420	42598	66450
5	1913	11076	4199	2161	2006	384	4934	11695	7019	26363	22956
6	1040	1504	4887	1662	1451	1148	235	3183	9806	5098	11932
7	3550	489	1179	2282	832	384	704	152	2300	6368	2953
8	6390	1708	1348	738	1387	942	813	998	671	3184	2953

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	414813	667927	349430	369357	263290	324831	248671	139184	157428	223863
2	176627	129268	221394	103812	116721	77015	102101	82513	44432	54532
3	72997	91195	67928	71955	36298	39238	24272	44370	28910	11390
4	33829	35627	40469	20293	23835	11242	11957	7939	15404	6412
5	32310	18132	21349	13502	8124	7223	3806	4419	3169	5894
6	15961	16225	9854	9252	4791	3027	2275	1798	1919	1001
7	7432	8045	9876	4201	4390	1684	1359	794	636	876
8	4666	8077	3126	3296	2304	2073	710	576	406	725

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	231879	232651	131707	148802	171166	275725	113260	149490	117269	69165	199305
2	79424	82344	84828	47773	53331	60364	100140	40154	54322	41798	24285
3	26994	45184	50621	55641	26833	26546	33666	56090	24299	29323	22666
4	6452	17001	31949	34927	30003	15269	16209	15623	35096	14747	17946
5	3162	3801	12706	25260	19022	19042	10971	7895	9674	22562	10655
6	3156	2548	3017	9389	16025	12917	13264	5564	5364	5346	15607
7	593	1804	1846	2369	5982	11465	9053	7188	3844	3279	3422
8	1610	417	3862	2571	3583	8229	11801	9019	5958	3717	1295

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	64051	198166	128604	114486	121751	185521	62299	66186	69291	64754	144070
2	66310	23187	71756	45452	39032	39290	66467	21869	23640	23920	23718
3	12145	36664	11236	35056	18855	11004	19028	34848	13009	7866	10092
4	12505	7240	19111	6157	19937	8671	5537	10253	23244	4287	4738
5	9903	8453	4819	12297	4470	11088	3641	3525	7318	8713	2113
6	6555	6209	5217	3224	7711	2490	3738	1897	2660	3420	5613
7	9269	4408	3625	3625	2177	4815	1279	1504	1387	1520	2191
8	3604	6868	5684	5146	3711	1060	1791	881	1713	1081	1520

age	2004	2005	2006	2007	2008	2009	2010
1	126908	143446	174895	205506	129694	204089	202813
2	52597	44816	46250	55508	70718	43501	72196
3	13571	31431	18590	17900	30658	34899	27128
4	5263	6275	14594	8066	10997	16872	24144
5	1870	2717	3460	7585	5680	7034	13178
6	1078	1102	1381	1642	5126	3432	5363
7	2297	773	593	699	1142	3223	2661
8	433	986	605	525	772	1650	938

TABLE 7.6.15 Herring in Division VIIa North (Irish Sea). SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	year 2011
1	NA
2	70145
3	40772
4	17033
5	17327
6	9105
7	3805
8	2583

TABLE 7.6.16 Herring in Division VIIa North (Irish Sea). FITTED SELECTION PATTERN

Units : NA

age	2005	2006	2007	2008	2009	2010
1	0.266	0.266	0.266	0.266	0.266	0.266
2	1.171	1.171	1.171	1.171	1.171	1.171
3	1.145	1.145	1.145	1.145	1.145	1.145
4	1.000	1.000	1.000	1.000	1.000	1.000
5	1.164	1.164	1.164	1.164	1.164	1.164
6	1.049	1.049	1.049	1.049	1.049	1.049
7	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000

TABLE 7.6.17 Herring in Division VIIa North (Irish Sea). PREDICTED CATCH IN NUMBERS

Units : NA

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	4541	381	4837	1508	846	940	4440	1020	1321	5605	12168	40640
2	11471	12296	9441	18095	27077	15048	40922	30181	42799	31177	66921	46660
3	2629	7340	2341	4346	8180	15635	5598	13459	16908	33630	31940	26950
4	12427	1811	2887	710	987	1999	4633	4079	12681	16465	29405	13180
5	239	5433	2263	532	705	118	1351	816	1321	12611	5070	13750
6	478	191	2263	710	987	353	0	612	2642	1752	3549	6760
7	1195	191	546	0	423	118	0	0	528	2102	1014	2660
8	2151	667	624	177	705	0	0	0	0	1051	1014	1670

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	42150	43250	33330	34740	30280	15540	11770	5840	5050	5100	1305	1168
2	32740	109550	48240	56160	39040	36950	38270	25760	15790	16030	12162	8424
3	38240	39750	39410	20780	22690	13410	23490	19510	3200	5670	5598	7237
4	11490	24510	10840	15220	6750	6780	4250	8520	2790	2150	2820	3841
5	6920	10650	7870	4580	4520	1740	2200	1980	2300	330	445	2221
6	5070	4990	4210	2810	1460	1340	1050	910	330	1110	484	380
7	2590	5150	2090	2420	910	670	400	360	290	140	255	229
8	2600	1630	1640	1270	1120	350	290	230	240	380	59	479

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	2429	4491	2225	2607	1156	2313	1999	12145	646	1970	3204	5335
2	10050	15266	12981	21250	6385	12835	9754	6885	14636	7002	21330	17529
3	17336	7462	6146	13343	12039	5726	6743	6744	3008	12165	3391	9761
4	13287	8550	2998	7159	4708	9697	2833	6690	3017	1826	5269	1160
5	7206	4528	4180	4610	1876	3598	5068	3256	2903	2566	1199	3603
6	2651	3198	2777	5084	1255	1661	1493	5122	1606	2104	1154	780
7	667	1464	2328	3232	1559	1042	719	1036	2181	1278	926	961
8	724	877	1671	4213	1956	1615	815	392	848	1991	1452	1364

age	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
1	9551	3069	1810	1221	2713	179	694	3225	11326	15361	8437	7290	4971
2	21387	11879	16929	3743	11473	9021	4694	8833	17285	19390	12291	20604	5971
3	7562	3875	5936	5873	7151	1894	3345	5405	12447	8003	4069	9170	4916
4	7341	4450	1566	2065	13050	1866	2559	2161	2342	5938	1706	3077	2198
5	1641	6674	1477	558	3386	2395	882	623	1138	1574	1832	1802	1055
6	2281	1030	1989	347	936	953	2945	213	427	583	362	1493	468
7	840	2049	444	251	650	474	872	673	288	241	148	319	420
8	1432	451	622	147	803	337	605	127	368	246	111	216	215

age	2010
1	7713
2	14925
3	5757
4	4762
5	2972
6	1104
7	525
8	185

TABLE 7.6.18 Herring in Division VIIa North (Irish Sea). CATCH RESIDUALS

Units : Thousands NA

age	2005	2006	2007	2008	2009	2010
1	-0.265	-0.997	0.877	0.204	-0.241	0.218
2	-0.212	-0.240	0.398	-0.082	1.927	0.166
3	-0.165	0.024	0.202	-0.203	1.530	0.149
4	0.339	0.062	-0.030	-0.132	1.437	0.264
5	0.222	-0.172	-0.545	0.144	1.134	0.074
6	-0.028	0.038	-0.108	0.165	1.163	-0.177
7	0.012	0.082	-0.192	0.026	0.753	-0.350
8	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 7.6.19 Herring in Division VIIa North (Irish Sea). PREDICTED INDEX VALUES

NINEL

Units : NA NA

age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
all	NA	NA	NA	NA	27	28	30	25	20	21	21	23	12	12

age	2003	2004	2005	2006	2007	2008	2009	2010
all	12	19	18	17	25	27	33	38

Northern Ireland Acoustic Surveys

Units : NA NA

age	1994	1995	1996	1997	1998	1999
1	335464.017	213783.285	185244.138	189050.291	311564.825	103035.819
2	63004.918	196166.956	109911.684	70647.128	106709.268	191590.245
3	73372.007	23343.977	74893.020	34348.008	21444.890	39039.550
4	14817.861	38130.176	13448.296	35658.042	12561.491	10959.670
5	13791.619	8352.674	20305.325	6754.810	11495.023	5231.364
6	7973.275	7634.336	4617.347	10414.899	2904.494	3630.116
7	4399.146	3756.535	3718.286	1933.921	4053.616	1192.964
8	10792.528	9275.930	8310.903	5191.787	1405.049	2631.777

age	2000	2001	2002	2003	2004	2005
1	110895.793	113170.958	110564.689	245390.306	210836.032	222587.4432
2	69299.384	48452.746	58581.501	72999.921	167242.537	108369.3458
3	83903.136	18456.395	17544.447	20204.488	24822.538	57674.6238
4	22111.789	30924.594	7004.063	6553.396	8902.770	11150.9178
5	6687.557	9692.138	14681.101	2987.997	2947.878	3833.5293
6	2883.481	3361.697	4708.301	5521.576	1614.698	1331.6041
7	1703.808	1096.001	1479.523	1915.084	2284.029	697.9024
8	1571.371	2132.199	1656.486	2092.383	678.742	1402.2565

age	2006	2007	2008	2009	2010
1	268197.8692	334847.1458	207300.671	339496.414	331715.857
2	106171.2842	166376.2199	194795.292	142816.313	220033.760
3	32421.2412	40521.7249	63901.341	86359.749	62421.074
4	24810.7739	17220.4170	21844.213	38930.494	52282.501
5	4635.5311	13248.3925	9121.551	13449.226	23401.074
6	1592.9710	2404.4099	6959.725	5452.945	7972.240
7	512.4089	757.9230	1152.638	3779.297	2928.403
8	822.4993	896.6708	1227.235	3046.577	1625.391

TABLE 7.6.20 Herring in Division VIIa North (Irish Sea). INDEX RESIDUALS

NINEL

Units : NA

age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
all	NA	NA	NA	NA	0.368	0.916	-0.684	-1.655	0.364	-1.295	-0.234	0.44

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
all	1.518	0.951	0.293	0.169	0.366	0.955	-0.691	-0.486	-0.662	-0.632

Northern Ireland Acoustic Surveys

Units : NA

age	1994	1995	1996	1997	1998	1999
1	-1.613362617	0.4005919	-2.7933383	-0.3430843	-1.0371531	0.4259729
2	0.080550556	-0.8691298	-0.9531894	-0.3461346	-1.3627819	-0.9022206
3	0.002137396	-0.6708638	-0.1043332	-0.8411064	-0.9757233	-0.1377148
4	-0.222661862	-0.2652632	-0.4067521	-1.1774440	-0.3042841	-0.7634142
5	-0.394154225	-0.6021937	0.2650911	-1.3500678	-0.5733479	0.6735807
6	-0.054547808	-0.7798930	-0.1016645	-0.8274511	-0.4907702	1.3149796
7	-0.128931353	0.2630817	0.4635522	-1.2199157	-0.5869028	0.2847744
8	-0.064538012	-0.2967714	-0.3571274	-0.9999748	-0.5885338	0.8711428

age	2000	2001	2002	2003	2004	2005
1	-0.3451867	1.23096852	1.2630608	0.3528406	0.1337743	-0.85852075
2	0.4005460	0.65632374	0.2053440	1.1032328	-0.3699235	0.01437131
3	0.2270650	-0.59361163	0.5916108	0.4593310	0.1757858	0.52103737
4	0.2196375	-0.56997968	1.2645145	-0.3250017	0.5478752	0.42304356
5	0.1881527	-0.22957541	0.7563220	0.2717434	-0.3549873	0.73927413
6	0.6333092	-0.89617630	1.1473250	-0.3003628	0.3533264	-0.49710535
7	1.0561652	-0.56007322	0.6220603	-0.6730302	-2.2614257	-0.13955041
8	0.4062893	0.05953771	0.9906743	-0.8370196	-1.0396022	1.42046461

age	2006	2007	2008	2009	2010
1	0.33448341	1.36918923	0.8305646	0.08935843	0.5597867
2	-0.09423687	0.41230033	0.8425379	0.24597414	0.9363765
3	-0.72994161	0.13911831	0.5806985	0.72221074	0.6342276
4	-0.91049452	0.20322472	0.5815724	0.86803280	0.8372841
5	-2.16862905	0.45194177	1.0615872	0.88201082	0.3830920
6	-1.46255946	-0.69498294	0.8967723	1.01661646	0.7429699
7	-0.06951216	-0.05411223	1.3058067	1.30522447	0.3924950
8	-0.56174490	-0.47792054	-0.7172576	0.81329105	1.3787964

TABLE 7.6.21 Herring in Division VIIa North (Irish Sea). FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2005	0.50	0.21	0.33	0.75
F, 2006	0.55	0.21	0.36	0.84
F, 2007	0.25	0.23	0.16	0.39
F, 2008	0.35	0.24	0.22	0.56
F, 2009	0.15	0.79	0.03	0.69
F, 2010	0.23	0.26	0.14	0.38
Selectivity at age 1	0.27	0.58	0.09	0.83
Selectivity at age 2	1.17	0.23	0.75	1.83
Selectivity at age 3	1.15	0.23	0.73	1.80
Selectivity at age 5	1.16	0.21	0.77	1.75
Selectivity at age 6	1.05	0.20	0.70	1.56
Terminal year pop, age 1	202812.47	1.21	19053.15	2158850.05
Terminal year pop, age 2	72195.14	0.37	34805.01	149752.57
Terminal year pop, age 3	27126.95	0.35	13585.63	54165.42
Terminal year pop, age 4	24142.84	0.27	14214.88	41004.68
Terminal year pop, age 5	13177.31	0.25	8035.13	21610.28
Terminal year pop, age 6	5362.21	0.25	3281.92	8761.11
Terminal year pop, age 7	2660.33	0.26	1607.60	4402.45
Last true age pop, 2005	771.83	0.38	367.65	1620.37
Last true age pop, 2006	592.17	0.31	324.55	1080.49
Last true age pop, 2007	697.67	0.30	390.17	1247.53
Last true age pop, 2008	1141.01	0.28	661.26	1968.80
Last true age pop, 2009	3222.27	0.30	1784.09	5819.80
Index 1, biomass, Q	0.00	0.10	0.00	0.00
Index 2, age 1 numbers, Q	3.63	0.81	0.74	17.66
Index 2, age 2 numbers, Q	4.68	0.26	2.82	7.77
Index 2, age 3 numbers, Q	3.26	0.26	1.97	5.41
Index 2, age 4 numbers, Q	2.78	0.26	1.67	4.61
Index 2, age 5 numbers, Q	2.34	0.26	1.41	3.90
Index 2, age 6 numbers, Q	1.92	0.26	1.15	3.22
Index 2, age 7 numbers, Q	1.41	0.27	0.84	2.38
Index 2, age 8 numbers, Q	2.22	0.27	1.32	3.74

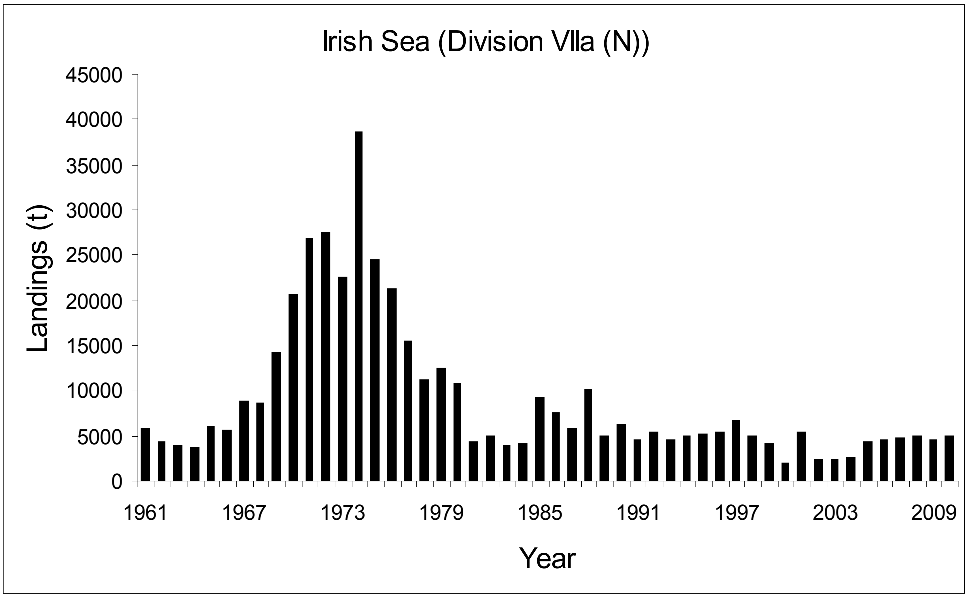


Figure 7.1.1 Herring in Division VIIa North (Irish Sea). Landings of herring from VIIa(N) from 1961 to 2010.

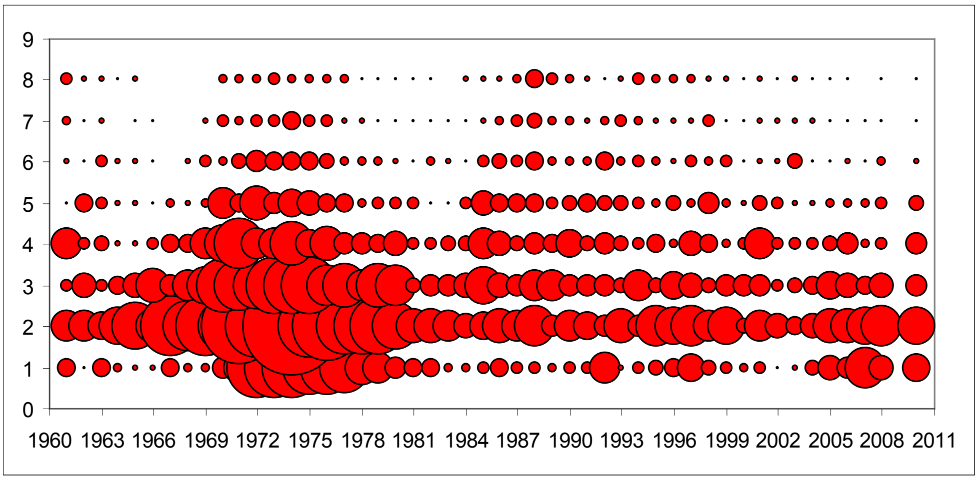


Figure 7.2.1 Herring in Division VIIa North (Irish Sea). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2010. No 2009 commercial samples.

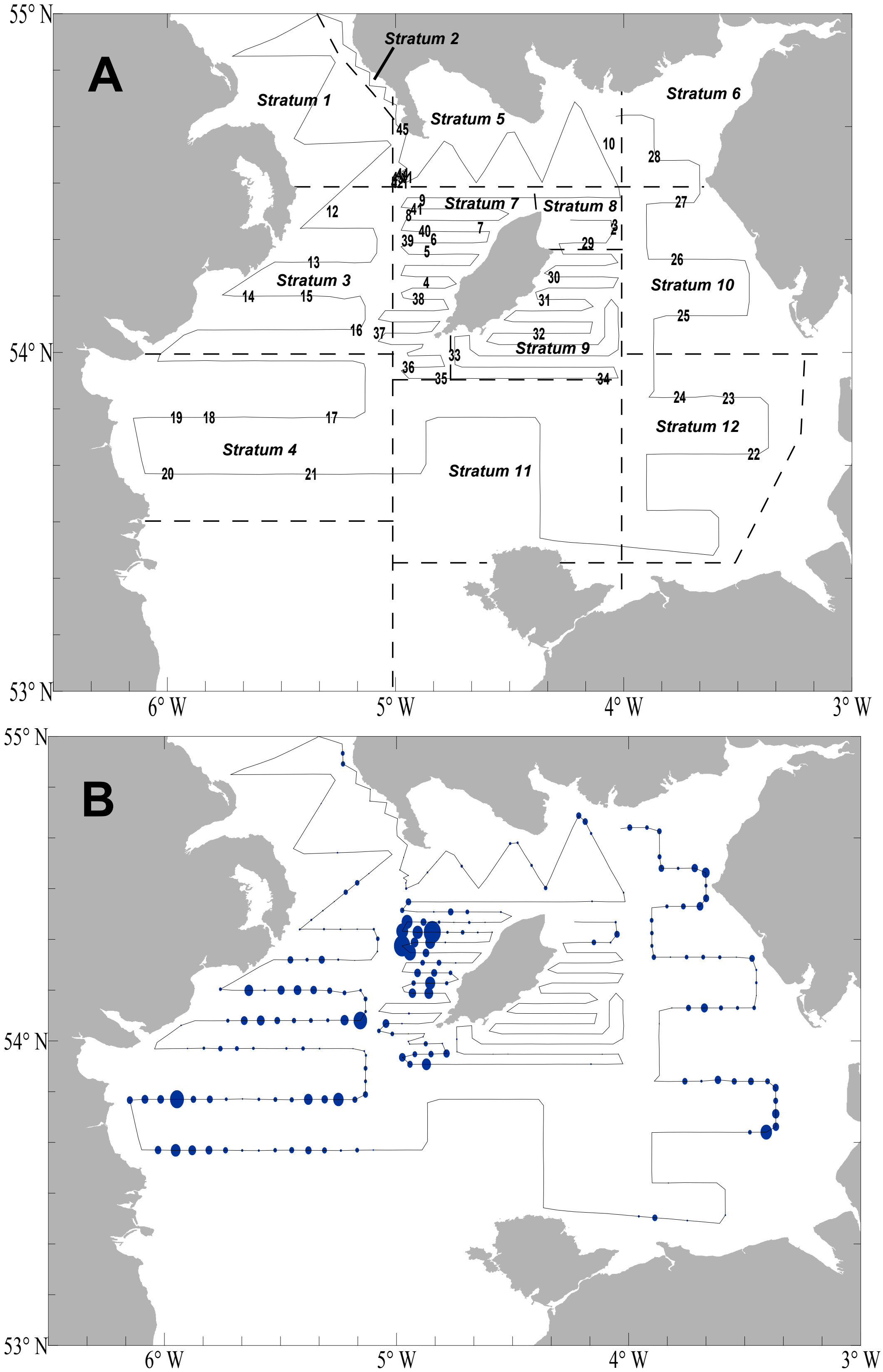
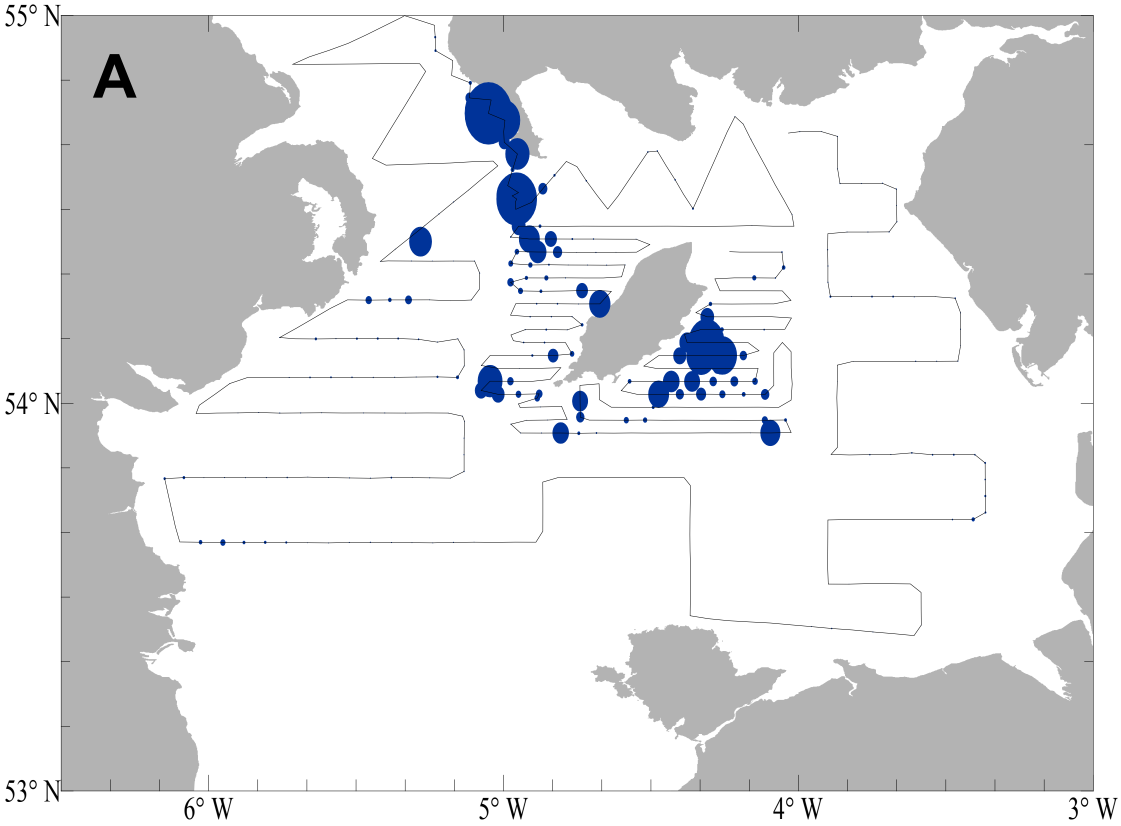


Figure 7.3.1 Herring in Division VIIa North (Irish Sea). (A) Transects, stratum boundaries and trawl positions for the 2010 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t n.mile-2) per 15-minute interval). Maximum density was 420 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures.



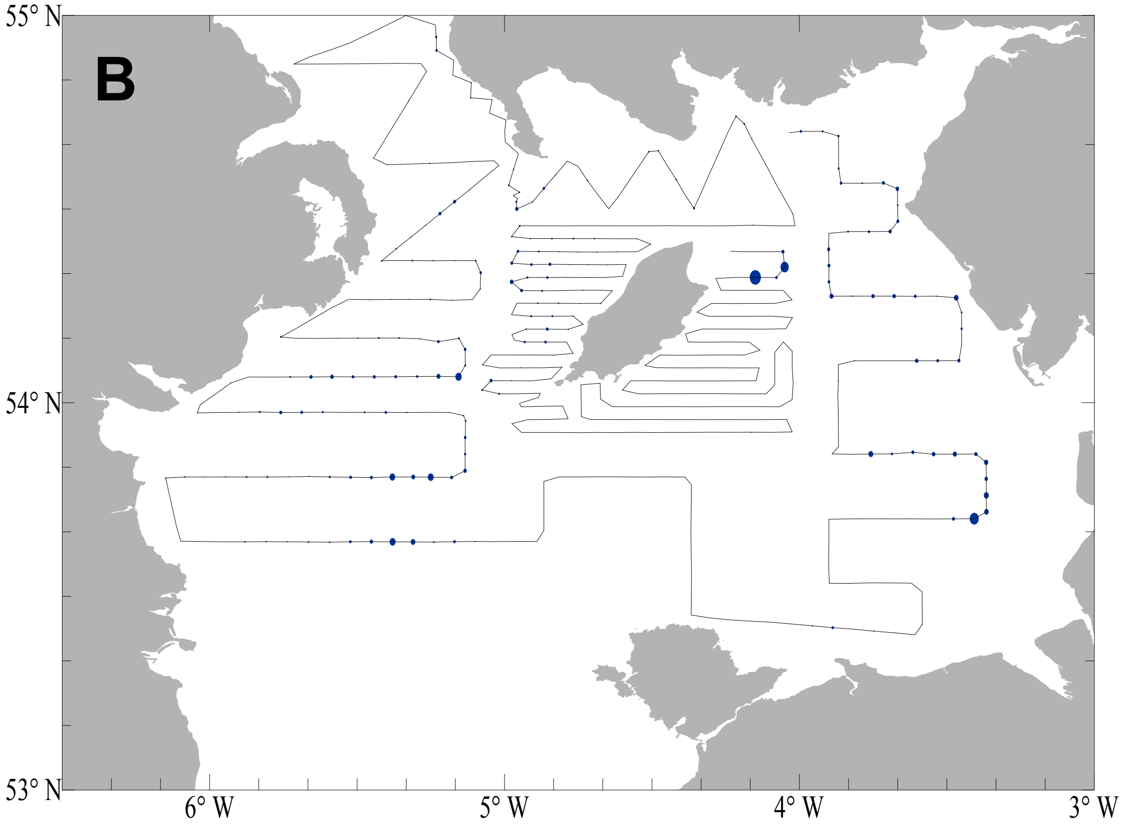


Figure 7.3.2 **Herring in Division VIIa North (Irish Sea). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 2 119 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 110 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures.**

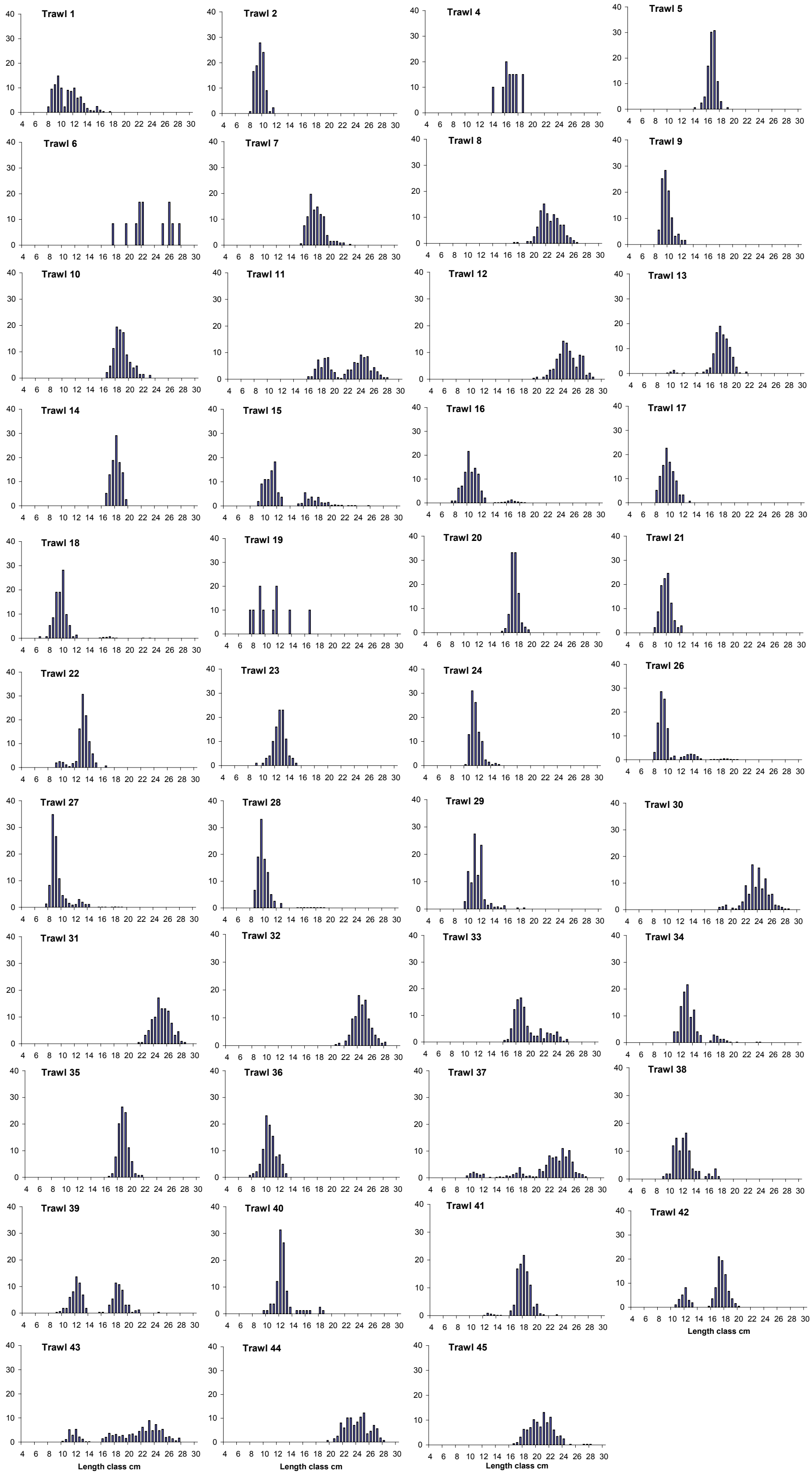


Figure 7.3.3 **Herring in Division VIIa North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2010 acoustic survey.**

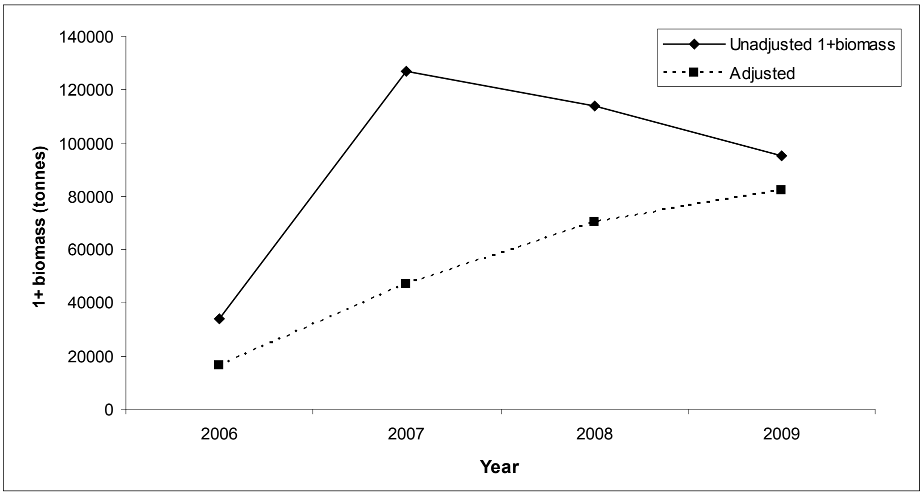


Figure 7.3.4 Herring in Division VIIa North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

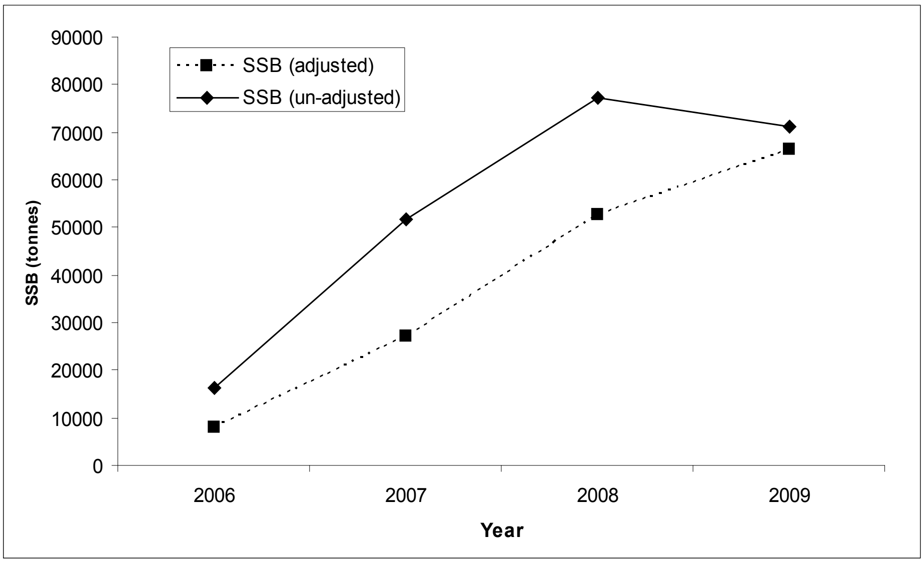


Figure 7.3.5 Herring in Division VIIa North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.

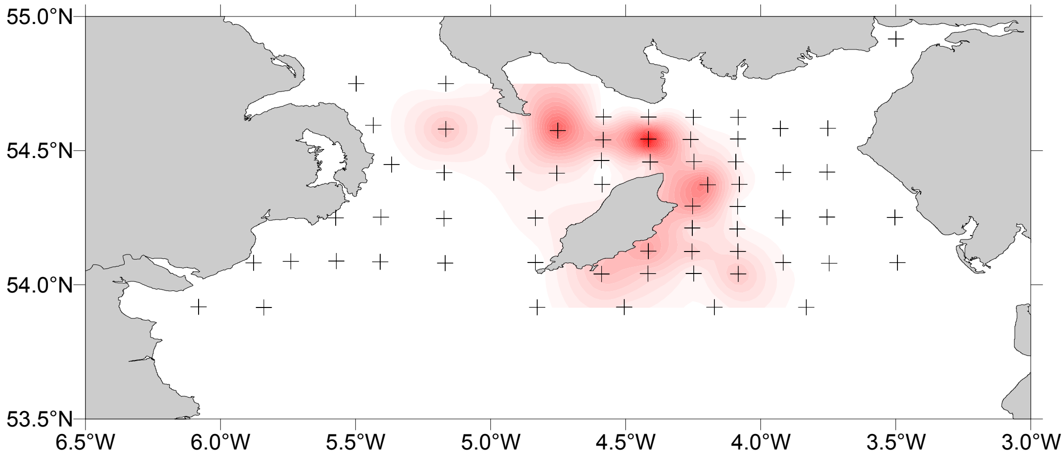


Figure 7.3.6 **Herring in Division VIIa North (Irish Sea). Estimates of larval herring abundance in the Northern Irish Sea in 2010. Crosses indicate sampling stations. Areas of shading are proportional to larva abundance (maximum = 143 per m²).**

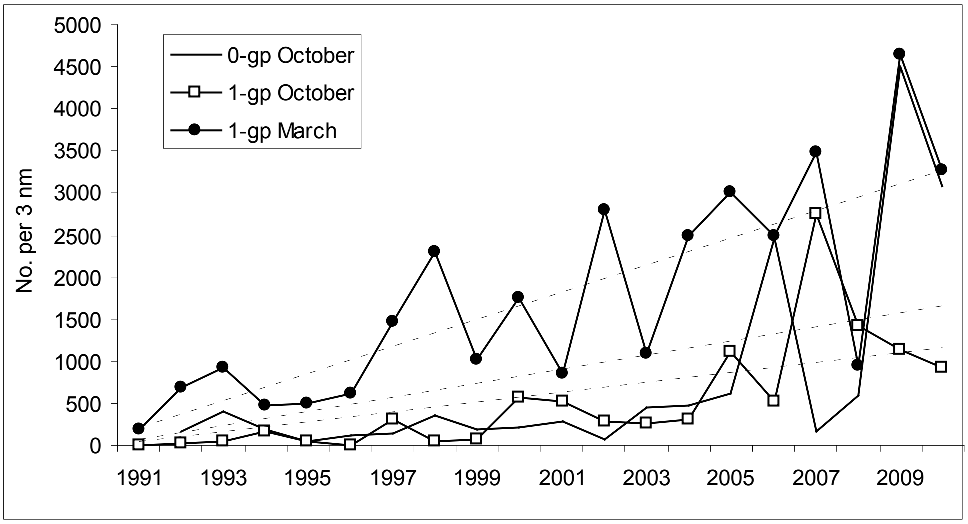


Figure 7.3.7 **Herring in Division VIIa North (Irish Sea). Trends in 0-gp and 1-gp herring indices from the Northern Irish March and October groundfish surveys in the northern Irish Sea 1991 - 2010. [Ages are length sliced].**

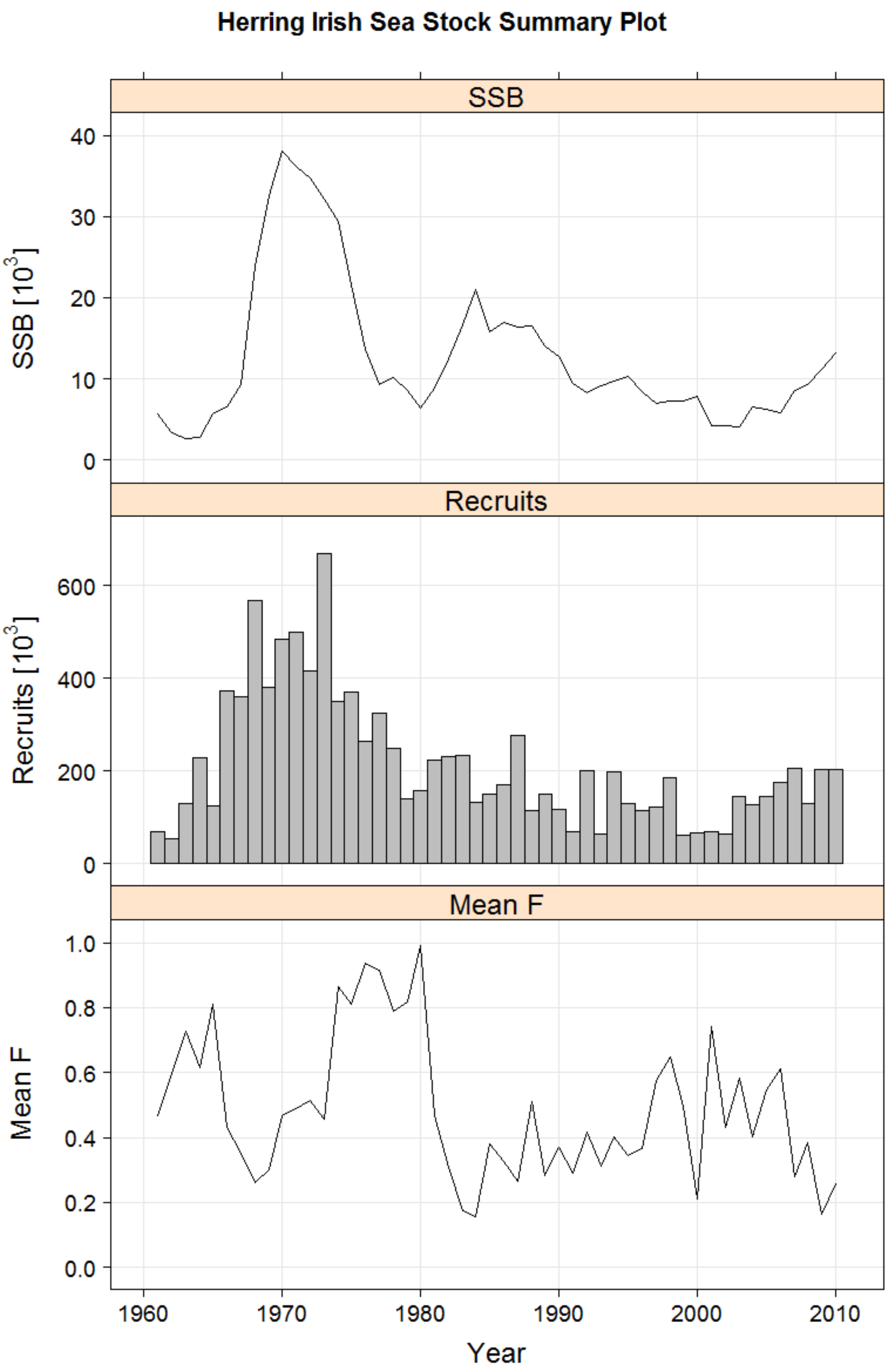


Figure 7.6.1 **Herring in Division VIIa North (Irish Sea). SPALY FLICA run output illustrations of stock trends from deterministic calculation (6-year separable period) using down-weighted catch at age data. Summary of estimates of spawning stock at spawning time, recruitment at 1-ring, mean $F_{2\text{-}6}$.**

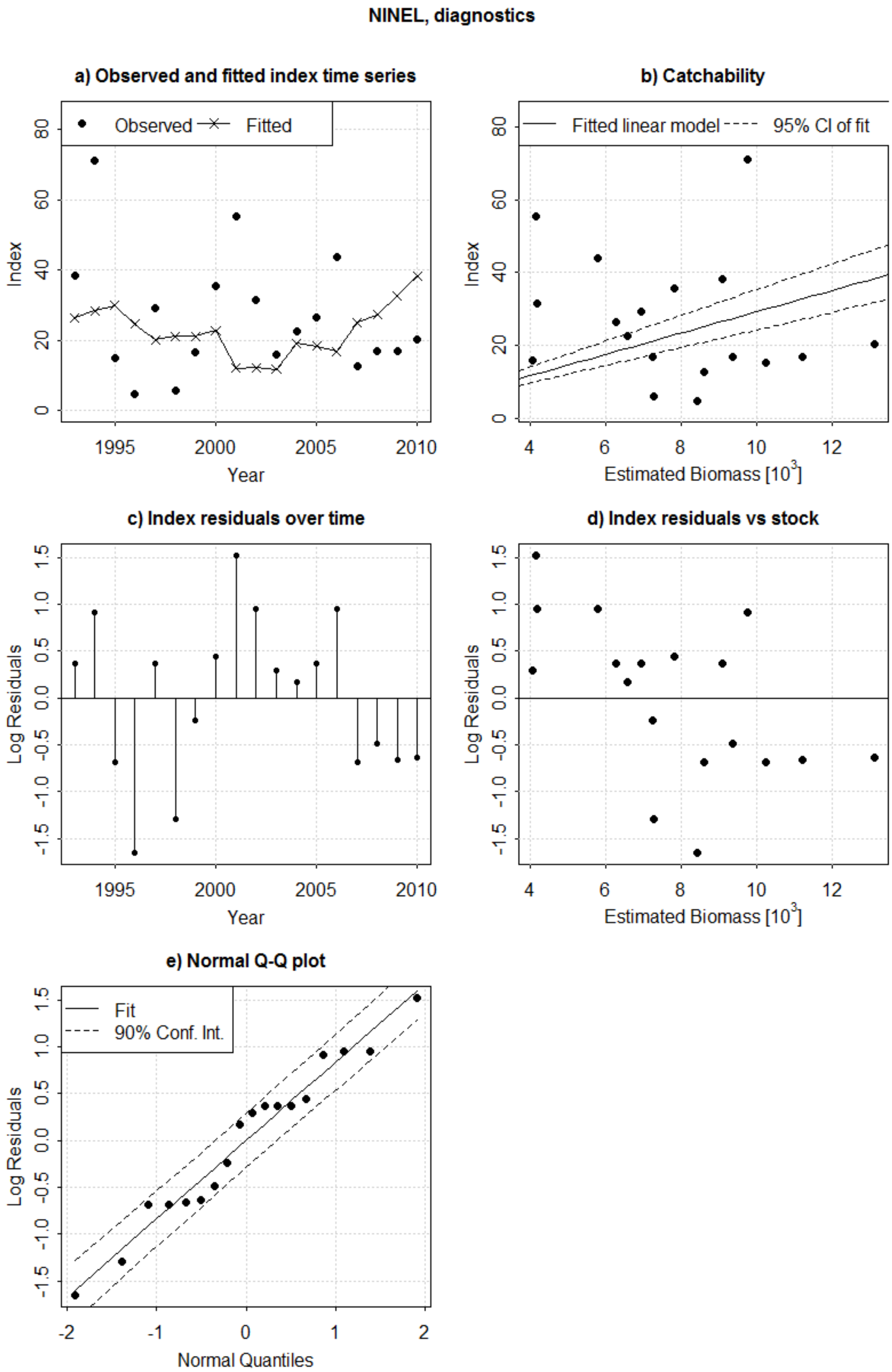


Figure 7.6.2 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of NINEL survey catchability at all ages. Top left: VPA estimates of biomass of all ages and biomass predicted from index abundance for all ages. Top right: scatterplot of index observations versus VPA estimates of all ages with the best-fit catchability model. 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.

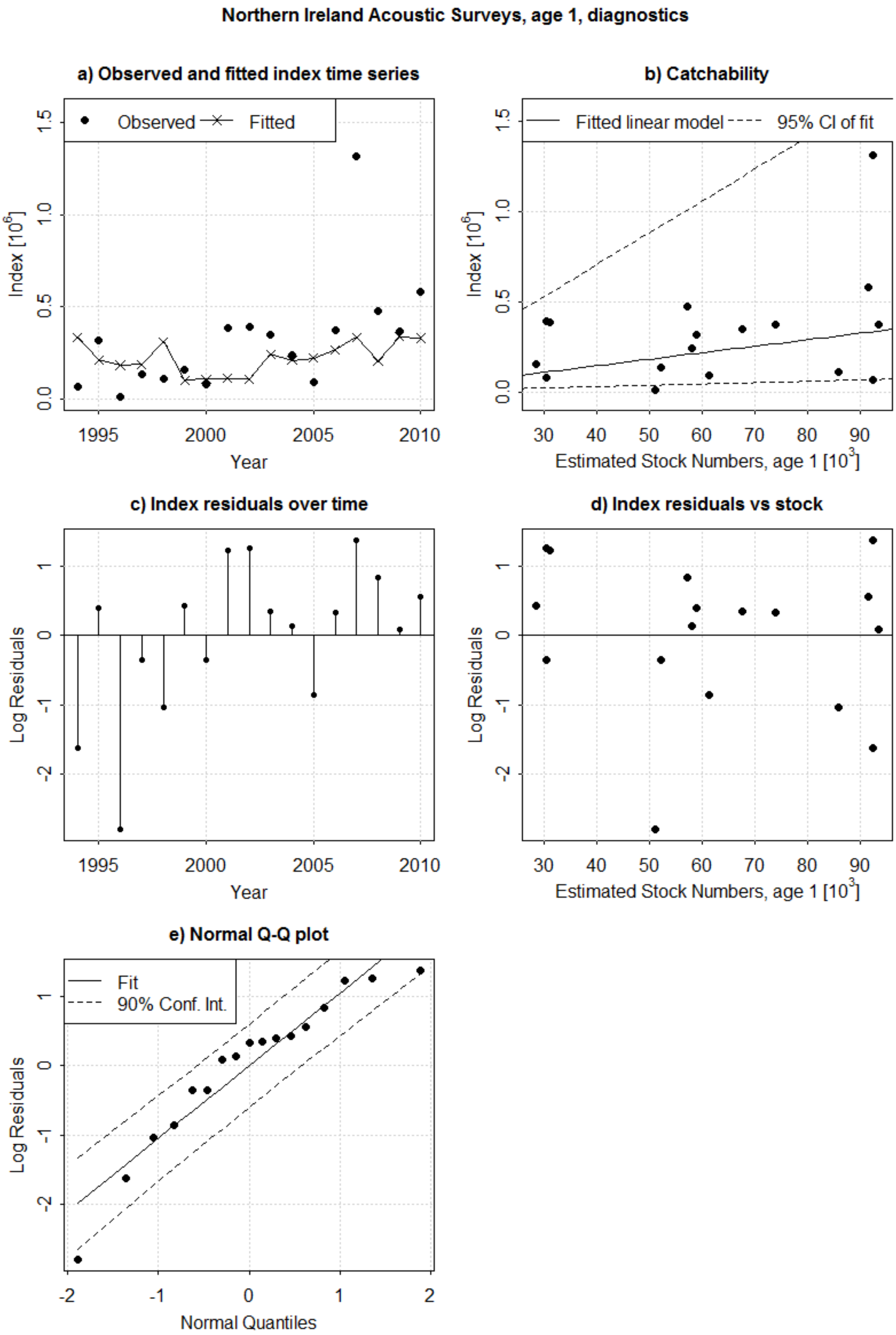


Figure 7.6.3 **Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.**

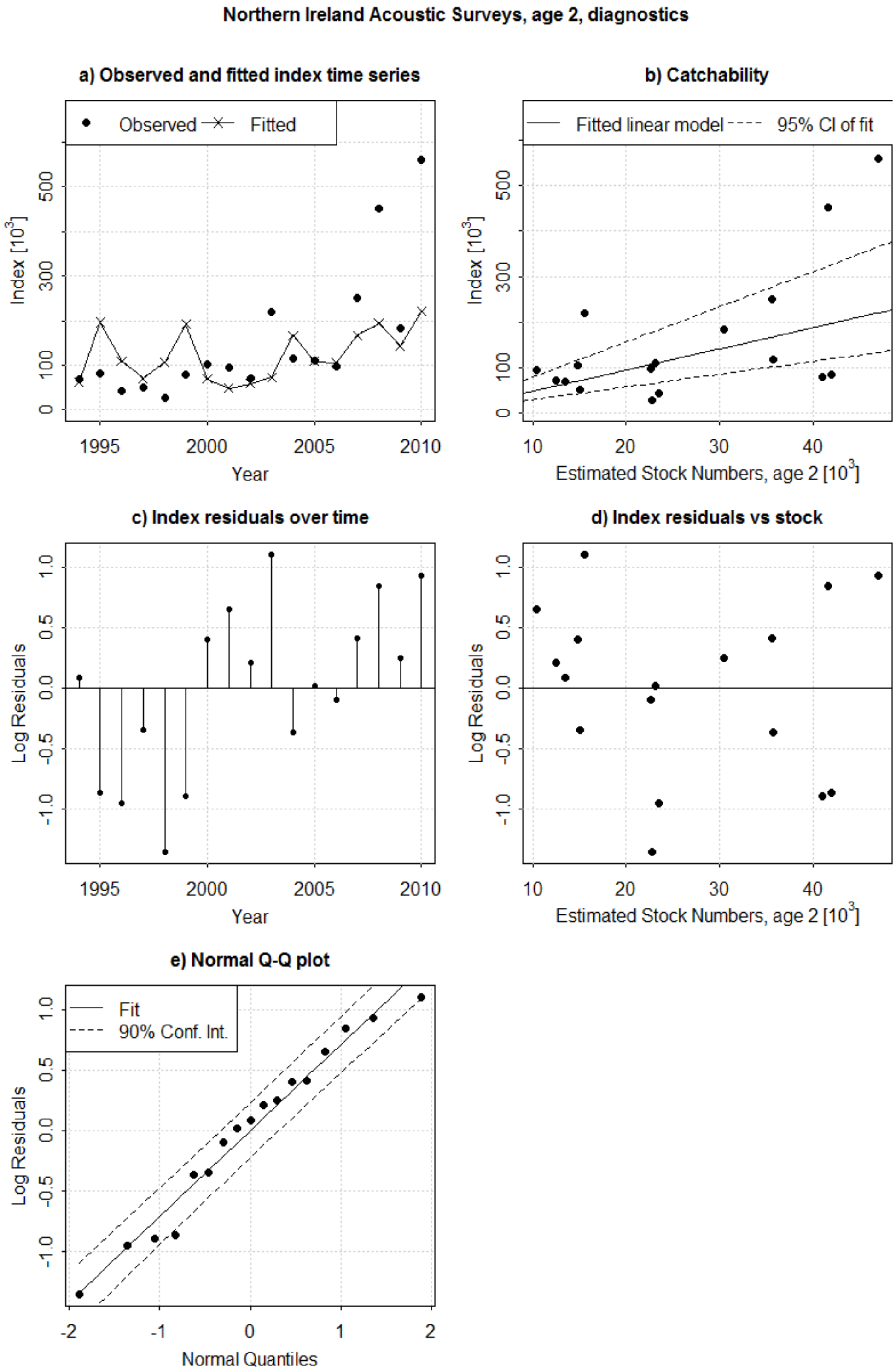


Figure 7.6.4 **Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.**

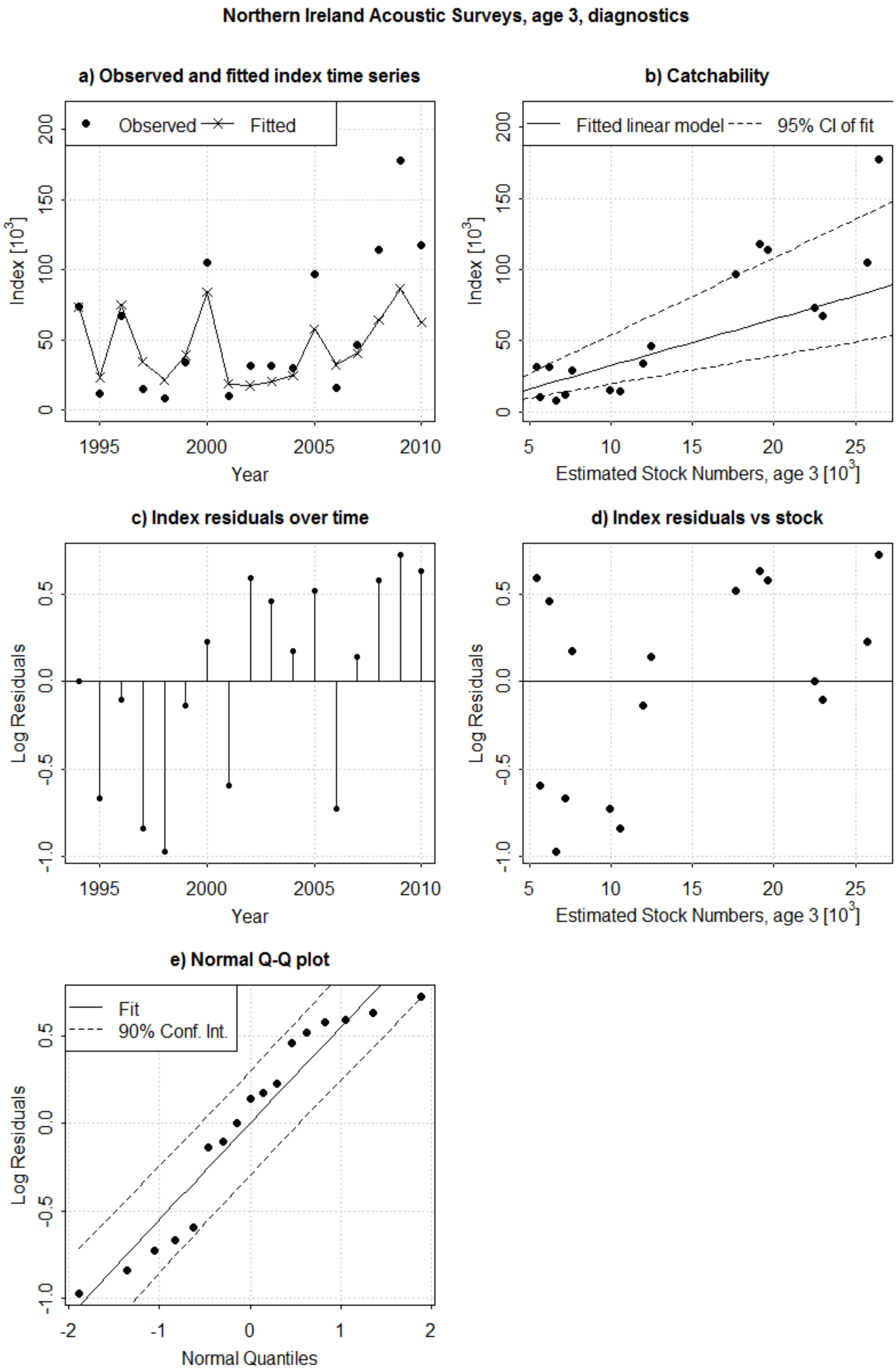


Figure 7.6.5 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

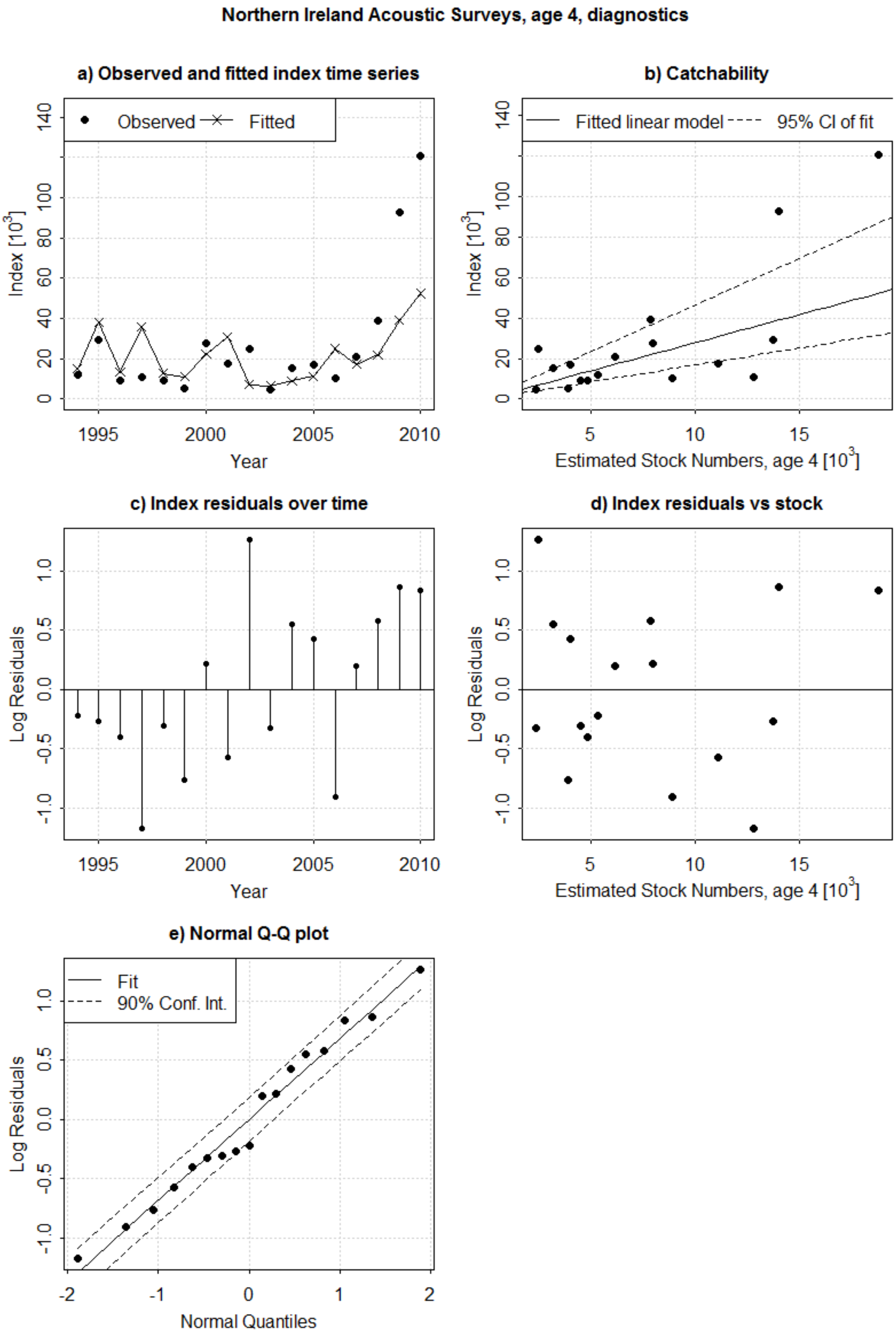


Figure 7.6.6 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

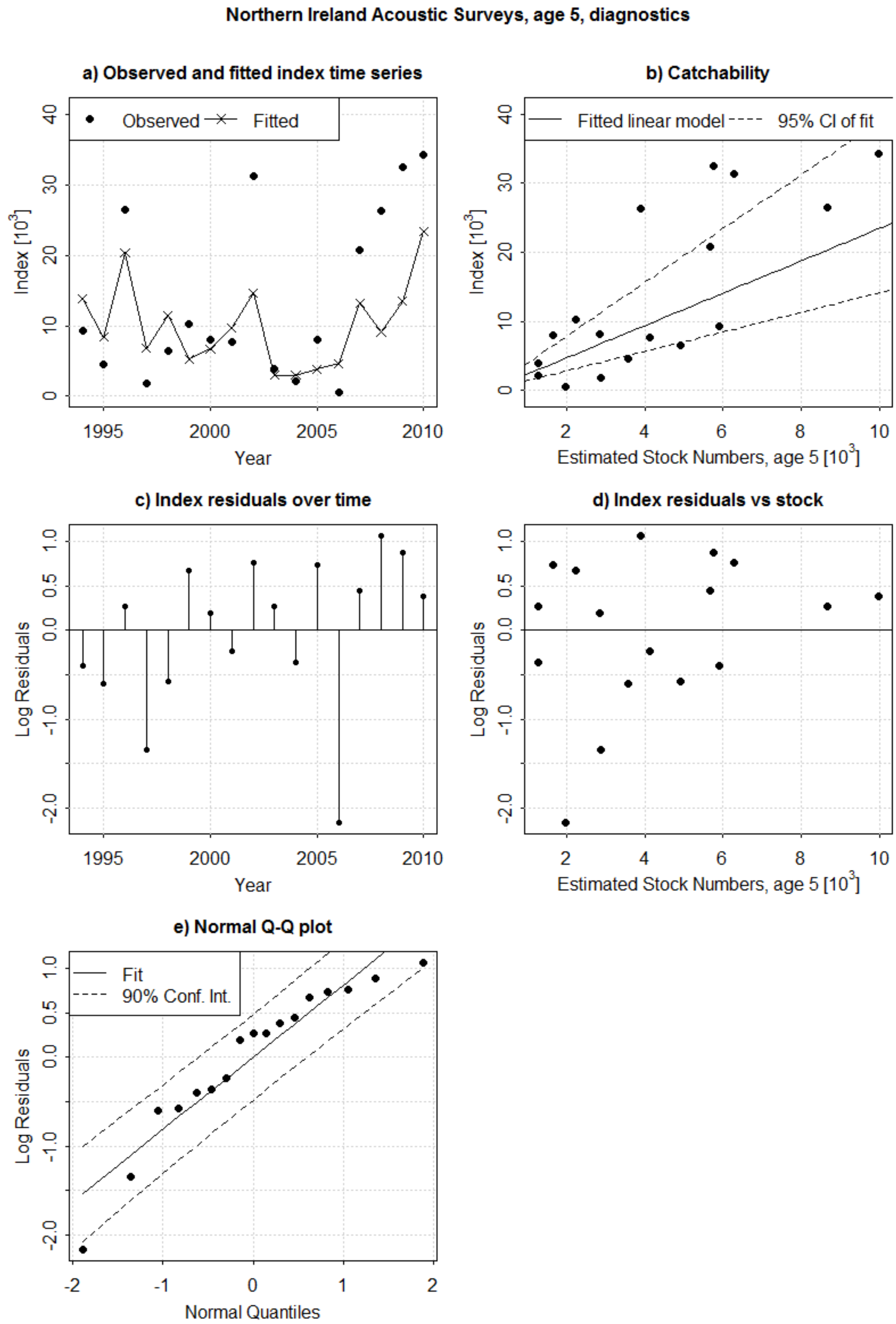


Figure 7.6.7 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

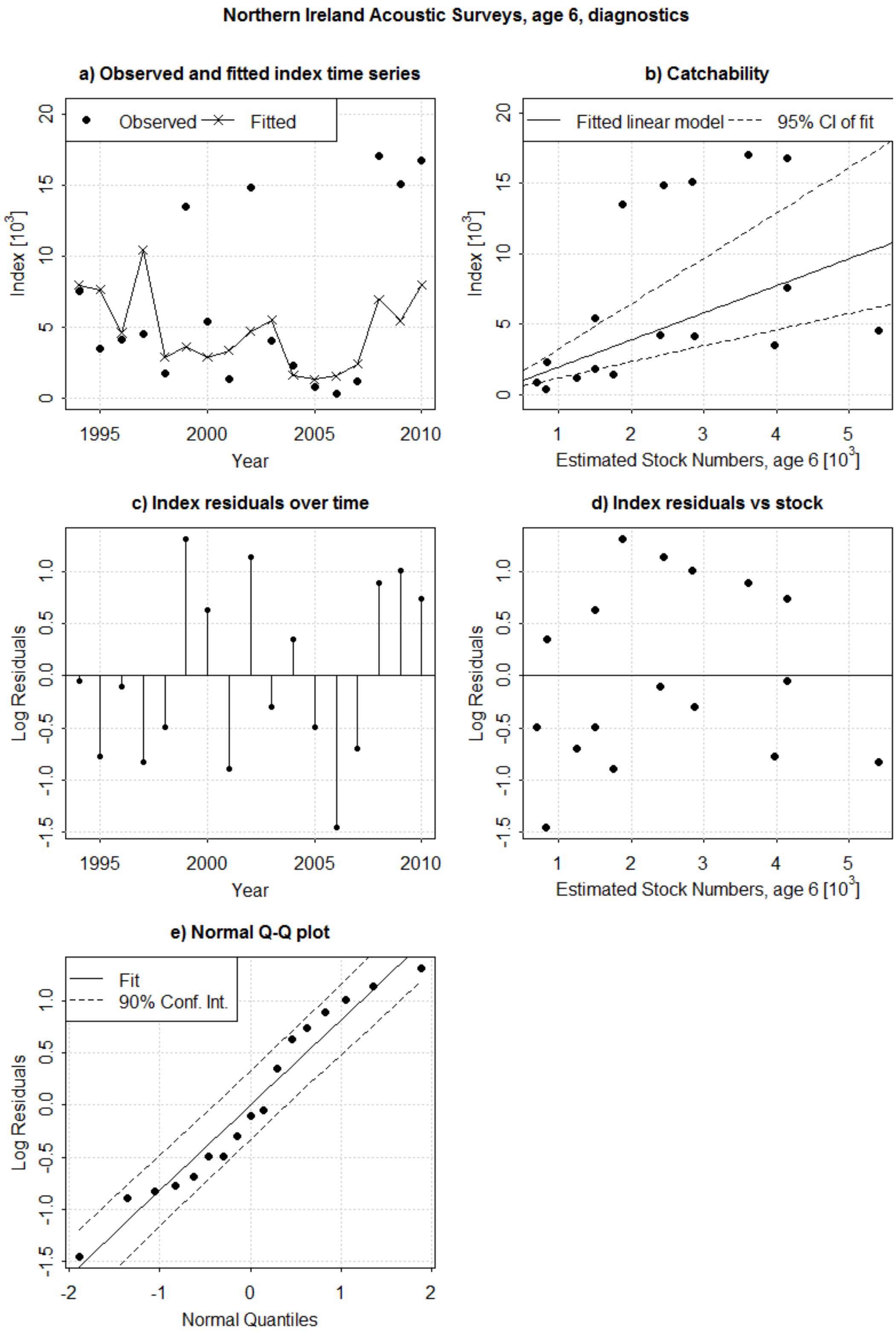


Figure 7.6.8 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

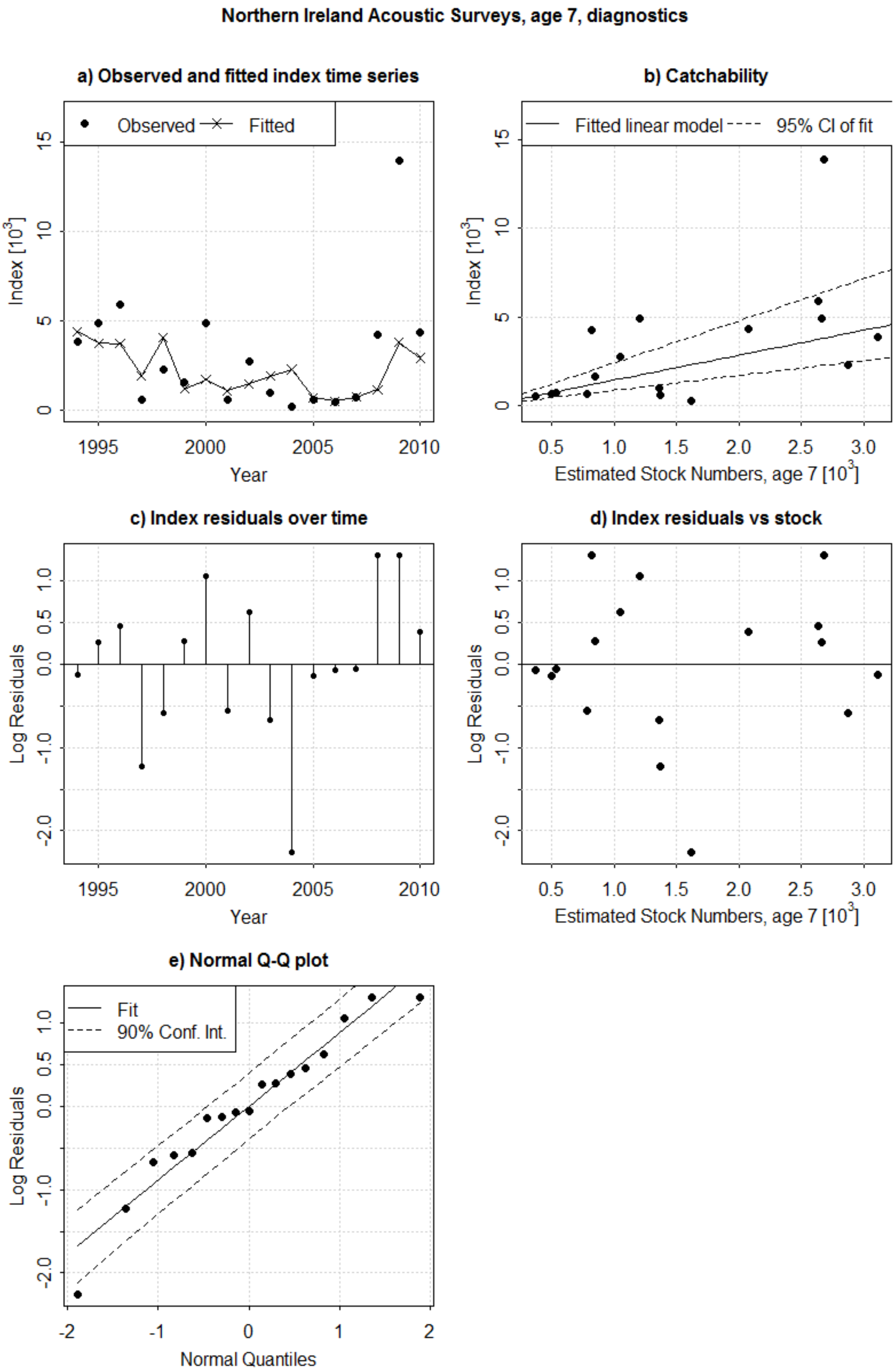


Figure 7.6.9 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

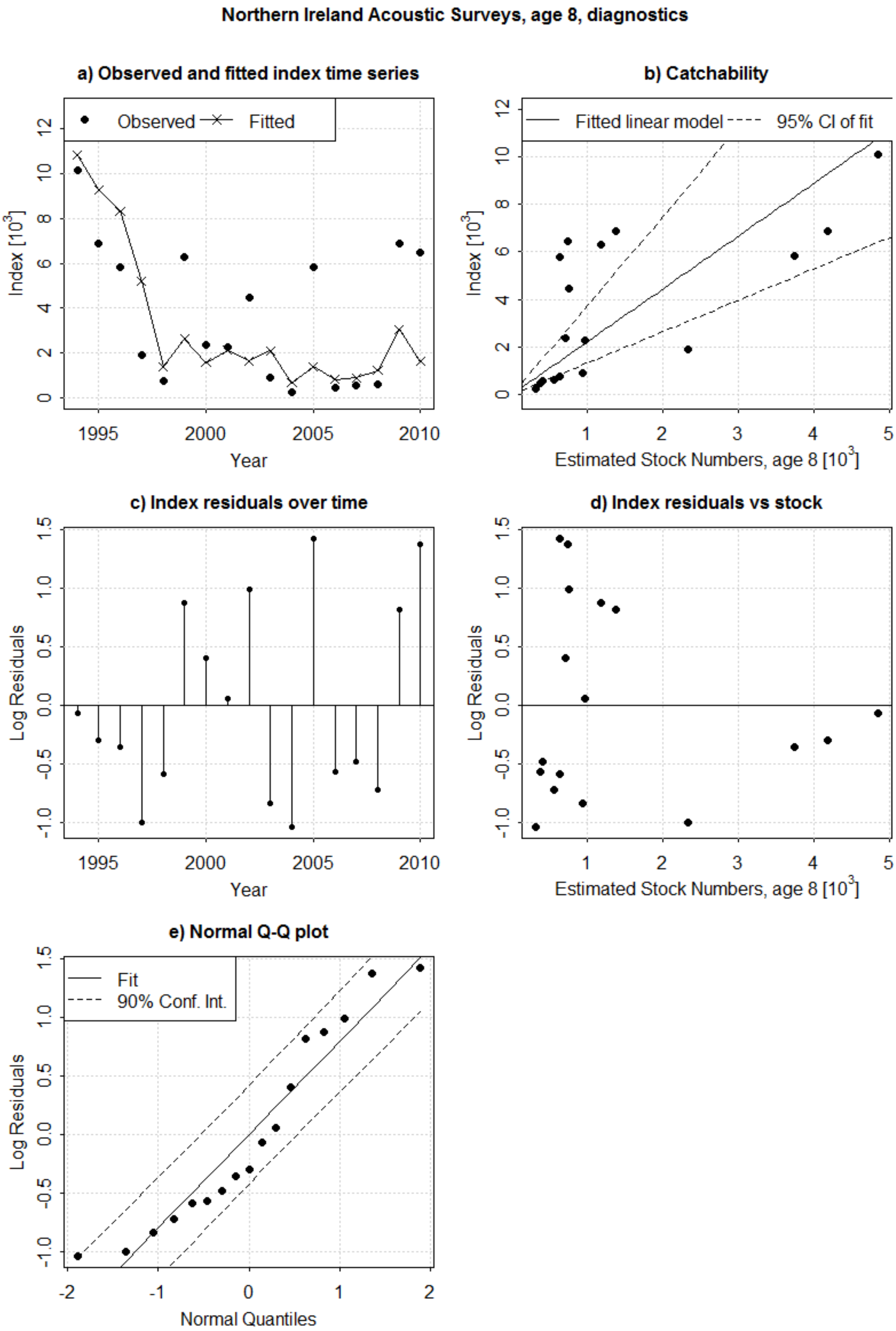


Figure 7.6.9 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

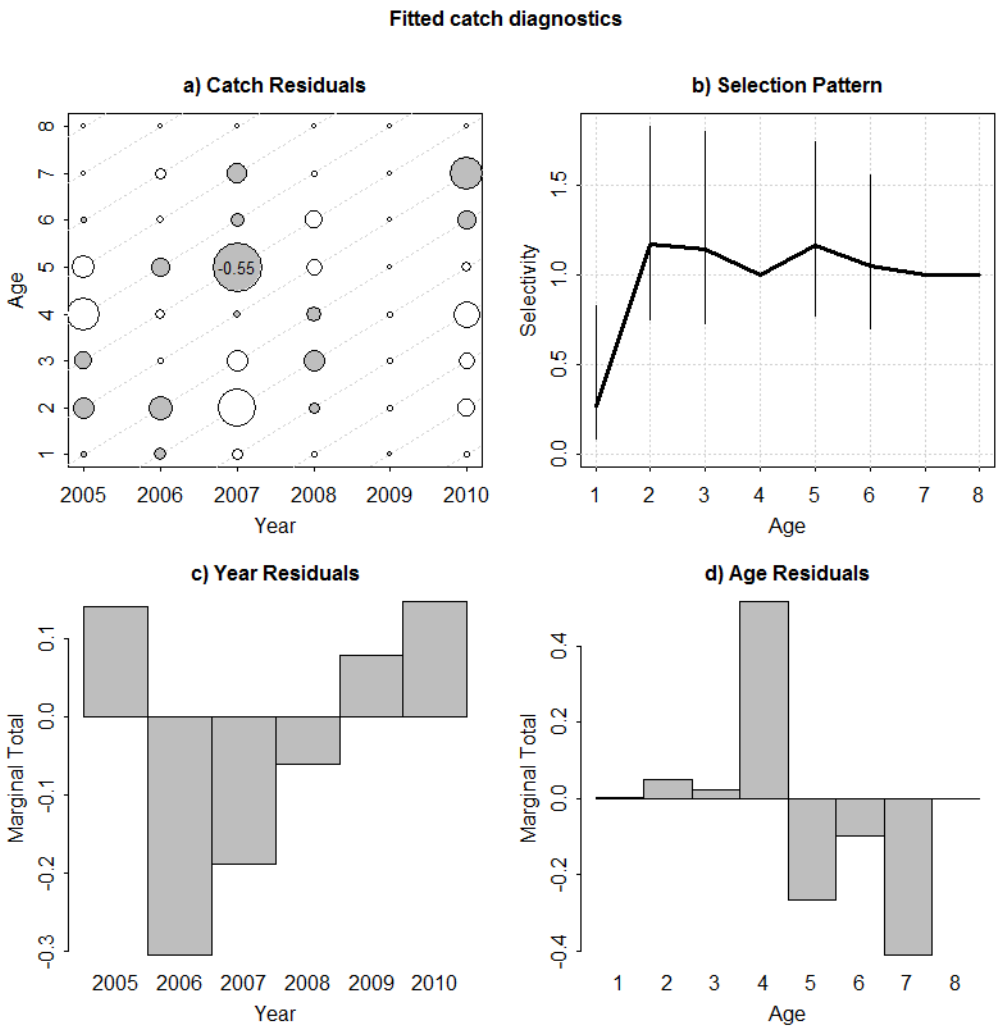


Figure 7.6.10 **Herring in Division VIIa North (Irish Sea). SPALY FLICA run output. Selection pattern diagnostics from deterministic calculations (6-year separable period). a) catch residuals. b) estimated selection (relative to 4-wr)+/- standard deviation. c) marginal totals of residuals by year and d) ring (ages 2-7 only).**

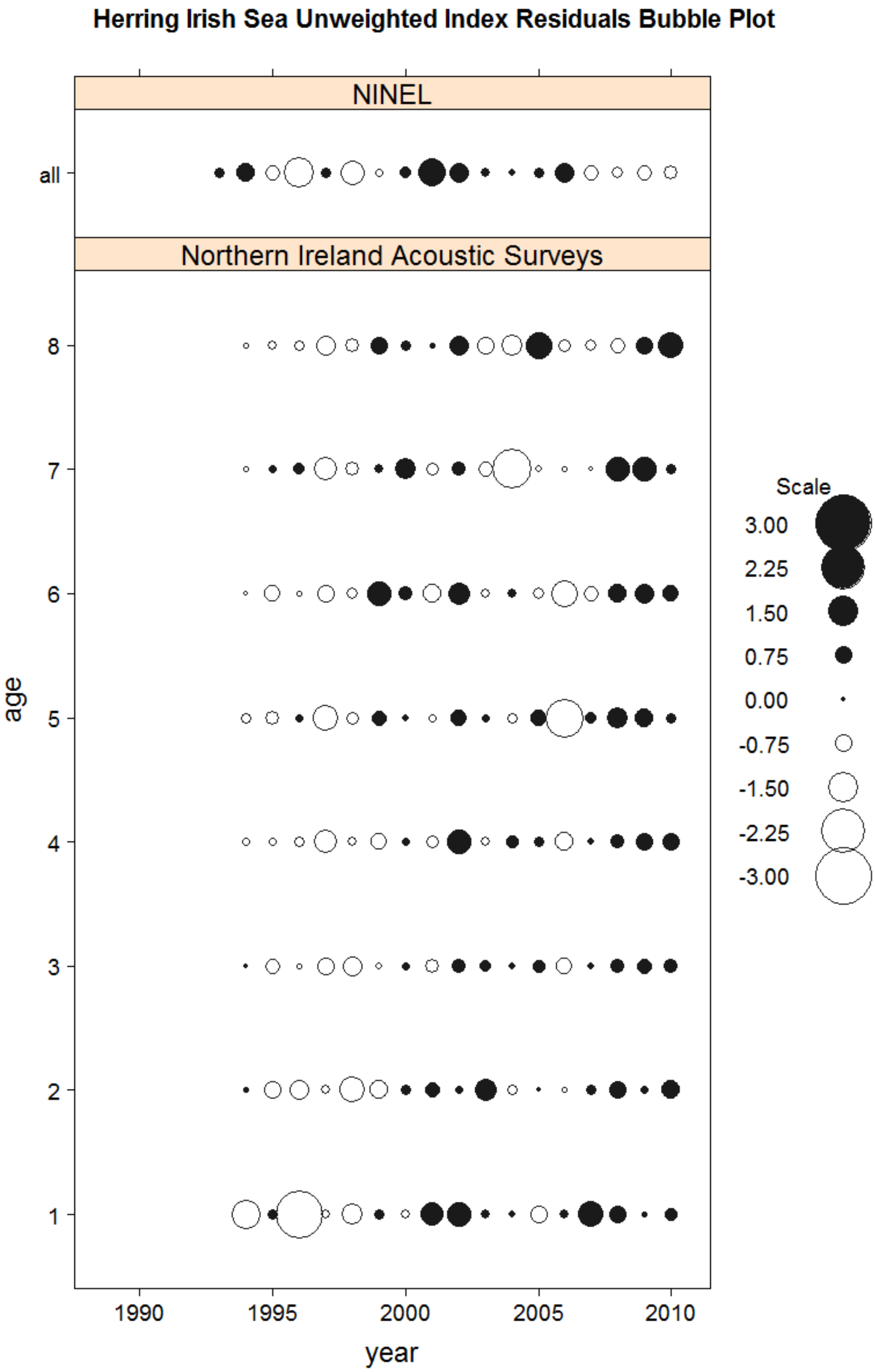


Figure 7.6.11 Herring in Division VIIa North (Irish Sea). SPALY FLICA run output unweighted residuals of larval survey (SSB index) and acoustic for the assessment up to 2010.

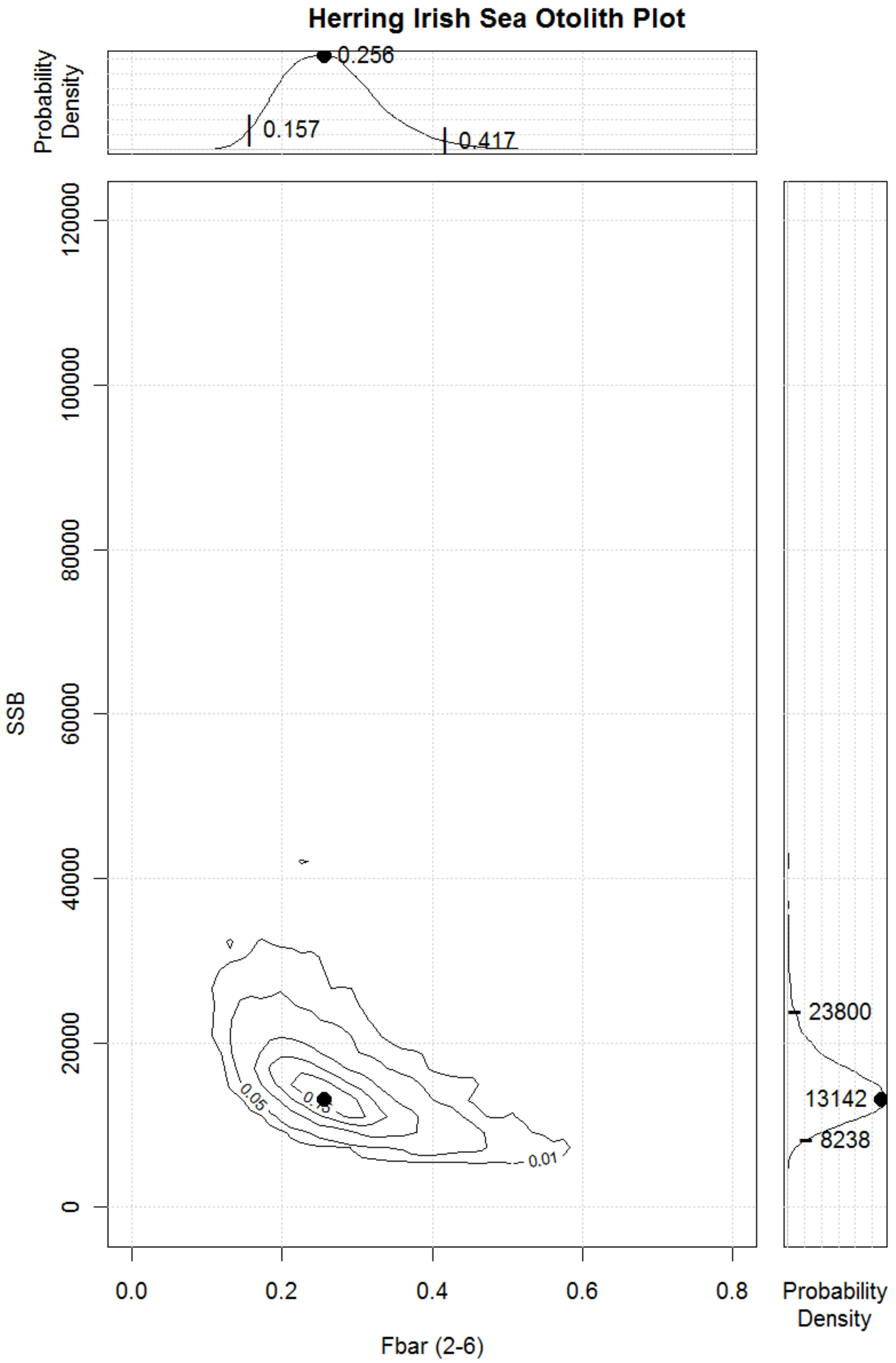


Figure 7.6.12 **Herring in Division VIIa North (Irish Sea). Results of parametric bootstrapping from FLICA. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters and are estimated from a parametric bootstrap based on the variance covariance matrix in the parameters returned by FLICA. The plots to the right and top of the main plot give the probability distribution in the SSB and mean fishing mortality respectively. The SSB and fishing mortality estimated by the method is plotted on all three plots with a heavy dot. 95% confidence intervals, with their corresponding values, are given on the plots to the right and top of the main plot.**

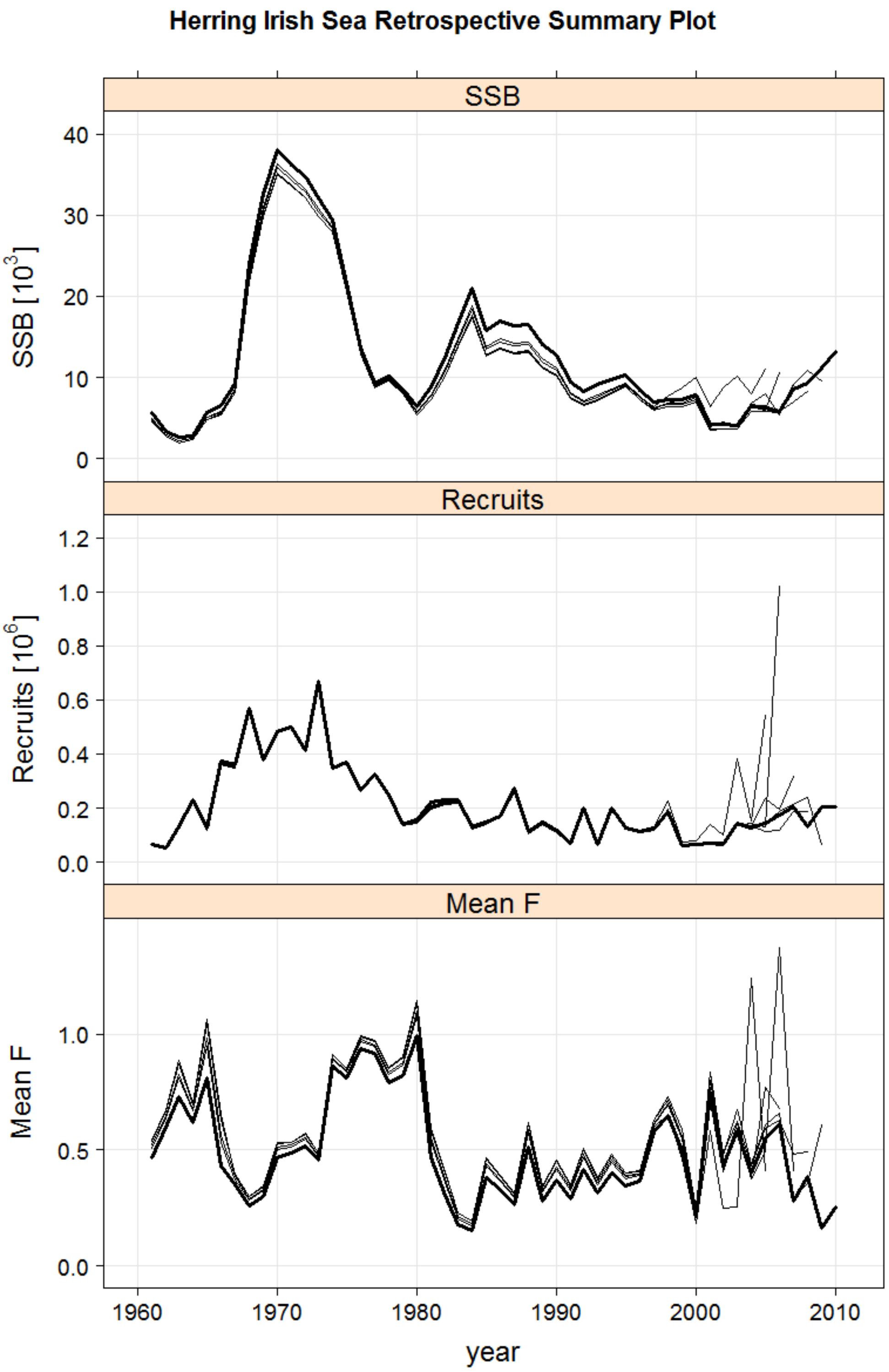


Figure 7.6.13 Herring in Division VIIa North (Irish Sea). Analytical retrospective patterns (2010 to 2005) of SSB, recruitment and mean $F_{2\text{-}6}$ from the final assessment.

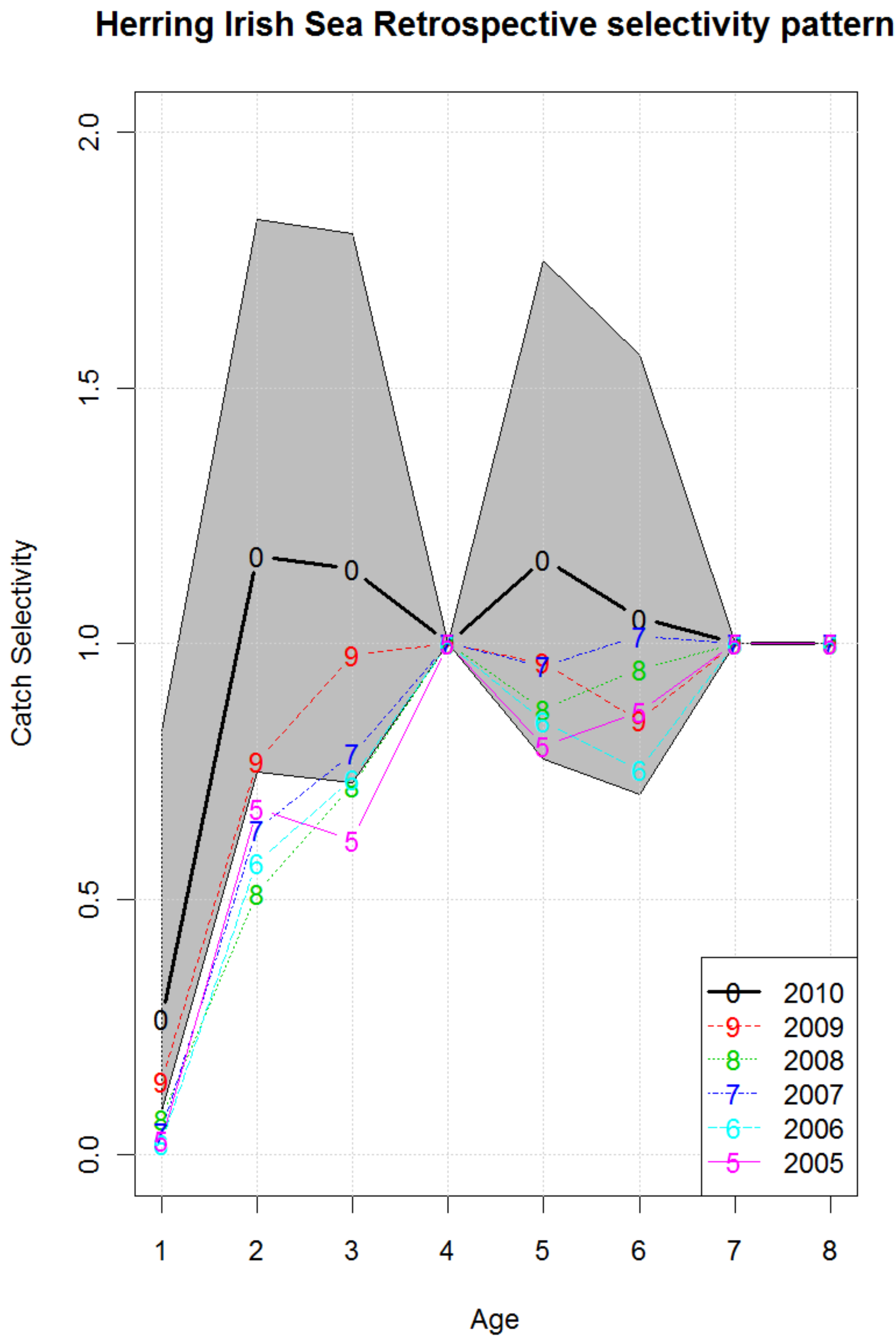


Figure 7.6.14 **Herring in Division VIIa North (Irish Sea). Retrospective Selection pattern for years 2005 to 2010 at ages 1 to 8.**

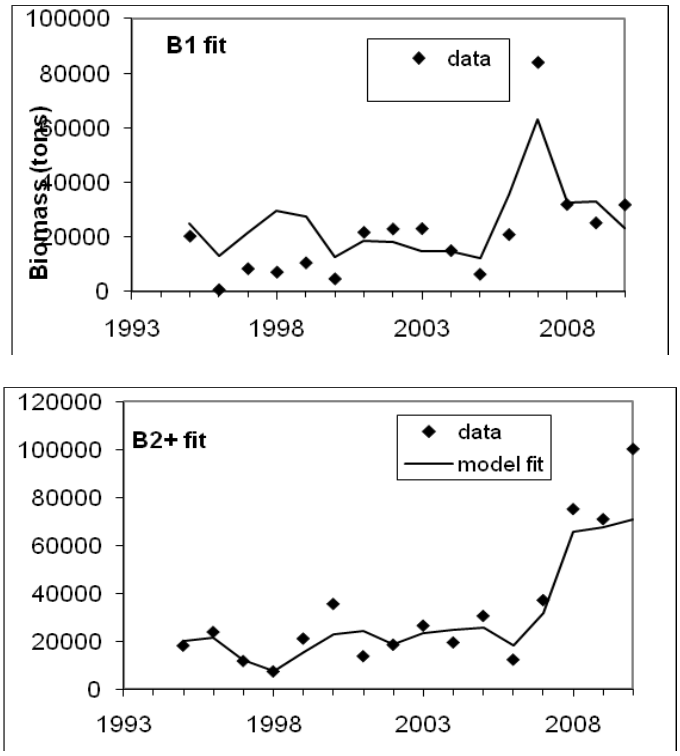


Figure 7.6.15 **Herring in Division VIIa North (Irish Sea). Two-stage biomass model fit to the AC(VIIaN) survey biomass estimates of 1-ringers (B1 fit) and 2⁺-ringers (B2⁺ fit); recruitment variability = 0.4.**

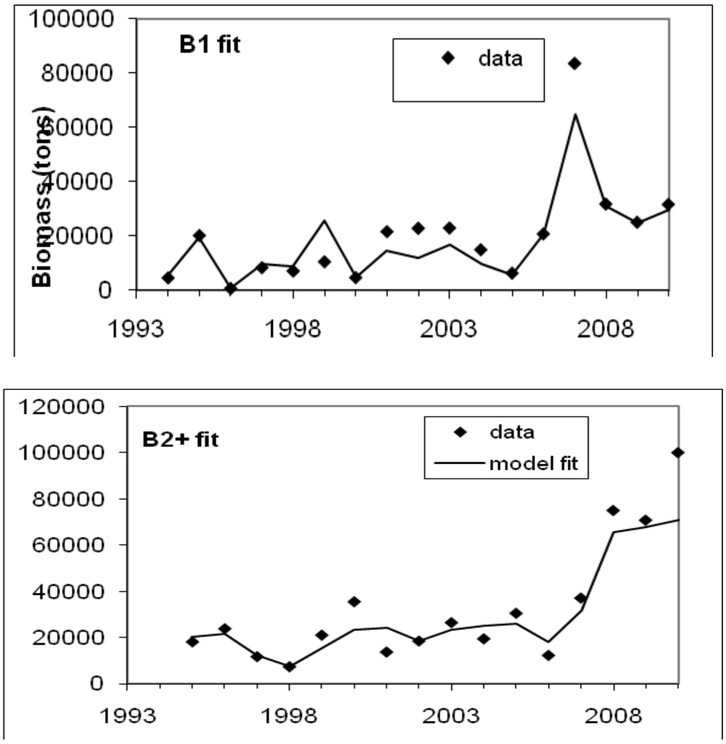


Figure 7.6.16 **Herring in Division VIIa North (Irish Sea). Two-stage biomass model fit to the AC(VIIaN) survey biomass estimates of 1-ringers (B1 fit) and 2⁺-ringers (B2⁺ fit); recruitment variability = 0.8.**

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACOM Advice Applicable to 2010 and 2011

There have never been any explicit management objectives for this stock. The TAC set for 2010 was 170 000 t. For 2010, the by-catch quota of herring (EU fleet) was set at 13 587 t. For 2011 a preliminary TAC of 170 000 t is set and a revised mid-year advice is expected. For 2011, the by-catch quota of herring (EU fleet) was set at 16 539 t.

Catches in 2010

Catch statistics for 1996–2010 for sprat in the North Sea by area and country are presented in Table 8.1.1. Catch data prior to 1996 are considered unreliable (see Stock Annex). As in previous years 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 2010 were 143 500 t. This is only slightly more than in 2009, and about average for the time series. The Danish catches represent 90% of the total catches. The Norwegian sprat fishery caught 11 100 t of sprat.

In 2010 the catches were taken in IVb and IVc . The catches in IVc increased to 37% of the total catches, compared to only 8% in 2009. Only small catches were landed in the second and third quarter in 2010 (Table 8.1.2). Quarterly and annual distribution of catches per rectangle for Subarea IV show a fishery located in the southern North Sea in the first quarter, the western areas in the second, the eastern areas in the third quarter and in the central parts of the southern North Sea in the last quarter (Figures 8.1.1a-d and Figure 8.1.2).

8.1.2 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the 2nd quarter or July in the EU and the Norwegian zone. There is also a maximum vessel quota of 800 t. A herring by-catch of up to 10% in biomass is allowed in Norwegian sprat catches. In the Danish sprat catches, a by-catch of up to 20% in biomass of herring is allowed. Most sprat catches are taken in an industrial fishery where catches are limited by herring by-catch restrictions. By-catches of herring are practically unavoidable except in years with high sprat abundance or low herring recruitment. By-catch is especially considered to be a problem in area IVc. The landings from area IVc increased from 8% in 2009 to 37% in 2010, probably increasing the by-catch of herring in 2010. Unfortunately, the catch sampling from area IVc is very poor, with less than 0.1 sample per 1000 tonnes.

8.1.3 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported.

8.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 8.2.1). The Danish sprat fishery has recently been conducted with a low by-catch of herring. The total amount of herring caught as by-catch in the sprat fishery has mostly been less than 10% except in 2008 (11%).

The Danish biological sampling from 1996 and onwards is considered reliable due to the changes in the Danish sampling scheme. The estimated quarterly landings at age in numbers for the period are presented in Table 8.2.2. In 2010 the one-year old sprat contributed 36% of the total landings, which is below the average contribution (62% since 1996, range: 18-96%). 2-year olds contributed in 2010 with 44% of the total landings, leaving 21% of the contribution to 0- and 3+- year olds. The oldest sprat (3+) contributed with 14%, which is the highest since the maximum of 29% in 1996.

Mean-weight-at-age (g) in the landings in 2010 was a bit lower than the 2009 values (Table 8.2.3).

Denmark and Norway provided age data of commercial landings in 2010 for quarters 1, 3 and 4 (Table 8.2.4). The small fishery in quarter 2 was unsampled, and the landings data were raised by using samples from quarter 1 and 3. The sample data were used to raise the landings data from the North Sea. The landings by UK-England, UK-Scotland and Sweden were minor and unsampled. The sampling level (no. per 1000 t landed) in 2010 (0.3) was lower than 2007-2009 considering the number of samples (0.4 samples for 2007-2009), number aged (2010: 12, 2009: 16, 2008: 16, 2007: 18), and number measured (2010: 31, 2009: 41, 2008: 40, 2007: 57). The sampling level is especially low for the quarter with most of the catches (quarter 4: 0.1 samples per 1000 tonnes), and these samples are moreover not equally distributed between areas according to catches (IVb and IVc: 0.16 and 0.08 sample per 1000 tonnes). The required sampling level in the EU directive for the collection of fisheries data (Commission Regulation 1639/2001) is 1 sample per 2000 tonnes (also see Stock Annex).

8.3 Fishery Independent Information

8.3.1 IBTS (February)

Sprat of age 1 and 2 were mostly found in the south-east, with the highest concentrations in the more central parts of the distribution area (Figure 8.3.1a-c), as well as the English Channel (age 2). 3+-ringers were found in the central part of the North Sea and the English Channel. Table 8.3.1 gives the time series of IBTS indices by age.

8.3.2 Acoustic Survey (HERAS)

The sprat in 2010 was almost exclusively found in the eastern and southern parts of the North Sea, with highest abundances mainly in the south-eastern part, a bit further southwest than in 2009 (Figure 8.3.2). Total abundance was estimated by WGIPS (see section 1.4.2) to be 36 000 million individuals and total biomass 376 000 t (Table 8.3.2), which is a decrease by 32% in terms of biomass when compared to last year (ICES CM 2011/SSGESST:02). In 2010, as in most recent years, the majority of the stock consists of mature sprat. The estimated abundance of the 1-year-olds in 2010 (the 2009 year class) is about average for the time series. The sprat stock is dominated by 1- and 2-year old fish representing more than 90% of the biomass.

8.4 Mean weights-at-age and maturity-at-age

Data on maturity by age, mean weight- and length-at-age during the 2010 summer acoustic survey are presented in the WGIPS report (ICES CM 2011/SSGESST:02).

8.5 Recruitment

The IBTS (February) 1-group index (Table 8.3.1) is used as a recruitment index for this stock.

The incoming 1-group in 2011 (2010 year class) was estimated to be below the average of the time series, whereas in 2010 the 1-group (2009 year class) was estimated to be the 6th highest in the time series.

8.6 Stock Assessment

The last benchmark of this stock was in September 2009 (ICES CM 2009/ACOM:34). The main conclusion was that previously used assessment methods are inappropriate, and that there is no basis for performing an analytical assessment of this stock (see section 1.4.6).

However, earlier acoustic surveys have proven to be reliable at estimating sprat abundance (e.g. Baltic Sea), and also the acoustic survey for the North Sea sprat stock seems promising.

8.6.1 Data Exploration

The time series indices of the IBTS Q1 and Q3 surveys were recalculated last year following the method described in the stock annex of the 2009 HAWG report (ICES CM 2009/ACOM:03).

The 2010 HAWG data exploration showed that even though the survey indices are highly variable and dominated by few large hauls; visual inspection of the time series does indicate some correlation between the three independent data sources. However this correlation was not significant at a 0.05 level. Further analysis of the survey data may increase the signal-to-noise ratio. Further work should be done e.g. in analysing catchability in IBTS hauls, spatial distribution, and comparisons taking fisheries and natural mortality for the intermediate period into account. Alternative ways of index calculation and accounting for extraordinary large hauls and zero catches in a rigorous statistical method should also be explored.

New exploratory analyses of the ability of the IBTS surveys to represent the abundance of sprat were performed this year (Rindorf & Payne WD12): full details are provided in the working document. Briefly, the individual hauls in each of the major IBTS surveys (Q1, Q3) were analysed using a statistical approach that accounts for both the likelihood of observing sprat in a haul and the abundance of sprat (CPUE) in the haul. Internal consistency plots were then prepared using the revised indices to check the ability of the surveys to track cohorts. It was found that while the ability of a single survey to track a cohort from year to year was poor, the surveys that were only six months apart showed a significantly improved ability to track cohorts. This result was interpreted as suggesting that the natural mortality of this stock (known to be high) is also variable, but that the IBTS may have some ability to represent the abundance of sprat. This promising result suggests that a model incorporating all available IBTS time series (Q1-Q4) may have potential in the assessment of this stock. Further work is therefore recommended.

In HAWG 2011, the IBTS and the catch data series were explored in order to find out whether they could provide some information about the exploitation level of the sprat stock. The sprat fishery is dominated by the 1-year-olds, and the only time series giving information of the 1-year-old sprat during the current year is the IBTS Q1 (February) age 1 sprat index. As in-year advice is given for the North Sea, IBTS Q1 could give some indication about the catch levels for a given year. IBTS is a cpue index, and the age 1 index (in 1st quarter) was therefore compared to the annual catch of age 1 in numbers (Figure 8.6.1). Also the total IBTS sprat index was compared to the total catches of sprat in tonnes (Figure 8.6.1). The data used in the latter comparison correspond to the data in the regression method earlier used for giving advice on North Sea sprat (ICES HAWG 2001-2008).

The 1st quarter IBTS index for 1-year-olds appears to have rather similar pattern with the annual catch numbers of 1-year-olds, and a regression analysis suggests a significant correlation between these two time series (Figure 8.6.1). The correspondence of the total IBTS index for all age classes and total annual catch biomass is much poorer, and also the correlation coefficient is relatively low (Figure 8.6.1). We should bear in mind that in 2001-2008 a regression method predicting total catch from the total IBTS index was used for giving TAC advice. This may have influenced these results, however, the good correlation for abundance of age 1 sprat is valid also for the period before 2001.

8.6.2 State of the Stock

No absolute estimates or reliable trends of the North Sea sprat stock can be calculated given the poor data sets available.

8.7 Short-term projections

No projections are presented for this stock.

8.8 Reference points

Precautionary reference points have not been defined for this stock and the available information is inadequate to estimate the absolute stock size.

Uncertainties in the survey indices make the current understanding of the dynamics of this stock extremely poor.

8.9 Quality of the assessment

See above.

8.10 Management Considerations

There are no explicit management objectives for this stock.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year.

In the forecast table for North Sea herring, industrial fisheries are allocated a by-catch of approx 17 900 t of juvenile herring in 2012. It is important to continue monitoring by-catch of juvenile herring to ensure compliance with this allocation.

Catches in recent years have been well below the advised and agreed TAC. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa.

8.10.1 Stock units

North Sea sprat is considered an independent stock. This approach of managing North Sea sprat, IIIa sprat and VIId sprat as separate stocks was tested in 2009 by including IBTS survey data from the subdivisions VIId and IIIa for comparison of the CPUE for each statistical rectangle at which data were available. No distinct separation was obvious between North Sea sprat and sprat in VIId, whereas IIIa sprat and North Sea sprat showed a lesser overlap (see Stock Annex).

8.11 Ecosystem Considerations

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

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; SGRECVAP 2006: ICES CM 2006/LRC:03). However, sprat is mainly distributed in the southern North Sea where these trends have not been observed (SGRECVAP 2006).

8.12 Changes in the environment

Temperatures in this area have been increasing over the last few decades. It is considered that this may have implications for sprat, although it is not possible to quantify either the magnitude or direction of such changes.

Table 8.1.1. North Sea sprat. Catches (' 000 t) 1996-2010. See ICES CM 2006/ACFM:20 for earlier catch data. Catch in fjords of western Norway excluded.
(Data provided by Working Group members except where indicated). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.
The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02

Country	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
		Division IVa													
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*	
Norway														*	
Sweden						0.1									
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*	
		Division Ivb													
Denmark	76.5	93.1	119.3	160.3	162.9	143.9	126.1	152.9	175.9	204.0	79.5	55.5	51.4	115.6	80.8
Norway	52.8	3.1	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3	4.0	8.0
Sweden	0.5		1.7	2.1		1.4				*				0.3	0.6
UK(Engl.&Wales)														*	
UK(Scotland)				1.4								0.1		2.5	1.1
Total	129.8	96.2	136.3	176.9	163.8	151.2	126.1	152.9	176.0	204.1	80.3	59.3	52.7	122.4	90.4
		Division IVc													
Denmark	3.9	5.7	11.8	3.3	28.2	13.1	14.8	22.3	16.8	2.0	23.8	20.6	8.1	8.2	48.5
Netherlands				0.2											
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2
Sweden														0.6	0.6
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8
UK(Scotland)													0.2		
Total	6.5	7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4	10.6	53.0
		Total North Sea													
Denmark	80.7	98.8	131.1	164.3	191.1	157.1	142.0	175.2	192.7	206.0	103.4	76.8	59.6	123.8	129.3
Netherlands				0.2											
Norway	52.8	3.2	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3	5.8	11.1
Sweden	0.5		1.7	2.1		1.5				*				0.9	1.2
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8
UK(Scotland)				1.4								0.1	0.2	2.5	1.1
Total	136.6	103.4	164.3	188.4	195.9	170.2	143.6	176.5	194.3	207.7	113.7	83.8	61.1	133.1	143.5

* < 50 t

Table 8.1.2. North Sea sprat. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996-1999 in ICES CM 2007/ACFM:1 The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02.

Year	Quarter	Area				Total
		IVaW	IVaE	IVb	IVc	
2000	1			18 126	28 063	46 189
	2			1 722	45	1 767
	3			131 306	1 216	132 522
	4			12 680	2 718	15 398
	Total			163 834	32 042	195 876
2001	1	115		40 903	9 716	50 734
	2			1 071		1 071
	3			44 174	481	44 655
	4	79		65 102	8 538	73 719
	Total	194		151 249	18 735	170 177
2002	1	1 136		2 182	2 790	6 108
	2			435	93	528
	3			70 504	647	71 151
	4			52 942	12 911	65 853
	Total	1 136		126 063	16 441	143 640
2003	1			11 458	7 727	19 185
	2			625	26	652
	3			56 207	165	56 372
	4			84 629	15 651	100 280
	Total			152 919	23 570	176 489
2004	1			827	1 831	2 657
	2	7		260	16	283
	3			54 161	496	54 657
	4			120 685	15 937	136 622
	Total	7		175 932	18 280	194 219
2005	1			11 538	2 457	13 995
	2			2 515	123	2 638
	3			107 530		107 530
	4			82 474	1 033	83 507
	Total			204 057	3 613	207 670
2006	1	25	22	13 713	33 534	47 294
	2			190	8	198
	3			40 051	8	40 059
	4	2		26 579	77	26 658
	Total	27	22	80 533	33 627	114 209
2007	1			582	247	829
	2			241	3	244
	3			16 603		16 603
	4	769		41 850	23 531	66 150
	Total	769		59 276	23 781	83 826
2008	1			2 872	43	2 915
	2			52	*	52
	3			21 787		21 787
	4			27 994	8 334	36 329
	Total			52 706	8 377	61 083
2009	1			36	1 268	1 304
	2			2 526	1	2 527
	3		22	41 513		41 535
	4			78 373	9 336	87 709
	Total		22	122 448	10 604	133 075
2010	1			10 976	17 072	28 048
	2			3 235	3	3 238
	3			14 220		14 220
	4			62 006	35 973	97 979
	Total			90 437	53 048	143 485

* < 0.5 t

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 1998-2010.

	Year	Sprat	Herring	Horse mack.	Whiting	Haddock	Mackerel	Cod	Sandeel	Other	Total
Tonnes	1998	129 315	11 817	573	673	6	220	11	2 174	1 188	145 978
Tonnes	1999	157 003	7 256	413	1 088	62	321	7	4 972	635	171 757
Tonnes	2000	188 463	11 662	3 239	2 107	66	766	4	423	1 911	208 641
Tonnes	2001	136 443	13 953	67	1 700	223	312	4	17 020	1 142	170 862
Tonnes	2002	140 568	16 644	2 078	2 537	27	715	0	4 102	800	167 471
Tonnes	2003	172 456	10 244	718	1 106	15	799	11	5 357	3 509	194 214
Tonnes	2004	179 944	10 144	474	334		4 351	3	3 836	1 821	200 906
Tonnes	2005	201 331	21 035	2 477	545	4	1 009	16	6 859	974	234 250
Tonnes	2006	103 236	8 983	577	343	25	905	4	5 384	576	120 033
Tonnes	2007	74 734	6 596	168	900	6	126	18	6	253	82 807
Tonnes	2008	61 093	7 928	26	380	10	367	0	23	1 735	71 563
Tonnes	2009	112 721	7 222	44	307	3	116	1	1 526	407	122 345
Tonnes	2010	115 246	6 544	36	261	8	20	2	1 371	747	124 235
Percent	1998	88.6	8.1	0.4	0.5	0.0	0.2	0.0	1.5	0.8	100.0
Percent	1999	91.4	4.2	0.2	0.6	0.0	0.2	0.0	2.9	0.4	100.0
Percent	2000	90.3	5.6	1.6	1.0	0.0	0.4	0.0	0.2	0.9	100.0
Percent	2001	79.9	8.2	0.0	1.0	0.1	0.2	0.0	10.0	0.7	100.0
Percent	2002	83.9	9.9	1.2	1.5	0.0	0.4	0.0	2.4	0.5	100.0
Percent	2003	88.8	5.3	0.4	0.6	0.0	0.4	0.0	2.8	1.8	100.0
Percent	2004	89.6	5.0	0.2	0.2	0.0	2.2	0.0	1.9	0.9	100.0
Percent	2005	85.9	9.0	1.1	0.2	0.0	0.4	0.0	2.9	0.4	100.0
Percent	2006	86.0	7.5	0.5	0.3	0.0	0.8	0.0	4.5	0.5	100.0
Percent	2007	90.3	8.0	0.2	1.1	0.0	0.2	0.0	0.0	0.3	100.0
Percent	2008	85.4	11.1	0.0	0.5	0.0	0.5	0.0	0.0	2.4	100.0
Percent	2009	92.1	5.9	0.0	0.3	0.0	0.1	0.0	1.2	0.3	100.0
Percent	2010	92.8	5.3	0.0	0.2	0.0	0.0	0.0	1.1	0.6	100.0

Table 8.2.2 North Sea sprat. Catch in numbers (millions) by quarter and by age 1996-2010.

Year	Quarter	Age						
		0	1	2	3	4	5+	Total
1996	1		524.7	4 615.4	2 621.9	316.4	11.3	8 090
	2		1.9	241.5	32.7	15.5	0.3	292
	3		400.5	100.7	22.9	0.3		524
	4		1 190.7	1 069.0	339.6	5.6		2 605
	Total		2 117.8	6 026.6	3 017.1	337.8	11.6	11 511
1997	1		74.4	314.0	229.2	55.3	2.5	675
	2		11.3	47.8	34.9	8.4	0.4	103
	3		1 991.9					1 992
	4	127.6	3 597.2	996.2	117.8	58.1		4 897
	Total	127.6	5 674.8	1 358.1	381.9	121.8	2.8	7 667
1998	1		683.2	537.2	18.3	0.1		1 239
	2		70.9	55.3	1.8			128
	3	74.2	3 356.6	693.3				4 124
	4	772.4	4 822.4	2 295.1	483.5	39.5		8 413
	Total	846.6	8 933.1	3 580.9	503.6	39.6		13 904
1999	1		728.1	2 226.0	554.2	86.6	9.2	3 604
	2		38.6	58.4	18.1	2.6		118
	3		12 919.0	38.9				12 958
	4	105.0	2 143.2	211.5				2 460
	Total	105.0	15 828.9	2 534.8	572.3	89.2	9.2	19 139
2000	1		559.2	3 177.3	797.5	247.5	72.0	4 854
	2		6.8	107.4	60.1	12.8	0.5	188
	3		9 928.9	1 111.9	77.8			11 119
	4		1 153.7	129.2	9.0			1 292
	Total		11 648.7	4 525.8	944.4	260.3	72.6	17 452
2001	1		746.3	3 197.7	1 321.9	22.2		5 288
	2		15.9	66.2	26.1			108
	3	0.4	3 338.8	299.9				3 639
	4	1 205.0	4 178.7	1 224.6	261.9			6 870
	Total	1 205.4	8 279.8	4 788.4	1 609.9	22.2		15 906
2002	1		104.7	400.3	30.2	11.2		546
	2		13.7	27.9	2.4	0.6		45
	3	40.9	5 745.6	582.1	42.3	4.1		6 415
	4	415.0	4 578.0	626.2	119.8	3.1		5 742
	Total	455.9	10 441.9	1 636.5	194.8	19.0		12 748
2003	1		1 953.9	1 218.9	85.3	11.3		3 269
	2		41.8	46.3	4.7	0.6		93
	3	1.1	3 481.3	772.0	42.9			4 297
	4	539.3	7 051.8	1 115.1	93.8	36.5	21.9	8 858
	Total	540.4	12 528.7	3 152.3	226.6	48.4	21.9	16 518
2004	1		16.5	214.0	26.3	1.6	0.6	259
	2		22.1	14.9	3.0	0.1		40
	3	210.0	3 661.9	558.2	31.4			4 462
	4	15 674.4	5 582.8	632.1	59.2			21 949
	Total	15 884.4	9 283.2	1 419.2	119.8	1.8	0.6	26 709
2005	1		2 476.5	268.5	13.8	2.2		2 761
	2		499.6	23.4	4.3	4.9		532
	3		11 920.2	192.3	7.6			12 120
	4	302.5	7 467.9	191.1				7 962
	Total	302.5	22 364.3	675.3	25.7	7.0		23 375
2006	1		1 559.2	5 119.1	95.7	2.3		6 776
	2		5.8	21.5	0.2			27
	3		3 077.8	625.0	129.1			3 832
	4		2 048.5	416.0	85.9			2 550
	Total		6 691.2	6 181.6	310.8	2.3		13 186
2007	1		12.1	57.4	17.3			87
	2		3.9	18.5	5.6			28
	3		1 025.3	194.5	17.7	25.3		1 263
	4	858.6	4 047.6	1 066.0	150.9			6 123
	Total	858.6	5 088.8	1 336.5	191.4	25.3		7 501
2008	1		356.0	170.9	8.4	1.0		536
	2		7.8	2.7	0.1			11
	3	1.7	444.3	1 225.8	189.9	29.3		1 891
	4	486.3	1 812.5	1 032.8	147.5	13.9		3 493
	Total	488.0	2 620.5	2 432.2	345.9	44.2		5 931
2009	1		886.6					887
	2	0.5	252.8	12.7	1.3			267
	3	2.9	4 160.0	210.4	21.6			4 395
	4	415.5	8 259.0	413.0	44.8			9 132
	Total	418.9	13 558.4	636.1	67.6			14 681
2010	1		66.9	3 335.3	339.1	50.7	6.2	3 798
	2	5.6	211.9	177.0	8.4	2.2	0.3	405
	3	38.3	1 447.9	289.9	4.9	1.7	1.7	1 784
	4	1 056.4	3 824.3	2 956.0	773.7	531.8	388.5	9 531
	Total	1 100.4	5 551.0	6 758.2	1 126.1	586.4	396.7	15 519

Table 8.2.3 North Sea sprat. Mean weight (g) by quarter and by age for 1996 - 2010.
* Any inconsistencies in total catches and SOP are due to rounding errors.
** These weights come from allocation of quarter 3 samples
*** These weights come from allocation of quarter 1 and quarter 3 samples

Year	Quarter	Age						SOP*
		0	1	2	3	4	5+	Tonnes
1996	1		3.9	9.3	14.9	15.3	16.1	88 807
	2		6.9	8.4	11.6	20.0	15.2	2 735
	3		11.6	14.2	18.2	21.5		6 501
	4		12.1	15.9	17.2	20.5		37 359
Weighted mean			10.0	10.5	15.1	15.6	16.0	135 401
1997	1		8.0	10.0	15.0	17.0	19.0	8 161
	2		8.0	10.0	15.0	17.0	19.0	1 243
	3		14.2					28 285
	4	3.7	11.9	16.4	19.1	19.6		63 083
Weighted mean		3.7	12.7	14.7	16.3	18.2	19.0	100 772
1998	1		5.6	6.0	8.7	15.0		7 232
	2		5.6	6.0	8.3			743
	3	3.7	14.7	15.3				60 149
	4	4.1	10.6	13.8	16.3	14.6		94 173
Weighted mean		4.0	11.7	12.8	16.0	14.7		162 297
1999	1		3.3	8.7	12.5	14.4	16.3	30 168
	2		3.1	10.1	13.6	15.4		993
	3		10.0	18.3				129 383
	4	4.4	11.0	14.4				27 126
Weighted mean		4.4	9.8	9.4	12.5	14.4	16.3	187 670
2000	1		4.2	10.1	10.7	10.2	10.5	46 192
	2		3.3	9.0	10.2	12.8	10.5	1 767
	3		11.9	11.9	11.0			132 563
	4		11.9	11.9	11.0			15 403
Weighted mean			11.6	10.6	10.7	10.3	10.5	195 925
2001	1		3.3	9.7	12.9	16.5		50 794
	2		3.3	10.3	12.9			1 071
	3	4.0	12.0	15.3				44 656
	4	3.8	11.6	12.6	19.1			73 444
Weighted mean		3.8	11.0	10.8	13.9	16.5		169 965
2002	1		7.0	12.0	14.0	13.0		6 106
	2		5.3	11.2	12.5	12.4		423
	3	2.0	10.9	15.0	15.0	24.0		72 173
	4	3.9	12.0	15.0	15.7	24.0		67 902
Weighted mean		3.7	11.2	13.4	14.9	14.8		146 604
2003	1		3.6	9.4	11.0	15.0		19 599
	2		3.1	9.9	11.0	15.0		648
	3	3.0	13.0	16.0	13.0			58 169
	4	4.6	10.8	14.8	16.9	15.0	18.0	97 670
Weighted mean		4.6	10.3	12.9	13.8	15.0	18.0	176 085
2004	1		3.6	10.3	13.8	16.6	16.1	2 663
	2		6.0	8.5	7.3	10.2		282
	3	4.5	11.9	17.0	20.0			54 639
	4	4.0	11.4	14.6	18.3			136 653
Weighted mean		4.0	11.0	10.9	14.5	16.8	16.1	194 238
2005	1		4.6	8.9	12.1	16.0		13 995
	2		4.8	6.5	9.8	10.0		2 641
	3		8.9	9.9	18.6			107 531
	4	4.1	10.7	12.0				83 515
Weighted mean		4.1	8.9	10.0	13.6	11.8		207 682
2006	1		4.3	7.7	9.6	13.0		47 293
	2		3.7	8.1	11.2			198
	3		9.8	12.5	16.1			40 053
	4		9.8	12.5	16.1			26 658
Weighted mean			8.5	8.5	14.1	13.0		114 202
2007	1		4.0	9.0	12.0			829
	2		4.0	9.0	12.0			244
	3		12.0	17.0	13.0	17.0		16 603
	4	5.1	10.9	13.5	16.3			66 150
Weighted mean		5.1	11.1	13.8	15.5	17.0		83 826
2008	1		4.2	7.8	10.3	10.0		2 930
	2		3.9	7.5	8.7			52
	3	2.0	11.1	11.4	12.9	14.6		21 759
	4	3.7	10.4	13.1	13.8	14.0		36 362
Weighted mean		3.7	9.6	11.9	13.2	14.3		61 102
2009	1		1.5					1 330
	2**	3.9	9.2	14.1	15.7			2 531
	3	3.9	9.2	14.1	15.7			41 628
	4	3.9	9.7	14.0	14.0			88 005
Weighted mean		3.9	9.0	14.0	14.5			133 494
2010	1		3.3	7.0	10.8	14.3	17.1	28 144
	2***	6.1	6.2	9.1	13.0	16.8	18.0	3 109
	3	6.1	7.6	9.9	13.9	18.0	18.0	14 249
	4	3.2	8.7	11.4	14.9	16.7	18.7	97 926
Weighted mean		3.3	8.3	9.1	13.7	16.5	18.6	143 428

Table 8.2.4. **North Sea sprat.** Sampling for biological parameters in 2010.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	24.831	10	1157	465
	2	3.228			
	3	13.844	11	1164	408
	4	87.392	11	1162	444
	Total	129.295	32	3483	1317
UK (England & Wales)	1	0.067			
	2				
	3				
	4	0.724			
	Total	0.791			
UK (Scotland)	1				
	2				
	3				
	4	1.075			
	Total	1.075			
Norway	1	3.150	3	300	150
	2	0.007			
	3	0.376	4	527	149
	4	7.588	2	182	60
	Total	11.121	9	1009	359
Sweden	1				
	2				
	3				
	4	1.200			
	Total	1.200			
All countries	1	28.048	13	1457	615
	2	3.235			
	3	14.220	15	1691	557
	4	97.979	13	1344	504
Total North Sea		143.483	41	4492	1676

* < 1 t

Table 8.3.1. North Sea sprat. Abundance indices by age from IBTS (February) from 1984-2011. * Preliminary

Year	Age					
	1	2	3	4	5+	Total
1984	233.76	329.00	39.61	6.20	0.29	608.86
1985	376.10	195.48	26.76	3.80	0.35	602.49
1986	44.19	73.54	22.01	1.23	0.24	141.21
1987	542.24	66.28	19.14	1.92	0.24	629.82
1988	98.61	884.07	61.80	6.99	0.00	1 051.46
1989	2 314.22	476.29	271.85	5.47	1.65	3 069.48
1990	234.94	451.98	102.16	28.06	2.22	819.37
1991	676.78	93.38	23.33	2.63	0.12	796.24
1992	1 060.78	297.69	43.25	7.23	0.53	1 409.48
1993	1 066.83	568.53	118.42	6.07	0.34	1 760.19
1994	2 428.36	938.16	92.16	3.59	0.50	3 462.77
1995	1 224.89	1 036.40	87.33	2.52	0.76	2 351.90
1996	186.13	383.53	146.84	18.28	0.74	735.53
1997	591.86	411.95	179.55	15.52	2.24	1 201.13
1998	1 171.05	1 456.51	305.91	15.75	3.38	2 952.60
1999	2 534.53	562.10	80.35	4.83	0.45	3 182.25
2000	1 058.20	851.58	274.71	43.89	0.88	2 229.27
2001	883.06	1 057.00	185.47	17.55	0.35	2 143.42
2002	1 152.33	812.45	91.63	11.93	0.38	2 068.72
2003	1 842.26	309.92	44.49	2.21	0.04	2 198.92
2004	1 593.89	495.70	78.24	3.50	1.54	2 172.87
2005	3 053.46	267.89	36.39	0.87	0.00	3 358.60
2006	421.80	1 212.87	92.38	8.26	0.07	1 735.39
2007	1 053.68	1 339.83	274.81	11.18	0.01	2 679.52
2008	1 432.45	769.17	96.89	6.86	0.02	2 305.38
2009	3 171.29	468.36	26.32	1.60	1.22	3 668.79
2010	2 103.50	1 739.36	156.54	24.40	1.12	4 024.92
2011*	680.34	913.51	627.73	98.01	149.47	2 469.06

Table 8.3.2 **North Sea sprat.** Time-series of sprat abundance and biomass (ICES areas IVa-c) as obtained from summer North Sea acoustic survey. The surveyed area has increased over the years. Only figures for the last 6 years are roughly comparable. In 2003, information on sprat abundance is available from one nation only.

Abundance (million)						Biomass (1000 tonnes)				
Year/Age	0	1	2	3+	sum	0	1	2	3+	sum
2010	1,991	19,492	13,743	798	36,023	22	163	177	14	376
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2001	0	12,639	1,812	110	14,561	0	97	24	2	122
2000	0	11,569	6,407	180	18,156	0	100	92	3	196

***Re-calculated by the means of FishFrame (ICES 2009/LRC:02)**

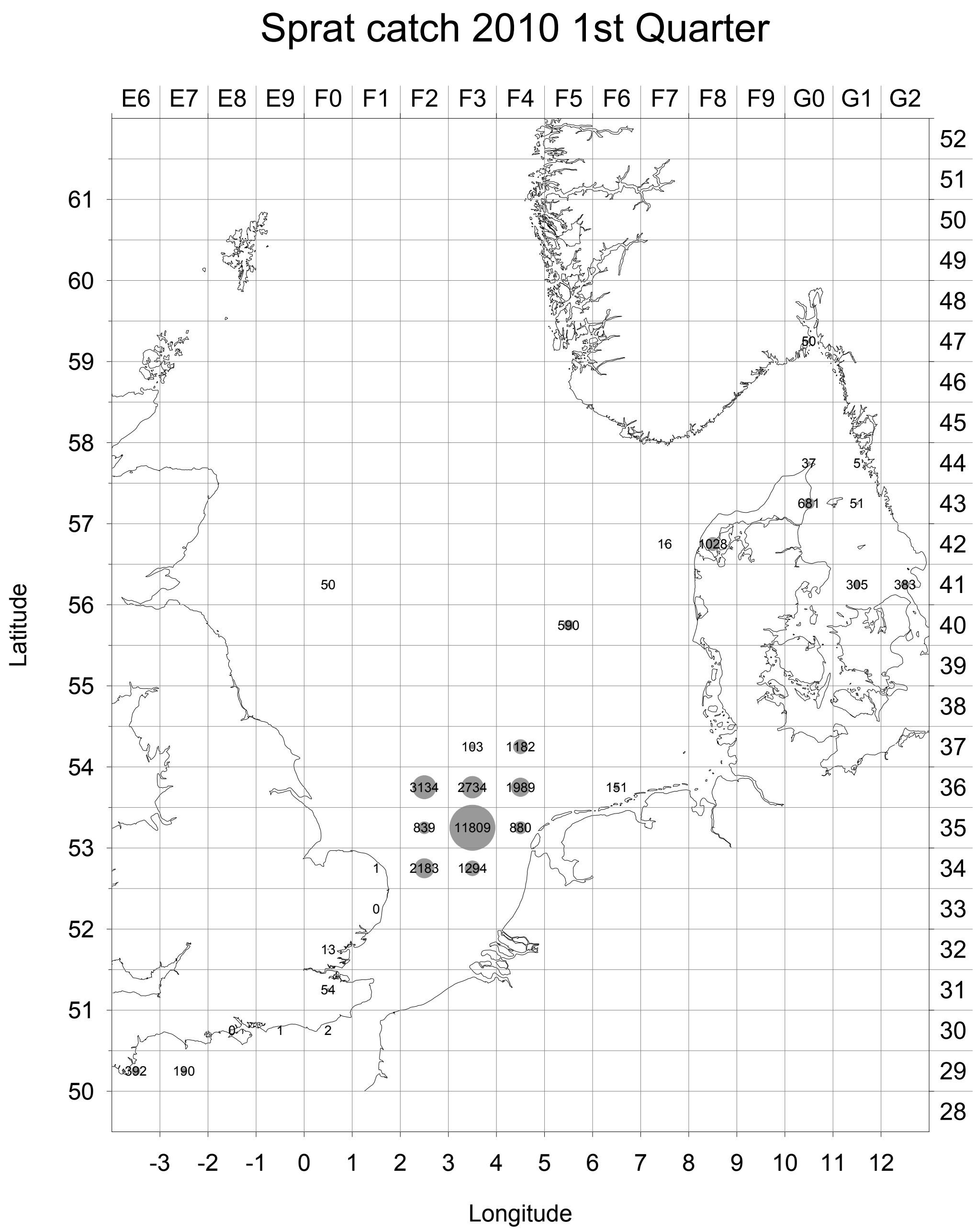


Figure 8.1.1a **Sprat catches in the North Sea and Div. IIIa (in tonnes) in the first quarter of 2010 by statistical rectangle.**

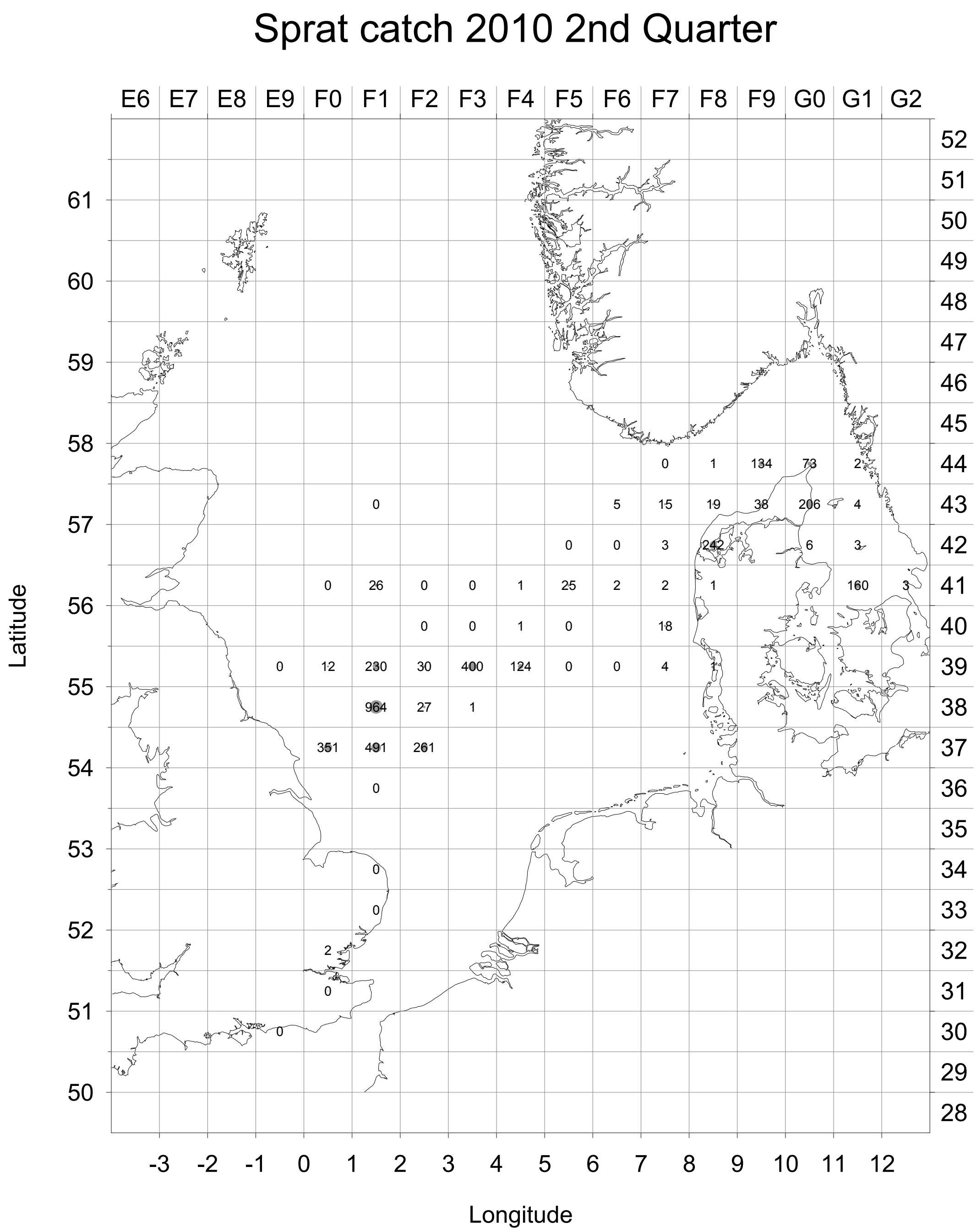


Figure 8.1.1b Sprat catches in the North Sea and Div. IIIa (in tonnes) in the second quarter of 2010 by statistical rectangle.

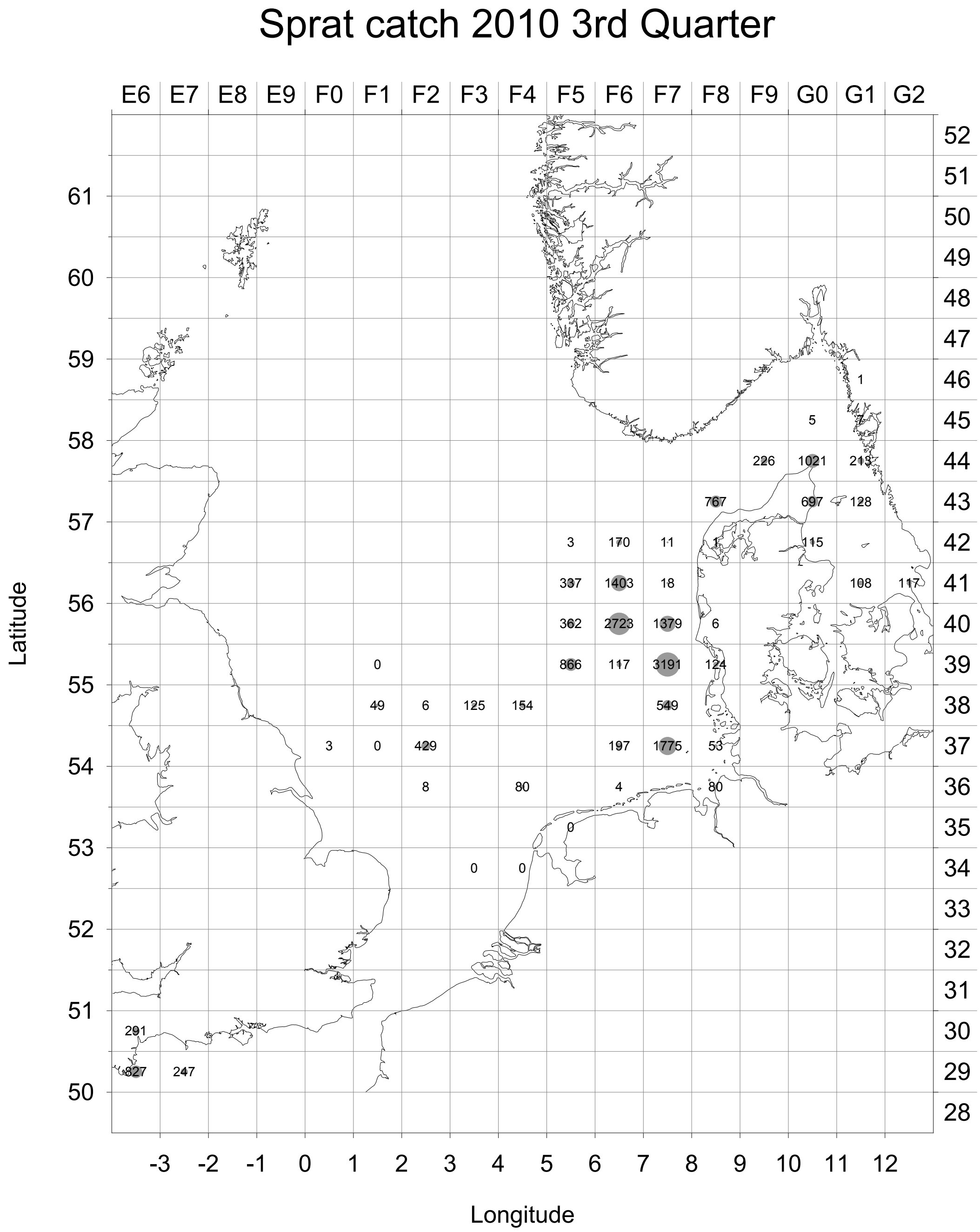


Figure 8.1.1c **Sprat catches in the North Sea and Div. IIIa (in tonnes) in the third quarter of 2010 by statistical rectangle.**

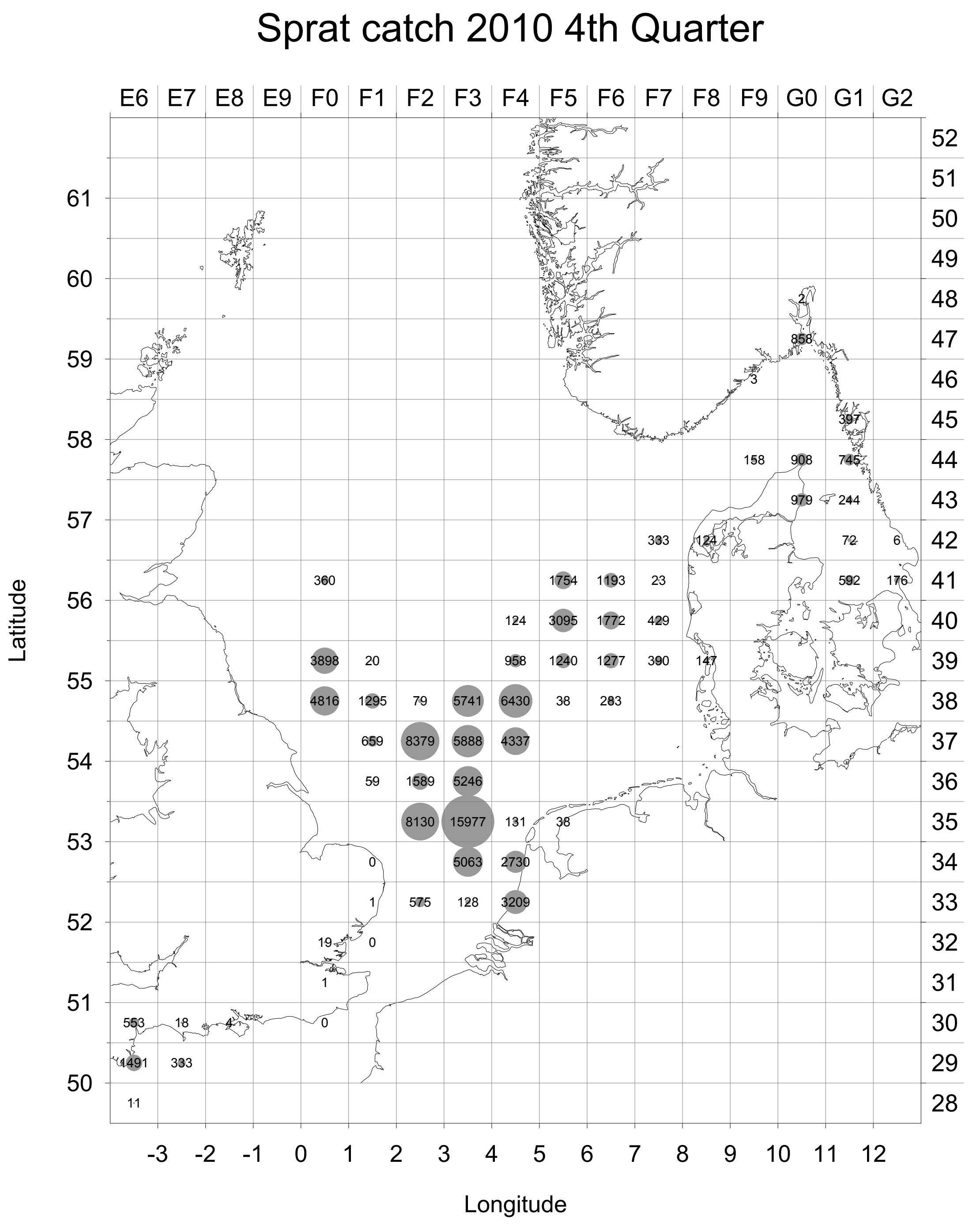


Figure 8.1.1d **Sprat catches in the North Sea and Div. IIIa (in tonnes) in the fourth quarter of (in tonnes) in 2010 by statistical rectangle.**

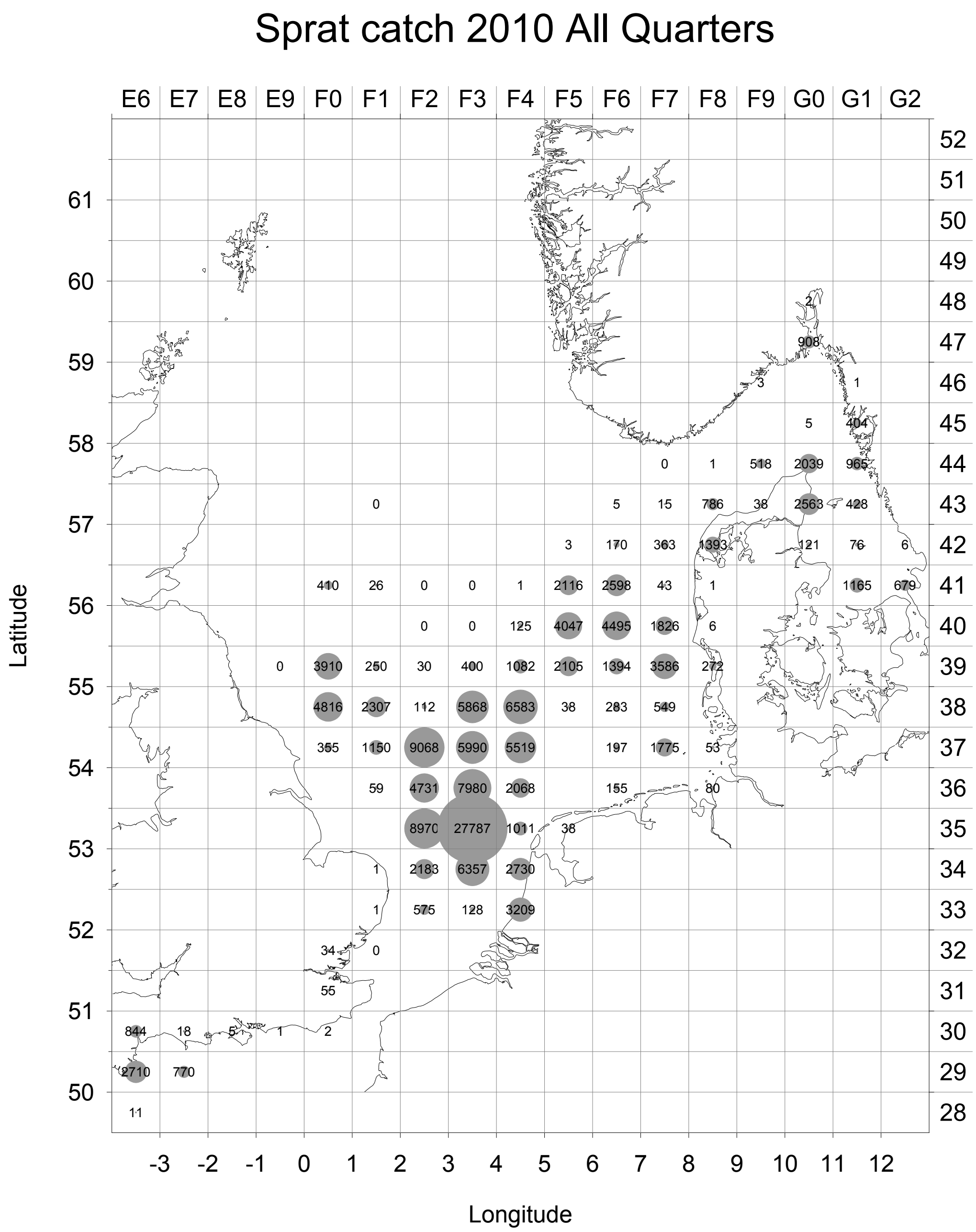


Figure 8.1.2 **Sprat catches in the North Sea and Div. IIIa (in tonnes) in 2010 by statistical rectangle.**

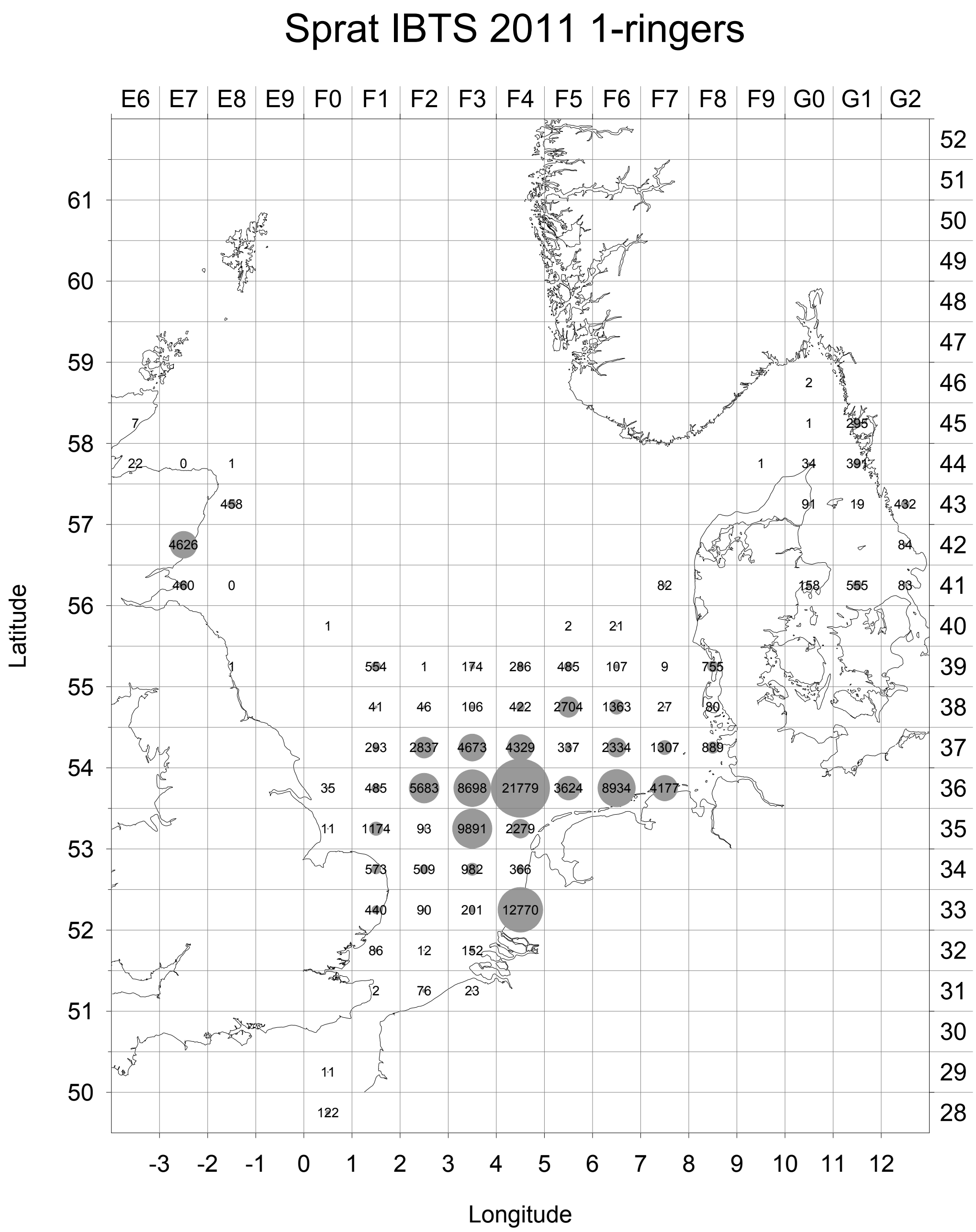


Figure 8.3.1a Distribution of 1-ringers in the IBTS (February) 2011 in the North Sea and Division IIIa (Mean number per hour per rectangle).

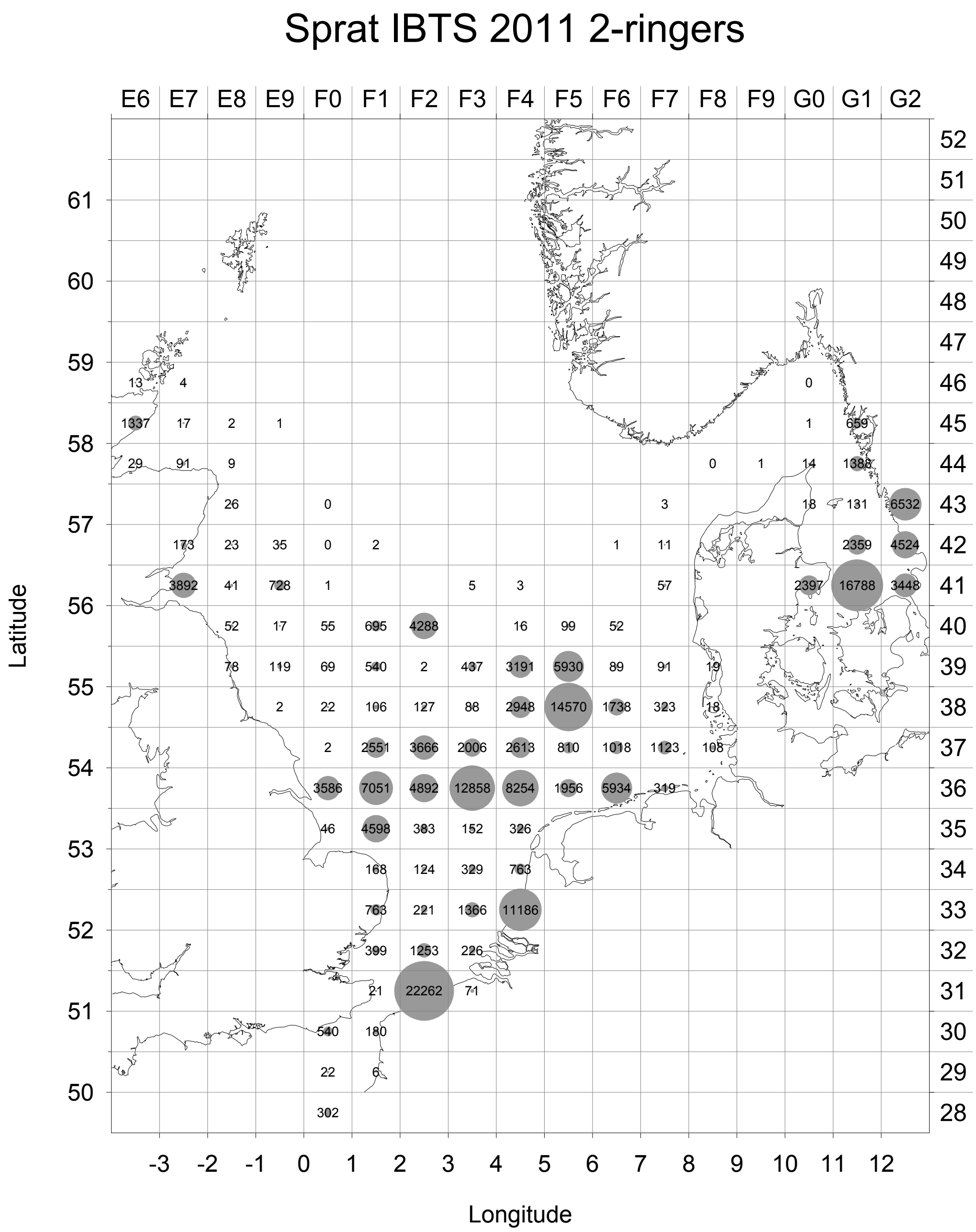


Figure 8.3.1b Distribution of 2-ringers in the IBTS (February) 2011 in the North Sea and Division IIIa (Mean number per hour per rectangle).

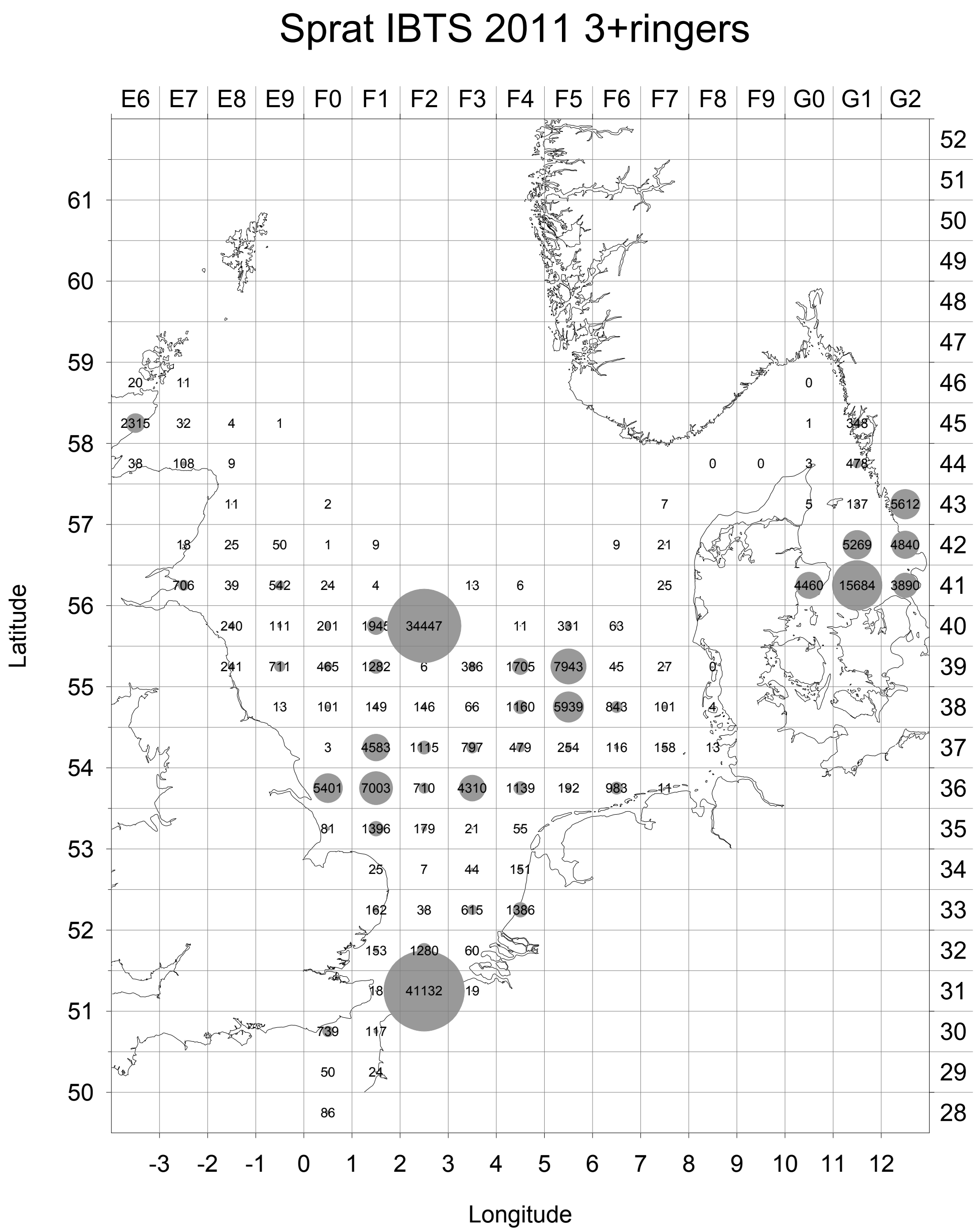


Figure 8.3.1c **Distribution of 3+-ringers in the IBTS (February) 2011 in the North Sea and Division IIIa (Mean number per hour per rectangle).**

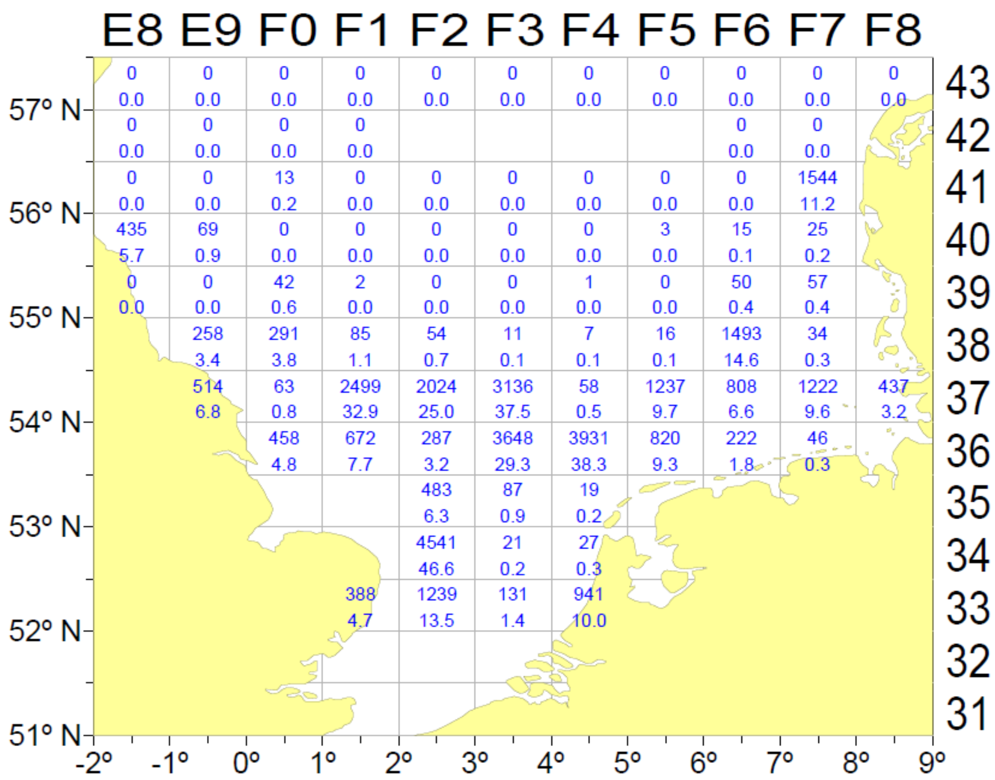


Figure 8.3.2 North Sea Sprat. Abundance (upper figure in each rectangle, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the herring acoustic survey (HERAS) 2010. Blank rectangles were not covered.

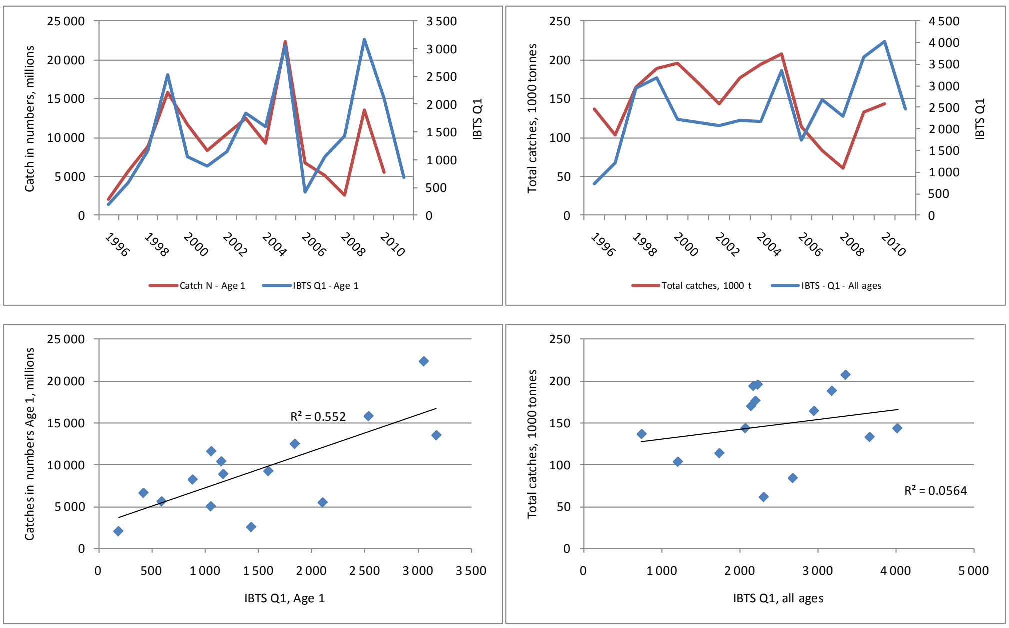


Figure 8.6.1 North Sea Sprat. Data exploration of the IBTS and catch time series. Annual landings (in numbers) of 1-year-olds and the IBTS index of one-year-olds in 1st quarter and their regression ($R^2 = 0.552$), left side plots. Total annual landings (in 1000 t) and the IBTS index of all age classes in 1st quarter and their regression ($R^2 = 0.0564$), right side plots.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ICES advice applicable for 2010 and 2011

The ACOM advice on sprat management is that exploitation of sprat will be limited by the restrictions imposed on fisheries for juvenile herring. This is a result of sprat being fished mainly together with juvenile herring. The sprat fishery is controlled by a herring by-catch quota as well as by-catch percentage limits (Norway and Denmark: respectively max 10% and 20% by-catch of herring in weight). No advice on sprat TAC has been given in recent years. In 2010, the TAC for sprat was set at 52 000 t and the by-catch quota for herring for the EU fleet at 7 515 t. For 2011, the TAC for sprat is set at 52 000 t and the by-catch quota for herring for the EU fleet, is set at 6 659 t.

9.1.2 Landings

The total landings increased from 9 200 t in 2009 to 10 706 t in 2010 (Table 9.1.1). The table presents the landings from 1996 onwards. The data prior to 1996 can be found in the HAWG report from 2006 (ICES 2006/ACFM:20).

There were sprat landings in all quarters (Table 9.1.2, see Figures 8.1.1–8.1.2). In 2010 nearly 80% of the total landings were taken in the 3rd and 4th quarter. In the Norwegian fishery sprat were, as before, taken in the 1st and 4th quarter, all as part of the fishery for canning production.

9.1.3 Fleets

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa.

The Danish sprat fishery consists of trawlers using 16 mm mesh size codend, and all landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches from the herring fishery using 32 mm mesh size codends. There is a Swedish fishery (mainly pelagic trawlers, but also a few purse seiners) directed at herring for human consumption, with by-catches of sprat.

The Norwegian sprat fishery in Division IIIa is a coastal / fjord purse seine fishery for human consumption.

9.1.4 Regulations and their effects

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa.

Most sprat catches are taken in a small-meshed industrial fishery where catches are limited by herring by-catch restrictions.

9.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns for the sprat fisheries in IIIa have been reported for 2010.

9.2 Biological Composition of the Catch

9.2.1 Catches in number and weight-at-age

The total numbers of sprat landed in 2010 was at the same level as in the last four years (Table 9.2.1). In 2009 the 1-year-olds dominated the landings (in numbers) by contributing to about 80% of the total number, whereas the distribution was more evenly spread among the age classes in 2010: 1-year-olds contributed about 40%, 2-year-olds about 35%, and 3-year-olds about 15%.

Mean weight-at-age (g) in the catches are presented by quarter in Table 9.2.2. Mean-weight-at-age for all ages is in the same order as the previous years, except for 2007 where the mean weight-at-age for 2-and 3-years old were at their largest in the last years. As in 2009, the mean catch weight-at-age obtained from 2nd quarter show smaller values than expected. Mean weights-at-age for 1996-2003 are presented in ICES CM 2005/ACFM:16. Denmark provided biological samples from all quarters, Norway from the 1st and 4th, and Sweden from the 4th quarter. Landings in 2010, for which no samples were collected, were raised using a combination of Swedish, Danish and Norwegian 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 2010/SSGESST:03).

In 2010 sprat was observed in both the Kattegat (ICES squares 41G1-G2, 42G0-G2, 43G0-G1 and 44G1) and in Skagerrak area (43F8-F9, 44F8-F9). The total abundance was estimated to be 1 556 million individuals, a 30% decrease compared to 2 233 million sprat in 2009.

The IBTS (February) sprat indices for 1984-2011 are presented in Table 9.3.1. The preliminary total IBTS index for 2011 increased by 300% compared to the 2010 index. The abundance index for the 1-group was the lowest since 1998, whereas the index for the 5+-group was highest since 1984.

9.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2010 summer acoustic survey are presented in Table 4.2.3 in the WGIPS report (ICES CM 2011/SSGESST:02). HAWG 2010 considered the results on age and maturity distribution from the 2009 Acoustic survey (HERAS) in Division IIIa (Kattegat) as questionable, because of the unexpected and high proportion of 3-year-olds and 4-year-olds defined as immature (80% and 65%, respectively). The 2009 results were revised by WGIPS 2011 (ICES CM 2011/SSGESST:02) such that all the 3+ fish in HERAS 2009 were in the revision considered mature.

9.5 Recruitment

For this stock, the IBTS index for 1-group sprat in the first quarter is the only available recruitment index (Table 9.3.1). The 1-group index for 2011 is the second lowest for the period, making less than 2% of the total index. In 2010 the 1-group index contributed 15% of the total index. The procedure for the survey did not differ from previous years. However, the index does not fully reflect the strong and weak cohorts seen in the catch. This has also been expressed in a previous working group report (ICES 1998/ACFM:14), and may be linked to difficulties in age determination and/or methodological issues related to the way the indices are estimated (see 3.1.7). This was also shown by the WKSHORT (ICES CM 2009/ACOM:34) for sprat in the North Sea.

9.6 Stock Assessment

9.6.1 Data exploration

The IBTS and the catch data series were explored in order to find out whether they could provide some information about the exploitation level of the sprat stock (see section 8.6.1. in this report for details of this analysis).

The 1st quarter IBTS index for 1-year-olds appears to have rather similar pattern with the annual catch numbers of 1-year-olds, and a regression analysis suggests a relatively high correlation between these two time series (Figure 9.6.1). The correspondence of the total IBTS index for all age classes and total annual catch biomass is much poorer, and the correlation coefficient is low (Figure 9.6.1).

9.6.2 Stock Assessment

No assessment of IIIa sprat was made.

9.6.3 State of the Stock

No assessment of the sprat stock in Division IIIa has been presented since the mid-1980ies. Various methods have been explored without success (ICES CM 2007/ACFM:11).

9.7 Short term projections

No assessment is presented for this stock.

9.8 Reference Points

No precautionary reference points are defined for this stock.

9.9 Quality of the Assessment

See above.

9.10 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. In the last years the sprat fisheries has not been limited by the sprat quota, since this quota has not been taken.

9.11 Ecosystem Considerations

No information of the ecosystem and the accompanying considerations are known at present. In the adjacent North Sea, multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no data available on the total amount of sprat taken by seabirds in the IIIa area (Tycho Anker-Nilssen, pers. communication, ICES WGSE). Many of the plankton feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout). The implications for sprat in IIIa are at present unknown.

9.12 Changes in the environment

Temperatures in the Skagerrak area have increased over the last few years. In the North Sea a shift in species composition and biomass of zooplankton have been observed. This has reduced the availability of food sources for some species (cod, sandeel). There are no indications of systematic changes in growth or age at maturity in sprat in the North Sea or in Division IIIa.

Table 9.1.1 Division IIIa sprat. Landings in ('000 t) 1996-2010.
(Data provided by Working Group members). These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

	Skagerrak				Kattegat			Div. IIIa total
	Denmark	Sweden	Norway	Total	Denmark	Sweden	**Total**	
1996	7.0	3.5	1.0	11.5	3.4	3.1	6.5	18.0
1997	7.0	3.1	0.4	10.5	4.6	0.7	5.3	15.8
1998	3.9	5.2	1.0	10.1	7.3	1.0	8.3	18.4
1999	6.8	6.4	0.2	13.4	10.4	2.9	13.3	26.7
2000	5.1	4.3	0.9	10.3	7.7	2.1	9.8	20.1
2001	5.2	4.5	1.4	11.2	14.9	3.0	18.0	29.1
2002	3.5	2.8	*	6.3	9.9	1.4	11.4	17.7
2003	2.3	2.4	0.8	5.6	7.9	3.1	10.9	16.5
2004	6.2	4.5	1.1	11.8	8.2	2.0	10.2	22.0
2005	12.1	5.7	0.7	18.5	19.8	2.1	21.8	40.3
2006	1.2	2.8	0.3	4.3	6.6	1.6	8.2	12.5
2007	1.4	2.8	1.6	5.9	8.5	1.3	9.8	15.7
2008	0.3	1.5	0.9	2.6	5.6	0.9	6.5	9.1
2009	1.1	1.4	0.7	3.2	5.8	0.2	6.0	9.2
2010	3.4	1.2	0.9	5.4	5.0	0.2	5.3	10.7

* < 50 t

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter by countries, 2000-2010. Data for 1996-1999 in ICES CM 2007/ACFM:11 (Data provided by the Working Group members)

	Quarter	Denmark	Norway	Sweden	Total
2000	1	4.10	0.10	2.32	6.52
	2			1.85	1.85
	3	4.80	0.10		4.90
	4	3.80	0.70	2.26	6.76
	Total	12.70	0.90	6.43	20.03
2001	1	2.53		2.63	5.17
	2	6.55		0.11	6.67
	3	10.16		0.06	10.22
	4	0.90	1.40	4.75	7.05
	Total	20.15	1.40	7.56	29.11
2002	1	3.80		1.42	5.22
	2	2.06		0.37	2.43
	3	5.90		0.07	5.97
	4	1.68		2.41	4.09
	Total	13.45		4.26	17.70
2003	1	3.54	0.10	1.67	5.30
	2	0.59		0.80	1.40
	3	1.00		0.72	1.72
	4	5.04	0.80	2.31	8.13
	Total	10.18	0.80	5.50	16.54
2004	1	3.11		1.35	4.46
	2	0.64		0.87	1.51
	3	3.70		0.44	4.14
	4	6.94	1.10	3.83	11.88
	Total	14.39	1.10	6.49	21.98
2005	1	6.47		1.68	8.15
	2	4.65		0.07	4.72
	3	18.61	0.71	0.81	20.13
	4	2.13		5.17	7.30
	Total	31.86	0.71	7.73	40.30
2006	1	5.43	0.17	2.68	8.28
	2	0.17		0.16	0.32
	3	1.34		0.10	1.44
	4	0.88	0.13	1.46	2.46
	Total	7.82	0.30	4.39	12.51
2007	1	2.26	0.45	0.38	3.09
	2	0.70		0.59	1.29
	3	5.15	*	0.21	5.36
	4	1.79	1.16	2.98	5.92
	Total	9.90	1.60	4.16	15.66
2008	1	2.25	0.20	0.64	3.09
	2	0.67		0.35	1.02
	3	0.45		0.19	0.64
	4	2.46	0.70	1.21	4.37
	Total	5.83	0.90	2.39	9.12
2009	1	2.20	0.40	0.40	3.00
	2	0.30			0.30
	3	3.20		0.10	3.30
	4	1.20	0.24	1.20	2.64
	Total	6.90	0.64	1.70	9.24
2010	1	1.45	0.05	0.02	1.51
	2	0.64		0.01	0.65
	3	3.38		0.03	3.41
	4	2.93	0.86	1.35	5.14
	Total	8.39	1.50	1.40	10.71

* < 50 t

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 2004-2010. The landed numbers in 1996-2003 can be found in the ICES CM 2007/ACFM:11.

	Quarter	Age						Total
		0	1	2	3	4	5+	
2004	1		539.6	39.3	47.2	20.7	8.0	654.8
	2		36.7	22.3	44.9	11.8	1.1	116.8
	3	10.0	254.4	19.4	4.1	2.4		290.3
	4	874.0	366.8	33.0	24.9	3.4	0.3	1302.3
	Total	883.9	1197.5	113.9	121.1	38.3	9.3	2364.2
2005	1		1609.1	185.6	25.5	17.4	5.1	1842.7
	2		827.1	19.2	0.6			846.9
	3	1.8	1557.0	91.3	9.9	12.9		1672.9
	4	11.5	447.4	60.5	7.3	4.0	0.7	531.3
	Total	13.4	4440.6	356.6	43.3	34.2	5.8	4893.9
2006	1		219.8	433.3	93.7	16.6	10.3	773.7
	2		7.5	17.8	1.6	0.3		27.2
	3		9.4	55.8	13.7	2.8	1.3	83.1
	4	4.0	38.5	71.6	18.4	0.9	0.7	134.0
	Total	4.0	275.2	578.5	127.4	20.6	12.3	1018.0
2007	1		61.2	47.5	120.9	12.5	1.8	243.9
	2		26.1	17.8	53.5	4.9	0.5	102.9
	3		401.1	22.8	12.3	3.2		439.3
	4	33.4	248.6	57.0	50.5	6.6	1.1	397.1
	Total	33.4	737.0	145.1	237.2	27.2	3.4	1183.3
2008	1		3.1	127.1	41.0	36.7	15.0	222.8
	2		0.4	45.6	15.7	7.2	1.9	70.8
	3	71.5	33.4	2.7	1.0	0.8	1.1	110.5
	4	386.7	203.9	28.7	10.6	8.1	6.9	644.9
	Total	458.2	240.8	204.1	68.3	52.8	24.9	1049.0
2009	1		353.2	31.1	47.9	19.5	11.1	462.9
	2		70.4	3.1	1.0	2.2		76.8
	3		251.5	9.4	7.6	1.8		270.3
	4	11.8	120.1	25.3	11.7	3.6	3.2	175.7
	Total	11.8	795.3	68.9	68.1	27.2	14.4	985.7
2010	1		52.3	38.1	27.8	13.5	5.8	137.6
	2		21.9	39.6	6.5	0.8	0.1	68.9
	3	4.7	92.7	119.6	38.1	13.0	8.6	276.8
	4	13.2	140.6	79.4	46.2	24.3	13.0	316.7
	Total	17.9	307.5	276.8	118.7	51.5	27.5	799.9

Table 9.2.2. Division IIIa sprat. Quarterly mean weight-at-age (g) in the landings for the years 2004-2010. The equivalent data for 1996-2003 can be found in ICES CM 2007 /ACFM: 11. (Danish and Swedish data)

Year		Age					
	Quarter	0	1	2	3	4	5+
2004	1		4.6	14.6	17.8	17.3	17.3
	2		7.0	13.6	16.7	17.0	19.5
	3	3.0	14.1	16.7	20.0	21.4	
	4	3.5	16.8	19.9	22.2	20.9	28.0
Weighted mean		3.5	10.4	16.3	18.4	17.8	17.9
2005	1		3.0	14.6	16.3	20.3	21.1
	2		5.4	11.7	26.8		
	3	2.9	11.9	14.6	15.4	11.0	
	4	3.3	13.1	19.1	20.1	21.1	23.1
Weighted mean		5.0	7.6	15.4	17.1	17.2	21.5
2006	1		5.0	12.2	15.4	15.2	18.5
	2		7.0	13.3	16.3	22.0	
	3		11.2	17.4	20.3	18.6	22.8
	4	4.3	16.1	19.6	21.4	23.8	26.6
Weighted mean		4.3	6.8	13.6	16.8	16.1	19.4
2007	1		2.3	12.3	16.3	17.0	25.2
	2		6.1	17.1	20.6	21.9	20.4
	3		12.0	13.0	17.0	17.6	
	4	7.9	14.1	20.3	23.4	22.6	26.2
Weighted mean		7.9	11.5	15.9	18.4	19.3	25.2
2008	1		5.6	11.7	15.5	18.1	18.3
	2		8.0	12.5	17.1	19.3	22.2
	3	3.4	7.9	21.1	21.5	25.3	22.5
	4	3.4	9.2	20.7	21.4	25.2	22.8
Weighted mean		3.4	9.0	13.3	16.9	19.5	20.0
2009	1		3.9	11.5	14.7	17.4	21.4
	2		3.9	6.1	5.1	7.2	
	3		12.0	14.6	13.8	12.4	
	4	5.2	13.7	18.7	20.3	20.8	19.8
Weighted mean		5.2	8.0	14.3	15.5	16.7	21.1
2010	1		4.6	11.8	16.4	18.4	20.7
	2		8.3	9.8	10.4	14.9	16.7
	3	4.5	10.6	12.3	14.9	16.0	17.4
	4	6.2	16.2	15.8	17.5	18.7	20.3
Weighted mean		5.8	12.0	12.9	16.0	17.9	19.4

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2010.

Country	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged	Samples per 1000 t
Denmark	1	1 445	5	446	272	3
	2	636	4	450	280	6
	3	3 380	16	1 570	986	5
	4	2 930	8	678	303	3
	Total	8 391	33	3 144	1 841	4
Norway	1	50	1	100	50	20
	2					
	3					
	4	863	1	100	49	1
	Total	913	2	200	99	2
Sweden	1	17				
	2	12				
	3	25				
	4	1 348	11	550	550	8
	Total	1 402	11	550	550	8
Denmark		8 391	33	3 144	1 841	4
Norway		913	2	200	99	2
Sweden		1 402	11	550	550	8
	Total	10 706	46	3 894	2 490	4

Table 9.3.1. **Division IIIa sprat**. IBTS (February) indices of sprat per age group 1984-2011.

Year	No Rect	No hauls	Age Group					
			1	2	3	4	5+	Total
1984	15	38	5 675.45	868.88	205.10	79.08	63.57	6 892.08
1985	14	38	2 157.76	2 347.02	392.78	139.74	51.24	5 088.54
1986	15	38	628.64	1 979.24	2 034.98	144.19	37.53	4 824.58
1987	16	38	2 735.92	2 845.93	3 003.22	2 582.24	156.64	11 323.95
1988	13	38	914.47	5 262.55	1 485.07	2 088.05	453.13	10 203.26
1989	14	38	413.94	911.28	988.95	554.53	135.79	3 004.48
1990	15	38	481.02	223.89	64.93	61.11	45.69	876.65
1991	14	38	492.50	726.82	698.11	128.36	375.44	2 421.23
1992	16	38	5 993.64	598.71	263.97	202.90	76.04	7 135.25
1993	16	38	1 589.92	4 168.61	907.43	199.32	239.64	7 104.92
1994	16	38	1 788.86	715.84	1 050.87	312.65	70.11	3 938.32
1995	17	38	2 204.07	1 769.53	35.19	44.96	4.23	4 057.98
1996	15	38	199.30	5 515.42	692.78	111.98	173.75	6 693.23
1997	16	41	232.65	391.23	1 239.13	139.14	134.51	2 136.67
1998	15	39	72.25	1 585.22	619.76	1 617.71	521.52	4 416.46
1999	16	42	4 534.96	355.24	249.86	44.25	313.52	5 497.83
2000	16	41	292.32	737.80	59.69	51.79	23.21	1 164.80
2001	16	42	6 539.48	1 144.34	676.71	92.37	45.87	8 498.77
2002	16	42	1 180.52	1 035.71	89.96	58.85	12.93	2 377.96
2003	17	46	462.64	1 247.49	1 172.13	382.29	123.17	3 387.72
2004	16	41	402.87	49.00	156.62	86.57	27.48	722.54
2005	17	50	3 314.17	1 563.16	470.84	837.09	538.37	6 723.63
2006	17	45	1 323.59	11 855.76	1 753.92	299.05	159.23	15 391.55
2007	18	46	774.11	306.63	250.81	42.08	13.74	1 387.37
2008	17	46	150.85	982.68	132.54	228.48	107.70	1 602.26
2009	17	46	2 686.72	124.46	259.15	29.60	37.43	3 137.36
2010	17	45	218.66	618.49	151.69	354.14	157.65	1 500.62
2011*			135.55	2 887.27	1 472.91	721.10	839.95	6 056.77

* Preliminary

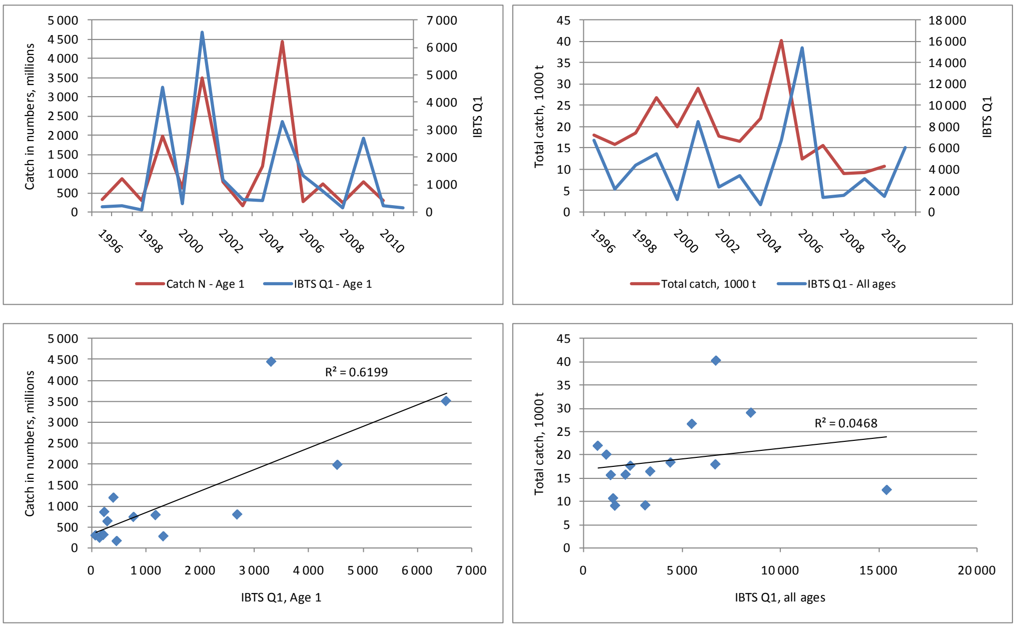


Figure 9.6.1 IIIa sprat. Data exploration of the IBTS and landings time series. Annual landings (in numbers) of 1-year-olds and the IBTS index of one-year-olds in 1st quarter and their regression (R^2 = 0.6199), left side plots. Total annual landings (in 1000 t) and the IBTS index of all age classes in 1st quarter and their regression (R^2 = 0.0468), right side plots.

10 Sprat in the Celtic Seas (Subareas VI and VII)

In 2011, ICES has been asked by the European Commission, for the first time, to provide advice on sprat. Most sprat fisheries are sporadic and occur in different places at different times. Separate fisheries have taken place in the Minch, and the Firth of Clyde (VIaN); in Donegal Bay (VIaS); Galway Bay and in the Shannon Estuary (VIIb); in various bays in VIIj; in VIIaS; in the Irish Sea and in the English Channel (VIIde). A map of these areas is provided in Figure 10.1.

The stock structure of sprat populations in this eco-region is not clear. In 2011, HAWG will work with the Stock Identification Methods Working Group to define stock units for sprat. In 2011, HAWG presents all available data on these sprat populations, in a single chapter. However HAWG does not necessarily advocate that VI and VII constitutes a management unit for sprat, and further work is required.

10.1 The Fishery

10.1.1 ICES advice applicable for 2009 and 2010

There is no ICES advice for sprat in the Celtic Seas ecoregion. The TAC for the English Channel (VIId, e) is the only one in place for sprat in this area.

10.1.2 Landings

The total sprat landings, by ICES subdivision (where available) are provided in Tables 10.1.1. – Table 10.1.6 and in Figures 10.2.1-10.2.10).

Division VIa (West of Scotland and Northwest of Ireland)

In all years landings have been dominated by UK-Scotland and Ireland (Table 10.1.1). The Scottish fisheries have taken place in both the Minch and in the Firth of Clyde. The Irish fishery has always been in Donegal Bay. Despite the wide separation of these areas, the trends in landings between the two countries are similar, though the Scottish data have always been higher.

Scottish landings were consistently above 4 000 t in the 1970s, declining to about 1 000 t in 1979. They fluctuated between 500 t and 4 000 t until 1994 and then increased markedly to over 8 000 t in 1999, after which they have declined to between 1 200 and 2 000 t.

Some Swedish landings in VI (unspecified) prior to 1985 were included in VIa.

Division VIIa (Irish Sea)

The main historic fishery was by Irish boats, in the 1970s, in the western Irish Sea (Table 10.1.2a). This was an industrial fishery and landings were high throughout the 1970s, peaking at over 8 000 t in 1978. The fishery came to an end in 1979, due to the closure of the fish meal factory in the area. It is not known what proportion of the catch was made up of juvenile herring, though the fishing grounds were in the known herring nursery areas. Irish Landings from 1950-1994 may be from VIIaN or VIIaS. Recent Irish landings are mainly from VIIaS, mainly Waterford Harbour (Table 10.1.2b).

In the late 1990s and early 2000s, UK vessels landed up to 500 t per year. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion.

Divisions VIIbc (West of Ireland)

Sporadic fisheries have taken place, mainly in Galway Bay and the Mouth of the Shannon. The highest recorded landing was in 1980 and 1981 during the winter of 1980/1981, when over 5 000 t were landed by Irish boats (Figure 10.2.4). This fishery took place in Galway Bay in the winter of 1980/1981 (Department of Fisheries and Forestry (1982). Since the early 1990s landings fluctuated from very low levels to no more than 700 t per year.

Divisions VIIg-k (Celtic Sea)

Sprat landings in the Celtic Sea from 1985 onwards are WG estimates. In the Celtic Sea Ireland has dominated landings. Patterns of Irish landings in Divisions VIIg and VIIj are similar, though the VIIj landings have been higher. Landings for VIIg and VIIj were aggregated in this report. Landings have increased from low levels in the early 1990s, with catches fluctuating between 0 t in 1993 and just under 4 200 t in 2005 (Table 10.1.6).

Divisions VIIde (English Channel)

Sprat landings prior to 1985 in VIId,e were extracted from FishBase, from 1985 onwards they are WG estimates. Since 1985 sprat catch has been taken mainly by UK, England and Wales, with some substantial catches taken by Denmark in the late 1980s (Figure 10.2.5). Early landings from Denmark are being looked into as there may be some discrepancies between FishBase and WG data.

The fishery starts in August and runs into the following year into February and sometimes March. Most of the catch is taken in VIId, where 88% on average of landed sprat are caught.

The UK has a history of taking the quota, but sprat is found by sonar search and sometimes the shoals are found too far offshore for sensible economic exploitation. Skippers then go back to other trawling activity. This offshore/ near shore shift may be related to environmental changes such as temperature and/ or salinity.

10.1.3 Fleets

Most sprat in the Celtic Seas ecoregions are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as pelagics. Targeted fishing takes place when there are known sprat abundances. However the availability of herring quota is a confounding factor in the timing of a sprat-targeted fishery.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown.

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type three under 15m vessels actively target sprat and are responsible for the majority of landings (since 2003 they took on average 94% of the total landings). Sprat is also caught by driftnet, fixed nets, lines and pots. Most of the landings are sold for human consumption.

In Ireland, larger sprats are sold for human consumption whilst smaller ones for fish meal. Other countries mainly land catches for industrial purposes.

10.1.4 Regulations and their effects

There is a TAC for sprat for VIId, e, English Channel. No other TACs or quotas for sprat exist in this eco-region. Most sprat catches are taken in a small-mesh fisheries for either human consumption or reduction to fish meal and oil. It is not clear whether regulations to prevent by-catch of herring are enforced.

10.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

10.2 Biological Composition of the Catch

10.2.1 Catches in number and weight-at-age

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

10.3 Fishery-independent information

Celtic Sea Acoustic Survey

The Irish Celtic Sea Herring Acoustic Survey has been used to calculate sprat biomass. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2010 are provided in Table 10.3.1. However, it is not clear that the survey results prior to 1997 are comparable because different survey designs were applied.

There was a gap in the time series before acoustic surveys in the Celtic Seas began again in 2002. Since 2004 the survey has taken place each October in the Celtic Sea.

Due to the lack of reliable 36 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large inter-annual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. In addition, it can be seen that for recent years, the highest biomasses are approximately 25% of those measured in the early 1990s.

Northern Ireland Groundfish Survey

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) groundfish survey of ICES Division VIIaN are carried out in March and October at standard stations between 53° 20′N and 54° 45′N (see Annex 8 for more detail on the survey). Sprat is routinely caught in the groundfish surveys however, data were not available at the time of submission of this report.

AFBI Acoustic Survey

The Agri-Food and Biosciences Institute of Northern Ireland (AFBINI) carries out an annual acoustic survey in the Irish Sea each September (see Annex 8 for a description of the survey). While targeting herring, a sprat biomass is also calculated. The annual calculated biomass from 1998-2010 is shown in Figure 10.4. and Table 10.3.2. The biomass is estimated to have peaked in 2002 with 405 000 t and it has declined since then to just under 95 000t. Further work is required to investigate the utility of this survey for measuring sprat biomass in this area.

10.4 Mean weight-at-age and length-at-maturity

No data on mean weight at age or maturity at age in the catch are available.

10.5 Recruitment

The various ground fish surveys may provide an index of sprat recruitment in this ecoregion. However further work is required.

10.6 Stock Assessment

10.6.1 Data exploration

No data exploration of sprat from the Celtic Seas Ecoregion was made in 2011. An LPUE time-series for English Channel sprat based on mid-water trawlers data was examined (Figure 10.5). Concerns were expressed about considering LPUE as an index of abundance for a shoaling fish like sprat. The index that included searching time was considered potentially more appropriate as an indicator of stock trends. Increase in fishing technology over time should also be factored out.

No assessment of sprat from the Celtic Seas Ecoregion was made in 2011.

10.6.2 State of the Stock

No assessment of the sprat stock from the Celtic Seas Ecoregion was made in 2011.

10.7 Short term projections

No assessment is presented for this stock.

10.8 Reference Points

No precautionary reference points are defined for sprat populations in this region.

Molloy and Bhatnagar (1977) estimated $F_{0.1}$ separately for Irish Sea and Celtic Sea sprat populations. They concluded that the Celtic Sea population could withstand a higher F. The estimates of F0.1 were F = 0.5 and F= 0.8 for Irish Sea and Celtic Sea respectively (Molloy and Bhatnagar, 1977).

10.9 Quality of the Assessment

NA

10.10 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. Most management areas in this ecoregion do not have a quota for sprat. However, there is a quota in VIId e, English Channel, which was restrictive in recent years.

10.11 Ecosystem Considerations

In the North Sea Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no data available on the total amount of sprat taken by seabirds in this area.

The Celtic Sea is a feeding ground for several species of large baleen whales (O'Donnell et al, 2004-2009). These whales feed primarily on sprat and herring from September to February.

Table 10.1.1 Sprat in the Celtic Seas. Landings of sprat, 1985-2010 VIa

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	0	0	269	364	0	0	0	28	22	0	241	0	0
Faeroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	51	348	0	150	147	800	151	360	2350	39	0	269	1596
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	557	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	0	2	0	0	0	0	0	0	0	0	0	0	0
UK - Scotland	2946	520	582	3864	1146	813	1526	1555	2230	1491	4124	2418	5313
	3554	870	851	4378	1293	1613	1677	1943	4602	1530	4365	2687	6909

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	40	0	0	0	0	887	0	0	0	0	0	0	0
Faeroe Islands	0	0	0	0	0	0	0	252	0	0	0	0	0
France	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
Ireland	94	2533	3447	4	1333	1060	97	1134	601	333	892	104	332
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	0	310	0	98	0	0	0	13	0	0	0	0	0
UK - Scotland	2749	8160	4238	1294	2657	2593	1416	894	0	13.59	0.1	70	537
	2883	11003	7685	1396	3990	4540	1513	2293	601	346.6	892.1	174	869

Table 10.1.2a Sprat in the Celtic Seas. Landings of sprat, 1985-2010 VIIa (not specified).

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	668	1152	41	0	0	0	0	0	0	0	0	0	0
Isle of Man	0	1	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	20	6	0	4	1	0	3	0	0	0	30	0	2
UK - Scotland	0	0	0	6	0	0	0	0	0	0	0	0	0
	688	1159	41	10	1	0	3	0	0	0	30	0	2

VIIaN

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0
Isle of Man	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	3	146	371	269	306	592	134	591	563	0	2	0	0
UK - Scotland	0	0	0	3	0	0	0	0	0	0	0	0	0
	3	146	371	272	306	592	134	591	563	0	2	0	0

Table 10.1.2b Sprat in the Celtic Seas. Irish Landings of sprat, 1995-2009 from VIIaS

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Ireland	0	0	0	0	0	0	0	0	0	0	0	0	0

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ireland	7	25	123	7	0	3103	408	361	114	0	102	0	422

Table 10.1.3. Sprat in the Celtic Seas. Landings of sprat, 1985-2010 VIIbc.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	100	0	0	400	40	50	3	145	150	21	28
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	100	0	0	400	40	50	3	145	150	21	28

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	331	5	698	138	11	38	68	260	40	32	1	238	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	0	0	0	0	0	0	0	0	0	0	0	0	0
	331	5	698	138	11	38	68	260	40	32	1	238	0

Table 10.1.4 Sprat in the Celtic Seas. Landings of sprat, 1995-2010 VIIde.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	15	250	2529	2092	608	0	0	0	0	0	0	0
Faeroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0
France	14	0	23	2	10		0	35	2	1	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	3771	1163	2441	2944	1319	1508	2567	1790	1798	3177	1515	1789	1621
UK - Scotland	0	0	0	0	0	0	0	0	0	0	0	0	0
	3785	1178	2714	5475	3421	2116	2567	1825	1800	3178	1515	1789	1621

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0
Faeroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	18	0	0	0	0	0	0	0	0	0	3
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	1	1	0	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	2024	3559	1692	1349	1196	1377	836	1635	1974	1819	3366	2765	4404
UK - Scotland	0	0	0	0	0	0	0	0	0	0	0	0	0
	2024	3560	1711	1349	1196	1377	836	1635	1974	1819	3366	2765	4407

Table 10.1.5 Sprat in the Celtic Seas. Landings of sprat, 1985-2010 VIIf.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Netherlands	273	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	0	0	0	0	0	0	1	0	0	2	0	0	0
Un. Sov. Soc. Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0
	273	0	0	0	0	0	1	0	0	2	0	0	0

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	51	0	0	0	0	0	0	0	0	2	0	1	7
Un. Sov. Soc. Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0
	51	0	0	0	0	0	0	0	0	2	0	1	7

Table 10.1.6 Sprat in the Celtic Seas. Landings of sprat, 1985-2010 VIIg-k.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Denmark	0	538	0	0	0	0	0	0	0	0	250	0	0
France	0	0	1	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	3245	3032	2089	703	1016	125	14	98	0	48	649	3924	461
Netherlands	0	0	0	1	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng+Wales+N.Irl.	0	2	0	0	0	0	0	0	0	0	0	0	6
	3245	3572	2090	704	1016	125	14	98	0	48	899	3924	467

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	1146	3263	1764	306	385	747	3523	4173	768	3380	1358	3431	2436
Netherlands	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	1	0	0	0
UK - Eng+Wales+N.Irl.	0	0	0	0	0	0	0	0	0	0	0	0	0
	1146	3263	1764	306	385	747	3523	4173	768	3381	1358	3431	2436

Table 10.1.7 Sprat in the Celtic Seas. Landings of sprat, 1985-2010 Total Landings, Division VI, VII.

Country	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	553	519	2893	2092	608	0	28	22	0	491	0	0
Faeroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0
France	14	0	24	2	10	79	0	35	3	1	0	2	1
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	3964	4532	2230	853	1163	1325	205	508	2353	232	799	4214	2085
Isle of Man	0	1	0	0	0	0	0	0	0	0	0	0	0
Netherlands	273	0	0	2	0	0	0	0	0	0	0	0	0
Norway	557	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - England & Wales	3791	1173	2441	2948	1521	1562	2571	1791	1798	3178	1546	1789	1629
UK - Scotland	2946	520	582	3870	1146	813	1526	1555	2230	1531	4124	2350	5313
Un. Sov. Soc. Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0
	11545	6779	5796	10568	5932	4387	4302	3917	6406	4942	6960	8355	9028

Country	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Belgium	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	40	0	0	0	0	887	0	0	0	0	0	0	0
Faeroe Islands	0	0	0	0	0	0	0	252	0	0	0	0	0
France	0	0	1	0	0	2	6	0	7	0	0	2	3
Germany	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	1578	5826	6032	455	1729	4948	4096	5928	1523	3745	2353	3773	3189
Isle of Man	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	1	1	0	0	72	0	0	0	0	0	0	0
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	0	0	0	1	0	0	0
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0
UK - Eng&Wales+N. Irl.	2027	4014	2064	1716	1502	1960	970	2239	2532	2708	3369	2774	4411
UK - Scotland	3467	8161	4238	1297	2657	2593	1416	0	0	14	0	70	537
Un. Sov. Soc. Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0
	7112	18002	12336	3468	5888	10462	6488	8419	4062	6468	5722	6619	8140

Table 10.3.1. Sprat in the Celtic Seas. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2010, from Irish Celtic Sea Herring Acoustic Survey.

		Abundance (millions)						Biomass (tonnes)					
Date	Code	Definitely	Probably	Mixture	Total Est.	Possibly	Est. incl. poss.	Definitely	Probably	Mixture	Total Est.	Possibly	Est. incl. poss.
Nov/Dec-91	294[1]										36880		36880
Jan-92	294[1]										15420		15420
Jan-92	294[1]										5150		5150
Nov-92	295[2]										27320		27320
Jan-93	295[2]										18420		18420
Nov-93	299[3]										95870		95870
Jan-94	299[3]										8035		8035
Nov-95	304										75440		75440
Sep/Oct-02	316							12700	900	7000	20600		20600
Oct/Nov 03	317							0	361	1034	1395		1395
Nov/Dec 04	318	552	1000	67	1619	395	2014	4594	659	9422	14675	3392	18067
Oct-05	510	900	0	1671	2571	0	2571	8882	0	20137	29019	0	29019
Oct-07	791	97	0	35	132			1549	0	369	1918		1918
Oct-06	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Oct-08	792	93	0	447	540			690	0	4803	5493		5493
Oct-09	n/a	497	0	921	1418			4530	0	11699	16229		16229
Oct-10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Footnotes:

Three separate acoustic surveys. The first survey was from 27/11/91 to 4/12/91 and covered the area from Carnsore Point to the Aran Islands. The second was from 16/1/92 to 20/1/92 covered the area from Carnsore Point to Dingle Bay. The third was from 22/1/92 to 27/1/92 and covered the area from Galley Head to the Saltee Islands.

Two separate acoustic surveys. The first survey was from 2/11/92 to 12/11/92 and covered the area from Carnsore Point to Loop Head. The second was from 18/1/93 to 30/1/93 and covered the area from Bantry Bay to Carnsore Point.

Two separate acoustic surveys. The first survey was from 2/11/93 to 12/11/93 and covered the area from Loop Head to Carnsore Point. The second was from 16/1/94 to 26/1/94 and covered the area from Old Head of Kinsale to Carnsore Point.

Table 10.3.2. Sprat in the Celtic Seas. Annual sprat biomass in ICES subdivision VIIa (Source: AFBINI annual herring acoustic survey).

	Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Biomass	228,000	272,200	234,700	299,700	413,900	265,900	281,000	141,900	143,200	204,700	252,300	175,200	107,400
	CV	0.11	0.1	0.11	0.08	0.09	0.1	0.07	0.1	0.09	0.09	0.12	0.08	0.1
Sprat and 0-group herring	% sprat	97	98	94	99	98	95	96	96	87	91	83	78	87
	Sprat Biomass	221160	266756	220618	296703	405622	252605	269760	136224	124584	186277	209409	136656	93438

Figure 10.1. Sprat in the Celtic Seas. Map showing areas mentioned in the text.

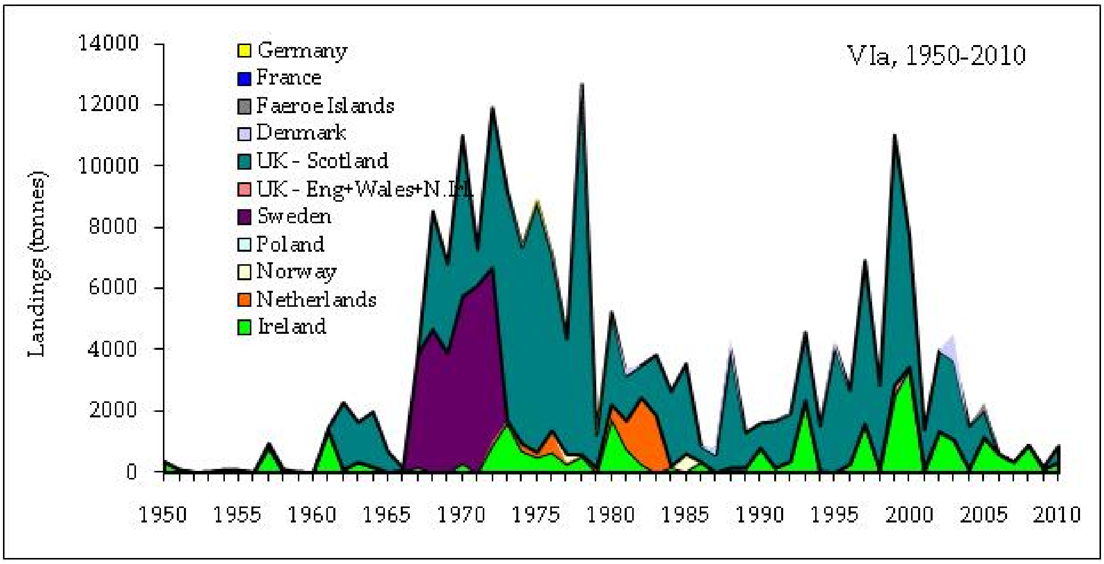


Figure 10.2.1. Sprat in the Celtic Seas. Landings of sprat 1950-2010 ICES Subdivision VIa.

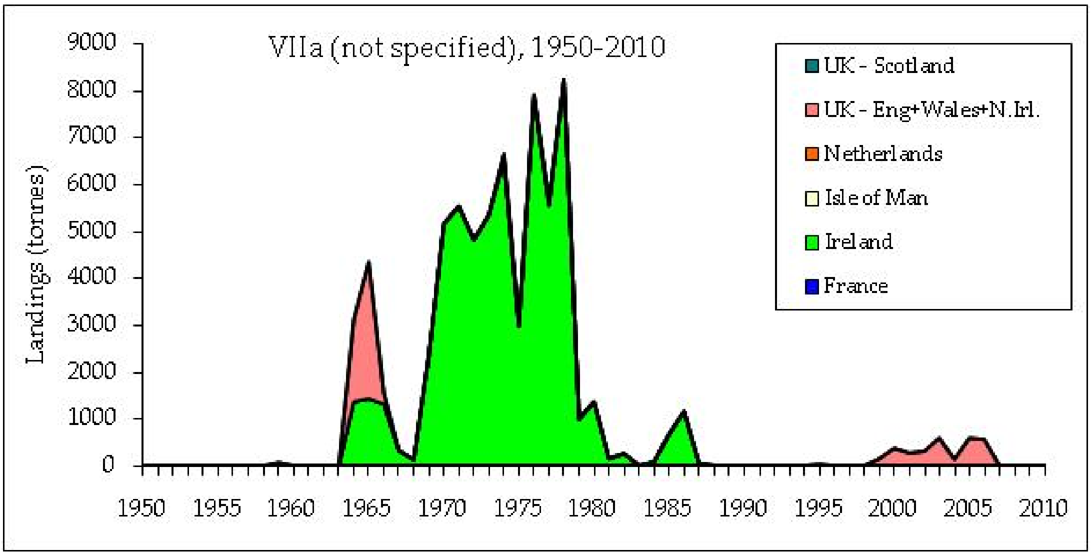


Figure 10.2.2. Sprat in the Celtic Seas. Landings of sprat 1950-2010 ICES Subdivision VIIaN. Note: Southern Irish landings from 1973-1995 may be from VIIaN or VIIaS.

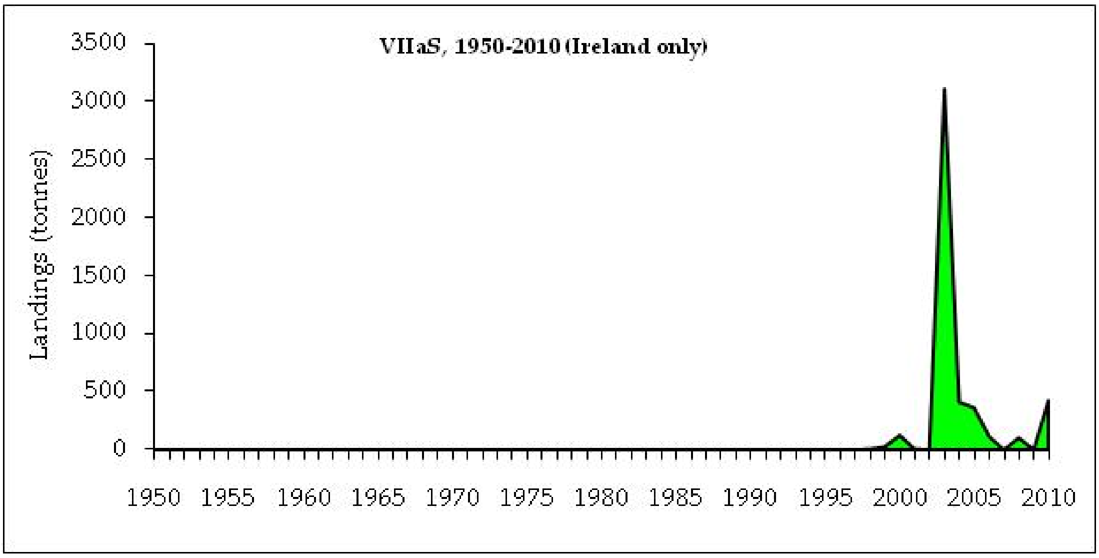


Figure 10.2.3. Sprat in the Celtic Seas. Landings of sprat 1950-2010 ICES Subdivision VIIaS.

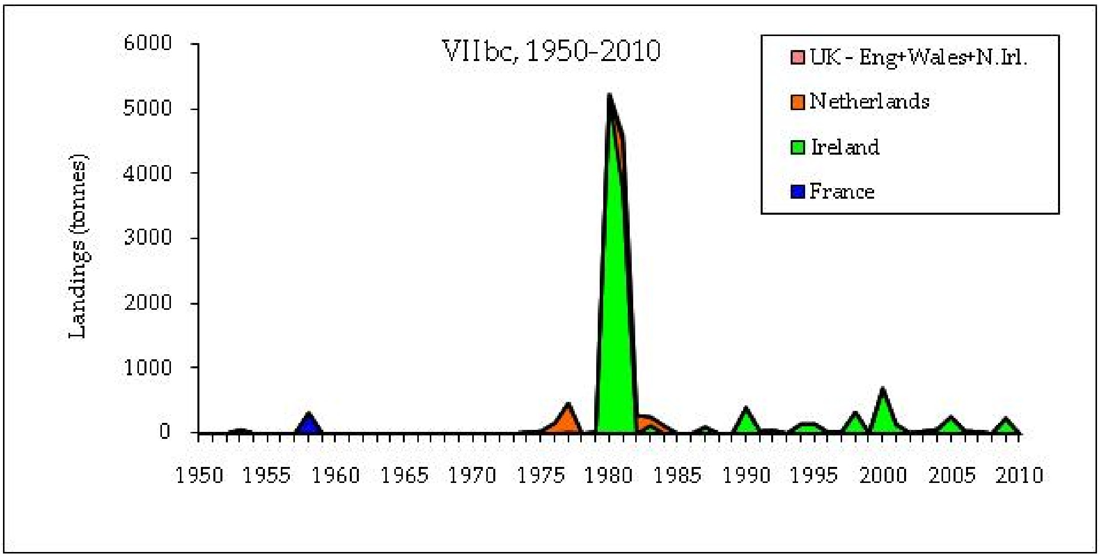


Figure 10.2.4. Sprat in the Celtic Seas Landings of sprat 1950-2010 ICES Subdivisions VIIbc.

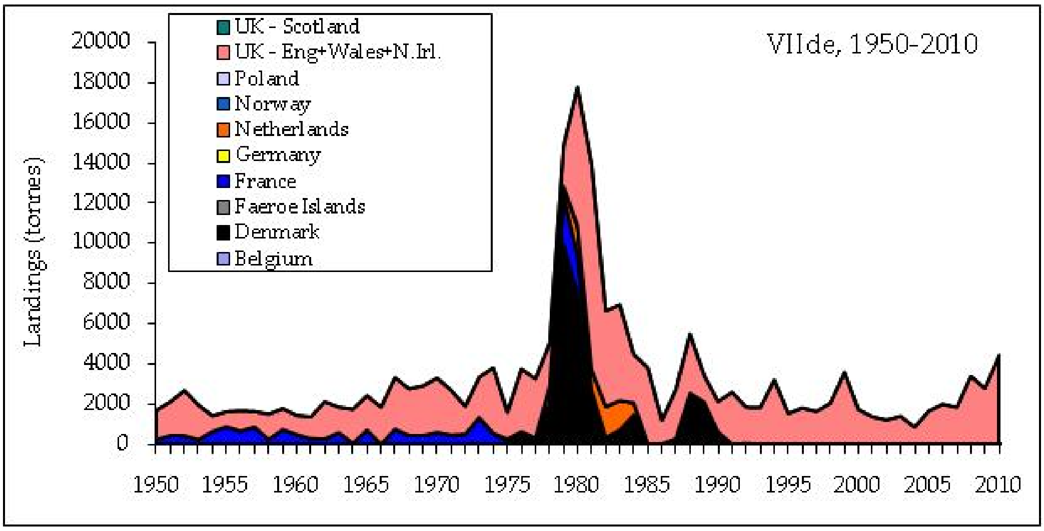


Figure 10.2.5. Sprat in the Celtic Seas. Landings of sprat 1950-2010 ICES Subdivisions VIIde.

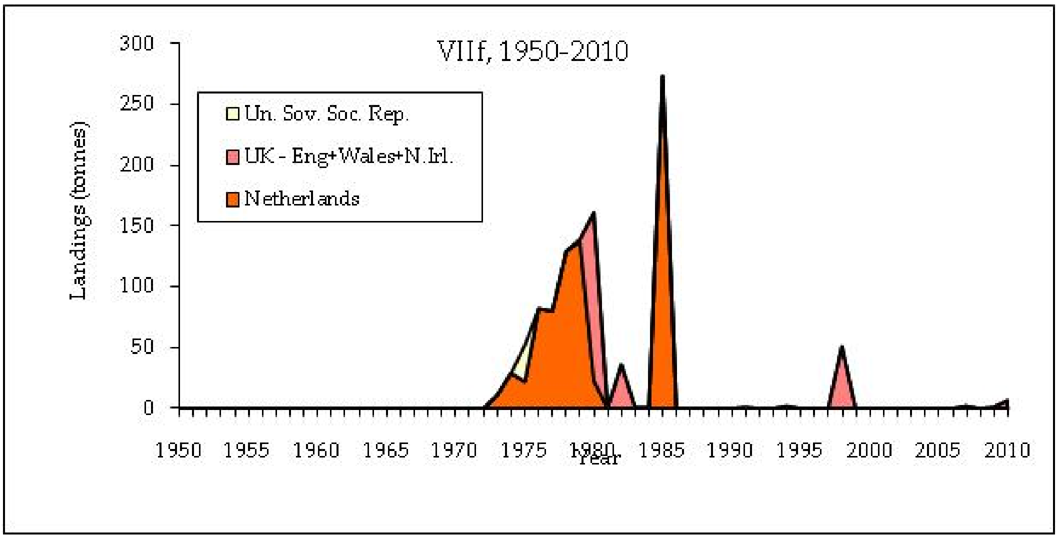


Figure 10.2.6. Sprat in the Celtic Seas. Landings of sprat 1950-2010 ICES Subdivision VIIf.

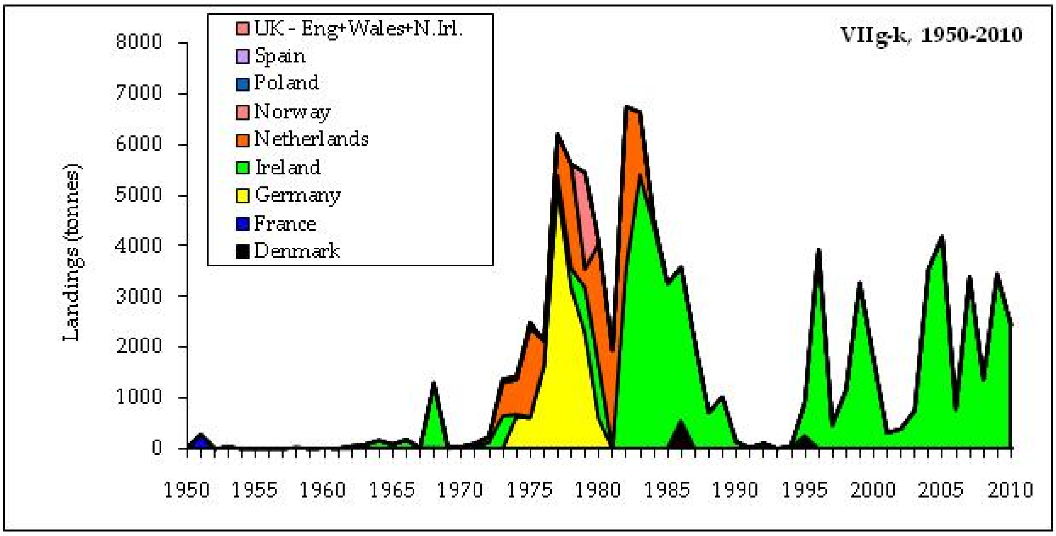


Figure 10.2.7. Sprat in the Celtic Seas Landings of sprat 1950-2010 ICES Subdivisions VIIg-k.

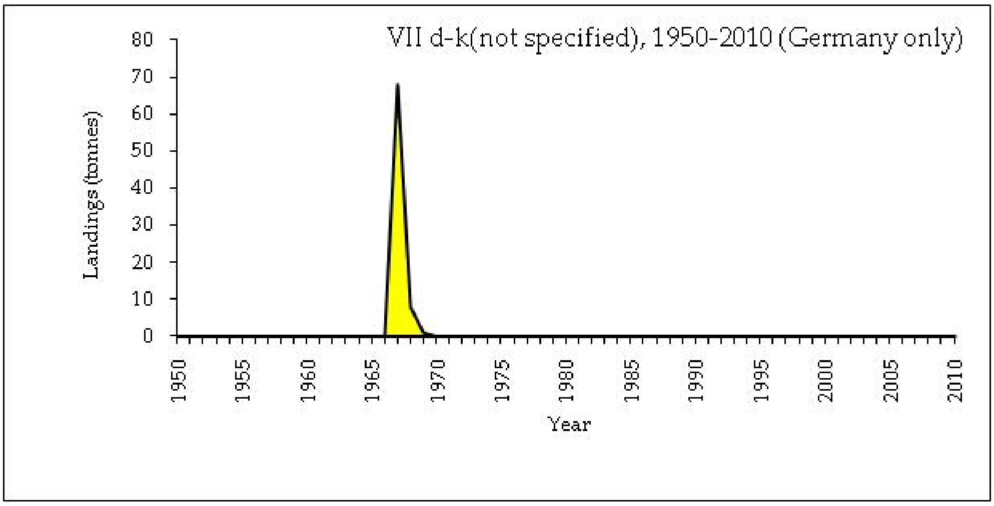


Figure 10.2.8. Sprat in the Celtic Seas Landings of sprat 1950-2010 ICES Subdivisions VIId-k (not specified).

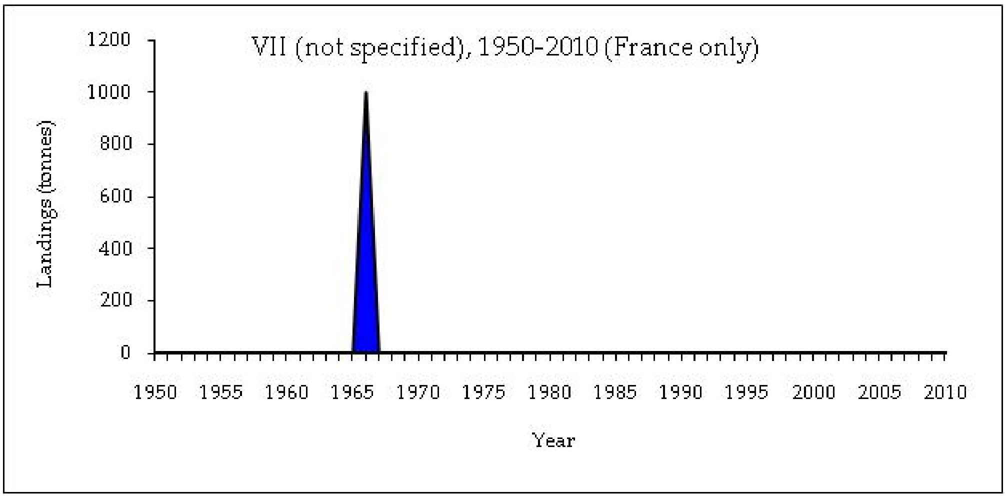


Figure 10.2.9. Sprat in the Celtic Seas Landings of sprat 1950-2010 ICES Subdivisions VII (not specified).

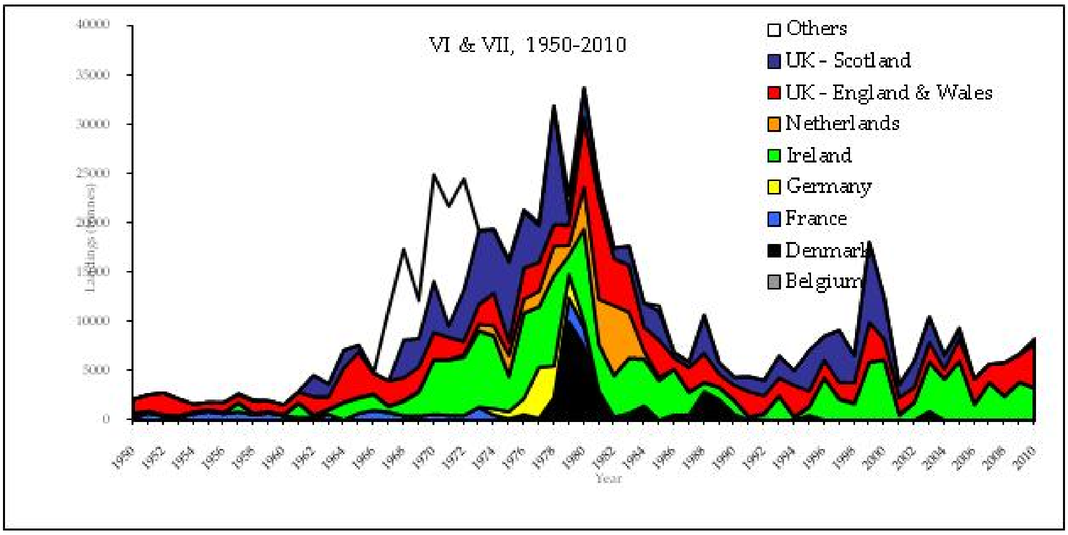


Figure 10.2.10. Sprat in the Celtic Seas Landings of sprat 1950-2010 ICES Divisions VI and VII (Celtic Seas Ecoregion).

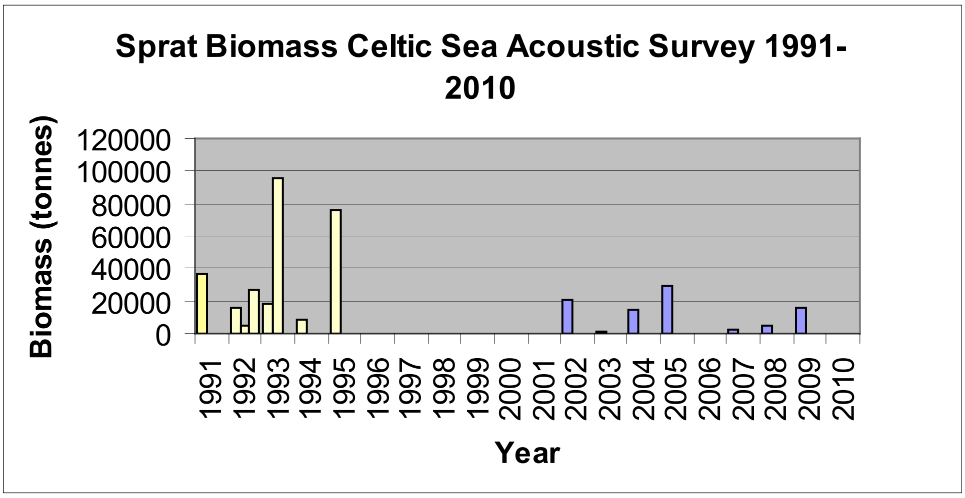


Figure 10.3. Sprat in the Celtic Seas. Annual sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey).

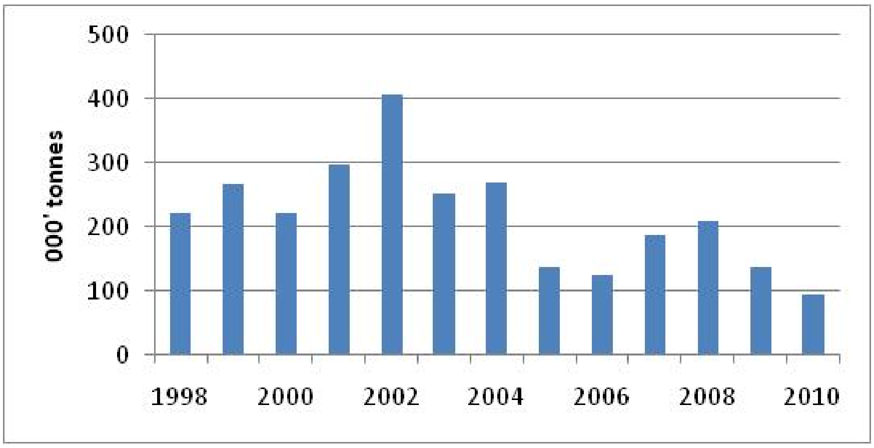


Figure 10.4. Sprat in the Celtic Seas. Annual sprat biomass in ICES subdivision VIIa (Source: AFBINI annual herring acoustic survey).

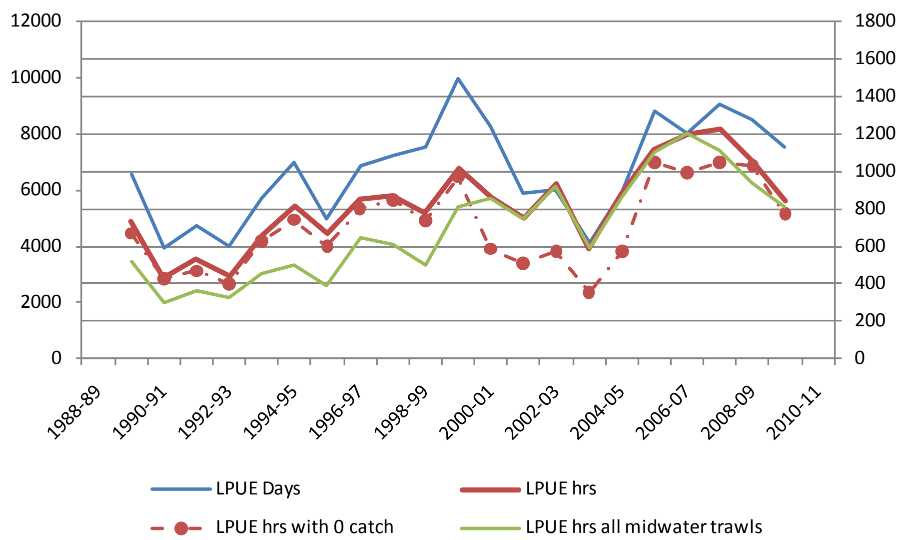


Figure 10.5. Sprat in the Celtic Seas. VIIe d. Landing per unit of effort (LPUE) for main mid-water trawlers as positive landings of sprat (in days left axis and hours right axis), including effort linked to zero landings (in hours) and for all mid-water trawls (in hours).

11 Stocks with limited data

Three herring stocks have very little data associated with them and have been poorly described in recent reports. These are Clyde herring, part of Division VIaN (Section 5.11 in ICES 2005a), herring in VII ,f and herring in the Bay of Biscay (Subarea VIII). In this section only the times series of landings are maintained.

There was no sampling of the catch in 2010 for Clyde herring. The catch of Clyde herring, overestimated in 2009 was updated at this HAWG meeting and set up below the agreed TAC (Table 11.1). In 2010, the catch was 301 tonnes, lower than the agreed TAC of 720 tonnes .

Figure 11.1 shows time series of landings over the period 1950-2010 in VIIe and VIIf. Data before 2005 were taken from the FISHSTAT database, and may be of poor quality. Data for later years were adjusted, where possible, with data supplied by working group members. It can be seen that there was a pulse of landings in VIIf in the late 1970s, with landings since being very low in comparison. There was a pulse of landings in VIIe in the early 1980s. Since then landings have fluctuated between 150 and 900 t in recent years, without any obvious trend (Table 11.2).

In the Bay of Biscay, French landings peaked at 1 700 t in 1976, declining gradually to very low levels by the late 1980s. More recently there was a sudden peak pulse of Dutch landings of 8 000 t in 2002, declining to low levels since (Figure 11.2, Table 11.3). Data before 2005 were taken from the FISHSTAT database, and may be of poor quality. Data for later years were adjusted, where possible, with data supplied by working group members.

Table 11.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1955–2010. 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**	**1982**
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	4 021

Year	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**
Scotland	2 530	2 991	3 001	3 395	2 895	1 568	2 135	2 184	713	929	852	608	392	598
Other UK	273	247	22	-	-	-	-	-	-	-	1	-	194	127
Unallocated[1]	293	224	433	576	278	110	208	75	18	-	-	-	-	-
Discards	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	1 000
Total		4 361	5 770	4 800	4 650	3 612	1 923	2 343	2 259	731	929	853	608	725

Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Scotland	371	779	16	1	78	46	88	-	-	+	163	54	266	-
Other UK	475	310	240	0	392	335	240	-	318	512	458	622	488	301
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	800	800	800	720
Total	846	1089	256	1	480	381	328	0	318	512	621	676	754	301

[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 11.2. Stocks with limited data. Landings of herring in Divisions VIIe and VIIf. Source: ICES FISHSTAT and National Database from 2005 to 2010.

Division	Country	2003	2004	2005	2006	2007	2008	2009	2010
VIIe	UK (Eng,Wal,NI,Scot,Guer	315	199	66	189	106	78	136	185
VIIe	Denmark	-	-	-	-	.	.	-	0
VIIe	France	497	496	516	516	502	499	489	493
VIIe	Germany, Fed. Rep. of	.	.	.	.	.	.	-	0
VIIe	Netherlands	-	-	440	-	-	433	-	2
VIIe	Poland	-	-	-	-	-	.	-	0
	Total	812	695	1 022	705	608	1 010	625	678

Division	Country	2003	2004	2005	2006	2007	2008	2009	2010
VIIf	UK (Eng, Wal, Scot, NI)	21	47	198	76	115	29	8	23
VIIf	Belgium	-	-	-	-	-	-	-	0
VIIf	France	-	-	-	-	.	.	-	0
VIIf	Netherlands	-	-	-	-	-	-	-	0
VIIf	Poland	-	-	-	.	.	.	-	0
VIIf	USSR	.	.	.	.	.	.	-	0
	Total	21	47	198	76	115	29	8	23

Table 11.3. Stocks with limited data. Landings of herring in Sub-area VIII.

Country	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
France	80	48	81	43	15	14	6	12	12	8	36
Netherlands	0	0	7575	1425	1396	0	0	0	0	0	402
Norway	-	-	-	-	-	-	.	.	.	-	0
Portugal	-	-	-	-	-	-	-	.	.	-	0
Spain	232	232	266	197	0	50	214	120	131	-	0
UK	0	0	0	0	0	0	0	0	0	-	0
USSR	.	.	.	.	.	.	.	.	.	-	0
	312	280	7922	1665	1411	64	220	132	143	8	438

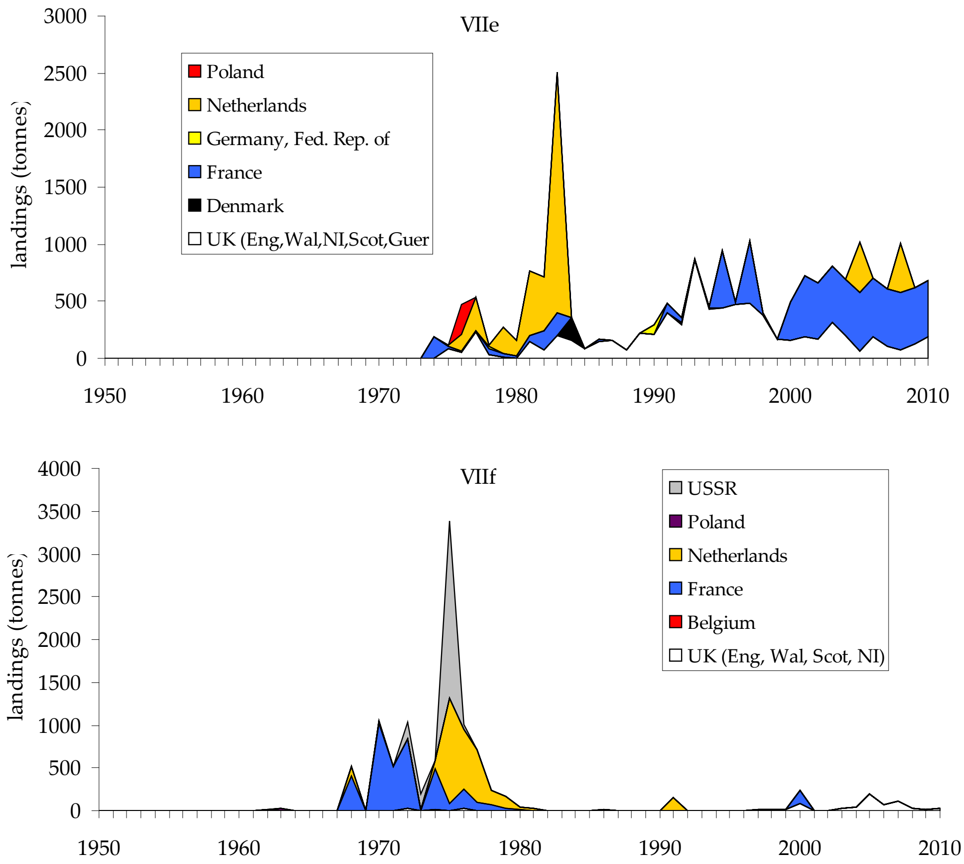


Figure 11.1. Stocks with limited data. Landings over time of herring in Divisions VIIe and VIIf.

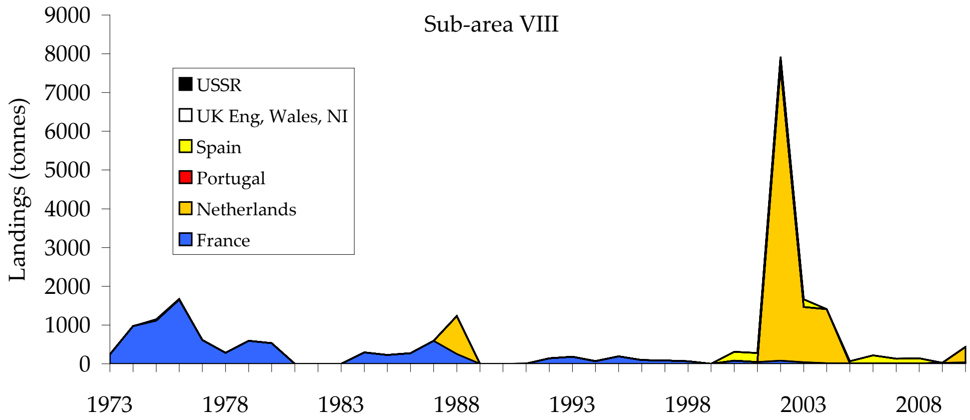


Figure 11.2. Stocks with limited data. Landings over time of herring in Sub-area VIII.

12 Working documents.

WD01. T.Gröhsler. Fisheries & Stock assessment data in the Western Baltic 2010

WD02. T. Gröhsler, R. Oeberst, M. Schaber. Mixing of two herring (*Clupea harengus*) stocks in ICES Subdivision 24 (Arkona Sea, Western Baltic) – Implications and consequences for stock assessment.

WD03. Aloysius T.M., van Helmond and Harriët M.J. van Overzee. IMARES, Wageningen UR. Estimates of discarded herring by Dutch flagged vessels 2003_2010

WD04. Sascha M.M. Fässler, Mark R. Payne, Thomas Brunel, Mark Dickey-Collas. Does larval mortality influence population dynamics? An analysis of North Sea herring time series.

WD05. A.J. Geffen, Department of Biology, University of Bergen, Norway.Characterisation of herring populations to the west of the British Isles: an investigation of mixing based on otolith microchemistry.

WD06. Christine Rockmann, Mark Dickey-Collas, Mark R. Payne and Ralf van Hal Realized habitats of early-stage North Sea herring: looking for signals of environmental change. ICES Journal of Marine Science (2011), 68(3), 537–546. doi:10.1093/icesjms/fsq171.

WD07. Mark R. Payne Mind the gaps: a state-space model for analysing the dynamics of North Sea herring spawning components.

WD08. Saunders, R.A., O'Donnell, C., and Reid, D. Marine Institute, Rinville, Oranmore, Galway, Ireland. Utility of 18 kHz-derived Atlantic herring (Clupea harengus) abundance estimates for assessment and management purposes

WD09. Maurice Clarke. Extension of VIaS VIIbc time series.

WD10. Norbert Rohlf and Joachim Gröger. Report of the herring larvae surveys in the North Sea in 2010/2011

WD11. Afra Egan and Maurice Clarke. The Development of a Long Term Management Plan for Celtic Sea Herring.

13 References

Aasen O, *et al.*, 1961 ICES herring tagging experiments in 1957 and 1958. Rapp.P.-V.Reun.Cons. Perm.Int.Explor.Mer., 152:43

Armstrong, M. J., Schön, P-J., Neville, S., Clarke, W., Peel, J., McAliskey, M., McCurdy, W., McCorriston, P., Briggs, R., Bloomfield, S. and Allen, M. 2005. Survey indices of abundance for herring in the Irish Sea (Area VIIaN):1992-2004. ICES WD23.

Bailey, R. S., and Steele, J. H. 1992. North Sea herring fluctuations. In: Climate Change, Climate Variability and Fisheries, pp. 213–230. Ed. by M. Glantz. Cambridge University Press, Cambridge.

Beaugrand, G. 2003. Long-term changes in copepod abundance and diversity in the north-east Atlantic in relation to fluctuations in the hydrodynamic environment. Fisheries Oceanography 12: 270-283

Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A., Edwards, M. 2002. Reorganization of North Atlantic Marine Copepod Biodiversity and Climate. Science, 296: 1692-1694.

Beggs, S., Schon, P.J., McCurdy, W, Peel., J., McCorriston, P., McCausland, I (2008). Seasonal origin of 1 ring+ herring in the Irish Sea (VIIaN) Management Area during the annual acoustic survey. Working Document to the herring assessment working group 2008.

Beggs, S., Allen, M. and Schön, P.-J. 2008. Stock Identification of 0-group Herring in the Irish Sea (VIIaN) using Otolith Microstructure and Shape Analysis. HAWG 2008 WD 08.

Berx, B., and Hughes, S.L. (2009) Climatology of surface and near bed temperature and salinity on the north-west European continental shelf for 1971–2000. Cont. Shelf Res. 29: 2286–2292.

Bierman, S. M., Dickey-Collas, M., van Damme, C. J. G., van Overzee, H. M. J., Pennock-Vos, M. G., Tribuhl, S. V., and Clausen, L. A. W. 2010. Between-year variability in the mixing of North Sea herring spawning components leads to pronounced variation in the composition of the catch. – ICES Journal of Marine Science, 67: 885–896.

Borges, Lisa, Olvin A. van Keeken, Aloysius T.M. van Helmond, Bram Couperus and Mark Dickey-Collas 2008. What do pelagic freezer-trawlers discard? ICES Journal of Marine Science, 65: 605–611.

Breslin J.J. (1998) The location and extent of the main Herring (Clupea harengus) spawning grounds around the Irish coast. Masters Thesis: University College Dublin

Brophy, D., and Danilowicz, B.S. 2002. Tracing populations of Atlantic herring (Clupea harengus L.) in the Irish and Celtic Seas using otolith microstructure. ICES Journal of Marine Science 59: 1305-1313

Brunel, T. 2010. Age-structure-dependent recruitment: a meta-analysis applied to Northeast Atlantic fish stocks. ICES Journal of Marine Science, 67: 1921–1930.

Brunel, T., & Dickey-Collas, M. 2010. Effects of temperature and population density on Atlantic herring von Bertalanffy growth parameters: a macro-ecological analysis. Marine Ecology Progress Series, 405: 15-28.

Brunel, T., Piet, G. J., van Hal, R., & Röckmann, C. 2010. Performance of harvest control rules in a variable environment. ICES Journal of Marine Science, 67: 1051–1062.

Burd, A.C. 1985. Recent changes in the central and southern North Sea herring stocks. Can. J. Fish Aquatic Sci., 42: 192-206.

Cardinale, M. 2006. Effect of mesh size, subdivision and quarter on the proportion and weight at age of herring in IIIa. WD 4 at WGBFAS 2006

Cardinale, M., Hjelm, J. and Casini M. 2008. Disentangling the effect of adult biomass and temperature on the recruitment dynamic of fishes. Cod and Climate, Alaska Sea Grant College Program, AK-SG-08-01.

Cardinale, M., Mölmann, C., Bartolino, V., Casini, M., Kornilovs, G., Raid, T., Margonski, P., Raitaniemi, L., and Gröhsler, T. 2009. Climate and parental effects on the recruitment of Baltic herring (Clupea harengus membras) populations. Marine Ecology Progress Series, 388: 221-234

Chaput, G., Legault, C. M., Reddin, D. G., Caron, F., and Amiro, P. G. 2005. Provision of catch advice taking account of non-stationarity in productivity of Atlantic salmon (Salmo salar L.) in the Northwest Atlantic. ICES Journal of Marine Science, 62: 131–143.

Clarke, M. and Egan, A. 2008. Developing a rebuilding plan and moving towards long term management of Celtic Sea herring. Presentation to Linking Herring Symposium.

Clarke, M., Egan, A., Molloy, J. and McDaid, C. 2008. Scoping study on recruit surveys for Celtic Sea herring. Irish Fisheries Investigation. In prep

Codling, E.A., Kelly, C.J. 2006. F-PRESS: a stochastic simulation tool for developing fisheries management advice and evaluating management strategies. Irish Fisheries Investigation Series, No. 17 (34pp).

Collie, J.S., M.P., Sissenwine. 1983. Estimating population size from relative abundance data measured with error. Can. J. Fish. Aquat. Sci., 40:1871-1879.

Corten, A. 1986. On the causes of the recruitment failure of herring in the central and northern North Sea in the years 1972–1978. Journal du Conseil International pour l'Exploration de la Mer, 42: 281–294.

Cushing, D. H. 1955. On the autumn-spawned herring races of the North Sea. Journal du Conseil Permanent International pour l'Exploration de la Mer, 21: 44–60.

Cushing, D.H., 1992. A short history of the Downs stock of herring. ICES J. Mar. Sci., 49: 437-443.

Cushing, D.H., 1968. The Downs stock of herring during the period 1955-1966. J. Cons. Perm. Int. Explor. Mer, 32 :262-269.

Cushing, D. H., and Bridger, J. P. 1966. The stock of herring in the North Sea, and changes due to fishing. Fishery Investigations London, Series II, 25(1): 1–123.

Darby, C.D., Flatman, S., 1994. Virtual population analysis: version 3.1 (Windows/DOS) user guide. MAFF Information Technology Series No.1. Directorate of Fisheries Research: Lowestoft.

Dickey-Collas, Mark, Pastoors, Martin A., van Keeken, Olvin A. (2007). Precisely wrong or vaguely right: simulations of the inclusion of noisy discard data and trends in fishing effort on the stock assessment of North Sea plaice. ICES Journal of Marine Science, 64: 1641-1649.

Dickey-Collas, M, Nash, RDM., Brunel, T, Damme, CJG van, Marshall, CT, Payne, MR, Corten, A, Geffen, AJ, Peck, MA, Hatfield, EMC, Hintzen, NT, Enberg, K, Kell, LT, & Simmonds EJ 2010a. Lessons learned from stock collapse and recovery of North Sea her-ring: a review. ICES Journal of Marine Science, 67: 1875–1886.

Dickey-Collas M. Engelhard G.H. & Möllmann C 2010b. Herring. In: Rijnsdorp, AD, Peck, MA, Engelhard, GH, Möllmann, C Pinnegar (Eds). Resolving climate impacts on fish stocks. ICES Cooperative Research Report 301. pp 121-134

Dickey-Collas, M 2010c. North Sea Herring. In: Petitgas, P. (Ed.). Life cycle spatial patterns of small pelagic fish in the Northeast Atlantic. ICES Cooperative Research Report 306: 7-18.

Department of Fisheries and Forestry. 1982. Sea and Inland Fisheries Report for 1981. Dublin. The Stationery Office. 77 pp.

EC 2008 COUNCIL REGULATION (EC) No 1300/2008 of 18 December 2008 Management agreement for herring in area V and VIa North.

EC 2007 Report of SGMOS-07-03 WG review of closed areas.

Fassler, SMM, Payne, MR, Brunel, T, Dickey-Collas, M (in press). Does larval mortality influence population dynamics? An analysis of North Sea herring time series. Fisheries Oceanography

Fauchald, P. 2010. Predator–prey reversal: A possible mechanism for ecosystem hysteresis in the North Sea? Ecology, 91(8), 2010, pp. 2191–2197

Gröger, J., Schnack, D., Rohlf, N. (2001) Optimisation of survey design and calculation procedure for the International Herring Larvae Survey in the North Sea. Arch. Fish. Mar. Res. 49(2), 2001, 103–116

Gröger, J. P., Kruse, G. H., and Rohlf, N. 2010. Slave to the rhythm: how large-scale climate cycles trigger herring (Clupea harengus) regeneration in the North Sea. ICES Journal of Marine Science, 67: 454–465.

Groeger, JP, Missong, M, Rountree, RA 2011. Analyses of interventions and structural breaks in marine and fisheries time series: Detection of shifts using iterative methods. Ecol. Indicat. (2011), doi:10.1016/j.ecolind.2010.12.008

Hammond, P.S. & Harris, R.N. (2006) Grey seal diet composition and prey consumption off western Scotland and Shetland. Final Report to Scottish Executive, Environment and Rural Affairs Department and Scottish Natural Heritage.

Harden Jones, F. R. 1968. Fish Migration. Edward Arnold Ltd, London. 325 pp.

Heath, M., Scott, B., & Bryant, A. D. 1997. Modelling the growth of herring from four different stocks in the North Sea. Journal of Sea Research, 38: 413–436.

Hinrichsen, HH, Dickey-Collas, M, Huret, M, Peck, MA & Vikebø, F (2011). Evaluating the suitability of coupled bio-physical models for fishery management. ICES J Mar Sci 67: 000-000. doi: 10.1093/icesjms/fsq115

Hjøllo, S.S., Morten D. Skogen, and Svendsen, E. (2009) Exploring currents and heat within the North Sea using a numerical model. J. Mar. Syst. 78: 180-192.

Link, JS, Yemane, D, Shannon, LJ, Coll, M., Shin, Y-J, Hill, L, and Borges, MF 2010. Relating marine ecosystem indicators to Fishing and environmental drivers: an elucidation of contrasting responses. – ICES Journal of Marine Science, 67: 787–795.

ICES 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/ACFM:15.

ICES 1995. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1995/ACFM:13.

ICES 1996. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1996/ACFM:10.

ICES 1997. Report of the Study Group on Multispecies Model Implementation in the Baltic. ICES CM 1997/J:2.

ICES 1997. Report of the ICES Study Group on the Precautionary Approach to Fisheries Management Assess: ICES CM 1997/.

ICES 1997. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 1997/ACFM:08. 560pp.

ICES 1998. Report of the Study Group on the Precautionary Approach to Fisheries Management. Feb 1998. ICES CM 1998/ACFM:10.

ICES 1998. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 1998/ACFM:14.

ICES, 1999. Manual of the International Bottom Trawl Surveys. Revision VI ICES C.M. 1999/D:2, Addendum 2.

ICES 1999. Report of the International Bottom Trawl Survey Working Group. ICES CM 1999/D:2.

ICES 1999. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1999/ACFM:12.

ICES 1999. Report of the ICES Advisory Committee on Fishery Management, 1998. ICES Cooperative Research Report No 229.

ICES 1999. Report on the ICES study group on market sampling methodology. ICES CM 1999/ACFM:23. 5pp

ICES 2000. Report on the ICES study group on market sampling methodology. ICES CM 2000/D:01. 58pp

ICES 2000. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2000/ACFM:12.

ICES 2000. Report of the International Bottom Trawl Survey Working Group. ICES CM 2000/D:07

ICES 2001. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2001/ACFM:10.

ICES 2001. Report of Herring Assessment WG for the Area South of 62º N. CM 2001/ACFM:12.

ICES 2001. Report of the Study Group on evaluation of current assessment procedures for North Sea herring. CM 2001/ACFM:22.

ICES 2002. Report of the Study Group on the Precautionary Approach. ICES CM 2002/ACFM:10

ICES 2002. Report of Herring Assessment Working Group for the Area South of 62º N. ICES CM 2002/ACFM:12.

ICES 2003. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. ICES CM 2003/ACFM:15.

ICES 2003. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2003/ACFM:17.

ICES 2004. Report of Herring Assessment WG for the Area South of 62º N. ICES CM 2004/ACFM:16.

ICES 2005. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM:16.

ICES 2005. Report of the ad hoc Group on Long Term Advice [AGLTA], 12-13 April 2005, ICES Headquarters, Copenhagen. ICES CM 2005/ACFM:25.

ICES 2006- Report of the Working Group on the Assessment of Northern Shelf Demersal Stocks (WGNSDS). ICES ACFM:30

ICES 2006. Report of Working Group for Regional Ecosystem Description (WGRED). ICES CM 2006/ACE:03.

ICES 2006. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM:20.

ICES 2006. Report of the Study Group on Management Strategies. ICES CM 2006/ACFM:15

ICES 2006. Report of the International Bottom Trawl Survey Working Group (IBTSWG), 27-31 March 2006, Lysekil, Sweden. ICES CM 2006/RMC:03, Ref. ACFM. 298 pp.

ICES 2006. Report of the Study Group on Recruitment Variability in North Sea Planktivorous Fish (SGRECVAP). ICES CM 2006/LRC:03, 82 pp.

ICES 2007. Report of the Planning Group for herring surveys. ICES. 2007/LRC:01

ICES 2007. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 2007/ACFM:11.

ICES 2007. Report of the Working Group on Discard Raising Procedures. ICES CM 2007 ACFM:06 Ref RMC PGCCDBS.

ICES 2007. Report of the Workshop on Limit and Target Reference Points. ICES CM 2007/ACFM:05.

ICES 2007. Report of the Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA). 18–22 June 2007. ICES CM 2007/ACFM:25.

ICES 2007. Report of the Working Group for Regional Ecosystem Description (WGRED), 19 - 23 February 2007, ICES Headquarters, Copenhagen. ICES CM 2007/ ACE:02. 153 pp.

ICES 2008. Report of the Workshop on Implementation in DATRAS of Confidence Limits Estimation of, 10–12 May 2006, ICES Headquarters, Copenhagen. 53 pp.

ICES, 2010. Improving complex governance schemes around Western Baltic Herring, through the development of a Long-Term Management Plan in an iterative process between stakeholders and scientists. ICES CM 2010/P:07

ICES 2008. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 2008/ACOM:02.

ICES 2008. Report of the Benchmark Workshop Planning Group: Report of the Chair (PGBWK). ICES CM 2008/ACOM:62.

ICES 2008. Report of the Planning Group for Herring Surveys. ICES CM 2008/LRC:01. 257 pp.

ICES 2008. Report of the Workshop on Herring Management Plans (WKHMP). ICES CM 2008/ACOM:27.

ICES 2008. Report of the Working Group for Regional Ecosystem Descriptions. ICES CM 2008/ACOM:47

ICES 2008. Report of the Working Group on Multispecies Assessment Methods (WGSAM). ICES DOCUMENT CM 2008/RMC: 06. 113 pp.

ICES 2009. Report of the ICES-STECF Workshop on Fishery Management Plan Development and Evaluation (WKOMSE). ICES CM 2009/ACOM:27. 36pp

ICES 2009. Report of the Planning Group of International Pelagic Surveys (PGIPS), 20–23 January 2009, Aberdeen, Scotland, UK. ICES CM 2009/LRC:02. 217 pp.

ICES 2009. Report of the Herring Assessment Working Group for the area South of 62° N. ICES CM 2009 /ACOM:03.

ICES 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT). ICES CM/ACOM:34

ICES 2009. Report of the Workshop on Multi-annual management of Pelagic Fish Stocks in the Baltic,. ICES CM 2009/ACOM:38. 126 pp.

ICES. 2010. Report of the Workshop on procedures to establish the appropriate level of the mixed herring TAC (Spring Western Baltic (WBSS) and Autumn Spawning North Sea (NSAS) stocks) in Skagerrak and Kattegat. Division IIIa, 23-25 November, ICES Headquarters, Copenhagen. ICES CM 2010/ACOM:64. 63 pp.

ICES 2010. Report of the Working Group for International Pelagic Surveys (WGIPS). ICES CM 2010/SSGESST:03

ICES. 2010. Report of the Herring Assessment Working Group for the Area South of 62n (HAWG), 15 - 23 March 2010, ICES Headquarters, Copenhagen, Denmark.. 688 pp.

ICES 2011. Report of the Working Group for International Pelagic Surveys (WGIPS). ICES CM 2010/SSGESST:02.

Iles, I.D., Sincair, M. 1982. Atlantic herring–stock discreteness and abundance. Science, 215: 627-633.

Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J-M., Garcia, D., Hillary, R., Jardim, E., Mardle, S., Pastoors, M. A., Poos, J. J., Scott, F., and Scott, R. D. 2007. FLR: an open-source framework for the evaluation and development of management strategies. – ICES Journal of Marine Science, 64.

Kell, L. T., Dickey-Collas, M., Hintzen, N. T., Nash, R. D. M., Pilling, G. M., and Roel, B. A. 2009. Lumpers or splitters? Evaluating recovery and management plans for metapopulations of herring. – ICES Journal of Marine Science, 66: 1776–1783.

Kempf, A., Floeter, J., and Temming, A. 2006. Decadal changes in the North Sea food web between 1981 and 1991 - implications for fish stock assessment. Canadian Journal of Fisheries and Aquatic Sciences, 63: 2586–2602.

Lleonart, J. and Salat, J. 1992. VIT software for fishery analysis. Rome: FAO Computerised Information Series.

Limborg, M.T., Pedersen, J.S., Hemmer-Hamsen,J., Tomkiewicz,J., Bekkevold, D. 2009. Genetic population structure of European sprat (Sprattus sprattus): differentiation across a steep environmental gradient in a small pelagic fish. Marine ecology progress series 379: 213–224.

Link, JS, Yemane, D, Shannon, LJ, Coll, M., Shin, Y-J, Hill, L, and Borges, MF 2010. Relating marine ecosystem indicators to Fishing and environmental drivers: an elucidation of contrasting responses. – ICES Journal of Marine Science, 67: 787–795.

Lynch, D. (2011). Long term changes in the biology of Celtic Sea Herring . MSc. Thesis, Trinity College Dublin.

Martin, T.G. Wintle, A.B. Rhodes, J.R. Kuhnert, P.M. Field, S.A. Low-Choy, S.J. Tyre A.J. Possingham, H.P. 2006. Zero tolerance ecology: improving ecological inference by modelling the source of zero observations. Ecol. Lett. 8: 1235–1246.

McLeod, KL, and Leslie, HM 2009. Ecosystem-Based Management for the Oceans. Island Press, Washington, DC.

McPherson, A., Stephenson, R. L., O'Reilly, P. T., Jones, M. W., and Taggart, C. T. 2001. Genetic diversity of coastal Northwest Atlantic herring populations: implications for management. Journal of Fish Biology, 59A: 356–370.

Melvin, G. D., & Stephenson, R. L. 2007. The dynamics of a recovering fish stock: Georges Bank herring. ICES Journal of Marine Science, 64: 69–82.

Minami, M., Lennert-Cody, C.E., Gao, W. and Roman-Verdesoto, M. 2007. Modelling shark by-catch: the zero-inflated negative regression model with smoothing. Fish. Res. 84: 210–221.

Mesnil, B. 2003. The catch-survey analysis (CSA) method of fish stock assessment: An evaluation using simulated data. Fish. Res., 63: 193-212.

Mesnil, B. 2003. Catch-Survey Analysis (CSA): A very promising method for stock assessment, particularly when age data are missing or uncertain. WD at WGMFSA, ICES CM 2003/D:03.

Mesnil, B. 2005. Assessment program documentation. April 2005. IFREMER.

Molloy, J., Bhatnagar, K.M. 1977. Preliminary investigations on Irish sprat stocks. ICES CM 1977/H:16.

Myers R 1998. When do environment – recruitment correlations work? Reviews in Fish Biology and Fisheries 8: 285-305.

Nash, R. and Dickey-Collas, M. 2005. The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (Clupea harengus L.). Fisheries Oceanography, 14: 279–291.

Nash, RDM, Dickey-Collas, M & Kell, LT (2009). Stock and recruitment in North Sea herring (Clupea harengus); compensation and depensation in the population dynamics. Fish Res 95: 88-97.

Needle, C.L. 2003. Survey-based assessments with SURBA. Working Document to the ICES Working Group on Methods of Fish Stock Assessment, Copenhagen, 29 January - 5 February.

Needle, C.L. 2004. Absolute abundance estimates and other developments in SURBA. Working Document to the ICES Working Group on Methods of Fish Stock Assessment, Lisbon, 11–18 February.

Needle, C.L. 2004. Data simulation and testing of XSA, SURBA and TSA. WD to WGNSSK.

Nolan, G., and Lyons, K, (2006). Ocean Climate variability on the western Irish shelf, an emerging time series. ICES CM/C:28

O'Donnell, C, Mullins., E., Saunders, R, Lyons, K., Blaszkowski, M., Sullivan., M., Hoare, D. and Bunn, R. 2009. Northwest Herring Acoustic Survey Cruise Report 2009 FSS Survey Series:2009/03

Oeberst, R., Klenz, B., Gröhsler, T., Dickey-Collas, M., Nash, R. D. and Zimmermann, C. (2009). When is year-class strength determined in western Baltic herring? ICES Journal of Marine Science, Vol. 66/8: 1667-1672

Patterson, K.R. 1998a. A programme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Patterson, K.R. 1998b. Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38.

Patterson, K. R.; D. S. Beveridge 1994: Report of the Herring Larvae Surveys in 1992/1993. Counc. Meet. Pap., H 25, 15 pp.

Patterson, K. R.; D. S. Beveridge 1995a: Report of the Herring Larvae Surveys in the North Sea and Adjacent Waters in 1993/1994. Counc. Meet. Pap., H 22, 17 pp.

Patterson, K. R.; D. S. Beveridge 1995b: Report of the Herring Larvae Surveys in the North Sea and Adjacent Waters in 1994/1995. Counc. Meet. Pap., H 21, 11 pp.

Patterson, K. R.; D. S. Beveridge 1996: Report of the Herring Larvae Surveys in the North Sea in 1995/1996. Counc. Meet. Pap., H 9, 10 pp.

Patterson, K. R.; Schnack, D.; Robb, A. P., 1997: Report of the Herring Larvae Surveys in the North Sea in 1996/1997. Counc. Meet. Pap., Y 14, 15 pp.

Payne MR. Mind the gaps: a state-space model for analysing the dynamics of North Sea herring spawning components. ICES Journal of Marine Science. 2010;67(9):1939-1947. Available at: http://icesjms.oxfordjournals.org/cgi/doi/10.1093/icesjms/fsq036

Payne MR, Clausen LW, Mosegaard H. Finding the signal in the noise: objective data-selection criteria improve the assessment of western Baltic spring-spawning herring. ICES Journal of Marine Science. 2009;66(8):1673-1680.

Available at: http://icesjms.oxfordjournals.org/cgi/doi/10.1093/icesjms/fsp185.

Payne, M. R., Hatfield, E. M. C., Dickey-Collas, M., Falkenhaug, T., Gallego, A., Gröger, J., Licandro, P., Llope, M., Munk, P., Röckmann, C., Schmidt, J. O., and Nash, R. D. M. 2009. Recruitment in a changing environment: the 2000s North Sea herring recruitment failure. - ICES Journal of Marine Science, 66: 272-277.

Payne, MR. 2011. Taylor diagrams can aid in the Interpretation of Fisheries Models. Submitted, Canadian Journal of Fisheries and Aquatic Science.

Petitgas, P., Huret, M., Léger, F., Peck, M. A., Dickey-Collas, M., and Rijnsdorp, A. D. 2009. Patterns and schedules in hindcasted environments and fish life cycles. ICES CM 2009/E:25. 12 pp

Reid, P.C., Edwards, M., Beaugrand, G., Skogen, M., Stevens, D. 2003. Periodic changes in the zooplankton of the North Sea during the twentieth century linked to oceanic inflow. Fish. Ocean. 12: 260-269.

Röckmann, C., Dickey-Collas, M., Payne, M. R., and van Hal, R. Realized habitats of early-stage North Sea herring: looking for signals of environmental change. ICES Journal of Marine Science, doi:10.1093/icesjms/fsq171.

Roel B.A., De Oliveira J. 2005. A two-stage biomass model given additional variance in the recruitment index. Working Document/ HAWG WG 2005.

Saunders, R, O Donnell, C., Campbell, A., Lynch, D, Lyons, K and Wall, D. (2009). Celtic Sea Herring Acoustic Survey Cruise Report 2009 FSS Survey Series:2009/03

Saville, A., 1968: Report on the International Herring Larval Surveys in the North Sea and adjacent waters, 1967/68. Counc. Meet. Pap., H 20: 20 pp.

SCOS 2005. Scientific Advice on matters related to the management of seal populations. 2005. Special Committee on Seals (SCOS). smub.st.and.ac.uk/CurrentResearch.htm/ SCOS%2005_v2f.pdf

P-J. Schön, S. Beggs, I. McCausland, P. McCorriston, W. McCurdy, E. O'Callaghan and J. Peel. Extended pelagic acoustic survey in the Irish Sea (Division VIIa (North)) – preliminary results 2007-2009. Agri-Food and Bioscience Institute, UK. HAWG 2010 WD11.

Shepherd, J.G. 1991. Simple Methods for Short Term Forecasting of Catch and Biomass. ICES J. Mar. Sci., 48: 67–78.

Shepherd, J.G. 1999. Extended survivors analysis: an improved method for the analysis of catch at age data and abundance indices. ICES J. Mar. Sci., 56: 584-591.

Secor, D. H., Kerr, L. A., and Cadrin, S. X. 2009. Connectivity effects on productivity, stability, and persistence in a herring metapopulation model. ICES Journal of Marine Science, 66: 1726–1732.

Shin, Y. J., and Rochet, M-J. 1998. A model for the phenotypic plasticity of North Sea herring growth in relation to trophic conditions. Aquatic Living Resources, 11: 315–324.

Simmonds, E.J. 2003. Weighting of acoustic and trawl survey indices for the assessment of North Sea herring. ICES Journal of Marine Science, 60:463-471.

Simmonds, E. J. 2009. Evaluation of the quality of the North Sea herring assessment. ICES Journal of Marine Science, 66: 1814–1822.

Simmonds, J. and Keltz, S., 2007. Management implications and options for a stock with unstable or uncertain dynamics: West of Scotland herring. ICES J. Mar. Sci., 64: 679–685.

Skagen, D.W. 2003. Programs for stochastic prediction and management simulation (STPR3 and LTEQ). Program description and instruction for Skagen, 2010 use. WD to HAWG 2003.

Skagen, 2010. HCS program for simulating harvest rules: Outline of program and instructions for users. Revision February- March 2010. Unpublished Report. Bergen: Institute of Marine Research. 24 pp.

Smith, M. T. 2000. Multi Fleet Deterministic Projection (MFDP), a Users Guide

Speirs D.C., Guirey E.J., Gurney W.S.C., Heath M.R. 2010. A length-structured partial ecosystem model for cod in the North Sea. Fisheries Research 106: 474–494.

STECF, 2006. Report of the Scientific, Technical and Economic Committee for Fisheries, November 2006.

STECF 2008. 20th Plenary Meeting Report of the Scientific, Technical and Economic Committee for Fisheries (Plen-08-03).

Stige, L. C., Ottersen, G., Brander, K., Chan, K-S., and Stenseth, N. C. 2006. Cod and climate: effect of the North Atlantic Oscillation on recruitment in the North Atlantic. Marine Ecology Progress Series, 325: 227–241.

Taylor, K. E. (2001), Summarizing multiple aspects of model performance in a single diagram, J. Geophys. Res., 106, 7183–7192, doi:10.1029/2000JD900719.

Torstensen, E. 1994. Results of the Workshop on comparative age reading on sprat from ICES Div. IIIa. ICES Doc. C.M. 1994/H:13, ref. D,J.

Torstensen, E. 1996. Results of the Workshop on comparative age reading on sprat, Fl□devigen, 20-22 September 1994. WD Herring assessment working group for the area south of 62°N. 1996. 1-41

Torstensen, E. 2002. North Sea Sprat Otolith Exchange. WD 5/ICES HAWG-2002. 7pp

Torstensen, E., Eltink,A.T.G.W., Casini, M., McCurdy, W. J. And Clausen, L.W. 2004. Report of the Workshop on age estimation on sprat. Institut of Marine Research, Fl□devigen, Arendal, Norway, 14-17 December 2004.

Ulrich-Rescan, C., Andersen, B.S. 2006. Description of the activity of the Danish herring fleets in IIIa. Working Document-1\HAWG WG 2006.

Van Deurs, M., Worsøe, L.A.C. 2006. Catches of Spring- and Autumn spawners in Division IIIa distributed by fleet, sub region, and length group. Working Document-2/ HAWG WG 2006.

ANNEX 1: List of Participants

Herring Assessment Working Group South of 62° N [HAWG]

16–24 March 2011

LIST OF PARTICIPANTS

Name	Address	Phone/Fax	Email
Valerio Bartolino	Marine Research Institute, Swedish Board of Fisheries, Turistgatan 5, 45321 Lysekil, Sweden	+46722002197	valerio.bartolino@gmail.com
Steven Beggs	Agri-food and Biosciences Institute 18a Newforge Lane BT9 5PX Belfast United Kingdom	Phone +44 2890 255 472	steven.beggs@afbini.gov.uk
Maurice Clarke Co-chair	Marine Institute Rinville Oranmore Co. Galway Ireland	Phone +353 91387200 Fax +353 91387201	maurice.clarke@marine.ie
Lotte Worsøe Clausen Co-chair	National Institute of Aquatic Resources, Section for Population Ecology and Genetics Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 33963364 Fax +45 33963333	law@aqua.dtu.dk
Mark Dickey-Collas	IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31 317 487166 Fax +31 317 487326	mark.dickeycollas@wur.nl
Afra Egan	Marine Institute Rinville Oranmore Co. Galway Ireland	Phone +353 91387200 Fax +353 91 387201	afra.egan@marine.ie
Katja Enberg	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	Phone +47 55 23 86 92 Fax +47 55 23 86 87	katja.enberg@imr.no
Joachim Gröger	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	Phone +49 4038905266 Fax +49 4038905263	joachim.groeger@vti.bund.de
Tomas Gröhsler	Johann Heinrich von Thünen-Institute, Institute of Baltic Sea Fisheries Alter Hafen Süd 2 D-18069 Rostock Germany	Phone +49 381 811 6104 Fax +49 381 811 6199	tomas.groehsler@vti.bund.de
Emma Hatfield	Marine Scotland - Science 375 Victoria Road Aberdeen AB11 9DB United Kingdom	Phone +44 1224 295434 Fax +44 1224 295511	e.hatfield@marlab.ac.uk
Niels Hintzen	IMARES P.O. Box 68 1970 AB IJmuiden Netherlands	Phone +31 317 487 090 Fax +31 317 487326	niels.hintzen@wur.nl

Name	Address	Phone/Fax	Email
Cecilie Kvamme	Institute of Marine Research P.O. Box 1870 Nordnes N-5817 Bergen Norway	Phone +47 55 23 69 31 Fax +47 55 23 86 87	cecilie.kvamme@imr.no
Susan Mærsk Lusseau	Marine Scotland - Science 375 Victoria Road Aberdeen AB11 9DB United Kingdom	Phone: +44 1224 295654 Fax +44 1224 295511	s.lusseau@marlab.ac.uk
Henrik Mosegaard	National Institute of Aquatic Resources, Section for Population Ecology and Genetics Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 33 96 34 61 Fax +45 33 96 33 33	hm@aqua.dtu.dk
Peter Munk	National Institute of Aquatic Resources, Section for Ocean Ecology Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark	Phone +45 35883409 Fax +45 35883434	pm@aqua.dtu.dk
Mark Payne	ETH Zurich Environmental Physics CHN E 26.1 Universitaetstrasse 16 8092 Zurich SWITZERLAND National Institute of Aquatic Resources, Section for Ocean Ecology Charlottenlund Slot, Jægersborg Alle 1 DK-2920 Charlottenlund Denmark		mpa@aqua.dtu.dk
Beatrice Roel	Centre for Environment, Fisheries & Aquaculture Science Lowestoft Laboratory Pakefield Road Lowestoft Suffolk NR33 0HT United Kingdom		
Norbert Rohlf	Johann Heinrich von Thünen-Institute, Institute for Sea Fisheries Palmaille 9 D-22767 Hamburg Germany	Phone +49 40 38905 166 Fax +49 40 38905 263	norbert.rohlf@vti.bund.de
Barbara Schoute	H. C. Andersens Boulevard 44-46 DK-1553 Copenhagen V Denmark	Phone: +45 3338 6700 Fax: +45 3393 4215	barbara@ices.dk
Yves Vérin	IFREMER Boulogne-sur-Mer Centre P.O. Box 699 F-62 321 Boulogne Cedex France	Phone +33 321 995 600 Fax +33 321 995 601	yves.verin@ifremer.fr

Annex 2 – Recommendations

HAWG 2011 makes the following recommendations:

RECOMMENDATION	ACTION
WGIPS to investigate possibilities to calculate a larvae production estimate including uncertainties in the Southern North Sea.	WGIPS
WGIPS to comment on anomalies in parameters estimated on surveys (maturities, weights-at-age, numbers at age, eg low maturity for age 2 in North Sea 2010) and provide guidance to HAWG on their reliability. WGIPS should provide report to HAWG by a certain date that allows HAWG members to consider content and results before the commencement of HAWG.	WGIPS
HAWG recommends that WGIPS address the request for extra information required under the Marine Strategy Framework Directive by their next meeting in December 2011. WGIPS should be in a position to deliver information on proportion of fish larger than the mean size of first sexual maturation, mean maximum length of fish found in research vessel surveys and 95th % percentile of the fish length distribution observed to assessment working groups meeting in 2012.	WGIPS
The Secretariat is asked to collate a definitive inventory of TACs and quotas that is updated regularly.	ICES Secretariat
HAWG is concerned to learn that there is a strong likelihood that certain countries will lose their pelagic observer programmes in 2011. HAWG recommends that all efforts be made to maintain observer coverage across fleets that catch a substantial proportion of pelagic fish	PGCCDBS
With the addition of a new VIa MIK survey to the collection of surveys that provide potential indices, there is a requirement for understanding the catchability of small larvae with this gear, based on experimental observations. This has implications for both the new VIa survey and for our understanding of the current IBTS0 (North Sea) survey. HAWG recommends that the standard MIK net mesh be tested along with a finer mesh to determine the selectivity curve.	WGIBTS
HAWG recommends the establishment of a dedicated workshop to examine the effect of WBSS herring and Central Baltic herring mixing in subdivision 24.	ACOM/SCICOM
Provision of survey indices (total biomass, numbers at length, and/or numbers at age) for sprat in the Celtic seas eco-region	WGIBTS, WGIPS
HAWG recommends to PGCCDBS, WGIPS and ACOM that the work to split the VIaN acoustic survey (Malin Shelf Acoustic Survey MSHAS) according to spawning season should continue. This work is essential to make the survey useable as a tuning index for VIaS/VIIbc herring, and is expected to improve the tuning diagnostics for VIaN herring also.	WGIPS, ACOM, PGCCDBS

Recommend to SIMWG to evaluate stock structure for all sprat stocks in NEA.	SIMWG
HAWG recommends to PGCCDBS that the effect of possible changes of autumn, winter and spring spawning components in VIaS/VIIbc, on the catch at age data be performed. In particular, PGCCDBS is asked to investigate the effect that the interpretation of the last winter ring may have in this mixed stock, bearing in mind that the birth date is the 1st January.	PGCCDBS
InterCatch should produce outputs in a format that can be directly incorporated into a stock assessment (e.g. FLR objects, Lowestoft VPA format).	ICES Secretariat
Uncertainty estimates should be provided for all values used in stock assessment, including weights at age and maturity ogives.	PGCCDBS, IBTSWG, WGIPS
The sprat benchmark in 2009 highlighted that the current understanding of the reliability of sprat ageing is not well understood, in spite of four aging workshops on the topic. HAWG requests that the upcoming exchange of sprat otoliths identify where the discrepancies in the aging of sprat arise and suggest further potential improvements.	PGCCDBS
The upcoming HAWG benchmarks have already posed many questions about surveys that are best solved taking into account both the spatial and statistical nature of the data. However, the working group currently lacks expertise in the field of geostatistics. HAWG therefore requests that ICES and interested institutes provide such expertise to the benchmark process	ICES Secretariat (ACOM)
Given the short lead-in time and the desire for all work in the upcoming HAWG benchmarks to be collaborative in nature, a pre-meeting is viewed as essential. HAWG therefore requests ICES to establish a three-day data compilation and model development workshop prior to the main benchmark meeting. Such a meeting could potentially take place during early 4th quarter in 2011	ICES Secretariat
HAWG recommends to investigate natural mortality estimates in the light of multi-species interactions of North Sea herring in preparation to the benchmark in 2012	WGSAM investigates natural mortality
HAWG recommends to investigate the quality of the IBTS data for sprat in quarters 1 and 3	IBTSWG
HAWG recommends WGIPS to compile a time series of the sprat abundance and biomass in Division IIIa (ICES CM 2011/SSGESST:02), similar to the Table 4.2.2. on North Sea sprat.	WGIPS compiles a data series based on earlier reports
HAWG recommends WGIPS to compile a time series of the size at age and maturity information for North Sea and Division IIIa sprat (the information currently in Tables 4.2.1. and 4.2.3 ICES CM 2011/SSGESST:02).	WGIPS compiles a time series based on earlier reports
HAWG recommends WGIPS to include Kattegat-Skagerrak area (IIIa) in the map regarding acoustic survey (Figure 4.2.1. in ICES CM 2011/SSGESST:02).	WGIPS includes Kattegat-Skagerrak area in the map

HAWG recommends WGIPS to provide the average weight and length for immature and mature sprat in Division IIIa in Table 4.2.3. Currently same weight and length are given for immatures and matures, which seems unlikely. If the sample size is small, range or variance should then rather be given together with the averages.	WGIPS recalculates the average weight and length for immature and mature individuals, or at least does this in the next report
HAWG recommends PGCCDBS to pay attention to the poor biological sampling of North Sea sprat catches. The sampling intensity should be increased in order to follow the sampling recommendations by the DCF.	PGCCDBS demands sampling according to the DCF recommendations
HAWG recommends that all information in the exchange sheets should be available in InterCatch (e.g., catch per rectangle, length frequency plots of sampled catches). This will provide the stock coordinators with the same opportunities in InterCatch compared to common allocation routines.	ICES Secretariat
The Exchange Spreadsheet should take precedence for data exchange for the 2012 HAWG, until InterCatch provides the additional functionality.	ICES Secretariat

Annex 3– Stock Annex North Sea Herring

Quality Handbook ANNEX: hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock: North Sea Autumn Spawning Herring (NSAS)

Working Group: Herring Assessment WG for the Area south of 62°N

Date: 16 March 2010

Authors: C. Zimmermann, J. Dalskov, M. Dickey-Collas, H. Mosegaard, P. Munk, J. Nichols, M. Pastoors, N. Rohlf, E.J. Simmonds, D. Skagen, M. Payne, N. Hintzen

A. General

A.1. Stock definition:

Autumn spawning herring distributed in ICES area IV, Division IIIa and VIId. Mixing with other stocks occurs especially in Division IIIa (with Western Baltic Spring Spawning herring). Genetic studies have failed to prove that the stock is not one unit (Mariani *et al*., 2005; Reiss *et al*., 2009).

A.2. Fishery

North Sea Autumn Spawners are exploited by a variety of fleets, ranging from small purse seiners to large freezer trawlers, of different nations (Norway, Denmark, Sweden, Germany, The Netherlands, Belgium, France, UK, Faroe Islands). The majority of the fishery takes place in the Shetland-Orkney area and northern North Sea in the 2nd and 3rd quarter, and in the English Channel (Division VIId) in the 4th quarter. Juveniles are caught in Division IIIa and as by-catch in the industrial fishery in the central North Sea. For management purposes, 4 fleets are currently defined: Fleet A is harvesting herring for human consumption in IV and VIId, but includes herring by-catches in the Norwegian industrial fishery; fleet B is the industrial (small mesh, <32 mm mesh size) fleet of EU nations operating in IV and VIId. North Sea Autumn spawners are also caught in IIIa in fleets C (human consumption) and D (small mesh).

A.3. Ecosystem aspects:

Herring is the key pelagic species in the North Sea and is thus considered to have major impact as prey and predator to most other fish stocks in that area (Dickey-Collas *et al*., 2010).

The North Sea is semi-enclosed and situated on the continental shelf of North-western Europe and is bounded by England, Scotland, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium and France. It covers an area of ~750 000 km^2 of which the greater part is shallower than 200 m. It is a highly productive (>300 gC m^{-2} yr^{-1}) ecosystem but with primary productivity varying considerably across the sea. The highest values of primary productivity occur in the coastal regions, influenced by terrestrial inputs of nutrients, and in 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, birds and for sea mammals (see review Dickey-Collas *et al.*, 2010). Over the past century the top predator, man, has exerted the greatest influence on the abundance and distribution of herring in the North Sea. Spawning stock biomass has fluctuated from estimated highs of around 4.5 million tonnes in the late 1940s to lows of less than 100 000 tonnes in the late 1970s (Mackinson, 2001; Mackinson and Daskalov, 2007; Simmonds 2007). The species has demonstrated robustness in relation to recovery from such low levels once fishing mortality is curtailed in spite of recruitment levels being adversely affected (Payne *et al*., 2009, Nash *et al*., 2009).

Their spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences. The most serious of these is the ever increasing pressure for marine sand and gravel extraction and the development of wind farms. This has the potential to seriously damage and to destroy the spawning habitat and disturb spawning shoals and destroy spawn if carried out during the spawning season. It also has the potential to destroy traditional spawning grounds which are currently unused but likely to be recolonised (Schmidt *et al*., 2009). Similarly, trawling at or close to the bottom in known spawning areas can have the same detrimental effects. It is possible that the disappearance of spawning on the western edge of the Dogger Bank could well be attributable to such anthropogenic influences.

In more recent years the oil and gas exploration in the North Sea has represented a potential threat to herring spawning although great care has been taken by the industry to restrict their activities in areas and at times of known herring spawning activity.

By-catch and Discard

By-catch consists of the retained 'incidental' catch of non-target species and discard is a deliberately (or accidentally) abandoned part of the catch returned to the sea as a result of economic, legal, or personal considerations. This section therefore deals with these two elements of the fishery, looking specifically at fishery-related issues. Cetacean, seabird and other threatened, rare and charismatic species which may form part of a by-catch are considered separately in the next section. Discarding is illegal for Norwegian vessels and slippage and high grading is now illegal for EU vessels if quota is still available and the fish are above minimum landing size.

Incidental Catch: The incidental catch of non-target species in the North Sea pelagic herring fishery in general is considered to be low (Borges *et al*., 2008). A study by Pierce *et al.* (2002) investigated incidental catch from commercial pelagic trawlers over the period January to August 2001. The target species, herring, accounted for 98% by weight of the overall catch with an overall incidental catch of 2.3% made up of mackerel, haddock, horse mackerel and whiting. However, onboard sampling over 2002 by Scottish and German observers found substantial discards of herring, taken as by-catch in the mackerel fishery over the 3rd and 4th quarters, after herring quotas had been exhausted. This was not found in a study of the Dutch fleet (Borges *et al*., 2008) when the herring fishery was found to be relatively "clean". Updates of the time series of Dutch discarding due to sorting suggest an approximate discard of <5% of the catch (Helmond and Overzee, 2010a).

Discards and slipping: The indications are that large-scale discarding is not widespread in the directed North Sea herring fishery. A number of direct-observer surveys have been conducted on Scottish, Dutch and Norwegian pelagic trawlers, (Napier *et al*, 1999; 2002; Borges *et al*., 2008). The overall discard rate was less than 5% of the landed catch. It is likely that there are different discard rates between the specific fishing types. There is disagreement about the amount of slippage compared to discarding by the differing fleets (**slippage**- fish released from the nets whilst still in the water but still resulting in the mortality of the majority of pelagic fish, **discarding**- fish dumped back into the sea after having been brought on board). In freezer trawlers discarding can occur through sorting the catch and through emptying of tanks via the processing belts without sorting. For both pursers and trawlers 'poor' fish quality was a significant cause of discarding. Another reason is the processing capacity of freezer trawlers when catches are abundant (Helmond and Overzee, 2010b). The strength of year classes influences discarding behaviour, particularly of undersized fish. The influence of strong herring year classes was apparent in the composition of discards with smaller, younger fish accounting for a high proportion of the fish discarded in 2001. In the mid 2000s the stronger recruitment of mackerel has probably lead to the increase in discarding of smaller mackerel.

Ecosystem Considerations. The incidental non-target fish catch by directed North Sea herring fisheries appears to be low (ca. 2%), mainly consisting of mackerel when fishing mixed shoals. Thus it is likely that the impact of incidental fish catches is negligible. The discard of unwanted herring, mostly in the form of high-grading to improve catch quality and grade sizes of fish between 2-4 years of age is low and now illegal in both the EU and Norway. Discarding is thought to be reducing.

Interactions with Rare, Protected or charismatic mega fauna: Interactions between the directed North Sea herring fishery with rare, protected or charismatic mega fauna species are, in general, considered to be low. Species which may interact with the fishery are considered below.

Cetacean by-catch: Since 2000, the Sea Mammal Research Unit (SMRU) of St. Andrew's University in Scotland, under contract to DEFRA, has carried out a number of surveys to estimate the level of by-catch in UK pelagic fisheries. SMRU, in collaboration with the Scottish Pelagic Fishermen's Association, placed observers on board thirteen UK vessels for a total of 190 days at sea, covering 206 trawling operations around the UK. No cetacean by-catch was observed in the herring pelagic fishery in the North Sea. Pierce (2002) also reports that no by-catches of marine mammals were observed over 69 studied hauls and considers that the underlying rate for marine mammals in the pelagic fisheries studies (pelagic trawls in IVa and VIa) is no more than 0.05 (i.e. five events per 100 hauls) and may well be considerably lower than this. Consequently, the cetacean by-catch by the pelagic trawl fishery can be regarded as negligible. This was also confirmed by an UK observer programme that ended in 2003 (Northridge, pers. Comm.) and Dutch observers (1 catch from 2007-2009: over 210 days observed; Couperus 2009).

Other than the above, there are no reliable estimates of by-catch for pelagic trawl fisheries, though observations have been made and by-catch rates have been established for several fisheries. Data are now collected routinely through the DRF and have yet to be analysed. Kuklik and Skóra (2003) refer to a single record of a harbour porpoise (*Phocoena phocoena*) by-catch in a herring trawl in the Baltic. Observations in several other pelagic trawl fisheries were reported by Morizur *et al*. (1999) and Couperus (1997). All appear to agree that incidental catches of cetaceans in the Dutch pelagic trawl fishery are largely restricted to late-winter/early-spring in an area along the continental slope southwest of Ireland, so outside the North Sea.

Seal by-catch: The by-catch of seals in directed pelagic herring fishery in the North Sea is reported to be "very rare" (Aad Jonker, pers. comm.). Independent verification also confirms this to be so, with perhaps one animal being caught by the whole North Sea fleet a year (Bram Couperus (IMARES, pers. comm.). Northridge (2003) observed 49 seals taken in 312 pelagic trawl tows throughout UK waters and reports that the fishery in North-western Scotland has the highest observed seal by-catch levels of UK pelagic trawl fisheries, possible amounting to dozens per year. Although not confirmed, it was assumed that the majority were grey seal *Halichoerus grypus*. This species is mainly distributed around the Orkneys and Outer Hebrides – out of a UK population of 129 000, only around 7 000 and 5 900 are distributed off the Scottish and English North Sea coasts respectively (SCOS, 2002), and so by-catch rates in the North Sea are likely to be substantially less than off the NW Scottish coast. The eastern Atlantic population of the Grey seal is not considered to be threatened.

Other by-catch: Sharks are occasionally caught by pelagic trawlers in the North Sea, although this is rare with a maximum of two fish per trip (Aad Jonker, pers. comm.). Survival rates are apparently high, sharks are released during or after the cod-end has been emptied. The species are unknown, although blue shark *Prionace glauca*, which preys primarily upon schooling fishes such as anchovies, sardines and herring, are known to have been caught by pelagic trawls off the SW English coast (Bram Couperus (IMARES), pers. comm.). Gannets (*Morus bassanus*), which frequently dive at and around nets, were observed by Napier *et al.* (2002) entangled in the nets but were not present in samples. Actual mortality rates of caught gannets have not been assessed in detail, and some have been observed alive after release from the gear. An extrapolation from observed mortalities corresponds to around 560 gannet deaths per year, although this is based on a relatively low sample frame. Seabird by-catch in the North Sea is considered to be comparatively rare. In the NW Scotland, 1-3 birds may be caught, especially in grounds off St. Kilda (Aad Jonker (former freezer trawler skipper), pers. comm.). IMARES observers in the North Sea only recorded one incident of seabird by-catch over 10 trips (Bram Couperus, pers. comm.).

B. Data

B.1. Commercial catch:

Commercial catch is obtained from national laboratories of nations exploiting herring in the North Sea. Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2007 catch data was v1.6.4. This method is now run in parallel with INTERCATCH, which is maintained by ICES. INTERCATCH is still in development and thus HAWG uses both. The data in the exchange spreadsheets are allocated samples to catch using the SALLOCL-application (Patterson, 1998). This programme gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

In addition, commercial catch and sampling data were stored and processed using the Intercatch-software for the first time during the WG in 2007. While at that time larger discrepancies up to 5 % between the SALLOCL routines and Intercatch did occur, INTERCATCH performed quite well in 2008. The estimates of CANON, CATON and WECA were highly comparable. However INTERCATCH is still not completely satisfactory in terms of flexibility and outputs. Thus both methods are still being used.

The "wonderful table". The following figure explains were the estimates in the wonderful table are derived from:

Year		2007	2008	Annotation
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	Total TAC for human consumption in North Sea
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		Herring caught in the North Sea
National landings Divisions IVc, VIId 3		34.3		
Unallocated landings Divisions IVc,VIId		4.7		
Discard/slipping Divisions IVc, VIId 4		-		
Total catch Divisions IVc, VIId		39.0		Herring caught in the North Sea
Total catch IV and VIId as used by ACFM 5		**387.8**		
CATCH BY FLEET/STOCK (IV and VIId) 10				
North Sea autumn spawners directed fisheries (Fleet A)		379.6		NS catch human consumption
North Sea autumn spawners industrial (Fleet B)		7.1		NS catch industrial fishery
North Sea autumn spawners in IV and VIId total		**386.7**		
Baltic-IIIa-type spring spawners in IV		1.1		Catch of WBSS in IV, estimated by splitting
Coastal-type spring spawners		0.0		e.g. spring spawner in river estuaries (Thames, Wash)
Norw. Spring Spawners caught under a separate quota in IV 20		0.7		direct information from Norway
Division IIIa: TAC (IIIa)				
Predicted catch of autumn spawners	22			
Recommended spring spawners	22			
Recommended mixed clupeoids				
Agreed herring TAC		69.4	51.7	
Agreed mixed clupeoid TAC				
Bycatch ceiling in the small mesh fishery		15.4	11.5	
CATCH (IIIa)				
National landings		47.3		
Catch as used by ACFM		47.4		
CATCH BY FLEET/STOCK (IIIa) 10				
Autumn spawners human consumption (Fleet C)		16.4		
Autumn spawners mixed clupeoid (Fleet D) 19		3.4		
Autumn spawners other industrial landings (Fleet E)				
Autumn spawners in IIIa total		**19.8**		Catch of NSAS in IIIa, estimated by splitting
Spring spawners human consumption (Fleet C)		25.3		
Spring spawners mixed clupeoid (Fleet D) 19		2.3		
Spring spawners other industrial landings (Fleet E)				
Spring spawners in IIIa total		**27.6**		
North Sea autumn spawners Total as used by ACFM		**406.5**		

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year. Since 2007, the corresponding datasets are also stored in Intercatch, where they are accessible to the stock coordinators only.

Current methods of compiling fisheries assessment data. The stock co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to un-sampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the 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 un-sampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

The Working Group acknowledges the effort some members have made to provide "corrected" data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the scientist responsible and the fishermen. In addition the Working Group recognises and would like to highlight the inherent conflict of interest in obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) is derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described above. For information on recent sampling levels and nations providing samples, see Sec. 2.2. of the most recent HAWG report.

Mean weights-at-age in the stock and proportions mature (maturity ogive) are derived from the June/July international acoustic survey (see next paragraph). All 1 ring fish are assumed to be immature, and all fish over five rings are assumed to be mature.

B.3. Surveys

B.3.1 Acoustic: ICES Co-ordinated Acoustic Surveys for herring in North Sea, Skagerrak and Kattegat

The ICES Coordinated acoustic surveys started in 1979 around Orkney and Shetland with first major coverage in 1984. An index derived from that survey has been used in assessments since 1994 with the time-series data extending back to 1989. The survey was extended to IIIa to include the overlapping Western Baltic spring spawning stock in 1989, and the index has been used with a number of other tuning indices since 1991. The early survey had occasionally covered VIa (North) during the 1980s and was extended westwards in 1991 to cover the whole of VIa (North). Since 1991, this survey provides the only tuning index for VIa (North) herring and from 2008 for the whole Malin Shelf, By carrying out the co-ordinated survey at the same time from the Kattegat to Donegall all herring in these areas are covered simultaneously, reducing uncertainly due to area boundaries as well as providing input indices to three distinct stocks. The surveys are co-ordinated under ICES Working Group for International Pelagic Surveys (WGIPS).

The acoustic recordings are carried out using Simrad EK60 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. Prior to 2006, Simrad EK500 and EY500 were also used. Further data analysis is carried out using either BI500, Echoview or Echoann software. The survey track is selected to cover the area giving a basic sampling intensity over the whole area based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles is used in most parts of the area with the exception of some relatively high density sections, east and west of Shetland, north of Ireland in the Skagerrak where short additional transects were carried out at 7.5 nautical miles spacing, and in the southern area, where a 30 nautical miles transect spacing is used.

The following target strength to fish length relationships have been used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L -71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

Data are reported through standardised data exchange format and uploaded into the FishFrame database, currently held at DTU Aqua, Charlottenlund, Denmark. National estimates are aggregated through Fishframe during PGIPS to calculate global estimates for the North Sea, the Malin Shelf and the western Baltic Sea. The exchange format currently holds information on the ICES statistical rectangle level, with at least one entry for each rectangle covered, but more flexible strata are accommodated by allowing multiple entries for abundance belonging to different strata. Data submitted consists of the ICES rectangle definition, biological stratum, herring abundance by proportion of autumn spawners (North Sea and VIa North) and Spring spawners (Western Baltic, age and maturity, and survey weight (survey track length). Data are presented according to the following age/maturity classes: 1 immature (maturity stage 1 or 2), 1 mature (maturity stage 3+), 2 immature, 2 mature, 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+. In addition to proportions at age data on mean weights and mean length are reported at age/maturity by biological strata. Data are combined using an effort weighted mean based on survey effort reported as number of nautical miles of cruise track per statistical rectangle. A combined survey report is produced annually. Apart from the Biomass index for 1-9+-ringers, mean weights at age in the catch and proportions mature are derived from the survey to be used in the NSAS assessment.

B.3.2 International Bottom Trawl Survey:

The International Bottom Trawl Survey (IBTS) started out as a Young Herring Survey (IYHS) in 1966 with the objective of obtaining annual recruitment indices for the combined North Sea herring stocks (Heessen *et al*., 1997). It has been carried out every year since, and it was realized that the survey could provide recruitment indices not only for herring, but for roundfish species as well. Examination of the catch data from the 1st quarter IBTS showed that these surveys also gave indications of the abundances of the adult stages of herring, and subsequently the catches have been used for estimating 2-5+ ringer abundances. The surveys are carried out in 1st quarter (February) and in 3rd quarter (August-September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. In 2007 the IBTS was extended into English Channel. In addition, historical IBTS indices have been updated from 2004 onwards (in 2007).

In 1977 sampling for late stage herring larvae was introduced at the IBTS 1st quarter, using Isaccs-Kidd Midwater trawls. These catches appeared as a good indicator of herring recruitment, however examination of IKMT performance showed deficiencies in its catchability for herring larvae, and a more applicable gear, a ring net (MIK) was suggested as an alternative gear. Hence, gear type was changed in the mid 90'ies, and the MIK has been the standard gear of the programme since. This ring net is of 2 meter in diameter, has a long two-legged bridle, and is equipped with a black netting of 1.5 mm mesh size. Two oblique hauls per ICES statistical rectangle are made during night.

Indices of 2-5+ ringer herring abundances in the North Sea (1st quarter). Fishing gear and survey practices were standardised from 1983, and herring abundance estimates of 2-5+ ringers from 1983 onwards has shown the most consistent results in assessments of these age groups. This series is used in North Sea herring assessment. Catches in Division IIIa are not included in this index. These estimates are determined by the standard IBTS methodology developed by the ICES IBTS working group.

Index of 1-ringer recruitment in the North Sea (1st quarter). The 1-ringer index of recruitment is based on trawl catches in the entire survey area, hence, all 1-ringer herring caught in Division IIIa is included in this index. Indices are calculated as an area weighted mean over means by ICES statistical rectangle, and are available for year classes 1977 to recent. The Downs herring hatch later than the other autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated using the standard procedure, but solely based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:10, and ICES CM 2001/ ACFM:12).

MIK index of 0-ringer recruitment in the North Sea (1st quarter). The MIK catches of late stage herring larvae are used to calculate an 0-ringer index of autumn spawned herring in the North Sea, this represents recruitment strength (Nash & Dickey-Collas 2005). A flowmeter at the gear opening is used for estimation of volume filtered by the gear, and using this information together with information on bottom depth, the density of herring larvae per square meter is estimated. The mean herring density in statistical rectangles is raised to mean within subareas, and based on areas of these subareas an index of total abundance is estimated (see also ICES 1996/Asses:10). The series estimates for subareas as well as the total index.

B.3.3. Larvae:

Surveys of larval herring have a long tradition in the North Sea. Sporadic surveys started around 1880, and available scientific data goes back to the middle of the 20th century. The co-ordination of the International Herring Larvae Surveys in the North Sea and adjacent waters (IHLS) by ICES started in 1967, and from 1972 onwards all relevant data are achieved in a data base (ICES PGIPS). The surveys are carried out annually to map larval distribution and abundance (Schmidt *et al.*, 2009). Larval abundance estimates are of value as relative indicators of the herring spawning biomass in the assessment.

Nearly all countries surrounding the North Sea have participated in the history of the IHLS. Most effort was undertaken by the Netherlands, Germany, Scotland, England, Denmark and Norway. A number of other nations have contributed occasionally. A sharp reduction in ship time and number of participating nations occurred in the end of the 1980s. Since 1994 only the Netherlands and Germany contribute to the larvae surveys, with one exception in 2000 when also Norway participated.

Larvae Abundance Index (LAI): The total area covered by the surveys is divided into 4 sub areas corresponding to the main spawning grounds. These sub areas have to be sampled in different given time intervals. The sampling grid is standardized and stations are approximately 10 nautical miles apart. The standard gear is a GULF III or GULF VII sampler (Nash *et al.*, 1998). Newly hatched larvae less than 10 mm total length (11 mm for the Southern North Sea) are used in the index calculation. To estimate larval abundance, the mean number of larvae per square meter obtained from the Ichthyoplankton hauls is raised to rectangles of 30x30 nautical miles and the corresponding surface area. These values are summed up within the given unit and provide the larval abundance per unit and time interval.

Multiplicative Larval Abundance Index (MLAI): The traditional LAI and LPE (Larval Production Estimates) rely on a complete coverage of the survey area. Due to the substantial decline in ship time and sampling effort since the end of the 80s, these indices could not be calculated in their traditional form since 1994. Instead, a multiplicative model was introduced for calculating a Multiplicative Larvae Abundance Index (MLAI, Patterson & Beveridge, 1995). In this approach the larvae abundances are calculated for a series of sampling units. The total time series of data are used to estimate the year and sampling unit effects on the abundance values. The unit effects are used to fill un-sampled units so that an abundance index can be estimated for each year.

Calculation of the linearised multiplicative model was done using the equation:

$$\ln(Index_{year,LAI\ unit}) = MLAI_{year} + MLAI_{LAI\ unit} + u_{year,\ LAI\ unit}$$

where $MLAI_{year}$ is the relative spawning stock size in each year, $MLAI_{LAI\ unit}$ are the relative abundances of larvae in each sampling unit and year, LAI unit are the corresponding residuals (Gröger *et al.*, 1999, 2000). The unit effects are converted such that the first sampling unit is used as a reference (Orkney/Shetland 01-15.09.72) and the parameters for the other sampling units are redefined as differences from this reference unit. The model is fitted to abundances of larvae less than 10 mm in length (11 mm for SNS). The MLAI is updated annually and represent all larval data since 1972. The time series is used as a biomass index in the herring assessment.

Another larval abundance index (**SCAI- Spawning Component Abundance Index**) has been developed to reduce the problems of missing observations and a high sampling noise (Payne 2010). It is a simple state-space statistical model that is considered robust to these problems. The model gives a good fit to the data and is demonstrated to be capable of both handling and predicting missing observations well. Furthermore, the sum of the fitted abundance indices across all components is a proxy for the biomass of the total stock, even though they only model processes at the component level. The use of this index will be further explored in the future.

B.4. Commercial CPUE

Not used for pelagic stocks.

B.5. Other relevant data

B.5.1 Separation of North Sea Autumn Spawners and IIIa-type Spring Spawners

North Sea Autumn Spawners and IIIa-type Spring Spawners occur in mixtures in fisheries operating in Divisions IIIa and IVaE (ICES, 1991/Assess:15; Clausen *et al.*, 2007): mainly 2+ ringers of the Western Baltic spring-spawners and 0-2-ringers from the North Sea autumn-spawners, including winter-spawning Downs herring. In addition, several local spawning stocks have been identified with a minor importance for the herring fisheries (ICES, 2001/ACFM 12).

The method of separating herring in Norwegian samples, using vertebral counts as described in former reports of this Working Group (ICES 1990/ Assess:14) assumes that for autumn spawners, the mean vertebral count is 56.5 and for Spring spawners 55.80. The fractions of spring spawners (fsp) are estimated from the formula (56.50-v)/(56.5-55.8), where v is the mean vertebral count of the (mixed) sample with the restriction that the proportion should be one if fsp>=1 and zero if fsp<=0. The method is quite sensitive to within-stock variation (e.g. between year classes) in mean vertebral counts.

Experience within the Herring Assessment Working Group has shown that separation procedures based on size distributions often will fail. The introduction of otolith microstructure analysis in 1996-97 (Mosegaard & Popp-Madsen, 1996) enables an accurate and precise split between three groups, autumn, winter and spring-spawners. However, different populations with similar spawning periods are not resolved with the present level of analysis. Different stock components that are not easily distinguished by their otolith microstructure (OM), are considered to have different mean vertebral counts (vs) as, e.g., winter-spawning Downs herring: 56.6 (Hulme, 1995), and the small local stocks, the Skagerrak winter/spring-spawners: 57 (Rosenberg and Palmén, 1982). Further, the estimated stock specific mean vs count varies somewhat among different studies; North Sea: 56.5, Western Baltic Sea: 55.6 (Gröger & Gröhsler, 2001) and North Sea: 56.5, Western Baltic Sea: 55.8 (ICES 1992/H:5). Comparison between separation methods using frequency distributions of vertebral counts and otolith microstructure showed reasonable correspondence. Using this information the years from 1991 to 1996 was reworked in 2001, applying common splitting keys for all years by using a combination of the vertebral count and otolith microstructure methods (ICES, 2001/ACFM:12). From 2001 and onwards, the otolith-based method only has been used for the Division IIIa.

Different methods of identifying herring stocks in the Division IIIa and Subdivisions 22-24 were evaluated in EU CFP study project (EC study 98/026). The study involved several inter-calibration sessions between microstructure readers in the different laboratories involved with the WBSS herring. After the study was finished a close collaboration concerning reader interpretations has been kept between the Danish and Swedish laboratories. Sub-samples of the 2002 and 2003 Danish, Swedish, and German microstructure analyses were double-checked by the same Danish expert reader for consistency in interpretation. The overall impression is an increasingly good agreement among readers (Clausen *et al.*, 2007).

New molecular genetic approaches for stock separation are being developed within the EU-FP5 project HERGEN (EU project QLRT 200-01370). Sampling of spawning aggregations during spring, autumn and winter has been carried out in 2002 and in 2003 in Division IIIa and in the Western Baltic at more than 10 different locations. Preliminary results point at a substantial genetic variation between North Sea and Western Baltic herring (Bekkevold *et al*., 2005; 2007; Ruzzante *et al*., 2006).

After the introduction of otolith microstructure analysis in 1996 it was discovered that in the western Baltic a small percentage of the herring landings might consist of autumn-spawners individuals. Before molecular genetic methods became available for Atlantic herring the existence of varying proportions of autumn spawners in Subdivisions 22–24 in different years was considered a potential problem for the assessment.

B.5.2 Mixing of North Sea spawning components

The relative populations of the spawning components of herring in the North Sea vary over time and show different dynamics (see Dickey-Collas *et al*., 2010). These broad dynamics can be monitored through the surveys and of larvae (Schmidt *et al*. 2009; Payne, 2010) or investigated in the catch (Bierman *et al*, 2010). For conservation and biodiversity objectives it is important to monitor the dynamics and resilience of the different spawning components, especially when they experience differing exploitation rates or changes in productivity (Kell *et al*., 2009).

C. Historical Stock Development

C.1 Model used:

A benchmark assessment for North Sea herring was carried out in 2006. Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is ICA. However, the environment to execute the ICA has changed from the original ICA software into FLR (now called FLICA). Justification of the choice of assessment model, catch and survey weightings and the length of separable period are found in HAWG 2006 and Simmonds (2003; 2009). After extensive testing HAWG assumes there are no differences between the old ICA and FLICA. Thus FLICA was used to carry out the assessments after 2008.

The assessment has the same set-up and basic assumption as the assessment that was carried out last year. Input data are given in Tables 2.6.2.2. The ICA programme operates by minimising the following general objective function:

$$\sum \lambda_c \left(C - \hat{C}\right)^2 + \sum \lambda_i \left(I - \hat{I}\right)^2 + \sum \lambda_r \left(R - \hat{R}\right)^2$$

which is the sum of the squared differences for the catches (separable model), the indices (catchability model) and the stock-recruitment model.

The final objective function chosen for the stock assessment model was:

$$\sum_{a=0,y=1997}^{a=8,y=2002} \lambda_a \left(\ln(\hat{C}_{a,y}) - \ln(C_{a,y}) \right)^2 +$$
$$\sum_{y=1979}^{y=2002} \lambda_{mlai} \cdot \left(\ln(q_{mlai} . \widehat{SSB}_y^K) - \ln(MLAI_y) \right)^2 +$$
$$\sum_{a=1,y=1983^{**}}^{a=5+,y=2003} \lambda_{a,ibtsa} \left(\ln(q_{a,ibtsa} \cdot \hat{N}_{a,y}) - \ln(IBTS_{a,y}) \right)^2 +$$
$$\sum_{a=1,y=1989}^{a=9+,y=2002} \lambda_{a,acoust} \left(\ln(q_{a,acoust} \cdot \hat{N}_{a,y}) - \ln(ACOUST_{a,y}) \right)^2 +$$
$$\sum_{y=1977}^{y=2003} \lambda_{mik} \left(\ln(q_{mik} \cdot \hat{N}_{0,y}) - \ln(MIK_y) \right)^2 +$$
$$\sum_{y=1960}^{y=2002} \lambda_{ssr} \left(\ln(\hat{N}_{0,y+1}) - \ln\left(\frac{\alpha \, \widehat{SSB}_y}{\beta + \widehat{SSB}_y} \right) \right)^2$$

** 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
$\widehat{SSB}$	Estimated spawning stock size
MLAI	MLAI index (biomass index)
ACOUST	Acoustic index (age disaggregated)
IBTS	IBTS index (1-5+ ringers)
MIK	MIK index (0-ringers)
q	Catchability
k	power of catchability model
α, β	parameters to the Beverton stock-recruit model
λ	Weighting factor

Software used: FLICA, based on ICA (Patterson, 1998; Needle, 2000; Kell *et al*., 2007)

Model Options chosen:

The model settings should be as follows (as determined by the last benchmark, HAWG 2006)

FLICA control settings	Settings	Description
sr	TRUE	Stock and recruitment relationship
sr.age	1	age at recruitment
lambda.age	0.1 0.1 3.67 2.87 2.23 1.74 1.37 1.04 0.94 0.91	Weighting matrices for catch-at-age; for aged surveys; for SSB surveys
lambda.yr	1 1 1 1 1	Relative weights by year
lambda.sr	0.1	weight for the SRR term in the objective function
index.model	linear – IBTS Q1 linear – MIK linear – Acoustic power - MLIA	Catchability model for each survey
index.cor	False	Are the age-structured indices correlated across ages
sep.nyr	5	Number of years for separable model
sep.age	4	Reference age for fitting the separable model
sep.sel	1	Selection on last true reference age

Input data types and characteristics:

Type	*Name*	*Year range*	*Age range*	*Variable from year to year* *Yes/No*
Caton	***Catch in tonnes***	***1960-2009***		***Yes***
Canum	***Catch at age in numbers***	***1960-2009***	***0-9+***	***Yes***
Weca	***Weight at age in the commercial catch***	***1960-2009***	***0-9+***	***Yes***
West	***Weight at age of the spawning stock at spawning time.***	***1960-2009***	***1-9+***	***Yes (3 year running mean)***
Mprop	***Proportion of natural mortality before spawning***	***1960-2009***	***1-9+***	***No***
Fprop	***Proportion of fishing mortality before spawning***	***1960-2009***	***1-9+***	***No***
Matprop	***Proportion mature at age***	***1960-2009***	***1-9+***	***Yes***
Natmor	***Natural mortality***	***1960-2009***	***1-9+***	***No***

Tuning data:

Type	*Name*	*Year range*	*Age range (wr)*
Tuning fleet 1	***IBTS Q1***	***1984-2010***	***1-5***
Tuning fleet 2	***MIK***	***1992-2010***	***0***
Tuning fleet 3	***Acoustic***	***1989-2009***	***1-9+***
Tuning fleet 4	***MLAI***	***1973-2009***	***SSB***

C.2 Variance and weighting factors for ICA

In the ICA model a fixed set of inverse variance weights for surveys and catch at age have been used. In the benchmark assessment in 2006 (ICES 2006/ACFM:20) the weighting factors of the indices used in ICA were fixed and have been used with the same values since. This reflects a slight change from a major investigation in 2001 carried out by the Study Group on Evaluation of Current Assessment Procedures for North Sea herring (SGEHAP, ICES 2001/ACFM:22). The original weighting factors were derived from the survey and catch data by methods given in ICES 2001/ACFM:22 and Simmonds (2003). The variance used is the variance of the natural logarithm of the estimates of the index based on a 2 stage bootstrap procedure. The choice matches the use of a maximum log likelihood method with a lognormal error distribution used within the ICA model. All indices are treated in the same manner. The individual station estimates at all ages are bootstrapped using a simple resampling with replacement procedure. This provides a variance covariance estimate of estimates of indices at age for each index assuming identically independently distributed samples. (iid)

As the spatial distributions are correlated and the sampling on the surveys are non-random in space, the spatial autocorrelation was taken into account using geostatistics. The methodology is described in Rivoirard *et al*. (2000), who provide the formulae and methods required to estimate variograms and calculate the estimation variance. Petitgas and Lafont (1997) provide the free software (EVA2) that has been used here for calculating the estimation variance for all the surveys. The iid estimates are corrected to provide overall estimates of variance covariance estimates across ages for each survey. The mean variance covariance estimate for the survey time series 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 (Simmonds 2009). 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 intermediate year and SSB taken from the assessment one year after demonstrates that the current prediction procedure for stock numbers is working well.

Method

The procedure and programme used changed considerably and is a copy of the (MFSP Skagen; WD to HAWG 2003) code but rewritten in R. Both the Short Term Forecast Module North Sea (STFMNS, Hintzen) and the MFSP program have extensively been tested in 2009. 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.

Input data

Fleet Definitions

The current fleet definitions are:

North Sea

Fleet A: Directed herring fisheries with purse seiners and trawlers. By-catches in industrial fisheries by Norway are included.

Fleet B: Herring taken as by-catch under EU regulations.

Division IIIa

Fleet C: Directed herring fisheries with purse seiners and trawlers

Fleet D: By-catches of herring caught in the small-mesh fisheries

The fleet definitions are the same as last year.

In some years, it has been agreed that Norway can take parts of its IIIa quota in the North Sea. When estimating the expected catch in the intermediate year, it is assumed that this transfer takes place, hence the assumed catch by the C-fleet of both stocks combined is reduced and the catch by the A-fleet increased with the agreed amount.

Input Data for Short Term Projections: All the input data for the short term projections are shown in Table 2.7.1 – Table 2.7.11, which is the input file for the predictions.

Stock Numbers: For the start of the intermediate year the stock numbers at age by 1. Jan that year are taken from the prediction made by ICA.

Recruitment: For the prediction years, the recruitment has in recent years been set to the geometric mean of the recruitments of the year classes from 2001 onwards, as estimated in this year's assessment. The low recruitment was assumed because all the year classes from 2001 onwards have been poor except for 2008 year class. Analysis of the time series of SSB and recruitment data by the SGRECVAP (ICES CM 2006/LRC:03) clearly indicates a shift in the recruitment success in 2001. The underlying cause for the change in 2001 is not clear, but there is no evidence to justify an assumption of long term average recruitment in the near future. Consequently, the advice is adapted to the current low recruitment regime.

Fishing Mortalities: Selection by fleet at age is calculated by splitting the total fishing mortality in the last assessment year at each age (from the assessment output) proportional to the catches by fleets at that age. These selections at age were used for all years in the prediction.

Mean weights in the catch by fleet: The 3 year average mean weights at age for each fleet are used for all prediction years, unless there are indications that some year class has abnormal growth.

Mean Weights at age in the stock: The weights at age applied in the last assessment year were used for all predictions years. These are running averages of the raw data. In previous years, the procedure was different, to account for the special growth of the 2000 year class.

Maturity at age: The 3 years average maturity was used.

Natural Mortality: Equal to those assumed in the assessment.

Proportion of M and F before spawning: Standard values of 0.67 for both.

Prediction

Assumptions for the intermediate year.

A-fleet: The TAC for the A fleet has been over-fished every year since 2003 until 2008. In 2009 however the catches equalled the TAC and it is assumed that this will be the case in the intermediate year as well.

The catches by the B-fleet have been well below the by-catch quota for the B-fleet. The quota has been reduced recently, and the fraction used has increased. Therefore, the same fraction as last year is assumed. Also the C and D fleets have catches well below the quota, partly because the quota also includes WBSS herring. For 2010, the same fraction as in 2009 was assumed; previously a 3 year average has been used in some cases.

Points of interpretation:

In years when Norway is allowed to transfer some of its quota in IIIa to IV, this transfer is assumed in the predictions

Management Option Tables for the TAC year

The EU-Norway agreement on management of North Sea herring was updated in 2008, to adapt to the present reduced recruitment, accounting for the results by WKHMP. The revised rule specifies fishing mortalities for juveniles (F_{0-1}) and for adults (F_{2-6}) not to be exceeded, at 0.05 and 0.25 respectively, for the situation where the SSB is above 1.5 million tonnes. When the SSB is below 1.5 million tonnes F is reduced to give

$F_{2-6} = 0.25-(0.15*(1500-SSB)/700)$,

with allowance for a stronger reduction in TAC if necessary. Below 0.8 million tonnes $F_{2-6} = 0.1$ and $F_{0-1} = 0.04$.

Furthermore, there is a constraint at 15% change in the TAC from one year to the next. The F_{0-1} and F_{2-6} stated in the rule are assumed to apply to the total F summed over all fleets. The SSB referred to is taken to be the SSB in the prediction year, i.e. the fishing mortalities for 2010 should reflect its consequence for SSB in 2010.

Catches by the C and D fleet influence the fishing opportunities for the B-fleet in particular, since the NSAS herring caught by these fleets mostly are at age 0-2. The assumed catch of NSAS herring by the C and D fleets is derived according to a likely TAC for WBSS herring in a three step procedure:

1) The fraction of the total TAC for WBSS that is taken in Division IIIa is assumed to be the same as last year, giving an expected catch of WBSS in Division IIIa.
2) The WBSS caught in Division IIIa is allocated to the C and D fleets assuming the same share as last year. The total expected catch of WBSS in IIIa is split accordingly, which gives expected catch of WBSS by fleet.
3) Using the ratio between NSAS and WBSS in the catches by each fleet, the total catch by fleet and the catch of NSAS by fleet are derived from the catch of WBSS by fleet.

These expected catches of NSAS by the C and D fleets are used as catch constraints in the prediction.

The basis for deriving these catches is weak. The main purpose is to provide realistic assumptions on the impact of these fleets when predicting the catches for the North Sea fleets. The effect of other assumptions for the C and D fleet should be calculated if needed, but are not presented in the advice.

The catches for the A and B fleets are derived according to the harvest rule.

When the harvest rule leads to SSB below the trigger biomass (1.5 million tonnes), an iterative procedure is needed to find a fishing mortality and a corresponding SSB in accordance with the rule. At present, this is done manually by scanning over ranges of F for the A and B fleet.

E. Medium-Term Projections – *–are made as needed.*

Model used: 10 year stochastic prediction Software used: STPR3 has been used as a standard in the past, as it allows for independent regulations of two 'flles' (fisheries)

Initial stock size: As for the short term prediction, but with random variation according the variance-covariance matrix taken from the ICA assessment

Natural mortality: Constant as in the assessment

Maturity: As in the short term prediction

F and M before spawning: Constant values: 0.67 for both.

Weight at age in the stock: Obtained each projection year by drawing a historical year randomly and using the weights from that year.

Weight at age in the catch: As weight at age in the stock.

Exploitation pattern: As for short term forecast. Fleet A separately, fleets B-C-D merged.

Intermediate year assumptions: As for short term prediction

Stock recruitment model used: Beverton Holt or Hockey stick

Uncertainty models used:

Initial stock size: See above

Natural mortality: Constant

Maturity: Constant

F and M before spawning: Constant

Weight at age in the stock: See above

Weight at age in the catch: See above

Exploitation pattern: Constant

Intermediate year assumptions: Constant

Stock recruitment model used: Log-normal variation around a stock-recruit function with fixed parameters. Opportunity to truncate the distribution.

F. Long-Term Projections – *–not done since 1996*

G. Biological Reference Points

The precautionary reference points for this stock were adopted in 1998. The situation has now arisen that North Sea herring is nominally being managed by a precautionary management plan, although the SSB is now below the precautionary biomass reference point. We consider that the critical issue is identifying the risk of SSB falling below B_{lim}. 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 B_{lim}

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 B_{lim} (800 000 tonnes) was set at a level below which the recruitment may become impaired and was also the formally used MBAL. In 2007, WKREF (ICES CM 2007/ACFM:05) explored limit reference points for North Sea herring and concluded that there is no basis for changing B_{lim}. A low risk of SSB falling below B_{lim} is therefore the basis of ICES precautionary advice.

F_{pa} and B_{pa}

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

Concept of a management plan (harvest control rule)

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

Concept of precautionary reference points

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

ICES will accept that a harvest control rule is in accordance with the precautionary approach as long as it implies a low risk to being below B_{lim}, even if other reference points may be exceeded occasionally. When a rule is regarded as precautionary, ICES gives its advice according to the rule. If the rule is followed, then ICES classifies exploitation as precautionary. Within this framework, other precautionary reference points generally will be redundant. However, the precautionary reference points may also be used to classify the stock with respect to precautionary limits, which may lead to a conflicting classification. This discrepancy is still unresolved. 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 F_{pa} or B_{pa}.**

The consequences for the management plan and the reference points of the development of the MSY approach is currently unknown.

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. Herring originated in the Pacific and colonised the Atlantic approximately 3 million years ago. The herring's unique habit is that it produces benthic eggs which are attached to a gravely substrate on the seabed (Geffen 2009). Herring evolved from fish that spawned in rivers and at some later date re-adapted to the marine environment (Geffen 2009). The spawning grounds in the southern North Sea are located in the beds of rivers which existed in geological times and some groups of spring spawning herring still spawn in very shallow inshore waters and estuaries. Spawning typically occurs on coarse gravel (0.5-5 cm) to stone (8-15 cm) substrates and often on the crest of a ridge rather than hollows. For example, in a spawning area in the English Channel, eggs were found attached to flints 2.5-25 cm in length, where these occurred in gravel, over a 3.5 km by 400m wide strip.

As a consequence of the requirement for a very specific substrate, spawning occurs in small discrete areas in the near coastal waters of the western North Sea (Schmidt *et al.*, 2009). They extend from the Shetland Isles in the north through into the English Channel in the south. Within these specific areas actual patches of spawn can be extremely difficult to find.

The fecundity of herring is length related and varies between approximately 10 000 and 60 000 eggs per female (Damme *et al.*, 2009). This is a relatively low fecundity for 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 growth. Over the past 15 years the proportion mature at age 3 years (2 ringers) has ranged from 47% to 86% and for 4 year old fish (3 winter ringers) from 63% to 100%. Above that age, all are considered to be mature.

The benthic eggs take about three weeks to hatch dependant on the temperature. The larvae on hatching are 6 mm to 9 mm long and rise due to buoyancy changes to become planktonic (Dickey-Collas *et al*, 2009). Their yolk sac lasts for a few days during which time they will begin to feed on phytoplankton and small zooplankton. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to various coastal nursery areas on both sides of the North Sea and into the Skagerrak and Kattegat (Heath *et al.*, 1997).

Herring continue to be mainly planktonic feeders throughout their life history although there are numerous records of them taking small fish, such as sprat and sandeels, on an opportunistic basis. Calanoid copepods, such as *Calanus*, *Pseudocalanus* and *Temora* and the Euphausids, *Meganyctiphanes* and *Thysanoessa* still form the major part of their diet during the spring and summer (Hardy, 1924; Savage, 1937; Bainbridge and Forsyth, 1972; Last, 1989) and are responsible for the very high fat content of the fish at this time. They also consume fish eggs (Segers *et al*., 2007).

In the past, herring age has been determined by using the annual rings on the scales. In more recent years the growth rings on the otolith have proved more reliable for age determination. Herring age is expressed as number of winter rings on the otolith rather than age in years as for most other teleost species where a nominal 1 January birth date is applied. Autumn spawning herring do not lay down a winter ring during their first winter and therefore remain as '0' winter ringers until the following winter. When looking at year classes, or year of hatching, it must be remembered that they were spawned in the year prior to their classification as '0' winter ringers.

North Sea herring comprise both spring and autumn spawning groups, but the major fisheries are carried out on the offshore autumn/winter spawning fish. The spring spawners are found mainly as small discrete coastal groups in areas such as The Wash, the Thames estuary, Danish Fjords and the now extinct Zuiderzee herring. Juveniles of the spring spawning stocks are found in the Baltic, Skagerrak and Kattegat, and may also be found in the North Sea as well as Norwegian coastal spring spawners. There is thought to be an input of larvae from the west of Scotland (Heath *et al*., 1997).

The main autumn spawning begins in the northern North Sea in August and progresses steadily southwards through September and October in the central North Sea to November and as late as January in the southern North Sea and eastern English Channel. The widespread but discrete location of the herring spawning grounds throughout the western North Sea has been well known and described since the 19th century (Heincke, 1898; Bjerkan, 1917). This led to considerable scientific debate and eventually to investigation and research on stock identity. The controversy centred on whether or not the separate spawning grounds represented discrete stocks or 'races' within the North Sea autumn spawning herring complex (McQuinn, 1997). Resolution of this issue became more urgent as the need for the introduction of management measures increased during the 1950's. The International Council for the Exploration of the Sea (ICES) encouraged tagging and other racial studies and a review of all the historic evidence to resolve this problem and innovative approaches to assessing mixed and connective stocks (Secor *et al*., 2009; Kell *et al*., 2009). The conclusions were the basis for establishing the working hypothesis that the North Sea autumn spawning herring comprise a complex of at least four spawning components each with separate spawning grounds, migration routes and nursery areas. There is mixing between these components during the summer

The main four spawning components are:

- The Orkney/Shetland component which spawn from July to early September in the Orkney Shetland area. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.
- The Buchan component which spawn from August to early September off the Scottish east coast. Nursery areas for fish up to two years old are found

along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.

- The Banks or central North Sea component, which derive their name from their former spawning grounds around the western edge of the Dogger Bank. These spawning grounds have now all but disappeared and spawning is confined to small areas along the English east coast, from the Farne Islands to the Dowsing area, from August to October. The juveniles are found along the east coast of England, down to the Wash, and also off the west coast of Denmark.
- The Downs component which spawns in very late Autumn through to February in the southern Bight of the North Sea and in the eastern English Channel. The drift of their larvae takes them north-eastwards to nursery areas along the Dutch coast and into the German Bight (Burd 1985).

At certain times of the year, individuals from the three stock units may mix and are caught together as juveniles and adults but they cannot be readily separated in the commercial catches other than using otolith methods (Clausen *et al*, 2007; Bierman *et al*., 2009). However North Sea autumn spawning herring are managed as a single unit with the understanding that they comprise of many spawning components.

A further complication is that juveniles of the North Sea stocks are found, outside the North Sea, in the Skagerrak and Kattegat areas and are caught in various fisheries there. The proportions of juveniles of North Sea origin, found in these areas varies with the strength of the year class, with higher proportions in the Skagerrak and Kattegat when the year class is good.

Recruitment strength is determined during the larval phase (Nash & Dickey-Collas 2005) and this is likely to occur prior to the larvae being 20mm in length (Oeberst *et al*., 2009).

H.2 Stock dynamics, regulation and catches through 20th century

Over many centuries the North Sea herring fishery has been a cause of international conflict sometimes resulting in war, but in more recent times in bitter political argument. The North Sea herring fishery has a long history and catches between 1600 and 1850 were usually between 40 000 and 100 000 tonnes per year (Poulsen 2006). Catching opportunities for the fishery were known to be variable. Since the 1900s the annual average catch was 450 Kt. Changes in fleet catching potential have been driven both by changes in catching power and in response to changes in market requirements, particularly the demand for fish meal and oil. Most of these changes have resulted in greater exploitation pressures that increasingly led to the urgent need to ensure a more sustainable exploitation of North Sea herring. Such pressures really began to exert themselves for the first time during the 1950's when the spawning stock biomass of North Sea autumn spawning herring fell from 5 million tonnes in 1947 to 1.4 million tonnes by 1957 (Simmonds 2007, 2009). That period also witnessed the decline and eventual disappearance of a traditional autumn drift net fishery in the southern North Sea (Burd, 1978).

At the time and with the exception of the 12-mile coastal zone, the North Sea was still a free fishing area and the stock was exploited by fleets from at least 14 different nations (ICES, 1977). Despite the conclusions of the ICES Herring Assessment Working Group becoming more alarming each year (ICES, 1977), the North East Atlantic Fisheries Convention (NEAFC) had no mandate to impose measures unless they were agreed by all member states (Ackefors, 1977). As a consequence, NEAFC could only agree on measures that constituted no real obstacle to any of the national fleets involved (Simmonds, 2007).

The annual landings from 1947 through to the early 1960's were high, but stable, averaging around 650 000t (Cushing and Bridger, 1966). Over the period 1952-62, the high fishing mortality (F 0.4 ages 2-6) resulted in a rapid decline in the spawning stock biomass from around 5 million tonnes to 1.5 million tonnes.

Fishing mortality on the herring in the central and northern North Sea began to increase rapidly in the late 1960's and had increased to F1.3 ages 2-6, or over 70% per year of those age classes, by 1968. Landings peaked at over 1 million tonnes in 1965, around 80% of which were juvenile fish. This was followed by a very rapid decline in the SSB and the total landings. By 1975 the SSB had fallen to 83 500 t, although the total landings were still over 300 000t (Simmonds 2007). At the same time, spawning in the central North Sea had contracted to the grounds off the east coast of England whilst spawning grounds around the edge of the Dogger Bank were no longer used. Recruitment collapsed. This heralded the serious decline and collapse of the North Sea autumn spawning herring stock which led to the moratorium on directed herring fishing in the North Sea from 1977 to 1981 (Cushing, 1992; Dickey-Collas *et al.*, 2010).

On the 1st of January 1977, all countries around the North Sea extended their exclusive economic zones (EEZ) to 200 miles (Coull, 1991). The North Sea was no longer a free fishing area and suddenly national governments could introduce conservation measures within their own areas. Using this opportunity, the British government was the first (March 1st, 1977) to declare a total ban on all directed herring fisheries in the British EEZ (Coull, 1991). Other governments were slow to follow. The scientific argument that a closure of the fishery was required finally persuaded all other countries to join in. By the end of June 1977, all directed herring fisheries in the North Sea ceased.

In general, the fishing ban was well respected, except in the Channel area where local trawlers continued to fish small quantities of spawning herring (ICES, 1982). Also, herring could still be landed as a by-catch taken in other fisheries, and limited directed fishing did occur on this basis. It was during this time that the European Union agreed on a Common Fisheries Policy and took responsibility for the management in all community waters. Some fleets moved to exploit herring stocks in adjacent areas. Following reports of a recovery of the Downs component, a small TAC for the southern North Sea and Channel area was set in 1981 and 1982. The ban on directed fishing in other areas of the North Sea was lifted in June 1983.

International larvae surveys and acoustic surveys were used to monitor the state of the stocks during the moratorium. By 1980 these surveys were indicating a modest recovery in the SSB from its 1977 low point of 52 000 t. By 1981 the SSB had increased to over 200 000 t. This was associated with an increase in the productivity of the stock, i.e. apparent compensatory recruitment (Nash *et al.*, 2009). Once the fishery reopened in 1981 the North Sea autumn spawning herring stock was managed by a Total Allowable Catch (TAC) constraint through the EU Common Fisheries Policy and agreement with Norway. The TAC was only applied to the directed herring fishery in the North Sea which exploited mainly adult fish for human consumption. Targeted fishing for herring for industrial purposes was banned in the North Sea in 1976 but there was a 10% by-catch allowance in the fisheries for other species, including the small meshed fisheries for industrial purposes, mainly for sprat. Following the reopening of the now controlled fishery the SSB steadily increased, peaking at 1.3 million tonnes in 1989. Annual recruitment was well above the long-term average over this period. The 1985 year class was the biggest recorded since 1960 and the third highest in the records dating back to 1946 (Nash *et al.*, 2009). Landings also steadily increased over this period reaching a peak of 876 000 tonnes in 1988. This resulted from a steady increase in fishing mortality to $F_{ages\ 2\text{-}6}$ = 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 further increased 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 ICES advice

In 1996, the total allowable catches (TACs) for Herring caught in the North Sea (ICES areas IV and Division VIId) were changed mid-year with the intention of reducing the fishing mortality by 50% for the adult part of the stock and by 75% for the juveniles. For 1997, the regulations were altered again to reduce the fishing mortality on the adult stock to 0.25 and for juveniles to less than 0.1 with the aim of rebuilding the SSB up to 1.1 million t in 1998 (Simmonds 2007).

According to the EU and Norway agreement adopted in December 1997, efforts should be made to maintain the SSB above the MBAL (Minimum Biologically Acceptable Level) of 800 000 tonnes. An SSB reference point of 1.3 million has been set above which the TACs will be based on an F= 0.25 for adult herring and F= 0.12 for juveniles. If the SSB falls below 1.3 million tonnes, other measures will be agreed and implemented taking account of scientific advice. The management agreement was revised in 2004 and now reads:

The stock is managed according to the EU-Norway Management agreement which was updated in November 2008, the relevant parts of the text are included here for reference:

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

0.25-(0.15*(1,500,000-SSB)/700,000) for 2 ringers and older, and no more than 0.05 for 0 - 1 ringers

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

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

H.4 Sampling of commercial catch

Sampling of commercial catch is conducted by the national institutes. HAWG has recommended for years that sampling of commercial catches should be improved for most of the stocks. In January 2008, a new directive for the collection of fisheries data was implemented for all EU member states (Commission Regulations 2008/949/EC, 2008/199 and 2008/665). The provisions in the "data directive" define specific sampling levels. As most of the nations participating in the fisheries on herring assessed here have to obey this data directive, the definitions applicable for herring and the area covered by HAWG are given below:

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

Exemptions to the above mentioned sampling rules are:

Concerning lengths:

(1) the national 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

I. References

References have not been thoroughly checked this year and are likely to be incomplete!

Ackefors, H. 1977. Production of Fish and Other Animals in the Sea. Ambio, 6: 192-200.

Bainbridge, V and Forsyth, DCT (1972). An ecological survey of a Scottish herring fishery. Part V: The plankton of the northwestern North Sea in relation to the physical environment and the distribution of the herring. Bulletins of Marine Ecology 8: 21-52.

Borges L, van Keeken OA, van Helmond ATM, Couperus B, Dickey-Collas M (2008). What do pelagic freezer-trawlers discard? ICES J Mar Sci. 65: 605–611

Bowers, A. B. (1969). Spawning beds of Manx autumn herrings. J. Fish Biol. 1, 355-359.

Burd, AC (1978). Long term changes in North Sea herring stocks. Rapp. P.-v. Réun. Cons. Int. Explor. Mer, 172: 137-153

Burd, AC (1985) Recent changes in the central and southern North Sea herring stocks. Can. J. Fish. Aquatic Sci., 42 (Suppl 1): 192-206

Bekkevold, D., Carl André, Thomas G. Dahlgren, Lotte A. W. Clausen, Else Torstensen, Henrik Mosegaard, Gary R. Carvalho, Tina B. Christensen, Erika Norlinder, and Daniel E. Ruzzante (2005): Environmental correlates of population differentiation in Atlantic herring. Evolution, 59(12): 2656–2668

Bekkevold, D., Lotte A. W. Clausen, Stefano Mariani, Carl André, Tina B. Christensen, Henrik Mosegaard (2007): Divergent origins of sympatric herring population components determined using genetic mixture analysis. Mar Ecol Prog Ser Vol. 337: 187–196.

Bierman, S. M., Dickey-Collas, M., Damme, C. J. C. van, Overzee, van H. J., Pennock-Vos, M. G., Tribuhl, S. V., Clausen, L. A. W. (2010). Between-year variability in the mixing of North Sea herring spawning components leads to pronounced variation in the composition of the catch. ICES Journal of Marine Science, 67: 000-000. doi:10.1093/icesjms/fsp300

Bjerkan P. (1917). Age, maturity and quality of North Sea herrings during the years 1910-13. Rep. Norw. Fish. Mar. Invest. III no 1.

Clausen LAW, Bekkevold D, Hatfield EMC, Mosegaard H (2007) Application and validation of otolith microstructure as stock identifier in mixed Atlantic herring (Clupea harengus) stocks in the North Sea and western Baltic. ICES J Mar Sci 64:1–9

Corten, A. (1986). On the causes of the recruitment failure of herring in the central and northern North

Coull, J. R. 1991. The North Sea herring fishery in the twentieth century. In The development of integrated sea use management, pp 122-138. Ed by Smith, H.D. and Vallega, A. Routledge, New York.

Couperus, A.S. (1997). Interactions Between Dutch Midwater Trawl and Atlantic Whitesided Dolphins (*Lagenorhynchus acutus*) Southwest of Ireland. Northw. Atl. Fish. Sci., Vol. 22: 209–218

Couperus, A.S. (2009). Annual Report of the Netherlands to the European Commission on the implementation of Council Regulation 812/2004 on cetacean bycatch Results of fishery observations collected during 2008. Centre for Visserij Onderzoek report: CVO 09.006.

Cushing, D.H. 1955. On the autumn spawned herring races of the North Sea. J.Cons.perm.int.Explor.Mer., 21, 44-60.

Cushing, DH (1992). A short history of the Downs stock of herring. ICES J. mar. Sci., 49: 437-443.

Cushing, D.H. and Bridger, J.P. 1966. The stock of herring in the North Sea and changes due to the fishing. Fishery Invest. Lond., Ser.II, XXV, No.1,123pp.

Damme, C. J. G. van, Dickey-Collas, M., Rijnsdorp, A. D., and Kjesbu, O. S. 2009. Fecundity, atresia and spawning strategies in Atlantic herring. Canadian Journal of Fisheries and Aquatic Sciences, 66: 2130-2141.

Dickey-Collas, M., Bolle, L. J., van Beek, J. K. L., and Erftemeijer, P. L. A. 2009. Variability in transport of fish eggs and larvae. II. The effects of hydrodynamics on the transport of Downs herring larvae. Marine Ecology Progress Series, 390: 183-194.

Dickey-Collas, M., Nash, R. D. M., Brunel, T., Damme, C. J. G. van, Marshall, C. T., Payne, M. R., Corten, A., Geffen, A. J., Peck, M. A., Hatfield, E. M. C, Hintzen, N. T., Enberg, K., Kell, L. T., and Simmonds, E. J. 2010. Lessons learned from stock collapse and recovery of North Sea herring: a review. - ICES Journal of Marine Science, 67: 000-000. in press

De Groot (1980). The consequences of marine gravel extraction on the spawning of herring, *Clupea harengus* Linné. J. Fish. Biol. 16, 605-611.

DEFRA (2003). UK Small cetacean by-catch response strategy.

EC Control Regulation : Regulation 2847/93 establishing a control system applicable to the CFP

EC Proposal CEM (2003) 451 final. Laying down measures concerning incidental catches of cetaceans in fisheries and amending Regulation (EC) No 88/98

EC REGULATION (EC) No 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy

EC REGULATION (EC) No 665/2008 of 14 July 2008 laying down detailed rules for the application of Council Regulation (EC) No 199/2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy

EC DECISION of 6 November 2008 adopting a multiannual Community programme pursuant to Council Regulation (EC) No 199/2008 establishing a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy (2008/949/EC)

EC Satellite monitoring : Regulation 2930/86 defining characteristics for fishing vessels (Article 3 deals with VMS).

EC Technical Conservation : Regulation 850/98 (as amended in particular by Regulation 1298/2000) on the conservation of fisheries resources through technical measures for the protection of juveniles.

EU Quota Regulations for 2003 : Regulation 2341/2002 fixing the fishing opportunities --- for community vessels in waters where catch limitations are required.

Geffen, A. J. 2009. Advances in herring biology: from simple to complex, coping with plasticity and adaptability. ICES Journal of Marine Science, 66: 1688–1695.

Gröger, J., and Schnack, D. 1999. History and status quo of the international herring larvae survey (IHLS) in the North Sea. Information für die Fischwirtschaft aus der Fischereiforschung, 46: 29–33.

Gröger, J., Schnack, D., and Rohlf, N. 2000. Optimisation of survey design and calculation procedure for the international herring larvae survey in the North Sea. Archiv für Fischerei und Meeresforschung, 49: 103–116.

Gröger, J. and Gröhsler, T. 2001. Comparative analysis of alternative statistical models for herring stock discrimination based on meristic characters. J. Appl. Ichthy. 17(5):207-219.

Hansen, V. Kr. (1955). The food of the herring on the Bløden Ground (North Sea) in 1953. J. Cons. Perm. Int. Explor. Mer 21, 61-64

Hardy, A.C. (1924). The herring in relation to its animate environment. Part 1. The food and feeding habits of herring with specific reference to the east coast of England. Fishery Invest., Lond., Ser. II, 7(3), 1-53

Heath, M., Scott, B. & Bryant, AD (1997). Modelling the growth of herring from four different stocks in the North Sea. J Sea Research 38: 413-436.

Heincke F, (1898). Naturgeschichte des Herings. Abhandl. Deutschen Seefisch Ver II

Helmond van A.T.M. and Overzee, van H M J.(2010a). Estimates of discarded herring by Dutch flagged vessels 2003-2009 and other PFA vessels in 2009. Working Document to the Hering assessment working Group. 4pp.

Helmond van A.T.M. and Overzee, van H M J.(2010b). Can pelagic freezer trawlers reduce discarding?. Working Document to the Hering assessment working Group. 4pp.

HERGEN 2000. EU Project QLRT 200-01370.

Heessen, H.J.L., Dalskov, J. and Cook, R.M. (1997). The International Bottom Trawl Survey in the North Sea, the Skagerrak and Kattegat. ICES CM 1997/Y:31. 23pp

Hulme, T.J. 1995. The use of vertebral counts to discriminate between North Sea herring stocks. ICES J. Mar. Sci., 52: 775–779.

Huntington, T., C. Frid, I. Boyd, I. Goulding and G. Macfadyen (2003). 'Determination of Environmental Variables of Interest for the Common Fisheries Policy Capable of Regular Monitoring'. Final Report to the European Commission. Contract SI2.348197 of Fish/2002/13.

ICES (1969). Preliminary report of the assessment group on North Sea Herring. CM.1969/H:4. Copenhagen, 6 - 11 January 1969

ICES. 1977. Assessment of herring stocks south of 62°N, 1973 – 1975. ICES Cooperative Report Series No. 60, 117 pp.

ICES. 1982. Report of the Herring Assessment Working Group South of 62oN (HAWG). ICES CM 1982/Assess:17. 127 pp.

ICES (2002). Report of the Workshop on MSVPA in the North Sea. Resource Management Committee ICES CM 2002/D:04. Charlottenlund, Denmark. 8–12 April 2002

ICES (2003a). Report of the Herring Assessment Working Group for the Area South of 62°N Advisory Committee on Fishery Management ICES CM 2003/ACFM:17. ICES Headquarters, 11–20 March 2003

ICES (2003b). Report of the Planning Group for Herring Surveys. Living Resources Committee ICES CM 2003/G:03. Aberdeen, UK 21–24 January 2003

ICES 1990. Report of the Herring Assessment Working Group for the Area South of 62 oN. ICES C.M. 1990/Assess: 14. (mimeo).

ICES 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/Assess:15.

ICES 1992. Report of the Workshop on Methods of Forecasting Herring Catches in Division IIIa and the North Sea. ICES CM 1992/H:5.

ICES 1993. Report of the Herring Assessment Working Group for the Area South of 62 oN. ICES C.M. 1993/Assess: 15. (mimeo).

ICES 2001a. Herring Assessment WG for the Area South of 62° N. CM 2001/ACFM:12.

ICES 2001b. Report of the Advisory Committee on Fishery Management. ICES ACFM May 2001.

ICES 2001. Report of the Study Group on Evaluation of Current Assessment procedures for North Sea herring. ICES 2001 CM /ACFM:22

ICES 2002a. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2002/ACFM:12 (mimeo).

ICES 2002b. Report of the Advisory Committee on Fisheries Management, ICES ACFM May 2002.

ICES 2003. Report of the Advisory Committee on Fishery Management. ICES ACFM May 2003.

ICES 2006. Report of the Herring Assessment Working Group. ICES 2006 CM /ACFM:20

ICES 2006. Report of the Herring Assessment Working Group. ICES 2006 CM /ACFM:20

Jennings, S. and M.J. Kaiser (1998). The effects of fishing on the marine ecosystem. Advances in Marine Biology Vol. 34 (1998) 203-302

Kell, L. T., Mosqueira, I., Grosjean, P., Fromentin, J-M., Garcia, D., Hillary, R., Jardim, E., Mardle, S., Pastoors, M. A., Poos, J. J., Scott, F., and Scott, R. D. 2007. FLR: an open-source framework for the evaluation and development of management strategies. – ICES Journal of Marine Science, 64: 640–646.

Kell, L. T., Nash, R. D. M., Dickey-Collas, M., Pilling, G. M., Hintzen, N. H., and Roel, B. A. 2009. Lumpers or splitters? - evaluating recovery and management plans for metapopulations of herring. ICES Journal of Marine Science, 66: 1776-1783.

Kuklik, I., and Skóra, K.E. 2000 (in press). By-catch as a potential threat for harbour porpoise (*Phocoena phocoena* L.) in the Polish Baltic Waters. NAMMCO Scientific Publications.

Last, JM (1989). The food of herring Clupea harengus, in the North Sea, 1983-1986. J Fish Biol, 34: 489-501.

Mackinson S. 2001. Representing trophic interactions in the North Sea in the 1880s, using the Ecopath mass-balance approach. In Fisheries impacts on North Atlantic ecosystems: models and analyses, pp. 35-98. Ed. by S. Guenette, V. Christensen, and D. Pauly. Fisheries Centre Research Reports, 9 (4).

Mackinson, S., and Daskalov, G. 2007. An ecosystem model of the North Sea to support an ecosystem approach to fisheries management: description and parameterisation. Science Series, Technical Reports, Cefas Lowestoft, 142: 195pp.

Mariani, Hutchinson, W.F. Hatfield, E.M.C., Ruzzante D.E., Simmonds, J., *et al*. (2005). North Sea herring population structure revealed by microsatellite analysis. Mar Ecol Prog Ser 303: 245–257, 2005

McQuinn, IH (1997). Metapopulations and the Atlantic herring. Reviews in Fish Biology and Fisheries 7: 297-329.

Misund, O.A. and A.K. Beltesand (1991). Dogelighet av sild ved lassetting og simulert notsprengning. Fiskens Gang, 11: 13-14

Morizur, Y., Berrow, S.D., Tregenza, N.J.C., Couperus, A.S., and Pouvreau, S. 1999. Incidental catches of marine-mammals in pelagic trawl fisheries of the Northeast Atlantic. Fisheries Research, 41: 297–307.

Napier, I.R., A. Robb and J. Holst (2002). Investigation of Pelagic Discarding. Final Report. EU Study Contract Report 99/071. North Atlantic Fisheries College and the FRS Marine Laboratory. August 2002.

Napier, I.R., A.W. Newton and R. Toreson (1999). Investigation of the Extent and Nature of Discarding from Herring and Mackerel Fisheries in ICES Sub-Areas IVa and VIa. Final Report. EU Study Contract Report 96/082. North Atlantic Fisheries College, Shetland Islands, UK. June 1999.

Nash, RDM & Dickey-Collas M (2005). The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (Clupea harengus L.). Fish Oceanogr 14: 279-291

Nash, RDM, Dickey-Collas, M & Milligan, SP (1998). Descriptions of the Gulf VII/Pro-Net and MAFF/Guildline unencased highspeed plankton samplers. J Plankton Res 20: 1915-1926

Nash, RDM, Dickey-Collas, M, Kell, LT (2009). Stock and recruitment in North Sea herring (Clupea harengus); compensation and depensation in the population dynamics.. Fisheries Research 95: 88-97

Nichols, J.H. 2001. Management of North Sea Herring and Prospects for the New Millennium. (pp 645- 655 in 'Herring: Expectations for a new millennium.' University of Alaska Sea Grant, AK-SG-01-04, Fairbanks. 800 pp.)

Northridge, S.P. (2003). Seal by-catch in fishing gear. SCOS Briefing Paper 03/13. NERC Sea Mammal Research Unit, University of St. Andrews, UK pp1

Oeberst, R., Klenz, B., Gro¨hsler, T., Dickey-Collas, M., Nash, R. D. M., and Zimmermann, C. 2009. When is year-class strength determined in western Baltic herring? ICES Journal of Marine Science, 66: 1667–1672.

Ogilvie, H.S. (1934). A preliminary account of the food of herring in the north-western North Sea. Rapp. P.-v Cons. Reun. Int. Explor. Mar 89, 85-92

Patterson, K.R. 1998: A programmeme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Patterson, K.R. and D.S. Beveridge, 1995: Report of the herring larvae surveys in the North Sea and adjacent waters in 1994/1995. ICES CM 1995/H:21

Patterson, K.R., and G.D. Melvin. 1996. Integrated catch at age analysis, version 1.2. Scottish Fisheries Research Report No. 38. Aberdeen.

Payne, M. R. 2010. Mind the gaps: a model robust to missing observations gives insight into the dynamics of the North Sea herring spawning components. ICES Journal of Marine Science, 67: 000-000. In press.

Payne MR, Hatfield EMC, Dickey-Collas, M, Falkenhaug, T, Gallego, A, Gröger, J., Licandro, P, Llope, M, Munk, P, Röckmann, C, Schmidt, JO & Nash, RDM (2009). Recruitment in a changing environment: the 2000s North Sea herring recruitment failure. ICES J Mar Sci. 66: 272-277; doi:10.1093/icesjms/fsn211

Petitgas, P. & Lafont, T. 1997. Estimation and Variance EVA2. (http://pierre.petitgas@ifremer.fr).

Pierce, G.J., J. Dyson, E. Kelly, J. Eggleton, P. Whomersley, I.A.G. Young, M. Begoña Santos, J. Wang and N.J. Spencer (2002). Results of a short study on by-catches and discards in pelagic fisheries in Scotland (UK). Aquat. Living. Resour. 15 (2002) 327-334

Poulsen, B. 2006. Historical exploitation of North Sea herring stocks – an environmental history of the Dutch herring fisheries, c. 1600–1860. PhD dissertation, Centre for Maritime and Regional Studies, Department of History and Civilization, University of Southern Denmark.

Reiss H, Hoarau G, Dickey-Collas, M, Wolff WG (2009) Genetic population structure of marine fish: mismatch between biological and fisheries management units. Fish and Fisheries doi: 10.1111/j.1467-2979.2008.00324.x

Rivoirard, J., Simmonds, J., Foot, K. G., Fernandes, P. G., and Bez, N., 2000. Geostatistics for Fish Stock Estimation. Blackwell, London.

Rosenberg, R. and Palmén, L.-E. 1982. Composition of herring stocks in the Skagerrak-Kattegat and the relations of these stocks with those of the North Sea and adjacent waters. Fish. Res., 1:83–104.

Ruzzante DE, Mariani S, Bekkevold D, André Henirk Mosegaard, Lotte A.W. Clausen, Thomas G. Dahlgren, Willian F. Hutchinson, Emma M.C. Hatfield, Else Torsensen, Jennifer Brigham, E. John Simmonds, Linda Laikre, Lena C. Larsson, René J.M. Stet, Nils Ryman and Gary R. Carvalho (2006) Biocomplexity in a highly migratory pelagic marine fish, Atlantic herring. Proc R Soc Lond Ser B 273:1459–1464

Savage, R.E. (1937). The food of the North Sea herring in 1930-1934. Fishery Invest., Lond., Ser. II, 15(5), 1-60

Secor, D. H., Kerr, L. A., and Cadrin, S. X. (2009). Connectivity effects on productivity, stability, and persistence in a herring metapopulation model. ICES Journal of Marine Science, 66: 000-000

Segers, FHID, Dickey-Collas, M & Rijnsdorp, AD (2007). Prey selection by North Sea herring (Clupea harengus L.), with special regard to fish eggs. ICES J Mar Sci 64: 60-68

Schmidt, J. O., Damme, C. J. G. van, Röckmann, C., and Dickey-Collas, M. 2009. Recolonisation of spawning grounds in a recovering fish stock: recent changes in North Sea herring. Scientia Marina, 73S1: 153-157.

SCOS (2002). Scientific advice on matter relating to the management of seal populations. Natural Environment Research Council, UK.

Simmonds, E.J. 2003. Weighting of acoustic- and trawl-survey indices for the assessment of North Sea herring. ICES J Mar Sci 60:463-471.

Simmonds, E. J. 2007. Comparison of two periods of North Sea herring stock management: success, failure, and monetary value. ICES Journal of Marine Science, 64: 686–692.

Simmonds, E. J. 2009. Evaluation of the quality of the North Sea herring assessment. ICES Journal of Marine Science, 66: 1814-1822.

Suuronen, P., D. Erikson and A. Orrensalo (1996). Mortality of herring escaping from pelagic trawl codends. Fisheries Research, 25: 305-321.

Treganza, N. and A. Collet (1998). Common dolphin (Delphinus delphis) by-catch in pelagic trawl and other fisheries in the North-East Atlantic. Rep. Int. Whal. Commn. 48, pp 453-459.

Zijlstra, J.J., 1969. On the 'Racial' structure North Sea autumn spawning herring. J. Cons. int. Explor. Mer. 33, p 67-80.

Annex 04 – Stock Annexes – Herring WBSS

Quality Handbook ANNEX: HAWG-herring WBSS

Stock specific documentation of standard assessment procedures used by ICES and relevant knowledge of the biology.

Stock	Western Baltic Spring spawning herring (WBSS)
Working Group:	Herring Assessment Working Group for the Area South of 62º N
Date:	24.03.2011
Authors:	J. Dalskov, T. Gröhsler, H. Mosegaard, M. van Deurs, J. Gröger, T. Jansen, L. Worsøe Clausen, V. Bartolino

A. General

A.1. Stock definition and biology

Stocks

Herring caught in Division IIIa and in 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 (Subdivision 20), Kattegat (Subdivision 21) and the Western Baltic (Subdivisions 22, 23 and 24) are treated as one stock. The main spawning area of the WBSS is considered to be Greifswalter Bodden at Rügen Island (therefore also referred to as the Rügen-herring) (ICES, 1998), whereas NSAS utilizes spawning areas mainly along the British east coast (e.g. Burd, 1978; Zijlstra, 1969). The assessment also takes into account the few Norwegian Spring Spawners (NSS) caught in IVa north.

The contribution of Downs-herring to the mix-area of Division IIIa is likely to be relatively small (un-published data from otolith readings, DIFRES) and Downs-herring are therefore included in the NSAS stock.

In the Western Baltic, almost solely WBSS are being caught (although few autumn spawners have been observed). The majority of 2+ ringers, however, migrate out of the area during the 2th quarter of the year, to feed in Division IIIa and in the North Sea and return in the Western Baltic in the 1st quarter for spawning (Biester, 1979; Nielsen *et al*., 2001; van Deurs and Ramkaer, 2007).

In the Kattegat and in the eastern Skagerrak, mainly 2+ ringers of the WBSS and 0 to 2-ringers of the NSAS are being caught (ICES, 2004; ICES WD, 2006). The area provides a nursery habitat for juvenile NSAS (although also other areas in the North Sea function as nursery areas) that have likely been drifted in the Kattegat and in the eastern Skagerrak as larvae (Burd, 1978; Heath *et al*, 1997). On the other hand, WBSS 0-1 ringers mainly use nursery areas in Subdivision 22-24 and move to the southern Kattegat as 1-ringers. The largest concentrations of WBSS herring during June and July appear along the southern edge of the Norwegian Trench and in the Kattegat, eastern Læsø, (ICES, 2005; ICES, 2006). In the 3rd quarter large concentrations of 2+ ringers of the WBSS are found in the southern Kattegat and in Subdivision 23 as they aggregate for over-wintering (Nielsen *et al*., 2001; Clausen *et al*., 2006).

In the eastern North Sea and in the western Skagerrak mainly 2+ ringers WBSS and 1 to 2-ringer NSAS are caught (Clausen *et al*., 2006). Peak catches of WBSS in these areas occur in quarter 3, during which the spawning stock of WBSS feed (ICES, 2002). According to the herring acoustic survey (ICES, 2006), the largest concentrations of herring in these areas 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 in this area, since part of the NSAS spawning stock over-winter in the Norwegian trench (Burd, 1978; Cushing and Bridger, 1966; Clausen *et al*., 2006).

In historical time several local winter and spring spawning populations in the Skagerrak and the Kattegat has been described (e.g. Ackerfors, 1977; Rosenburg and Palmen, 1982). The largest of these seems to have been largely reduced already several decades ago (ICES, 2004). However, local spawning events in a rather large number of fjords on the coasts of Skagerrak and Kattegat regularly occur (HERGEN, EU project QLRT 200-01370, final report) but are 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 historically more complex puzzle 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 coasts of the Western Baltic spring spawning grounds are located in the Sleich Fjord (Kühlmorgen-Hille, 1983). It is unknown whether herring visiting those spawning grounds belong to the Rügen-herring or should be considered as an independent population. However, results presented by Biester (1979) and the population diversity found by Bekkevold *et al*. (2005) indicates that they 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 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 previously 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 about the tag parasite *A. simplex* present in herring indicate that this may be the case (van Deurs and Ramkaer, 2007).

The introduction of otolith microstructure analysis in 1996 (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 and 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 the 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 for 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 interpretation 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 Subdivisions 22-24 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 spring spawning populations to the mix in Division IIIa.

For Subdivisions 22-24 it is assumed that all individuals caught in those areas belong to the WBSS. However, after the introduction of OM analysis in 1996 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 yearly varying proportions of autumn spawners in Subdivisions 22–24 was considered a potential problem for the assessment, as those fishes 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, herring with OM indicating autumn hatch that are found in Subdivisions 22-24 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 complexity of different spring spawning populations, is very limited (un-published results, DIFFRES). Large effort 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 has been 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). This procedure involves photographing the shapes of the otolith edge and subsequent analysing those in different image enhancing tools in MATLAB to automatically extract the best silhouette outline of the sagitta otolith edge. The x-y coordinates of the closed outline curve are then transformed into 60, size-, location- and rotation- invariate Elliptic Fourier harmonics each having 4 parameters (EFA). Further shape descriptors are added based on various transformations of the EFAs, these include sum of squared parameters within harmonics and means as well as standard deviations from average shapes in 25 angular sectors.

OM and otolith shape variables are together with the fish metrics length, weight, maturity, age and transformations of these used in Discriminant analyses to make OM based classification baselines for age groups 0, 1-2, and 3+ to discriminate between NSAS and WBSS in test samples that only have otolith shape and/or fish metrics.

Nearest neighbour non parametric discriminant analysis is used to assign individuals to hatch type (NSAS or WBSS) and these values are then used to raise samples to proportions of hatch type by year, season, subdivision and age 0-8+.

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, Norway pout and blue-whiting fisheries are included in fleet D.

In Subdivisions 22–24 most of the catches are taken in a directed fishery for herring and some as by-catch in a directed sprat fishery. All landings from Subdivisions 22–24 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. The change in fishing pattern was caused by the opening of a fish factory on Rügen Island in 2003 which can process 50 000 t per year.

Historical Danish fishing pattern

A descriptive analysis of the Danish fleet dynamics during the last decade, in terms of the distribution of herring catches over fleets and effort 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 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.

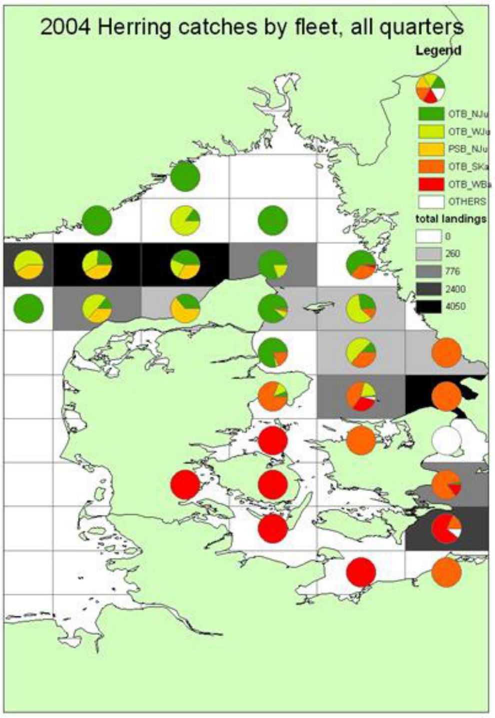


Figure A.2.1 Danish landings in IIIa by vessel and homeport.

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 the 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. This would allow predictions of the mix of herring in the area. Furthermore, by using the above four fleets/metiers and disaggregating those into industrial or commercial activities, stock selective metiers were identified (a stock selective metier was defined as: a metier with 80% or more of its landings constituting the same stock). 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 was a necessary prerequisite for any use of improved fleet- and stock-based management objectives. We have thus demonstrated that a more precise advice for the mixed stock in IIIa using elaborate fleet- and stock-based desegregations could be implemented. A projection method for predicting both stock- and metier-specific Fs is being developed accordingly.

The general dynamics of the Danish herring activities in Division IIIa can be thus summed up as the following points:

- During the first half of the 1990s, the activity was relatively local. The fleets were mostly fishing in their immediate waters. For some of the vessels mainly participating in the small mesh size fisheries, catching herring for human consumption was a minor but stable activity.
- The second half of the 1990s 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. In the same period, the large purse seiners (most of the vessels are polyvalent) increased significantly their geographical mobility. A majority of the effort was spent outside the traditional Danish fishing grounds in the North Sea and Division IIIa fishing for blue whiting and Norwegian spring spawning herring.

The full consequence of the implementation of the ITQ system in the Danish pelagic fishery 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.

Historical Swedish fishing pattern

The Swedish fleet definition is based on mesh size of the gear as for the Danish fleet. 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 only herring for human consumption. The Swedish fleet is mainly operating in the Skagerrak and in Subdivisions 24. However, there are no detailed spatial-temporal analyses of the activity of the Swedish fleet in this area.

A.3. Ecosystem aspects

Recent results from the HERGEN research-project (HERGEN, EU project QLRT 200-01370, final report) reveals an increase in genetic distance between herring populations in the Eastern Baltic and populations in Subdivisions 24 to 20 and finally the North Sea, where genetic distance reach a maximum constant difference from 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 suggests that the herring spawning in spring in local areas of the fjords of the Kattegat and Skagerrak and in the Western Baltic, 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 to the WBSS are considerable (Bekkevold *et al*., 2005; HERGEN, EU project QLRT 200-01370, final report).

By comparing five different Baltic herring stocks, temperature and SSB was shown as a the main predictors contributing to explain recruitment in the whole Baltic Sea, (Cardinale *et al*. 2009) except for Western Baltic herring where the Baltic Sea Index was the selected proxy in the final model. However, Baltic Sea Index is also known to be related to SST in the area.

B. Data

B.1. Commercial catch

A Danish regulation and control initiative, that prohibits catches in the North Sea and the Skagerrak during the same fishing trip has from 2009 efficiently stopped misreporting. Before 2009, considerable amounts of NSAS herring were taken in IVa West and misreported as catches from Division IIIa (in recent years before 2009 about 30% of the C-fleet quota).

These catches were removed from the WBSS catches and transferred into the catch of NSAS herring thus reducing the total take out of WBSS herring so that catches were normally less than the WBSS TAC. Except for a small amount (20% in 2009-2010) of the Norwegian quota the total TAC of the C-fleet is after 2008 now taken within Division IIIa. Lastly, some landings reported as taken Subdivision 22-24 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 populations in relation to the fisheries and their possible influence on the stock assessment. Recent studies on the genetic differentiation among spawning aggregations in the Skagerrak suggests a potential high representation of these local spawning stocks (Bekkevold *et al*., 2005). Other results suggest that at least the mature proportion of the different stock components shares migration patterns and feeding areas (Ruzzante *et al*., 2006; van Deurs and Ramkaer, 2007).

B.2. Biological parameters for assessment

Mean weights-at-age in the catch in the 1st quarter were used as stock weights.

In order to check if this is a valid assumption and represents the actual weights in the stock, the index was compared to the average weights in the catch by age during the whole year. The relationship followed the expected pattern where the weight of the younger age classes in the catch are somewhat higher than in the stock as these are taken as an average over the whole year allowing for growth. From age-class 4 the relation between weight in catch and weight in stock followed a 1:1 line as expected.

Thus the use of weight in the catch in quarter 1 is a sound indicator for the weight in the stock and does not give a biased representation of the stock.

The proportion of F and M before spawning was assumed constant. F-prop was set to be 0.1 and M-prop 0.25 for all age groups.

Natural mortality was assumed constant at 0.2 for all years and 2+ ringers. A predation mortality of 0.1 and 0.2 was added to the 0 and 1 ringers, which resulted in an increase in their natural mortality to 0.3 and 0.5, respectively (Table 3.6.4). The estimates of predation mortality were derived as a mean for the years 1977–1995 from the Baltic MSVPA (ICES 1997/J:2).

The maturity ogive was assumed constant between years:

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

B.3. Surveys

As a part of the **HERAS** acoustic survey; Division IIIa are covered by the Danish vessel R/V DANA in late June to early July. Numbers and weight at age, maturity and spawning component are calculated from acoustic backscattering, TS and trawl catches. The values are stratified by sub-area. For each sub area the TS are 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). Further details of HERAS can be found in the ICES reports of the Working Group of International Pelagic Surveys (WGIPS).**Used in the final assessment**.

Since 1993 subdivisions 21 (Southern Kattegat, 41G0-42G2) to 24 have, as a part of BIAS (Baltic International Acoustic Survey), been surveys with acoustics by the Ger-German R/V 'Solea' in October (**GERAS**). Further details of GERAS can be found in following ICES reports: Working Group of International Pelagic Surveys (WGIPS) and Baltic International Fish Survey Working Group (WGBIFS). The survey design and the specific settings of the hydroacoustic equipment follow the guidelines of the 'Manual for the Baltic International Acoustic Surveys (BIAS)', which is part of the WGBIFS report. **Used in the final assessment**.

The IBTS 3rd quarter survey in Division IIIa is part of the North Sea and Division IIIa bottom trawl survey carried out in the 1st and 3rd quarter. The IBTS has been conducted annually in the 1st quarter since 1977 and 3rd quarters from 1991. From 1983 and onwards the survey was standardised according to the IBTS manual (ICES 2002/D:03). During the HAWG 2002 the IBTS survey data (both quarter) were revised from 1991 to 2002. Historical catch rates are heavily skewed and therefore the survey indices by winter rings 1-5 were calculated as geometric means from observed abundances ($n{\cdot}h^{-1}$) at age at trawl stations. However, inspections of the distributions of CPUE ($n{\cdot}h^{-1}$) reveals that they are characterized by a relatively large number of low values, including true zeroes, but also occasional catches comprising large number of individuals. Statistical inference based on such data is likely to be inefficient or wrong unless an appropriate distribution is carefully chosen. Generally, a quasi-Poisson distribution (with a log-link function in order to constraint the estimates of CPUE to be positive) and a so called zero inflated models (Minami *et al*. 2006; Martin *et al.*, 2005) are used. While quasi-Poisson can treat zeroes and non-zeroes in the same models, zero-inflated models are expressed in two parts: the probability of being in a 'perfect-state' (e.g., no catch), and the probability of being in an 'imperfect-state' where positive events (e.g., catch) may occur (Minami *et al*. 2006). The perfect-state is usually modeled with a logistic, and a quasi-Poisson or a negative binomial distribution is assumed for the imperfect state. Those models are usually referred to as zero-inflated (ZIP and ZINB) models. Zero-inflated models are also attractive because they make a distinction between covariates associated with the perfect state (no catch) and covariates associated with the imperfect state in which catch can occur, but is not certain. Analysis is ongoing to test the use of ZIP and ZINB for estimating catch at age from IBTS dataset to be included in the next benchmark assessment. Thus, the IBTS indices were not used in the final assessment from 2008 and onwards. **Not used in the final assessment**.

The German herring larvae monitoring started in 1977 and takes place every year from March/April to June in the main spawning grounds. These are the Greifswalder Bodden and adjacent waters. For the calculation of the number of larvae per station and area unit, the methods of Smith and Richardson (1977) and Klenz (1993) were used and projected to length-classes. Further details concerning the surveys and the treatment of the samples are given in Brielmann (1989), Müller and Klenz (1994) and Klenz (2002). Data revision was made in 2007 with a new method in calculating number at 20mm. There was a high correlation between the indices N20 and HA_1 which are based on significantly different methods, areas and periods. Thus, results suggest that the index N20 is a suitable estimator of the new year-class of the spring spawning herring in ICES subdivision 22 – 24 (Oeberst *et al*, 2007, WD 7 in HAWG 2008 report). The time series now starts in 1992. **Used in the final assessment.**

B.4. Commercial CPUE

None

B.5. Other relevant data

None

C. Historical Stock Development

Model used: ICA
Software used: FLICA

Model Options chosen:
No of years for separable constraint: 5
Reference age for separable constraint: 4
Constant selection pattern model: yes
S to be fixed on last age: 1.0
First age for calculation of reference F: 3
Last age for calculation of reference F: 6
Relative weights-at-age: 0.1 for 0-group, all others 1
Relative weights by year: all 1
Catchability model used: for all indices linear
Survey weighting: Manual all 1
Estimates of the extent to which errors in the age-structured indices are correlated across ages: all 1
No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	**Catch in tonnes**	**1991- last data year**	**0-8+**	**Yes**
Canum	**Catch-at-age in numbers**	**1991- last data year**	**0-8+**	**Yes**
Weca	**Weight-at-age in the commercial catch**	**1991- last data year**	**0-8+**	**Yes**
West	**Weight-at-age of the spawning stock at spawning time.**	**1991- last data year**	**0-8+**	**Yes, assumed as the Mw in the catch first quarter**
Mprop	**Proportion of natural mortality before spawning**	**1991- last data year**	**0-8+**	**No, set to 0.25 for all ages in all years**
Fprop	**Proportion of fishing mortality before spawning**	**1991- last data year**	**0-8+**	**No, set to 0.1 for all ages in all years**
Matprop	**Proportion mature at age**	**1991- last data year**	**0-8+**	**No, constant for all years**
Natmor	**Natural mortality**	**1991- last data year**	**0-8+**	**No, constant for all years**

Presently used Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	**Danish part of HERAS in Div. IIIa**	**1993 – last year data Except 1999**	**3-6**
Tuning fleet 2	**German part of BIAS in SDs 22-24**	**1994 – last year data Except 2001**	**1-3**
Tuning fleet 3	**N20 larval survey, Greifswalder Botten**	**1992 – last year data**	**0**

D. Short-Term Projection

Model used: Age structured
Model used: Age structured

Software used*:* MFDP

Initial age structure of the stock for the intermediate year: ICA estimates of survivors (except age0 and age1)

Recruitment (age0): Geometric mean of the recruitment over the 5 years previous to the assessment year

Age1: calculated by simple exponential decay [$N_{1,t+1} = N_{0,t} \cdot e^{-(F_0+M_0)}$] assuming the same geometric mean recruitment in the year of the assessment

Natural mortality: The same values as in the assessment is used for all years

Maturity: The same values as in the assessment is used for all years

F and M before spawning: The same ogives as in the assessment is used for all years

Weight-at-age in the stock: Average weight of the three last years

Weight-at-age in the catch: Average weight of the three last years

Exploitation pattern (selectivity): Average weighting of the three last years not re-scaled to the last year (Catch constraint)

Intermediate year assumptions: Catch constraint with the following assumptions:

A catch of 3 900 t of WBSS in 2009 taken in the transfer area in Division IVa East by the A-fleet is assumed constant and taken in the same area in 2010.

20% of the Norwegian quota in Division IIIa for 2010 is caught as NSAS in Subarea IV, and subtracted from the TAC for the C-fleet in Division IIIa.

The fractions of the catch by fleet to the above reduced total TAC in 2010 is the same as in 2009.

The proportion of WBSS in the catches in 2010 by fleet are assumed equal to 2009.

Stock recruitment model used: None

Procedures used for splitting projected catches: Projected catches are for WBSS herring only, therefore no splitting is needed.

E. Medium-Term Projections

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:

The medium term projections are being replaced by the MSY framework and thus not carried out

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:

The long term projections are being replaced by the MSY framework and thus not carried out

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 (i.e. a proxy for F_{msy}) should be a level of fishing mortality should not exceed F = 0.25. Using a similar approach during the HAWG (2010 section 1.3) a candidate F_{msy} would be in the range of 0.22 – 0.30.

Risk assessment performed in 2007

To address the issue of risk assessment with respect to simulation based optimizations carried out for Division 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:

$$\begin{aligned}\text{Risk} &= \text{P(harmful event)} \times \text{severity of harmful event} \\ &= \text{P(lower SSB limit undercut)} \times \text{EL}\end{aligned} \qquad (1)$$

with expected loss (EL) being defined as

$$\text{EL} = \text{E}[\text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}} \mid \text{SSB}_{\text{estimated}} < \text{SSB}_{\text{lower limit}}] \;. \qquad (2)$$

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

I. References

Ackefors, H. 1977. On the winter-spring spawning herring in the Kattegat. [225]. 1977. Meddelande från Havsfiskelaboratoriet - Lysekil.

Clausen, L. A. W., Bekkevold, D., Hatfield, E. M. C., and Mosegard, H. 2007. Application and validation of otolith microstructure as a stock identification method in mixed Atlantic herring (Clupea harengus) stocks in the North Sea and western Baltic. – ICES Journal of Marine Science, 64: 377–385.

Burd, A. C. 1978. Long term changes in North Sea herring stocks. *Rapp.P.-Reun.Cons.int.Explor.Mer* **172**, 137-153.

Burgmann, M.A. 2005. Risks and decision for conservation and environmental management. Cambridge University Press, Cambridge UK. ISBN 0 521 54301 0. 488 pp.

Brielmann, **N**. 1989. Quantitative analysis of Ruegen spring-spawning herring larvae for estimating 0-group herring in Subdivisions 22 and 24. Rapp. P.-v. Reun. Cons. int. Explor. Mer, 190: 271–275.

Cardinale, M., Mölmann, C., Bartolino, V., Casini, M., Kornilovs, G., Raid, T., Margonski, P.,Raitaniemi, L., and Gröhsler, T. 2009. Climate and parental effects on the recruitment of Baltic herring (*Clupea harengus membras*) populations. Marine Ecology Progress Series, 386: 197–206.

Clausen, L.A.W, C. Ulrich-Rescan, M. van Deurs, and D. Skagen. 2007. Improved advice for the mixed herring stocks in the Skagerrak and Kattegat. EU Rolling Programme; Fish/2004/03.

Cushing D.H. and Bridger, J. P. 1966. The stock of herring in the North Sea, and changes due to fishing. *Fishery Invest, Ser II* **25**, 1-123.

Francis, R.I.C.C. and Shotton, R. 1997. ARisk@ in fisheries management: a review. Can. J. Fish. Aquat. Sci. Vol. 54, 1997, Canada.

Gröger, J. and Gröhsler, T. 2001. Comparative analysis of alternative statistical models for herring stock discrimination based on meristic characters. J. Appl. Ichthy. 17(5):207-219.

Heath, M. R., Scott, B., and Bryant, A. D. 1997. Modelling the growth of four different herring stocks in the North Sea. *J.Sea Research* **38**, 413-436.

HERGEN 2000. EU Project QLRT 200-01370.Hulme, T.J. 1995. The use of vertebral counts to discriminate between North Sea herring stocks. ICES J. Mar. Sci., 52: 775–779.

ICES 1979: Biester, E. The distribution of the Rügen spring herring. J:31. 1979. ICES C.M.

ICES 1979: Biester, E., Jönsson, N., Hering, P., Thieme, Th., Brielmann, N., and Lill, D. Studies on Rügen Herring 1979. J:32. 1979. ICES C.M.

ICES 1983: Kühlmorgen-hille, G. Infestation with larvae of Anisakis spec. as a biological tag of herring in subdivision 22, Western Baltic Sea. J:11. 1983. ICES C.M.

ICES 1991: Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/Assess:15.

ICES 1992: Report of the Workshop on Methods of Forecasting Herring Catches in Div. IIIa and the North Sea. ICES CM 1992/H:5.

ICES 1997: Report of the Study Group on Multispecies Model Implementation in the Baltic. ICES CM 1997/J:2.

ICES 1998: Report of the Study Group on the Stock Structure of the Baltic Spring-spawning Herring. D:1 Ref. H. 1998. ICES C.M.

ICES 2001: Report of Herring Assessment WG for the Area South of 62° N. CM 2001/ACFM:12.

ICES 2002: Report of the Planning Group for herring surveys. 2002/G:02.

ICES 2002: Study Group on Herring Assessment Units in the Baltic Sea. H:04 Ref. ACFM, D. 2002. ICES C.M.

ICES 2004: Report Of The Planning Group On Herring Surveys. ICES PGHERS-report.

ICES 2004: Herring assessment wg-group for the area south of 62oN. 2004b. ICES HAWG-report.

ICES 2005: Report Of The Planning Group On Herring Surveys. ICES PGHERS-report.

ICES 2006: Report Of The Planning Group On Herring Surveys. ICES PGHERS-report.

ICES 2006/RMC:04. Report of the Study Group on Risk Assessment and Management Advice (SGRAMA), 18–21 April 2006, ICES Headquarters, Copenhagen. ICES CM 2006/RMC:04, Ref. LRC, ACFM, ACE, ACME. 75 pp.

Nielsen, J. R., Lundgren, B., Jensen, T. F., and Staehr, K. J. (2001). Distribution, density and abundance of the western Baltic herring (Clupea harengus) in the Sound (ICES Subdivision 23) in relation to hydrographical features. *Fisheries Research* 50, 235-258.

Klenz, B. 2002. Starker Nachwuchsjahrgang 2002 des Herings der westlichen Ostsee. Inf. Fischwirtsch. 49(4): 143-144.

Lane, D. E. and Stephenson, R. L. 1997. A framework for risk analysis in fisheries decision-making. ICES Journal of Marine Science, 55: 1B13.

McNeil, A. Frey, R. and Embrechts, P. 2005. Quantitative Risk Management. Concepts, Trechniques and Tools. Princeton University Press, Princeton, N.J.

Müller, H. and Klenz, B. 1994. Quantitative Analysis of Rügen Spring Spawning Herring Larvae Surveys with Regard to the Recruitment of the Western Baltic and Division IIIa Stock. ICES CM 1994/L:30.

Rosenberg, R. and Palmén, L.-E. 1982. Composition of herring stocks in the Skagerrak-Kattegat and the relations of these stocks with those of the North Sea and adjacent waters. Fish. Res., 1:83–104.

Ruzzante,D.E., Mariani,S., Bekkevold,D., Andre,C., Mosegaard,H., Clausen,L.W., Dahlgren,T.G., Hutchinson,W.F., Hatfield,E.M.C., Torstensen,E., Brigham,J., Simmonds,E.J., Laikre,L., Larsson,L.C., Stet,R.J.M., Ryman,N. and Carvalho,G.R. (2006) Biocomplexity in a highly migratory pelagic marine fish, Atlantic herring. Proceedings of the Royal Society B-Biological Sciences 273, 1459-1464.

Smith, P.E. and Richardson, S.L. 1977. Standard techniques for pelagic fish egg and larva surveys. FAO Fish. Techn. Pap., 175 pp.

van Deurs, M. 2005. Forårsgydende sild (*Clupea harengus*) i Kattegat og Skagerrak. Master Thesis from DIFRES.

van Deurs, M. and Ramkaer, K. 2007. Application of a tag parasite, *Anisakis* sp., indicates a common feeding migration for some genetically distinct neighbouring populations of herring, *Clupea harengus*. Acta Ichthyologica et Piscatoria, 37: 73-79.

Zijlstra, J. J. (1969). On the racial structure of North Sea Autumn spawning herring. *J Cons Perm Int Explor Mer* 33, 67-80.

Annex 5 – Stock Annex Herring in the Celtic Sea and VIIj

Quality Handbook Herring in Celtic Sea and VIIj

Stock specific documentation of standard assessment procedures used by ICES

Stock: Herring in the Celtic Sea and VIIj

Working Group: Herring Assessment Working Group for the area south of 62^{0}

Date: March 2011

Authors: Afra Egan, Maurice Clarke and Deirdre Lynch

A. General

The herring (*Clupea harengus*) to the south of Ireland in the Celtic Sea and in Division VIIj comprise both autumn and winter spawning components. For the purpose of stock assessment and management, these areas have been combined since 1982. The inclusion of VIIj was to deal with misreporting of catches from VIIg. The same fleet exploited these stocks and it was considered more realistic to assess and manage the two areas together. This decision was backed up by the work of the ICES Herring Assessment Working Group (HAWG) in 1982 that showed similarities in age profiles between the two areas. In addition, larvae from the spawning grounds in the western part of the Celtic Sea were considered to be transported into VIIj (ICES, 1982). Also it was concluded that Bantry Bay which is in VIIj, was a nursery ground for fish of south coast (VIIg) origin (Molloy, 1968).

A study group examined stock boundaries in 1994 and recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb,c be moved southwards from latitude 52°30’N to 52°00’N (ICES, 1994). However, a recent study (Hatfield, *et al* 2007) examined the stock identity of this and other stocks around Ireland. It concluded that the Celtic Sea stock area should remain unchanged.

Some juveniles of this stock are present in the Irish Sea for the first year or two of their life. Juveniles, which are believed to have originated in the Celtic Sea move to nursery areas in the Irish Sea before returning to spawn in the Celtic Sea. This has been verified through herring tagging studies, conducted in the early 1990s, (Molloy, *et al* 1993) and studies examining otolith microstructure (Brophy and Danilowicz, 2002). Recent work carried out also used microstructure techniques and found that mixing at 1 winter ring is extensive but also suggests mixing at older ages such as 2 and 3 ring fish. The majority of winter spawning fish found in adult aggregations in the Irish Sea are considered to be fish that were spawned in the Celtic sea (Beggs *et al*, 2008).

Age distribution of the stock suggests that recruitment in the Celtic Sea occurs first in the eastern area and follows a westward movement. After spawning herring move to the feeding grounds offshore (ICES, 1994). In VIIj herring congregate for spawning in autumn but little is known about where they reside in winter (ICES, 1994). A schematic representation of the movements and migrations is presented in Figure 1. Figure 2 shows the oceanographic conditions that will influence these migrations.

The management area for this stock comprises VIIaS, VIIg, VIIj, VIIk and VIIh. Catches in VIIk and VIIh have been negligible in recent years. The linkages between this stock and herring populations in VIIe and VIIf are unknown. The latter are managed by a separate precautionary TAC. A small herring spawning component exists in VIIIa, though its linkage with the Celtic Sea herring stock area is also unknown.

A.2. Fishery

Historical fishery development

Coastal herring fisheries off the south coast of Ireland have been in existence since at least the seventeenth century (Burd and Bracken, 1965). These fisheries have been an important source of income for many coastal communities in Ireland. There have been considerable fluctuations in herring landings since the early 1900s.

In the Celtic Sea, historically, the main fishery was the early summer drift net fishery and the Smalls fishery which also took place in the summer. In 1933 several British vessels, mainly from Milford Haven, began to fish off the coast of Dunmore East and the winter fishery gained importance. The occurrence of the world war changed the pattern of the herring fishery further with little effort spent exploiting herring in the immediate post war years (Burd and Bracken, 1965). Landings of herring off the south west coast increased during the 1950s.

In 1956 Dunmore East was considered as the top herring port in Ireland with over 3,000 t landed. This herring was mainly sold to the UK or cured and sent to the Netherlands (Molloy, 2006). During this time many boats from other European countries began to exploit herring in this area during the spawning period. This continued until the 1960s when catches began to fall. In 1961 the Irish fishery limits changed whereby non-Irish vessels were prohibited from fishing in the inshore spawning grounds (Molloy, 1980). Consequently, continental fleets could no longer exploit herring on the Irish spawning grounds. They had to purchase herring from Irish vessels in order to meet requirements (Molloy, 2006).

During the period from 1950-1968 the fleet exploiting the stock changed from mainly drift and ring nets to trawls. Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1966 – 1971 (Molloy, 1972). In the mid-sixties, the introduction of mid-water pair trawling led to greater efficiency in catching herring and this method is still employed today. Overall the 1960s saw a rise in herring landings with 1969 seeing a rise to 48,000t. The North Sea herring fisheries were becoming depleted and several countries were turning to Ireland to supply their markets. Prices also increased and additional vessels entered the fleet (Molloy, 1995). Increases in effort led to increased catches initially but this did not continue and this combined with poor recruitment began the decline of the fishery. It was eventually closed in April 1977 and remained closed until November 1982 (Molloy, 2006). When the fishery reopened the management area now included VIIj also. In 1983 a new management committee was formed.

Fishery in recent years

In the past, fleets from the UK, Belgium, The Netherlands and Germany as well as Ireland exploited Celtic Sea herring. In recent years however this fishery has been prosecuted entirely by Ireland. This fishery is managed by the Irish "Celtic Sea Herring Management Advisory Committee", established in 2000 and constituted in law in 2005.

The Irish quota is managed by allocating individual quotas to vessels on a weekly basis. Participation in the fishery is restricted to licensed vessels and these licensing requirements have been changed. Previously, vessels had to participate in the fishery each year to maintain their licence. Since 2004 this requirement has been lifted. This has been one of the contributing factors to the reduction in number of vessels participating in the fishery in recent seasons (ICES, 2005b). Fishing is restricted to the period Monday to Friday each week, and vessels must apply a week in advance before they are allowed to fish in the following week. Triennial spawning box closures are enshrined in EU legislation (Figure 3).

The stock is exploited by two types of vessels, larger boats with RSW storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). There has been less fishing in VIIj in recent seasons.

The fleet can be classified into four categories of vessels:

Category 1:	"Pelagic Segment".	Refrigerated seawater trawlers
Category 2:	"Polyvalent RSW Segment".	Refrigerated seawater or slush ice trawlers
Category 3:	"Polyvalent Segment".	Varying number of dry hold pair trawlers,
Category 4:	Drift netters.	A negligible component in recent years, very small vessels

The term "Polyvalent" refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law. Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in July on the Labadie Bank and caught large fish. In 2004-2006 it opened in August and in 2007 and in 2008 began in September. Only RSW and bulk storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

In recent years, the targeting fleet has changed. The fleet size has reduced but an increasing proportion of the catch is taken by RSW and bulk storage vessels and less by dry-hold vessels. There has been considerable efficiency creep in the fishery since the 1980s with greater ability to locate fish.

A.3. Ecosystem aspects

The ecosystem of the Celtic Sea is described in ICES WGRED (2007b). The main hydrographic features of this area as they pertain to herring are presented in Figure 2.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES, 2006a). Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions (Pinnegar, *et al* 2002). However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain in the Irish Sea for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock (Molloy, 1989). Distinct patterns were evident in the microstructure and it is thought that this is caused by environmental variations. Variations in growth rates between the two areas were found with Celtic Sea fish displaying fastest growth in the first year of life. These variations in growth rates between nursery areas are likely to impact recruitment (Brophy and Danilowicz, 2002). Larval dispersal can further influence maturity at age. In the Celtic Sea faster growing individuals mature in their second year (1 w. ring) while slower growing individuals spawn for the first time in their third year (2 winter ring). The dispersal into the Irish Sea which occurs before recruitment and subsequent decrease in growth rates could thus determine whether juveniles are recruited to the adult population in the second or third year (Brophy and Danilowicz, 2003).

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. The main spawning grounds are displayed in Figure 4, whilst the distributions of spawning and non-spawning fish are presented in Figure 5.

Herring are an important component of the Celtic sea ecosystem. There is little information on the specific diet of this stock. Farran (1927) highlighted the importance of *Calanus* spp. copepods and noted that they peaked in abundance in April/May. Fat reserves peak in June to August (Molloy and Cullen, 1981). Herring form part of the food source for larger gadoids such as hake. A study was carried out which looked at the diet of hake in the Celtic Sea. This study found that the main species consumed by hake are blue whiting, poor cod and Norway Pout. Quantities of herring and sprat were also found in fish caught in the northern part of the Celtic sea close to the Irish coast. Large hake, >50cm tended to have more herring in their stomachs than smaller hake (Du Buit, 1996).

Recent work by Whooley *et al*. (2011) shows that fin whales *Balaenoptera physalus* are an important component of the Celtic Sea ecosystem, with a high re-sighting rate indicating fidelity to the area. There is a strong peak in sightings in November, and fin whales were observed actively feeding on many occasions, seeming to associate with sprat and herring shoals. These authors go on to suggest that the peak in fin whale sightings in November may coincide with the inshore spawning migration of herring. Fin whales tend to be distributed off the south coast in VIIg in November, but further east, in VIIaS by February (Berrow personal communication). This suggests that their occurrence coincides with peak spawning time in these areas. The peak in fin whale sightings was in 2004 (Irish Whale and Dolphin Group unpublished data), coinciding with the lowest population estimate of herring.

By Catch

By catch is defined as the incidental catch of non target species. There are few documented reports of by catch in the Celtic Sea herring fishery. A European study was undertaken to quantify incidental catches of marine mammals from a number of fisheries including the Celtic Sea herring fishery. Small quantities of non target whitefish species were caught in the nets. Of the non target species caught whiting was most frequent (84% of tows) followed by mackerel (32%) and cod (30%). The only marine mammals recorded were grey seals (*Halichoerus grypus*). The seals were observed on a number of occasions feeding on herring when the net was being hauled and during towing. They appear to be able to avoid becoming entangled in the nets. It was considered unlikely by Berrow, *et al* 1998, that this rate of incidental catch in the Celtic

Sea would cause any decline in the Irish grey seal population. Results from this project also suggested that there was little interaction between the fishing vessels and the cetaceans in this area. Occasional entanglement may occur but overall incidental catches of cetaceans are thought to be minimal (Berrow, *et al* 1998). The absence of any other by caught mammals does not imply that by catch is not a problem only that it did not occur during this study period (Morizur, *et al* 1999).

Discards

Catch is divided into landings (retained catch) and discards (rejected catch). Discards are the portion of the catch returned to the sea as a result of economic, legal, or personal considerations (Alverson *et al* 1994). In the 1980s a roe (ovary) market developed in Japan and the Irish fishery became dependent on this market. This market required a specific type of herring whose ovaries were just at the point of spawning. A process developed whereby large quantities of herring were slipped at sea. This type of discarding usually took place in the early stages of spawning and was reduced by the introduction of experimental fishing (Molloy, 1995). This market peaked in 1997 and has been in decline since with no roe exported in recent years. Markets have changed with the majority of herring going to the European fillet market.

Presently there are no estimates of discards for this fishery used in assessments. Berrow, *et al* 1998 also looked at the issue of discarding during the study on by catch. The discard rate was found to be 4.7% and this compares favourably with other trawl fisheries. Possible reasons for discarding were thought to be the market requirements for high roe content and high proportions of small herring in the catch. Overall this study indicated that the Celtic Sea herring fishery is very selective and that discard rates are well within the figures estimated for fishery models.

Since the demise of the roe fishery, it is considered that the incentive to discard is less. However it is known that discarding still takes place, in response to a constrained market situation.

B. Data

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota/fisheries for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish logbook data. Figure 6 shows the trends in catches over the time series. Ireland acts as stock coordinator for this stock. Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are processed either using SALLOCL (Patterson, 1998b), or using *ad hoc* spreadsheets, usually the latter. The relevant files are placed on the ICES archive each year.

Intercatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data, was also used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. The comparisons to date have been very good and it is envisaged that this system will replace SALLOCL and other previously used systems. InterCatch cannot deal with catches from two calendar years therefore for example data from the 2008/2009 season are uploaded to InterCatch as 2008 figures. Catches from quarter 1 2009 are entered as being from quarter 1 2008.

B.2 Biological

Sampling Protocol

Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.Sampling (of the Irish catches) is conducted using the following protocol

- Collect a sample from each pair of boats that lands. Depending on the size range, a half to a full fish box is sufficient. If collecting from a processor make sure sample is ungraded and random.
- Record the boat name, ICES area, fishing ground, date landed for each sample.
- Randomly take 75 fish for ageing. Record length in 0.5cm, weight, sex, maturity (use maturity scale for guideline). Extract the otolith taking care not to break the tip and store it in an otolith tray. Make sure the tray is clean and dry.
- Record a tally for the 75 aged fish under "Aged Tally" on the datasheet.
- Measure the remaining fish and record a tally on the measured component of the datasheet

Ageing Protocol

Celtic Sea herring otoliths are read using a stereoscopic microscope, using reflected light. The minimum level of magnification (15x) is used initially and is then increased to resolve the features of the otolith. Herring otoliths are read within the range of 20x – 25x. The pattern of opaque (summer) and translucent (winter) zones is viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st April. This "birth date" is used because the assessment year for Celtic Sea and Division VIIj herring runs from this date to the 31st March of the following year (ICES, 2007). This ageing and assessment procedure is unique in ICES. A fish of 2 winter rings is a 3 year old. This naming convention applies to all ICES herring stocks where autumn spawning is a significant feature.

Age composition in the catch

In recent years there is a decreasing proportion of older fish present in the catch. Figure 7 shows the age composition of the catches over the time series. It is clear that there is a truncation of older age classes with low amounts caught in recent years.

Precision in Ageing

Precision estimates from the ageing data were carried out in the HAWG in 2007, for the 2006/2007 season (ICES, 2007). Results found that CVs are highest on youngest and oldest ages that are poorly represented in the fishery. The main ages present in the fishery had low CVs, of between 5% and 13%, which is considered a very good level of precision. In the third and the fourth quarter, estimates of 1 wr on CS herring were also remarkably precise. An overall precision level of 5% was reached in Q1 and Q4 in the 2007/2008 season.

Mean Weights and Mean Lengths

An extensive data set on landings is available from 1958. Mean weights at age in the catch in the 4th and 1st quarter are used as stock weights. Trends in mean weights at age in the catches are presented in Figure 8, and for weights in the spawning stock in

Figure 9. Clearly there has been a decline in mean weights since the early 1980s, to the lowest values observed.

Mean length at age from a historic source (Burd and Bracken, 1965) combined with Irish data is presented in Figure 10. Data from 1921 to 1963 are taken from Burd and Bracken (1965) and from 1964 onwards are taken from the Irish dataset. Mean length for the main age groups increased to above the long term average from the late 1950s, and reached a peak in 1975. After that mean length declined, falling below the long term average again, by the early 1990's (Lynch, 2011).

Natural Mortality

The natural mortality is based on the results of the MSVPA for North Sea herring. Natural mortality is assumed to be as follows:

1 ringer	1
2 ringer	0.3
3 ringer	0.2
4 and subsequent ringer	0.1

Maturity Ogive

Clupea harengus is a determinate one-batch spawner. In this stock, the assessment considers that 50% of 1 ringers are mature and 100% of two ringers mature. The percentage of males and females at 1 winter ring are presented in Figure 11. It shows wide fluctuations in percentage maturity from year to year (Lynch, 2011).

It is to be noted that the fish that recruit to the fishery as 1-ringers are probably precocious early maturing fish. Late maturing 1-ringers may not be recruited. Thus maturity at 1-ringer in the population as a whole may be different to that observed in the fishery. Late maturing 1-, 2- and even 3-ringers may recruit from the Irish Sea. Brophy and Danilowicz (2002) showed that late maturing 1-ringers leave the Irish Sea and appear as 2-ringers in the Celtic Sea catches. Beggs, 2008 WD indicated that some older fish also stay in the Irish Sea and return as 3- or even 4-ringers to the Celtic Sea. It is possible that when stock size was low, the relative proportion of late maturing fish from the Irish Sea was greater. This may explain why observed maturity in the catches was later in those years.

B.3. Surveys

Acoustic

Acoustic surveys have been carried out on this stock from 1990-1996, and again from 1998-2010. During the first period, two surveys were carried out each year designed to estimate the size of the autumn and winter spawning components. The series was interrupted in 1997 due to the non-availability of a survey vessel. Since 2005, a uniform design, randomised survey track, uniform timing and the same research vessel have been employed. A summary of the acoustic surveys is presented in Table 1.

Revision of acoustic time series

A review of the acoustic survey programme was conducted to check the internal consistency of the previous surveys and produce a new refined series for tuning the assessment (Doonan, 2006, unpublished). The old survey abundance at age series is presented in Table 2 and the revised survey time series is shown in the Table 3 (ICES, 2006).

The surveys were divided into two series, early and late, based on how far from the south coast of Ireland the transects extended. The early group, 1990-91 to 1994-95, extended to about 15 nautical miles offshore with two surveys, one in autumn and another in winter. This design aimed to survey spawning fish close inshore with two surveys, the results of which could be added, the two legs covering the two main spawning seasons. The off shore limits were extended in 1995 and some of these surveys had more fish off shore than close inshore. This changed the catchability, suggesting the later series should be separated from the earlier one. Consequently the years before 1995 were removed. This is not considered to be a problem because the earlier series would contribute little to the assessment anyway.

The autumn surveys did not cover the southwest Irish coast of VIIj in all years (3 years missing). In order to correct for this, the missing values were substituted with the mean of the available western bays SSB estimates, 7 800 t (11 values, range from 0 to 16 000 t). Numbers-at-age in these surveys were adjusted upwards by the ratio of the adjusted SSB in the SW to the south coast SSB. The current time series included autumn surveys only.

Analysis errors were found in the surveys from 1998 onwards. The 2003 biomass (SSB, 85 500 t) was re-analysed after the discovery of errors in the spreadsheets used to estimate biomass. The errors affected the calculation of the weighted mean of the integrated backscatter when positive samples had lengths shorter than the base one (here, 15 minutes) and the partitioning of the backscatter for a mixture of species. Also, no account was taken of different sampling frequencies within a 10x20 minute cell (the analysis unit). The 2003 SSB came mainly from two cells that included an intensive survey in Waterford Harbour and these cells had an SSB of about 68 000 t, which was reduced to 7 300 t when all errors were corrected. There were some minor corrections in three other cells. The revised total biomass was 24 000 t and the revised spawning biomass was 22 700 t.

In addition, the cell means took no account of the implicit sampling area of transects so that the biomass coming from a large sample value depended on the number of transects passing through the cell. The data were re-analysed using mean herring density by transect as the sample unit and dividing the area into strata based on transect spacing. Areas with no positive samples were excluded from the analysis (since they have zero estimates). Zigzags in bays were analysed as before. For each stratum, a mean density was obtained from the transect data (weighted by transect length) and this was multiplied by the stratum area to obtain a biomass and numbers-at-age. The overall total was the sum of the strata estimates. The same haul assignments as in the original analysis were used. At the same time, a CV was obtained based on transect mean densities, i.e. a survey sample error. For surveys before 1998 and the western part survey in 2002, a CV was estimated using;

$$\sqrt{\log(1.3^2)/n}$$

where n is the number of positive sample values (15 minute of survey track) from Definite and Probably Herring categories. This was based on the data from the autumn surveys in 1998, 2000, 2001, 2002, and 2005.

Current acoustic survey implementation

The acoustic data are collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel or in the case of a commercial vessel mounted within a towed body. The survey area is selected to cover area VIIj, and the Celtic Sea (areas VIIg and VIIaS). Transect spacing in these surveys has varied between 1 to 4 nmi. For bays and inlets in the southwest region (VIIj) a combined zigzag and parallel transect approach was used to best optimise coverage. Offshore transect extension reached a maximum of 12 nmi, with further extension where necessary to contain fish echotraces within the survey area.

The data collected is scrutinised using Echoview® post processing software. The allocated echo integrator counts (S_a values) from these categories were used to estimate the herring numbers according to the method of Dalen and Nakken (1983). The following target strength to fish length relationships is used for herring.

TS = 20logL – 71.2 dB per individual (L = length in cm)

Acoustic Survey Time Series

The acoustic survey design has been standardised and the timing has been consistent each year since 2005. The 2002 and 2003 surveys had similar timing and are comparable to the uniform time series. In the benchmark assessment (2007) the time series used was from 1995-2006. At the time of the benchmark, there were not enough comparable consistent surveys available for tuning. In 2009, four consistent surveys (2005-2008) and two additional fairly consistent surveys (2002-2003) were available. The 2010 assessment also used the 2009 survey.

Irish Groundfish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The utility of the IGFS as a tuning series was investigated (Johnston and Clarke, 2005 WD). Strong year effects were evident in the data. Herring were either caught in large aggregations or not at all. The signals from this survey were very noisy, but when a longer time series is developed, it will at least provide qualitative information. The absence of the 2001 year class was supported in the survey data in 2004.

French EVHOE Survey

The Herring Assessment Working group in 2006 had access to data from the French EVHOE quarter 4 western IBTS survey (GOV trawl). The French survey series is from 1997 to 2005 and displayed very variable observed numbers at age between years. Consequently, further exploration of the series was not performed.

UK Quarter 1 survey

The UK quarter 1 survey was also explored and strong year and age effects, particularly at 2- and 5-ringers were found. Due to strong year and age effects and because it was discontinued in 2002 this survey is considered unsuitable as a recruit index (ICES 2006:ACFM 20).

While these data are useful for comparisons between surveys, as with the Irish data, at the moment it is difficult to see how these data can be used in an assessment. The data, particularly towards the end of the time series are very noisy and the absence of very small (juvenile) fish, particularly 1 ringers for the majority of time series is not encouraging (Johnston and Clarke, 2005).

Irish and Dutch juvenile herring trawl surveys

Juvenile herring surveys were carried out from 1972 – 1974 by Dutch and Irish scientists. These surveys aimed to get information on the location and distribution of young herring. They were also used to examine if young herring surveys in the Irish Sea could provide abundance indices for either the Irish Sea or Celtic Sea stocks. Further young fish surveys were carried out in the Irish Sea from 1979 – 1988. They were discontinued when it was decided that it was not possible to use the information as recruitment indices for the Celtic Sea or Irish Sea stocks despite earlier beliefs (Molloy, 2006). This was because it was not known what proportion of the catches should be assigned to each stock.

Northern Ireland GFS surveys

These surveys take place in quarters 1 and 3 each year. Armstrong *et al* (2004) presented a review of these surveys. They are likely to be useful if the natal origin can be established. Further work in this area is required to examine if this survey can be used as a recruit index for Celtic Sea Herring.

Larval Surveys

Herring larval surveys were conducted in the Celtic Sea between October and February from 1978 to 1985 with further surveys carried out in 1989 and 1990. These surveys provided information on the timing of spawning and on the location of the main spawning events as well as on the size of autumn and winter spawning components of the stock. The larval surveys carried out after the fishery reopened in 1982 showed an increase in the spawning stock (Molloy, 1995).

The surveys covered the south coast and stations were positioned 8 nautical miles apart in a grid formation. A Gulf III sampler, with 275 µm mesh was used to collect the samples. The total abundance of <10mm larvae (prior to December 15th) or <11mm (after December 15th) was calculated by raising the numbers per m^2 by the area represented by each station. The mean abundance of <11mm larvae in December – February gave the winter index which when multiplied by 1.465 and added to the Autumn index to give a single index of the whole series (Grainger *et al* 1982). Larval surveys have not been undertaken in this area since 1989 and until the acoustic survey became established, no survey was available to tune the assessment.

B.4. Commercial CPUE

In the 1960s and 1970s CPUE (Catch per unit effort) data from commercial herring vessels were used as indices of stock abundance because there were no survey data available. These data provided an index of changes that were occurring in the fishery at the time. CPUE data were used to tune the assessment (Molloy, 2006). However it is likely that the decline in the stock in the 1970s was not picked up in the CPUE until it was at an advanced stage. It is now demonstrated that CPUE data does not provide an accurate index of herring abundance, as they are a shoaling fish.

C. Historical Stock Development

Time Periods in the Fishery

This fishery can be divided into time periods. A number of factors have changed in this fishery overtime such as the markets, discards and the water allowance. These changes have implications for the trustworthiness of the catch data used in the assessment. The time periods are presented in the Table 4. The recent biological history of the stock is presented in Table 5. It is clear that growth rate has changed over time. Mean length and mean weight at age have declined by about 15% and 30% respectively since the late 1970s. Fish are shorter and lighter at age now than at any time in the series. Trends in mean weights in the catch and in the stock are presented in Figure 8 and Figure 9.

Exploration of basic data

Data exploration consisted of examining a number of features of the basic data. These analyses included log catch ratios, cohort catch curves in survey and catch at age series. Log catch ratios were constructed for the time series of catch at age data, as follows:

log[C(a,y)/C(a+1,y+1)]

These are presented in Figure 12. It can be seen that 1-ringers, and the oldest ages, have a noisy signal, being poorly represented in the catches. There was an increase in ratios in 1998, that seems quite abrupt. Overall there is a trend towards greater mortality in recent years. The increased mortality visible in the older ages corresponds with the truncation in oldest ages in the catch at age profile. It can also be seen that the gross mortality signal was low in 2002, corresponding to the big decrease in catch in that year. The signal increased again in 2003, concomitant with increasing catch. Log catch ratios by cohort are presented in Figure 13.

The total mortality (Z) over ages 2-7 for the cohorts 1958-1997 is presented in Figure 14 and in Table 6. Fluctuations are evident with an increasing trend in recent years. Total mortality was low for cohorts 1956 to 1964. Cohorts in the late 1960s seem to display higher Z, but those from 1975 to 1982 displayed the highest Z (0.6 to 1.1). The most recent year classes for which enough observations are available (1991-1997) show higher Z again, in the range about 0.6 to 1.0. Cohort catch curves were also constructed from the catch at age data across ages 2-5 (Figure 15) and the survey data for year classes where enough data were available (Figure 16). A secondary peak corresponding to the 2003/2004 season is obvious in the cohort catch curves. The same patterns in raw mortality are visible, but the Zs from the acoustic survey are somewhat higher than those from the commercial data. This may be explained as differing catchability between the two, and it should be noted when interpreting the assessment results below.

In conclusion only the cohorts from before the stock collapsed and a few from the late 1980s contributed many of the older fish that appear in the catches. Raw mortality signals, from cohort catch curves suggest that some of the recent year classes have displayed a higher total mortality.

Assessments 2007-2011

In 2007, a benchmark assessment used a variety of models including ICA (Patterson, 1998), separable VPA, XSA, CSA and Bayesian catch at age methods. In addition an analysis of long term dynamics of recruitment was conducted. Simulations of various fishing mortalities were conducted based on stock productivity. Though no final model formulation was settled upon, the assessment provided information on trends. ICA was preferred to XSA because it is more influenced by younger ages that dominate the stock and fishery, and because of consistency. The settings that had been used before 2007 were found to produce the most reasonable diagnostics.

In 2007 it was considered that the assumption that a constant separable pattern could be used may not have been valid and it was recommended that future benchmark work should consider models that allow for changes in selection pattern.

Also in 2007 a reduction of the plus group to 7+ was recommended. This change did not achieve better diagnostics in 2007, but exploratory assessments in 2008 did find that this change improved the diagnostics.

In 2008 and 2009, the working group continued to explore different assessment settings in ICA. The working group treated these explorations as extensions of the benchmark of 2007. In 2008 ICA was replaced by FLICA and the same stock trajectories were found in each.

In 2009 a final analytical assessment was proposed and was conducted using FLICA (flr-project.org). This assessment was based on exploratory work done in 2008 and 2009. The refinements to the benchmark assessment of 2007 were as follows:

- Further reduction of plus group to 6+
- Exclusion of acoustic surveys before 2002, because a sufficient series of comparable surveys was now available.

The assessment showed improved precision and coherence between the catch at age and the survey data. The survey residuals were lower since 2002 which is reflected in better tuning diagnostics.

The model formulation used for ICA in the 2007 benchmark and the final assessment carried out in 2009 -2011 are presented in the table below. The stock trajectory, based on the most recent assessment is presented in Figure 17.

ICA Settings	2007 Benchmark	Final Assessments in 2009 -2011
Separable period	6 years (weighting = 1.0 for each year)	6 years (weighting = 1.0 for each year)
Reference ages for separable constraint	3	3
Selectivity on oldest age	1.0	1.0
First age for calculation of mean F	2	2
Last age for calculation of mean F	6	5
Weighting on 1 ringers	0.1	0.1
Weighting on other age classes	1.0	1.0
Ages for acoustic abundance estimates	2-5	2-5
Plus group	9	6

Update Assessments 2010 and 2011.

In 2011 the same procedure as in 2009 and 2010 was carried out.

Estimation of terminal year Recruitment

Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. Therefore an adjustment is made, by replacing 1-ring abundance from ICA.out with GM recruitment from (1995 – final year – 2).

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1958-2010	1-6+	Yes
Canum	Catch at age in numbers	1958-2010	1-6+	Yes
Weca	Weight at age in the commercial catch	1958-2010	1-6+	Yes
West *	Weight at age of the spawning stock at spawning time.	1958-2010	1-6+	Yes
Mprop	Proportion of natural mortality before spawning	1958-2010	1-6+	No
Fprop	Proportion of fishing mortality before spawning	1958-2010	1-6+	No
Matprop	Proportion mature at age	1958-2010	1-6+	No
Natmor	Natural mortality	1958-2010	1-6+	No

* mean weights in the stock in the new plus group were re-weighted using catch numbers at age.

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Acoustic Survey	CSHAS	2002-2010	2-5

Analysis of productivity over time

To account for the influence of the ecosystem on the productivity of this herring stock (ICES, 2007, Chapter 1) the methods of Nash and Dickey-Collas (2005) were applied. The recruit per spawner ratio was calculated. These calculations formed the basis for the detection of periods of high and low production of the stock (Figure 18).

The next step was to calculate the net and surplus production of the whole stock, including the recruits and the growth of all non-recruits, the natural and the fishing mortality. To subtract the influence of the spawning stock biomass a hockey stick and a Ricker stock recruitment relationship were fitted to the data to obtain the residuals of the recruits of a given year. The residuals were used to remove the year effect from the estimation of the stock size and to gain the net production and the surplus production respectively without the effect of the SSB on the number of recruits. Contrary to ICES (2007, Technical Minutes) the stock recruit model is not presented. This is because the model is not considered a good fit to the data and because the aim of this analysis is to examine recruitment, having removed the effect of SSB.

The data used in this analysis was derived from the assessment outputs from the HAWG in 2006 (ICES, 2006 ACFM:20, Table 1.8.3.1).

Calculation of the surplus production

$$Ps = Br + Bg - M$$

where Br is the biomass of the recruits, Bg the gain of biomass due to growth of all fish excluding the recruits and M the natural mortality. The net production equals the surplus production minus the fishing mortality (F).

The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks (ICES, 2007). The net and surplus production is very noisy displaying no clear trend. The impact of a varying F was tested using the Hockey Stick stock recruitment relationship (Figure 18). The stock showed variable production over time (Figures 19 and 20). It can be seen that $F_{0.1}$ is associated with high though variable surplus production over the series, whilst F's greater than 0.4 are associated with reduced productivity in the most recent years. This analysis demonstrates the benefits of harvesting at an F of around $F_{0.1}$. Exploitation in the range of recent F (~0.7-1.2) is detrimental to stock productivity.

D. Short-Term Projection

Short term forecasts were routinely performed until 2004. There was no final assessment from 2005-2008 and therefore no short term forecast was conducted. A forecast was again carried out in 2009, 2010 and 2011. The method used in 2009 and 2010 was the "Multi fleet Deterministic Projection" software (Smith, 2000). In 2011 the forecast was carried out using FLR. A short-term projection is carried out under the following assumptions. Recruitment was set at geometric mean, from 1995 - minus the most recent two years. This value is considered a good proxy for recruitment strength in recent years. This is because the recent recruitments have fluctuated about this value. Mean weights in the catch and in the stock were calculated as means over the last three years. Selection is taken from the most recent assessment. Population number of 2 ringers in the intermediate season was calculated by the degradation of geometric mean recruitment using the equation below, following the same procedure as in previous years.

$$N_{t+1} = N_t * e^{-Ft+Mt}$$

E. Medium-Term Projections

Yield per recruit analyses have been conducted for this stock since the mid 1960s, though not necessarily every year. Recent analyses have used the "Multi Fleet Yield Per Recruit" software and using FLR. A comparison of the results is shown in the table below. Based on the most recent yield per recruit $F_{0.1}$ is estimated to be 0.17 (Figure 21).

Table 7 presents estimates of $F_{0.1}$ from the literature and from yield per recruit analyses conducted over time. $F_{0.1}$ estimates from the YPR analysis have been in the range 0.16-0.19. F_{max} has been undefined in recent studies but earlier work suggested values of around 0.45, based on the good recruitment regime of the 1960s. Fmsy for this stock is 0.25.

F. Long-Term Projections

A long term plan has been proposed for Celtic Sea herring and simulations have been carried out in conjunction with this work. HCS10 (Skagen, 2010) was used to project the stock forward twenty years and screen over a range of possible trigger points, F values and % constraints on TAC change. It was agreed by the Irish industry that a target F of 0.23 would be proposed and that 61 000 t would be used as a trigger biomass. Once the stock falls to this level, reductions in F would be implemented. A 30% constraint in TAC change would also apply. Simulations have shown that this combination of options shows that the risk of falling below the breakpoint which is 41 000 t is less than 5% over the simulation period (Egan and Clarke, 2011 WD 11).

G. Biological Reference Points

B_{pa} is based on a low probability of low recruitment and is currently 44 000 t.

B_{lim} is set at B_{loss} and is 26 000 t (ICES, 2001).

F_{pa} and F_{lim} are not defined. F_{msy} has not been as 0.25 and $F_{0.1}$ as 0.17.

The reference points for this stock have not been revised in recent years. There is some evidence that B_{lim} should be revised upwards, to the point of recruitment impairment estimated by Egan and Clarke (2011, WD No 11). These authors showed a changepoint in a segmented regression at 41 000 t.

H.1. Biology of the species in the distribution area

Herring shoals migrate to inshore waters to spawn. Their spawning grounds are located in shallow waters close to the coast and are well known and well defined. This stock can be divided into autumn and winter spawning components. Spawning begins in October and can continue until February. A number of spawning grounds are located along the South coast, extending from the Saltee Islands to the Old Head of Kinsale. These grounds include Baginbun Bay, Dunmore East Co Waterford, around Capel and Ballycotton Islands and around the entrance to Cork Harbour (Molloy, 2006). The areas surrounding the Daunt Rock and old Head of Kinsale have also been recognised as spawning grounds (Breslin, 1998). These spawning grounds are shown in Figures 2 -.5.

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A spawning bed is the area over which the eggs are deposited
- A spawning ground consists of one or more spawning beds located in a small area.
- A spawning area is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006).

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until hatching. Fertilized eggs hatch into larvae in 7-10 days depending on the water temperature. The size of the egg determines the size of the larvae. Larger eggs have a greater chance of survival but this must be balanced against environmental conditions and the inverse relationship between fecundity and egg size (Blaxter and Hunter, 1982).

A study on fecundity of Celtic Sea herring, conducted in the 1920s found that the eggs produced by spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938). Later studies of Celtic Sea herring fecundity by Molloy (1979), found that there were two spawning populations with the autumn one being most important.

The relationship between fecundity and length has been calculated for both spawning components of Celtic Sea herring. The regression equations are as shown in Molloy, 1979, are as follows:

Autumn spawning component: Fecundity = 5.1173 L – 56.69 (n=53)

Winter spawning component: Fecundity = 3.485 L – 35.90 (n=37)

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Currents transport the newly hatched larvae to areas in the Celtic Sea or to the Irish Sea (Molloy, 2006). The conditions experienced during the larval phase as well as during juvenile phase are likely to have some influence on the maturation of Celtic Sea herring. Fast growing juveniles can recruit to the population a year earlier than slow growing juveniles. Faster growth may also lead to increased fecundity (Brophy and Danilowich, 2003). Fluctuating environmental conditions play an important role in the growth and survival of herring in this area.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Celtic Sea herring have undergone changes in growth patterns and a declining trend in mean weights and lengths can be seen over time. It is important to detect these changes from a management perspective because changes can have an impact on the estimation of stock size. Growth has an impact on factors such as maturity and recruitment (Molloy, 2006). Trends in mean weights and lengths are currently being examined over the time series and possible links to environmental factors investigated (Lynch, 2011).

The locations of spawning and non spawning fish in the Celtic Sea are shown in Figure 5. This is based on the knowledge of fishermen and shows spawning herring are found close inshore and non spawning fish are found in areas further off shore.

H.2. Management and ICES Advice

The assessment year is from 1st April to 31st March. However for management purposes, the TAC year is from 1st January to 31st December.

The first time that management measures were applied to this fishery was during the late 1960s. This was in response to the increasing catches particularly off Dunmore East. The industry became concerned and certain restrictions were put in place in order to prevent a glut of herring in the market and a reduction in prices. Boat quotas were introduced restricting the nightly catches and the number of boats fishing. Fishing times were specified with no weekend fishing and herring could not be landed for the production of fishmeal. A minimum landing size was also introduced (Molloy, 1995).

The TAC (total allowable catch) system was introduced in 1972, which meant that yearly quotas were allocated. This continued until 1977 when the fishery was closed. During the closure a precautionary TAC was set for Division VIIj. This division was not assessed analytically (ICES, 1994). After the closure of this fishery a new management structure was implemented with catches controlled on a seasonal basis and individual boat quotas were put in place (Molloy 1995).

Table 8 shows the history of the ICES advice, implemented TACs and ICES' estimates of removals from the stock. It can be seen that the implemented TAC has been set higher than the advice in about 50% of years since the re-opening of the fishery in 1983. The tendency for the TAC to be set higher than the advice has also increased in recent years. It can also be seen that ICES catch estimates have been lower than the agreed TAC in most years.

This fishery is still managed by a TAC system with quotas allocated to boats on a weekly basis. Participation in the fishery is restricted to licensed vessels. A series of closed areas have been implemented to protect the spawning grounds, when herring are particularly vulnerable. These spawning box closures were implemented under EU legislation.

The committee set up to manage the stock has the following objectives.

- To build the stock to a level whereby it can sustain annual catches of around 20,000 t.
- In the event of the stock falling below the level at which these catches can be sustained the Committee will take appropriate rebuilding measures.
- To introduce measures to prevent landings of small and juvenile herring, including closed areas and/or appropriate time closures.
- To ensure that all landings of herring should contain at least 50% of individual fish above 23 cm.
- To maintain, and if necessary expand the spawning box closures in time and area.
- To ensure that adequate scientific resources are available to assess the state of the stock.
- To participate in the collection of data and to play an active part in the stock assessment procedure.

The Irish Celtic Sea Herring Management Advisory Committee has developed a rebuilding plan for this stock. This Committee proposes that this plan be put forward for Council Regulation for 2009 and subsequent years. The plan incorporates scientific advice with the main elements of the EU policy statement on fishing opportunities for 2009, local stakeholder initiatives and Irish legislation.

Rebuilding plan

1. For 2009, the TAC shall be reduced by 25% relative to the current year (2008).
2. In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of $F_{0.1}$.

3. If, in the opinion of ICES and STECF, the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.
4. Division VIIaS will be closed to herring fishing for 2009, 2010 and 2011.
5. A small-scale sentinel fishery will be permitted in the closed area, Division VIIaS. This fishery shall be confined to vessels, of no more than 65 feet in length. A maximum catch limitation of 8% of the Irish quota shall be exclusively allocated to this sentinel fishery.
6. Every three years from the date of entry into force of this Regulation, the Commission shall request ICES and STECF to evaluate the progress of this rebuilding plan.
7. When the SSB is deemed to have recovered to a size equal to or greater than B_{pa} in three consecutive years, the rebuilding plan will be superseded by a long-term management plan.

Evaluation of the Management Plan

The proposed rebuilding plan for Celtic Sea and Division VIIj herring is estimated to be in accordance with the precautionary approach, if the target fishing mortality of $F_{0.1}$ is adhered to.

2010 Advice

The advice for 2010 was based on the rebuilding plan.

The rebuilding plan is due to end in 2011 when it is expected to be replaced by a long term management plan. In early 2011 the Irish industry agreed a long term management plan. The plan has not yet been evaluated.

The text of the proposed plan is below.

<u>Text of the proposed Long term management plan Herring in the Celtic Sea and Division VIIj.</u>

1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 41,000 t, the level below which recruitment becomes impaired.

2. Where the SSB, in the year for which the TAC is to be fixed, is estimated to be above 61,000 t ($B_{trigger}$) the TAC will be set consistent with a fishing mortality, for appropriate age groups, of 0.23 (F_{target}).

3. Where the SSB is estimated to be below 61,000 tonnes, the TAC will be set consistent with a fishing mortality of:

$$SSB * 0.23 / 61,000$$

4. Where the rules in paragraphs 2 and 3 would lead to a TAC which deviates by more than 30 % from the TAC of the preceding year, the TAC will be fixed such that it is not more than 30 % greater or 30 % less than the TAC of the preceding year.

5 Where the SSB is estimated to be below 41,000 tonnes, Subdivision VIIaS will be closed until the SSB has recovered to above 41,000 tonnes.

6. Where the SSB is estimated to be below 41,000 tonnes, and Subdivision VIIaS is closed, a small-scale sentinel fishery will be permitted in the closed area. This fishery will be confined to vessels, of no more than 50 feet in registered length. A maximum catch limitation of 8% of the Irish quota will be exclusively allocated to this sentinel fishery.

7. Notwithstanding paragraphs 2, 3 and 4, if the SSB is estimated to be at or below the level consistent with recruitment impairment (41,000 t), then the TAC will be set at a lower level than that provided for in those paragraphs.
8. No vessels participating in the fishery, if requested, will refuse to take onboard any observer for the purposes of improving the knowledge on the state of the stock. All vessels will, upon request, provide samples of catches for scientific analyses.
9. Every three years from the date of entry into force of this Regulation, the Commission will request ICES and STECF to review and evaluate the plan.
10. This arrangement enters into force on 1st January, 2012.

If this plan is agreed and accepted it will then undergo a more detailed evaluation before it will be used as a basis for scientific advice.

H.4. Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

References

Alverson, D.L., Freeberg, M.H., Murawski, S.A., Pope, J.G. (1994) A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. No. 339. Rome, FAO. 1994. 233p.

Armstrong, M., Clarke, W., Peel, J., McAliskey, M., McCurdy, W., McCorriston, P., Briggs, R., Schön, P.-J., Bloomfield, S., Allen, M. and Toland, P. (2004). Survey indices of abundance for herring in the Irish Sea (Area VIIaN): 1992 – 2003. Working Document to ICES HAWG 2004.

Beggs, S., Schon, P.J., McCurdy, W, Peel., J., McCorriston, P., McCausland, I (2008). Seasonal origin of 1 ring+ herring in the Irish Sea (VIIaN) Management Area during the annual acoustic survey. Working Document to the herring assessment working group 2008.

Berrow, S. D., M. O'Neill, Brogan, D. (1998). "Discarding practices and marine mammal bycatch in the Celtic Sea herring fishery. "Biology and Environment: Proceedings of the Royal Irish Academy 98B(1): 1-8.

Blaxter, J.H.S., Hunter, J.R. (1982) The Biology of the Clupeoid Fishes. Advances in Marine Biology, Vol 20, pp. 1-223. Academic Press, London.

Breslin J.J. (1998) The location and extent of the main Herring (*Clupea harengus*) spawning grounds around the Irish coast. Masters Thesis: University College Dublin

Brophy, D and Danilowicz, B.S., (2002). Tracing populations of Atlantic herring (*Clupea Harengus* L.) in the Irish and Celtic Seas using otolith microstructure. ICES Journal of Marine Science, 59: 1305-1313

Brophy, D and Danilowicz, B.S., (2003) The influence of pre recruitment growth on subsequent growth and age at first spawning in Atlantic herring (*Clupea harengus* L.) ICES Journal of Marine Science, 60: 1103-1113

Burd, A. C. (1958). "An analysis of sampling the East Anglian herring catches." Journal du Conseil International Pour L'exploration de la Mer 24(1): 94 pp.

Burd, A. C. and J. Bracken (1965). "Studies on the Dunmore herring stock. 1. A population assessment." Journal du Conseil International Pour L'exploration de la Mer 29(3): 277-300.

Clarke, M. and Egan, A. (2008). Rebuilding Celtic Sea herring and the development of a long term management plan. ICES CM 2007 O:09.

Codling E and Kelly, C.J. (2005) F-PRESS: a stochastic simulation tool for developing fisheries management advice and evaluating management strategies. Irish Fisheries Investigation Series No. 17 2006 34pp ISSN 05787476

Corten, A, (1974) Recent changes in the stock of Celtic Sea herring {*Clupea harengus* L.) J. Cons. int. Explor. Mer, 35 (2): 194-201. Fevrier 1974.

Dalen, J. and Nakken, O. (1983) "On the application of the echo integration method"ICES CM 1983/B:19

Doonan, I. (2006). A review of herring acoustic surveys conducted by the Marine Institute. Galway : Marine Institute. Unpublished briefing document to MI>

Dransfeld, L (2006) From ecology to fisheries management: Celtic Sea Herring. Reports from the FSS mini symposia 2004 –2005

Du Buit, M.H. (1996). Diet of Hake (*Merluccius merluccius*) in the Celtic Sea. Fisheries Research 28: 381-394.

Farran, G. P. (1927). "The reproduction of *Calanus finmarchicus* off the south coast of Ireland." Journal du Conseil International Pour L'exploration de la Mer 2(2): 13 pp.

Farran, G. P. (1938). "On the size and numbers of the Ova of Irish Herrings." Journal du Conseil International Pour L'exploration de la Mer 13(1).

Grainger, R. J., Barnwall, Cullen, A. (1982). "Herring larval surveys in the Celtic Sea in 1981/82." ICES CM H:38: 16 pp.

Grainger, R.J.R. (1983) Managing the recovery of the Celtic Sea and Division VIIj herring stock ICES CM:1983 H:30

Grainger, R. J., E. Barnwall, Cullen, A (1984). "Herring larval surveys in the Celtic Sea and Division VIIj in 1983/1984." ICES CM H:29: 14 pp.

Hay, D.E. *et al* 2001. Taking Stock: An Inventory and Review of World Herring Stocks in 2000. Herring Expectations fro a new Millennium, Alaska Sea Grant College Program. AK-SG-04, 2001

Hatfield *et al*, 2007 (WESTHER, Q5RS-2002-01056): A multidisciplinary approach to the identification of herring (*Clupea harengus* L.) stock components west of the British Isles using biological tags and genetic markers.

ICES (1982). Report of the Herring Assessment Working Group South of 62ºN (HAWG) - Part 2 of 2. Copenhagen, ICES: 18 pp

ICES (1983). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1983/Assess:9

ICES (1990). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1990/Assess:14

ICES 1992. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1996/Assess:11.

ICES (1994). Report of the Study group on Herring Assessment and Biology in the Irish Sea and Adjacent Waters. Belfast, Northern Ireland, ICES CM 1994/H:5

ICES (1994b). Herring assessment working group for the Area South of 62ºN. ICES CM 1994/Assess:13

ICES (1995). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1995/Assess:13

ICES (1996). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1996/Assess:10

ICES (1997). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1997/Assess:8

ICES (1999). Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES C.M. 1999/ACFM:12

ICES (2000). Herring assessment working group for the Area South of 62ºN (HAWG) ICES CM 2000/ACFM:10

ICES (2001) Report on the study group on the further development of the precautionary approach to fishery management. ICES CM:2001/ACFM:11.

ICES (2002).Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES CM:2002/ACFM:12.

ICES 2003. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. ICES CM 2003/ACFM:15.

ICES (2004).Report of the Herring Assessment Working Group South of 62ºN (HAWG) ICES CM:2004/ACFM:18.

ICES (2005): Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory committee on Ecosystems. Volume 5. Avis du Ciem

ICES (2005b) Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM: 16

ICES (2005c): Report of the Study group on Regional Scale Ecology of Small Pelagics (SGPESP) ICES CM:2005/G:06

ICES (2006a). Report of working group for regional ecosystem description (WGRED). ICES CM 2006/ACE:03.

ICES (2006). Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM: 20

ICES (2007). Report of the Herring Assessment Working Group South of 62ºN (HAWG). Copenhagen, ICES CM/2007/ACFM:11: 546 pp.

ICES (2007b). Report of the Working Group for Regional Ecosystem description (WGRED). ICES:CM/2007 ACE:02

ICES (2008). Report of the Herring Assessment Working Group South of 62ºN (HAWG). Copenhagen, ICES CM/2008/ACOM:02: 613 pp.

Johnston, G and Clarke, M. (2005) An exploration of the Irish groundfish survey as a recruit index for Celtic Sea Herring. Working Document 20: ICES Herring Assessment Working Group 2005.

Kelly, C.J., Campbell, A., (2006). Use of FPRESS in Celtic Sea Herring. Marine Institute Internal Briefing Document.

Lynch, D. (2011). Long term changes in the biology of Celtic Sea Herring . MSc. Thesis, Trinity College Dublin.

Nash, R. and Dickey-Collas, M. (2005). The influence of life history dynamics and environment on the determination of year class strength in North Sea herring (*Clupea harengus* L.). Fisheries Oceanography, 14: 279–291.

Molloy, J. (1968). Herring Investigations on the Southwest Coast of Ireland, 1967. ICES CM:68/H:14

Molloy, J. (1969). A review of the Dunmore East herring fishery (1962-1968). Irish Fish. Invest., Series B (Marine) 6: 21 pp.

Molloy, J. (1972). "Herring fisheries on the south and south - west coasts 1971 - 1972." Fisheries Leaflet 37: 13 pp.

Molloy, J (1979). Fecundities of Celtic Sea Autumn and Winter Spawning Herring. ICES CM/H:47

Molloy, J. (1980). The assessment and management of the Celtic Sea herring stock. ICES Marine Science Symposia. 1980. 177: 159-165.

Molloy, J., Cullen, A. (1981). "The fat content of Irish herring." Fisheries Leaflet(107).

Molloy, J. (1984). "Density dependent growth in Celtic Sea herring." ICES CM 1984/H:30: 13 pp.

Molloy, J. (1989) The closure of herring spawning grounds in the Celtic Sea and Division VIIj. Fisheries Leaflet 145: 5pp

Molloy, J., Barnwall, E., Morrison, J (1993). "Herring tagging experiments around Ireland, 1991." Fisheries Leaflet(154): 7 pp.

Molloy, J. (1995). The Irish herring fisheries in the twentieth century: their assessment and management. Occasional Papers in Irish Science and Technology, Royal Dublin Society: 1-16.

Molloy, J., 2006. The Herring Fisheries of Ireland (1990 – 2005), Biology, Research, Development and Assessment.

Morizur, Y., S. D. Berrow, *et al*. (1999). "Incidental catches of marine-mammals in pelagic trawl fisheries of the northeast Atlantic." Fisheries Research 41(3): 297-307.

Patterson, K.R. (1998). Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38

Patterson, K.R., (1998b) A programme for calculating total international catch at age and weight at age. Marine Laboratory Aberdeen.

Pinnegar, J.K., Jennings, C., O Brien, M., Polunin, N.C.V. (2002) Long term, changes in the trophic level of the Celtic Sea fish community and fish market price distribution. Journal of Applied Ecology 39, 377 – 390

Skagen, D.W. 2003. Programs for stochastic prediction and management simulation (STPR3 and LTEQ). Program description and instruction for use. WD at HAWG 2003.

Smith, 2000 Multi Fleet Deterministic Projection. Unpublished document.

STECF (2006) Commission Staff Working Paper, 23rd Report of the Scientific, Technical and Economic Committee for Fisheries, Second Plenary, November 2006.

Whooley, P., Berrow, S. & Barnes, C. 2011 Photo-identification of fin whales (*Balaenoptera physalus* L.) off the south coast of Ireland. *Marine Biodiversity Records* **4**, 1-7.

http://flr-project.org/

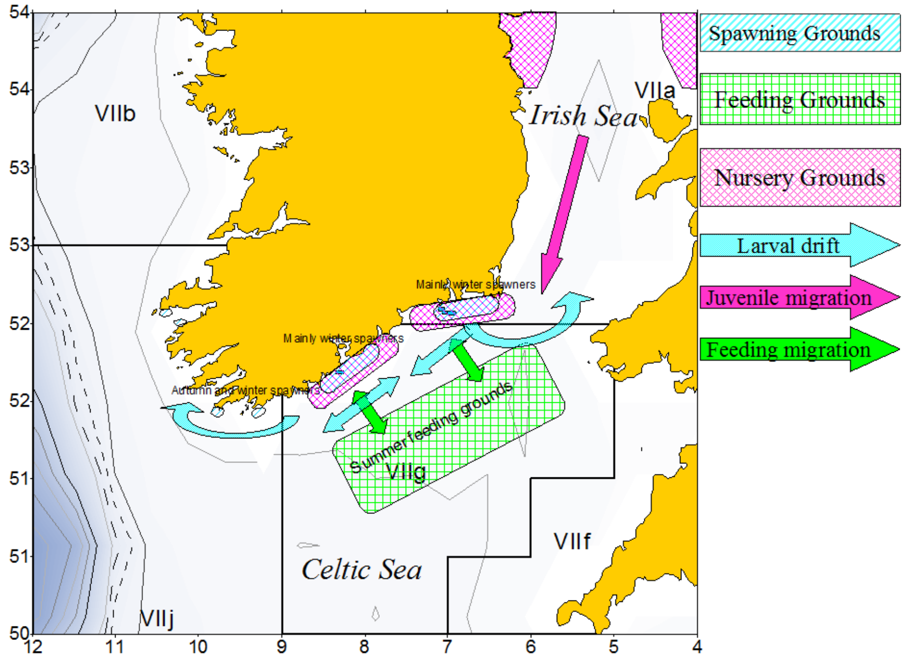


Figure 1. Herring in the Celtic Sea. Schematic presentation of the life cycle of Celtic Sea and VIIj Herring (ICES, 2005c, SGRESP).

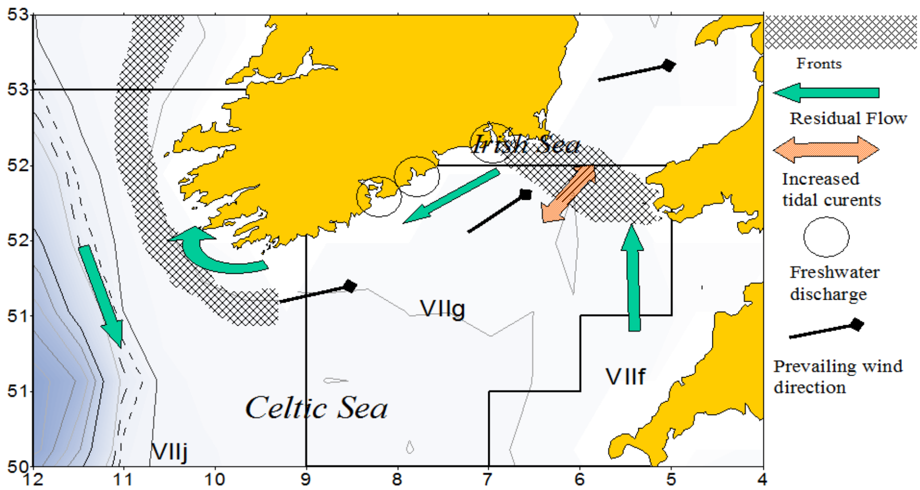


Figure 2. Herring in the Celtic Sea. Schematic presentation of prevailing oceanographic conditions in the Celtic Sea and VIIj (ICES, 2005c, SGRESP).

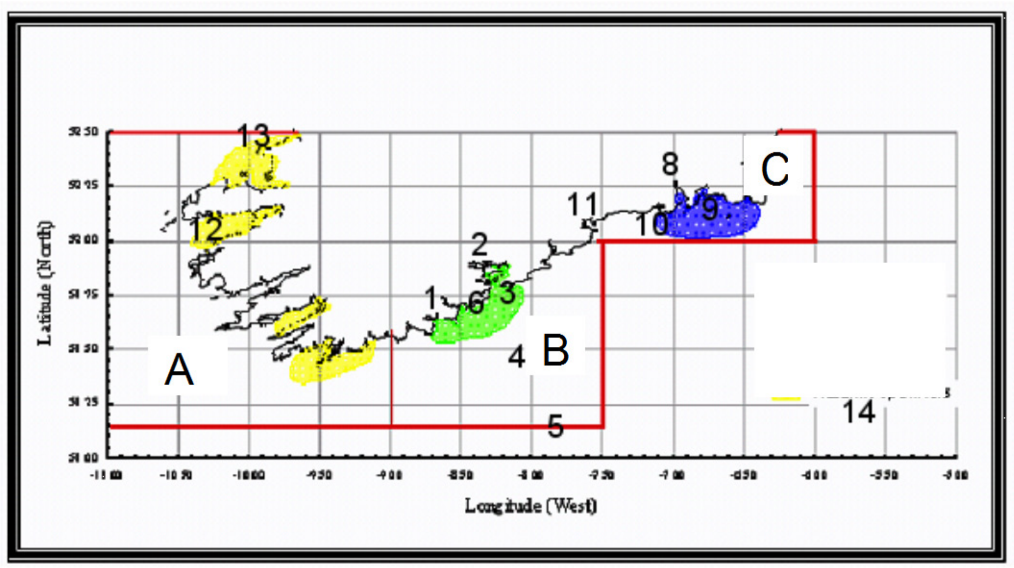


Figure 3. Herring in the Celtic Sea. Areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford Harbour, 9, Baginbun Bay, 10, Tramore Bay/ Dunmore East, 11, Ballycotton Bay, 12, Valentia Island, 13 Kerry Head to Loop Head, 14, The Smalls. The spawning boxes A-C correspond to ICES Divisions VIIj, VIIg and VIIaS respectively.

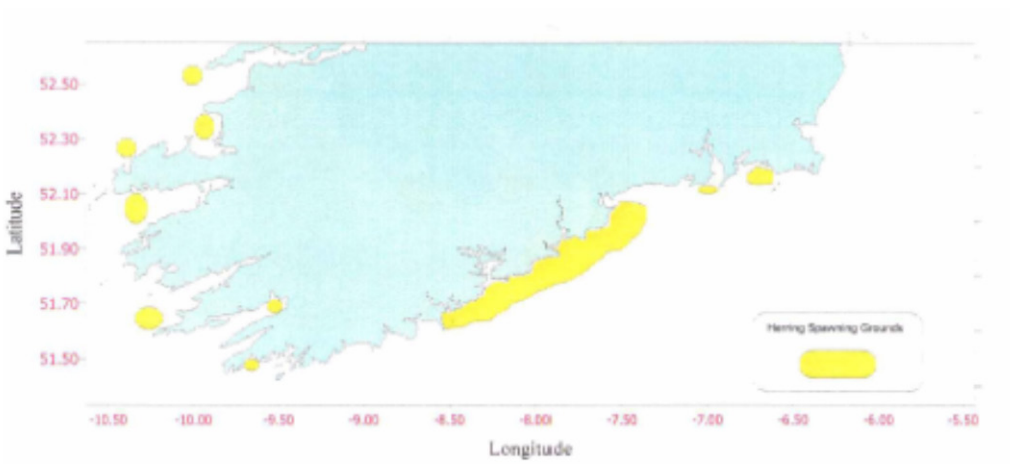


Figure 4. Herring in the Celtic Sea. Spawning ground of herring along the south coast of Ireland, inferred from information on the Irish herring fishery (Breslin, 1998).

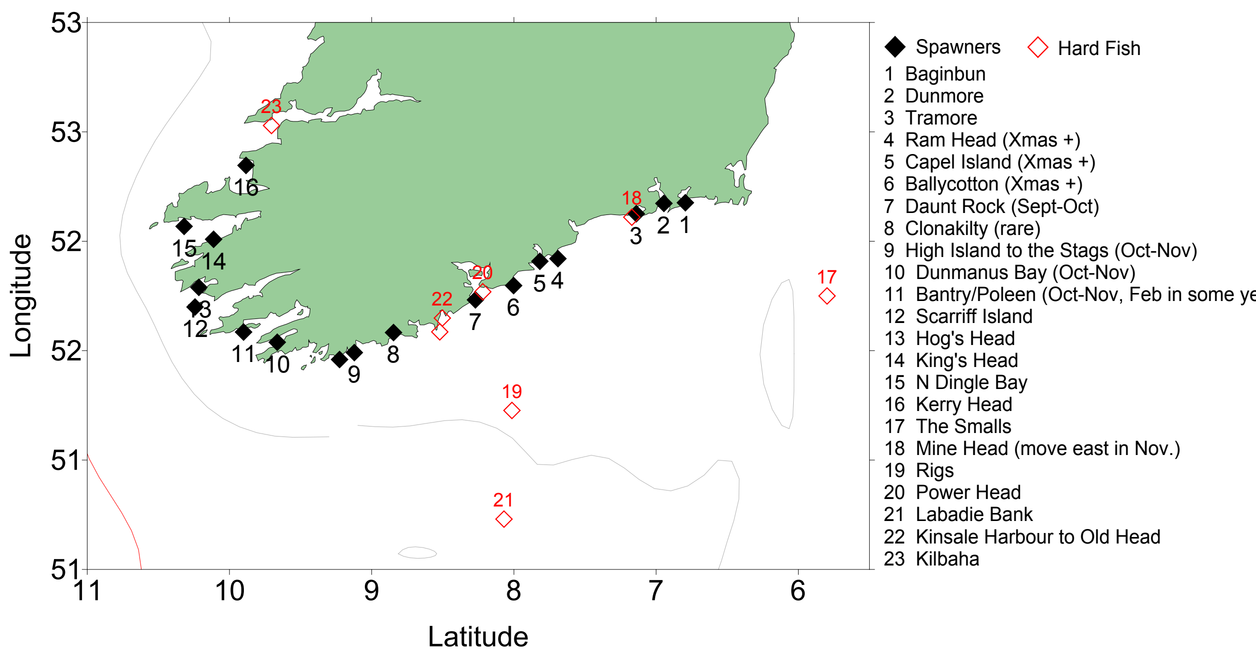


Figure 5. Herring in the Celtic Sea. Location of spawning (closed symbol) and non spawning (open symbol) herring in the Celtic Sea and SW of Ireland, based on expert fishemens' knowledge.

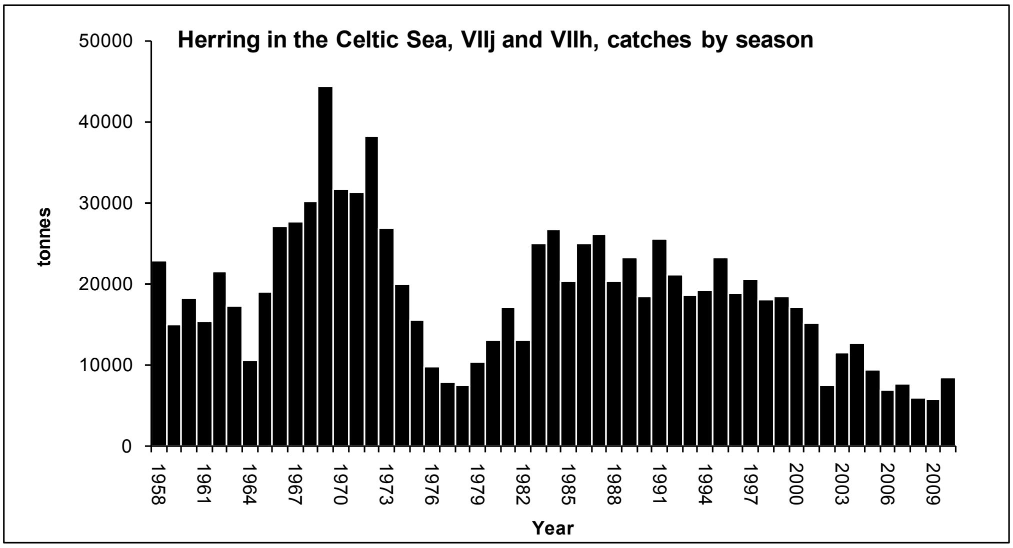


Figure .6. Herring in the Celtic Sea. ICES estimates of herring catches (tonnes) per season 1958/1959 to 2010/2011.

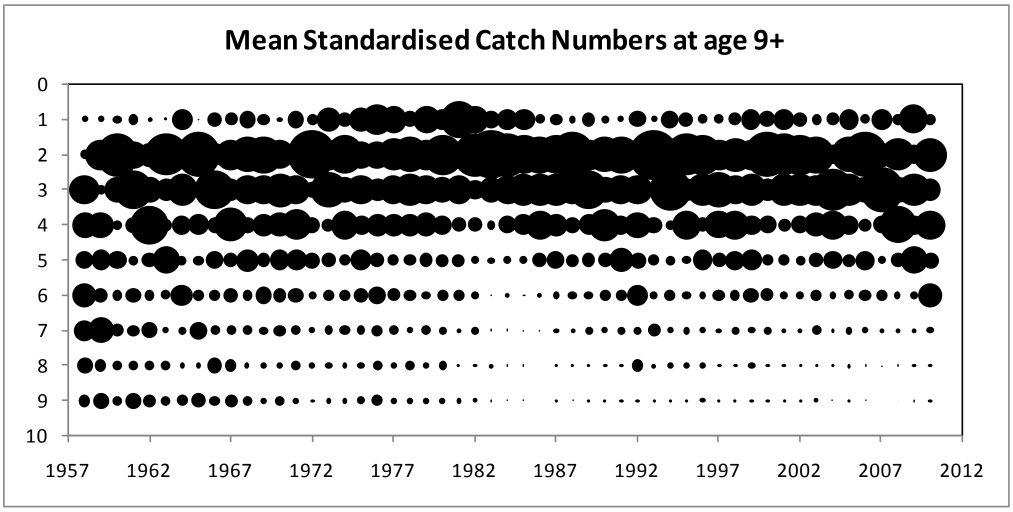


Figure 7. Herring in the Celtic Sea. Catch numbers at age standardised by yearly mean. 9+

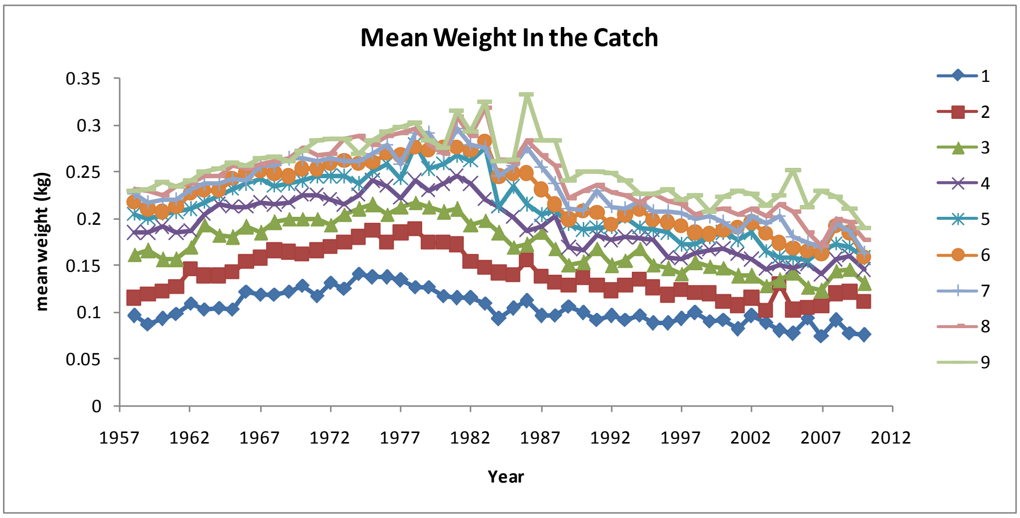


Figure 8. Herring in the Celtic Sea. Trends over time in mean weights in the catch.

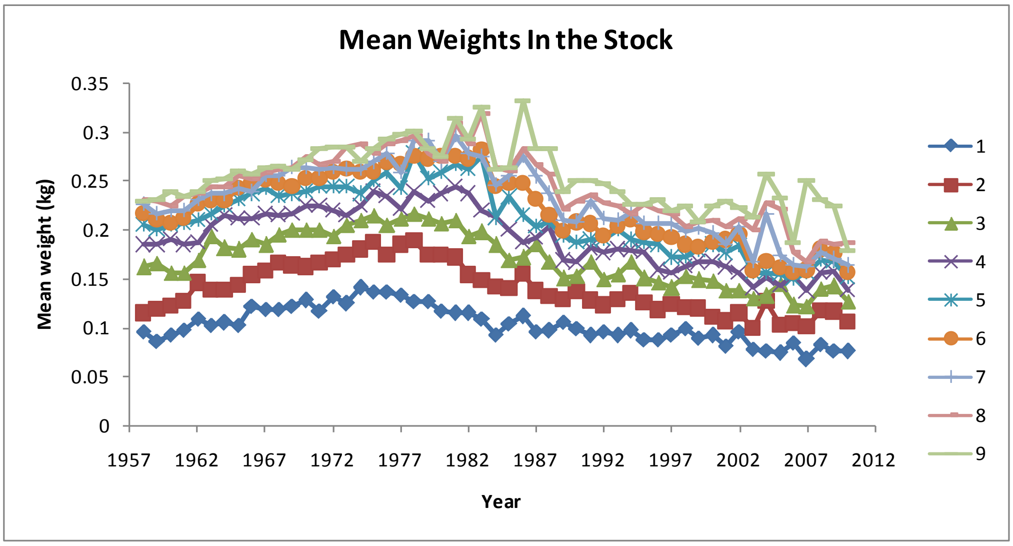


Figure 9. Herring in the Celtic Sea. Trends over time in mean weights in the stock at spawning time.

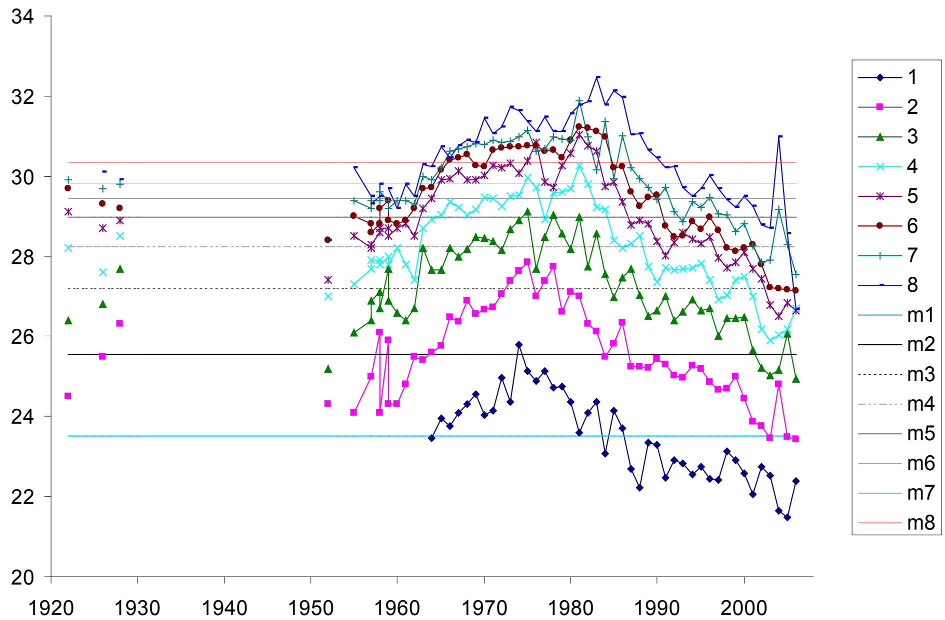


Figure 10. Herring in the Celtic Sea. Mean length at age from historic sources (Burd *et al*, 1965) and references therein. Data from 1964 onwards are Irish data. Long term means are shown for each age and are labelled m1-m8. The data from the 1920s are depicted as single years though they represent a group of years (Lynch, 2011).

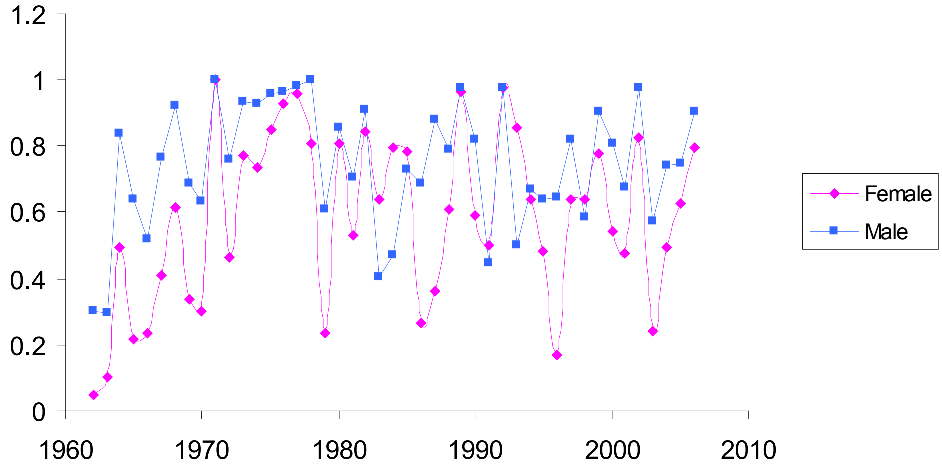


Figure 11: Herring in the Celtic Sea. Percentage maturity in males and females at 1 winter ring (Lynch, 2011).

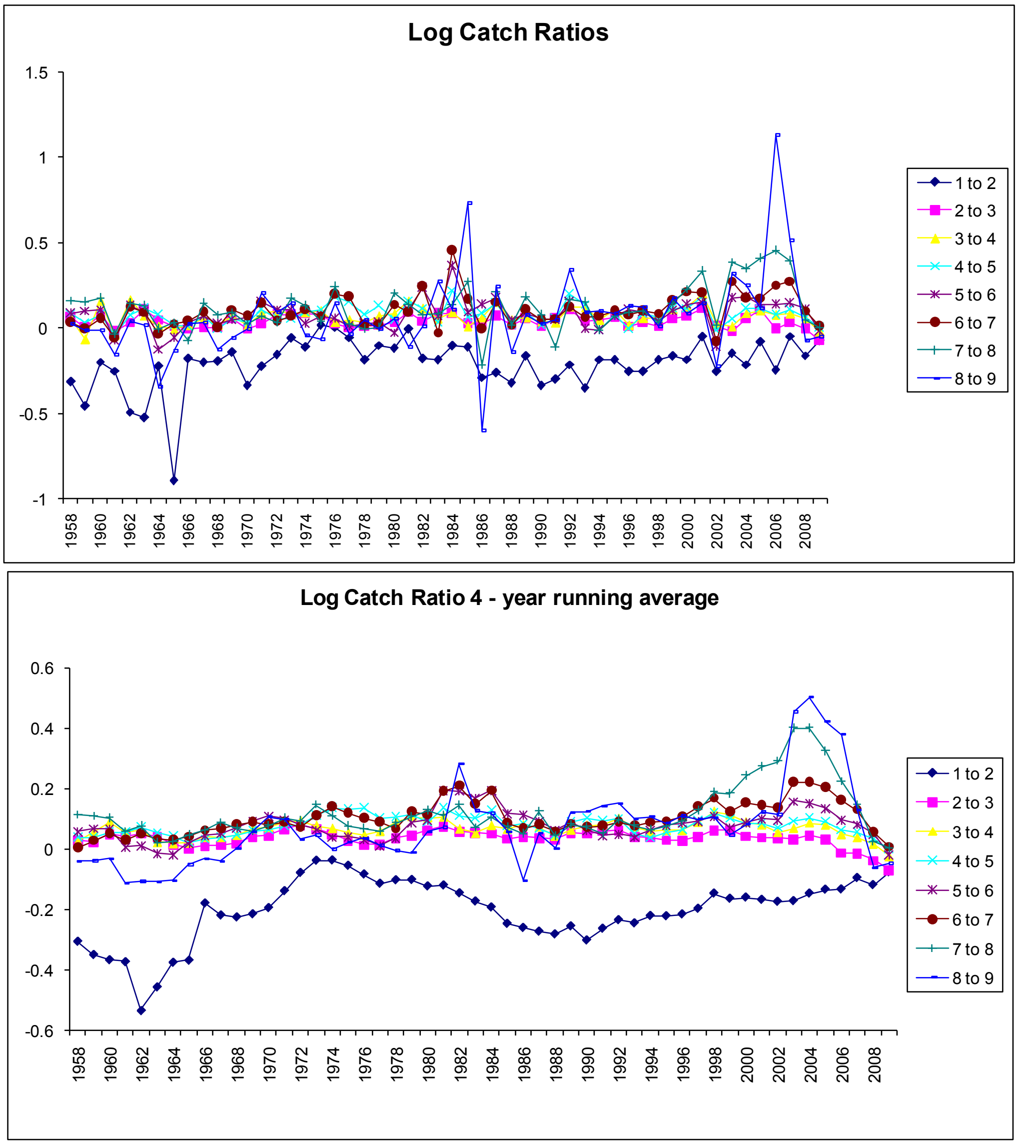


Figure 12. Herring in the Celtic Sea. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2010.

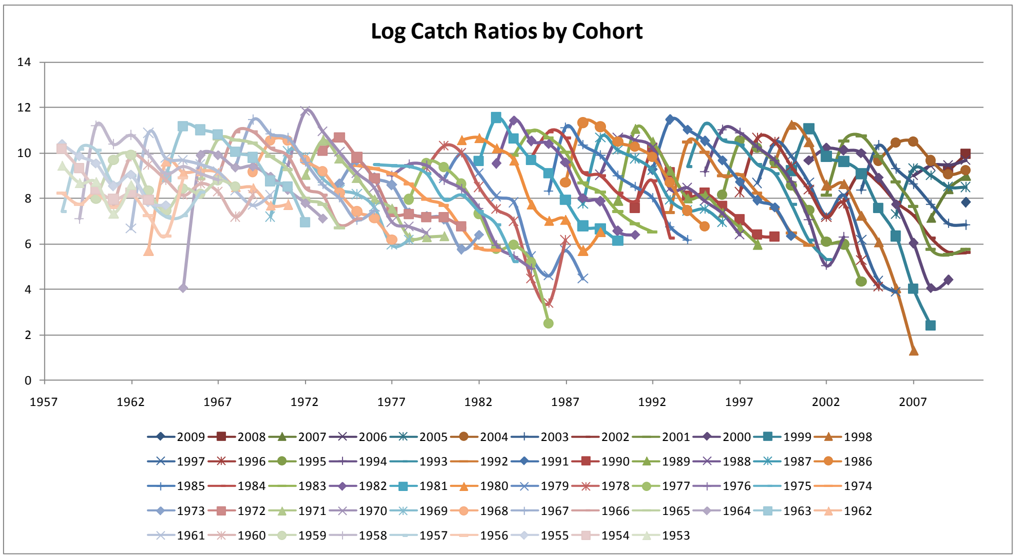


Figure 13. Herring in the Celtic Sea. Log Catch Ratios by cohort

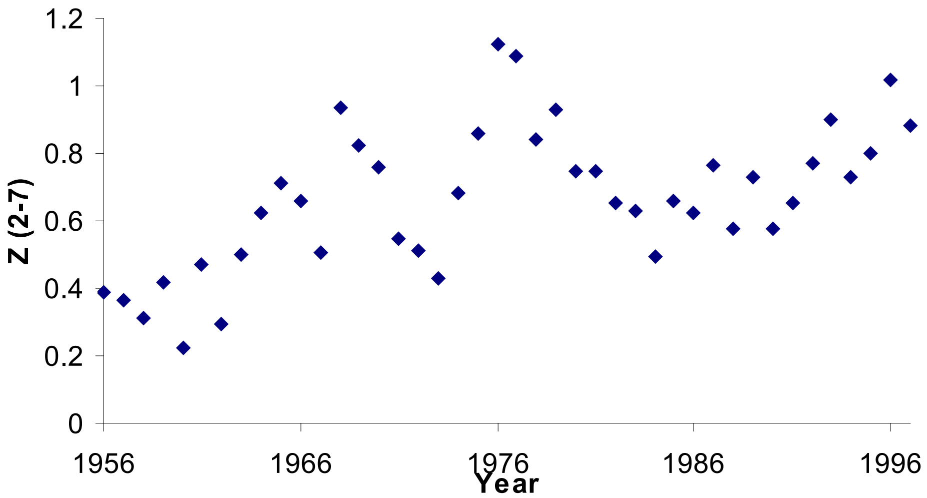


Figure 14: Herring in the Celtic Sea. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

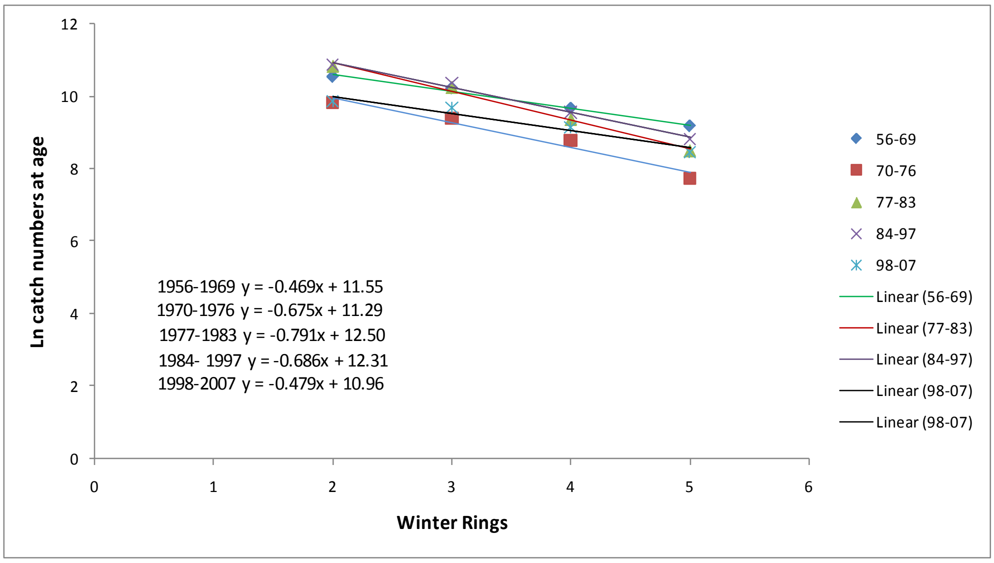


Figure 15. Herring in the Celtic Sea. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

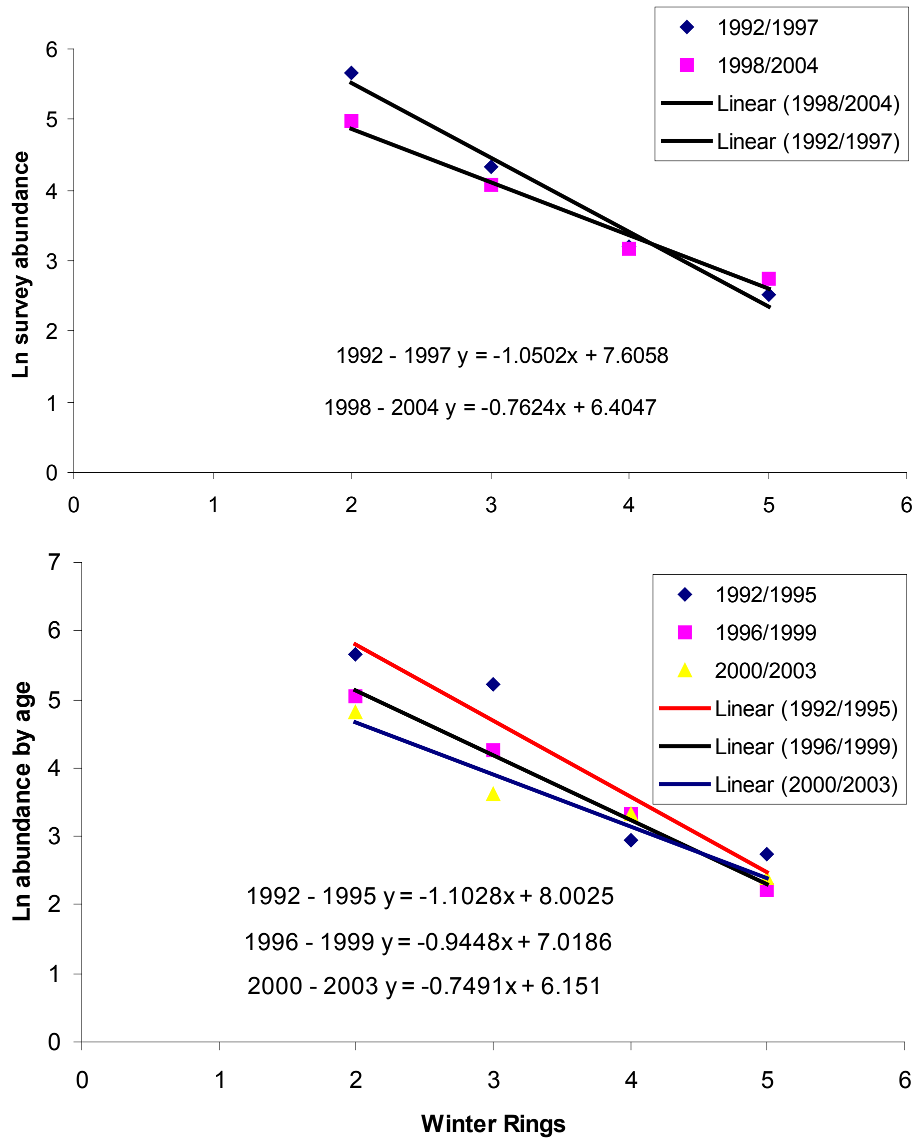


Figure 16. Herring in the Celtic Sea. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys

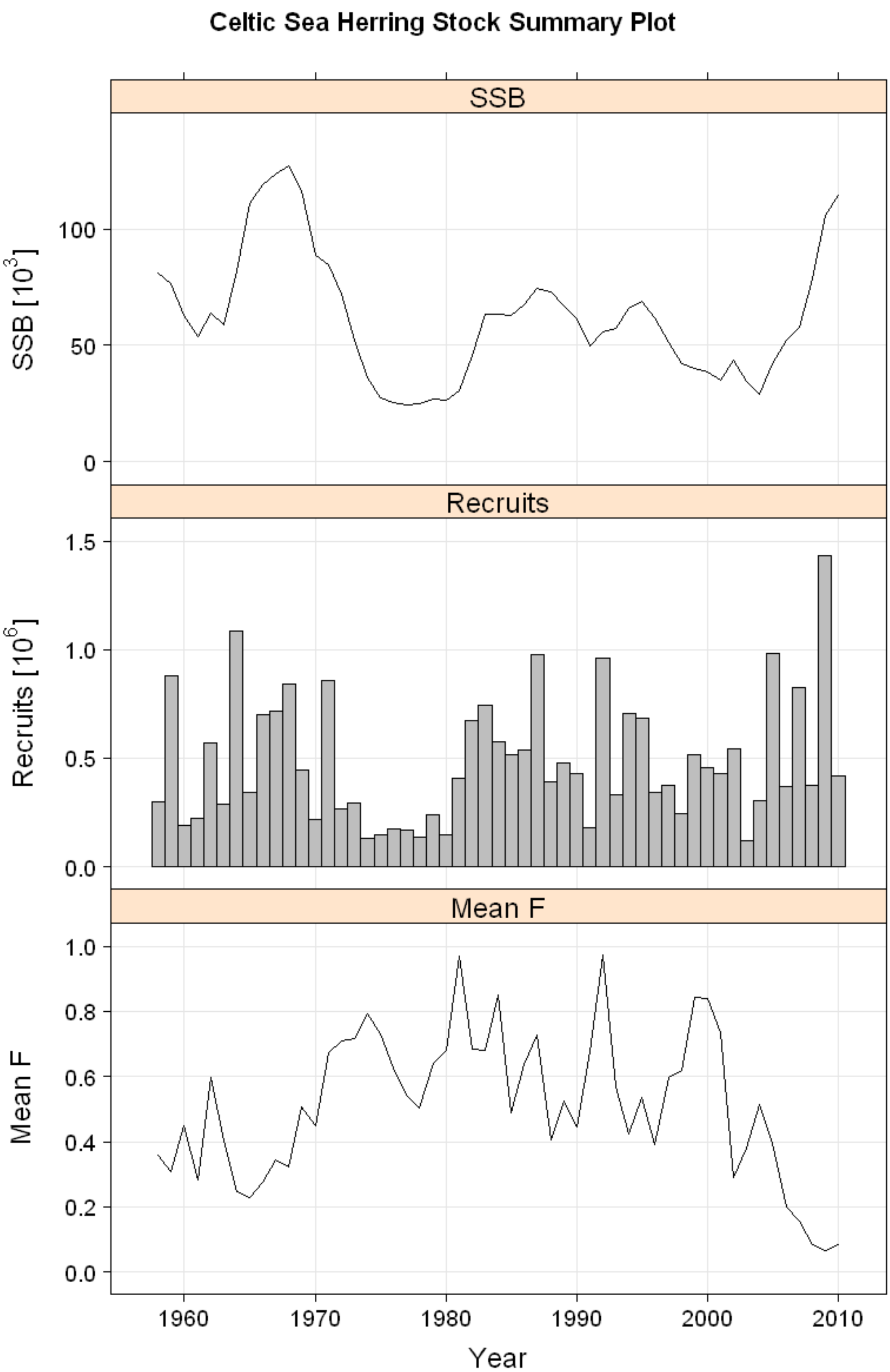


Figure 17. Herring in the Celtic Sea. SSB, F and recruitment (1-ringer) from the final assessment in 2011.

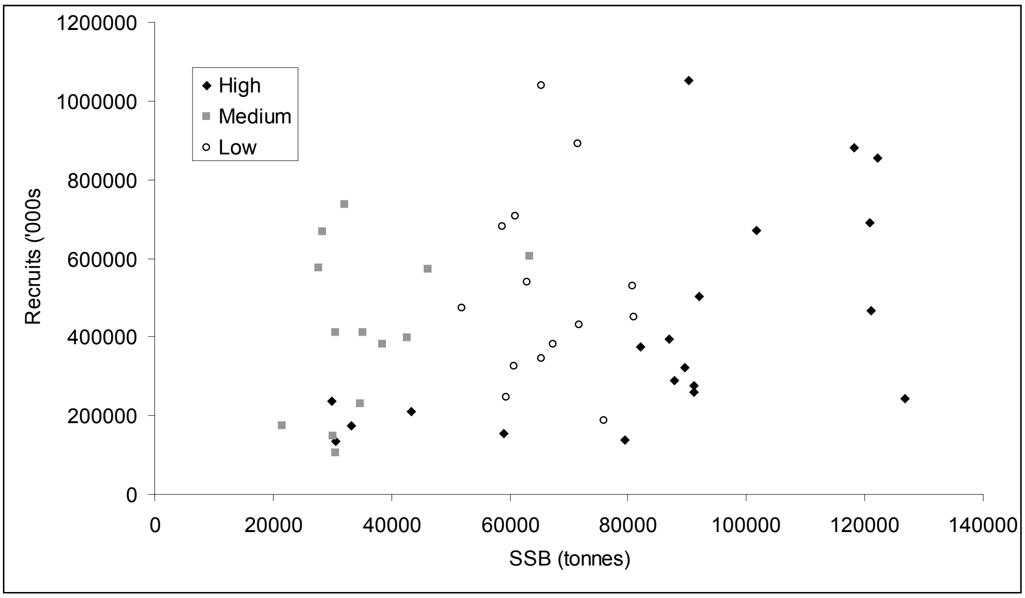


Figure 18. Herring in the Celtic Sea. Stock recruit relationship from ICA base case runs. Data classified according to quality of input data, see Table 4.

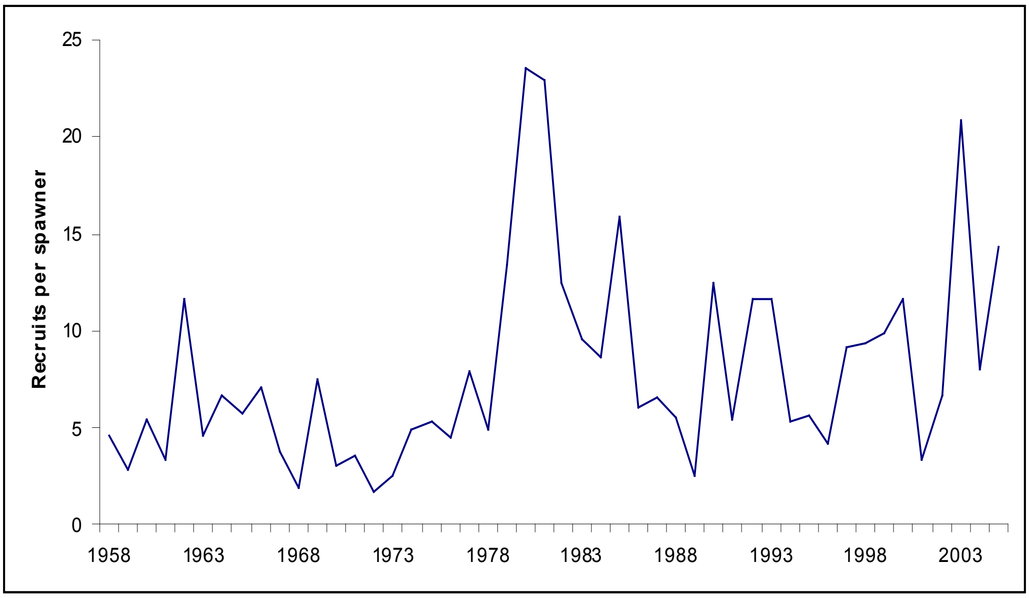


Figure 19. Herring in the Celtic Sea. Recruits per spawner, in '000s/tonnes

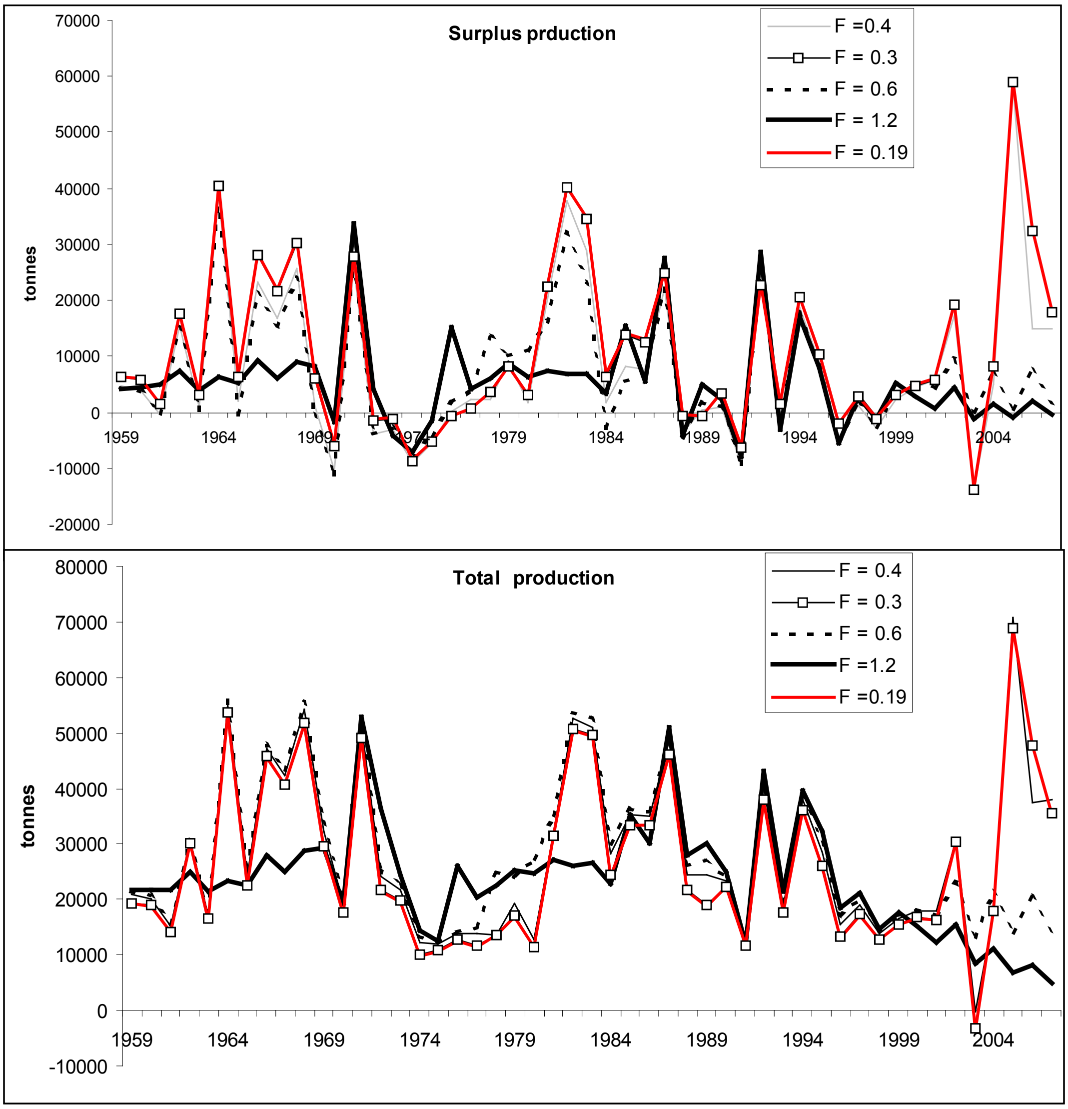


Figure 20. Herring in the Celtic Sea. Total and surplus production in the time series over a range of fishing mortalities.

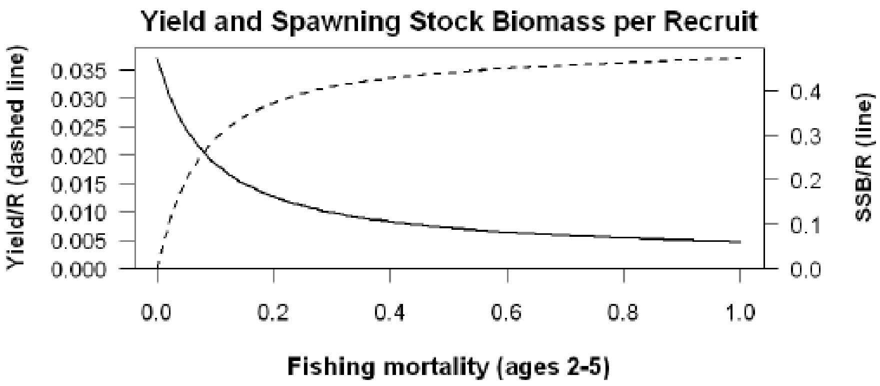


Figure 21. Herring in the Celtic Sea. Yield per recruit carried out in 2011.

Table 1. Herring in the Celtic Sea. Acoustic surveys of Celtic Sea and VIIj herring, by season. Number of surveys per season and type indicated along with biomass and SSB estimates. Shaded sections show surveys not used in tuning, in most recent assessment.

Season	No.	Type	Survey Timing	SSB
1990/1991	2	Autumn and winter spawners	Oct and Jan/Feb	-
1991/1992	2	Autumn and winter spawners	Nov/Dec and Jan	-
1992/1993	2	Autumn and winter spawners	Nov and Jan	-
1993/1994	2	Autumn and winter spawners	Nov and Jan	-
1994/1995	2	Autumn and winter spawners	Nov and Jan	-
1995/1996	2	Autumn and winter spawners	Nov and Jan	36
1996/1997	1	Autumn and winter spawners	Oct/Nov and Jan	151
1997/1998	-	No survey		-
1998/1999	1	Autumn spawners	Nov and Jan	100
1999/2000	1	Feeding phase	July	-
1999/2000	1	Winter-spawners	Nov and Jan	-
2000/2001	2	Autumn and winter spawners	Oct and Jan	20
2001/2002	2	Pre-spawning	Sept and Oct	95
2002/2003	1	Pre-spawning	Sept/Oct	41
2003/2004	1	Pre-spawning	Oct/Nov	20
2004/2005	1	Pre-spawning	Nov/Dec	-
2005/2006	1	Pre-spawning	Oct	33
2006/2007	1	Pre-spawning	Oct	36
2007/2008	1	Pre-spawning	Oct	46
2008/2009	1	Pre-spawning	Oct	90
2009/2010	1	Pre-spawning	Oct	91
2010/2011	1	Pre-spawning	Oct	122

Table 2. Herring in the Celtic Sea. Original acoustic survey abundance at age as used by ICES until HAWG 2006.

	1990 1991	1991 1992	1992 1993	1993 1994	1994 1995	1995 1996	1996* 1997	1997 1998	1998* 1999	1999** 2000	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2005	2006 2007
0	205	214	142	259	41	5	3	-	-	13	-	23	19	0	25	26	13	-
1	132	63	427	217	38	280	134	-	21	398	23	18	30	41	73	13	54	21
2	249	195	117	438	127	551	757	-	157	208	97	143	160	176	323	29	125	211
3	109	95	88	59	160	138	250	-	150	48	85	36	176	142	253	32	26	48
4	153	54	50	63	11	94	51	-	201	8	16	19	40	27	61	16	50	14
5	32	85	22	26	11	8	42	-	109	1	21	7	44	6	16	3	20	11
6	15	22	24	16	7	9	1	-	32	1	8	3	23	8	5	1	5	1
7	6	5	10	25	2	8	14	-	30	0	2	2	17	3	2	0	1	-
8	3	6	2	2	3	9	1	-	4	0	1	0	11	0	0	0	-	-
9+	2	-	1	2	1	5	2	-	1	0	0	1	23	0	0	0	-	-
Total	904	739	882	1107	399	1107	1253		705	677	252	250	542	404	758	119	292	305
Biomass (000't)	103	84	89	104	52	135	151		111	58	30	33	80	49	89	13	33	37
SSB (000't)	91	77	71	90	51	114	146		111	23	26	32	74	39	86	10	30	36

* Autumn survey

** Summer survey

Table 3. Herring in the Celtic Sea. Revised acoustic series as used by HAWG.

	2002	2003	2004	2005	2006	2007	2008	2009	2010
	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0	24	-	2	-	1	99	239	5
1	42	13	-	65	21	106	64	381	346
2	185	62	-	137	211	70	295	112	549
3	151	60	-	28	48	220	111	210	156
4	30	17	-	54	14	31	162	57	193
5	7	5	-	22	11	9	27	125	65
6	7	1	-	5	1	13	6	12	91
7	3	0	-	1	-	4	5	4	7
8	0	0	-	0	-	1		6	3
9	0	0	-	0	-	0		1	
							-		
Abundance	423	183	-	312	305	454	769	1,147	1,414
SSB	41	20	-	33	36	46	90	91	122
CV	49	34	-	48	35	25	20	24	20
Design	AR	AR		R	R	R	R	R	R

Table 4. Herring in the Celtic Sea. Rudimentary history of the Irish fishery since 1958.

Time period	**1958-1977**	**1977-1983**	**1983-1997**	**1998-2004**	**2004-2007**
Type of fishery	**Cured fish**	**Closure**	**Herring roe**	**Fillet/whole fish**	**Fillet/whole fish**
Quality of catch data	**High**	**Medium**	**Low**	**Medium/low**	**High**
Source of catch data	**Auction data**	**Auction data**	**Skipper logbook estimate**	**Skipper logbook estimate**	**Weighbridge landings**
Discard Levels	**Low**	**Low**	**High**	**Medium**	**Medium**
Incentive to discard	**None**	**None**	**Maturity stage**	**Size grade, market vs. quota**	
Alloowance for water*	**na**	**na**	**na**	**20%***	**2%***

*** RSW only. These vessels are more dominant in recent years.**

Table 5. Herring in the Celtic Sea. Biological history of the stock.

	1958-1972	1973-1977	1978-1980	1981-1983	1984-1995	1996-2008
MW 2-ring (kg) median	0.146	0.181	0.179	0.158	0.135	0.115
ML 2-ring (cm) median	26.4	27.5	27.1	26.3	25.2	24.4
Z (cohort catch curve)	0.22 - 0.93	0.42 - 1.12	0.74 - 0.93	0.62 - 0.74	0.49 - 0.89	0.48 - 1.01
GM recruitment 10^6	448	167	168	587	514	340
Recruitment anomaly	positive	negative	negative	positive	positive	both
SSB (000 t)	53 - 126	27 to 52	25 - 26	30 - 63	49 - 68	24 - 70
F (2-5 r)	0.23 - 0.71	0.55 - 0.80	0.50 - 0.68	0.68 - 0.87	0.40 - 0.98	0.12 - 0.88

Table 6. Celtic Sea and VIIj herring. Total mortality Z estimated from cohort catch curves.

Cohort	Z (2-7 ring)	Cohort	Z (2-7 ring)
1956	0.39	1977	1.09
1957	0.37	1978	0.84
1958	0.31	1979	0.93
1959	0.42	1980	0.75
1960	0.22	1981	0.75
1961	0.47	1982	0.65
1962	0.30	1983	0.63
1963	0.50	1984	0.50
1964	0.62	1985	0.66
1965	0.71	1986	0.62
1966	0.66	1987	0.76
1967	0.51	1988	0.58
1968	0.93	1989	0.73
1969	0.82	1990	0.57
1970	0.76	1991	0.65
1971	0.55	1992	0.77
1972	0.51	1993	0.90
1973	0.43	1994	0.73
1974	0.68	1995	0.80
1975	0.86	1996	1.02
1976	1.12	1997	0.88

Table 7. Celtic Sea and VIIj herring. Estimates of estimates of $F_{0.1}$, F_{max} and F_{msy} from the literature and HAWG work.

	$F_{0.1}$	F_{max}	F_{msy}	MSY	Comments	Reference
1965	-	>0.5		12 – 15 000 t	Years for calculation had lower recruitment	Burd and Bracken, 1965
1969	-	~0.45		22 000 t	Years for calculation had higher recruitment	Molloy, 1969
1974	-	>0.5		14 000 *	Fmsy calculated for periods of high and low recruitment	Corten, 1974
1983	0.16				Yield/Biomass ratio	HAWG, 1983
1990	0.16					HAWG, 1990
1994	0.16					HAWG, 1994
1995	0.16					HAWG, 1995
1996	0.16					HAWG, 1996
1997	0.1					HAWG, 1997
1999	<0.2					HAWG, 1999
2000	<0.2					HAWG, 2000
2002	0.17				MFYPR software	HAWG, 2002
2003	0.17				MFYPR software	HAWG, 2003
2004	0.17				MFYPR software	HAWG, 2004
2007	0.19				MFYPR software	HAWG, 2007
2009	0.17				MFYPR software	HAWG 2009
2010	0.18		0.25		HCS 10 Software	HAWG 2010
2011	0.17				FLR	HAWG 2011

***endorses Molloy (1969) provided that recruitment is at level 1966 – 1969**

Table 8 Celtic Sea and VIIj herring. Advice history.

Year	ICES Advice	Predicted catch to corresp to advice	Agreed TAC	Official Landings	Discards	Estimated Catch[1]
1974	NEAFC TAC		32	20	-	19.74
1975	Reduce F, TAC ≤ 25,000		25	16	-	15.13
1976	TAC between 10,000 and 12,000		10.8	10	-	8.2
1977	No Fishing	0	0	8	-	7.1
1978	No Fishing	0	0	8	-	15.5
1979	TAC set for VIIj only, No fishing in Celtic Sea	0	6	10	-	12.1
1980	TAC set for VIIj only, No fishing in Celtic Sea		6	9	-	9.2
1981	TAC set for VIIj only, No fishing in Celtic Sea		6	17	-	16.8
1982	TAC		8*	10	-	9.5
1983	TAC		8*	22	4	22.18
1984	TAC	13	13	20	3.6	19.7
1985	TAC	13	13	16	3.1	16.23
1986	No specific TAC, preferred overall catch 17,000t		17	13	3.9	23.3
1987	Precautionary TAC	18	18	18	4.2	27.3
1988	TAC	13	18	17	2.4	19.2
1989	TAC	20	20	18	3.5	22.7
1990	TAC	15	17.5	17	2.5	20.2
1991	TAC (TAC excluding discards)	15 (12.5)	21	21	1.9	23.6
1992	TAC	27	21	19	2.1	23
1993	Precautionary TAC (including discards)	20–24	21	20	1.9	21.1
1994	Precautionary TAC (including discards)	20–24	21	19	1.7	19.1
1995	No specific advice	-	21	18	0.7	19
1996	TAC	9.8	16.5–21	21	3	21.8
1997	If required, precautionary TAC	< 25	22	20.7	0.7	18.8
1998	Catches below 25	< 25	22	20.5	0	20.3
1999	F = 0.4	19	21	19.4	0	18.1
2000	F < 0.3	20	21	18.8	0	18.3
2001	F < 0.34	17.9	20	19	0	17.7
2002	F<0.35	11	11	11.5	0	10.5
2003	Substantially less than recent catches	-	13	12	0	11
2004	60% of average catch 1997–2000	11	13	12	-	11
2005	60% of average catch 1997–2000	11	13	10	-	8
2006	Further reduction 60% avg catch 2002–2004	6.7	11	9	-	8.5
2007	No fishing without rebuilding plan	--	9.4	9.6	-	8.3
2008	No targeted fishing without rebuilding plan	--	7.9	7.8	-	6.9
2009	No targeted fishing without rebuilding plan		5.9	6.2	-	5.8
2010	Fmgt 0.19	10.15	10.15			
2011	See scenarios					

*** TAC from 1st Oct – 31st Mar**

1) Calendar year

Annex 6 – Stock Annex Herring in VIaN

Quality Handbook ANNEX: Hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Herring in VIa (North)

Working Group: Herring Assessment WG for the Area south of 62°N

Date: 23 March 2011

Authors: E.M.C. Hatfield, E.J. Simmonds and A. Edridge

The section on short term forecast has been updated in 2011 to reflect the changes recommended by the 2011 Advice Drafting Group in 2010. Advice is now based on the average Fsq of the last three years in the assessment

A. General

A.1. Stock definition

The stock is distributed over ICES Division VIa (N). Some of the larger adults typically found close to the shelf break may be caught in division Vb.

A.2. Fishery

The dominant fleet fishing in VIa (N) since 1957 has been the Scottish fleet. In the early years the Scottish fishery was prosecuted using a mixture of vessel size and gear, including gill nets, ring-nets and trawls. The boats were small, and targeted the coastal stock, primarily fishing in the winter. Until 1970 the only other nations fishing in this area on a regular basis were the former German Federal Republic, and to a much lesser extend the Netherlands. These fleets operated in deeper water near the shelf edge.

In 1970 a large increase in exploitation occurred with the entry of fleets from Norway and the Faroes, and an increased Netherlands catch. In addition, considerably smaller catches were taken by France and Iceland.

Throughout this period juvenile herring catches from the Moray Firth, in the northeast 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 southwestern Hebrides. The Scottish and Norwegian purse seine fleets targeted herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). An international freezer-trawler fishery operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the Netherlands, Germany, France and England. In recent years the catch of these fleets has become more similar.

In recent years the Scottish fleet has changed to a predominantly purse-seine fleet to a trawl fleet. Norwegian vessels fish less in the area than in the past. Scottish catches still comprise around half of the total, the rest is dominated by the offshore, international fishery.

A recent EU-funded programme WESTHER has elucidated stock structures of herring throughout the western seaboard of the British Isles using a combination of morphometric measurements, otolith structure, genetics and parasite loads. The results provide information on mixing of stocks within and beyond VIa (N).

A.3. Ecosystem aspects

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

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

In addition to being a valuable protein resource for humans, herring represent an important prey item for many predators including cod and other large gadoids, dogfish and sharks, marine mammals and sea birds. Because the trophic importance of herring puts its stocks under immense pressure from constant exploitation, it is important that management takes into account all anthropogenic, environmental and biological variables.

A.4. Biology of the species in the distribution area

The Atlantic herring, *Clupea harengus*, is numerically one of the most important pelagic species in North Atlantic ecosystems with widespread distribution around the Scottish coast. Within the Northeast Atlantic they are encountered from the north of Biscay to Greenland, and east into the Barents Sea. It is thought that herring stocks comprise many reproductively isolated subpopulations through specific spawning grounds and seasons (e.g. autumn and spring spawners), but the taxonomic status of these subpopulations remains unclear.

Herring are demersal spawners and produce dense beds of benthic eggs deposited on gravelly substrates. This behaviour is considered to be an evolutionary remnant of herrings' river spawning past. Each female produces a single batch of eggs per year, releasing a ribbon of eggs that adheres to the benthos; the male sheds milt while swimming a few centimetres above the female. This particular behaviour renders herring vulnerable to anthropogenic activity such as offshore oil and gas industries and gravel extraction.

The eggs take about three weeks to hatch, dependant on the temperature. The larvae on hatching are 6-9mm long and are immediately planktonic. Their yolk sac lasts for about a week during which time they will begin to feed on phytoplankton and crustacean larvae. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to coastal nurseries. The habitats of juveniles are primarily pelagic, and hydrographical features such as temperature and the depth of thermocline, as well as abundance of zooplankton affect their distribution. Adult fish are pelagic and found mostly in continental shelf seas to depths up to 200m. They form large shoals with diurnal migration patterns through the water column which can be associated with the availability of prey and stage of maturity. In the winter the feeding activity and growth are very slow. Herring can reach 40cm in length and have a maximum lifespan of 10 years although most herring range between 20-30cm and are less than 7 years.

Assessing age and year class for herring can be problematic due to the extended spawning season of autumn spawners from September to January. Using the convention of January 1st as the birthday, 0-group refer to fish born between 3 and 18 months ago but 0-group autumn spawners belong to a different class from 0-group spring spawners. Time series of a stock's age structure helps its management and it is vital that they are extended for all the '*West of Scotland*' herring components in the VIaN (North), VIaS (South) and VIb areas. 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}.

B. Data

B.1. Commercial catch

Commercial catch is obtained from national laboratories of nations exploiting herring in VIa (N). Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2002 catch data was v1.6.4. The majority of commercial catch data of multinational fleets was provided on these spreadsheets and further processed with the SALLOCL-application (Patterson, 1998a). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing sampling data and raising the catch information of one nation/quarter/area with information from another data set.

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year.

Current methods of compiling fisheries assessment data. The species co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet) area quarter, if an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

Until 2003 the VIa(N) catch data extended back to the early 1970s; since 1986 the series has run from 1976 to present. In 2004 the data set was extended back to 1957. Details are given below.

Historic Catches from 1957 to 1975

The working group has obtained preliminary estimates of catch and catch-at-age for the period 1957 to 1975. These have been estimated from records of catch presented in HAWG reports from 1973, 1974, 1981 and 1982. Intervening reports were also consulted to check for changes or updates during the period. Catch-at-age data were available from 1970 to 1975 from the 1982 Working Group report, and catches-at-age for the period 1957 to 1972 were estimated from paper records of catch-at-age by national fleets for 1957 to 1972, held at FRS Marine Laboratory Aberdeen. The fishing practices of national fleets were established for the period 1970 to 1980 from catches in VIa and VIa (N) recorded in the 1981 and 1982 Working Group reports respectively. This procedure suggested that, on average, more than 90% of catch by national fleet could be fully assigned to either VIa (N) or VIa (S). The remaining catch was assigned assuming historic proportions. During this period catches were split into autumn and spring spawning components; anecdotal information on trials to verify this separation suggests it was not a robust procedure. Currently about 5% of herring in VIa (N) is found to be spent at the time of the acoustic surveys in July, and thought to be spring spawning herring. However, at present the Working Group assesses VIa (N) herring as one stock, regardless of spawning stock affiliation. In the earlier period higher proportions were allocated as spring spawners. Currently the designated 'spring spawning' component is not included in the catch at age matrix, but the catch tones express the full amount giving rise to SoP differences in the early years. Similarly, a small Moray Firth juvenile fishery was also included in VIa (N) catch in earlier years because it was thought that these juveniles were part of the VIa (N) stock. Separating this component in the historic data was difficult, and as the fishery ceased in the very early 70s this has no implications for current allocation of these fish. The Moray Firth is, geographically, part of IVa (ICES stat. rectangles 44E6, 44E7, 45E6) and is now managed as part of that area. Currently there are no juvenile herring catches from the Moray Firth. Full details of the analysis carried out is provided as an appendix (Appendix 11) to the 2004 Working Group report. Further investigations are required before determining the correct actions concerning the 'spring spawners' in early period. The consequence of this is to slightly reduce the apparent stock size in the early years, when is already at an all time high. It has no implications for fitting of any survey data, or influence on the B_{lim} reference point, however, it might further increase the high R seen at high SSB in a S/R relationship.

Allocation of catch and misreporting

This fishery has had a strong tradition of misreporting before 2000, though this has reduced in recent years. It is believed that the shortfall between the TAC and the catch was used to misreport catches from other areas (from IVa to the east and from VIa (S) to the south). In the past, fishery-independent information confirmed that large catches were being reported from areas with low abundances of fish, and informal information from the fishery and from other sources confirmed that most catches of fish recorded between 4°W and 5°W were most probably misreported North Sea catches. The problem was detailed in the Working Group report in 2002 (ICES 2002/ACFM:12). Improved information from the fishery in 1998 - 2002 allowed for re-allocation of many catches due to area misreporting (principally from VIa (N) to IVa (W)). This information was obtained from only some of the fleets

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

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa(North) since the late 1970s was opened to fishing in 2008 following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

Catches are included in the assessment. Biases and sampling designs are not documented. Discards are not included, though data from some fleets suggest these are very minor. Slippage and high grading are not recorded.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described in Section B.1 above. For information on recent sampling levels and nations providing samples, see Section 2.2. in the most recent HAWG report.

Proportions mature (maturity ogive) and mean weights-at-age in the stock derived from the acoustic survey (see next section) have been used since 1992 and 1993, respectively. Prior to these years, time-invariant values 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 –MSHAS_N

An acoustic survey has been carried out for VIa (N) herring in the years 1987, 1991-2010.

Biomass estimated from the acoustic survey tends to be variable. Herring are found in similar area each year, namely south of the Hebrides off Barra Head, west of the Hebrides and along the shelf edge.

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time series. Effort stratification has improved with knowledge of the distribution and this may be less of a problem in more recent years. The survey uses the same target strength as for the North Sea surveys and there is no reason to suppose why this should be any different. Species identification is generally not a great problem.

Review of acoustic survey time-series

In 2009, an examination of the time series of the spawning stock biomass (SSB) data derived from the annual acoustic survey for the west of Scotland herring stock, in preparation for a publication on the survey time-series, showed a number of discrepancies between the values given in the original survey reports, the PGHERS (or combined survey) reports, the HAWG reports and the combined acoustic survey data archive held in the Marine Lab. Aberdeen. The discrepancies could not be easily explained by simple means, e.g., the original survey report included data east of 4°W that was then subtracted for the SSB estimate later.

A simple calculation of the values in the survey assessment input files was performed:

Catch numbers-at-age in the survey * weights-at-age in the stock * proportion mature

to derive an estimate of the SSB. This showed up further discrepancies that warranted closer examination. Initially it was not certain from where the discrepancies may have arisen, and they were only in certain years.

The aim of this exercise was to produce a new set of survey input files of catch numbers-at-age in the survey (*fleet)*, weights-at-age in the stock (*west*) and proportion mature (*matprop*), with the correct values within and the reasons for those choices documented. The details are given in full in Hatfield and Simmonds (WD05 HAWG 2010). Several changes were calculated for 1987, 1991, 1993, 1994, 1995, 1997, 1999, 2000, 2001 and 2005. The updated numbers-, weights-at-age in the stock, proportion mature and revised SSB time series are given in the Stock Annex

The 1987 acoustic survey was carried out in November, and not in July like all but one of the subsequent surveys. Consequently, neither the actual proportions mature in July nor the mortalities between July and November were known and the historical values of weights-at-age and proportions mature were used. The survey was, initially, retained to lengthen the time series. This is no longer an issue. It is, therefore, recommended that the 1987 survey value be removed from the time series, to give a modified time-series (1991 onwards) of 19 years (to 2009).

B.3.2 Larvae survey

Larvae surveys for this stock were carried out from 1973 to 1993. Larval production estimates (LPE) and a larval abundance index (LAI) were produced for the time series. These values were used in the assessment, the LPE until 2001. However, in 2002 it was decided that the LAI had no influence on the assessment and has not been used since. Documentation of this survey time-series is given in ICES CM 1990/H:40.

B.4. Commercial CPUE

Not used for pelagic stocks

B.5. Other relevant data

C. Historical Stock Development

An experimental survey-data-at-age model was formulated at the 2000 HAWG. In 1999 and 1998 a Bayesian modification to ICA was used to account for the uncertainty in misreporting.

The ICA assessment (Patterson 1998a), implemented in FLR (Kell 2007) as FLICA, has exhibited substantial revision both up and down over the last few years, largely due to the noisy survey used for tuning the assessment. The model settings were last explored in detail in 2009 (ICES 2009/ACOM:03). The conclusion was that continuing with the current weighting and model settings is an acceptable solution, until more data, possibly as a result of the extended surveys from SGHERWAY, are available.

Model used: FLICA Software R / ICA (Patterson 1998b)

Model Options chosen:

Separable constraint over last 8 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 3

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.02 and 0.5

All survey weights equal i.e., 1.0 with the exception of 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1957 – last data year	NA	Yes
Canum	Catch at age in Numbers	1957 – last data year	1-9+	Yes
Weca	Weight at age in the commercial catch	1957-1972 1973-1981 1982-1984 1985-last data year	1-9+ 1-9+ 1-9+ 1-9+	No No No Yes
West	Weight at age of the spawning stock at spawning time.	1957 - 1992 1993-last data year	1-9+ 1-9+	No Yes
Mprop	Proportion of natural mortality before spawning	1957-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	1957-last data year	NA	No
Matprop	Proportion mature at age	1957 - 1991 1992-last data year	1-9+ 1-9+	No Yes
Natmor	Natural mortality	1957 – last year	1-9+	No

Tuning data:

Type	Name	Year Range	Age Range
Tuning fleet 1	VIa (N) Acoustic Survey	1991- last data year	1-9+

D. Short-Term Projection

In 2005 the Working Group tested an HCR applicable to VIa (N) (ICES 2005/ACFM:16), which was accepted by ICES as precautionary. This has formed the basis for the proposed agreement and was implemented in December 2008 by the European Commission.

Model used: Age structured Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. Geometric mean recruitment of 1-ringers (1989-2009) replaced recruitment for 1-ringers in both 2010 and 2011. Geometric mean recruitment (1989-2009) of 2-ringers from the "estimated population abundance" table in the assessment output replaced recruitment for 2-ringers in 2011. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period.

Maturity: Mean of the last three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: Mean of the last three years in the assessment.

Weight at age in the catch: Mean of the last three years in the assessment.

Exploitation pattern: Mean of the previous eight years, scaled by the Fbar (3-6) to the level of the last year (eight because this is the assessment model assumption of 8 years separable period).

Intermediate year assumptions: **F** constraint, based on an average of $F_{3\text{-}6}$ for the most recent 3 years. Stock recruitment model used: None used. Until 2010 HAWG the advice basis was a TAC constraint. The ADGCS advised the change to the above F constraint in 2010.

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections (done intermittently)

Model used: STPR as described in Skagen (2003)

Initial stock size: Population parameters Terminal year survivors from ICA assessment with recruits replaced as in short term projections (D above). Drawn from a multivariate lognormal distribution with mean equal to the values estimated in the stock assessment model, and with covariance as estimated in the same model fit. Geometric mean recruitment for 1- and 2-ringers is used to replace the values in the assessment for the first projected year, covariance at age 2 retained and used for age 1 and 2.

Natural mortality: Mean of the last three years in the assessment.

Maturity: drawn randomly by year from 1990 to present.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: drawn randomly by year from 1990 to present.

Weight at age in the catch: drawn randomly by year from 1990 to present.

Exploitation pattern: from the eight year separable model

Intermediate year assumptions: TAC constraint

Stock recruitment model used: Variable Hockey-Stick or Beverton Holt fitted to recent data (1989 on) , but other options tested for robustness max year three years prior to the assessment.

G. Biological Reference Points

The report of SGPRP (ICES 2003/ACFM:15) proposed a B_{lim} of 50,000 t for VIa (N) herring. This is calculated from the values in the converged part of the VPA (1976-1999) and the Working Group endorsed this value in 2003 (ICES 2003/ACFM:17).

Suggested Precautionary Approach reference points:

B_{LIM} is 50,000 t	B_{PA} be set at 75,000 t

Technical basis:

B_{LIM}: B_{LOSS} Estimated SSB for sustained recruitment	Bpa: 1.5 * Blim

H. Other Issues

H.1 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that:

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being. "

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

I.1. Management and ICES Advice

COUNCIL REGULATION (EC) No 1300/2008 of 18 December 2008 established a multi-annual management agreement for the stock of herring distributed to the west of Scotland and the fisheries exploiting that stock.

F = 0.25 if SSB > 75 000 t 20% TAC constraint.

F = 0.20 if SSB < 75 000 t but > 62 500 t 20% constraint on TAC change.

F = 0.20 if SSB <62 500 t but > 50 000 t 25% constraint on TAC change

F = 0 if SSB < 50 000 t.

There is derogation from the above constraints. If STECF considers that the herring stock in the area west of Scotland is failing properly to recover, the TAC constraints may differ from those in the management agreement. This plan is similar but not identical to the proposed plan.

I. References

Anon, 1982. Herring Assessment Working Group for the Area South of 62°N. ICES C.M. 1982/Assess:7.

Anon. 1987a. Report of the ad hoc Multispecies Assessment WG. ICES, Doc. C.M. 1987/Assess:9.

Anon. 1987b. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES Doc. C.M. 1987/Assess:19.

Anon. 1990. Report of the ICES Herring Larvae Surveys in the North Sea and adjacent waters. ICES CM 1990/H:40

ICES 1992. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES 1992/Assess:11

ICES 1996. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1996/Assess:10.

ICES 2002. Report of the Herring Assessment Working Group for the Area South of 62° N. CM 2001/ACFM:12.

ICES 2003. Report of the Study Group on Precautionary Reference Points for Advice on Fishery Management. ICES CM 2003/ACFM:15

ICES 2003. Report of the Herring Assessment Working Group for the Area South of 62° N. ICES 2003/ACFM:17

Patterson, K.R. 1998a: A programme for calculating total international catch-at-age and weight-at-age. WD to HAWG 1998.

Patterson, K.R. 1998b. Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38.

Simmonds, J., Keltz, S., 2007. Management implications and options for a stock with unstable or uncertain dynamics: West of Scotland herring. ICES J. Mar. Sci., 64: 000-000.

Skagen, D.W. 2003. Programs for stochastic prediction and management simulation (STPR3 and LTEQ). Program description and instruction for use. WD to HAWG 2003.

Table Annex 6-1. Revised values of numbers-at-age in the VIa (North) acoustic survey, to be used in the stock's assessment.

Year/Age	1	2	3	4	5	6	7	8	9
1991	338312	294484	327902	367830	488288	176348	98741	89830	58043
1992	74310	503430	210980	258090	414750	240110	105670	56710	63440
1993	2357	579320	689510	688740	564850	900410	295610	157870	161450
1994	494150	542080	607720	285610	306760	268130	406840	173740	131880
1995	441200	1103400	473300	450300	153000	187200	169200	236700	201700
1996	41220	576460	802530	329110	95360	60600	77380	78190	114810
1997	792320	641860	286170	167040	66100	49520	16280	28990	24440
1998	1221700	794630	666780	471070	179050	79270	28050	13850	36770
1999	534200	322400	1388000	432000	308000	138700	86500	27600	35400
2000	447600	316200	337100	899500	393400	247600	199500	95000	65000
2001	313100	1062000	217700	172800	437500	132600	102800	52400	34700
2002	424700	436000	1436900	199800	161700	424300	152300	67500	59500
2003	438800	1039400	932500	1471800	181300	129200	346700	114300	75200
2004	564000	274500	760200	442300	577200	55700	61800	82200	76300
2005	50200	243400	230300	423100	245100	152800	12600	39000	26800
2006	112300	835200	387900	284500	582200	414700	227000	21700	59300
2007	-1	126000	294400	202500	145300	346900	242900	163500	32100
2008	47840	232570	911950	668870	339920	272230	720860	365890	263740

Table Annex 6-2. Revised values of weights-at-age in the stock from the VIa (North) acoustic survey, to be used in the stock's assessment.

Year/Age	1	2	3	4	5	6	7	8	9
1991	0.09	0.164	0.208	0.233	0.246	0.252	0.258	0.269	0.292
1992	0.068	0.152	0.186	0.206	0.233	0.253	0.273	0.299	0.302
1993	0.073	0.164	0.196	0.206	0.225	0.234	0.253	0.259	0.276
1994	0.052	0.15	0.192	0.22	0.221	0.233	0.241	0.27	0.296
1995	0.042	0.144	0.191	0.202	0.225	0.227	0.247	0.26	0.293
1996	0.045	0.14	0.18	0.209	0.219	0.222	0.229	0.242	0.263
1997	0.054	0.142	0.180	0.199	0.213	0.222	0.231	0.242	0.263
1998	0.066	0.138	0.176	0.194	0.214	0.226	0.234	0.225	0.249
1999	0.054	0.137	0.166	0.188	0.203	0.219	0.225	0.235	0.245
2000	0.062	0.141	0.173	0.183	0.194	0.204	0.211	0.222	0.23
2001	0.062	0.132	0.17	0.19	0.198	0.212	0.22	0.236	0.254
2002	0.062	0.153	0.177	0.198	0.212	0.215	0.225	0.243	0.259
2003	0.064	0.138	0.176	0.19	0.204	0.213	0.217	0.223	0.228
2004	0.059	0.138	0.159	0.18	0.189	0.202	0.213	0.214	0.206
2005	0.0751	0.1296	0.1538	0.1665	0.1802	0.1911	0.2125	0.203	0.2284
2006	0.075	0.135	0.166	0.185	0.192	0.204	0.211	0.224	0.231
2007	0.075	0.1675	0.183	0.1914	0.1951	0.1951	0.2021	0.2034	0.2138
2008	0.0546	0.1721	0.1913	0.2083	0.2143	0.2139	0.2206	0.2242	0.2385

Table Annex 6-3. Revised values of proportions mature from the VIa (North) acoustic survey, to be used in the stock's assessment.

Year/Age	1	2	3	4	5	6	7	8	9
1991	0	0.57	0.96	1	1	1	1	1	1
1992	0	0.47	1	1	1	1	1	1	1
1993	0	0.93	0.96	1	1	1	1	1	1
1994	0	0.48	0.92	1	1	1	1	1	1
1995	0	0.19	0.98	1	1	1	1	1	1
1996	0	0.76	0.94	1	1	1	1	1	1
1997	0	0.55	0.95	1	1	1	1	1	1
1998	0	0.85	0.97	1	1	1	1	1	1
1999	0	0.57	0.98	1	1	1	1	1	1
2000	0	0.45	0.92	1	1	1	1	1	1
2001	0	0.93	0.99	1	1	1	1	1	1
2002	0	0.92	1	1	1	1	1	1	1
2003	0	0.76	1	1	1	1	1	1	1
2004	0	0.83	0.97	1	1	1	1	1	1
2005	0	0.84	1	1	1	1	1	1	1
2006	0	0.81	0.97	1	1	1	1	1	1
2007	0	1	1	1	1	1	1	1	1
2008	0	0.98	1	1	1	1	1	1	1

Table Annex 6-4. Revised values of the spawning stock biomass (SSB) from the VIa (North) acoustic survey.

Year	SSB (t)
1991	410,000
1992	351,460
1993	845,452
1994	533,740
1995	452,300
1996	370,300
1997	175,000
1998	375,890
1999	460,200
2000	444,900
2001	359,200
2002	548,800
2003	739,200
2004	395,900
2005	222,960
2006	471,700
2007	298,860
2008	788,200
2009	578,757

Annex 7 – Stock Annex Herring in Division VIa South and VIIb,c

Quality Handbook	ANNEX: Herring VIaS and VIIb, c

Stock specific documentation of standard assessment procedures used by ICES

Stock:	Herring in VIaS and VIIb, c
Working Group:	Herring Assessment Working Group for the area South of 62°N
Date:	March 2011
Authors:	Afra Egan and Maurice Clarke

A1. General

The herring (*Clupea harengus*) to the northwest of Ireland comprise both autumn and winter/spring spawning components. The age distribution of the catch and vertebral counts were used to distinguish these components (Bracken, 1964, Kennedy, 1970). Spawning takes place from September until March and may continue until April (Molloy and Kelly, 2000). Spawning in VIIb has traditionally taken place in the autumn and in VIaS, spawning occurs later in the autumn and in the winter.

For the purpose of stock assessment and management, these areas have been separated from VIaN since 1982 and are split at 56° N. This split is based on work carried out by working groups in the late 1970s and early 1980s which found that the stocks exploited off the west coast of Scotland were biologically different from those off the north coast of Ireland. A second new assessment area was also recommended by the 1981 Working Group (ICES, 1981). The Irish landings were taken mainly in the southern part of VIa and in VIIb, c. These catches were found to be biologically very similar with respect to age composition and spawning. It was decided at the 1981 working group to combine the areas and conduct a joint assessment (Molloy, 2006).

A herring tagging experiment was carried out in 1992 in order to investigate the movements and annual migrations of herring around the Irish Coast. 20,000 herring were tagged in total with 10,000 of these off the west coast. Some fish moved northwards and were recaptured along the north coast between July and February, in the main fishing areas. 90% of the fish tagged along the west coast were recovered from the Donegal Bay area. The maturity stages of the recaptured fish, suggests that the fish were migrating inshore towards spawning grounds (Molloy, *et al* 1993). There were no returns from north of Donegal although it is possible that there may not have been much fishing activity in the area at this time (Molloy and Kelly, 2000).

Biology

A study group on herring assessment and biology in the Irish Sea and adjacent areas met in 1994 (ICES, 1994). This meeting highlighted the problems associated with the assessment of herring stocks around Ireland. This group recommended that the boundary line separating 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 1. The spawning, nursery and feeding grounds are shown as well as the direction of larval drift and migration.

WESTHER and SGHERWAY

WESTHER was an EU-funded project, to review, the stock identity of herring west of the British Isles. A number of factors were examined including.

- Morphometrics and meristic characteristics
- Internal parasites
- Otolith microstructure and microchemistry
- Genetics

Results from this project identified distinct spawning grounds and spawning components. It was recommended that the stocks to the west of the British Isles should be managed as two stocks, the Malin Shelf stock and the Celtic Sea stock. Management plans should be fleet and area based in order to prevent the local depletion of any population unit in the areas (WESTHER, Q5RS-2002-01056). Further work on the management of these stocks was conducted by SGHERWAY (Study Group on the evaluation of assessment and management strategies of the western herring stocks) which met for the first time in late 2008 with further meetings in 2009 and 2010. This group had three main terms of reference and the findings of each are presented below:

1. Evaluate the utility of a synoptic acoustic survey in the summer for the Hebrides, Malin and Irish shelf areas, in conjunction with WGIPS surveys of VIaN and the North Sea.

The synoptic Malin Shelf survey began in 2008 and covers all areas in which mixing of the various western herring stocks is likely to occur at that time. However, such time-series will not be available for a number of years. The amount of mixing between stocks cannot be resolved by the current sampling regime in the Malin Shelf survey. Consequently, a sampling programme has been developed to allow proper identification of fish population origins, making use of otolith and body shape techniques. Analyses will be compared to the fish of known spawning origin collected during the EU project WESTHER. This sampling programme has been initiated in the 2010 synoptic acoustic survey.

2. Explore a combined assessment of the three stocks and investigate its utility for advisory purposes

A combined assessment of the three stocks VIaN, VIaS/VIIb,c and VIIaN (called the Malin Shelf metapopulation) was explored and its utility for advisory purposes investigated. It was found that the combined assessment gives important information on the Malin Shelf metapopulation, though it is unlikely to be useful for management advice purposes.

3. Evaluate, through simulation, alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN and the best way to maintain each spawning component in a healthy state.

Alternative management strategies for the metapopulation of VIaN, VIaS and VIIaN were investigated to show how metapopulations can be sustainably managed. This study has shown that managing metapopulations is only possible with detailed information on fisheries independent data. However, whenever subcomponents of the metapopulation differ considerably in abundance, sustainable management is impossible for the smallest subcomponent. Where there is uncertainty of stock identification fishing mortality should be kept at low levels. Whenever identification rates increase, fishing mortality may also be increased.

The work of this study group concluded in 2010.

A.2. Fishery

Development of this fishery

In the early 1900s the main herring fisheries in Ireland were located off the Donegal coast. Donegal matje herring were important in supplying the German markets. Herring fisheries, which took place every spring and summer off the coast of Donegal, have been under scientific observation since 1921. The fishing grounds were well known and were located between ten and forty miles offshore. Fishing during this time was split into three well defined time periods.

1. December/January
2. May (main fishing took place)
3. September/October

During the 1930s many of the major herring markets disappeared (Molloy, 1995). In contrast to the rapid expansion experienced in the Celtic Sea the revival of the northwest fishery occurred at a slower pace (Molloy, 2006). The revival first became evident in the 1950s when many Scottish ring netters took part in this fishery with many of the Irish boats also using this gear. Then several boats changed to pelagic midwater trawls. The herring fleet continued to expand throughout the 1960s with many skippers becoming experts in pelagic pair trawling (Molloy, 2006).

In the 1970s and 1980s the autumn spawners became more significant and accounted for the majority of the landings. Galway and Rossaveal gained increasing importance as herring ports in the 1970s. In the 1974/75 season landings decreased dramatically and it was the first indication that the stock might have started to decline. The North Sea stock was already in decline and many Dutch boats were fishing off the Irish west coast. TACs were reduced and the stock continued to decline. In 1978 it was advised that the fishery be closed (Molloy, 2006). This closure lasted until 1981 and was reopened with new management units. VIaS and VIIb,c were joined and were assessed separately from VIaN.

In recent years the northern grounds have regained importance with catch also coming from the west coast close to the VIa boundary line (ICES, 2005). Very little fishing now takes place on previously important grounds in Galway Bay and along the Mayo coast (Molloy and Kelly, 2000).

Since the late 1970s considerable changes have taken place in the type of pelagic fishing carried out by Irish boats off the North West Coast, with directed herring fishing having been largely replaced by mackerel fishing (Breslin, 1998).

Fishery in Recent Years

The TAC is taken mainly by Ireland, which has over 90% of the quota. In recent years, only Ireland has exploited herring in this area. The fishery is concentrated in quarters one and four. Landings have decreased markedly from about 44,000 t in 1990 to around 13,800t in 2004. Working group catches in the last two years have decreased over 17,000 t in 2007 to over 10,200 in 2010. Total catches over the complete time series are shown in the Figure 2. The number of boats participating in this fishery remained constant for a number of years at around 30 vessels. Increases were seen in recent years with 50 vessels landing northwest herring in 2010. The number of vessels engaged in fishing for herring depends very much on the availability of mackerel or horse mackerel. Many of the larger vessels target these species primarily.

The majority of the landings in recent years are taken in quarters one and four with small quantities landed in quarter three. The main age groups are 2, 3, 4 and 5 with older age groups accounting for small proportions of the catch. The proportions of older age groups have been decreasing over the last number of years.

A.3. Ecosystem aspects

Divisions VIaS and VIIb, c are located to the North West and west of Ireland respectively. This area is limited to the southwest by the Rockall Trough, where the transition between the Porcupine Bank and the trough is a steep and rocky slope with reefs of deepwater corals; further north, the slope of the Rockall Trough is closer to the coast line; west of the shelf break is the Rockall Plateau with depths of less than 200m. The shelf area consists of mixed substrates, with soft sediments (sand and mud) in the west and more rocky, pinnacle areas to the east. The area has several seamounts: the Rosemary Bank, the Anton Dohrn sea mount and the Hebrides, which have soft sediments on top and rocky slopes (ICES, 2007b).

The shelf circulation is influenced by the poleward flowing 'slope current', which persists throughout the year north of the Porcupine Bank, but is stronger in the summer. A schematic representation of the oceanographic conditions in this area is presented in Figure 2. Over the Rockall plateau, domes of cold water are associated with retentive circulation. Thermal stratification and tidal mixing generate a northwards running coastal current known as the Irish coastal current which runs northwards along the west coast (ICES, 2007). The main oceanographic features in these areas are the Islay and the Irish Shelf fronts. The waters to the west of Ireland are separated by the Irish shelf front. This front causes turbulence and this may bring nutrients from deep waters to the surface. This promotes the growth of phytoplankton and dinoflagellates where there is increased stratification. Associated with this is increased growth of zooplankton and aggregations of fish. The Islay front persists throughout the winter due to the stratification of water masses of different salinities (ICES, 2006). The ability to quantify any variability in frontal location and strength is an important element in understanding fisheries recruitment (Nolan and Lyons, 2006). These fronts play an important role in the transport of larvae and juveniles.

In the North, most of the continental shelf is exposed to prevailing southwesterly winds and saline oceanic waters cross the shelf edge between Malin head off the north coast of Ireland and Barra head in the Outer Hebrides. The Irish shelf current flows northwards and then eastwards along the north coast of Ireland (Reid *et al*, 2003). Freshwater discharges from rivers such as the Shannon and Corrib interact with the Eastern North Atlantic water on the Irish shelf front to produce the observed circulation pattern (ICES, 2006).

Sea surface temperature data have been collected from Malin head on the North coast of Ireland since 1958. During periods of low winter temperatures, there is less pronounced heating during the summer. This can be seen in 1963, 1978 and 1985-1986. During these years there were also stormy conditions. This is concurrent with the lower winter temperatures (ICES, 2007). There is considerable variability over the complete time series. A definite trend can be identified from the early 1990s. Since 1990 sea surface temperatures measured at stations along the northwest coast of Ireland have displayed a sustained increasing trend, with winter temperatures >6° and higher summer temperatures during the same period (Figure 3), (Nolan and Lyons, 2006).

Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. A study conducted in 1980 found that west coast herring catches showed strong correlations with temperature and salinity at a constant lag of three or four years. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the winter larval drift (Grainger 1980a).

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Historically, there were important commercial fisheries for many demersal species also. On the shelf, the main resident pelagic species is herring *Clupea harengus* (ICES, 2007b). Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s. Further information on this can be found in the HAWG report 2007 (ICES CM 2007).

Larvae that were spawned on the west and northwest coast follow a northwards drift. Larvae spawned further north off the Donegal coast were found to drift towards the Scottish west coast (Grainger and McArdle, 1985; Molloy and Barnwall, 1988) Studies have shown that the maximum larval depth is below the surface between 5-15m and there has been no evidence of diel migration, or variation in the distribution of different larval size categories (Grainger 1980b). Larvae that hatch further south also follow this northward drift (ICES, 1994). Galway Bay and Donegal Bay, several inshore lochs and also Stanton Bank, an offshore area northwest of the Irish north coast are important nursery areas (ICES, 1994; Anon., 2000). Evidence from the parasitic load of juvenile herring from the Scottish west coast sea lochs from two studies, in the mid 1980s (MacKenzie 1985) and more recently, from 2002-2005 (Campbell et al. 2007), suggests very strongly that this drift pattern occurs from the north and northwest of Ireland and has been doing so for at least the last 20 years (ICES, 2009).

The spawning grounds for herring along the northwest coast are located in inshore areas close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. The timing of spawning is not the same on each spawning ground. Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction.

Discards

Catch is divided into landings (retained catch) and discards (rejected catch). Discards are the portion of the catch returned to the sea as a result of economic, legal, or personal considerations. Discarding rates in pelagic trawling and seining are generally considered to be low (Alverson *et al*., 1994).

The main market for Irish herring in the late 1980s and early 1990s was the Japanese roe market. The development of this market coincided with a decline in a number of other herring markets. It was therefore only favourable to catch roe herring, whose ovaries are just at the point of spawning. This led to discarding of non roe herring due to the lack of a suitable market. The roe market is no longer the main market for Irish herring. It is not known what the level of discarding is in this stock area and if it is a problem in this fishery.

By Catch

Overall there is a paucity of data relating to by catch and discarding in this area. Interactions between cetaceans and fishing vessels have not been well documented and therefore no information is available. It is not possible therefore to make assumptions regarding implications for the marine ecosystem in area VIaS and VIIb, c.

B. Data

Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish sampling. Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.

Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are usually processed using SALLOCL (Patterson, 1998b). However, since only one country participates in this fishery this system is not required. Ireland acts as stock coordinator for this stock.

InterCatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data was used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. It is envisaged that this system will replace SALLOCL and other previously used systems.

Reallocation of Catches

Since 2007, landings data were revised with respect to reallocation of catches between area VIaS and VIaN, for the years 2000-2005. Before 2000, a comprehensive reallocation was used. For 2000-2005, various procedures were used. These attempted to deal with the increasing Irish catches along the 56° line and opportunistic Irish catches of herring in VIaN during the 4th and 1st quarter mackerel fishery. In some years some catches were reallocated, while in others no reallocations were made. In 2007, it was considered that the most correct procedure was that used before 2000. Therefore a retrospective reallocation has been conducted. It does not adequately consider the Irish herring catches in VIaN, nor does the reallocation consider fishing along the 56°line. However, in the absence of better information on Irish directed herring fishing in VIaN, this procedure provides the best possible method.

B.2. Biological

Sampling Protocol

Landings data are available for this area from 1970. Data on catch numbers at age, mean weights at age and mean lengths at age are derived from Irish data. Sampling is conducted by area and by quarter. Landings from this fishery, at present, are mainly into the port of Killybegs with lesser amounts landed into Rossaveal. Irish samples are collected from these commercial landings. Length frequency and age data is collected by ICES division by quarter. The length frequency data is added together for each division and quarter and raised to the landings for that area and quarter. The sample weight is divided into the catch weight to get the raising factor. The sum of the length frequencies per quarter is multiplied by the raising factor. An age length key is applied to this data and catch numbers at age calculated.

Age Reading Protocol

Northwest herring are currently aged using otoliths and are read using a stereoscopic microscope, with reflected light. The minimum level of magnification (15x) is used initially. It is then increased to resolve the features of the otolith. Herring otoliths are generally read in the magnification range of 20x – 25x. The patterns of opaque (summer) and translucent (winter) zones are viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1^{st} January. The first winter ring that is counted is that which corresponds to the second "birth date" of the fish. Therefore a fish of 2 winter rings is a 3 year old. This convention applies to all ICES herring stocks with autumn spawning (Lynch, 2009).

Age composition in the catch

Scales were used in the past for ageing and on average 4 and 5 ringers counted for 46% of the total catch. In 1929 however strong year classes were evident with 4 and 5 ringers making up 85% of the total (Farran, 1928). For the past few years the catch has been mainly composed of 2 ,3, 4 and 5 ringers with decreasing proportions of older fish in the catch. This stock is different from the Celtic Sea in that there is no recruitment failure and the Northwest stock is less reliant on incoming recruitment. The catch numbers at age have been mean standardised and are presented in Figure 4.

Precision Estimates

The precision estimates on 2006 ageing data were worked up using a bootstrap technique. The results of the method found that the relative error is below 20% over the age range 2-6wr. At older ages, estimates of NW herring show higher CVs which is likely to be due to the relative paucity in the catch.

Mean Weights

Mean weights in the stock (West) are calculated using samples taken from Q1 and Q4. A mean weight at age is then calculated. Mean weights in the catch (Weca) are calculated using samples from all quarters of the fishery and a mean weight per age derived.

Trends in mean weights over time

The mean weights in the catch display quite a stable pattern over the time series, although variable weights are only available from the early 1980s. Younger ages (1-6 ring) show an overall downward trend with more fluctuations evident in older ages (7-9 ring). The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period and show similar patterns to the mean weight in the catch.

Maturity ogive

The maturity ogive used in the assessment considers 1-ringers to be all immature and all subsequent age groups as fully mature. Maturity ogives have been produced from the data collected in the summer acoustic surveys from 2008-2010. The maturity data are presented in the text table below and show variations in the percentage of fish mature and immature at each age class between years.

	2008		2009		2010	
age	immature	mature	immature	mature	immature	mature
1	94	6	100		100	0
2	46	54	36	64	83	17
3	4	96	9	91	17	83
4	0.63	99		100	5	95
5		100		100		100
6	1	99		100		100
7		100		100		100
8		100		100		100
9	20	80		100		100
10		100				

Log Catch Ratios

The log catch ratios (ln $C_{a,y}$/ $C_{a+1,y+1}$) are presented below and are smoothed with a 4-year running average to show the main trends (Figure 5). Data for 1-ringers are noisy because this group is not fully selected by the fishery. The data for older fish are also noisy, particularly in later years, reflecting their relative paucity in the catches and suggest high variability in the exploitation rates of these age groups. These show an upward trend for all fully recruited year classes since the mid nineties. Overall, the catch data show a diminishing range of ages in the catches and older fish are at their lowest levels in the time series.

Catch Curves

Cohort catch curves, were constructed for each year class in the catch at age data (Figure 6). These catch curves show signals in total mortality over the time series. Low mortality seems evident on the very large 1981, 1985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Increasing mortality can be seen from 1990 on, whilst the 1970s cohorts show lower Z. Mortality on age classes 3-6 show fluctuations over the time series with increasing mortality in recent years (Figure 7).

B.3. Surveys

Acoustic Surveys

Acoustic surveys have been carried out in this area since 1994. The timing of these surveys has changed over this period. Initially the surveys were undertaken in the summer in order to coincide with international herring surveys and with the summer feeding period of this stock. From 1999-2003 surveys were undertaken in quarter four in order to survey the autumn spawning component. From 2004-2007 the survey was carried out in quarter one. A problem with the winter acoustic survey series has been synchronising the survey with the peak spawning event to ensure containment of the stock. The winter surveys that were carried out from 2004 – 2007 varied sharply in age profile and biomass estimates, and was not considered reliable. Bad weather often affected the survey as it took place in January. Also it was recognised that syn-optic coverage of a stock that spawns over a period from October to February in an area spanning all of Divisions VIaS and VIIb cannot be achieved with a winter survey. Thus the series was discontinued in 2007. The review group of the 2007 assessment highlighted that although there is an acoustic abundance estimate, the historical series is too short to consider it as a tuning survey in an analytical assessment.

In 2007 the WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf. This new time series of summer surveys began in 2008 with effort concentrating on summer feeding aggregations. This time series runs from 2008-2010.

The acoustic data were collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface.

Acoustic data analysis was carried out using Sonar data's Echoview® (V 3.2) post processing software and was backed up every 24 hrs. Partitioning of data was viewed and agreed upon by 2 scientists experienced in viewing echograms. Where no directed trawling had taken place, biological data from the nearest neighbour was used to determine the size classification of the echotrace.

The following TS/length relationships were used to analyse the data.

Herring TS = 20logL – 71.2 dB per individual (L = length in cm)

Sprat TS = 20logL – 71.2 dB per individual (L = length in cm)

Mackerel TS = 20logL – 84.9 dB per individual (L = length in cm)

Horse mackerel TS = 20logL – 67.5 dB per individual (L = length in cm)

Larval Surveys

Assessment of this stock was largely based on the results of larval surveys in the 1980s. Herring Larval surveys were first carried out on this stock, by Ireland, in 1981 and continued until 1988. Prior to this the surveys were carried out by the Scottish but only had limited coverage of the assessment area. The survey grid consisted of sampling stations about 18km apart. A gulf III plankton sampler with 275 µm mesh was towed at each station. The samples collected were preserved in 4% formalin. Herring larvae were identified and measured. Only larvae of less than 10mm were used for the assessment. The number of larvae below each square meter was calculated and then multiplied by the area of the sea at each station (Grainger and McArdle, 1981). These surveys did not produce a satisfactory index of stock size because of two very low values in 1984 and 1985 (Molloy, 1989). These surveys were never used in the assessment process. However these surveys did provide valuable information on the distribution of very small larvae and on the location of the spawning grounds (Molloy and Kelly, 2000).

Ground Fish Survey

The IGFS is part of the western IBTS survey and has been carried out on the *RV Celtic Explorer* since 2003. The gear used on the survey is a GOV 36/47 demersal trawl with a 20mm cod end liner to retain juvenile and small fish, including small herring. This survey has been conducted since the early 1990s but is of little utility as a herring recruit index, because the gear, timing and survey vessel changed throughout. Once a sufficient time series becomes available it will be investigated as a possible tuning fleet. The Scottish groundfish survey, which has some coverage of VIaS will also be investigated as an additional tuning fleet.

Scottish MIK net surveys

MIK net surveys were carried out off the west coast of Scotland in 2008 and 2009 and it is thought that these surveys may in time provide a reasonable index of recruitment. In both 2008 and 2009 the hatch dates were back calculated and the majority of the larvae caught were likely to be from winter spawning events from November onwards, with evidence of spawning activity into February. Previous studies have shown that larvae tend to be advected away from the coastal north and northwest of Ireland in a northerly and easterly direction towards the Minches and Hebrides. The results from these two surveys support this. It is likely, therefore, that the majority of the larvae present in both 2008 and 2009 are from spawning events in VIaS and possibly VIIb (ICES, 2009).

Commercial CPUE

Research surveys were not started in Ireland until the mid 1960s and in the absence of this information commercial catch per unit effort (CPUE) data was used as an index of stock size. It is known that CPUE data may not give an accurate index of stock size due to the shoaling nature of pelagic stocks. Fish can aggregate in dense shoals in a small area and CPUE may remain high even though the stock size is low. However the CPUE data collected in the 1960s and 1970s did provide an index of changes that were occurring in the fisheries around Ireland. F was calculated for the Northwest herring stock using this data during this time and showed an increasing trend in F. This CPUE data was used to show the dramatic decline that took place in this stock in the 1970s (Molloy, 2006).

C. Historical Stock Development

Time periods in the fishery

This fishery peaked in the late 1980s, largely as a result of two strong year classes in 1981 and 1985. This corresponded to the highest SSB and a medium level of F. In the late 1980s changes also took place with regard to the location and timing of the fishery. The North and West coast fisheries in December and January were now the most important with smaller amounts taken during the autumn fishery (Molloy, 2006). Since then there has been a downward trend in SSB and recruitment with no evidence of strong year classes entering the fishery. Mean F has been fluctuating but is thought to be at a high level.

Spawning stock size peaked in 1988 and has followed a steady decline since then. Landings have drastically fallen since 1999 (ICES, 2004). Long term changes in the spawning component have occurred in the area and time of spawning. In 1920-1930s there was a north coast fishery that spawned in the North in spring and an autumn fishery that spawned in the west of Donegal. Sligo and Galway had no important fishery. In the ‘40-50 herring all over Ireland declined and the recovery in the 1960s occurred mainly in Mayo, Sligo and Galway as autumn spawners. Recently there has been a shift to the northern fishery, while little fishing occurs on the west coast of Ireland. The northwest herring fishery was based on hard (stage V) herring but towards the late 1980s the focus shifted to spawning herring.

Assessment

In 1930, Farran made his first attempt to quantify the abundance of the herring stock in this area. In the 1930s many of the previous herring markets disappeared and there was widescale discarding of herring along the Donegal coast. It is thought that during this time that the herring population was at a very low level (Molloy, 1995).

Recent Assessments

In recent years the model used for this stock was a separable VPA. This was used to screen over three terminal fishing mortalities, 0.2, 0.4 and 0.6. In 2009 terminal F of 0.5 was also examined. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to age 3 winter rings. ICA was used in exploratory assessments with the acoustic surveys as a tuning fleet.

Model used: ICA and VPA

No final assessment has been accepted for this stock by the working group. However several scenarios are run, screening over a range of terminal F's (0.2, 0.4, 0.5 and 0.6). In 2006 and 2007 exploratory runs using the ICA model (Patterson, 1998) were performed. In the absence of a sufficient time series in this area the use of the ICA model has discontinued. Exploratory runs are carried out annually using a separable VPA with the settings below.

VPA

A separable VPA is used to track the historic development of this stock.

Software used: Lowestoft VPA Package (Darby and Flatman, 1994).

VPA Settings

- Reference Age = 3
- Selection in the terminal year = 1.0
- Terminal F = 0.2, 0.4, 0.5, 0.6
- 1 Ringers: downweighted to 0.1
- Reference ages for calculation of Mean F= 3-6

ICA (exploratory runs in 2006 and 2007 only)

Model Settings

- Separable constraint over the last 6 years (weighting = 1.0 for each year)
- Reference ages: 3
- Constant selection pattern model
- Selectivity on oldest age: 1.0
- First age for calculation of mean F: 3
- Last age for calculation of mean F: 6
- Weighting on 1 ringers: 0.01 Other age classes: 1.0
- Lowest feasible F: 0.05
- Highest feasible F: 2.0
- Ages for acoustic abundance estimates: 3-4
- Plus group: 9

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1957-2010	1-9 +	Yes
Canum	Catch at age in numbers	1957-2010	1-9 +	Yes
Weca	Weight at age in the commercial catch	1957-2010	1-9 +	Yes
West	Weight at age of the spawning stock at spawning time.	1957-2010	1-9 +	Yes
Mprop	Proportion of natural mortality before spawning	1957-2010	1-9 +	No
Fprop	Proportion of fishing mortality before spawning	1957-2010	1-9 +	No
Matprop	Proportion mature at age	1957-2010	1-9 +	No
Natmor	Natural mortality	1957-2010	1-9 +	No

Tuning data: Only used in ICA runs 2006 and 2007

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NWHAS	1999-2003	3-4
Tuning fleet 2	NWHAS	2004-2007	3-4

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. Peak spawning times from the autumn component have been inferred by larval surveys and occur late September and October in water temperatures ranging between 10-12ºC (Molloy and Barnwall, 1988).

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A 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 generally located in shallow waters close to the coast. Spawning in deeper water has also been recorded (Molloy and Kelly, 2000). The exact locations are not well documented. Areas where spawning fish have been found include the mouth of the Shannon, Galway Bay, around the Aran Islands, the stags of Broadhaven and off the coasts of Sligo and Mayo (ICES, 1994). Spawning begins in October and can continue until February.

Fecundity is the number of eggs produced by the female and is proportional to the length of the fish (Molloy, 2006). Several studies were carried out in the early 1980s to analyse the fecundity of winter and autumn spawning components of the North West herring stock and considerable differences were found. Donegal winter spawners produce significantly fewer eggs than autumn spawners. When compared to the Celtic Sea herring stock, Donegal herring have a higher fecundity and begin to spawn earlier (McArdle, 1983). A study conducted in the 1920s found that the eggs produced by winter/spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938). Grainger (1976) gave the following fecundity-length relationships for autumn spawning components:

Parameter	b	a	n	P
Galway	3.882	-20.981	17	0.001
Donegal	4.137	-27.325	25	0.001

Herring produce benthic eggs that are adhered to the bottom substrate where they remain until the larvae hatch. The larvae are carried by the currents and drift towards the west coast of Scotland (Grainger and McArdle, 1985).

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Their movements and survival are determined by favourable environmental conditions. Larvae originating from spawning grounds off the west coast are carried by currents to the northwest coast of Donegal and may even travel as far as Scotland (Molloy, 2006). Figure 1 shows a schematic presentation of the life cycle of Herring west and northwest of Ireland.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast, for example St. Johns point in Donegal Bay. Other nursery areas on the north coast include Lough Swilly and Sheephaven Bay. In division VIIb, Broadhaven Bay and the inner parts of Galway bay are also nursery grounds (ICES, 1994).The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Changes in the growth rate of this stock can be seen over time. In the late 1980s a sudden and unexplained drop in mean weights was observed. This had an impact on the estimate of SSB and the advised TAC. The growth rate of this stock has never recovered to the levels before this decline (Molloy, 2006).

Adult herring are found offshore until spawning time, when they move inshore. Occasionally very large herring are found off the Irish coast. Theses herring appear off the north coast and are usually in a spawning or pre spawning condition (Molloy, 2006). The main feeding grounds for this stock extend from Galway west of Ireland to the Stanton Bank and between Tory Island and Malin Head (Molloy 2006).

H.2. Management and ACFM advice

Local Management

Management measures were slowly introduced into this fishery with by-laws restricting fishing in certain areas off the coast in the early 1900s. This type of management continued until the 1930s when fishing was prohibited during April and May, in order to improve the quality of the herring being landed. In the 1970s management measured became more defined. Direct fishing of herring for fishmeal was banned. A minimum landing size of 20cm was implemented and also minimum mesh sizes. TACs were introduced in order to control the amount of herring landing each year from each ICES area (Molloy, 1995).

Various management measures have been introduced to control the exploitation of this stock. From 1972-1978 TACs were set by NEAFC and covered all of Division VIa. The TAC decreased rapidly and the stock was thought to be in decline. This continued until the fishery was closed in 1979 and 1980. During the closure because there was no analytical assessment of VIIb, fishing was allowed to continue on a precautionary basis (ICES, 1994). When the fishery was reopened it was decided to split the area into VIaS and VIaN. Landings from this area increased due to the increased efficiency of the Irish vessels and the participation in this fishery by Dutch vessels (Anon, 2000).

The management of the fishery has improved in recent years and catches have been considerably reduced since 1999. In 2000 the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The assessment period runs concurrently with the annual quota. Quotas are allocated on a fortnightly basis and there is some capacity to carry unused allocation into the following fortnight with overruns being deducted.

In 2000, the Irish North West Pelagic Management Committee was established to deal with the management of this stock. The committee has the following objectives:

- To rebuild this stock to above the B_{pa} level of 110 000 t.
- In the event of the stock remaining below this level, additional conservation measures will need to be implemented.
- In the longer term it is the policy of the committee to further rebuild the stock to the level at which it can sustain annual catches of around 25 000 t.
- Implement a closed season from March to October.
- Regulate effort further through boat quotas allocated on a weekly basis in the open season.

This committee manages the whole fishery for this stock at present, given that Ireland currently accounts for the entire catch.

The current state of the stock is uncertain. Preliminary assessments suggest that SSB may be stable at a low level. The current level of SSB is uncertain but likely to be below B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years. F appears to have increased concomitantly with increases in the catch. F is likely to be above F_{pa} and also likely above F_{lim}.

There is no explicit management plan for this stock. The local Irish management committee developed the objective to rebuild the stock to above B_{pa} and to maintain catches of 25 000 t per year. The implementation of the closed season from March to October has been successful in ensuring that the fishery mainly concentrates on the spawning component in this area. In recent years the ICES advice has remained unchanged. ICES have recommended that a rebuilding plan be put in place that will reduce catches. If no rebuilding plan is established, there should be no fishing. The rebuilding plan should be evaluated with respect to the precautionary approach.

H.4 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between “age” and “rings”. HAWG in 1992 (ICES 1992/Assess:11) stated that

“The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being.”

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

References

Bracken, J.(1964) Donegal herring investigations 1963/64. ICES CM 1965. Herring committee No. 88

Breslin J.J. (1998) The location and extent of the main Herring (Clupea harengus) spawning grounds around the Irish coast. Masters Thesis: University College Dublin

Darby, C.D. and Flatman, S. (1994). Virtual population analysis: version 3.1 (Windows/DOS) user guide. MAFF Information Technology Series No.1. Directorate of Fisheries Research: Lowestoft.

Farran, G.P., (1928): The Herring Fisheries off the North Coast of Donegal. Department of Agriculture Journal. 34, No 2

Farran, G.P.,(1930) Fluctuations in the stock of herrings in the Norh coast of Donegal. Rapports Et Proces-Verbaux Des Reunions Du Conseil Permanent International Pour L'Exploration De La Mer 65(14): 6 pp.

Farran, G. P. (1938). "On the size and numbers of the Ova of Irish Herrings." Journal du Conseil International Pour L'exploration de la Mer 13(1).

Grainger, R.J.(1976). The inter-relationships of populations of autumn spawning herring off the west coast of Ireland. BIM Resource Record Paper. 21 pp.

Grainger, R.J.(1978) A Study of Herring Stocks West Of Ireland and their Relations to Oceanographic Conditions. Phd thesis, University College Galway.

Grainger, R.J., (1980a). Irish West coast herring fluctuations and their relation to oceanographic conditions. Symposium on the Biological basis of Pelagic Stock Management No. 29

Grainger, R. J., (1980b). The distribution and abundance of early herring (Clupea harengus L.) larvae in Galway Bay in relation to oceanographic conditions. Proc. R. Ir. Acad., Sect. B 80:1-60.

Grainger, R. J. and E. McArdle (1981) "Surveys for herring larvae off the northwest and west coasts of Ireland in 1981." Fisheries Leaflet (No 117): 10 pp.

ICES (1981) Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1981/H:08.

ICES (1992). Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1992/Assess:11

ICES (1994). Report of the Study group on Herring Assessment and Biology in the Irish Sea and Adjacent Waters. Belfast, Northern Ireland, ICES CM 1994/H:5

ICES (1994b). Herring assessment working group for the Area South of 62ºN. ICES CM 1994/Assess:13

ICES (2001) Report on the study group on the further development of the precautionary approach to fishery management. ICES CM:2001/ACFM:11

ICES (2003) Study group on Precautionary Reference Points for Advice on Fishery Management (SGPRP). ICES CM 2003/ACFM: 15 (2003)

ICES (2005): Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM: 18.

ICES (2005b): Report of the Study group on Regional Scale Ecology of Small Pelagics ICES CM:2005/G:06

ICES (2006). Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM: 20.

ICES (2006b). Report of working group for regional ecosystem description (WGRED). ICES CM 2006 ACE:03

ICES (2007). Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2006/ACFM: 11.

ICES (2007b). Report of working group for regional ecosystem description (WGRED). ICES CM 2007 ACE:02

ICES (2007c). Working group on Oceanic Hydrography (WGOH). ICES CM 2007 OCC:05

ICES (2009). Study Group on the evaluation of assessment and management strategies of the western herring stocks (SGHERWAY) ICES CM:2009 RCM:15

ICES (2010). Study Group on the evaluation of assessment and management strategies of the western herring stocks (SGHERWAY) ICES 2010 SSGSUE:08

Kennedy, T.D. (1970) The herring fisheries on the North west and West coasts 1970 and 1971. Fishery Leaflet. No. 29

Lynch, D. 2009. Long term changes in the biology of Celtic Sea Herring. MSc. Thesis, Trinity College Dublin.

McArdle, E., (1983) Fecundities of winter spawning herring off the Northwest coast of Ireland. ICES CM 1983/H:59

Molloy, J., (1989) Herring Research – Where do we go from here? Fisheries Research Centre, Unpublished document, 6pp.

Molloy, J., and E. Barnwall. 1988. Herring larval surveys off the west and northwest coasts 1984-1986. Fishery Leaflet 142:8pp.

Molloy, J., Barnwall, E., Morrison, J (1993). "Herring tagging experiments around Ireland, 1991." Fisheries Leaflet(154): 7 pp.

Molloy, J. (1995). The Irish herring fisheries in the twentieth century: their assessment and management. Occasional Papers in Irish Science and Technology, Royal Dublin Society: 1-16.

Molloy, J, Kelly, C. (2000): Herring in VIaS and VIIbc, a review of fisheries and biological information. Report of the workshop between Scientists and Fishermen, Killybegs Fishermen's Organisation, Bruach Na Mara, July 2000.

Molloy, J. (2006): The Herring Fisheries of Ireland (1990 – 2005). Biology, Research and Development.

Nolan, G., and Lyons, K, (2006). Ocean Climate variability on the western Irish shelf, an emerging time series. ICES CM/C:28

Patterson, K.R. (1998) Integrated Catch at Age Analysis Version 1.4. Scottish Fisheries Research Report. No. 38

Patterson, K.R., (1998b) A programme for calculating total international catch at age and weight at age. Marine Laboratory Aberdeen.

Reid, J.B., Evans, P.G.H. and Northridge, S.P. (2003). Atlas of Cetacean distribution in northwest European waters. Joint Nature Conservancy Committee, Peterborough.

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

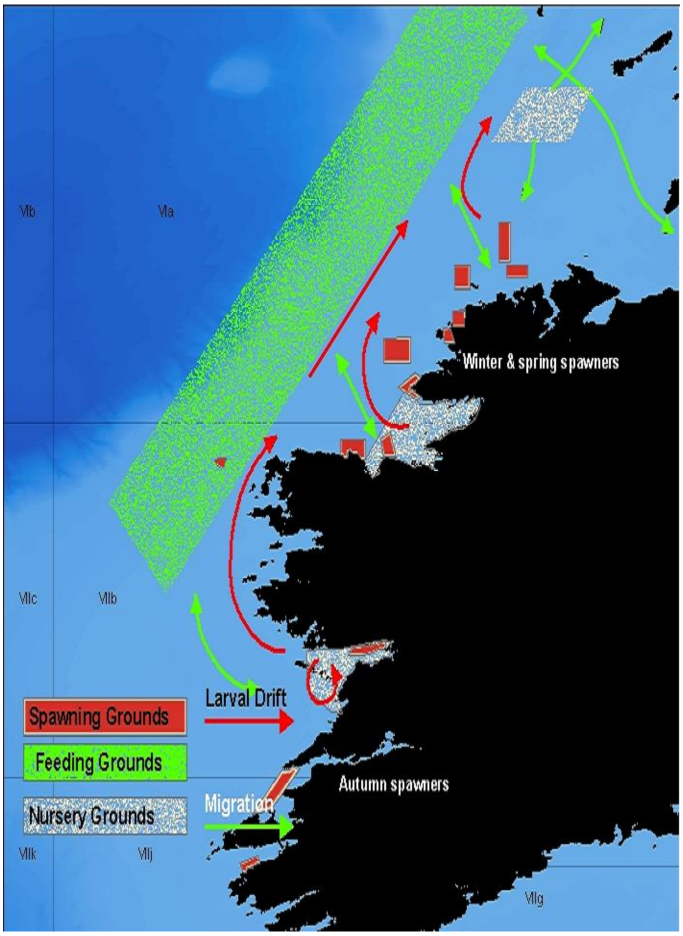


Figure 1: Schematic presentation of the life cycle of Herring west and northwest of Ireland.

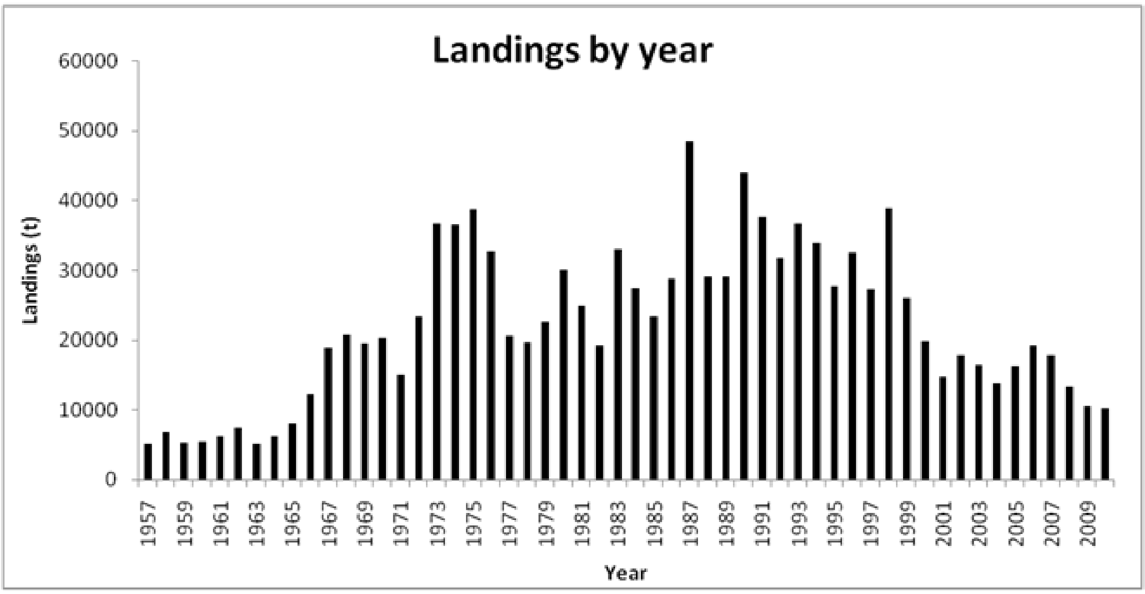


Figure 2: Total landings from VIaS, VIIb,c

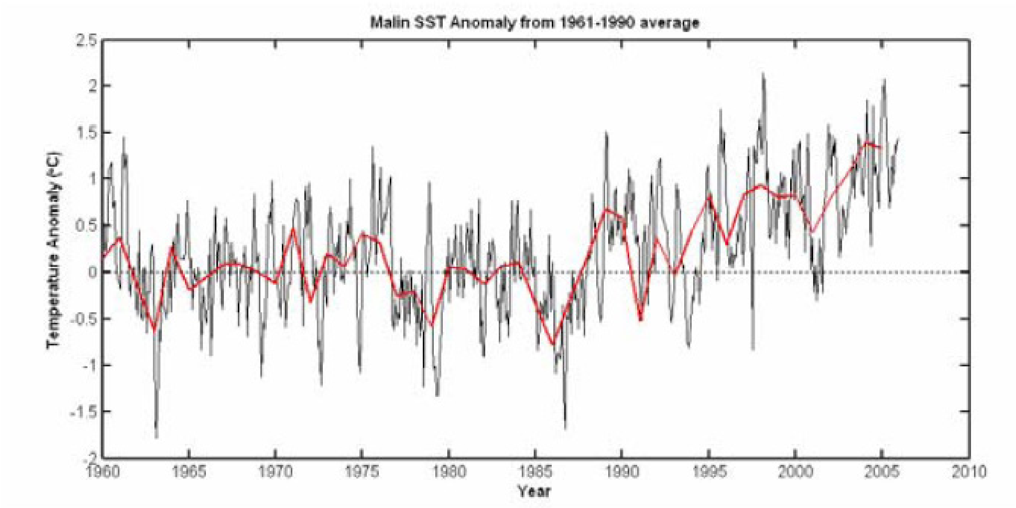


Figure 3: Sea surface temperature anomaly at Malin Head (1960-2005) (Nolan and Lyons, 2006)

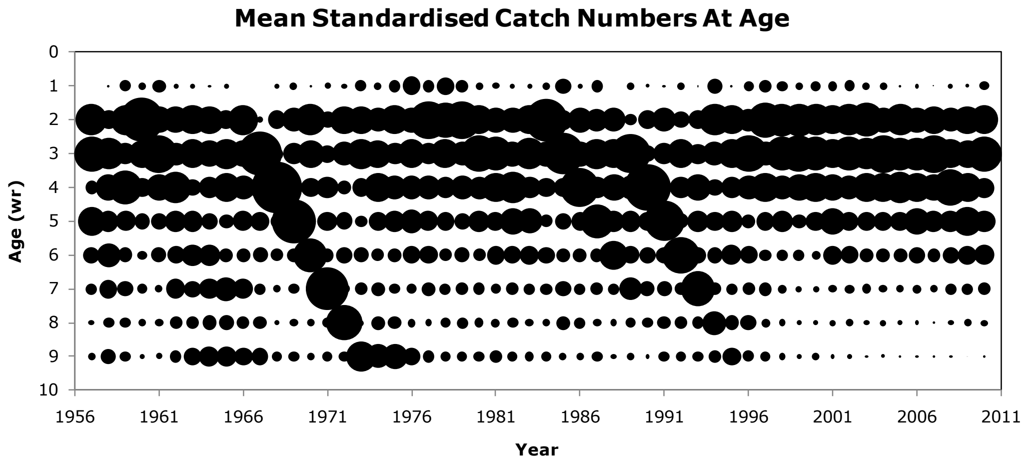


Figure 4: Mean Standardised Catch Numbers at Age

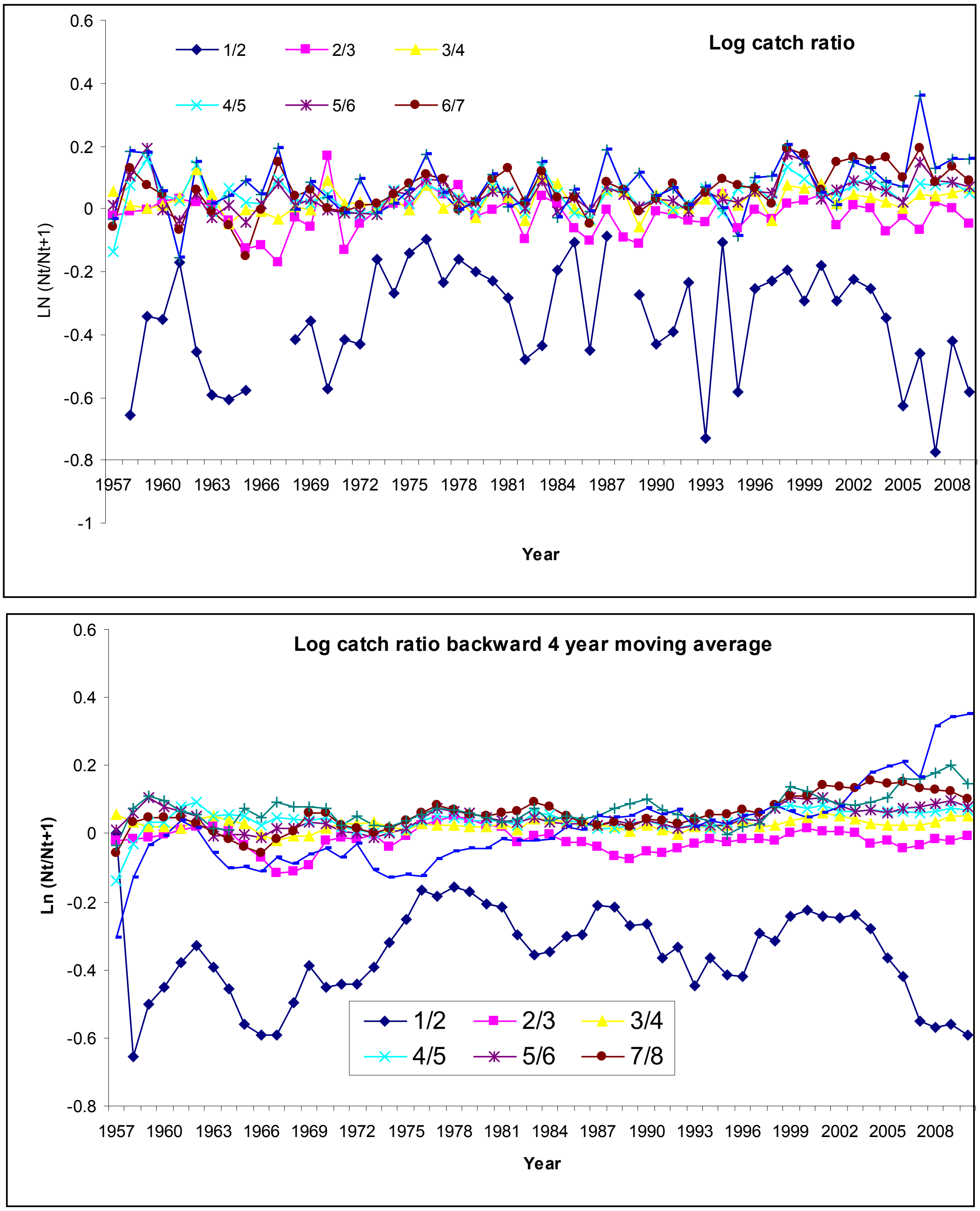
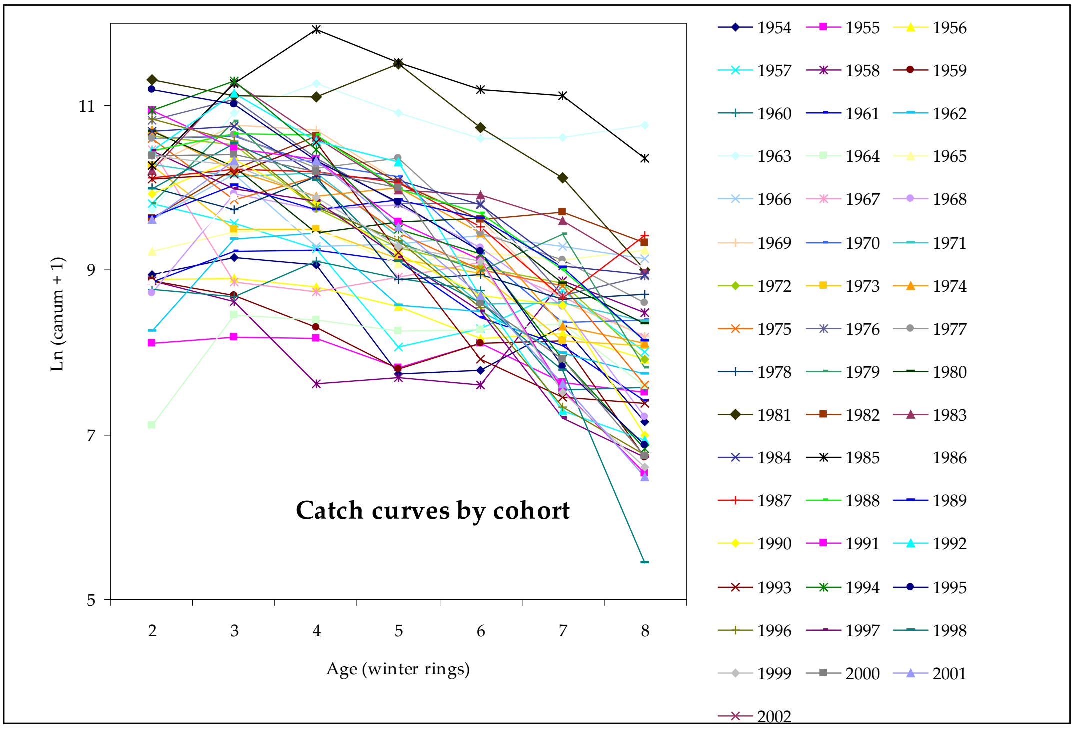


Figure 5. Log catch ratios 1957-2010. Top panel individual years, lower panel applying a backward 4 year moving average smoother.



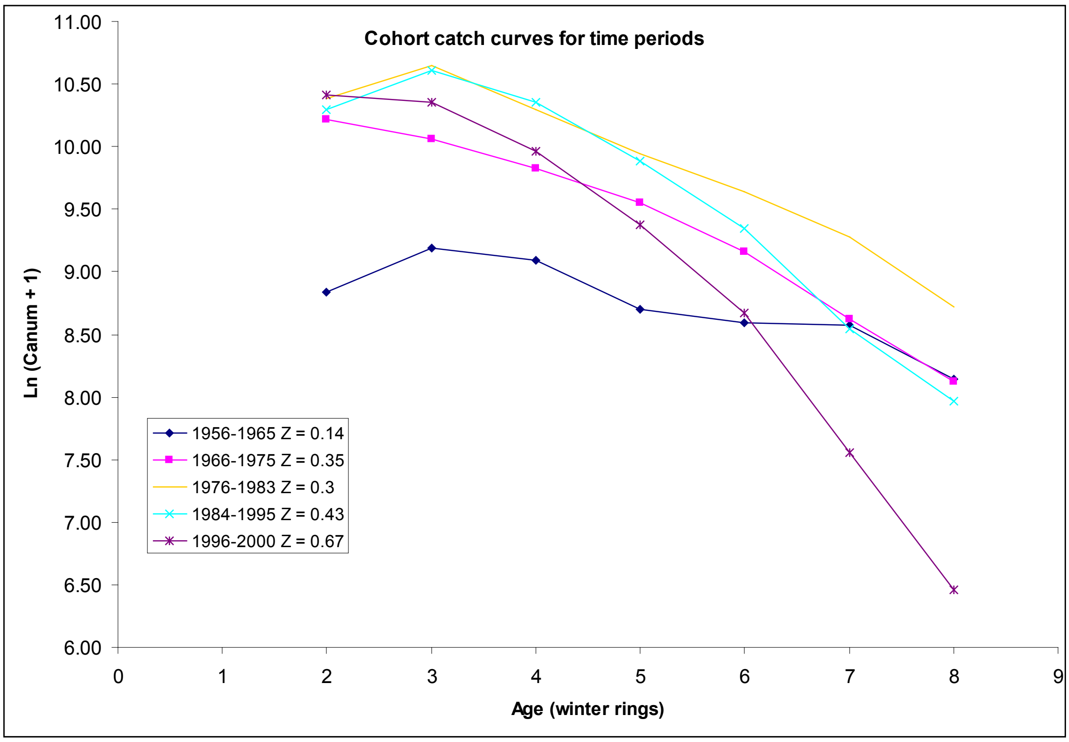


Figure 6: Cohort catch curves by birth year, 1954-2002 (top panel) and for various time periods 1956-2000 (bottom panel).

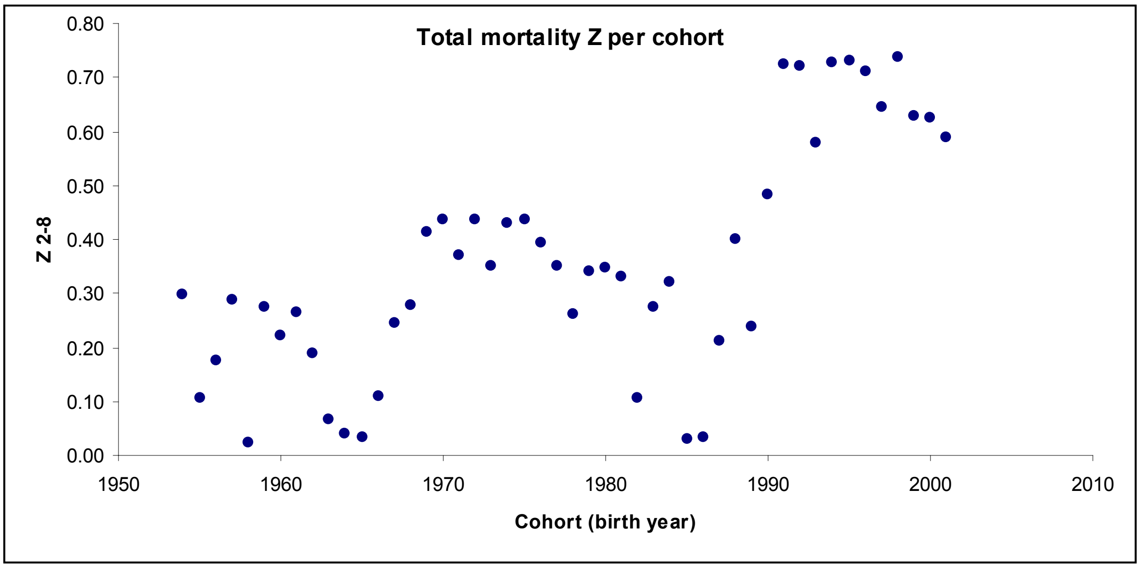


Figure 7: Total mortality (2-8 winter rings) by cohorts born from 1954-2001.

Adjunct to Annex 7 (2011) Extension of VIaS VIIb,c time series

Maurice Clarke

Introduction

The present data series spans 1970 to 2009. It was felt that extending the series back in time would improve our understanding of stock productivity. It was known that sampling of Irish catches began in 1962 (Killybegs only) and in 1963/64 more extensively (Bracken , 1962,1963). Therefore an attempt was made to extend the series at least as far back as 1963. Before this, German and Dutch sampling was understood to have taken place (Molloy pers. comm.), and data were available as far back as 1957.

A similar extension of the VIaN time series was conducted in 2004 (ICES 2004, Appendix 11; Keltz and Simmonds 2004). Also available was an historical series of catch numbers at age for VIa (incl. Moray Firth juvenile fishery) for the years 1957-1980 (ICES HAWG, 1974; 1980; 1981; 1982). The broad approach taken here was to subtract the VIaN extended series (HAWG 2004) from the ViaN historic series.

This document outlines the approach taken to extend the current time series back from 1957-1969.

Materials and methods

The following data were available:

Catch-numbers-at-age	VIa (incl. Moray Firth)	1957-1980	(Keltz and Simmonds, 2004, and references therein)
Catch in tones	VIa (south of 57°N)	1967-1980	(HAWG, 1978)
	VIIbc	1970-1980	(HAWG, 1981)

The data presented in HAWG 1978 could not be used because they were for the area south of 57°N, rather than south of 56°N.

Catch in tonnes (CATON)

Catch in tones for VIa S/VIIbc was estimated by subtracting the estimated catch in tones for VIaN (incl. Moray Firth) as presented by ICES (2004). Table 1 shows catch in tones for VIaN (incl. Moray Firth) from various working group reports. It can be seen from this that revisions were only applied in the terminal year, and the data were stable back in time. Table 2 shows the calculations used to achieve the best estimate of VIa S/VIIbc. The VIa total catch in tones was taken from the ICES HAWG 1974. These data were partitioned using the compliment of the raising factor presented by Keltz and Simmonds (2004, Table 11). Their raising factor was used to segregate VIa into VIaN. Thus, the remaining data can be considered as the best estimate of VIaS landings. VIIbc landings (ICES, HAWG, 1981) were added to these data to obtain the best estimate for the stock. The compliment of Keltz and Simmonds' ratio is presented in Table 3. These ratio compliments were calculated over the period 1970 -1980, but were applied to the years 1957 to 1969.

As a check these estimates were compared using the following check on totals by year:

(VIa $_{\text{total, Table 1}}$– ViaN caton $_{\text{HAWG 2010}}$) + VIIbc $_{\text{HAWG 1981}}$) /best estimate from ratio in Table 3..

It can be seen that the data agree very well with the data presented by ICES HAWG (1974) for all of VIa (minus VIaN) and for VIIbc.

Catch in number (CANUM)

Catch in numbers was calculated by subtracting the matrix for VIaN currently used in the assessment (ICES HAWG, 2010) from the historic VIa (incl. Moray Firth) matrix presented in ICES HAWG (1974). The latter data set is presented in Table 4. This approach assumes that catch numbers at age for VIIbc are included in the VIa matrix for the years 1967-1969, as this was the procedure at the time.

Mean weight in the catch and in the spawning stock (WECA and WEST).

In the absence of weight at age data constant values were extended backwards from 1970 to 1957, using 1983 values. This follows the procedure in recent working groups (HAWG, 2010).

Results and Discussion

The best estimate catch in tonnes estimated for VIaS and VIIbc over the time series is presented in Table 3, and in Figure 1.

The catch at age matrix, based on the extension of the data 1957-1969, is presented in Table 5. The value for 5 ring in 1966 was negative, the only instance where this occurred. This value was replaced by interpolation along the cohort.

To test the data further, a Sum-of-Product (SOP) check was performed by multiplying the canum from Table 5 by the new WECA, and comparing it with the reconstructed caton. SOP errors were encountered, of between 0 and 30%. In all but one case, where error was found, the caton was higher. To account for missing catch at age, the canum was raised by this SOP error to produce a final canum (Table 6).

The revision shows that the 1963 year class was very strong, and was the only strong cohort in the catches until the 1981 year class (Figure 2).

Negative values after 1969 in the canum suggests that there additional fish now in the VIAN data series as revised by Simmonds and Keltz (2004). However the VIaN series seems to be internally consistent (John Simmonds pers. comm..). A discrepancy exists in this new dataset with regard to the German Democratic Republic (East German) landings in VIaS (Table 3). Though it is known that such fisheries existed, no information on catch is available.

References

Bracken, J. 1963 Herring investigations in Donegal Bay (1962 and 1963). ICES CM 1963/111, 4 pp.

Bracken, J. 1964 Report on Donegal herring investigations 1963/1964. ICES CM 1964/88, 5 pp.

Keltz and Simmonds, 2004. Annex I to Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 551 pp. Copenhagen: ICES

ICES. 1974 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 38 pp. Copenhagen: ICES.

ICES. 1975 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 44 pp. Copenhagen: ICES.

ICES. 1976 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 69 pp. Copenhagen: ICES.

ICES. 1977 Report of the Herring Assessment Working Group South of 62ºN (HAWG) - Part 1 of 2, pp. 86 pp. Copenhagen: ICES.

ICES. 1977 Report of the Herring Assessment Working Group South of 62ºN (HAWG) - Part 2 of 2, pp. 46 pp. Copenhagen: ICES.

ICES. 1978 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 74 pp. Copenhagen: ICES.

ICES. 1979 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 82 pp. Copenhagen: ICES.

ICES. 1980 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 128 pp. Copenhagen: ICES.

ICES. 1981 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 120 pp. Copenhagen: ICES.

ICES. 2004 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 551 pp. Copenhagen: ICES.

ICES. 2007 Report of the Herring Assessment Working Group South of 62ºN (HAWG), pp. 540 pp. Copenhagen: ICES.

Table 1. Catch in tonnes (VIA incl. Moray Firth) from various Herring Working Groups 1974-1981. Data not presented in WG reports for shaded areas.

HAWG	AREA	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1974	Via	46805	65290	67984	68230	51941	63699	53949	69718	66383	92032	102694	100323	123593	178796	220941	173938	239993							
1974	Moray	1703	1164	2451	906	585	1842	118	660	10278	20734	6507	4985	3100	1385	5666	10242	7219							
1975	Via										92444	102871	100326	124009	179003	221271	174873	247148	205358						
1975	Moray										20734	6507	4985	3100	1385	5666	10242	7219	-						
1976	Via										92444	102871	100326	124009	179003	221271	174873	247148	209561	128240					
1976	Moray										20734	6507	4985	3100	1385	5666	10242	7219	13003	2454					
1977	Via											102871	100326	124009	179003	221271	174873	247148	209561	141263	106504				
1977	Moray											6507	4985	3100	1385	5666	10242	7219	13003	2454	313				
1978	Via												100330	124012	179004	221825	181749	248080	209564	141269	111420	47615			
1978	Moray												4985	3100	1385	5666	10242	7219	13003	2454	313	249			
1979	Via													124012	179004	221825	181749	248080	209564	141269	111420	48568	32371		
1979	Moray													3100	1385	5666	10242	7219	13003	2454	313	205	276		
1980	Via														179004	221825	181749	248080	209564	141269	111420	48568	34388	6028	
1980	Moray														1385	5666	10242	7219	13003	2454	313	205	1502	28	
1981	Via															221825	181749	248080	209564	141269	111420	48568	34388	7602	6661
1981	Moray															5666	10242	7219	13003	2454	313	205	1502	21	273
Total Via incl Moray		48508	66454	70435	69136	52526	65541	54067	70378	76661	113178	109378	105315	127112	180389	227491	191991	255299	222567	143723	111733	48773	35890	7623	6934

Table 2. best estimate of VIaS VIIbc catch in tones, 1957 to 1979.

	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
VIaN summ 2010 HAWG	43438	59669	65221	63759	46353	58195	49030	64234	68669	100619	90400	84614	107170	165930	207167	164756	210270	178160	114001	93642	41341	22156	60
VIaN Caton 2009 HAWG		59669	65221	63759	46353	58195	49030	64234	68669	100619	90400	84614	107170	165930	207167	164756	210270	178160	114001	93642	41341	22156	60
VIaT - VIaN	5070	6785	5214	5377	6173	7346	5037	6144	7992	12559	18978	20701	19942	14459	20324	27235	45029	44407	29722	18091	7432	13734	7563
(ViaT - VIaN)+ VIIbc	5070	6785	5214	5377	6173	7346	5037	6144	7992	12559	19086	21969	20513	17071	22125	31142	50270	50171	46693	36403	20353	21266	22204
VIaS and VIIbc best estimate	5070	6825	5226	5401	6182	7399	5059	6169	8016	12215	18881	20731	19607	20306	15044	23474	36719	36589	38764	32767	20567	19715	22608
(ViaT - VIaN)+ VIIbc / best estimate	1	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00	0.97	0.99	0.94	0.96	1.19	0.68	0.75	0.73	0.73	0.83	0.90	1.01	0.93	1.02
Via (s of 57deg) HAWG 1978											26236	24502	24088	21721	18603	26274	41326	28229	28962	17989	7918		
VIIbc HAWG 1981											108	1268	571	2612	1801	3907	5241	5764	16971	18312	12921	7532	14641

Table 3. Ratios used to segregate VIA (incl. Moray Firth) landings into VIa S data. These ratios are the compliments of the ratios used by Keltz and Simmonds (2004). Catch data for German Democratic Republic are not available.

	VIAS	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Belgium	1	0	192	24	40	0	0	1	0	0	23	0	0	0
UK (Eng.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faeroe Isl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0
German D.R.	0.82													
German F.R.	0.3	0	2578	753	1593	545	3384	1422	1616	1520	4390	5195	4462	4742
Netherlands	0.17	0	0	0	0	0	0	0	12	56	43	778	503	257
Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	1	5069	4049	4449	3768	5637	4015	3633	4540	6440	7759	12290	13390	11895
UK (N.Irl.)	1	1	6	0	0	0	0	3	1	0	0	0	4	3
Norway	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0.85	0	0	0	0	0	0	0	0	0	0	618	2372	2710
UK (Scot)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USSR	0.36	0	0	0	0	0	0	0	0	0	0	0	0	0
unallocated	1													
Moray Firth	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5070	6825	5226	5401	6182	7399	5059	6169	8016	12215	18881	20731	19607

Table 4. Catch numbers at age for VIa (incl. Moray Firth) as presented in ICES HAWG (1974).

		1974 HAWG	VIa (inc. Moray Firth)							
					AGE (RINGS)					
	0	1	2	3	4	5	6	7	8	9+
1957		6496	80817	66094	26882	38989	21547	9643	1658	4817
1958		15695	33616	152801	43895	28108	32025	19986	10795	8887
1959		54063	74615	38547	124307	27898	18942	18833	8158	9364
1960	21	3940	115501	65703	25388	50558	12196	11096	6770	4856
1961		14473	50809	72914	38321	24455	14296	5791	5370	2887
1962		55278	99167	27189	76706	49002	22707	27787	7614	8435
1963		11890	82849	57688	13310	42796	28698	10171	14585	7885
1964	2781	26609	87652	74309	29583	8857	27075	21347	10109	17655
1965	46891	299701	23351	72085	67768	24525	7001	28806	21475	23515
1966	211639	211675	517616	45317	70793	38471	22691	12656	20790	33175
1967	186598	207947	28648	273723	49755	48320	36143	15226	10397	33967
1968	71425	220870	105348	26031	243304	19679	28436	17699	7275	14389
1969	192368	39160	107189	84565	27604	264558	25795	45908	27932	29258

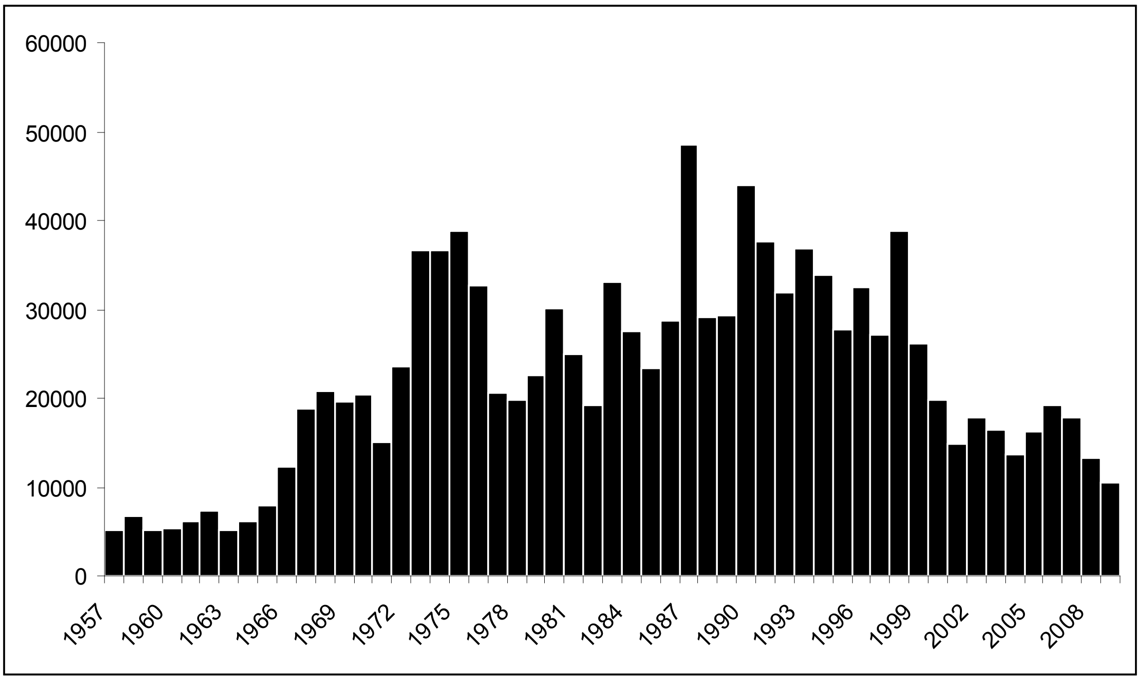


Figure 1. Best estimate of landings in VIaS VIIbc from 1957 to 2009. Data for 1957-1969 reconstructed in the current study.

Table 5. Extended catch at numbers at age matrx for VIaS and VIIbc. Only data for period 1957-1969 were reconstructed. Value for 5-ringer in 1966 was interpolated because it was a negative value (indicated in mauve). The interpolation was conducted either side along the cohort.

6aS and VIIb	1	2	3	4	5	6	7	8	9
1957	0	6195	8008	1120	5010	1657	758	231	394
1958	79	2636	7407	4825	3200	4395	2581	938	1728
1959	971	6643	3284	7917	2952	1610	1834	786	769
1960	379	13377	5413	2607	1677	565	749	424	239
1961	1392	5614	11295	5196	1954	1884	446	556	305
1962	230	6362	4911	9252	4645	2948	3648	1467	1353
1963	94	4602	4233	1451	2279	2528	1484	923	1797
1964	63	5041	4233	2903	1574	2848	2710	1312	2552
1965	218	3584	9443	8393	2260	1881	5915	2550	3984
1966	0	16763	11861	10291	7372	3347	7093	2979	6092
1967	0	1232	55034	12686	9074	6350	3456	4864	8168
1968	615	10910	5033	84182	5691	4854	2022	898	3575
1969	1454	14628	12658	4290	53315	4784	3146	1901	3051
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	27818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17

Table 6. SOP-error-corrected catch numbers at age for VIaS and VIIbc, 1957-1969.

	1	2	3	4	5	6	7	8	9	SOP error
1957	0	994	1644	266	1303	458	218	68	118	0.80
1958	11	432	1553	1171	850	1240	757	282	529	0.79
1959	117	935	591	1651	673	390	462	203	202	0.92
1960	57	2350	1217	678	477	171	236	137	78	0.73
1961	194	920	2366	1260	519	531	131	167	93	0.79
1962	29	925	913	1991	1094	738	950	392	367	0.89
1963	14	831	978	388	667	786	480	306	607	0.71
1964	10	907	974	773	459	882	873	434	858	0.72
1965	26	496	1672	1721	507	448	1467	649	1031	0.93
1966	0	2168	1962	1971	1545	745	1643	708	1472	1.00
1967	0	159	9077	2422	1896	1409	798	1152	1968	1.00
1968	63	1315	776	15020	1111	1007	436	199	805	1.07
1969	164	1940	2147	842	11455	1092	747	463	756	0.97

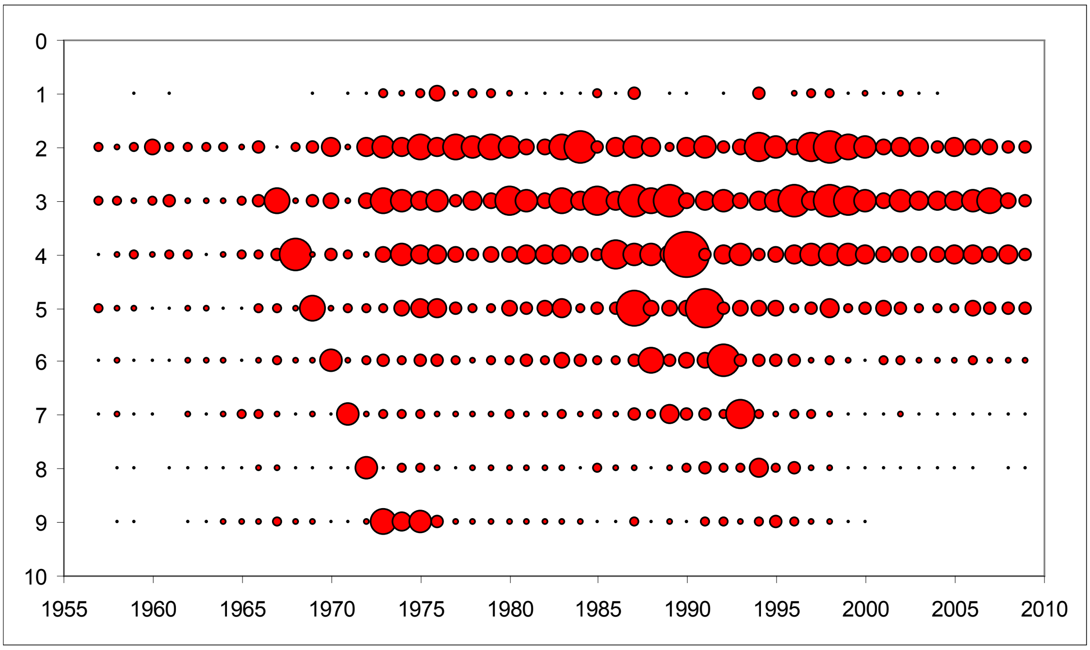


Figure 2. Bubble plot of catch numbers at age for extended series in VIaS and VIIbc.

Annex 8 – Stock Annex Irish Sea Herring VIIa (N)

Quality Handbook	ANNEX:_hawg-nirs
Stock specific documentation of standard assessment procedures used by ICES.	
Stock:	Irish Sea herring (VIIa(N)
Working Group	Herring Assessment Working Group (HAWG)
Date:	22 March 2011
Revised by	Steven Beggs

A. General

A.1. Stock definition

Herring spawning grounds in the Irish Sea are found in coastal waters to the west and north of the Isle of Man and on the Irish Coast at around 54°N (ICES, 1994; Dickey-Collas *et al.*, 2001). Spawning takes place from September to November in both areas, occurring slightly later on average on the Irish Coast than off the Isle of Man. ICES Herring Assessment Working Groups from 19XX to 1983 used vertebral counts to separate catches into Manx and Mourne stocks associated with these spawning grounds. However, taking account of inaccuracies in this method and the results of biochemical analyses, the 1984 WG combined the data from the two components to provide a "more meaningful and accurate estimate of the total stock biomass in the N. Irish Sea." All subsequent assessments have treated the VIIa(N) data as coming from a single stock. During the 1970s, catches from the Manx component were about three times larger than those from the Mourne component. By the early 1980s, following the collapse of the stock, the catches were of similar magnitude. The fishery off the Mourne coast declined substantially in the 1990s then ceased, whilst acoustic and larva surveys in this period indicate that the spawning population in this area has been very small compared to the biomass off the Isle of Man.

The occurrence in the Irish Sea of juvenile herring from a winter-spring spawning stock has been recognized since the 1960s based on vertebral counts (ICES, 1994). More recently, Brophy and Danilowicz (2002) used otolith microstructure to show that nursery grounds in the western Irish Sea were generally dominated by winter-spawned fish. Samples from the eastern Irish Sea were mainly autumn-spawned fish. Recaptures from 10,000 herring tagged off the SW of the Isle of Man in July 1991 occurred both on the Manx spawning grounds and along the Irish Coast with increasing proportions from the Celtic Sea in subsequent years (Molloy *et al.*, 1993). The pattern of recaptures indicated a movement towards spawning grounds in the Celtic Sea as the fish matured.

A proportion of the Irish Sea herring stocks may occur to the north of the Irish Sea outside of the spawning period. This was indicated by the recapture on the Manx spawning grounds of 3-6 ring herring tagged during summer in the Firth of Clyde (Morrison and Bruce, 1981). Aggregations of post-spawning adult herring were detected along the west coast of England during an acoustic survey in December 1996 (Department of Agriculture and Rural Development for Northern Ireland, unpublished data), showing that a component of the stock may remain within the Irish Sea.

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

A.2. Fishery

There have been three types of fishery on herring in the Irish Sea in the last 40 years:

i) Isle of Man- aimed at adult fish that spawn around the Isle of Man.

ii) Mourne- aimed at adult fish that spawn off the Northern Irish eastern coast.

iii) Mornington- a mixed industrial fishery that caught juveniles in the western Irish Sea.

The Mornington fishery started in 1969 and at its peak it caught 10,000 tonnes per year. It took place throughout the year. The fishery was closed due to management concerns in 1978 (ICES, 1994). In the 1970s the catch of fish from the Mourne fishery made up over a third of the total Irish Sea catch. The fishery was carried out by UK and Republic of Ireland vessels using trawls, seines and drift nets in the autumn. However the fishery declined and ceased in the early 1990s (ICES, 1994). The biomass of Mourne herring, determined from larval production estimates is now 2-4% of the total Irish Sea stock (Dickey-Collas *et al*., 2001).

The main herring fishery in the Irish Sea has been on the fish that spawn in the vicinity of the Isle of Man. The fish are caught as they enter the North Channel, down the Scottish coast, and around the Isle of Man. Traditionally this fishery supplied the Manx Kipper Industry, which requires fish in June and July. However the fish appeared to spawn slightly later in the year in the 1990s and this lead to problems of supply for the Manx Kipper Industry. In 1998 the Kipper companies decided to buy in fish from other areas. Generally the fishery has occurred from June to November, but is highly dependent on the migratory behaviour of the herring.

The fishery has been prosecuted mainly by UK and Irish vessels. TACs were first introduced in 1972, and vessels from France, Netherlands and the USSR also reported catches from the Irish Sea during the 1970s before the closure of the fisheries from 1978 to 1981. By the 1990s only the fishery on the Manx fish remained, and by the late 1990s this was dominated by Northern Irish boats. The number of Northern Irish vessels landing herring declined from 24 in 1995-96 to 6-10 in 1997-99 and to 4 in 2000. Only two vessels operated in 2002 and 2003. However, total landings have remained relatively stable since the 1980s whilst the mean amount of fish landed per fishing trip has increased, reflecting the increase in average vessel size

A.3. Ecosystem aspects

The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*). The size composition of herring in the stomach contents indicates that predation by whiting is mainly on 0-ring and 1-ring herring whilst adult hake and spurdogfish also eat older herring (Armstrong, 1979; Newton, 2000; Patterson, 1983). Sampling since the 1980s has shown cod (*Gadus morhua*), taken by both pelagic and demersal trawls in the Irish Sea, to be minor predators on herring. Small clupeids are an important source of food for piscivorous seabirds including gannets, guillemots and razorbills (ref…) which nest at several locations in and around the Irish Sea. Marine mammal predators include grey and harbour seals (ref.) and possibly pilot whales, which occur seasonally in areas where herring aggregate.

Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). The biomass of small herring has typically been less than 5% of the combined biomass of small clupeids estimated by acoustics (ICES, 2008 ACOM:02). However in recent years the proportions have increased in favour of small herring (ICES, 2009 ACOM:??).

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

Changes in Environment

There has been an increase in water temperatures in this area (ICES, 2006) which is likely to affect the distribution area of some fish species, and some changes of distribution have already been noted. Temperature increase is likely to affect stock recruitment of some species. In addition, the combined effects of over exploitation and environmental variability might lead to a higher risk of recruitment failure and decrease in productivity (ICES, 2007).

B. Data

B.1. Commercial catch

National landings estimates

The current ICES assessment of Irish Sea herring extends back to 1961, and is based on landings only. ICES WG reports (ICES 1981, 1986 and 1991) highlight the occurrence of discarding and slippage of catches, which can occur in areas where adult and juvenile herring co-occur. Discarding has been practised on an increasing scale since 1980 (ICES, 1986). This increase is primarily related to the onset of slippage of catches that coincided with the cessation of the industrial fishery in early 1979 (ICES, 1980). As a result of sorting practices, slippage has led to marked changes in the age composition of the catch since 1979 and considerable change in the mean weights at age in the catch of the three youngest age groups (ICES 1981). Estimates of discarding were sporadically performed in the 1980s (ICES, 1981, 1982, 1985 and 1986), but there are no estimates of discarding or slippage of herring in the Irish Sea fisheries since 1986. Highly variable annual discard rates are evident from the 1980s surveys. For example, discards estimates of juvenile herring (0-group) for the Mourne stock taken in the 1981 *Nephrops* fishery was estimated at 1.9×10^6 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 have provided data for the VIIa(N) assessment:

Survey Acronym	Type	Abundance data	Area and Month	Period
AC(VIIaN)	Acoustic survey	Numbers at age (1-ring and older); SSB	VIIa(N) from 53°20’N – 55°N; September	1994 – present
NINEL	Larva survey	Production of larvae at 6mm TL	VIIa(N) from 53° 50’N – 54° 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	Groundfish survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53°20’N – 54° 50’N (stratified); October	1993 - 1999
GFS-mar	Groundfish survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53°20’N – 54° 50’N (stratified); March	1993 - 1999

Data from a number of earlier surveys have been documented in the ICES WG reports. These include:

NW Irish Sea young herring surveys (Irish otter trawl survey using commercial trawler; 1980 – 1988)

Douglas Bank (East Isle of Man) larva surveys (ring net surveys; 1974 – 1988) (Port Erin Marine Lab)

Douglas Bank spawning aggregation acoustic surveys (1989, 1990, 1994, 1995) (Port Erin Marine Lab)

Western Irish Sea acoustic survey (July 1991, 1992) (UK(NI))

Eastern Irish Sea acoustic survey (December 1996)

Surveys used in recent assessments are described below.

AC(VIIaN) acoustic survey

This survey uses a stratified design with systematic transects, during the first two weeks of September. Vessel currently used is the R.V. Corystes (UK(NI)) replacing the R.V. *Lough Foyle* (UK(NI)). Starting positions are randomized each year (see recent HAWG reports for transect design and survey results). The survey is most intense around the Isle of Man (2 to 4 n.mile transect spacing) where highest densities of adult herring are expected based on previous surveys and fishery data. Transect spacing of 6 to 10 n.miles are used elsewhere. A sphere-calibrated EK-500 38kHz sounder is employed, and data are archived and analysed using Echoview (SonarData, Tasmania). Targets are identified by midwater trawling. Acoustic records are manually partitioned to species by scrutinising the echograms and using trawl compositions where appropriate. ICES-recommended target strengths are used for herring, sprat, mackerel, horse mackerel and gadoids. The survey design and implementation follows, where possible, the guidelines for ICES herring acoustic surveys in the North Sea and West of Scotland. The survey data are analysed in 15-minute elementary distance sampling units (approx. 2.5 n.miles). An estimate of density by age class, and spawning stock biomass, is obtained for each EDSU and a distance-weighted average calculated for each stratum. These are raised by stratum area to give population numbers and SSB by stratum.

NINEL larva survey

The DARD herring larva survey has been carried out in November each year since 1993. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Double-oblique tows are made to within 2m of the seabed at each station. Internal and external flow rates, and temperature and salinity profiles, were recorded during each tow. Lengths of all herring larva captured are recorded.

Mean catch-rates (nos.m^{-2}) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardised to a larva of 6mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35mm day^{-1} and instantaneous mortality of 0.14 day^{-1} are assumed based on estimates made in 1993 - 1997. More recent studies have indicated a mortality rate of 0.09, and this value is also applied to examine the effect on trends in estimates of larval production

DBL larva survey

Herring larvae were sampled on the east side of the Isle of Man in September or October each year. Double oblique tows with a 60 cm Gulf VII/PRO-NET high-speed plankton sampler with a 40cm aperture nose cone were undertaken on a 5 Nm square grid. The tow profile was followed with a FURUNO net sonde attached to the top of the equipment. The volume of water filtered was calculated from the nose cone mouth flow meter. The samples were preserved in 4% seawater buffered formalin and stored in 70% alcohol.

All herring larvae were sorted from the samples. The numbers of larvae per m^3 were calculated from the volume of water filtered and the number of larvae per tow. Up to 100 larvae from each tow were measured with an ocular graticule in a stereo microscope. Each sample was assigned to a sampling square and the total number of larvae per 0.5mm size class calculated from the average depth of the square and the surface area.

The total production and time of larvae hatch was calculated using an instantaneous mortality coefficient (k) of 0.14 and a growth rate of 0.35 mm d^{-1} in the formula:

$$N_t = N_o e^{-(kt)}$$

Production was calculated as the sum of all size classes/hatching dates. Spawning dates were taken as 10 days prior to the hatching date (Bowers 1952).

The Douglas Bank Larva survey has not been updated since 1999. Examination of the sum of squares surface from SPALY in 2005 indicated that the Douglas Bank larvae index (DBL) was having no influence in the assessment estimates for the current year. Therefore, the WG agreed on removing DBL from the analysis (ICES, 2005). The DBL time series is listed in Table 6

GFS-oct and –mar groundfish surveys

The DARD groundfish survey of ICES Division VIIaN are carried out in March and October at standard stations between 53° 20'N and 54° 45'N (Figure 2). Data from additional stations fished in the St George's Channel since October 2001 have not been used in calculating herring indices of abundance. As in previous surveys, the area was divided into strata according to depth contour and sediment type, with fixed station positions (note that the strata in Fig. 2 differ from those in the September acoustic survey shown in Fig. 1). The sampling gear was a Rockhopper otter trawl fitted with non-rotating rubber discs of approximately 15 cm diameter on the footrope. The trawl fishes with an average headline height of 3.0 m and door spread of 30 - 40 m depending on depth and tide. A 20mm stretched-mesh codend liner was fitted. During March, trawling was carried out at an average speed of 3 knots across the ground, over a standard distance of 3 nautical miles at standard stations and 1 nautical mile in the St. George's Channel. Since 2002, all survey stations in the October survey have been of 1-mile distance. Comparative trawling exercises during the October surveys and during an independent exercise in February 2003 indicate roughly similar catch-rates per mile between 1-mile and 3-mile tows. It is planned to continue with some comparative trawling experiments during future surveys to improve the statistical power of significance tests between the 1-mile and 3-mile tows.

As the surveys are targeted at gadoids, ages were not recorded for herring. The length frequencies in each survey were sliced into length ranges corresponding to 0-ring and 1-ring herring according to the appearance of modes in the overall weighted mean length frequency for each survey. Some imprecision will have resulted because of the overlap in length-at-age distributions of 1-ring and 2-ring herring. The error is considered to be comparatively small for most of the surveys where clear modes are apparent. There was no clear division between 1-ring and 2-ring herring in the March 2003 groundfish survey, and the estimate for 1-ringers may include a significant component of small 2-ringers. The arithmetic mean catch-rate and approximate variance of the mean was computed for each age-class in each survey stratum, and averaged over strata using the areas of the strata as weighting factors.

Groundfish surveys were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring in the Irish Sea. These indices have performed poorly in the assessment and have not been used since 1999. The time-series is listed in Table 7.

B.4. Commercial CPUE

Commercial CPUE's are not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Model used: ICA

Software used: ICA (Patterson 1998)

Model Options chosen:

Separable constraint over last 6 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 2

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.05 and 2.0

All survey weights fitted by hand i.e., 1.0 with the 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tonnes	1961-last data year	NA	Yes
Canum	Catch at age in numbers	1961-last data year	1-8+	Yes
Weca	Weight at age in the commercial catch	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
West	Weight at age of the spawning stock at spawning time.	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
Mprop	Proportion of natural mortality before spawning	1961-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	11961-last data year	NA	No
Matprop	Proportion mature at age	1961-last data year	1-8+	Yes
Natmor	Natural mortality	1961-last data year	1-8+	No

Tuning data:

Type	Name	Year range	Age range
Tuning fleet 1	NINEL	1993-2003	SSB
Tuning fleet 2	DBL	1989-1999	SSB
Tuning fleet 3	GFS-octtot	1993-2005	1 & 2
Tuning fleet 4	GFS-martot	1992-2003	1
Tuning fleet 5	ACAGE	1994-2003	1-8+
Tuning fleet 6	AC_VIIa(N)	1994-2003	SSB
Tuning fleet 7	AC_1+	1994-2003	SSB/Total biomass

Two-stage biomass model

In 2005 a Two-Stage Biomass model for the assessment of Irish Sea VIIa(N) herring given additional variance in the recruitment index was presented by Roel and De Oliveira (ICES 2005 WD10).

The model addresses the problem of the high uncertainty in the assessment of Irish Sea herring, which to some extent may be related to the presence of juvenile Celtic Sea herring in both the fishery and the survey area. In the absence of a Celtic Sea herring recruitment index, the biomass model presented addressed the problem by limiting recruitment variability in Irish Sea herring on the basis of information available for other herring stocks. The total variability in the recruitment data was divided into two components: the one related to Irish Sea herring recruitment variability and the rest which was likely to represent variability related to the presence of Celtic Sea juveniles.

The model is fitted to biomass indices of 1-ringer fish and to aggregated biomass indices for the 2-rings+ from Northern Ireland acoustic surveys. The survey age composition data and the weights-at-age from the catch are used to calculate the proportion of 1-ring fish in the survey. The proportion is then applied to the total acoustic biomass to compute the 1-ring biomass index while the 2-ring+ index is obtained by subtraction. The catch in weight was split in a similar manner but based on commercial catch samples.

The model

The dynamics take into account only two stages in the population: the recruits, 1-ringer fish, and the fully recruited that comprise 2-ringer and older fish. The biomass dynamics is represented by the following:

$$B_{y+1} = B_{1,y+1} + \left[(B_{2+,y} + B_{1,y})e^{-3g/4} - C_y\right]e^{-g/4} \quad [1]$$

where

$B_{1,y}$ is the biomass of recruitment (tons) at the start of year y;

$B_{2+,y}$ is the biomass of 2+ aged fish (tons) at the start of year y;

C_y is the biomass of fish caught (tons) during year y, assumed to be taken in a pulse fishery 3/4 of the way into year y; and

g is a composite parameter, treated as an annual rate, which accounts for natural mortality and growth.

Maximum likelihood estimation is used, assuming survey indices are log-normally distributed about their expected values. Standard errors of the log-distributions are approximated by the sampling CVs of the untransformed distributions.

The estimable parameters are g, $B_{2+,1994}$, $B_{1,1994},\ldots,B_{1,2004}$, λ^2 and q

where q corresponds to the catchability associated with the survey indices $I_{1,y}$ and $I_{2+,y}$ and λ^2 is the additional variance.

The data were explored for values of recruitment variability (σ_R) = 0.4 and 0.8. The value 0.4 corresponds to the variability in recruitment age 1 as estimated by ICA for the period used in this analysis, but excluding the most recent estimate (1994 – 2006). The two parameters, g and q, may be confounded in the model indicating that fixing g was appropriate. This parameter was fixed to 0.2 following a similar approach as in Roel and De Oliveira (ICES 2005 WD10).

D. Short-Term Projection

NOT USED IN 2004
Model used: Age structured

Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1-ring recruits taken from a geometric mean for the years 1983 to two years prior to the current year. Where 1-ringers are absurdly estimated in the assessment 2-ringers are estimated as a geometric mean of the previous 10 year period.

Maturity: Mean of the previous three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.9 and 0.75 respectively for all years.

Weight at age in the stock: Mean of the previous three years in the assessment.

Weight at age in the catch: Mean of the previous three years in the assessment.

Exploitation pattern: Mean of the previous three years, scaled by the Fbar (2-6) to the level of the last year.

Intermediate year assumptions: TAC constraint.

Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

Not done

G. Biological Reference Points

Until there is confidence in the assessment the Working Group decided not to revisit the estimation of $\mathbf{B}_{pa}$ (9,500 t) and $\mathbf{B}_{lim}$ (6,000 t). There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:10).

H. Other Issues

I. References

Anon. 1985. Report of the Herring Assess. WG for the Area South of 62oN. ICES Doc.

Anon. 1987a. Report of the ad hoc Multispecies Assessment WG. ICES, Doc. C.M. 1987/Assess:9.

Anon. 1987b. Report of the Herring Assess. WG for the Area South of 62oN. ICES Doc C.M. 1987/Assess:19.

Bowers, A.B. 1952 Studies on the herring (Clupea harengus L.) in Manx waters:- The autumn spawning and the larval and post larval stages. Proc. Liverpool Biol. Soc. 58: 47-74.

Bowers, A.B. and Brand, A.R. 1973.Stock-size and recruitment in Manx herring. Rapp …. 164: 37-41.

Brophy, D. and Danilowicz, B. 2002. Tracing populations of Atlantic herring (Clupea harengus L.) in the Irish and Celtic Seas using otolith microstructure. – ICES Journal of Marine Science, 59: 1305-1313.

Dickey-Collas, M., Nash, R.D.M. and Armstrong, M.J. 2003. Re-evaluation of VIIa(N) herring time series of catch and maturity at age, and the impact on the assessment. ICES herring Assessment Working Group Document. 8pp.

Dickey-Collas, M., Nash, R.D.M. and Brown, J. 2001. The location of spawning of Irish Sea herring (Clupea harengus). J. Mar. Biol. Assoc., UK., 81: 713-714.

ICES 1980 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1980/H:4

ICES 1981 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1981/H:8

ICES 1982 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1982/Assess:7.

ICES 1983 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1983/Assess:9.

ICES 1985 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1985/Assess:12.

ICES 1986 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1986/Assess:19.

ICES 1987 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1987/Assess:19.

ICES 1989 Report of the Herring Assessment Working Group for the Area South of 62 °N. ICES C.M. 1989/Assess:15

ICES 1990. Report of the Herring Assessment Working Group for the Area South of 62 oN. ICES C.M. 1990/Assess: 14. (mimeo).

ICES 1991. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1991/ACFM:15.

ICES 1994. Report of the study group on herring assessment and biology in the Irish Sea and adjacent waters. ICES C.M. 1994/H:5. 69pp.

ICES 1996. Landings statistics and biological sampling. Working Document. 1996 ICES Herring Assessment WG.

ICES 1998. Report of the Herring Assessment Working Group for the Area south of 62ºN. ICES CM 1998/ACFM:14.

ICES 2000. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2000/ACFM:12.

ICES 2001. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2001/ACFM:10.

ICES 2003. Report of Herring Assessment WG for the Area South of 62º N. CM 2003/ACFM:17.

ICES 2005. Report of Herring Assessment WG for the Area South of 62º N. ICES CM 2004/ACFM: 16.

Molloy, J.P., Barnwall, E. and Morrison, J. 1993. Herring tagging experiments around Ireland in 1991. Dpt. of Marine. Dublin. Fish. Leaf. No. 154. 1993.

Morrison, J.A. and Bruce, T. 1981. Scottish herring tagging experiments in the Firth of Clyde 1975-1979 and evidence of affinity between Clyde herring and those in adjacent areas. ICES CM 1981/H:53.

Newton, P. 2000. The trophic ecology of offshore demersal teleosts in the North Irish Sea. PhD Thesis, Univ. Liverpool.323 pp.

Patterson, K.R. 1983. Some observations on the Ecology of the Fishes of a Muddy Sand Ground in the Irish Sea. PhD. Thesis. Univ. Liverpool.

Table 1. Biological sampling of Irish Sea (VIIa(N)) landings. Country denotes sampling nation.

	Coverage	% of landings sampled	No of samples	Total landings	landings by Q?	IRELAND				NORTHERN IRELAND				ISLE OF MAN				OTHERr UK/UK OFFSHORE				TOTAL			
Year						Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages
1988	(4)					**2579																	0	0	0
1989	(3) temp spread good		88	4962	NO	1430	21	1843	555		45	11464	2249		21	5173	1057		1	96	0	4962	88	18576	3861
1990	p(1,2)	68%	100	6312	YES	1699	44	5176	1022	2322	38	9310	1900	542	18	5276	897	179/1570	0	0	0	6312	100	19762	3819
1991	g	90%	138	4398	YES	80	5	1255	247	3298	105	16724	2484	629	28	8280	1392	0/391	0	0	0	4398	138	26259	4123
1992	g	98%	32	5270	YES	406	3	593	99	4120	16	1588	770	741	13	3488	680	3	0	0	0	5270	32	5669	1549
1993	p (1)	65%	48	4408	YES	0	5	1378	245	3632	34	3744	832	776	9	1560	448	0	0	0	0	4408	48	6682	1525
1994	v.g	95%	59	4828	YES	0	21	569	100	3956	43	3691	1175	716	14	3724	614	156	0	0	0	4828	59	7984	1889
1995	g (1)	87%	85	5076	YES	0	21	569	100	3860	75	8282	2545	615	8	2182	400	601	0	0	0	5076	85	11033	3045
1996	g (1,5)	70%	51	5301	YES	100	1	537	55	4335	45	4813	1050	537	5	997	228	329	0	0	0	5301	51	6347	1333
1997	g (1,2)	91%	34	6649	YES	0	2	473	50	5679	25	2900	1199	765	7	2246	340	205	0	234	76	6649	34	5853	1665
1998	g (2)	84%	31	4904	YES	0	2	150	50	4131	29	2979	1450	0	0	0	0	7732	0	0	0	4904	31	3129	1500
1999	g (2)	72%	32	4127	YES	0	4	0	200	2967	28	2518	1400	0	0	0	0	11602	0	0	0	4127	32	2518	1600
2000	v.g	97%	28	2002	YES	0	5	932	0	2002	23	1915	1150	0	0	0	0	0	0	0	0	2002	28	2847	1150
2001	p (2)	70%	31	5461	YES	862	8	1031	222	3786	23	2915	1149	86	0	0	0	7272	0	0	0	5461	31	3946	1371
2002	p (1)	62%	9	2392	YES	286	0	0	0	2051	9	949	450	4	0	0	0	51	0	0	0	2392	9	949	450
2003			9	2399	YES	0				2399	9	1132	445												
2004			9	2531	YES	749	2	190	133	1782	7	991	350												
2005			26	4387	YES	1153	5	1312	372	3234	21	4135	1018												
2006			22	4402	YES	581	8	2248	549	3821	14	1982	686												
2007			29	4629	YES	0				4629	29														
2008			19	4895	YES	0				4895	19														
2009	p (6)			4594	YES					4594	4											4594			
2010	g (2)	79%	31	4894	YES					4894	31	4115	1517									4894	31	4115	1517

COVERAGE: Sum of the landings (by Q and Nation(UK disaggregated))/total landings. From 1993 (possibly from 1990) to date landings and sampling levels are presented by quarter so coverage is related to this level of detail:

VERY GOOD (v.g) : all landings which individually are >10% of the total were sampled, all Q for which there were landings were sampled

GOOD (g) : landings that constitute the majority of the catch (adding to approx 70% or more of total) were sampled

POOR (p) : some of the large landings not sampled

(1): unsampled quarters

(2): large landings with few samples or unsampled. High level of sampling corresponds to 1 sample per 100t landed (WG rep 1997)

(3): Comment from WG rep. From 1990 going back, Report landings and sampling levels are shown aggregated for the whole year. UK landings lumped in one figure.

(4): no information in the WGrep of level of sampling prior to 1988. Sampling levels believed to be good. Actual figures to be provided by R. Nash, M Armstrong and CEFAS after going back to their labs.

(5): NO samples for NI landings in 4th Q, there is a suspicion that the figures correspond to 'paper landings'.

[1]Samples applied to NI landings: [2]Large unsampled landings.

(6): no samples taken from pair trawlers landings.

Table 2: Data and method used to estimate landings from Division VIIa(N) herring.

															Estimates of maximum likely catch for VIIa(N) incl. of French and ROI catches								
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**16**		**17**		**18**		**19**	
	ICES table							British Isles catches						**CATCH IN ASSESS-MENT**		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1955								0	0	72	3815		3887	**8056**		60500	4900					3630	539
1956								5	0	20	4762		4787	**8743**		52000	7600					3120	836
1957								21	0	1638	2832		4491	**7966**		36100	11900					2166	1309
1958								31	0	12	2482		2525	**6261**		38800	12800					2328	1408
1959								20	0	96	3577		3693	**7833**		40400	15600					2424	1716
1960								1	0	9	2093		2103	**6607**		36200	21200					2172	2332
1961								32	0	144	1941		2117	**5710**		36600	12700					2196	1397
1962								4	0	21	1528		1552	**4343**		29100	9500					1746	1045
1963								5	0	34	974		1013	**3947**		33500	8400					2010	924
1964								2	0	0	556		558	**3593**		35000	8500					2100	935
1965								1629	0	398	1135		3162	**5923**		26400	10700					1584	1177
1966								2041	0	46	596		2683	**5666**		22400	14900					1344	1639
1967								2911	0	8	1959		4878	**8721**		20600	23700					1236	2607
1968								1504	0	5	3253		4762	**8660**		22800	23000					1368	2530
1969								3591	0	63	5044		8698	**14141**		27100	34700					1626	3817
1970								4662	0	16	9782		14461	**20622**		24400	42700					1464	4697
1971	3131	21861	1815				26807							**26807**		23500	31200	1815	3131	0.08	0.10		
1972	2529	23337	1224	260			27350							**27350**		29900	47800	1224	2529	0.04	0.05		
1973	3614	18587	254	143			22598							**22598**		30800	38900	254	3614	0.01	0.09		
1974	5894	27489	3194	1116	945		38638							**38638**		21199	39608	3194	5894	0.15	0.15		
1975	4790	18244	813	630	26		24503							**24503**		25645	29752	813	4790	0.03	0.16		
1976	3205	16401	651	989			21246							**21246**		20466	22227	651	3205	0.03	0.14		
1977	3331	11498	85	500			15414							**15414**		4164	23436	85	3331	0.02	0.14		
1978	2371	8432	174	98			11075							**11075**		4201	27717	174	2371	0.04	0.09		
1979	1805	10078	455				12338							**12338**		3596	27454	455	1805	0.13	0.07		
1980	1340	9272	1				10613							**10613**		6126	36917	1	1340	0.00	0.04		
1981	283	4094					4377							**4377**		6952	29926			0.00	0.00		
1982	300	3375				1180	4855							**4855**									
1983	860	3025	48				3933							**3933**						0.06	0.11		
1984	1084	2982					4066							**4066**									
																Estimates of maximum likely catch for VIIa(N) incl. of French and ROI catches							
Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**16**		**17**			**18**		**19**

No.																							
	ICES table						British Isles catches							**CATCH IN ASSESS-MENT**		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1985	1000	4077				4110	9187							**9187**									
1986	1640	4376				1424	7440							**7440**									
1987	1200	3290				1333	5823							**5823**									
1988	2579	7593					10172							**10172**									
1989	1430	3532					4962							**4962**									
1990	1699	4613					6312							**6312**									
1991	80	4318					4398							**4398**									
1992	406	4864					5270							**5270**									
1993	0	4408					4408							**4408**									
1994	0	4828					4828							**4828**									
1995	0	5076					5076							**5076**									
1996	100	5180				22	5302							**5302**									
1997	0	6651					6651							**6651**									
1998	0	4905					4905							**4905**									
1999	0	4127					4127							**4127**									
2000	0	2002					2002							**2002**									
2001	862	4599					5461							**5461**									
2002	286	2107					2393							**2393**									
2003	0	2399					2399							**2399**									
2004	749	1782					2531							**2531**									
2005	1153	3234					4387							**4387**									
2006	581	3821					4402							**4402**									
2007	0	4629					4629							**4629**									
2008	0	4895					4895							**4895**									
2009	0	4594					4594							**4594**									
2010	0	4894					4894							**4894**									

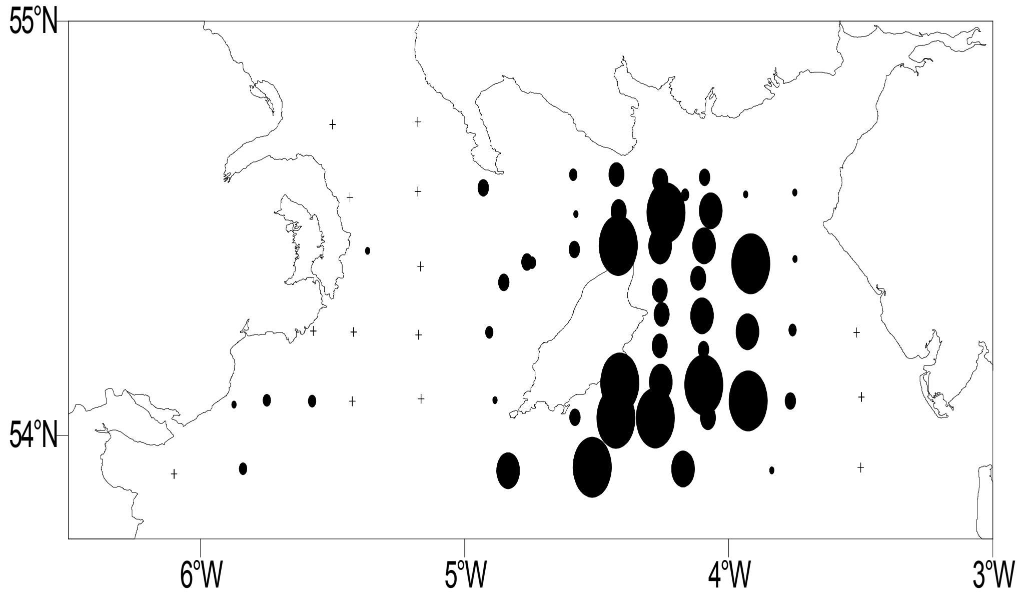
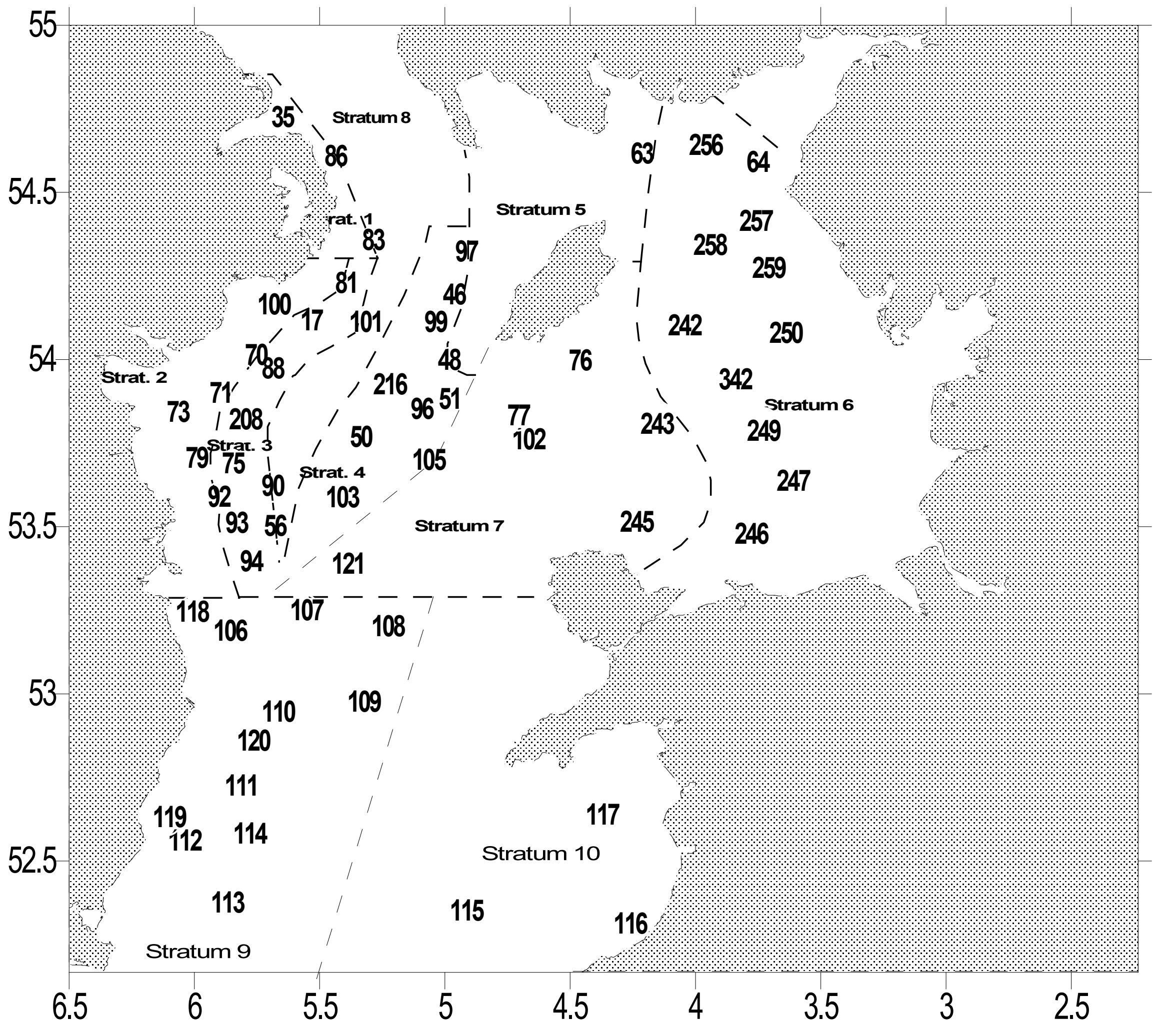


Figure 1. Sampling stations for larvae in the North Irish Sea (NINEL). Sampling is undertaken in November each year.



Key to strata:
1. Irish Coast (N), <100m, Mixed sediments
2. Irish Coast, < 50m, sand and finer sediments
3. Irish Coast, 50 - 100m, Muddy sediments
4. W and SW Isle of Man, 50 - 100m, mud and muddy sand
5. N Isle of Man, <50m, gravel sediments
6. Eastern Irish Sea, <50m, sand and finer sediments
7. S. Isle of Man, <100m, gravel sediments
8. Deep western channel and North Channel >100m
9. St George's Channel west; sandy/mixed sediments; <100m
10. St George's Channel east; sandy/mixed sediments; <100m

Figure 2. Standard station positions for DARD groundfish survey of the Irish Sea in March and October. Boundaries of survey strata are shown. Indices for the "Western Irish Sea" use data from strata 2 - 4. Indices for the "Eastern Irish Sea" use data from stratum 6 only (few juvenile herring are found in stratum 7). (Note different stratification to Fig. 1.). New stations fished in the St Georges Channel (strata 9 and 10) since October 2001 are not included in the survey indices. Stratum 5 (1 station only in recent years) is also excluded from the index. There are no stations in stratum 8 due to difficult trawling conditions for the gear used in the survey. Station 121 in stratum 7 has been fished only once and is excluded from the index.

Table 3. Irish Sea Herring Division VIIa(N). Mean weights-at-age in the catch.

Year	Weights-at-age (g) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	87	125	157	186	202	209	222	258
1986	68	143	167	188	215	229	239	254
1987	58	130	160	175	194	210	218	229
1988	70	124	160	170	180	198	212	232
1989	81	128	155	174	184	195	205	218
1990	77	135	163	175	188	196	207	217
1991	70	121	153	167	180	189	195	214
1992	61	111	136	151	159	171	179	191
1993	88	126	157	171	183	191	198	214
1994	73	126	154	174	181	190	203	214
1995	72	120	147	168	180	185	197	212
1996	67	116	148	162	177	199	200	214
1997	64	118	146	165	176	188	204	216
1998	80	123	148	163	181	177	188	222
1999	69	120	145	167	176	188	190	210
2000	64	120	148	168	188	204	200	213
2001	67	106	139	156	168	185	198	205
2002	85	113	144	167	180	184	191	217
2003*	81	116	136	160	167	172	186	199
2004	73	107	130	157	165	187	200	205
2005	67	103	136	156	166	180	191	209
2006	64	105	131	149	164	177	184	211
2007	67	112	135	158	173	183	199	227
2008	71	110	135	153	156	182	196	206
2009*	68	107	133	155	165	182	194	212
2010	53	106	131	145	153	164	175	172

*** Average for the preceding five years**

Table 4. Irish Sea Herring Division VIIa(N). Mean length-at-age in the catch.

Year	Lengths-at-age (cm) Age (rings)							
	1	2	3	4	5	6	7	8+
1985	22.1	24.3	26.1	27.6	28.3	28.6	29.5	30.1
1986	19.7	24.3	25.8	26.9	28.0	28.8	28.8	29.8
1987	20.0	24.1	26.3	27.3	28.0	29.2	29.4	30.1
1988	20.2	23.5	25.7	26.3	27.2	27.7	28.7	29.6
1989	20.9	23.8	25.8	26.8	27.8	28.2	28.0	29.5
1990	20.1	24.2	25.6	26.2	27.7	28.3	28.3	29.0
1991	20.5	23.8	25.4	26.1	26.8	27.3	27.7	28.7
1992	19.0	23.7	25.3	26.2	26.7	27.2	27.9	29.4
1993	21.6	24.1	25.9	26.7	27.2	27.6	28.0	28.7
1994	20.1	23.9	25.5	26.5	27.0	27.4	27.9	28.4
1995	20.4	23.6	25.2	26.3	26.8	27.0	27.6	28.3
1996	19.8	23.5	25.3	26.0	26.6	27.6	27.6	28.2
1997	19.6	23.6	25.1	26.0	26.5	27.1	27.7	28.2
1998	20.8	23.8	25.2	26.1	27.0	26.8	27.2	28.7
1999	19.8	23.6	25.0	26.1	26.5	27.1	27.2	28.0
2000	19.7	23.8	25.3	26.3	27.1	27.7	27.7	28.1
2001	20.0	22.9	24.8	25.7	26.2	26.9	27.5	27.8
2002	21.1	23.1	24.8	26.0	26.6	26.7	27.0	28.1
2003	21.1	23.7	25.0	26.5	26.9	27.1	27.8	28.5
2004	20.7	23.1	24.6	25.8	26.1	27.1	27.6	28.3
2005	20.0	22.6	24.5	25.5	26.0	26.6	27.1	27.8
2006	19.5	22.7	24.3	25.3	26.0	26.6	26.9	28.0
2007	20.1	23.0	24.1	25.1	25.8	26.2	26.7	27.8
2008	20.0	22.7	24.1	25.0	25.2	26.3	26.9	27.3
2009*	-	-	-	-	-	-	-	-
2010	19.2	23.2	24.3	25.0	25.2	25.8	26.3	26.1

***no commercial samples available**

Table 5. Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2010. Numbers of fish in thousands.

Length	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
14															
14.5															
15			95												
15.5			169							10					
16	6		343			21	21	17		19	12	9			
16.5	6	2	275			55	51	94		53	49	27			13
17	50	1	779		84	139	127	281	26	97	67	53			25
17.5	7	4	1106		59	148	200	525	30	82	97	105			84
18	224	31	1263		69	300	173	1022	123	145	115	229			102
18.5	165	56	1662		89	280	415	1066	206	135	134	240	36		114
19	656	168	1767	39	226	310	554	1720	317	234	164	385	18		203
19.5	318	174	1189	75	241	305	652	1263	277	82	97	439	0	29	269
20	791	454	1268	75	253	326	749	1366	427	218	109	523	0	73	368
20.5	472	341	705	57	270	404	867	1029	297	242	85	608	18	215	444
21	735	469	705	130	400	468	886	1510	522	449	115	1086	307	272	862
21.5	447	296	597	263	308	782	1258	1192	549	362	138	1201	433	290	1007
22	935	438	664	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495
22.5	581	782	927	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140
23	2400	1790	1653	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089
23.5	1908	1974	1156	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214
24	3474	2842	1575	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054
24.5	2818	2311	2412	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269
25	4803	2734	2792	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749
25.5	3688	2596	3268	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206
26	4845	3278	3865	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823
26.5	3015	2862	3908	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587
27	3014	2412	3389	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510
27.5	1134	1449	2203	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383
28	993	922	1440	1538	1294	834	906	638	1235	276	212	496	162	726	198
28.5	582	423	569	944	900	123	564	440	170	169	58	179	108	569	51
29	302	293	278	473	417	248	210	280	111	61	42	10	36	163	
29.5	144	129	96	160	165	56	79	59	92		12	0	36	129	
30	146	82	70	83	9	40	32	8	84		6	9		43	
30.5	57	36	36	15	27	5	0	5	3					43	
31	54	12	2	4		1	2							43	
31.5	31	3													
32	29														
32.5															
33															
33.5															
34															

Table 5 (continued). Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2010. Numbers of fish in thousands.

Length	2005	2006	2007	2008	2009*	2010
14					-	
14.5					-	
15					-	
15.5			16		-	93
16		2			-	107
16.5	1	44	33	1	-	487
17	39	140	69	3	-	764
17.5	117	211	286	11	-	1155
18	291	586	852	34	-	1574
18.5	521	726	2088	64	-	1405
19	758	895	2979	85	-	866
19.5	933	1246	3527	108	-	673
20	943	984	3516	100	-	787
20.5	923	1443	2852	133	-	888
21	1256	1521	3451	192	-	1470
21.5	1380	1621	2929	217	-	1758
22	1361	2748	3821	271	-	2363
22.5	1448	3629	3503	229	-	3362
23	1035	4358	4196	322	-	4530
23.5	1256	2920	3697	264	-	5232
24	1276	3679	3178	259	-	4559
24.5	1083	2431	2136	204	-	3616
25	1086	3438	1503	148	-	3083
25.5	584	2198	952	114	-	2582
26	438	1714	643	78	-	1777
26.5	203	605	330	42	-	950
27	165	445	147	23	-	460
27.5	60	155	72	10	-	216
28	45	104	33	12	-	9
28.5	18	9	26	1	-	
29	12	46			-	9
29.5			7		-	
30					-	
30.5					-	
31					-	
31.5					-	
32					-	
32.5					-	
33					-	
33.5					-	
34					-	

***no commercial samples available.**

Table 6. Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(a) 0-ring herring: October survey

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N. obs	SE
1991	54	34	22						
1992	210	31	99	240	8	149	177	46	68
1993	633	26	331	498	10	270	412	44	155
1994	548	26	159	8	7	5	194	41	55
1995	67	22	23	35	9	18	37	35	11
1996	90	26	58	131	9	79	117	42	50
1997	281	26	192	68	9	42	138	43	70
1998	980	26	417	12	9	10	347	43	144
1999	389	26	271	90	9	29	186	43	96
2000	202	24	144	367	9	190	212	38	89
2001	553	26	244	236	11	104	284	45	93
2002	132	26	84	18	11	10	63	45	31
2003	1203	26	855	75	11	47	446	45	296
2004	838	26	292	447	11	191	469	45	125
2005	1516	26	1036	256	11	152	627	45	363
2006	4677	26	2190	2140	11	829	2468	45	822
2007	215	26	82	263	11	114	177	45	52
2008	1075	26	436	540	11	505	599	45	247
2009	3073	26	1803	8908	11	4186	4499	45	1730
2010	2123	26	974	6071	11	2844	3075	45	1147

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(b) 1-ring herring: March Surveys.

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1992	392	20	198	115	10	73	190	34	77
1993	1755	27	620	175	10	66	681	45	216
1994	2472	25	1852	106	9	51	923	39	641
1995	1299	26	679	73	8	32	480	42	235
1996	1055	22	638	285	9	164	487	39	230
1997	1473	26	382	260	9	96	612	43	137
1998	3953	26	1331	250	9	184	1472	43	466
1999	5845	26	1860	736	9	321	2308	42	655
2000	2303	26	853	546	10	217	1009	44	306
2001	3518	26	916	1265	11	531	1763	45	381
2002[a]	2255	25	845	185	11	84	852	44	294
2002[b]	7870	26	5667	185	11	84	2794	45	1960
2003	2103	26	876	896	11	604	1079	45	382
2004	6611	25	2726	491	11	163	2486	44	945
2005	7274	26	3097	1240	8	375	3001	42	1121
2006	4249	26	1687	2630	11	813	2496	45	662
2007	9340	26	3051	631	11	388	3480	45	1066
2008	2310	26	568	404	11	141	956	45	204
2009	11738	26	2853	1490	11	664	4638	45	1357
2010	2327	26	525	6304	11	3782	3272	45	1470

a. Unusually large catch removed, b. unusually large catch retained.

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles.).

(c) 1-ring herring: October Surveys

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1991	102	34	34	n/a	n/a	n/a	n/a	n/a	n/a
1992	36	31	18	20	8	11	21	46	8
1993	122	26	66	4	10	2	44	44	23
1994	490	26	137	17	6	10	176	40	47
1995	153	22	61	3	9	1	55	35	21
1996	30	26	13	2	9	1	11	42	5
1997	612	26	369	0.2	9	0.2	302	43	156
1998	39	26	15	13	9	10	53	43	35
1999	81	26	41	104	9	95	74	43	40
2000	455	24	250	74	9	52	579	38	403
2001	1412	26	641	5	11	3	513	45	223
2002	370	26	111	4	11	2	291	45	158
2003	314	26	143	410	11	350	267	45	144
2004	710	26	298	103	11	74	299	45	108
2005	3217	25	1467	18	11	12	1121	44	507
2006	1458	26	669	40	11	18	523	45	231
2007	6194	26	3169	1569	11	1379	2758	45	1218
2008	1922	26	1207	1930	11	1210	1410	45	626
2009	3169	26	2115	112	11	55	1146	45	732
2010	2318	26	1115	173	11	72	935	45	391

Table 7. Irish Sea Herring Division VIIa (N). Larval production (10^{11}) indices for the Manx component.

Year	Douglas Bank		
		Isle of Man	
	Date	Production	SE
1989	26 Oct	3.39	1.54
1990	19 Oct	1.92	0.78
1991	15 Oct	1.56	0.73
1992	16 Oct	15.64	2.32
1993	19 Oct	4.81	0.77
1994	13 Oct	7.26	2.26
1995	19 Oct	1.58	1.68
1996			
1997	15 Oct	5.59	1.25
1998	6 Nov	2.27	1.43
1999	25 Oct	3.87	0.88

Annex 09 – 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:	21 March 2010
Authors	E. Torstensen, L. W. Clausen, C. Frisk, C. Kvamme, M. Payne

A. General

A.1. Stock definition

Sprat (*Sprattus sprattus* Linnaeus 1758) in ICES area IV (North Sea).

Sprat in the North Sea is treated as a single management unit. However, questions have recently been raised about the geographic distribution of this stock and its interaction with neighbouring stocks: in particular, large abundances have been observed close to the southern boundaries of the stock (ICES HAWG 2009). The apparent overlap between North Sea sprat and English Channel sprat is very strong, whereas the overlap between North Sea sprat and Kattegat sprat is not as strong and varies between years.

A detailed genetic study has been performed to analyze the population structure of sprat over large ranges, from scales of seas to regions (Limborg *et al*., 2009). The study was performed with individuals from the Baltic Sea, Danish waters, Kattegat, North Sea, Celtic Sea and Adriatic Sea (Figure 2). The analysis partitioned the samples into groups based upon their genetic similarity (Figure 3). The Adriatic Sea population exhibited a large divergence from all other samples. The samples from the North Sea, Celtic Sea and Kattegat were separated from the Baltic Sea samples, with the Belt Sea (Kattegat) sample in between. The authors concluded that there exists a barrier to gene flow from the North Sea to the Baltic Sea, with the Belt Sea being a transition zone. This analysis does not support the separation of sprat into three stocks that is currently employed by ICES (i.e. subdivision VIId (English Channel), subdivision IIIa (Skagerrak/Kattegat) and division IV (North Sea). However, it is also important to note that this work is based on neutral markers, which are relatively insensitive. Further research on this issue is required.

A.2. Fishery

The majority of the sprat landings are taken in the Danish industrial small-meshed trawl fishery. The Norwegian sprat fishery is mainly carried out by purse seiners. Both landings are used for reduction to fish meal and fish oil. In the last decade, also the UK occasionally lands small amounts of sprat.

The commercial catches are sampled for biological parameters. In the most recent years Denmark, Norway and Scotland have sampled their sprat catches. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001, requiring 1 sample per 2000 tonnes.

In 2007 a new quota regulation (IOK) for the Danish vessels was implemented and realized from 2008 and onwards. The regulation gives quotas to the vessel, but these can be traded or sold. A large number of small vessels have been taken out of the fishery and their quotas sold to larger vessels. Today the Danish fleet is therefore dominated by large vessels.

There exists no information about discards and unallocated catches, but it is not expected to be a problem for this fishery.

Historically, the by-catch of juvenile herring in the industrial sprat fisheries has been problematically high (Figure 4). To reduce this by-catch, an area closed to the sprat fishery (the "sprat box") was established off the western coast of Denmark (from Vadehavet to Hanstholm) in October 1984 (Hoffman *et al* 2004). It was estimated that about 90% of the by-catches of juvenile herring in the industrial fisheries was taken within this box, and the intention of the sprat box was thus to reduce this juvenile herring by-catch.

Despite the establishment of this sprat box, the juvenile herring by-catches increased in the early 1990's, partly because of larger incoming year classes having a wider distribution (Hoffman *et al* 2004). It was concluded that there was no clear connection between the sprat box and the decrease in herring by-catches in the period 1984-1996. The sprat box is still in operation (Fiskeridirektoratet 2007).

After 1996, the by-catch mortality of juvenile herring was reduced (ICES HAWG 2009). This coincided with the introduction of a by-catch limit on herring in the industrial fisheries and improvements in the catch sampling.

Evaluation of the quality of the catch data

Due to large but unknown by-catches of juvenile North Sea herring in the industrial sprat fisheries prior to 1996 (Figure 4), sprat landings are only considered reliable from 1996 onwards. The reduction in by-catches of juvenile herring in 1996 coincides with the introduction of a by-catch limit on herring in the industrial fisheries, and improvements in catch-sampling.

The by-catches in the Danish industrial small-meshed trawl fishery for sprat (1998-2009) have been estimated from samples of the commercial catches. The major by-catches are herring (4.2-11.1% in weight), horse mackerel (0.0-1.6%), whiting (0.2-1.5%), haddock (0.0-0.1%), mackerel (0.2-2.2%), cod (<0.0%), sandeel (0.0-10.0%) and other (0.3-2.4%). Although these catches are relatively small by weight, they are often juveniles, and therefore can represent a significant number of individuals.

There exists no information about the by-catches of the other fleets.

A.3. Ecosystem aspects

Many predators in the North Sea feed extensively on sprat, including predatory fish, marine mammals and seabirds. Its role in the ecosystem has been evaluated in the 1981 and 1991 stomach sampling programs (ICES 1989, ICES 1997). Predation was strongest from whiting and mackerel (ICES SGMSNS 2006, ICES 1997). Predation from cod on sprat have been suggested to increase after the last sampling campaign in 1991 as sandeel and Norway pout stocks have decreased (ICES 1997).

Sprat can be very important for breeding seabirds in southern areas of the North Sea (Durinck *et al* 1991, Wilson *et al*. 2004). Estimates from 1985 have shown that the total seabird consumption in the North Sea could be on the same level as the fisheries

(Hunt and Furness (ed.) 1996). In winter, when sandeel are not available to most seabirds (because they are buried in the sand) many of the seabirds that overwinter in the North Sea take sprat as part of their diet. However, it is uncertain whether sprat abundance in the North Sea will affect seabird breeding success or overwinter survival.

Attempts have previously been made to include sprat in the MSVPA in the North Sea (ICES SGMSNS 2005). Recently, as no single species assessment on North Sea sprat has been performed, sprat was not included explicitly in the MSVPA. Sprat was therefore treated in the recent model as 'other food', and is thus included in the model indirectly as a prey organism. Unfortunately this method does not allow for an estimate on the predation mortality on sprat (ICES WGSAM 2008). Historically, MSVPA runs have included sprat by which it was found that the predation mortality on the species exceeds the fishing mortality (ICES SGMSNS 2005).

B. Data

B.1. Commercial catch

The majority of the sprat landings are taken in the Danish industrial small-meshed trawl fishery. The Norwegian sprat fishery is mainly carried out by purse seiners. Both landings are used for reduction to fish meal and fish oil. In the last decade, also the UK occasionally lands small amounts of sprat.

The commercial catches are sampled for biological parameters. In the most recent years Denmark, Norway and Scotland have sampled their sprat catches. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001, requiring 1 sample per 2000 tonnes.

There exists no information about discards and unallocated catches, but it is not expected to be a problem for this fishery.

Due to large but unknown by-catches of juvenile North Sea herring in the industrial sprat fisheries prior to 1996 (Figure 4), sprat landings are only considered reliable from 1996 onwards. The reduction in by-catches of juvenile herring in 1996 coincides with the introduction of a by-catch limit on herring in the industrial fisheries, and improvements in catch-sampling.

B.2. Biological

Sprat in the North Sea has a prolonged spawning season ranging from early spring to the late autumn, and is triggered by the water temperature (Alheit *et al*., 1987; Alshulth 1988a; Wahl and Alheit 1988). Sprat is a batch spawner, producing up to 10 batches in one spawning season and 100-400 eggs per gram of body weight (Alheit 1987; George 1987). The majority of the sprat in age groups 1+ in the summer acoustic surveys in June-July are shown to be spawners (ICES WGIPS 2010).

Disagreements in the age reading in North Sea sprat have been reported (*e.g*. Torstensen *et al*. 2004). The problems arise due to interpretation of winter rings. False winter rings can be set in periods of bad feeding conditions/starvation and due to rapid changes in temperature (E. Torstensen, personal communication 2009). False winter rings also occur in other species and areas, e.g. Baltic sprat (Kornilovs (edi.) 2006), herring (ICES WKARGH 2008) and sandeel (Clausen *et al*. 2006). Furthermore, the interpretation of the first winter ring can be difficult, as sprat can spawn until late autumn and larvae from these late spawning will likely not set down a winter ring during their first winter (Torstensen *et al* 2004). The absence of such rings can lead to errors in age determination, as these individuals cannot be distinguished from the individuals born the following year. Age readings in North Sea sprat were estimated to have a high coefficient of variance (CV) of 28% (Torstensen *et al*. 2004).

Mean weight-at-age in the North Sea sprat is variable over time (ICES HAWG 2009). This may be ascribed due to both the aging problems previously described, and also the prolonged spawning period, by which the individuals can have very different birthdates and thus also different growth conditions, i.e temperature and nutrition available. The mean weight-at-age in the catches for age 1 is approximately 4 g, at age 2 app. 10 g, at age 3 app. 11 g, and at age 4+ app. 14 g (se Sec 8-North Sea sprat in ICES HAWG 2010).

B.3. Surveys

Three surveys cover this stock. Two International Bottom Trawl Surveys (IBTS) cover the stock in the first and third quarters of the year, respectively. Additionally, the herring acoustic survey covers the same area during June-July.

The appropriateness and suitability of these surveys for use in the assessment of the North Sea sprat stock, was examined by the WKSHORT (2009).

B.3.1 International Bottom Trawl Surveys (IBTS)

Background

The North-Sea International Bottom Trawl Surveys started as a coordinated international survey in the mid-1960s as a survey directed towards juvenile herring. The gear used was standardised in 1977 to use the GOV trawl, but took time to be phased in. By 1983 all participating nations were using this gear, and the index can be considered consistent from this point onwards. A third-quarter North Sea IBTS survey using the same methodology was started in 1991 and can be considered consistent from its initiation. IBTS Surveys were also performed in the North Sea in the second and fourth quarters in the period 1991-1996, but are not considered further here (ICES 2006). More details on the survey are available from the manual (ICES 2004).

Suitability

The appropriateness of the IBTS survey for use as an estimate of the abundance of North Sea sprat was examined in a working document to the WKSHORT (Jansen *et al* 2009). Acoustic data collected during trawls performed as part of the IBTS were analysed, with focus on the vertical distribution. The relationship between the amount of sprat available in the water column (from acoustics) and the amount of sprat captured by the gear was found to be weak and highly variable in nature. The proportion of sprat in the water column that were in the bottom five metres was found to range widely between 0 and 100%, and also found to be a function of the time of day. The work therefore suggests that the IBTS survey, as it exists, may not be appropriate for use with sprat in the North Sea. However, further investigation, including the addition of further data points and comparison with results from other species (*e.g.* herring) are required before firm conclusions can be drawn.

Internal Consistency

Internal consistency analysis (Payne *et al* 2009 and references therein) was used to examine the ability of the IBTS survey to track the abundance of individual cohorts. This method involves plotting the log-abundance estimated by the survey at one age against the log-abundance of the same cohort in the following year: in cases where the total mortality is constant and the relative survey noise is low, this relationship should be linear. However, deviations from linearity may arise due to either high noise levels in the survey or variations in the total mortality experienced by the stock. The test is therefore asymmetric, in that a linear relationship is a strongly positive result, whilst the absence of a relationship does not automatically mean that the survey is of poor quality. Examination of the internal consistency can therefore be used as a measure (albeit biased) of the survey quality.

We find that the relationship between the abundance of successive ages in a cohort from the first quarter (Figure 5) and third quarter (Figure 6) surveys is extremely poor, and is dominated by noise. This noise may arise due to either the nature of the survey (e.g. survey design, variability in catchability) or variations in total mortality. In the absence of information regarding either fishing mortality (e.g. from a stock assessment) or natural mortality (e.g. from a multispecies model), it is not possible to separate these two sources of variability.

Confidence Intervals

Distribution of the IBTS indices are available from the ICES DATRAS database, following a bootstrapping procedure agreed upon in 2006 (ICES 2006). This data was analysed to extract key values characterising the distribution, including the confidence intervals for both IBTS Q1 (Figure 7) and Q3. Generally, the confidence intervals for the indices were found to be extremely broad. The median upper confidence limit is 250% greater than the value of the index estimated (although in some cases this can be as much as 4600% greater) and the median lower confidence limit is 40% less than the estimated index. The uncertainties are therefore much larger than the estimated dynamics of the stock and it is thus not possible to say, statistically, that the index value in one year is statistically different from another.

Composition of the Index

Catches of North Sea sprat in hauls in the IBTS survey can occasionally be extremely large; this phenomenon has previously been suggested as being important to the dynamics and uncertainty of IBTS survey indices (ICES HAWG 2007, ICES HAWG 2009). In order to examine this phenomenon more closely, the importance of each haul to the index was assessed by calculating the individual contribution of each haul to the total. These hauls were then ranked according to size and aggregated to produce an estimate of the cumulative contribution ranked by sized: in this manner, it is therefore possible to assess, for example, the proportional contribution of the largest 20 hauls in a given year. For all years in the both the IBTS Q1 (Figure 8) and Q3 (Figure 9), the 10 largest hauls contribute at least 35% of the survey index, and in some cases up to 85% of the index. The IBTS Q3 index appears to have more severe problems with large hauls than the Q1 index: in every year, the five largest hauls make up more than 50% of the index.

Alternative Analysis Methods

The method used by the ICES DATRAS database to calculate the IBTS indices is relatively simplistic, essentially comprising a set of stratified means (i.e. the mean CPUE per statistical rectangle is averaged over the entire North Sea). As an attempt to resolve problems caused by the presence of large hauls in the calculation of the index, a Log-Gaussian Cox Process (LGCP) was fitted to the individual haul data (Kristensen *et al* 2006, Kristensen 2009a, Kristensen and Lewy 2009). The LGCP model is a statistical model that can be used to account for the statistical nature of the catch process, including correlations between size classes, spatial correlation and between years. The model was fitted in a simplified form, where only spatial correlations were included. Total CPUE of sprat, CPUE by age and CPUE by length class were all used as classification schemes and each fitted individually using the model.

Unfortunately, the LGCP model failed to fit the IBTS survey data adequately. Goodness of fit tests on the fitted model showed that a number of key assumptions in the model were frequently violated. Furthermore, the confidence intervals on the estimated abundances were extremely broad, in some cases spanning more than six orders of magnitude. It was therefore concluded that the model, as fitted, was in appropriate for the data set.

It is currently unclear as to why the LGCP model fails to fit the IBTS sprat data. A number of candidate explanations have been considered, including the high number of zero hauls and the extreme "boom-bust" nature of the catches. It is currently unclear whether this modelling framework is capable of dealing with the nature of the sprat catches in the IBTS survey: the ultimate appropriateness of this method should be considered carefully before further work is performed.

Conclusions

The IBTS Q1 and Q3 surveys are the best time series of data available for use in characterising the abundance of sprat in the North Sea, covering the years from 1984 and 1991 onwards respectively: for comparison, the time series of catches begins in 1996 and the acoustic survey (see below) in 2004. However, the survey is greatly impacted by the presence of extremely large individual hauls that can make up 85% or more of the index in some years. The problem is compounded by the manner in which the ICES DATRAS database calculates the indices – the use of simple arithmetic means here does not account for the extremely high variability of sprat catches in the IBTS survey and propagates these problems through to the index value. The extremely broad confidence intervals and the lack of internal consistency can also be understood as consequences of this problem. Variability in the catchability of sprat in the IBTS's GOV gear caused by the time of day and the pelagic nature of sprat may contribute to this problem to a degree but seem unlikely to explain the order-of-magnitude variability observed. Instead, the highly schooling nature of sprat is likely to be the most important underlying cause: if the gear encounters and captures a high-density school of sprat, an extremely large haul could be produced.

Given the potential importance of the IBTS indices for the assessment of this stock, further investigations are warranted. The current analysis method is extremely simplistic and appears to be the main source of the problem. Future investigations should focus on attempting to analyse this large and valuable source of information in a manner that can account for both the large number of zero hauls and also the extremely large individual hauls. Qualitative indicators, such as distribution area, presence/absence metrics, and the frequency of large hauls may also be of use in an advice context.

B.3.2. Herring Acoustic Survey (HERAS)

Background

The Herring Acoustic Survey is a summer acoustic survey that has been performed by an international consortium since the 1980s. Sprat has been reported as a separate species in this survey from 1996 onwards. However, as the survey is targeted towards herring, which are generally in the northern half of the North Sea during summer, coverage in the southern-half has received less attention. The area covered was expanded progressively over time, and by 2004 covered the majority of the stock, reaching 52°N (the eastern entrance to the English Channel) and all of the way into the German Bight (ICES PGHERS 2005). The coverage of this survey has remained relatively unchanged since 2004 (*e.g.* ICES PGIPS 2009) and we consider the survey from this point and onwards.

Suitability

In theory, the herring acoustic survey should be better suited for the estimation of sprat abundance than the bottom trawl IBTS survey, given that it integrates over the entire water column and is thus less susceptible to changes in vertical distribution and the presence of large schools.

However, there are a number of difficulties with the acoustic estimation of sprat that must be considered. Each survey report since 2004 has noted that the survey does not appear to reach the southern boundary of the stock, with there being significant concentrations of sprat at or close to this limit. Failing to reach the southern boundary line would lead to an underestimation of the stock size and may increase the interannual variability of the estimate. Similar observations have also been obtained from the IBTS survey, suggesting that the population may continue into the English Channel and subdivision VIId (ICES HAWG 2009; see also section 6.3).

The acoustic signatures of herring and sprat are also very similar and make the separation of these two species challenging. In the 2005 survey, an area containing large amounts of sprat was covered by two of the vessels, allowing a direct comparison of the estimated abundances. Unfortunately, the results varied widely, suggesting that the precision of the total abundance estimate may be poor (ICES PGHERS 2006).

Finally, the time series of acoustic estimates is short, and may not be of sufficient length for use in a stock assessment.

Internal Consistency

The internal consistency analysis employed above was also employed for the HERAS estimates of sprat abundance (Figure 10). The coefficients of determination for the relationship between the abundance at age for each cohort were appreciably better than those seen for the IBTS surveys, and are comparable to those used in other assessments (*e.g.* western Baltic spring-spawning herring (Payne *et al* 2009)). However, the length of the time series is also extremely short (four pairs of observations), and there is therefore insufficient information to draw meaningful conclusions. Further data points in the time series would be beneficial to understanding the suitability of this survey.

Confidence Intervals

There are currently no confidence intervals available for the estimated acoustic abundances. Future versions of the FISHFRAME database used to estimate the abundances from the raw acoustic data are intended to include the estimation of uncertainties (T. Jansen, personal communication 2009).

Conclusions

The herring acoustic survey shows potential as an estimate of the abundance of sprat in the North Sea. However, the current time series is too short for use, and further data points are required before its potential can be fully assessed. Furthermore, problems regarding the acoustic identification of sprat and herring, and the southern boundary of the stock may severely limit the applicability of this survey: resolving these issues should be considered a high priority.

B.4. Commercial CPUE

None available.

B.5. Other relevant data

C. Assessment methodology

No assessment is currently available for this stock.

D. Short-Term Projection

No projections are performed.

E. Medium-Term Projections

No projections are performed.

F. Long-Term Projections

No projections are performed.

G. Biological Reference Points

No reference points are available.

H. Other Issues

None.

I. References

Alheit, J. 1987. Variation of batch fecundity of sprat, Sprattus sprattus, during spawning season. ICES CM 1987/H:44.

Alheit, J., Wahl, E., and Cibangir, B. 1987. Distribution, abundance, development rates, production and mortality of sprat eggs. ICES CM 1987/H:45.

Alshult, S. 1988. Seasonal variations in length-frequency and birthdate distribution of juvenile sprat (Sprattus sprattus). ICES CM 1988/H:44.

Bailey, R.S. 1980. Problems in the management of short-lived pelagic fish as exemplified by North Sea sprat. Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer 177: 477-488.

Clausen L.W., Davis C.G. and Hansen S. (2006). Report of the sandeel otolith ageing workshop.

Durinck J., Skov H. and Danielsen F. 1991. The winter food of guillemots Uria-aalge in the Skagerrak. Dansk ornitologisk forenings tidsskrift 85: 145-150.

Fiskeridirektoratet 2007. Fiskeridirektoratet – Årsrapport 2006. ISBN: 87-89443-23-3.

George, M.R. 1987. Ovarian maturation cycle of sprat, Sprattus sprattus. ICES CM 1987/H:47.

Hoffman E, Dolmer P, Nordberg E, Blanner P 2004. Beskyttede havområder i Norden. TemaNord 2004: 543.

Hunt G.L. and Furness R.W. 1996. Seabird/fish interactions, with particular reference to seabirds in the North Sea. ICES cooperative research report no. 216.

ICES 1989. Database report of the stomach sampling project 1981. Cooperative research report no. 164.

ICES 1997. Database report of the stomach sampling project 1991. ICES cooperative research report no. 219.

ICES 2004. Manual for the international bottom trawl surveys. Revision VII.

ICES 2006. Report of the Workshop on Implementation in DATRAS of Confidence Limits Estimation of, 10-12 May 2006, ICES Headquaters, Copenhagen. 39 pp.

ICES HAWG. 2007. Report of the Herring Assessment Working Group South of 62 N (HAWG), 13 -22 March 2007, ICES Headquarters. ICES CM 2007/ACFM:11. 538pp.

ICES HAWG. 2009. Report of the Herring Assessment Working Group for the Area South of 62 N, 17-25 March 2009, ICES Headquarters, Copenhagen. 648 pp.

ICES PGHERS 2005. Report of the Planning Group on Herring Surveys (PGHERS), ICES CM 2005/G:04.

ICES PGHERS. 2006. Report of the Planning Group on Herring Surveys (PGHERS), 24-27 January. 2006, Rostock, Germany. ICES CM 2006/LRC:04. 239 pp.

ICES PGIPS. 2009. Report of the Planning Group of International Pelagic Surveys (PGIPS), 20–23 January 2009, Aberdeen, Scotland, UK. ICES CM 2009/LRC:02. 217 pp.

ICES SGMSNS 2005. Report of the study group on multi species assessment in the North Sea. ICES CM 2005/D:06.

ICES SGMSNS 2006. Report of the study group on multispecies assessment in the North Sea. ICES CM 2006/RMC:02.

ICES WGIPS 2010. Report of the Working Group for International Pelagic Surveys. ICES CM 2010/SSGESST:03.

ICES WGSAM 2008. Report of the working group on multispecies assessment methods. ICES CM 2008/RMC:06.

ICES WKARBH 2008. Report of the workshop on age reading of Baltic herring. ICES CM 2008/ACOM:36.

ICES WKSHORT 2009. Report of the Benchmark Workshop on Short-lived Species. ICES CM/ACOM:34.

Jansen, T., Verin, V., Payne, M. (2009) IBTS bottom trawl survey CPUE index for sprat (Sprattus sprattus) abundance estimation evaluated by simultaneous acoustic observations. Working document.

Kornilovs, G. (edi.) 2006. Sprat age reading workshop.

Kristensen, K. 2009. Statistical aspects of heterogeneous population statistics. PhD Thesis. University of Copenhagen.

Kristensen, K and Lewy, P. 2009. Incorporation of size, space and time correlation into a mode of single species fish stock dynamics. In preparation.

Kristensen, K. and Lewy, P. and Beyer, J.E. 2006. How to validate a length-based model of single-species fish stock dynamics. Canadian Journal of Fisheries and Aquatic Sciences, 63,2531—2542.

Limborg, M.T., Pedersen,J.S., Hemmer-Hamsen,J., Tomkiewicz,J., Bekkevold, D. 2009. Genetic population structure of European sprat (*Sprattus sprattus*): differentiation across a steep environmental gradient in a small pelagic fish. Marine ecology progress series 379: 213-224.

Payne, M. R., Clausen, L. W., and Mosegaard, H. 2009. Finding the signal in the noise: objective data-selection criteria improve the assessment of western Baltic spring-spawning herring. ICES Journal of Marine Science, 66: 1673–1680.

Torstensen E., Eltink, A.T.G.W., Casini, M., McCurdy, W.J., Clausen, L.W. 2004. Report of the Work Shop on age estimation of sprat.

Wahl, E., and Alheit, J. 1988. Changes in the distribution and abundance of sprat eggs during spawning season. ICES CM 1988/H:45.

Wilson L.J., Daunt F. And Wanless S. 2004. Self-feeding and chick provisioning diet differ in the Common Guillemot Uria aalge. Ardea 92: 197-207.

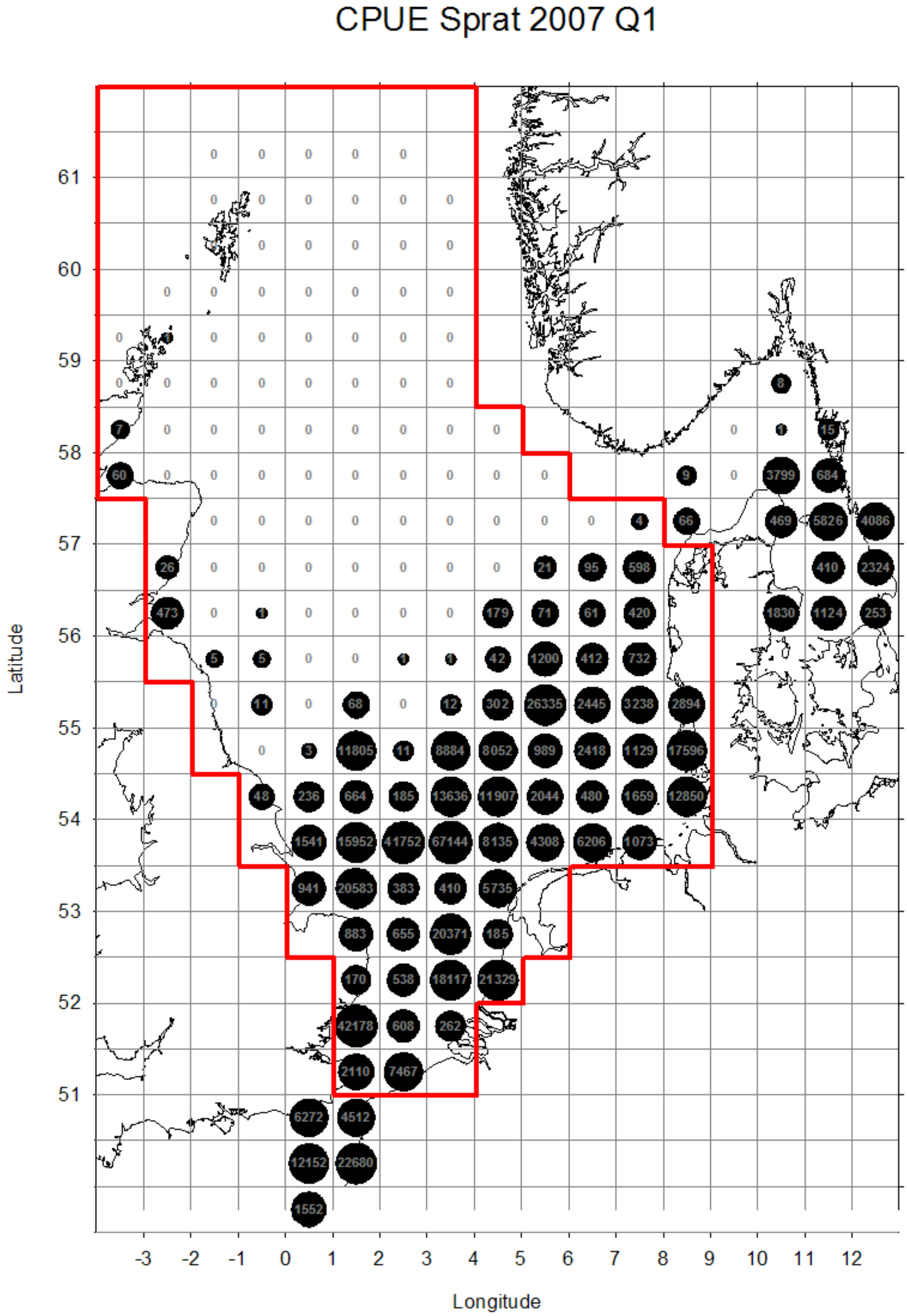


Figure 1. North Sea sprat. IBTS logCPUE from subareas; IV, IIIa, VII. The red area encircles the management area used for North Sea sprat. After ICES HAWG 2009.

Figure 2. North Sea sprat. Sampling stations (Limborg *et al*. 2009).

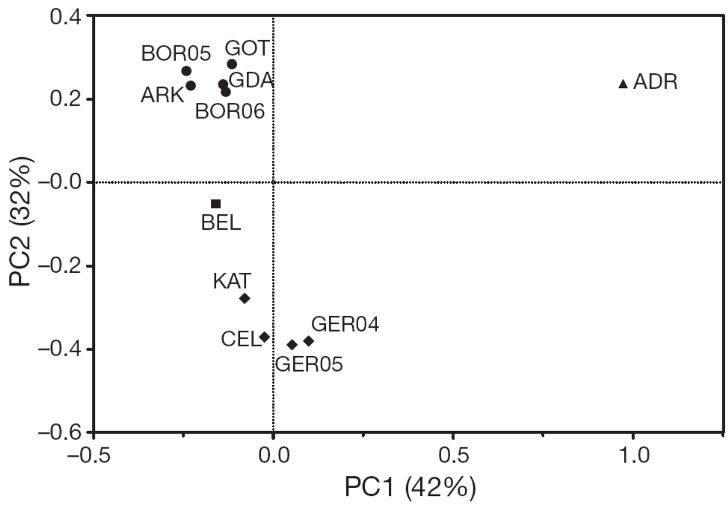


Figure 3. North Sea sprat. Plot of the generic variance in the samples. ADR = Adriatic Sea, ARK = Arkona Basin, BEL = Danish Belt, BOR = Bornholm Basin, CEL = Celtic Sea, GDA = Gdansk Deep, GER = German Bight (North Sea), GOT = Gotland Basin (Limborg *et al*. 2009).

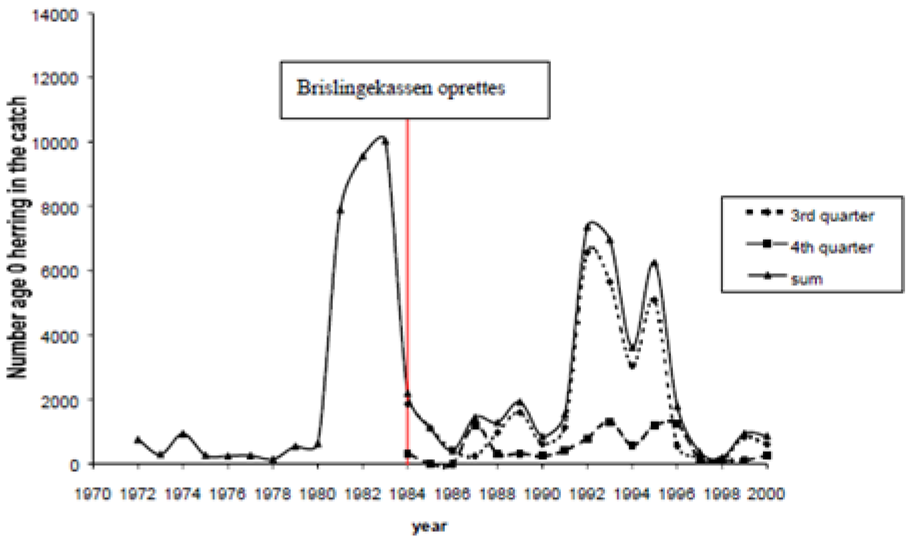


Figure 4: Catches of 0-group herring in the industrial fisheries in the central North Sea (IVb) in the 3rd and 4th quarter 1972-2000. The red line shows the time for establishing the sprat box. From Hoffman *et al* 2004.

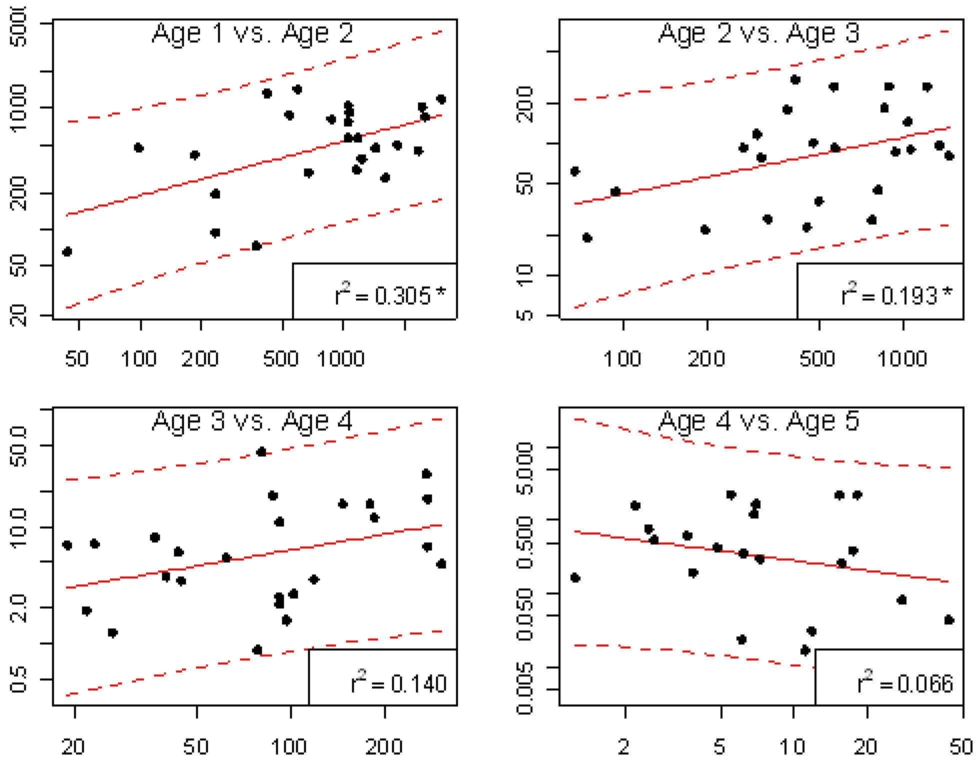


Figure 5 North Sea sprat. Internal consistency analysis from the IBTS Q1 survey. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (r^2) is given in the lower-right corner and is based upon log-transformed values. The title of each panel gives the ages plotted, with the first age plotted on the horizontal axis and the second on the vertical. The top two relationships are statistically significant at the 95% level, whilst the bottom two are not.

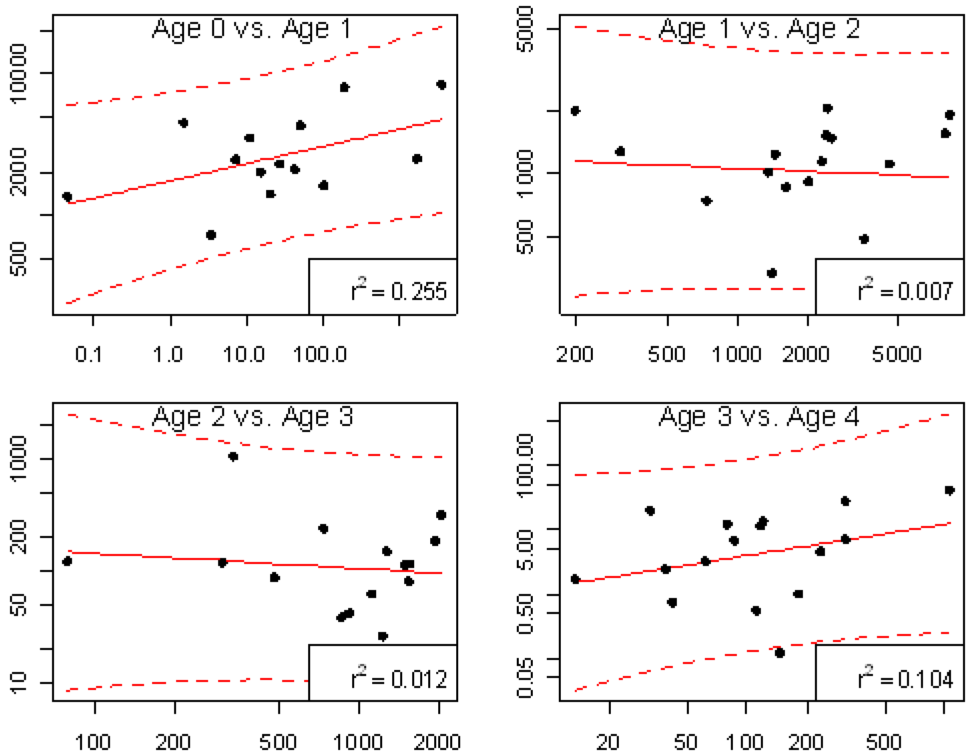


Figure 6. North Sea sprat. Internal consistency analysis from the IBTS Q3 survey. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (r^2) is given in the lower-right corner and is based upon log-transformed values. The title of each panel gives the ages plotted, with the first age plotted on the horizontal axis and the second on the vertical. No correlations are statistically significant at the 95% level.

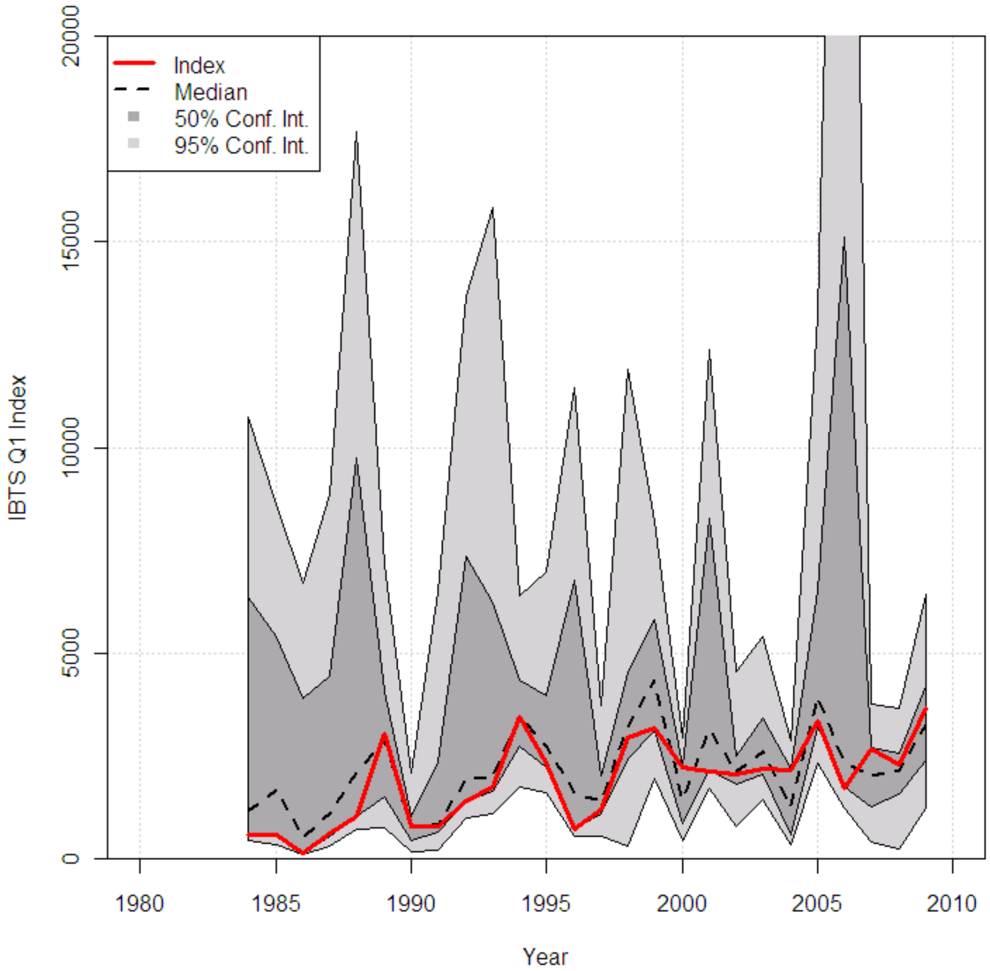


Figure 7. North Sea sprat. Distribution of index values for the IBTS Q1 index, as estimated by the DATRAS database. Values of both the mean index and median value are plotted, in addition to the 50% and 95% confidence bands.

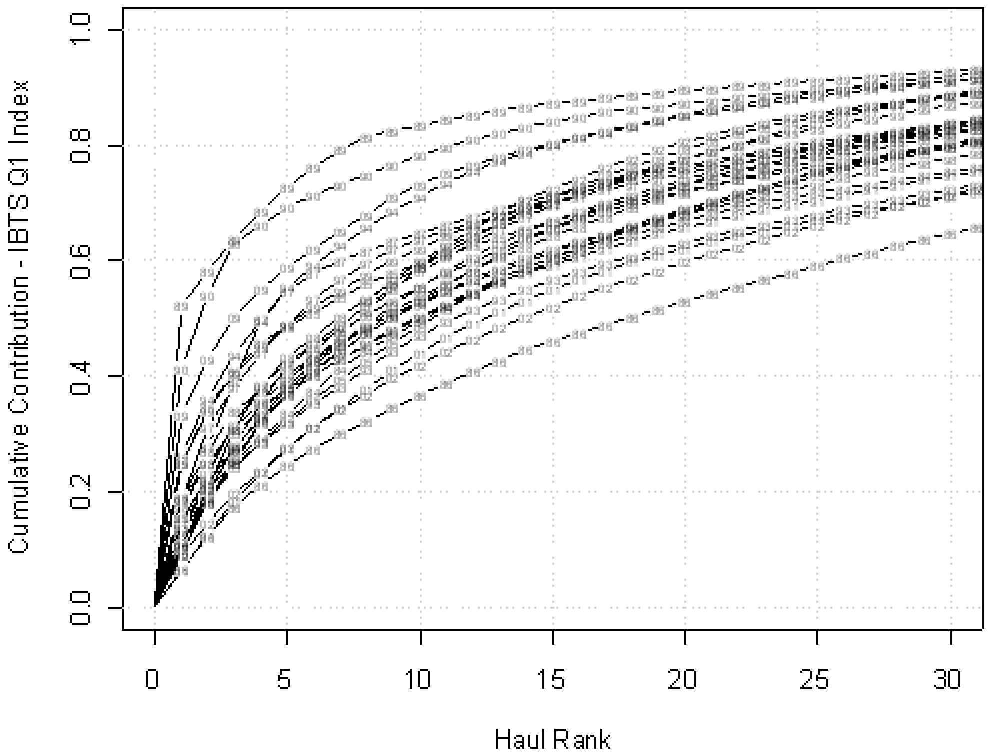


Figure 8. North Sea sprat. Cumulative distribution of the per-haul contribution to the total IBTS Q1 index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 30 largest hauls. Numbers on each line indicate the year for the survey.

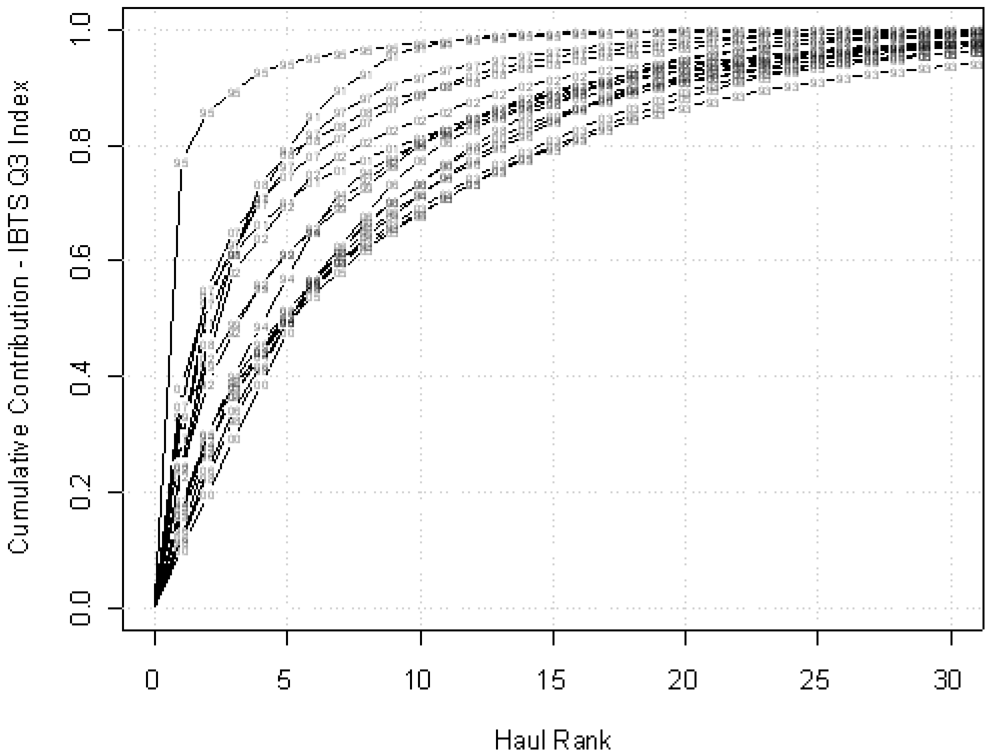


Figure 9. North Sea sprat. Cumulative distribution of the per-haul contribution to the total IBTS Q3 index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 30 largest hauls. Numbers on each line indicate the year for the survey.

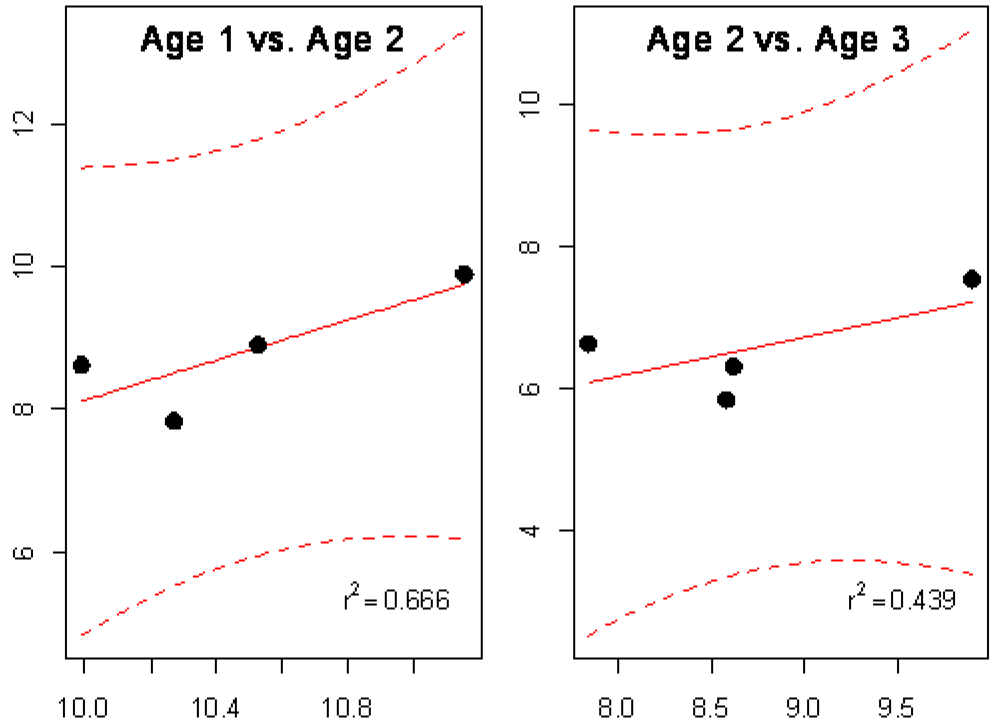


Figure 10. North Sea sprat. Internal consistency analysis from the herring acoustic survey, HERAS. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (r_2) is given in the lower-right corner and is based upon log-transformed values. The title of each panel gives the ages plotted, with the first age plotted on the horizontal axis and the second on the vertical. Neither correlation is statistically significant at the 95% level.

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:	22 March 2010
Authors:	Torstensen, E.; Clausen, L.W., Frisk, C., Kvamme, C.

A. General

A.1. Stock definition

Sprat distributed in ICES area IIIa is managed as one stock unit. Analyses of genetic population structure of European sprat (*Sprattus sprattus*) indicate a significant genetic differentiation in samples of sprat form Kattegat from neighbouring samples (North Sea and the Baltic) (Limborg *et al* 2009). This genetic differentiation mirror the gradient in mean surface salinity. This work is based on neutral markers, which are relatively insensitive. Further research on this issue is required.

A.2. Fishery

Sprat in IIIa are exploited by fleets from Denmark, Norway and Sweden. The Danish sprat fishery consists of trawlers using a < 32 mm mesh size and the landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches in the herring fishery using 32 mm mesh-size cod ends. The Swedish fishery is directed at herring with by-catches of sprat. The Swedish fleet is mainly pelagic trawlers and also a few purse seiners. The Norwegian sprat fishery in Division IIIa is an inshore purse seine fishery (vessels <27.5 m) for human consumption.

The majority of the landings are generally made by the Danish fleet. In 1997 a mixed-clupeoid fishery management regime was changed to a new agreement between the EU and Norway that resulted in a TAC for sprat as well as a 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. Norway has a general ban on sprat fishery from 1 January to 31 July.

There was a considerable increase in landings from about 10,000 t in 1993 to a peak of 96,000 t in 1994. The data prior to 1996 are considered un-reliable 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). From 1996 the landings have varied between 9,000 t (2008) and 40,000t (2005).

A.3. Ecosystem aspects

Sprat is an important prey to other fish species, sea birds and sea mammals. Sprat is an important part of the pelagic ecosystem. It is a plankton feeder and form an important part of the food chain up to the higher trophic levels. They spawn pelagic in coastal areas. In the adjacent North Sea many of the plankton feeding fish have recruited poorly in recent years (eg. herring, sandeel, Norway pout). The implications for sprat in IIIa are at present unknown.

B. Data

B.1. Commercial catch

Commercial catch data are submitted to ICES from the national laboratories belonging to nations exploiting the sprat in Division IIIa. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001 as Denmark, landing most of the catches, follows this regulation. This provision requires 1 sample per 2000 tonnes landed.

The majority of commercial catch and sampling data are submitted in the Exchange sheet v. 1.6.4. This method is now run in parallel with INTERCATCH, which is maintained by ICES. INTERCATCH is still in development and is not completely satisfactory in terms of flexibility and outputs. Thus HAWG uses both. The data in the exchange spreadsheets are samples allocated to catch using the SALLOCL-application (Patterson, 1998). This application gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the stock co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

The stock co-ordinator allocates samples of catch numbers, mean length and mean weight-at-age to unsampled catches using appropriate samples by gear (fleet), area and quarter. If an exact match is not available then a neighbouring area in the same quarter is used.

B.2. Biological

Mean-weight-at-age for all ages is in the range seen the last years. Mean weights-at-age for 1996-2003 are presented in ICES CM 2005/ACFM:16.

No estimation of natural mortality is made for this stock.

B.3 Surveys

Two surveys cover this stock. The International Bottom Trawl Surveys (IBTS) cover the stock in Div. IIIa in the first quarter of the year. Additionally, the herring acoustic survey covers the same area during June-July.

The appropriateness and suitability of these surveys for use in the assessment of the North Sea sprat stock, was examined by the HAWG in 2010.

B.3.1 International Bottom Trawl Survey (IBTS)

The International Bottom Trawl Surveys started as a international coordinated survey in the mid-1960s as a survey directed towards juvenile herring. The gear used was standardised in 1977 to use the GOV trawl, but took time to be phased in. By 1983 all participating nations were using this gear, and the index can be considered consistent from this point onwards. A third-quarter North Sea IBTS survey using the same methodology was started in 1991 and can be considered consistent from its initiation.

The IBTS (February) sprat indices (no per hour) in Division IIIa have been used as an index of abundance. In later years, the index has not been considered useful for management of sprat in Division IIIa. The indices are calculated as mean no./hr (CPUE) weighted by area where water depths are between 10 and 150 m (ICES 1995/Assess:13). The indices were revised in 2002 (ICES 2002/ACFM:12) based on an agreement in the IBTS WG in 1999, where it was decided to calculate the sprat index as an area weighted mean over means by rectangles for the IIIa (ICES 1999/D:2). The old time-series of IBTS indices (from 1984-2001) is shown in ICES 2001/ACFM:10.

B.3.2 Herring Acoustic Survey (HERAS)

The Herring Acoustic Survey is a summer acoustic survey that has been performed an ICES coordinated survey since the 1980s. Sprat has been reported as a separate species in this survey from 1996 onwards. The coverage of this survey in Division IIIa has remained relatively unchanged (*e.g.* ICES PGIPS 2009).

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic surveys since 1996. In Division IIIa, sprat has mainly been observed in the Kattegat.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

None

C. Historical Stock Development

Not performed

D. Short-Term Projection

Not performed

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set

H. Other Issues

None

I. References

ICES 1995. Report of the Herring Assessment Working Group for the Area South of 62ºN. ICES 1995/Assess:13

ICES 1999. International Bottom Trawl Survey in the North Sea, Skagerrak and Kattegat in 1998. ICES 1999/D:2

ICES 2001. Report of the Study Group on the Herring Assessment Units in the Baltic Sea. ICES CM 2001/ACFM:10.

ICES 2002. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2002/ACFM:12.

ICES 2005. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM:16.

ICES 2006. Report of the Herring Assessment Working Group. ICES 2006 CM /ACFM:20

ICES 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT). ICES CM/ACOM:34

Limborg, M.T., Pedersen, J.S., Hemmer-Hamsen,J., Tomkiewicz,J., Bekkevold, D. 2009. Genetic population structure of European sprat (Sprattus sprattus): differentiation across a steep environmental gradient in a small pelagic fish. Marine ecology progress series 379: 213–224.

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight-at-age. Working Document to Herring Assessment Working Group South of 62°N. ICES CM 1998/ACFM:14.

Annex 11 Stock Annex – Sprat in the Celtic Seas Ecoregion

Quality Handbook	ANNEX:_Sprat Celtic Seas Ecoregion
Stock specific documentation of standard assessment procedures used by ICES.	
Stock:	Sprat in Division Celtic Seas Ecoregion
Working Group:	Herring Assessment Working Group (HAWG)
Date:	6 April 2011
Author:	Clarke, M.

Sprat in Celtic Seas Ecoregion in general

For the first time, in 2011, ICES has been asked to provide advice on sprat stocks in the Celtic Seas Ecoregion. It is not clear if the sprat populations in this area constitute a separate stock or what the relationship is between them and neighbouring populations in the North Sea and Bay of Biscay.

In 2011 HAWG has compiled all available landings data for sprat in this region, and begun to compile fisheries independent information.

HAWG is working with ICES SIMWG, the Working Group on Stock Identification Methods, to identify the appropriate spatial stock units for sprat in this and neighbouring areas. In 2012, HAWG will consider the results of this work and provide information on sprat stocks at the most appropriate spatial scale.

Sprat in Division VIId,e

In previous years HAWG only considered sprat in Divisions VIId and VIIe. These Divisions comprise a management unit for sprat, with an annual TAC being set by the EC. However it is not clear if sprat populations in this area constitute a unit stock, and if this is an appropriate management unit.

HAWG is working with ICES SIMWG, the Working Group on Stock Identification Methods, to identify the appropriate spatial stock units for sprat in this and neighbouring areas. In 2012, HAWG will consider the results of this work and provide information on sprat stocks at the most appropriate spatial scale.

Annex 12 Technical Minutes of the North Sea Review Group

Review of ICES	**HAWG Report 2011**
Reviewers:	Gary Melvin (Canada, chair)
	Dorleta Garcia (Spain)
	Ciaran Kelly (Ireland)
	Anthony Wood (USA)
Chair WG:	Lotte Worsoe Clausen, Denmark and Maurice Clarke, Ireland
Secretariat:	Barbara Schoute

General

The Herring Assessment Working Group for the area South of 62 deg N (HAWG) was one of 3 working group reports used by The North Sea Review Group (RGNS) to complete our review. The RGNS would like to acknowledge the effort expended by the working group to produce the report and the work required to complete their documentation in a timely manner.

The Review Group considered the following stocks:

spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)
spr-nsea	Sprat in Subarea IV (North Sea)

Sprat in Subarea IV (North Sea) spr-nsea

1) **Assessment type: Update**
2) **Assessment**: No analytical assessment presented
3) **Forecast**: No short/long term forecast presented
4) **Assessment model**: Framework in 2009 concluded that previous assessment methods were inappropriate. No analytical assessment undertaken
5) **Consistency**: 3 indices of abundance: IBTS first and third quarter from 1984 and the herring acoustic survey since 2004 with roughly consistent coverage.
6) **Stock status**: Unknown. No absolute estimates or reliable trends available. SSB and F stable, decreasing trend in recruitment since 2003. Recruitment the lowest observed. F is larger than any proxy of $F_{msy.}$ SSB 2008=159,406, 2009=141,824, F3-6=0.37. 2008 recruitment estimated to be lowest in last 18 years
7) **Man. Plan.**: No. Management by TAC, ITQ. No defined reference points. However, exploratory management plan of F_{msy}=0.25, B_{lim}=110,00, TAC variation 15%, and Target F =0.25

General comments

Stock structure is uncertain with potentially strong overlap with English Channel sprat, but weak and variable with Kattegat sprat, based on genetic studies.

Sampling very poor and does not meet the recommended 1 sample per 2000t landed. Landings have increased substantially in the last couple of years. Average mean weight at age lowest in time series for age 1 and second lowest for age 2, suggesting the possibility of some environmental effects although it may be a function of ageing or sampling timing.

Catches well below the advised and agreed TAC. .By-catch of herring implemented in 1996 may restrict catches.

The 2009 and 2110 index IBTS Q1 (all ages) were the highest in the time series and may carry over into 2011 as older fish. The incoming 1-group (2010year class) in IBTS Q1 is estimated to be well below average for the whole time series, both in absolute and relative terms but this estimate should be considered as preliminary

Technical comments

There is some indication that all three indices of abundance track one another for over lapping periods. Relationship of successive cohorts for both the IBTS Q1 and Q3 extremely poor, although statistically significant for ages 1vs 2 and 2 vs 3, suggesting it is providing little information of biomass trends. A much better relation observed for acoustic data but the time series very short

Sprat commonly occur at the southern boundaries of both the IBTS and the acoustic surveys indicating that some unknown and variable amount of biomass is missed resulting in a under estimate.

Assuming the IBTS Q1 is age 1 sprat is reflective of annual catch of age 1 then a decline in catch would be expected based on the preliminary 2011 observations.

The IBTS results are considered to be the best available to characterize the abundance of sprat in the North Sea. How reliable are these results in unknown as day/night and seasonal affects have been observed. The acoustic survey may become an important index for this stock in time given early indications.

Conclusions

Given the absence of an analytical assessment and the uncertainties in the abundance indices, the decision not to present any stock status evaluation or forecast was justified.

Sprat in Subarea IIIa (Skagerrak-Kattegat) spr-kask

1) **Assessment type:** **SALY**
2) **Assessment**: No analytical assessment since the mid-1980's
3) **Forecast**: Not Applicable
4) **Assessment model**: No assessment model, but two indices of abundance: IBTS Q1 and herring acoustic survey in Division IIIa.
5) **Consistency**:
6) **Stock status**: Abundance and recruitment unknown
7) **Man. Plan.**: No. Management by TAC, herring by-catch quota, and percent herring by-catch limit. No advice on sprat TAC has been given in recent years.

General comments

Sprat is a short lived important forage species in Subarea IIIa. Sprat cannot be caught in this area without catching herring, thus the restrictions on percent herring and herring by-catch quota. The sprat fishery is generally managed to limit the amount of juvenile herring landed from the area. In 2010 the TAC was 52,000t with a herring by catch of 7515t and 52,000t with a herring by-catch of 6659 for 2011. Sprat landings have typically been far less than the TAC due to the restriction on by-catch. Total landings for 2010 were 10,706t.

Both the IBTS and the herring acoustic survey indicate a decline in abundance from 2009 to 2010. The preliminary estimate for 2011 IBTS index show a 300% increase from 2010, but Age 1 is the second lowest in the time series (1984)

Technical comments

As with the North Sea sprat IBTS index there is a significant relationship between the total catch in numbers and the Q1 age 1 index, but no significant relationship between total catch in tonnes and the all ages index.

Mean weight at age for Age 1 was the highest in the time series.

Conclusions

Same advice as last year

Annex 13 – Technical Minutes from RGCS1, 2011

Review of ICES **Herring Assessment Working Group [HAWG] Report 2011** 16 - 24 March 2011

Reviewers:	Asgeir Aglen (chair), Rick Officer, Rainer Oberst
Chair:	WG: Lotte Worsoe Clausen, Denmark, and Maurice Clarke, Ireland
Secretariat:	Mette Bertelsen, Cristina Morgado, Barbara Schoute

Review process

The Review Group considered the following stocks:

- her-iris
- her-VIaN
- her-irlw
- her-nirs
- spr-celt

These were reviewed along with the WGCSE flatfish stocks and the stocks of megrim and anglerfish from WGHMM. The Review Group conducted its work by correspondence. The reviews have been carried out according the Guidelines provided by ICES, particularly focusing on the need to quality assure the assessment results supporting the provision of fishery management advice by ICES in the annual ACOM advice sheets. All stocks were reviewed by at least two reviewers. This involved:

- Checking that update assessments have been correctly implemented using the methods described in the Stock Annexes;
- Checking that the assessments have been implemented correctly, which could involve re-running the assessments to ensure the results in the WG report can be replicated exactly;
- Ensuring the assessment results and forecast results are carried over correctly to the advice sheets and advising ICES of any errors detected;
- Evaluating the ability of the stock assessments for providing credible management advice, and suggesting alternative advice where assessments do not appear appropriate;
- Providing recommendations to the Working Group to help with future development of the assessments through benchmarking.

General comments

The WG report is very well organized and readable. The sharepoint site is well updated and structured.

Herring in the Celtic Sea (Division VIIa South of 52° 30' N and VIIg,h,j,) (report section 4)

1) **Assessment type: Update**
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: FLICA tuned by one acoustic survey
5) **Consistency**: Consistency The assessment is consistent with last year. The SSB of 2010 increased from 78 804 (estimated in 2010) to 114 319 (estimated in 2011). The trend of increasing SSB and low mean F is continued.
6) **Stock status**: : The precision of SSB is poor (see the changes of SSB of 2010) but SSB is above the B_{pa} of 44,000t
7) **Man. Plan.**: A rebuilding plan is implemented by the Irish fishing industry and considered precautionary by ICES. The rebuilding target in rebuilding plan (that the stock should be estimated above Bpa for three consecutive years) is now met. A proposed management plan implies a catch in 2012 corresponding to F=0.23, restricted by max 30% TAC change. The management plan has not been evaluated by ICES.

General comments

A) Stock annex

The stock annex describes the development of data and knowledge of this stock very detailed. The problems of mixing of age groups 1 – 3 with other stocks are described. Tables and figures present partly different time periods and some figures are given in the stock annex and in the report.

B) Report

The WG followed TOR's which are relevant for the stock assessment and the advice. The assessment is in correspondence with the stock annex.

The WG studied the effects of the extension of the plus group and analysed differences between the assessments based on the plus group 6+ (used in 2010) and 7+. The SSB based on both plus groups significantly differed (26 % higher based on 6+). The same plus group 6+ as in 2010 was used in the 2011 assessment because the diagnostics did not improve.

The SSB of 2010 significantly increase from 74804 (estimated 2010) to 114319 (current estimate).

The SSB is above B_{pa} (44 000 t) and WG stated that the stock has reached the rebuilding target.

Technical comments

The comments concerning discards are very general, partly based on the comments of fishermen. Presentation of direct quantitative estimates of discard and other reason of uncertainty in the report are necessary. In the stock annex mixing of age group 1 – 3 with other stocks are suggested.

Acoustic surveys (or other sources) which cover the areas of the different stocks should be used to quantify the mixing of age group 1 to 3 with other stocks. Such type of analyses can improve also estimates of the proportion of spawners and weight at age for these age groups because it is stated that spawning herring migrate back to the stock area.

The use of plus group 6+ should be evaluated again because "three strong cohorts recruited to this stock" which will influence the plus group in the future.

Conclusions

The assessment is accepted as a basis for advice

Herring in Divison VIa (North) (report section 5)

1) **Assessment type:** **Update, (SALY?)**
2) **Assessment**: Analytical
3) **Forecast**: Presented
4) **Assessment model**: FLICA tuned by one acoustic survey, both the survey series and catch at age have been revised
5) **Consistency**: The assessment is consistent with last year's results.
6) **Stock status**: : SSB is estimated to 61,649t in 2010 which is lower than estimated last year, but above B_{lim} (50,000t). F in 2010 is estimated to 0.266 which is above Fmsy of 0.25.
7) **Man. Plan.**: Because, it will be a number of years before ICES can provide a fully operational integrated strategy for these units HAWG recommends that the management plan for Division VIa (N) should be continued. This implies a catch in 2012 corresponding to F=0.2, constrained by max 25% TAC change.

General comments

A) Stock annex

Comments concerning mixing of different herring stocks are given at three places with comments concerning WHESTHER and SGHERWAY. The summary of the result of both projects can improve the understanding of the relations between the different herring stock. The variable mixture of the different stocks and the uncertainty of landing data are reasons for the uncertainty of the stock assessment.

Tables are added to the annex which give the number at age (Table 6-1) etc. The tables cover not the total time series and the data are also presented in the report. Therefore, it should be evaluated where the data are most appropriate presented to avoid redundancies.

B) Report

The WG addressed the TORs relevant to providing advice and the assessment followed the data given in the stock annex. The relation of the herring stock to other stocks is presented in the stock annex and in the report. Estimation concerning the quantification of the mixing based on the project will improve the understanding of the amount of the problem, although if estimates are only available for short periods based on the EU projects.

Only one fishery independent time series is available which contains internal inconsistencies. The RG proposes a deep analysis of the data also in relation to surveys in neighbouring areas to detect the reasons of uncertainty.

Furthermore, the effect of discard and misreporting should be described more detailed.

Based on the available data the implementation of the assessment and the forecast was consistent.

Conclusion

The RG considers that the updated assessment is suitable for providing management advice, but as uncertain due to the problems in the landing statistics and the estimates based on the acoustic surveys in relation to the low stock size over many years.

The WG recommended consider the management considerations "It will be a number of years before ICES can provide a fully operational integrated strategy for these units. In this context HAWG recommends that the management plan for Division VIa (N) should be continued". The conclusion seems to be questionable because the SSB further decreased and the F in 2010 was above Fmsy in combination with a low recruitment during the last years. The management plan will, however, lead to TAC=0 if, in the future, SSB is estimated below Blim.

Herring in Division VIa South and VIIbc (report section 6)

Short description of the assessment: extremely useful for reference of ACOM!

1) **Assessment type: SALY**
2) **Assessment**: no assessment has been accepted in recent years
3) **Forecast**: None
4) **Assessment model**: Seperable VPA
5) **Consistency**: Similar method was used based on extended time series. The assessment is not accepted.
6) **Stock status**: uncertain but a range of separable VPA scenarios indicate that SSB is below Blim
7) **Man. Plan.**: None adopted at present time. The WG proposes that a rebuilding plan is urgently required. A rebuilding plan was developed by the Federation of Irish Fishermens' Organisations and the Pelagic RAC in 2009. The plan was for *status quo* TAC in 2010, and, in subsequent years a TAC set at $F_{0.1}$. This plan was not adopted. However this plan is still the stated policy of the Pelagic RAC for management of this stock.

General comments

The WG addressed the TORs relevant for providing advice. The exploratory assessment based on separable VPA in correspondence with the stock annex. The preparation and the use of available data were in accordance with the model requirements. Forecast was not carried out.

The SSB and the recruitment are on a low level and the fishing mortality is on high level.

The pelagic RAC disagrees with the HAWG perception that the stock has decreased to a low level. The RAC noted that the industry does not share the perception that the stock is at a low level, and that experience from the fishing grounds suggests that herring abundance is high.

Technical comments

A new acoustic survey has been carried out in summer since 2008 to cover the summer feeding aggregations. It is suggested to evaluate the variability of the estimates between 2008 and 2010 and possible reasons of uncertainty as fast as possible to develop a time series with high quality because other fishery independent estimates are not available yet.

Further effort is required to understand and quantify the mixing of the different stock components during the surveys and the commercial fishery.

It is proposed to evaluate the stock annex to avoid time series which are not updated. Furthermore, the readability of the stock annex can be improved if standardized structure is used for all herring stocks in the area. In this case some information based on projects like WESTHER is available.

Conclusions

The RG supports the WG that the exploratory assessments are suitable describing trends which show low stock level and high fishing mortality in the last years. The improvement of the assessment will depends on the better understanding of the mixing of different stock within the landings and during the acoustic survey started in 2008.

A rebuilding plan as required by WG should be further discussed as starting point for additional studies related to the understanding of the stock dynamics, like effects of changing environment in relation to the reproduction success, etc.

Herring in Division VIIa North (Irish Sea) (report section 7)

1) **Assessment type: SALY**
2) **Assessment**: exploratory
3) **Forecast**: None
4) **Assessment model**: FLICA, tuned by 1 acoustic survey (both as total biomass index and stock number index for individual age groups 1-8) and 1 larvae survey (SSB index). Two stage biomass model was run with acoustic biomass of 1-ringers and 2+ as input.
5) **Consistency**: The assessment approach in 2011 is consistent with the 2009 assessment and stock annex. (Due to lack of fishery sampling data in 2009, the 2010 assessment deviated from the standard approach).
6) **Stock status**: The assessment is suitable for evaluating trends only, although the general level of F estimates is informative. Acoustic surveys at spawning time indicate a growth in the spawning stock biomass in 2008 and 2009 although this is not reflected in the larval production index.
7) **Man. Plan.**: None. MSY considerations and PA considerations both imply that catches can be maintained at recent level.

General comments

The WG addressed the TORs relevant to providing advice (SALY).

This was an exploratory assessment using the ICA method. Data of 2010 were added to the time series and preliminary modelling was carried out. However, it was pointed out "The exploratory FLICA runs conducted in 2011 did not improve the perception of the suitability of FLICA as an assessment method for the Irish Sea stock".

Taking into account that landing data, biological samples and fishery independent indices are available this statement needs more explanation, especially because no problems in the data from 2010 were announced.

Consequently, final assessment and short term as well as medium term projections were not provided.

Technical comments

1. Stock annex:

The results of the WESTHER project concerning this stock should be specified, especially possible mixture with other stocks.

It is clearly described that the landing statistics is uncertain due to missing quantification of misreporting, discard etc. In the report this problem is not announced. There is only a comment concerning the situation in 2010 which can lead to misinterpretation concerning the quality of the total landing statistics.

Some time series are presented as tables in the stock annex or in the report or in both. Standardized form of presentation for all stocks will improve the readability of the report.

2. Stock report

Different fishery independent time series are available for the stock. However, the stock indices are always influenced by uncertain amount of “winter” spawners of other stock components. Independent of this the surveys show similar tends in the last years. Detailed analyses of the all time series together can improve the understanding of the stock dynamics and offer the option of survey based stock assessment.

In 7.3.1 it was pointed out that 0-group herring and sprat were observed at same positions during the acoustic surveys. This common occurrence can lead to uncertainty of the estimation of 0-group herring. Is the observed increase of the 0-group herring in 2010 influenced by this mixing?

The reference of Table 7.3.2 in Point 7.4 and the reference of Figure 7.3.6 in Point 7.6 are wrong.

Conclusions

The RG supports the WG that the exploratory assessments are suitable describing trends. There are strong indications of increasing biomass in recent years due to improved recruitment, but the extent of the recent downward trend in F over the same period will be highly uncertain.

Detailed analyses of the survey results (including the estimation of confidence intervals) und further studies related to the mixing of different stock components could potentially improve the usability of the survey series.

Sprat in the Celtic Seas (subareas VI ans VII) (report section 10)

1) **Assessment type: New stock, collated data only**
2) **Assessment**: acoustic surveys, landings and lpue time series presented
3) **Forecast**: none
4) **Assessment model**: none
5) **Consistency**: new stock
6) **Stock status**: Indications that stock is fluctuating, driven by variable recruitment
7) **Man. Plan.**: None. TAC only for divisions VIId,e (Channel). 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.

General comments

Available data relating to sprat in the Celtic Seas was this year presented and described in the HAWG report. The background is a request to ICES for advice on sprat in these areas. The data are well presented and explained. Some additional data from demersal surveys are identified, but were not available at the EG-meeting. No data on age distribution in the catches has been identified. The data indicate considerable variation over the time series, without clear signs of a long term trend. Both the Irish Sea acoustic survey and the lpue series show a minimum around 2005, followed by a peak around 2008.

Technical comments

Some maps showing the typical area coverage of the acoustic surveys would be helpful. (The report section refers to Annex 8 where other survey names are used). The Irish Sea acoustic survey (AFBINI) give quite high biomass estimates (100-400 kt) compared to other surveys, while the historic cathes in this area have been moderate. The 36 kHz data mentioned in Sec 10.3 should be 38 kHz.

Conclusions

The RG considers the following conclusions from the EG to be reasonable: Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.