ICES HAWG REPORT 2012

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

13 - 22 March 2012

Copenhagen, Denmark

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

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Executive Summary

The ICES herring assessment working group (HAWG) met for 8 days in March 2012 to assess the state of 7 herring stocks and 3 sprat stocks/populations. The working group conducted update assessments for five of the herring stocks. No analytical assessments were carried out for the remaining herring stocks although available survey and/or fishery data were examined. An exploratory assessment was performed for North Sea and English Channel sprat but no assessments were possible for any of the IIIa sprat.

The SSB of North Sea autumn spawning herring was assessed using new revised data and new methods, based on the recent benchmark process. The new assessment changed our perception of the stock. SSB in 2011 was estimated at 2.34 m tonnes, Fishing mortality in 2011 was estimated at 0.09, hence far below the target F2-6 of 0.25. Recruitment appears still in the same low regime since 2002. The Western Baltic spring spawning stock's SSB in 2011 was estimated to be around 107 000 t and has declined substantially in the last three years. Fishing mortality has been estimated at 0.20, hence below Fmsy (0.25). The recruitment in 2011 is slightly lower than the good year class estimated in 2010, but appears still higher than the low estimates that characterized the late 2000s. 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 85 000 t, and mean F2-5 remained at a very low estimate. Catch in 2010/2011 increased to 11 500 t. Several strong year classes have recruited since 2005. West of Scotland autumn spawning stock's SSB in 2011 has been estimated at approximately 82 200 tonnes (+33% from 2010). Fishing mortality in 2011 was estimated 0.18 (-33% from 2010), and it is now below the F target of the management plan (0.25). Catches were 21 000 t in 2011. 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, below Blim. Current levels of SSB and F poorly estimated. Catch in 2010 was less than 7000 t, among the lowest in the series. There is some evidence that the 2008 year class was higher than recent average levels. Irish Sea autumn spawning herring was assessed analytically, based on its benchmark. This assessment indicates an increase in SSB, estimated at 18 800 t in 2011, and recruitment in recent years, with an associated downward trend in F (0.25 in 2011). Catches have been relatively stable since the 1980s, and close to TAC levels in recent years. Based on the most recent estimates the stock is being harvested sustainably and below FMSY. Catches of the Clyde spring spawning stock were 90 t in 2011, but no sampling or other information was available. Catches of herring in VIIef and in VIII were also collated and remained at low levels in 2011. An exploratory assessment of North Sea sprat was performed. The stock appears to be increasing judged from surveys as well as this explorative assessment. Catches in 2011 were 134 000 t at the level of the catches in 2010 (143 000 t). The data available for sprat in Division IIIa were too sparse to perform an assessment. The total landings were 10 800 t in 2010, compared to 10 700 t in 2009. Sprat in VIId,e catch in 2011 was 3 100 t compared to the catches in 2010 (4 400 t). Exploratory assessments estimated stock size as between 16 000 t and 50 000 t, based on two scenarios. The total catches in 2011 was estimated as 4 500 t, lower than 8 100 t in 2010. There was no assessment on sprat in this eco-region as further work is required to determine stock structures and identity.

There were no special requests to answer in 2012. 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
Andrew Campbell	Ireland
Maurice Clarke	Ireland (Co-Chair)
Ad Corten	The Netherlands (Guest)
Lotte Worsøe Clausen	Denmark (Co-Chair)
Mark Dickey-Collas	The Netherlands
Katja Enberg	Norway
Sasha Fassler	The Netherlands
Tomas Gröhsler	Germany
Emma Hatfield	UK/Scotland
Niels Hintzen	The Netherlands
Savas Kilic	Germany (Guest)
Susan Mærsk Lusseau	UK/Scotland
Henrik Mosegaard	Denmark
Richard Nash	Norway
Mark Paine	Denmark
Anna Rindorf	Denmark
Søren Post	Denmark
Beatriz Roel	UK/England & Wales
Norbert Rohlf	Germany
Pieter-Jan Schön	UK/Northern Ireland
Barbara Schoute	ICES Secretariat
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2011/2/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, 13–22 March 2012, incorporating an extra day for benchmark preparation to:

a) compile the catch data of North Sea and Western Baltic herring on 13–14 March

b) address generic ToRs for Fish Stock Assessment Working Groups 15–22 March (see table below)

c) prepare for benchmark of IIIa and 22-24 herring, planned for 2013.

d) consider guidance from ICES SIMWG on stock identity of sprat in the Celtic Seas Ecoregion.

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 2012 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice
her-3a22	Herring in Division IIIa and Subdivi-sions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Update
her-47d3	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Germany	NL	UK (Scot-land)	Update
her-irls	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Ireland	Ireland		Update
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland		Update
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (North-ern Ireland)	UK (North-ern Ire-land)		Update
her-vian	Herring in Division VIa (North)	UK (Scot-land)	UK S		Update
spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	Norway	Denmark	-	Update
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Update
spr-ech	Sprat in Division VIId,e	Norway	-	-	Update
spr-celt	Sprat in the Celtic Seas	UK (E&W)	-	-	Update

The following ToRs apply to: AFWG, HAWG, NWWG, NIPAG, WGWIDE, WGBAST, WGBFAS, WGNSSK, WGCSE, WGDEEP, WGHMM, WGEF and WGHANSA.

The working group should focus on:

ToRs a) to g) for stocks that will have advice (or biennial first year),

ToRs b) to d) and f) for stocks with biennial advice in the second year

a) Produce a first draft of the advice on the fish stocks and fisheries under con-siderations according to ACOM guidelines and implementing the ge-neric in-troduction to the ICES advice (Section 1.2).

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

   i) Load fisheries data on effort and catches (landings, discards, bycatch, in-cluding estimates of misreporting when appropriate) in the IN-TERCATCH database by fisheries/fleets. Data should be provided to the data coordinators at deadlines specified in the ToRs of the indi-vidual 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). Where relevant suggest improvement for the revision of the DCF.

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. Describe the fleets that are involved in the fishery.

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 catch options for next year;

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) In the autumn, where appropriate, check for the need to reopen the advice based on the summer survey information and the guidelines in AG-CREFA2 (2012 report).

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

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

1.3 Working Group's response to special requests

There were no special requests in 2012.

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:

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. A key addition is to develop the ecosystem section to provide information on, and plans to provide for, ecosystem drivers for fisheries advice.

Advice format: Few changes have been proposed for the advice sheets for 2012.

1.4.2 Working Group for International Pelagic Surveys [WGIPS]

The Working Group for International Pelagic Surveys (WGIPS) met at ICES Headquarters, Copenhagen, Denmark from 16.01.12 – 20.01.12 under the chairman Karl-Johan Stæhr, Denmark and Ciaran O'Donnell, Ireland: to coordinate acoustic and larvae surveys in the North Sea, Malin Shelf and Western Baltic; to coordinate acoustic surveys on Blue whiting spawning stock and international coordinated ecosystem surveys in the Nordic Seas; to combine recent survey results for assessment purposes and to clarify parameters influencing these calculations. This meeting was the first meeting of the new WGIPS after the former working groups WGIPS and WGNAPES has been merged. The meeting was attended by 14 participants from seven different nations. The first combined meeting of the new WGIPS, covering the full ToRs, is planned for December 2012.

Review of larvae surveys in 2011/2012: Six survey metiers 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 2012.

The larvae survey in the Western Baltic was conducted from late March to the end of June, in total a 15 week period. The recruitment index derived from the survey is 4444 Mill., lower than 2010 but more than double that calculated for the low-recruitment year 2008. Unlike the two previous years, 2009 and 2010, the current index is located below the arithmetic mean of the time series but only slightly below the median.

Results from larvae survey in the Irish Sea indicate a similar distribution pattern for 2011 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 2011: Seven acoustic surveys were carried out during late June and July 2011 covering the North Sea, West of Scotland and Malin Shelf area. The estimate of the North Sea autumn spawning herring stock biomass is at 2.4 million tonnes. This is 18% lower than the estimate from the previous year (3.0 million tonnes).

The West of Scotland estimate of SSB is 458 000 tonnes and 2 214 million herring. This was considerably higher than observed in 2010 and is more in line with estimates from 2008-9. Three and 4 winter ring fish dominate the age composition of the standing stock and immature fish were not as well represented as in 2010.

This is the fourth year of the synoptic survey in the Malin Shelf area. Estimates from survey data are presented as: the ‘West of Scotland’ in Division VIaN and ‘Malin Shelf’ component in Divisions VIaN-S and VIIb. The estimates are split for reporting purposes as requested by the HAWG. The SSB estimate for the Malin Shelf component was 494 000 tonnes and 2 468 million fish. The estimate is dominated by 3, 4 and 9+ winter rings respectively. The contribution of immature fish to total abundance was considerably lower than observed in 2010. The Clyde and Irish Sea are not included in the 2011 estimate as they were not surveyed due to financial restraints.

The estimates of Western Baltic spring-spawning herring SSB were 125 000 tonnes and 983 million herring, which is in the same order of magnitude as last year’s low estimate. The stock is dominated by 1 ring and, to a lesser extent, 2 ring fish. This year’s estimated abundance of 1 ringers is considerably larger than the previous two years.

Sprat: The total abundance in 2011 was estimated to be 42 600 million individuals and the biomass 444 000 tonnes. This is an increase of about 25% in terms of biomass when compared to last year. It is higher than the average for the period. In terms of abundance, it is the fifth 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 90% of the biomass.

In Div IIIa, sprat was only found in Kattegat. Last year sprat were abundant in both the Kattegat and the Skagerrak area. The abundance was estimated to be 1 574 mill individuals, a small increase compared to 1 556 million individuals in 2010 (Table 4.2.3). The biomass was estimated to be 27 464 tonnes, an increase of about 67%. Most sprat were 3+ group, and 90% of them were mature.

Western Baltic acoustic surveys in autumn 2011: A joint German-Danish acoustic survey was carried out with RV "Solea" in the Western Baltic in October 2011. The herring stock in Subdivisions 21-24 was estimated to be 5.5 x 109 fish or about 206.3 x 103 tonnes. For Subdivisions 22-24, the number of herring was calculated to be 4.5 x 109 fish or about 173.7 x 103 tonnes. As in previous years, young herring dominated the abundance estimates. Total abundance decreased compared to the comparatively high values from 2010, whereas biomass remained nearly constant. This was due to a weak year class in 2011 and a dominance of 1-year old herring (stronger year class in 2010).

The estimated sprat stock in Subdivisions 21-24 was 8.9 x 109 fish or 111.6 x 103 tonnes. For Subdivisions 22-24, the number of sprat was calculated to be 8.4 x 109 fish or 102.7 x 103 tonnes. The significant decline in numbers compared to 2010 (at almost constant biomass) is mainly caused by a weak incoming year class and a dominance of one year old sprat.

1.4.3 Study Group on the evaluation of management plan for North Sea herring [WKHIAMP]

The WKHIAMP evaluated whether the existing management plan is precautionary under various settings for a TAC constraint, as variations to the current Long Term Management Plan (LTMP), provided that expected recruitment is still low. All these variations to the LTMP come into play in the short term forecast where TACs are proposed for the A- and B-fleet given the harvest control rule and possible inter annual variation on TAC constraint.

The evaluation procedure was performed using a stochastic medium term simulation model. The model simulates the biological herring population and the behaviour of the fishing fleets and surveys, while the stock assessment is mimicked to estimate the stock status. Finally, the management advice and implementation are based on the adjusted management plan scenarios. In turn, management feeds back into the biological population and the fishery the year after. The simulations are run with 100 Monte Carlo realisations (MCR) to obtain a broad range of possible outcomes given the variability in the input data. Stochasticity (randomness) was added to variables and parameters to ensure that biological variation, and the uncertainty in the historic perception of the stock was thus reflected.

The five HCR options that were examined were: 1) Current HCR; 2) Current HCR without constraint, 3) 0.2 – 0.3 HCR, 4) 50-50 HCR and 5) Current HCR without constraint in 2012.

All options were concluded to be in conformity with the precautionary approach, as the risk of SSB falling below Blim is always low under the assumed conditions.

The stochastic simulation model was designed to explicitly incorporate the natural and stock assessment variability as observed over the recent years which have led to considerable revisions in recruitment and spawning stock biomass. The evaluation presented by WKHIAMP showed that the evaluated harvest control rules are all robust against this variability. However, the rules have not been evaluated against exceptional variations in biology which are beyond the variation observed in history, nor have the rules been tested for robustness under varying starting conditions in population size. These analyses, therefore, can be viewed as appropriate given the uncertainty in the current population size and they answer the request fully. However, they do not pro-vide a full Management Strategy Evaluation.

1.4.4 MULTBAL

The second meeting of WKMULTBAL, the Workshop on Integrated/Multispecies Advice for Baltic Fisheries, was held from the 6th to 8th of March. This working group met to assemble the scientific basis of an upcoming STECF group. Terms of reference were to:

a) Evaluate what integrated / multispecies models provide a reliable basis for providing management advice;

b) Using these models, develop a handful of alternative management scenarios for cod in 25–32, herring in 25–29 and 32 (Excluding the Gulf of Riga), and Sprat in 22–32, taking into account multispecies interactions and ecosys-tem functioning. The scenarios should define MSY and PA reference points, including maximum sustainable yield estimates in weight and income (in a simple form using e.g. average price per species), they should be precautionary and they should have a high probability that conservation of none of the three stocks will be jeopardised;

c) Evaluate the usefulness of basing the management strategy on escapement targets rather than on fishing mortality targets, in avoiding the ecosystem drifting to extreme states where one stock is too dominating.

d) Draft integrated/multispecies advice based on the 2011 assessments; these drafts will be updated by WGBFAS when the 2012 assessments are completed;

e) The meeting 16 December 2011 will be a scoping meeting. The tasks are to identify: 1) which multispecies and environmental factors to include in the assessment and advice; 2) which management scenarios to simulate; and 3) which models to run inter-sessionally and by whom. All this should be coor-dinated with the deliberations of the STECF meeting in Edinburgh 28 No-vember to 2 December 2011 in order to avoid duplication and secure supplementary of work. The scoping meeting should also decide meeting dates for the spring meeting.

At the meeting, the model chosen by STECF (Eastern Baltic SMS) was reviewed together with two production models of the same species. The models include eastern Baltic cod, herring and sprat. The SMS model was expanded compared to previous versions by implementing area-based predation and environmentally sensitive recruitment of sprat. Further reviewed expansions which have not yet been implemented include variable growth of cod and clupeids. The model expansions were reviewed by the group and predictions of yield at different fishing levels in a multispecies environment were shown. In addition to this model, two production models were reviewed which did not include the spatial aspects. The SMS model will be used by the STECF group assessments and management and in the Baltic to estimate multispecies reference points. The future implementation of these new reference points in ICES will proceed through the planned multispecies benchmark for the Baltic in 2012/13.

1.4.5 GAP Project

In the GAP2 project (see http://www.gap2.eu/ for information) the creation of a mutually agreed LTMP for the herring fishery in ICES Division IIIa and Sub Divisions 22-24 is the subject for a case-study lead by Lotte Worsøe Clausen, DTU Aqua, Denmark. An introductory seminar was held in November 2011 to establish common ground for such a LTMP between all stakeholders. The participants counted the Pelagic RAC, Danish Fishermen's Organisation, Pelagic PO, the Commission and several science related people. The output from the meeting was that the over-arching objectives of a LTMP were that the plan should be Specific, Measureable, Achievable, Realistic and Time-limited (SMART); it needs to be simple to grasp by all stakeholders and the most important objective to aim for is a high and stable yield based on a sensible F.

The LTMP should be amendable in a number of ways when necessary because of changes in the ecosystem. This feature of the LTMP is not meant as a yearly revision but rather an evaluation on a regular basis; the schedule for re-evaluations shall follow a plan agreed by all stakeholders. During a post-seminar meeting with Baltic RAC it was discussed whether a LTMP should be able to withstand changes in both the natural and political environment for a period of cay 3-4 years to give stability in the management. The more detailed objectives for the LTMP were concerned with the area based man-agement and how this can be done in a more transparent and stable manner than hitherto experienced. The separation between the TAC areas (Div. IIIa and SD 22-24) shall be upheld; however, the division of the catch opportunities between these two areas should be discussed, but finally carved in stone somewhere. The decision to divide the catch opportunities was concluded to be a subject for debate with the BSRAC, PRAC, Fishery representatives for all fleets, the Commission and representa-tives for the relevant governmental bodies. Thus it was decided to invite these highly relevant stakeholders to a meeting with the sole objective to reach agreement on the sharing of catch options and the IAV parameter of the LTMP. The meeting is planned to take place in April 2012 and will potentially be highly important for the planned work on a LTMP for the stocks in the area made by the Commission, STECF and Norway.

1.4.6 Scoping for Impact Assessments for Multi-Annual plans for Baltic Multi-species and cod in the Kattegat, North Sea, West of Scotland and Irish Sea (STECF EWG 15-11)

The EWG met from 28 November to 2 December 2011 in Edinburgh, for scoping the preparation of Impact Assessments for new management plans. The meeting involved observers (3 Commission staff, 14 managers and stakeholders) and 27 scientists dealing with (socio-) economics and biology and prepared for work on the following groups of stocks:

a) Impact Assessments for a new plan for cod, herring, sprat (and flounder) in the Baltic Sea.

b) Impact Assessments for new plans for cod in the Kattegat, North Sea, West of Scotland and the Irish Sea. For NS and consideration has been given to other demersal stocks. For WoS, IS and Kattegat more work is required to extend the cod advice to mixed species fisheries.

For each area (Eastern/Western Baltic, Kattegat, North Sea, West of Scotland, Irish Sea):

- The report provides information on the technical linkages between stocks in the area. For Baltic these interactions are of limited significance.
- The report provides a description of the status of understanding on biological interactions relevant for forward projection needed to give Impact Assessments.
- Only for the Eastern Baltic are the models sufficiently well developed and parameterised to account for multispecies interactions, though even for this area interactions are limited to later life stages. For NS and WoS biological interactions for cod are proposed, particularly for marine mammals. Proposals for approaches to incorporating the main linkages into multi-annual management plans are made for Baltic and NS and studies to consider MSY objectives for those plans in this context are proposed.
- Considerations are given to other objectives, relating to ecological and economic sustainability and for Baltic and NS modelling are proposed.
- Candidate management measures that could contribute to the delivery of the objectives of the plans are discussed and studies dealing with compliance and the opinions of stakeholders are proposed.
- The data, research and scientific advice needed to support the implementation of multi-stock management plans are identified,
- Major gaps in the availability of the relevant science are identified.
- Work plan for the work necessary to evaluate the potential impacts of these options are proposed.

The Impact Assessment report for multispecies plans for the Baltic should be prepared in March, provisional dates are 26-30 March 2012.

The Impact Assessment report for mixed fishery plans for NS and cod in WoS, IS and Kattegat should be prepared in June, provisional dates are 16-20 June 2012.

More work is needed to develop approaches to mixed fisheries in West of Scotland, Irish Sea and Kattegat. Its proposed that the needs for this work is considered at the next WG in March 2012.

1.4.7 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 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 2012. The PGCCDBS focused their approach to the recommendation system this year by underlining the importance of Expert Groups prioritising their recommendations on data issues as being either urgent data problems affecting advice quality or important but not urgent and a scope for longer term strategic studies.

Recent changes in data collection (e.g. through the revised EU DCF) were reviewed and the need for workshops was defined. PGCCDBS provided views on the revision of the Data Collection Framework, focusing on the need for statistically-sound, regional sampling programmes and task-sharing to improve cost effectiveness.

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.

The WKNARK workshop initiated by PGCCDBS in 2010 took place in 2011 for all National Age Reader Coordinators reviewed preparation methods by species and areas, material and techniques development, methods in images processing, and the validation methods for the purpose of inter-calibration between ageing labs. WKNARC reviewed tools for the exchanges and workshops (WebGR, PGCCDBS Guidelines for Otolith Exchanges). One of the expected outputs from the follow-up WKNARC in 2012 will be a review of the means of dealing with uncertainty in relation to age data in assessments, which in turn will be of major interest for assessment working groups.

1.4.8 WKFRAME III and WKLIFE

WKFRAME II met in early January 2012 to consider further refinements to the form of advice for stocks without population size estimates. In February WKLIFE met to consider life history approaches to stock assessment and the provision of advice. WKLIFE formed the basis of an advice drafting group to update the introduction to the ICES advice. At time of writing there was no guidance available from ACOM on how advice will be framed in 2012 for stocks without forecasts. WKLIFE considered 7 categories of stocks, and classified the stocks within HAWG into these, as follows:

1) – data rich stocks (quantitative assessments): North Sea and VIId herring, Celtic Sea herring, IIIa and Sub-division 22-24 herring, VIaN herrig.

2) – negligible landings stocks: None in HAWG.

3) – stocks with analytical assessments and forecasts that are only treated qualita-tively: Herring, Irish Sea; Herring VIaS, VIIbc.

4) – stocks for which survey-based assessments indicate trends: Sprat North Sea; Herring VIaS, VIIbc.

5) – stocks for which reliable catch data are available for short time-series: None in HAWG.

6) – data-limited stocks: Sprat IIIa; Sprat VId,e, Sprat Celtic Seas Ecoregion; Sprat North Sea

7) – stocks caught in minor amounts as by-catch: None in HAWG.

HAWG broadly agrees with this categorisation, at the time of WKLIFE writing its report. HAWG has made efforts to move stocks upwards in the categorisation, and this task will continue. In 2012, VIId,e sprat can now be classified as 3 and/or 4.

1.4.9 Multi Species Benchmark in the Batic

The multi-species benchmark for the Baltic Sea is planned to take place during February 2013. WKBALT will meet in November 2012 for a discussion on the modelling framework, the input data needed, and for assigning tasks in preparation for the benchmark. WKBALT will focus on the species interactions in the central Baltic (Baltic sprat, central herring, and eastern cod stocks), but the western Baltic cod will also been included as a single-species benchmark assessment.

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 2011 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 20th February 2012. All nations generally deliver their data in due time or a 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)	14829	14261	593	40
IVa(W)	125054	84778	4003	32
IVb	51865	40197	2126	41
IVc	2790	2241	75	27
VIId	23860	14881	521	22
VIIa(N)	5202	3844	1745	336
VIa(N)	21358	13808	974	46
IIIa	35476	29934	10182	293
Celtic, VIIj	11470	11470	1770	154
VIa(S), VIIb,c	6789	6789	1680	247

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 by-catches in the industrial fisheries), that catches landed abroad should be sampled, and information on these samples should be made available to the national laboratories.

1.5.3 Terminology

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

1.5.4 Intercatch

"InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models". Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. Comparisons between InterCatch and conventional used systems (e.g., Salloc and spreadsheets) have been carried out annually since 2007. The comparison is available for a collection of stocks (her_47d3, her_vian, her_irls, her_irlw, her_nirs). Maximum discrepancies between the systems are presented in Table 1.5.2.

For Herring caught in the North Sea, these discrepancies were in general small. The overall landings calculated by both procedures for herring caught in the North Sea matches by 19 t. For herring caught in VIa (North) the overall landings calculated by both procedures differed by 850 t. During the HAWG, there was no time for further detailed analysis on this issue.

Catch input data for the North Sea herring assessment are estimated in two runs, one for herring caught in the North Sea and a second one for NSAS and WBSS herring in the North Sea, to which splitting of catches has applied (due to the mixing of WBSS and NSAS in Subdivision IVa(E) and Division IIIa). So far, InterCatch offers only the opportunity to keep one final dataset for the stock. An opportunity should be implemented to store both dataset separately. When catches were splitted and broken down by area and stock, large differences occur by unknown reasons, while the overall estimates were still comparable. During HAWG, there was no time for further detailed analyses on this issue.

Furthermore, InterCatch does not provide the needed output for Division IIIa. Information on numbers-at-age and weight-at-age of NSAS for this area is not available. This is a major concern as these estimates are an essential need as input data for the assessment. Consequently, InterCatch could not be used for NSAS and WBSS solely unless this output is produced and no valid comparison is available on CANON and CATON including the splitting procedure.

Another issue in 2012 was the data upload from national coordinators during the HAWG. These uploads had overwritten the already imported catch and sample data. Some contained errors (locating landings to wrong areas) or non-representative samples (due to very low numbers of fishes aged or measured) and have interfered with the calculations done in the meantime. It took quite some to detect these errors. Data had to be deleted and the original file had to be re-uploaded and the allocations had to be redone. This happened two times during HAWG and was really time-consuming.

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 FLSAM

The assessments of Irish Sea and North Sea herring were carried out using FLSAM which is an R-platform to run SAM, a Spate-space stock assessment model. This model has the standard exponential decay equations to carry forth the N's (with appropriate treatment of the plus-group), and the Baranov catch equation to calculate catch-at-age based on the F's. The additional components of SAM are the introduction of process error down the cohort (additional error term in the exponential decay equations), and the random walk on F's. The steps (or deviations) in the random walk process are treated as random effects that are "integrated out", so are not viewed as estimable parameters. The sigma parameter controls how large the random walk deviations are, and this parameter is estimated. SAM provides the option of correlated errors across ages for the random walks on F, where the correlation is an additional parameter estimated to be estimated. This option of SAM was not used in HAWG.

1.6.4 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.

1.6.5 SHORT TERM PREDICTIONS

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 MFDP 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).

1.6.6 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.

1.6.7 FMSY management simulations

For the medium term projections to outline FMSY 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.

North Sea herring deterministic reference points were estimated using R-routines based on FLR. See Stock Annex for a description.

Irish Sea herring Fmsy reference points were estimated by means of stochastic simulations carried out by means of plotMSY, software developed by Cefas.

1.6.8 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.

1.7 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 countries conducted observer programmes in 2011: The Netherlands, Germany and Ireland. Scotland discontinued its observer programme in 2011. Of the nations that conducted observer programmes, only that of the Netherlands recorded discarding in 2011.

Irish Observer Programme

Of the 37 observed trips on board Irish RSW and dry hold vessels in 2011, negligible levels of discarding (slippage) occurred. It is not clear how representative this is for any of the Irish pelagic fisheries. In the case of the Celtic Sea herring fishery, there is good evidence that discarding has become a feature of the fishery in the past two seasons. The small individual boat quotas available in the Celtic Sea herring fishery are likely to result in discarding (slippage) of some excess catches, by the larger RSW-type boats. This effect is considered to have increased in the past two seasons as the

TAC has risen sharply and the number of vessels participating has increased. Further information on this is presented in Section 4.

German Observer Programme

The German observer programme covered 1 trip on a pelagic freezer trawler in 2011. No instances of slippage from the RSW holding tanks was observed. It should be noted that there is no information from this programme on discarding from the conveyor belt, or if this is a significant source of discarding.

Dutch Observer Programme

The amount of discarded herring for the pelagic Dutch-flagged vessels fishing in Euro-pean waters was estimated for 2011 (van Helmond and van Overzee, 2012, WD). Discard estimates were derived from the Dutch observer programme (Data Collection Framework), and raised to the fishery by trip (Table 1.7.1). In 2011,15 trips were monitored on board pelagic freezer trawlers (Table 1.7.1; Figure 1.7.1). Herring discards were observed during 10 trips; 9 trips on board Dutch flagged vessels and 1 trip on board a French flagged vessel (Figure 1.7.2), with all trips being treated as belonging to the same fleet.

On board trawlers, the crew generally sort out the catch and unwanted catch is removed from the conveyer belt and flushed over board, i.e. discarded. During the observer trips biological samples are taken from both the catch and the discards which allows to estimate the amount of discards per species per trip. Total discard weight per species and trip has been raised to fleet level by the total number of trips of the Dutch fleet in that year. When target species are not caught during a sampled trip, they are marked zero (Van Helmond & Van Overzee 2009; 2010; Van Overzee & Van Helmond, 2012). The raised herring discards, solely based on sampled information, are presented in Table 1.7.2 and Figure 1.7.3. In 2011, the raised herring discards was estimated at about 892 tonnes (CV of 28%).

The data collected by the scientific observers show that occasionally part of or the whole catch is discarded without sorting; relatively large amounts of catch are released directly or via the conveyer belt from the cooling tanks or directly from the net. In this working document this type of discarding is referred to as "unsampled discards". As it is impossible for the observers to biologically sample unsampled discards, accurate numbers per species cannot be calculated. It was therefore decided not to include unsampled discarding in the raised herring discards. While we recognize that by not including them this result in an underestimation of the herring discards, we believe that leaving out this correction is decreasing the noise in the data, and therefore a more desirable approach in estimating herring discards. In 2011, unsampled discards are estimated at 5,219 tonnes (raised to year).

The annual landings of the Dutch pelagic fleet show that this fishery is seasonal. It is therefore not surprising that the discarding of herring differs between fishing season. Discarding of herring was observed during quarters 2, 3 and 4 in 2011. Unfortunately, due to poor sampling resolution the sampling coverage was not optimal; raising the observed discards by quarter gives a CV of 33%-35% (Figure 1.7.4). It should be noted that these estimates are not as robust as those that are raised by year (CV of 28% in 2011) and are only given for indicative purposes. The length frequency shows that there appears to be very little selection by size between landed and discarded herring (Figure 1.7.5).

Due to the poor sampling resolution it is not possible to estimate herring discards by stock or to create numbers at age matrices (see Dickey-Collas *et al.*, 2007; Borges *et al.*, 2008). In the future it may be possible to estimate discards by age. However, this will not be possible under the current sampling strategy. The variance will increase when attempting to estimate to stock or area level. Thus, at present only total annual discards of herring can be estimated.

Table 1.7.1: Overview of the fleet activity and number of trips observed in the Dutch pelagic fleet by year (2003-2010).

	NUMBER TRIPS PELAGIC DUTCH FLAGGED FLEET	NUMBER SAMPLED TRIPS
2003	131	5
2004	131	6
2005	142	12
2006	122	12
2007	124	12
2008	110	12
2009	93	11*
2010	91#	8 **
2011	77	15 ***

* This includes 9 trips on board Dutch flagged vessels, 1 trip on board a German flagged vessel and 1 trip on board a British flagged vessel. Trips on board foreign vessels were treated as if they belonged to the Dutch fleet.

** This includes 5 trips on board Dutch flagged vessels, 1 trip on board a German flagged vessels and 2 trips on board British flagged vessels. Trips on board foreign vessels were treated as if they belonged to the Dutch fleet.

*** This includes 14 trips on board Dutch flagged vessels and 1 trip on board a French flagged vessel.

Number of trips have been adjusted according to the most recent information

Table 1.7.2: Overview of raised herring discards and Standard Error by the Dutch pe-lagic freezer trawler fleet per year.

YEAR	HERRING DISCARDS	STANDARD ERROR
2003	6350	4452
2004	2825	2398
2005	3683	1835
2006	2747	1462
2007	2238	1011
2008	1052	387
2009	2173	1136
2010#	646	417
2011	892	247

As the number of trips have been adjusted according to the most recent information, this estimate differs from the previous estimate.

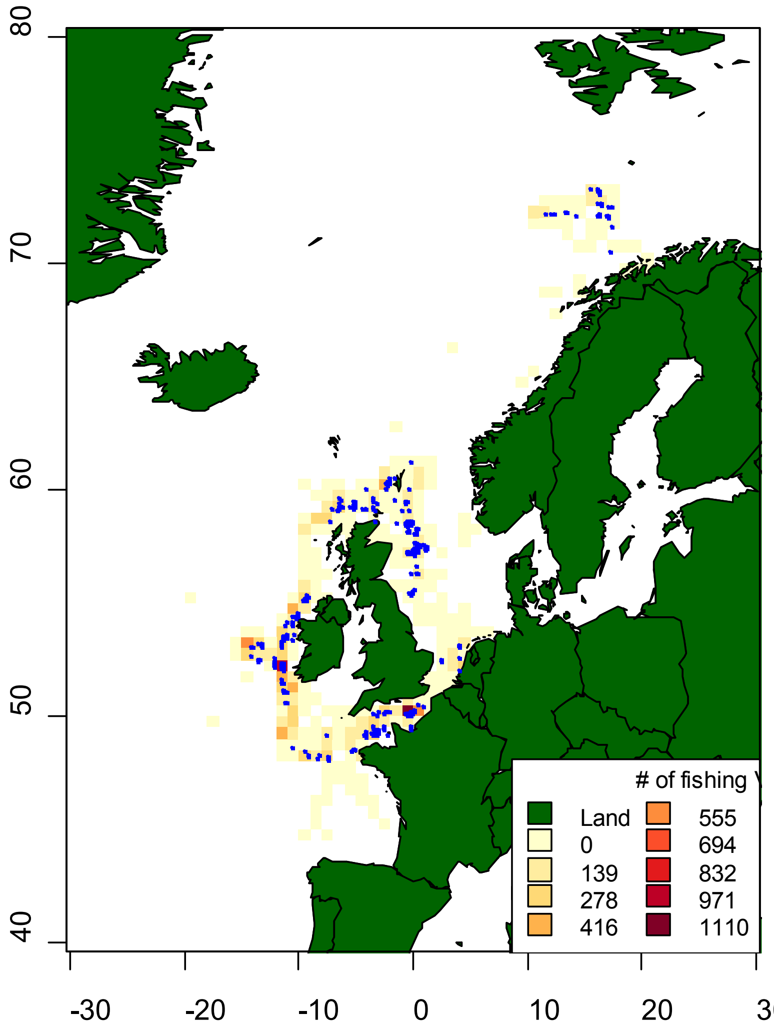


Figure 1.7.1: Distribution of the Dutch pelagic fleet (based on VMS data) and positions of the sampled pelagic discard trips per haul for 2011 (blue points). Discards that were observed in Norwegian waters were not thrown overboard but frozen as waste product.

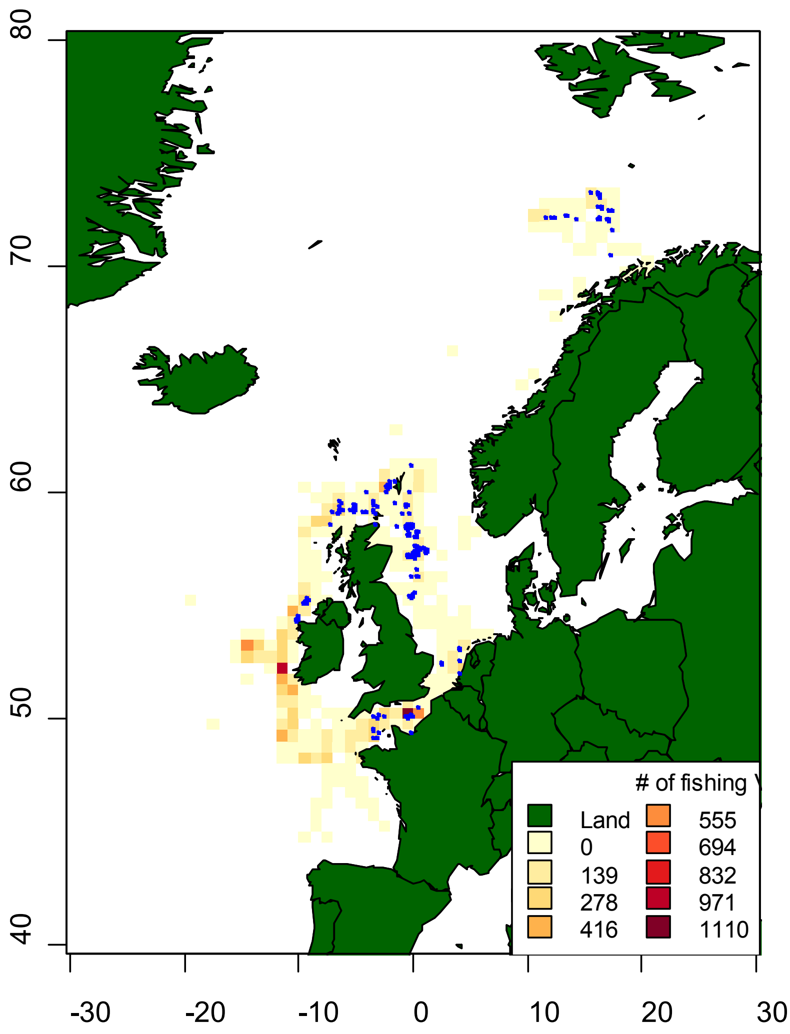


Figure 1.7.2: Distribution of the Dutch pelagic fleet (based on VMS data) and positions of the sampled pelagic discard trips per haul for 2011 where herring discards were observed (blue points). Discards that were observed in Norwegian waters were not thrown overboard but frozen as waste product.

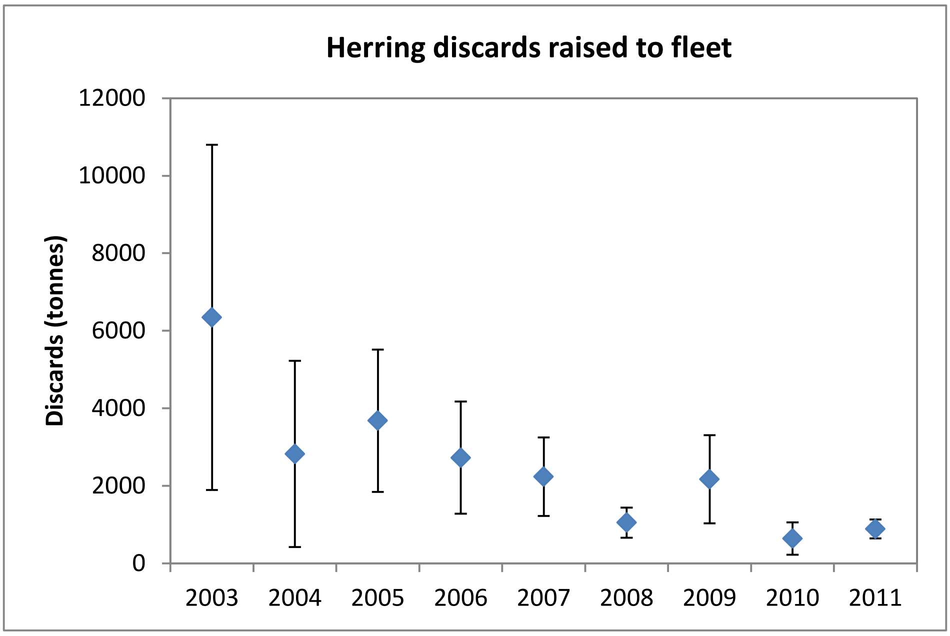


Figure 1.7.3: Raised herring discards by the Dutch flagged pelagic freezer trawler fleet per year (2003-2011 from all ICES areas). Error bars denote ±SE.

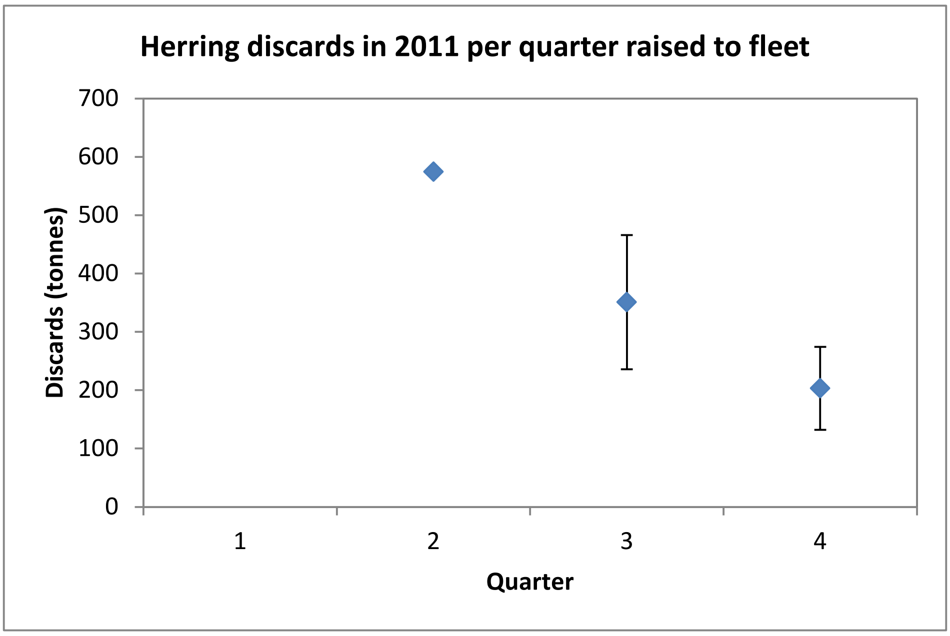


Figure 1.7.4: Estimates of raised herring discards by the Dutch pelagic freezer trawler fleet per quarter for 2011 (from all ICES areas). Estimates are based on one trip per quarter. Error bars denote ±SE.

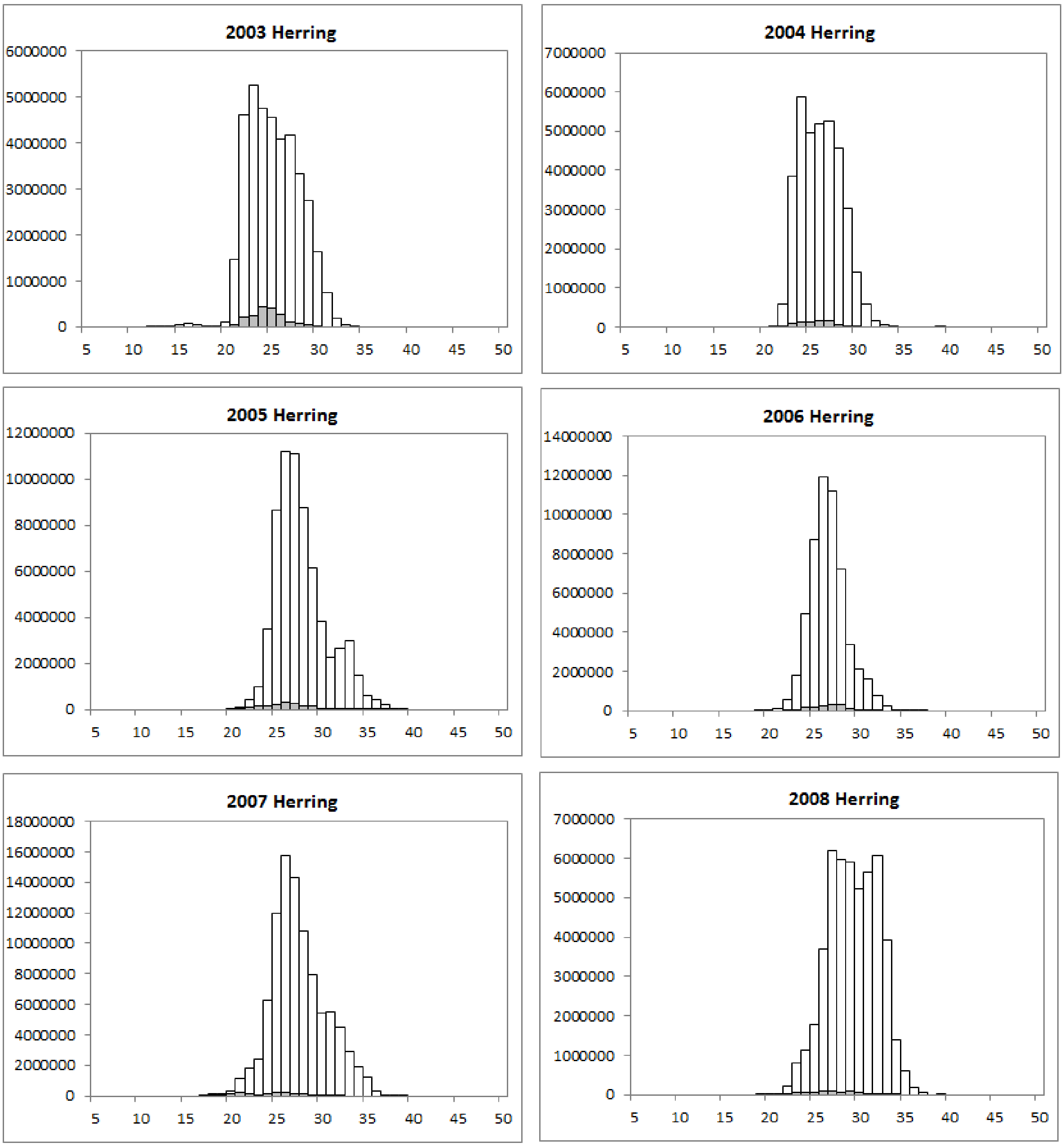


Figure 1.7.5: Numbers of herring landed and discarded against length (cm) by the sam-pled Dutch pelagic freezer trawler in 2003-2011.

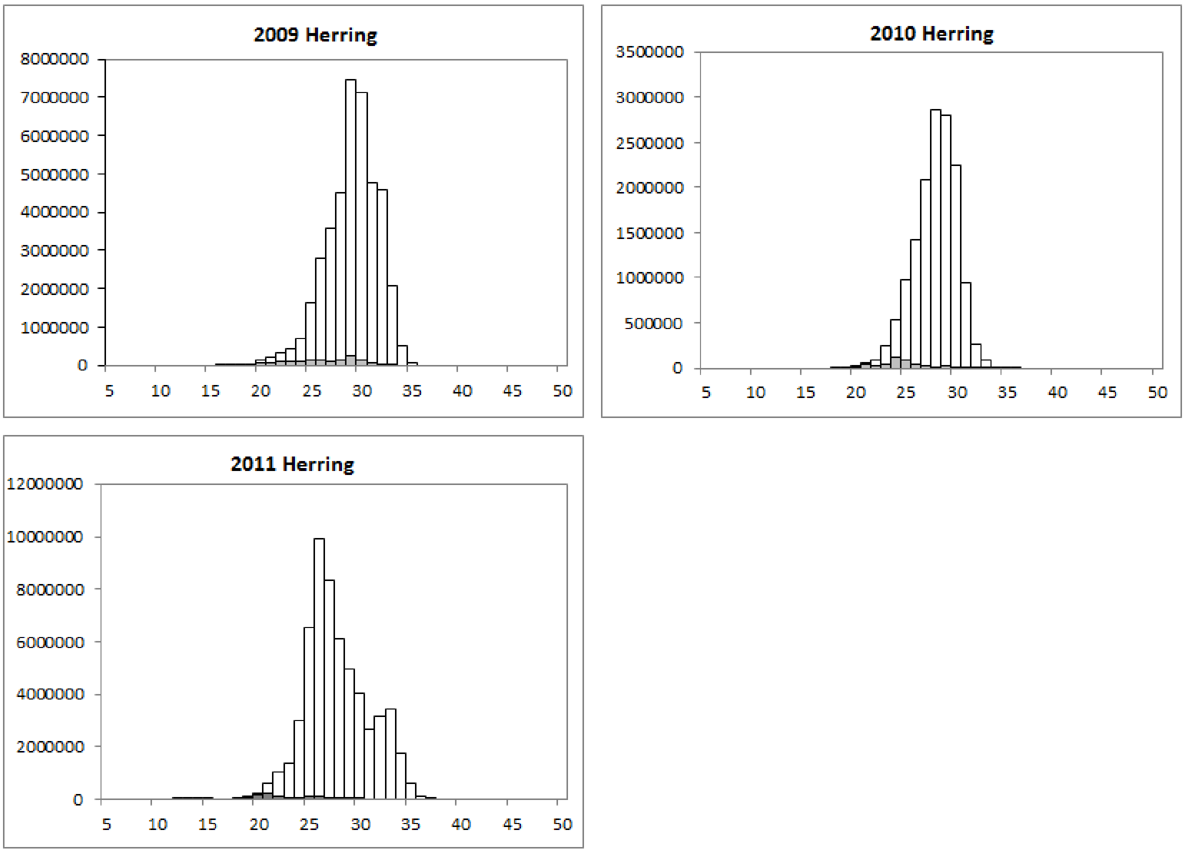


Figure 1.7.5: Continued.

No other nations reported on discards of herring in the pelagic fisheries. 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, it 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.

In conclusion it is not known to what extent discarding and slippage occurs in herring fisheries, and further work is required.

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 is based on single species dynamics mostly without considering environmental or ecosystem interactions of drivers. The system is generally assumed to be stable and management advices are given based on the assumption of equilibrium in the system and stationarity in the relationships. These assumptions are not appropriate for most fish stocks (ICES 2011), particularly for herring or sprat stocks (Nash *et al.*, 2009). Although progresses have been made towards incorporating ecosystem drivers in advice (e.g., through integrated assessment WGs) a lot of work needs to be done on finding appropriate ecosystem drivers for implementation into fisheries advice. This includes gaining more knowledge on the key forces driving ecosystem and fish population dynamics, but also developing an advice framework able to incorporate ecosystem considerations as informative priors. Moreover, very few cause-and-effect relationships have withstood the test of time (Myers, 1998) and ecosystem regime shifts and alternative stable states may hide new relationships within ecosystems.

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 human-induced environmental effects such as hydrographical, climatic, chemical influences, etc.).

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. In trying to project the productivity of North Sea herring forward, it is clear that recruitment adds most of the 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, 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.*, 2011) 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 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 suggests 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 still 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) found 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. Further research is definitely needed 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 how migration may be impacted by environmental changes, and this may affect the assessment or management of North Sea herring. Likewise the impact of herring on the North Sea ecosystem is difficult to predict (Dickey-Collas *et al*., 2010a). Herring population may impact on the cod productivity (Speirs *et al*. 2010; Fauchald, 2010) and simulation studies suggested that the cod stock recovery may be dependent in some extent on the size of the 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, Olsen *et al*., 2011). It is still unclear whether the population dynamics of the North Sea autumn spawning herring are controlled by 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. Disentangling and quantifying the relative contribute of the parental and environmental effect on herring stocks dynamics will influence the management of these stocks 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 under minor or gradual changes in the environment, the benefits from the implementation of eHCRs are difficult to be evaluated. 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 is currently lacking.

The recent benchmark (see WKPELA 2012, and paragraph 2.14 in this document) carried on the North Sea herring stock (NSAS) gave the opportunity to link the assessment of this stock with fundamental features of the ecosystem. The 2011 assessment of NSAS includes variable estimates of M directly derived from the integrated assessment for the North Sea. Moreover, a spawning-components abundance index (i.e., SCAI) able to account for changes in the relevance of the different spawning components for the NSAS has been adopted in the 2011 assessment with the aim to incorporate important elements of the population structure, but also the effect of environmental heterogeneity on recruitment success.

In conclusion, numerous studies highly improved our understanding on the effects of environmental forcing on the herring stock productivity and dynamics, however at present the potential to further include this understanding into the provision of management advices is limited. HAWG recognizes that information on the environmental drivers affecting the productivity of the herring stocks is still limited, and more research effort is required.

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 are 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 within 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 FMSY, 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 does 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 FMSY 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.

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 in the waters between Sweden and Denmark, the whole North Sea, and the waters around the UK and Ireland.

Descriptor 6 – sea bed integrity. Although most pelagic fisheries are expected to have limited impact on the sea bed, HAWG recommends that an assessment of the potential pressures of pelagic fisheries on the seabed should 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 (SI-ASM).

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 which indicators are available for assessment purposes and suggest those currently lacking. Moreover, it is relevant to identify which species and habitats need protection, for instance through the

identification of key species and essential 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 Common Fisheries Policy (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 the characterization of 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]

Again in 2012, the Pelagic RAC sent a communication to HAWG, expressing concerns on three stocks. HAWG considered these concerns and incorporated them into the work of the group. The communications are given below for each stock.

VIaN herring: "The Pelagic RAC acknowledges that the EU is ambitious in implementing an ecosystem approach in the management of fish stocks and in relation to this issue the Pelagic RAC considers that substantial predator-prey interactions exist between this stock and local seal stocks. Some RAC members representing fishermen in the VIaNorth area wondered whether it would be possible for HAWG to take account of mortality by seal predation in the assessment of this stock. If not, the Pelagic RAC would appreciate any information coming from HAWG on what would be necessary to do so in the future."

HAWG suggests that this stock be benchmarked in 2015. At that point, the natural mortality values used as inputs to the assessment will be reviewed, and if the deemed appropriate, shall be revised. HAWG is aware of work underway on multi-species assessment in the North Sea, and of future plans to carry out similar work in VIa. It is expected that this will take place over the next 3 years.

IIIa spring spawning herring: "On a number of occasions, this stock has been discussed in the Pelagic RAC and it should be acknowledged that there are very many complexities to the scientific advice as well as the management of this stock. Two issues have been raised which may be interesting to HAWG to consider in the context of the assessment for this stock. First, some members representing fishermen in the IIIa area have wondered whether ICES is considering the possibility that local stocks that were present in the IIIa area in the past but declined in abundance have shown recovery in recent years. If HAWG is in the opportunity to provide information on this specific issue, this would be well appreciated by the members of the Pelagic RAC.

A second issue is in relation to the management of the stock which is highly dependent on the observed and expected ratio of fish caught in area IIIa. This mix of fish originating from North Sea herring and Western Baltic herring is sampled to determine the percentage ratio between the two. The question arose whether HAWG felt that the sampling scheme for this purpose is suitable to establish a reliable estimate on this mixing ratio, especially in relation to whether the sampling scheme is representative in time and space of the fishery?"

HAWG is aware of both these concerns and is incorporating them into its issue list for the forthcoming benchmark in 2013.

North Sea herring: "It was noted at the latest Pelagic RAC meeting that HAWG has included statements in its reports in the past that density dependence effects have been observed in the North Sea herring stock. At the latest meeting of the Pelagic RAC, a presentation was held by Ad Corten who presented his views and hypothesis that a possible mechanism, which could explain these observations could be cannibalism. Some members wondered whether it is feasible for HAWG to address these views and if appropriate, try to estimate and incorporate effects of cannibalism in the assessment of this stock in the future? Any comments on what would be needed to determine these effects and/or how to take account of them would be much appreciated. For more detailed information, Ad Corten's views are attached to this letter."

HAWG notes that the benchmarking work conducted on this stock in 2012 did not finally incorporate cannibalism in assessment, stock-recruitment modelling or the forecast. However, HAWG invited Ad Corten to present a guest lecture on this subject (Corten, 2012 WD) and the considerations were debated. It is unknown if cannibalism is a significant impact on productivity of the stock. More work can be conducted on this question, and various hypotheses were considered by the group. Further work is required to resolve this matter before any possible implications for management would be considered.

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

Assessment Working Group (AWG) recommendations

During HAWG 2011, 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 2011 report). The PGCCDBS reviewed AWG reports with respect to recommendations addressed to PGCCDBS. The relevant recommendations from HAWG to the PGCCDBS and the response is listed in the below table.

Stock	Data problem	How to be addressed/ by whom	PGCCDBS Comments
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 refers this dataproblem to the applicable RCMs to specify a sampling strategy.		
Sprat in the North Sea	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	Increase sampling commercial catches, particularly with regards to spatiotemporal coverage	Under the curent DCF reference year 2007-2008 are used. Based on this reference, sampling is designed. MS are bound to the legal

	1000 tonnes)		DCF Regulations.
Need to be forwarded to RCMNS&EA 2012. They can provide an overview of the sampling. Recommendation level of 0.5 samples per 1000 tonnes do not hold anymore.			
ViaS/VIIbc herring	Consider effect mixed autumn and spring spawners on interpre-tation of winter ring	Interreader calibration within Ireland	Expertise of interpretation of winter ring with differimg birth dates available in Ireland
Clyde herring	Poor sampling has been performed for this stock for years	Sampling of age-weight-length infor-mation needed	No action taken by PGCCDBS referring to National Laboratories in UK to solve this sampling issue
Components within the Malin shelf her-ring acoustic survey (MSHAS)	Continuation of the survey by all National Laboratories and split-ting the index into stock components is highly warranted	The survey should be written into the DCF by the relevant coun-tries – and incorporate splitting methodology and sampling of indi-viduals for this in the survey design. G*et al*l participating coun-tries to split their herring into stock IDs	PGCCDBS refers this dataproblem to the applicable RCMs to specify a sampling strategy. No further action by PGCCDBS
All stocks	HAWG is concerned about the lack of in-formation on discard-ing levels in the herring fisheries.	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.	This comment was discussed at PG and RCMs in 2011. It is recognised that the 'observer effect' on board pelagic vessels can be detrimental to collection of accurate data. The new CFP will probably introduce a total discard ban on pelagic vessels in the first instance. This will have implications on future pelagic observer programmes.

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.		
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. PGCCDBS should push for this to happen
Sprat in the Celtic Seas (Subarea VI and VII)	No ALK are available for sprat in this eco-region	Collation of age-length keys of sprat in the Celtic Sea and West of Scotland should be done. A first step should be to validate the ageing of sprat from this area. HAWG recommends including available material on this part of the sprat stock complex in the upcoming large-scale exchange on Sprat in the North Sea.	PGCCDBS and Lotte Worsøe Clausen who is coordinating the planned exchange

1.11 Stock overview

The WG was able to perform analytical assessment for 5 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. 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 FMSY and management plan target. A new assessment was presented this year based on the recent benchmark.

The new assessment partially changed our perception of the stock, particularly in terms of the adult stock size. SSB in 2011 was estimated at 2.34 x106 tonnes, F2-6 in 2011 was estimated at 0.09, hence far below the target F2-6 of 0.25. Recruitment appears still in the same low regime since 2002. A small decrease in SSB is expected from 2011 to 2012 due to the higher TAC in 2012. In all the scenarios, except under a no-fishing regime, a further decrease is expected in 2013 and in 2014, including the management plan (2.0 million and 1.7 million tonnes, respectively). SSB is expected to be well above Btrigger, and therefore also Bpa, in the period 2012-2014.

Western Baltic Spring Spawners (her-3a22) is the only spring spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the Subdivisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners, and recently mixing with Central Baltic herring stock has been reported in the western Baltic area. Our assessment found that SSB slightly decrease from 2010, and the 107 000 tonnes estimated for 2011 repre-sent a new minimum over the whole time series. Beside this, fishing mortality in 2011 decreased from 2010. F3-6 has been estimated at 0.20, hence below Fmsy (0.25). The recruitment in 2011 is slightly lower than the good year class estimated in 2010, but appears still higher than the low estimates that characterized the late 2000s.

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 2011 assessment revises the SSB estimates downwards, but still supports previous indications of a recovery of the stock. SSB in 2011 is estimated to be approx. 85 000 tons, and continue to be above the Bpa reference of 61 000 t. Mean F2-5, although it slightly increased since 2009, remains at a low level. In 2010-2011 dis-carding showed an increase due to the small weekly quota, but no quantitative evaluation was possible. Short term projections under the rebuilding plan show a rather stable trajectory of the stock for the next year, and . all the scenarios show that SSB will be above Bpa in 2014.

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. SSB in 2011 has been estimated at approximately 82 200 tonnes (+33% from 2010). Fishing mortality in 2011 was estimated 0.18 (-33% from 2010), and it is now below the F target of the management plan (0.25). The 2008 recruitment appears to be the highest in the last ten years. The forecast shows that SSB (in 2012) will be approx. 1.7 times Blim. 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. In 2011 almost all the catches were reported in ViaS. Recruitment has been stable at a very low level or declining in recent years. Recruitment has been poor in recent years, though there is evidence that the 2008 year class was above the recent average. The current levels of SSB and F are not precisely known, however, there are indications that the stock is on a historically low level. In all our explorations SSB has been estimated below Blim. Es-timates of F for recent years are likely to exceed 0.5, though current F is unknown.

Herring in the Irish Sea (her-nirs) comprises two spawning groups (Manx and Mourne). This stock complex experienced a decline during the 1970s. In the mid-1980s the introduction of quotas resulted in a temporary increase, but the stock continued its declined from the late 1980s up to the early 2000s. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability in spawning migrations and mixing with the Celtic Sea stock. This assessment indicates an increase in SSB, estimated at 18 800 t in 2011, and recruitment in recent years, with an associated downward trend in F (0.25 in 2011). Catches have been relatively stable since the 1980s, and close to TAC levels in recent years. Based on the most recent estimates the stock is being harvested sustainably and below FMSY.

North Sea Sprat (spr-nsea) is mainly targeted by the Danish fleet in the North Sea (80% of a total catch of 134 000 t). The catches are usually dominated by recruits (age 1) but their contribution was below the average in 2011. The stock is dominated by age 1-2 fish. Due to the short life cycle and early maturation, the majority of the stock consists of mature fish. The mean-weight-at-age was comparable to the estimates for the previous years. The stock, known for its large fluctuations in size, shows a positive trend in the survey indices. Beside the acoustic survey (HERAS) covered a smaller sampling area this year, estimates of the stock biomass (444 000 t in 2011) suggest an 18% increase from 2010. The state of the stock is uncertain, but there are indications for a positive trend.

Sprat in IIIa (spr-kask) is mostly caught by a small-meshed industrial fishery from Denmark, Sweden and Norway in decreasing order of amount landed. 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 sprat TAC (52 000 t in 2012), herring by-catch quota (6 659 t in 2012), and 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. The total landings in 2011 (10 700 t) were similar to the landings in 2010. 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 eco-region (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 eco-region are caught by small pelagic vessels that also target herring, mainly Irish and Scottish vessels. No advice or TAC has been given in 2010-2011 for sprat in this eco-region. The quality and amount of information available for sprat is rather heterogeneous across this composite area. There is evidence from different survey sources of significant inter-annual variation in sprat abundance. Landed biomass, but not biological information on the catch, is available from 1970s in some areas (i.e., VIa and VIIa), while acoustic surveys started in 1991, with some gaps in the time series. The state of the stock is uncertain; no analytical assessment is available for sprat in the Celtic Sea eco-region.

1.12 Benchmark process

HAWG has made some strategic decision regarding the future benchmarking of its stocks (Table 1.12). In 2012 North Sea and Irish Sea herring stocks. In 2013 it is proposed to benchmark the western Baltic spring spawning herring stock. In 2015, it is proposed to benchmark VIaN and VIaS and VIIbc together. Before this happens it is necessary to successfully split the Malin Shelf survey (MSHAS) according to season of spawning. If this is not possible, then a modelling approach is required to deal with the fact that both stock are relying for tuning on an acoustic survey that covers both stocks. . In 2014 it is proposed benchmark the Celtic Sea herring.

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	2012	No	No		Consider mixing with IIIa in 2013
WBSS	Update	2008	Yes	NO		Consider mixing with North Sea in 2013
VIaN	Update	Never	2015	yes	Splitting of VIaN and Malin surveys	Consider stock mixing with VIaS/VIIbc
Celtic Sea	Update	2008	2014	No		Consider stock mixing withVIIaN
VIaS/VIIbc	Exploratory	Never	2015	yes	Splitting of VIaN and Malin surveys	Consider stock mixing with VIaS/VIIbc
VIIaN	Update	2012	No	Yes	Consider mixing with Celtic Sea	Consider stock mixing with Celtic Sea
Sprat NS	None	2009	Yes		2013	
Sprat IIIa	None	2009	Yes		2013	
Sprat VIId,e	None	Never	Yes			
Sprat Celtic	None	Never	Yes	No	2013	Need to evaluate stock identity

Benchmark planning

Sprat and herring will be dealt with in two separate benchmark groups next year. The Issue Lists for the benchmarks in 2013 are presented in Annex 13 to this report.

1.13 Assessment and forecast auditing process

HAWG performs independent audits of individual assessments and forecasts. This process continued in 2012 and no discrepancies were found in any case. The choice of assessment model, the model configuration and the data used in the assessments of Via N, Celtic Sea, North Sea, Western Baltic and Irish Sea herring were checked against the corresponding settings described in the Stock Annex. The results of the auditing process are summarised in the Table below.

Stock	Model used	Model configuration	Catch data	tuning data	Nat mort
VIaN	FLICA *V*	*V*	1957 to date	VIaN acoustics	*V*
Celtic Sea	FLICA *V*	*V*	1958 to date	Acoustic survey (CSHAS); ages 2-5. (2)	*V*
North Sea herring	FLSAM *V* (1)	*V* control file checked	1947 to date	HERAS, SCAI, IBTS 0 & 1	from SMS 1663 - 2010 (3)
WBSS herring	FLICA *V*	*V*	1991 to date	HERAS,GERAS,N20(larvae)	*V*
Irish Sea herring	FLSAM *V*	*V* control file checked	1961 to date; 2008 missing	Acoustics and NINEL (larvae)	*V*

(1) SAM model Version has changed from version 7 to 17 which was tested as providing the same output for NSAS.

(2) The survey tuning data includes the new stratum 20 in the survey.

(3) The procedure to estimate M outside the data was run as specified in the Annex.

All in all the results of this process indicate that HAWG update assessments were car-ried out according to the Stock Annex.

1.14 Incorporating Environmental Signals into Advice

HAWG this year discussed the question of how knowledge about the physical and biological environment could be incorporated into the advice. Recruitment predictions were widely viewed as the most desirable quantity: however, the working group also recognised that recruitment prediction is an extremely challenging task that has eluded fisheries science for over 100 years. Nevertheless, environmental variability is widely recognised as having a significant impact on both recruitment and the productivity of fish stocks. Furthermore, modern oceanographic observing systems generate a vast amount of data, at least some of which can give insight into the impact of the environment on a fish stock. In the absence of firm scientific understanding about the underlying mechanisms, the challenge is therefore attempting to identify the appropriate information and incorporate it into the advice-giving process. In particular, the use of qualitative considerations, rather than quantitative predictions, could form a key stepping stone along the way to improving the advice.

In an attempt to approach this challenge, HAWG has entered into a dialogue with the Working Group on Operational Oceanographic Products for Fisheries and the Environment (WGOOFE). Unfortunately many of the oceanographic products that are currently available do not exist in a form that can readily be incorporated into fisheries management. Furthermore, attempts to synthesise this data (e.g. ICES Report on Ocean Climate) into a more useable form, whilst valuable to the scientific community, cannot readily be incorporated into the advice drafting process. HAWG therefore discussed what specific products, in addition to those already in existence, could potentially be created to aid in the generation of its advice.

HAWG agreed that a "briefing sheet" providing an overview of the current state of the environment in regions of interest could be of use. Such a briefing sheet should be short and concise (e.g. 1 page text, plus figures), and describe the current state of following variables in relation to the long-term means:

- Temperature
- Primary production
- Zooplankton abundance

The suggested variables would ideally characterise some or all of the following spatial regions:

- North Sea
- Celtic and Irish Seas
- Malin Shelf
- Western Baltic, Skagerrak and Kattegat

The variables would ideally be presented on a seasonal basis covering the last year. Furthermore, expert interpretation, in addition to presentation of time series, would greatly benefit the usability of such products.

In addition, the North Sea herring group requested the generation of a specific set of indices that are thought to be of direct relevance to the survival of herring larvae. Fässler et. al (2011) suggested that there is a strong association between the temperatures on the spawning grounds and the survival of the early larvae. HAWG therefore requests the generation of indices of temperature anomalies on the four main spawning grounds (Orkney-Shetland, Buchan, Banks, and Downs) during the spawning period.

Furthermore, synoptic charts of prevalent currents in the Celtic Seas Ecoregion, including the English Channel could inform on eggs and larvae transport of sprat in this area.

HAWG will continue to discuss these issues with WGOOFE and other groups. WGOOFE will meet in November 2012, and therefore has the potential to address this issue before the next HAWG meeting. HAWG would therefore like to invite the WGOOFE group to present the results of their discussions on this topic to HAWG 2013, and to continue this dialogue.

1.15 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 2012 HAWG carried out five 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.
5) Irish sea herring

VIaS/VIIbc 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 stock identity of sprat in this area is still not solved, and no assessments were provided, though a review of available data is presented.

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

1.16 Recommendations

Please see Annex 2

Table 1.5.1: Available disaggregated data for the HAWG per March 2012. 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
	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
	2011	X	W		I	provided by Lotte Worsøe Clausen and Tomas Gröhsler, Mar. 2012
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
	2011		W		I	provided by Andrew Campbell, Mar. 2012
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
	2011		W		I	provided by Steven Beggs, Mar. 2012
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 200
	2000		W	D		provided by Christopher Zimmermann, Mar. 2001, updated Oct 200
	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
	2011		W	D	I	provided by Norbert Rohlf, Mar. 2012

Table 1.5.1: Available disaggregated data for the HAWG per March 2012. 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
	2011		W	D	I	provided by Emma Hatfield, Mar. 2012
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
	2011		W		I	provided by Andrew Campbell, Mar. 2012
Stocks with limited data						
(her_VIIe,f and VIII	2011	X				provided by Yves Verin, Mar. 2012)
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
	2011		W		I	provided by Richard Nash, Mar. 2012
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
	2011		W		I	provided by Katja Enberg, Mar. 2012
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
	2011		W		I	provided by Beatriz Roel, Mar. 2012

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

her-vian

2011 data		**canum**		**2011 data**		**weca**	
wr	sallocl	InterCatch	% discrepancy	wr	sallocl	InterCatch	% discrepancy
1	1667.19	1662.791	-0.3	1	0.0613	0.06122	-0.1
2	40587.92	37566.17	-8.0	2	0.155	0.1547	-0.2
3	15782.93	15190.71	-3.9	3	0.1894	0.18911	-0.2
4	10333.9	10106.55	-2.2	4	0.2178	0.21778	0.0
5	7190.29	6954.593	-3.4	5	0.234	0.23399	0.0
6	5071.43	4854.068	-4.5	6	0.2388	0.23873	0.0
7	3164.16	3125.347	-1.2	7	0.247	0.24664	-0.1
8	2611.38	2582.516	-1.1	8	0.2463	0.24615	-0.1
9+	7225.68	6924.728	-4.3	9+	0.2522	0.25218	0.0

NORTH SEA (47D3)

2011	CANUM	CANUM	Proportion	2011	WECA	WECA	Proportion
wr	Salloc	IC	Match (%)	wr	Salloc	IC	Match (%)
0	575132	575132	100.0%	0	0.0083	0.0082	101.2%
1	124072	124057	100.0%	1	0.0430	0.0430	100.0%
2	306293	305360	100.3%	2	0.1413	0.1413	100.0%
3	271359	270852	100.2%	3	0.1599	0.1598	100.1%
4	218034	218451	99.8%	4	0.1831	0.1832	99.9%
5	129721	130211	99.6%	5	0.1969	0.1970	99.9%
6	62752	62916	99.7%	6	0.2167	0.2168	100.0%
7	51877	52109	99.6%	7	0.2211	0.2211	100.0%
8	59892	60216	99.5%	8	0.2236	0.2234	100.1%
9+	65526	65326	100.3%	9+	0.2397	0.2398	100.0%
Sum	1864658	1864629	100.0%				

HER IRLW				
WG Excel	Intercatch	% Deviation		
Caton	Ring			
Canum	1	121	114	-5.65%
Canum	2	14207	14291	0.59%
Canum	3	9315	9337	0.24%
Canum	4	9114	9140	0.29%
Canum	5	3386	3352	-1.00%
Canum	6	3780	3748	-0.86%
Canum	7	2871	2847	-0.84%
Canum	8	980	958	-2.29%
Canum	9	95	91	-4.62%
Weca	1	0.094	0.095	1.06%
Weca	2	0.122	0.122	-0.31%
Weca	3	0.141	0.141	0.08%
Weca	4	0.174	0.174	-0.07%
Weca	5	0.193	0.194	0.42%
Weca	6	0.202	0.202	0.19%
Weca	7	0.217	0.217	0.08%
Weca	8	0.218	0.217	-0.24%
Weca	9	0.246	0.247	0.55%

HER IRLS	WG Excel	Intercatch	% Deviation	
Caton	Ring	11,470	11,470	0.00%
Canum	1	6384	6384	0.00%
Canum	2	17151	17151	0.00%
Canum	3	33453	33453	0.00%
Canum	4	7301	7301	-0.01%
Canum	5	13087	13087	0.00%
Canum	6	11738	11738	0.00%
Weca	1	0.07	0.070	-0.47%
Weca	2	0.104	0.104	0.20%
Weca	3	0.127	0.127	-0.04%
Weca	4	0.141	0.141	0.07%
Weca	5	0.154	0.154	0.05%
Weca	6	0.165	0.166	0.56%

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							

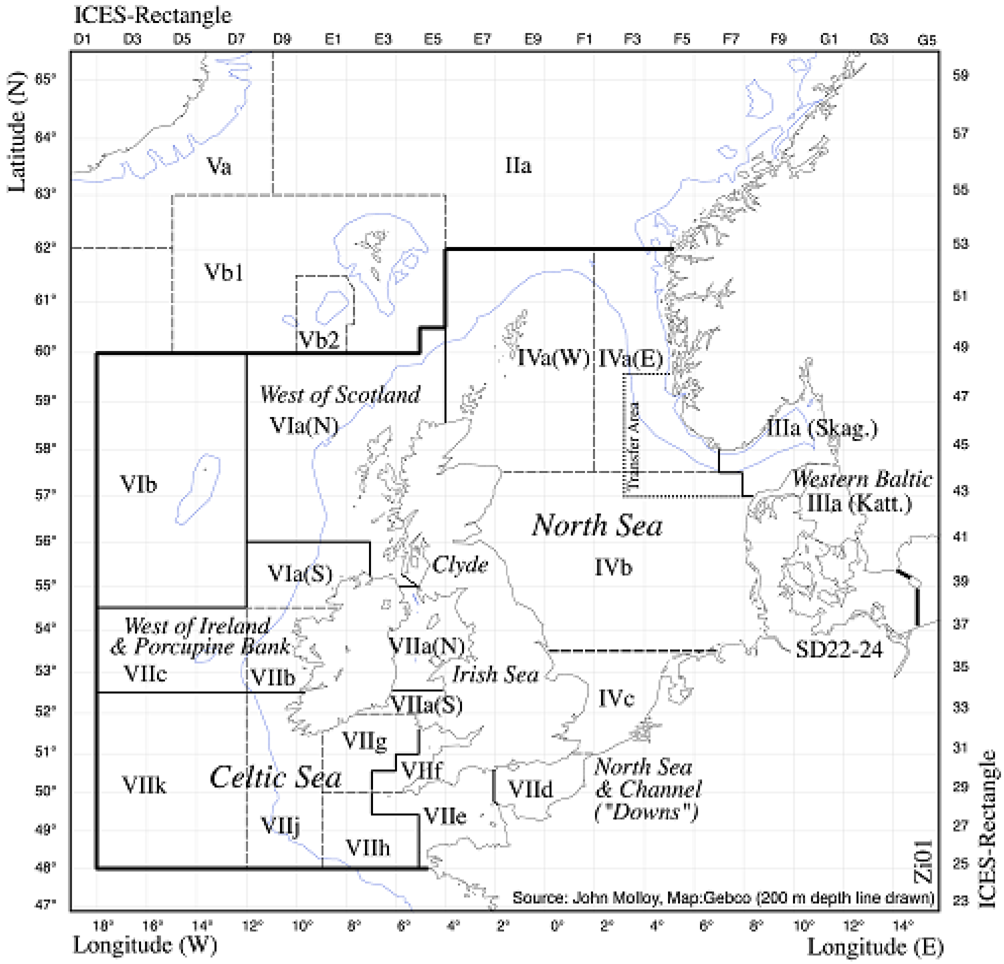


Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

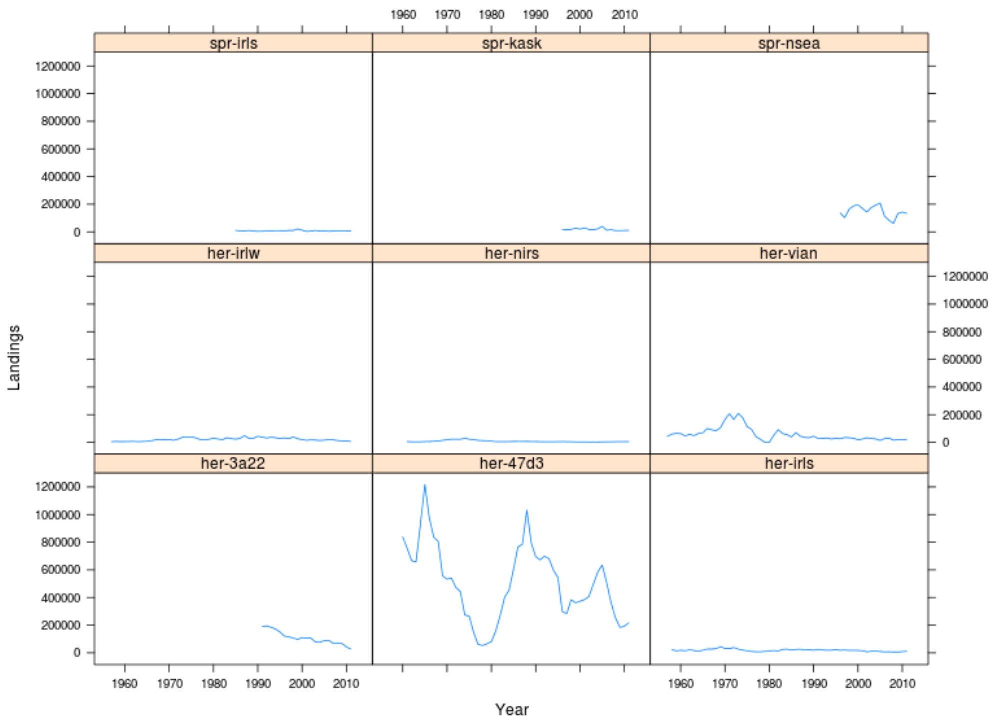


Figure 1.11.1 WG estimates of catch (yield) of the herring stocks presented in HAWG 2011.

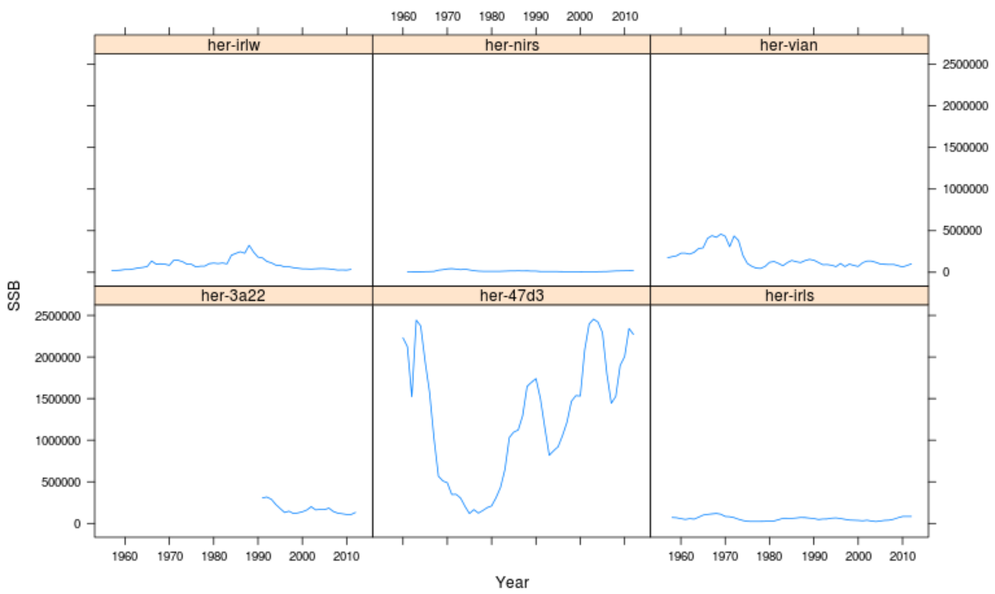


Figure 1.11.2 Spawning stock biomass estimates for the 5 herring stocks under analytical assessment, and for the exploratory assessment of the her-irlw, presented in HAWG 2011.

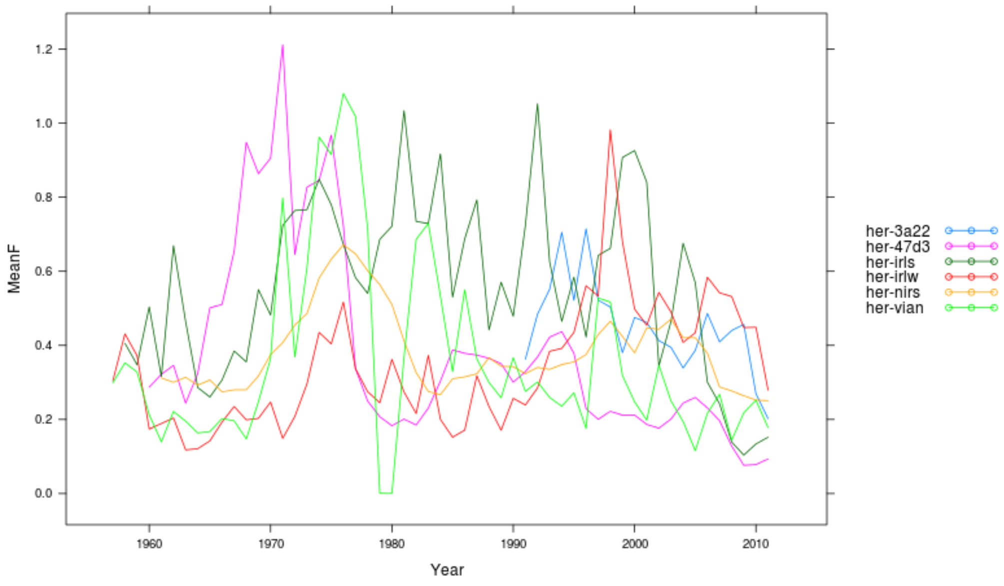


Figure 1.11.3 Estimates of mean F for the 5 herring stocks under analytical assessment, and for the exploratory assessment of the her-irlw, presented in HAWG 2011.

2 North Sea Herring

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2011 and 2012

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).

From January 2009 (EU Council Reg No 43/2009) high-grading and slipping of fish over the minimum landing size (as long as quota still exists) has been banned in EU waters. Discarding is illegal in Norwegian waters.

The EU–Norway agreement calls for a review of the current plan no later than December 2011. This has however not been performed and the demand for a full scale Management Strategy Evaluation and thus a revision of the North Sea Herring Management Plan has now increased considerably in the light of the changes made in the benchmark assessment performed in WKPELA 2012. The benchmark assessment has led to revisions of the perception of the stock and suggests that F_{msy} as well as a target-F should be reconsidered. The harvest control rules for the stock therefore need evaluation against variations in biology, testing for robustness under varying starting conditions in population size and changes in the North Sea Ecosystem. This should be done as a collaborative, iterative process between scientists, managers and stakeholders. To facilitate the process, it would be useful if the trade-off between the objectives of stability and maximising long term yield could be expressed clearly.

The final TAC adopted by the management bodies for 2011 was 200 000 t for Area IV and Division VIId, whereof not more than 26 536 t should be caught in Division IVc and VIId. For 2012, the total TAC was increased by 95% to 422 850 t (405 000 t for the A-Fleet), including a TAC of 44 550 t for Division IVc and VIId.

The by-catch TAC for the B-Fleet in the North Sea (and Div. IIa) was 16 539 in 2011 and is increased by 8% to 17 900 t for 2012, which is not in proportion to the increase in 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 spring spawning herring in the Thames estuary are in general low and not included in the TAC. This fishery was closed in 2011. 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 2011

Total landings and estimated catches are given in the Table 2.1.1 for the North Sea and for each Division in Tables 2.1.2 to 2.1.5. Total Working Group (WG) catches per statistical rectangle and quarter are shown in Figures 2.1.1 (a-d), the total for the year in Figure 2.1.1(e). Each nation provided most of their catch data (either official landings or Working Group catch) by statistical rectangle. The catch figures in Tables 2.1.1 - 2.1.5 are mostly provided by WG members and may or may not reflect national catch statistics. These figures can therefore **not** be used for legal purposes.

The total WG catch of all herring caught in the North Sea in 2011 amounted to 218 400 t. Official catches by the human consumption fishery were 209 500 t, corresponding to an overshoot of 5% of the TAC for the human consumption fishery (200 000 t).

In the southern North Sea and the eastern Channel, the total catch sums to 26 550 t. The separate TAC for this area was 26 536 t, so landings in Division IVc and VIId are in good accordance with the TAC. This is a large change compared to 2010, when landings overshot the TAC by 73%.

Information on by-catches in the industrial fishery is provided by Denmark. While the Norwegian by-catches are included in the A-fleet figure for Norway, catches taken in the small-meshed fishery by Denmark account to a separate EU quota (B-fleet).

Landings of herring as by-catch in the Danish small-meshed fishery in the North Sea have decreased by 2% to 8 927 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 (16 539 t). Since the introduction of yearly by-catch ceilings in 1996, these ceilings have never been exceeded.

The total North Sea TAC and catch estimates for the years 2006 to 2011 are shown in the table below (adapted from Table 2.1.6).

Year	2006	2007	2008	2009	2010	2011
TAC HC ('000 t)	455	341	201	171	164	200
"Official" landings HC ('000 t)[1]	478	354	219	157	166	209
Working Group catch HC ('000 t)	498	381	236	156	166	209
Excess of landings over TAC HC ('000 t)	43	40	35	0	1	5
By-catch ceiling ('000 t) [2]	42	32	19	16	14	17
Reported by-catches ('000 t) [3]	12	7	9	10	9	9
Working Group catch North Sea ('000 t)	511	388	245	166	175	218

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

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 2012, 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. Half of the EU quota for Division VIc and VIId can be taken in Division IVb (notification for IVb is needed in advance to the commission).

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. The majority of catches is still taken in Subdivision IVaW. After a sharp reduction in the catches taken in Division IVb in 2010, the proportion of catch taken in that area have increased again. They contribute roughly 25% to the total catches in 2011 and are in the same order of magnitude as in the period 2007-2009.

In 2007, the Danish administration 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 by-catch that they are allowed to hold on board.

Another change in the NSAS herring fishery was the substantial decline in misreporting of catch in the most recent years. 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, for Western Baltic spring spawners (only in IVaE), and for 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.

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 1996-2011 (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 2001-2011.

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 (1.8 billion fish) and the total number of NSAS (2.2 billion fish) have increased by 22% and 27%, as compared to last year. 0- and 1-ringers contributed 43% of the total catch in numbers of NSAS in 2011 (Table 2.2.5).

In 2011, catches in numbers of 0- and 1-ringers have increased by 9% and 47%, as compared to 2010. Most of these herring are still taken in the B-Fleet. Catches of 0- and 1-ringers are mostly taken in Divisions IVb, and, to a much lower extent, in Sub-division IVa(W). In Division IVb, 0- and 1-ringers amount to 73% of the total catch in numbers. As in previous years, roughly 45% of the total catch in numbers taken in the North Sea are 3-ringers or older.

Western Baltic (WBSS) and local Division IIIa spring-spawners 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 WBSS. Table 2.2.8 specifies the estimated catch numbers of WBSS caught in the North Sea, which are transferred from the North Sea assessment to the assessment of Division IIIa/Western Baltic in 1996-2011. After splitting the herring caught in the North Sea and IIIa between stocks, the total catch of North Sea Autumn spawners amounts to 226 500 tonnes.

Area	Allocated	Unallocated	Discards	Total
IVa West	125 054	-	-	125 054
IVa East	14 829	-	-	14 829
IVb	51 865	-	-	51 865
IVc/VIId	26 650	-	-	26 650
	Total catch in the North Sea			218 398
	Autumn spawners caught in Division IIIa (SOP)			8 388
	Baltic spring spawners caught in the North Sea (SOP)			-308
	Blackwater spring spawning herring			-2
	Other spring spawners			0
	Total catch NSAS used for the assessment			**226 478**

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian spring-spawners and local fjord-type spring spawning herring are taken in Division IVa (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in Tables 2.1.1 to 2.1.6, but are listed separately in the respective catch tables. Along with the increasing biomass of these spring spawning herring, the catches had increased in 2009 and 2010 (to 56 900 t). However, in 2011 these catches amount to 12 200 t, but are stated as preliminary.

In previous years, Blackwater herring were caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. This fishery was closed in 2011 and only regulated by-catches are allowed. These by-catches were only 1.5 t in 2011.

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

In previous years, some nations provided information on misreported and unallocated catches of herring in the North Sea and adjacent areas. However, in recent years no such information became available and misreporting and unallocation of catches is meanwhile regarded as a minor issue in the North Sea herring fishery. Consequently, no **Working Group catch**, which would include estimates of all fleets (and discards and misreported or unallocated catches; see Section 1.5), was estimated and all figures are given as official catch.

There was no information provided on discard levels in 2011. In recent years quantified discards associated with herring landings were only provided by Scotland. With the cessation of the Scottish pelagic observer programme this source of information is no longer available. The previously reported discards were in the range of 10 to 100's tonnes. Although discards are likely to occur in all national fisheries, and this figure therefore likely was an underestimate, the general level of discarding in this fishery is believed to be low.

Discard data have not been consistently available for the whole time series and are only included in the assessment when reported. Besides discarded catches, considerable loss of herring may also 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 (van Overzee & van Helmond, HAWG 2012, WD03).

The sampling of commercial landings is slightly higher in 2011 and covers 84% of the total catch (2010: 81%). However, the number of herring weighed and measured has decreased significantly compared to 2010 (Table 2.2.12).

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (here defined as each combination of fleet/nation/area and quarter). Of 84 different *reported* metiers, 36 were sampled in 2011. The recommended sampling level of more than 1 sample per 1 000 t catch has been met for 29 metiers. With regards to age readings, 25 metiers appear to be sampled sufficiently (recommended level >25 fish aged per 1 000 t catch).

On the other hand, some of the metiers yielded very little catch. In 49 metiers the catch is below 1 000 t. The total catch in these metiers sums to 10 469 t, so the remaining 35 metiers represent 207 930 t of the official catch (95%). However, only 26 metiers of these 35 were sampled, and only 19 fulfil the recommended level of more than 1 sample per 1 000 t catch and 15 the criteria of 25 age readings per 1 000 t catch.

In the human consumption fishery, Divisions IVc and VIId were not sampled in the 2nd and 3rd quarter at all. The amount of metiers sampled in the B-Fleet has slightly improved, but the amount of fish measured and aged is still inadequate to represent the catches taken in the B-Fleet. Larger quantities of catches are taken by France and

Sweden, but no biological information is available from these catches. According to the DCF regulations, some catches of UK (England) were landed into and sampled by other nations.

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

2.3 Fishery independent information

2.3.1 Acoustic Surveys in the North Sea (HERAS), West of Scotland VIa(N) and the Malin Shelf area (MSHAS) in June–July 2011

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 slope 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 2012/SSGESST:21). 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 2.4 million tonnes and 12 033 million herring (Table 2.3.1.2). In terms of biomass this is about 20 % lower compared to the previous year. The abundance of the 2006 year class (4-winter ringers this year) is consistent with a large estimate of 3-wr fish last year. The current estimate also confirms the strong 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 concentrated in the areas close to the Fladen grounds (as in previous years), but appears to stretch out 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.

Trends in acoustic survey catchability from the assessment

For the years 2005-2009, abundances of herring at ages 4-9+ observed in the acoustic survey were associated with large residual patterns in the 2009 ICA assessment model. Although this situation improved in 2010, an investigation into possible causes may help to identify any potential shortcomings of the survey design. In the case of the North Sea herring acoustic survey, three major effects may have caused a bias in the abundance estimate: (1) migration or alterations in either (2) schooling behaviour, or (3) fish target strength (Simmonds and MacLennan, 2005).

If the herring population has moved partly out of the survey area, portions of the stock may not have been sampled during the survey and therefore be underrepresented in the final abundance estimate. However, based on the spatial distribution of acoustic herring recordings over the time period in question, survey coverage does not seem to be a problem. Densities observed in the acoustic survey generally decrease towards the edge of the survey area, which is bounded by the 200 m depth contour at the northern and north-western borders of the North Sea (see Figure 2.3.1.2 in this and previous HAWG reports).

Another potential source of survey bias is the change in schooling behaviour. Acoustic techniques are well suited to sample fish occurring in dense aggregations. If these fish systematically change their behaviour and disaggregate into very low densities, they may not be sampled to the same extent anymore. Such behavioural changes may typically occur in correlation with changes in population sizes and time of the day (Petitgas and Lévénez, 1996; Beare *et al*. 2002; Muiño *et al*., 2003). No analysis in that respect has been done for the time period after 2000, however based on the observed change in stock size there may be merit in doing so.

There is evidence that fish depth (pressure) modulates the TS of Atlantic herring (Edwards *et al*., 1984; Ona, 2003) and this dependence may bias acoustic survey results if not taken into account (Løland *et al*., 2007). Herring are physostomes and thus do not have a gas gland to enable them to alter the swimbladder volume actively. Their swimbladder will therefore decrease in volume with increasing water pressure, leading to a steady decrease in TS with increasing depth. Using magnetic resonance imaging (MRI) observations of a herring in a pressure chamber, Fässler *et al*. (2009) showed that the decrease in swimbladder volume with pressure is in accordance with Boyle's law (Boyle). See Figure 2.3.1.4. for a graphic representation of this effect. If herring have changed their distribution systematically over the time period 2005-2009 compared to previous years, this may have caused a bias in abundance estimates. A preliminary analysis of herring depth distributions from the acoustic survey, using a mean sea bed depth per ICES rectangle was done during HAWG 2012. The result does not suggest that there is any evidence for such an effect (Figure 2.3.1.5.). Nonetheless, the use of an average depth per ICES rectangle assumes a homogeneous distribution of fish, low depth variability within ICES rectangles and close association of schools with the sea bed. There is a high probability that not all of these assumptions are justified and a thorough analysis of the effect should be based on true school depth distributions and locations. WGIPS will be looking into this issue and already presented some preliminary results on the use of a depth-dependent target strength relationship in the latest WGIPS report (ICES, 2012).

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

Herring larvae surveys were conducted in September and December 2011 and in January 2012. 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 2011 and January 2012 (Figures 2.3.2.1 – 2.3.2.4). The survey effort in vessel days and numbers of samples taken is comparable to recent years.

As anticipated, newly hatched larvae spatial distributions varied between areas and time periods. Compared to the previous year, the total number of newly hatched larvae increased slightly in the areas surveyed in September 2011. The estimate for the central North Sea is greatly influenced by larval patchiness, as some stations yielded very large quantities of newly hatched larvae (Fig. 2.3.2.1).

The overall abundance of newly hatched larvae in the southern North Sea in 2011 is lower than 2010, but still high and in the same order of magnitude as in the last six years, where the proportion of Downs offspring in the total larvae abundance has increased strongly.

However, due to variable survey coverage of the spawning areas and time periods, abundance estimates are not directly comparable. While the Downs component is surveyed three times (covering the whole hatching period), all others areas are in general covered only once a year, and most often during the same time period. This pattern is persistent for most of the last 20 years. It is obvious that these gaps must results in larger levels of uncertainty when calculating larvae abundance indices for the North Sea. To support the quality of larvae abundance estimates as input parameters for statistical models, one approach could be to alternate the survey time period in the Orkney/Shetland, the Buchan and the central North Sea as often as possible.

The Multiplicative Larvae Abundance Index (MLAI) is estimated to obtain an SSB index of North Sea autumn spawning herring. For the most recent year, the MLAI shows a reduction of larvae abundance (Tab. 2.3.2.1), corresponding to a SSB around 2.5 million tonnes. Due to inherent weighting procedures, the MLAI is robust to patchiness. The larger quantities of larvae caught on single stations in the central North Sea (representing > 65% of the total catch in that area) have an effect of 5% on the index only.

During the Benchmark procedure for North Sea herring (ICES, WKPELA 2012), it was decided to replace the MLAI model by the Spawning Component Abundance Index (SCAI) model (Payne 2010), which in addition to the total stock dynamics also monitors dynamics on a component level. Results of the SCAI model are described in Section 2.11.

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). During the latest benchmark of North Sea herring it was decided only to use the indices of 0-ringer and 1-ringer abundance in the assessment (ICES, WKPELA 2012).

2.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area is used as a recruitment index for the stock. This year's IBTS0 index is based on 713 depth-integrated hauls with the ring-net. The coverage of the survey area was excellent with at least 2 hauls in almost all ICES rectangles in the North Sea as well as in Kattegat and Skagerrak. Index values are calculated as described in detail in the Stock Annex. This year there were 19 hauls from the area south of 54° N with mean larval length <20mm. These hauls were excluded from the index calculation as specified in the calculation procedure and not illustrated in Figure 2.3.3.1. These small larvae in the southern area are thought to be larvae of the Downs component of North Sea herring. The exclusion of these small larvae from the index means that this component is not accounted for in the IBTS0 index. A detailed discussion of North Sea herring components and in particular

Downs herring can be found in section 2.11 in this report. The time series of IBTS0 estimates is shown in Table 2.3.3.1. The new index value of 0-ringer abundance of the 2011 year class is estimated at 68.0.

The index estimate is lower than last year's estimate for the 2010 year class. This is 62% of the long term mean, and shows a further continuation of the series of relatively low productivity starting from the 2002 year class. The 0-ringers caught in 2012 were predominantly found in dense concentrations off the Scottish coast south of the Moray Firth with some extension into the central North Sea (Figure 2.3.3.1). Moderate larval densities were found in the southern North Sea as well as in the Skagerrak whereas virtually no herring larvae were found in the northern and northeastern parts of the North Sea. This pattern of distribution is similar to that of last year with high concentrations close to the Scottish coast. The core of abundance was, however, slightly shifted to the south. In contrast to the most recent years of this survey there were no high concentrations of smaller Downs herring larvae found in the ring net catches in the area of the English Channel.

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 58%.

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

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 2010 is shown in Table 2.3.3.2. This year's 1-ringer index for the 2010 year class is 50% lower than the index for the 2009 year class from last years survey. The index from the 2012 survey of 1353 is at 70% of the long term mean. Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in February 2010, 2011 and 2012. Across years, the main areas of 1-ringer distribution are in the German Bight and south of Dogger Bank. For the 2010 year class, the majority of the 1-ringers were distributed in the eastern part of the North Sea and the Kattegat. The very high density in one of the rectangles in the Kattegat was influenced by one very large haul. Abundances were generally lower and the distribution more contracted than previous years resulting in the lower value of the index this year.

2.4 Mean weights-at-age, maturity-at-age and natural mortality

2.4.1 Mean weights-at-age

Table 2.4.1.1 shows the historic mean weights-at-age (winter ringers, wr) in the North Sea stock during the 3rd quarter in Divisions IV and IIIa from the North Sea acoustic survey (HERAS) as well as the mean weights-at-age in the catch from 1996 to 2011 for comparison. The data for 2011 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 2011, almost all age groups had similar mean weights-at-age when compared to 2010. On the other hand, 3- to 5-ringers in the acoustic survey and the catch were lower in mean weight, while 1, 2, and 6-ringers have increased. This pattern was observed in both the acoustic survey and catch data indicating that they 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. The general tendency of declining weights-at-age seems to have continued in 2010 and 2011 (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 was noted that the very strong 2000 year class, which was competing with an already large herring stock biomass, grew slower than other year classes throughout.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2011 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). The precision of percentage herring mature at age have also been estimated by WGIPS this year based on bootstrapping of all biological samples taken. Precision estimates were high and ranged from ±1.65% for the 2-ringers to <1% for the other ages (WGIPS, 2012).

A low proportion of mature 2-ringers, as observed in the 2010 survey (45%), was not observed in 2011, with values more in line to those of the most recent years. Compared to the majority of the most recent years, the 3-ringers were considered slightly less mature at 84% (Table 2.4.2.1.).

2.4.3 Natural mortality

One of the improvements of the recent benchmark of the North Sea herring stock (ICES, WKPELA 2012) is the integration of fundamental links between the North Sea ecosystem and the NSAS stock dynamics.

From 2012 onwards the assessment of NSAS includes variable estimates of natural mortality (M) at age derived directly from a multispecies stock assessment model, the SMS model, used in WGSAM (Lewy and Vinther 2004, ICES 2011). The input data to the assessment are the smoothed values of the raw SMS model annual *M* values, which are variable both at-age and over the time period 1963 – 2010. Natural mortality in years outside this time-period are filled and estimated for each age as a five year running mean in the forward direction for 2011+ and in the reverse direction for years prior. Detailed explanation regarding the natural mortality estimates can be found in Stock Annex 3.

The M estimates are variable along the time period covered by the assessment and are the result of predator-prey overlap and diet composition (Figure 2.4.3.1). The trends in total M of NSAS are a result of the contribution of each of the predators to the predation mortality of the NSAS stock. Inspection of the trends in the stock size of the main herring predators suggests that the increase in natural mortality of all age groups >1 in the early period, approximately 1963-1978, is likely linked to the gadoid outburst in the late 1960s, in particular predation by cod and saithe. From approximately 1979 onwards, natural mortality decreased again while the gadoid population reduced in size as well. From approximately 1991 onwards, close to the period where a regime shift in the North Sea is thought to have occurred, an increase in natural mortality can be observed again. In the more recent years (2008-2010) natural mortality appears to decrease again.

2.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS0 and the IBTS-1 indices are available. Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated. The recruitment trends from the assessment are dealt with in section 2.6.

2.5.1 Relationship between 0-ringer and 1-ringer recruitment indices

The estimation of 0-ringer abundance (IBTS0 index) predicts the year class strength one year before the strength is estimated from abundance of 1-ringers (IBTS-1 index). The relationship between year class estimates from the two indices is illustrated in Figure 2.5.1 and described by the fitted linear regression. Last year's prediction of the 2010 year class was in line with this year's IBTS-1wr index of the year class (circled in the figure). Over the time series there has generally been very good agreement between the indices in their description of temporal trends in recruitment (Figure 2.5.2), but in recent years (the 2009 and the 2006-2007 year classes) the predicted levels of recruitment has deviated between the two indices. 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).

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

During the course of 2011 and 2012, extensive data analyses and benchmark assessment trials were performed during the WKPELA ICES meetings (ICES, WKPELA 2012), prior to the regular working group meeting in 2012. The benchmark decided on revised input data sources and assessment methods which are thoroughly described in the WKPELA report and in Stock Annex 3. The tool for the assessment of North Sea herring is FLSAM, an implementation of the State-space assessment model (www.stockassessment.org), embedded inside the FLR (Kell et. al 2007) library..

Acoustic (HERAS ages 1-8+), bottom trawl (IBTS-Q1 age 1), IBTS0 and SCAI larval (IHLS) indices are available for the assessment of North Sea autumn spawning herring. The surveys and the years for which they are available are given in Table 2.6.1.1. In the benchmark each available tuning index was carefully scrutinized and it was decided to no longer use the IBTS-Q1 ages 2-5+, replace the MLAI index with the SCAI index and change the age 9 plus group of the HERAS survey to 8+, consistent with the reduction in plus group in the catch-at-age matrix. The age group sampling of catches and HERAS should be maintained at the highest age possible and should not be reduced to age 8+. The input data and the performance of the assessment have been carefully scrutinised to check for potential problems. The proportion mature of the 2-wr in 2010 were estimated to be low (0.45) while the weight of these fish was on average only 10 grams smaller than the 2-wr fish in 2009. The proportion mature in the cohort, in 2011 at 3-wr, has increased to 0.84, still below the average of the time series. Proportion mature of 2-wr in 2011 is considered to be on average to high (0.87) provide the entire time series (see Figure 2.6.1.1). Proportional catch numbers-at-age are given in Figure 2.6.1.2 and time series of natural mortality-at-age is given in Figure 2.6.1.3.

The SCAI continues its increase, stating another ultimate high of the time series. The IBTS0 shows a decline in 0-wr fish over the past 4 years while the pattern of the IBTS-Q1 1-wr index shows erratic trends with large variation over the years 2007-2011 and indicating a decline for 2012 compared to 2011.

The IBTS-Q1 entire survey index has been revised in 2012 for the years 2003-2012. Revisions in recent years in the index are considered common and relate to the limited time available to perform checks and prepare the index prior to the HAWG meeting. For this reason it is expected that after the Herring Assessment Working Group revised values will become available. It is expected that revisions in the IBTS-Q1 1-wr index will not affect the results of the assessment significantly.

The index values of all ages in the acoustic survey have gone down compared to the 2010 values but can still be considered relatively high in the recent five years (see Figure 2.6.1.4). The internal consistency of the acoustic survey remains high, as has been high for a long period. Trimming the plus group to age 8+ does reduce the consistency between age 7 and 8 but is comparable to the consistency of age 8 and 9+ in the 2010 assessment (see Figure 2.6.1.5, see Figure 2.6.1.29 ICES HAWG 2011).

The SAM model fits the catch well and residuals are random and small for all ages (Figures 2.6.1.6 to 2.6.1.25). A small block of positive residuals can be observed for age 7 catch data over the years 2000-2006, while at age 8 catch data a similar block of negative residuals can be found. These residuals are small however. They are not considered an issue for the performance of the assessment. The SCAI survey fit shows a clear residual pattern, which can partly be explained by the fact that the SCAI indices in individual years are not independent of each other, but instead are the output of an auto-correlated random-walk model. All other surveys fit well inside the model.

A feature of the assessment model is the estimation of an observation variance parameter for each data set (see Figure 2.6.1.26). Overall, all data sources are associated with low observation variances where the catch at ages 1-5 stands out at the most precise data source while the SCAI index and HERAS 1-wr are perceived to be the noisiest data series. The uncertainty associated with the parameter estimated is low for most data sources where only the CV of the catch at age 0 is somewhat higher (Figure 2.6.1.27). However, the CVs do not indicate a lack of convergence of the assessment model.

The retrospective pattern shows a very similar perception in SSB, F and recruitment for the years 2011 and 2010 (Figure 2.6.1.28). Going back further in time, however, shows consistent underestimation of SSB and overestimation of F over the years by the assessment model. A similar retrospective bias was observed in the FLICA assessment model in 2011. Preliminary analyses suggest that a combination of two effects cause the retrospective bias:

- The 1998 and 2000 year classes are considered strong and are targeted by the fishery up to older ages. This has caused a shift in selection to older ages in the years 2005-2008.
- From 2007 to 2008, fishing mortality has declined from approximately 0.2 to 0.13. Therefore, the contrast in the catch-at-age matrix has likely decreased.

The combination of these effects might have resulted in a persistent perception of higher selection on older ages, even in the years 2007-2009 where, in retrospect, this has been revised downwards. However, the higher selection not only affects the numbers-at-age in the older ages, but also propagates through to the younger ages which results in a different SSB and F perception.

Figure 2.6.1.29 shows the model uncertainty plot, representing the parametric uncertainty of the fit of the assessment model in terminal F and SSB. Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers- and weights-at-age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic IBTS survey and assessment parameters (see Figure 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 four 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 state space model (SAM, in the FLR environment). The input data and model settings are shown in Tables 2.6.3.1 – 2.6.3.11, the SAM output is presented in Tables 2.6.3.13 – 2.6.3.26, the stock summary in Table 2.6.3.12 and Figure 2.6.3.1 and model fit and parameter estimates in Table 2.6.3.25. Figure 2.6.3.2 shows the agreed management plan including the biomass trigger points and contains the $F_{2\text{-}6}$ estimates of the past 10 years.

The spawning stock at spawning time in 2011 is estimated at approximately 2.34 million tonnes [1.96, 2.80 million tonnes (95% CI)], this is above the estimated 2.0 million tonnes in 2010. The estimate of 0-wr fish in 2012 (2011 year class) is estimated to be at approximately 3.1 billion [2.1, 4.7 billion (95% CI)], just below the long term geometric mean (see Table 2.6.3.14). Mean $F_{2\text{-}6}$ in 2011 is estimated at approximately 0.09 [0.07, 0.12 yr^{-1} (95% CI)], which is below the management agreement target F, while mean $F_{0\text{-}1}$ is 0.03, also below the agreed ceiling. The updated assessment estimated an $F_{2\text{-}6}$ of 0.08 in 2010.

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 2011 was estimated at

2.34 million t, well above B_{pa}. $F_{2\text{-}6}$ in 2011 was estimated at 0.09, below the target $F_{2\text{-}6}$ of 0.25. The 2010 year class is estimated above the long term recruitment geometric mean while the 2011 year class is estimated below the long term recruitment geometric mean.

2.7 Short term predictions

Short term predictions for the years 2012, 2013 and 2014 were done with code developed in R software. In the short term predictions, recruitment is assumed constant for the years 2013 and 2014 following the same recruitment regime since 2002 (geometric mean of 2001 to 2010 year classes).

For the intermediate year, no overshoot for the A fleet was assumed, as there was minimal deviation from the TAC in 2011. 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 of the A fleet is increased by 18 885 tonnes (same proportion as in 2011). For the B-fleet the agreed by-catch ceiling in 2012 has been used but scaled down by the proportion taken as observed in 2011. 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 TACs in IIIa for these fleets. See Table 2.7.1 – 2.7.11 for other inputs.

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

i) No fishing;

ii) The EU-Norway management plan

iii) A roll over TAC from 2012 to 2013 of 405 kt for the A fleet;

iv) The EU–Norway Harvest Control Rule as implemented within the management plan (no restriction on TAC change);

v) A 15% decrease in the A fleet TAC between 2012 and 2013;

vi) A fishing mortality equalling 0.3 in the human consumption fishery.

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 2013. The consequence of other combinations of catch options can be explored on request .

For options b, c, d, e and f, the C and D fleets are assumed to have a North Sea autumn spawner catch for 2012 of 7.6 and 1.6 thousand tonnes respectively. In 2013 and 2014 they are assumed to have a North Sea autumn spawner catch of 9.6 and 2.1 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

From 2011 to 2012, SSB is expected to slightly decline, mainly driven by the higher TAC in 2012 and resulting in an increase in fishing mortality. Under all scenario's, except for the no-fishing scenario, SSB is predicted to decline in 2013 and 2014. The SSB is expected to further decline under the management plan in 2013 to 2.0 million tonnes and further in 2014 to levels of approximately 1.7 million tonnes. SSB is expected to be well above $B_{trigger}$, and therefore also B_{pa}, in 2012 , 2013 and 2014. Under option vi, a potential fishing mortality explored by WKPELA of 0.3, SSB is expected to decline to 2.0 million tonnes in 2013 and to 1.6 million tonnes in 2014.

The predicted catch according to the management plan for 2013 implies an increase in TAC of 15%, invoking the bounding 15% inter annual variation rule in TAC of the management plan.

2.7.2 Exploratory short-term projections

Exploratory short term predictions were run to investigate the utility of stochastic forecasts. The approach and software used were similar to the deterministic setup, but included the ability to vary starting conditions of stock numbers-at-age by sampling from the variance-co-variance matrix a hundred times, and sampling from historic observations on key population parameters like maturity-at-age and stock weight-at-age to populate the hundred replicates. The results of the median of these hundred replicates turned out to be very similar to the deterministic run (with differences explained by the slight difference in assumed maturity-at-age in the deterministic run and the stochastic run). The resulting tables with 5-95 percentile is given in Table 2.7.2.1.

2.8 Medium term predictions and HCR simulations

Medium term predictions were evaluated during WKHIAMP in 2011 (ICES CM 2011/ACOM:62).

2.9 Precautionary and Limit Reference Points and FMSY targets

The precautionary reference points for this stock were adopted in 1998. The analysis carried out by WKPELA 2012 implies that the reference points have shifted under the perception of the stock assessment. Performing both a deterministic time invariant approach and a deterministic time varying approach, the WKPELA 2012 considered precautionary and limit reference points for NSAS. A stochastic bootstrap based method was not applied, but is highly recommended for any evaluation of the applied reference points and FMSY targets. The sections below describe the applied reference points and FMSY targets for NSAS in the assessment performed in HAWG 2012.

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. The evaluation of the lower breakpoint in the WKPELA showed that the currently used 800 000 tonnes does not seem to have changed under the new perception of the stock..

Fpa and Bpa

Under the current management plan Fpa = 0.25 is the F target value in the harvest control rule. The current Bpa = 1.3 million tonnes was the trigger point in the LTMP established in 1998. These 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 previous management plan. In the management plan, the target fishing mortalities were intended as targets and not as limits. 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). The precision of the stock assessment has not changed following the benchmark in WKPELA 2012, and as there is no evidence that the B_{lim} has changed, then the precautionary reference points are assumed to still be valid.

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.**

MSY framework for North Sea herring

There is no ICES MSY framework biomass trigger point for this stock as the MP is thought to have primacy over the ICES MSY framework when providing advice.

In 2010 ACOM agreed with HAWG that Fmsy for NSAS was 0.25. This was supported by WKFRAME2. The analyses carried out by WKPELA 2012 suggested that MSY reference points may vary over time. Further, WKPELA suggested that a minor increase in Fmsy might be appropriate given the increase in SSB resulting from the FLSAM benchmark assessment. An Fmsy around 0.3 was considered. However, associated uncertainty with the WKPELA Fmsy has not yet been estimated. Such estimate is required to determine whether the WKPELA proposed estimate is significantly different from the ACOM agreed Fmsy. Therefore, and until a full evaluation of Fmsy under the current perception of the stock is carried out, Fmsy for NSAS remains = 0.25.

2.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were carefully scrutinized during the 2012 benchmark (ICES, WKPELA 2012). A complete overview of the choices made during the benchmark can be found in the ICES WKPELA 2012 report (ICES, WKPELA 2012) and the newly derived procedures are described in the North Sea Herring Stock Annex (Annex 3). Hence, the 2012 assessment was classified as an update assessment.

A summary of the quality improvements of the assessment is given below.

- Natural mortality is assumed to be variable over age and time. Natural mortality estimates are obtained from the North Sea Multi Species model (SMS) key-run evaluated in 2011 (ICES WGSAM). The time varying natural mortality estimated is pre-smoothed prior to being used in the assessment.

- The time series of catch-at-age data has been extended to also cover the period 1947 - 1959. The entire time series used within the assessment now spans 1947 – 2011
- The catch-at-age data in years 1977 – 1978 have been excluded from the assessment. There were strong indications that the catch data during the full closure of the fishery was not reliable.
- The plus-group was re-defined to age 8. Examination of the biological data suggested that there was no evidence to support an older plus group. Analyses also showed that there was insufficient information present in the data to provide reliable estimates of fishing mortality on the older ages when a 9+ age-group was used.
- The MLAI tuning index has been replaced by the SCAI tuning index allowing spawning component dynamics to be monitored.
- IBTS quarter 1 age 2-5+ indices have been excluded from the assessment. A suite of analyses suggest that the signal in the IBTS-Q1 ages 2-5+ is very poor and therefore does not contribute to the tuning of the assessment.
- The ICA assessment model has been replaced with the state-space assessment model (SAM: www.stockassessment.org). The SAM model provides a flexible and fully statistical framework for the analysis of the inputs and refinement of the model.

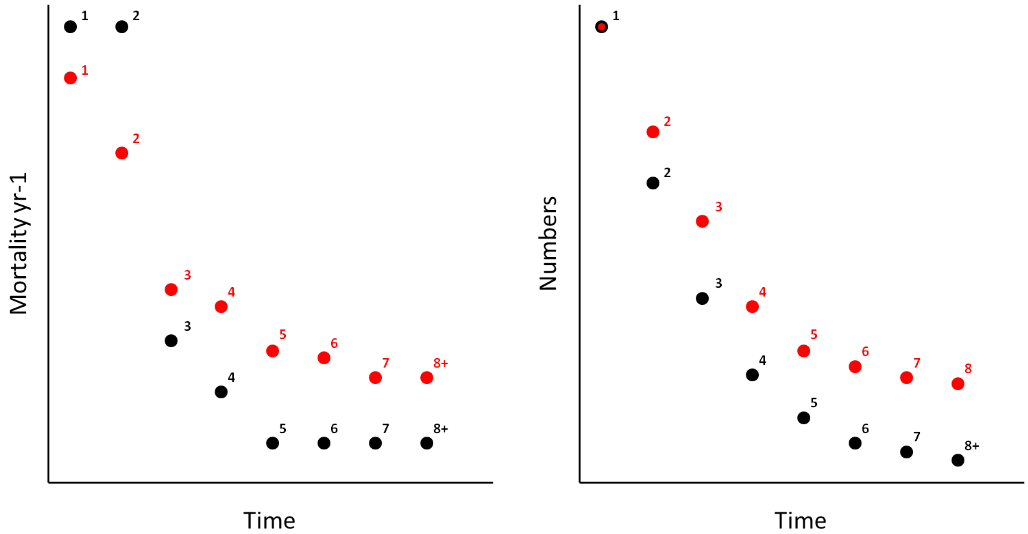
An extensive analysis of the output of the SAM assessment was made during the WKPELA benchmark (ICES, WKPELA 2012). No major violations of the assumption underpinning the assessment were found, suggesting that the model is both appropriate and describes the available data well. This situation is in clear contrast to the 2011 assessment where issues such as model convergence, strong residual patterns in key surveys (e.g. the HERAS and IHLS surveys) and the lack of understanding on the retrospective bias) were all present.

In the eyes of HAWG, these changes have led to a substantial improvement of the precision and accuracy of the North Sea herring assessment.

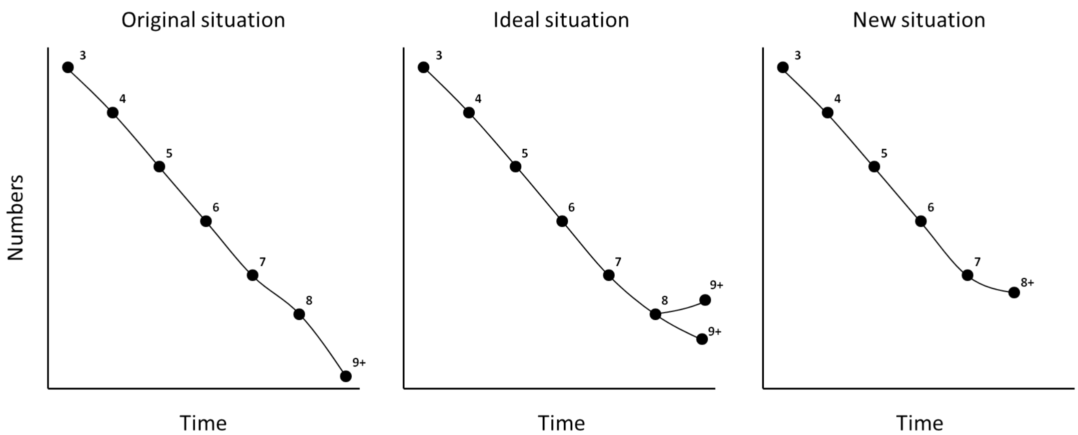
2.10.1 Change in perception:

The changes in both the input data and the model configuration have naturally led to a change in the perception of SSB and F relative to prior assessments of this stock (Figure 2.10.1). Generally speaking, the SSB has increased throughout the time series and the fishing mortality decreased, whilst recruitment estimates have remained unchanged (Figure 2.10.2). The two most important aspects underpinning this change are the incorporation of time varying natural mortality and the change in the plus group, together with the change in the underlying statistical model.

The changes in the natural mortality patterns have generally lead to an increase in the estimated stock numbers. The figure below shows schematically the difference in natural mortality between the 2011 assessment assumptions (in black) and the 2012 assessment assumptions (in red) on natural mortality. The first 2 ages are associated with considerable lower natural mortality in the 2012 assessment, while natural mortality at ages 3+ are considered to be higher than the 2011 assumption. This results in higher numbers at age in especially ages 2 and 3, where the perceived lower natural mortality is not compensated by an increase in fishing mortality. From age 3 onwards, the total mortality (fishing and natural) are very similar between the 2011 and 2012 assessment. However, the propagation of higher numbers at age 2 to the older ages increases the total numbers in the stock.



Changes in the plus group have also lead to increases in the estimated stock numbers. The illustration below shows the decay in numbers at age in a cohort of a hypothetical catch-at-age matrix, but with clear resemblance to the North Sea herring situation. In the original situation, the decay from the last true age (8) to the plus group (9+) is very steep and might result in a stock assessment model estimation of very high selection on the plus group. In the ideal situation this decay would be smaller or the numbers in the plus group amount up to larger numbers than in the last true age, allowing appropriate estimation of selection at these age groups which is also associated with higher numbers-at-age in the plus group and back-calculation to younger ages. The adjustment of the North Sea herring plus group has resulted in the right panel situation where the decay from age 7 to 8+ is less steep.



Changes in the assessment model can also be expected to have a significant impact on the perception of the stock. Relative to the previous assessment (using the FLICA model) the current assessment (using FLSAM) weights the data sets differently, and encapsulates a different set of underlying assumptions. Preliminary analyses performed in WKPELA (reproduced in Figure 2.10.3) indicated that using similar input data sets and settings, FLICA and FLSAM gave similar perceptions of the stock. However, a direct comparison between the outputs of these models is not the appropriate way in which to judge the quality of the assessments: such a comparison should be based solely on the appropriateness of the model and its ability to describe the observations at hand. As argued above, the modifications to the assessment procedure performed by WKPELA have resulted in a model that is capable of describing the observations well,does not show any major violations of the statistical assumptions and is consistent with our biological knowledge. The refined assessment therefore appears to be appropriate for estimating the dynamics of the stock.

2.10.2 Historical comparison:

The data from the 2012 stock summary table is compared with the stock summary from the 2011 assessment and the predicted 2011 values from the 2011 assessment (see also Figure 2.10.2). The source of difference is explained in the previous section.

	2011 Assessment				**2012 Assessment**				**Percentage change in estimate 2012/2011**			
Year	Rec	SSB	Catch	F_{2-6}	Rec	SSB	Catch	F_{2-6}	Rec	SSB	Catch	F_{2-6}
2009	38900	1442	168	0.10	35040	1900	168	0.08	-11%	+24%	-	-29%
2010	38849	1301	188	0.12	37095	2004	188	0.08	-5%	+35%	-	-50%
2011*	28718	1714	231	0.13	31140	2344	226	0.09	+8%	+27%	-2%	-33%

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

2.11 North Sea herring spawning components

The North Sea autumn-spawning herring stock is generally understood as representing a complex of multiple spawning components (Cushing, 1955; Harden Jones, 1968; Iles and Sinclair, 1982; Heath *et al.*, 1997). 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 the North Sea in August/September (the Orkney–Shetland, the Buchan and the Banks components). In the English Channel, the Downs component spawns during December and January. 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 increased resilience to both anthropogenic and natural stressors (Harden Jones, 1968; McPherson *et al.*, 2001; Secor *et al.*, 2009).

Here we collate the available information, from a variety of differenct sources, about the individual components. 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. Recent scientific developments now also provide additional information about the other components.

2.11.1 International Herring Larval Survey

The spawning component abundance index (SCAI: Payne 2010) was developed to characterize the relative dynamics of the individual North Sea spawning components (HAWG, 2011). The SCAI is a statistical model designed to analyze the larval abundance indices (LAIs) generated by the IHLS (see section 2.3.2). Interpretation of these time series is made difficult missing observations (especially since the 1990s), 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 (Payne 2010).

SCAI provides an index of the abundance of early larvae (less than 10-11mm) on the spawning grounds. The abundance of herring early-larvae have been shown to be an appropriate and reliable proxy for the corresponding biomass of spawning adults (Postuma and Zijlstra, 1974; Heath, 1993). The SCAI is also shown to be significantly correlated with the SSB estimated in the stock assessment here (Figure 2.11.0). The use of the SCAI as an index of the component spawning biomasses therefore appears justified.

The SCAI model analysis shows that the Downs component appears to have a different set of dynamics from the other three components (Figure 2.11.1). 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 increased consistently to a point where it was the largest component in the stock.

The SCAI indices can also be used to examine the relative composition of the stock (Figure 2.11.2). The composition of the stock has changed appreciably over time. The largest fraction of the total SSB 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%. During the 2000s the Downs fraction of the total stock has increased and in recent years has comprised around 40% of the stock. The most recent year suggests a decrease in the Downs component: however, the precision of the terminal year estimate in the SCAI index is reduced and therefore little weight should be placed on this change.

2.11.2 IBTS0 Larval Index

As mentioned in Section 2.3.3.1 the ring net hauls for 0-ringers during the IBTS in the eastern English Channel also include Downs herring larvae. Additional sampling in this region has been performed since 2007 and in contrast to the previous years, no high concentrations of smaller Downs herring larvae were found in the 2012 survey. Nevertheless, 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).

2.11.3 IBTS 1 ringer

The proportion of the autumn and winter spawning components in recruiting year classes of North Sea herring has previously been 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, because this component hatches later than the autumn spawned herring and generally appear as a smaller sized group during the 1st quarter IBTS. A recruitment index of small 1-ring fish 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 <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 (North Sea and IIIa) or the area excluding Division IIIa, and their relative proportions are also shown. In the time-series, the proportion of 1-ringers <13 cm (of total catches) is in the order of 22%, and the contribution from Division IIIa to the overall abundance of <13 cm herring varies markedly during the period (Table 2.3.3.2). 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) and fluctuates between 7 and 70 % (Figure 2.11.4). For the 2010 year class the contribution seems to be at the average level with 21 % which is much lower than the 2009 year class (Figure 2.11.4).

2.11.4 IBTS acoustic information

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). Acoustic data are also recorded and show large herring schools along the French coast. The mean density of these shoals of herring, which were regularly found during the survey in a localized area, can however not be raised to represent the whole area. This is due to the nature of the IBTS survey design, which does not adopt systematic area coverage with transects. Furthermore, large schools close to the coast in shallow and inaccessible waters were detected with a horizontal echo sounder. Figure 2.11.5 shows the catch composition (percentage by age) of the pelagic hauls carried out on these schools since 2007. In 2012, the 4wr and 5wr fish represented respectively 40% and 30 %.

2.11.5 Fisheries and TAC in the IVc/VIId

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 expressed concerns regarding Downs herring in 2005 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%). This proportion has increased slightly in 2011 and 2012, and was set respectively at 26 536 tonnes and 45 985 tonnes which represents 13 % and 16 % of the total human consumption TAC of Divisions IVa and IVb (Figure 2.11.6).

Except in 2010, the tendency to overfish the Downs TAC has markedly reduced since 2005 (Figure 2.11.7). For 2011, the catches of 26 700 tonnes were at the same level as the TAC.

The Downs herring has been considered highly sensitive to overexploitation (Burd, 1985; Cushing, 1968; 1992). 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 juvenile Downs and North Sea autumn spawning herring. 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).

2.11.6 Conclusions

In conclusion, the Downs TAC is set up to conserve the spawning aggregation of Downs herring. Uncertainties concerning the status of, and recruitment to, this component of the North Sea herring stock are high, and HAWG is not aware of any evidence to suggest that this measure is inappropriate. HAWG therefore recommends that the IVc-VIId TAC 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 for Downs herring. A future harvest control rule will have to be supported by increased research effort into the dynamics of the Downs component in the 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 and other components to the catch in all fisheries in the North Sea is reduced. Possible methods to approach this problem are discussed by Kell *et al*. (2009).

2.12 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% Inter Annual Variation limit on TAC change which leads to restricted TACs when the stock is improving and the trade-off between stability and high yield will limit the maximising of yield in some circumstances. 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 analysis carried out by the benchmark in 2012 implies that the reference points for NSAS may have shifted under the perception of the stock assessment and thus a full revision of the existing management plan for NSAS is highly warranted.

The fishing mortality is reliably estimated by the stock assessment. Fishing mortality is now below the target set by the management plan and based on the most recent estimates of SSB and fishing mortality, the NSAS stock can be classified as being at full reproductive capacity and harvested sustainably, though below Fmsy and the management target. Thus again HAWG reiterates the need for a MSE for this stock.

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 (see section 2.14 and Figure 2.14.3). 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, and this should be included in an upcoming MSE.

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.

The North Sea autumn spawning herring stock also includes the Downs herring component (herring in Divisions IVc and VIId). The management of this component is discussed in detail in Section 2.11.

Herring spawning and nursery areas are sensitive and vulnerable to anthropogenic influences. Extraction of marine aggregates (such as gravel and sand) and other activity (e.g. construction) that have an impact on the sea bed may be expected to impact on herring spawning. Herring abandon and repopulate spawning grounds and an absence of spawning in any particular year does not mean that the spawning ground is not required to maintain a resilient herring population. There is enough scientific information to support the advice that no gravel extraction occurs in areas with spawning grounds during the spawning season or within 1 month before or after this period, as this coincides with herring spawning in the area and egg and larval development.

2.13 Ecosystem considerations

Herring is considered as a major prey item for fish, seabirds and sea mammals in the North Sea area (Dickey-Collas *et al.*, 2010). Trophic interactions have been incorporated into the stock assessment of North Sea herring for the first time this year through the adoption of time-varying estimates of natural mortality. These estimates are derived from the Stochastic Multispecies model (SMS) and represent state-of-the-art knowledge about the effect of predation by higher-trophic levels upon herring. The outputs of this model suggest that the natural mortality of herring is dominated by cod and saithe, and that this source of mortality is both variable in time (see e.g. Figure 2.4.3.1) and, in recent years, greater than the fishing mortality. Changes in the dynamics of these two species in particular, due to either anthropogenic or natural processes, can therefore be expected to have a direct impact on the population dynamics of NSAS herring.

Furthermore, herring is also considered to have a major impact on many other fish stocks as an ichthyoplanktivorous predator. 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, strong cod recruitment is unlikely with the current state of the North Sea ecosystem.

The herring human consumption fisheries are considered to be relatively clean, with little by-catch of other fish, mega-fauna and almost no disturbance of the sea bed: direct ecosystem effects therefore appear to be limited. 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.

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.

2.14 Changes in the environment

This stock has recently produced a sequence of below average year classes in a row, which has never been observed before (Payne *et al*., 2009): the 2011 year class, the ninth in this sequence, appears to represent a continuation of this trend. This low recruitment has occurred in spite of a spawning stock biomass that is well above the B_{lim} of 800 000 tonnes (where impaired recruitment is expected to set in) (Figure 2.14.1). The number of recruits produced per spawner appears to have increased in recent years (Figure 2.14.2): however, the current value is still less than a third of that observed in the 1990s.

Year-class strength in this stock is determined during the larvae phase (Dickey-Collas and Nash 2005; Payne *et.* al 2009). Updating these analyses with the most recent data sets suggests that the trend of reduced larval survival between the early (as indicated by the SCAI index) and the late- (as indicated by the IBTS0 index) larval stages has continued in the most recent years (Figure 2.14.3). All indicators therefore suggest that the stock remains in the low-productivity regime observed in previous years.

The general reduction in larval survival is generally thought to be associated with changes in the physical and biological environment (ICES SGRECVAP 2008; Payne *et al* 2009). The change in survival rate co-varies with an increase in the mortality rate of the very young larvae (Fassler *et al*., 2011). The specific reasons for this are not known but there appears to be correlations between the mortality trends and the residuals of the stock-recruit relationship, the stock biomass and temperature. The pattern in the recruitment time series also shows a lagged correlation with the climatic forcing of the North Atlantic, via the NAO (North Atlantic Oscillation) and the AMO (Atlantic Multidecadal Oscillation; Gröger *et al*., 2010). The climatic signal indices are thought to integrate many of the local processes affecting the larvae including changes in temperature, salinity, water column stability, turbulence, primary production and zooplankton community: however a precise mechanism is currently missing.

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. However, recent work in the WKEPLA benchmark has also suggested that predictions of growth and mortality are currently not feasible (ICES WKPELA 2012).

Table 2.1.1: Herring caught in the North Sea. Catch in tonnes by country, 2002 – 2011. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2002	2003	2004	2005	2006
Belgium	23	5	8	6	3
Denmark [6]	70825	78606	99037	128380	102322
Faroe Islands	1413	627	402	738	1785
France	25422	31544	34521	38829	49475
Germany	27213	43953	41858	46555	40414
Netherlands	55257	81108	96162	81531	76315
Norway [1]	74974	112481	137638	156802	135361
Poland	-	-	-	458	-
Sweden	3418	4781	5692	13464	10529
USSR/Russia	-	-	-	99	-
UK (England)	13757	18639	20855	25311	22198
UK (Scotland)	30926	40292	45331	73227	48428
UK (N.Ireland)	944	2010	2656	2912	3531
Unallocated landings	31552 [5]	31875 [5]	48898 [5]	57788	18764
Total landings	335724	445921	533058	626101	509125
Discards	17093	4125	17059	12824	1492
Total catch	**352817**	**450046**	**550117**	**638925**	**510617**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
WBSS	6652	2821	7079	7039	10954
Thames estuary [2]	60	84	62	74	65
Others [3]	0	308	0	0	0
Norw. Spring Spawners [4]	4069	979	452	417	626

Country	2007	2008	2009	2010	2011
Belgium	1	-	-	-	4
Denmark [6]	84697	62864	46238	45869	58726
Faroe Islands	2891	2014	1803	3014	-
France	24909	30347	18114	17745	16693
Germany	14893	8095	5368	7670	9427
Netherlands	66393	23122	24552	23872	34708
Norway [1]	100050	59321	50445	46816	60705
Lithuania	-	-	-	90	-
Sweden	15448	13840	5299	4395	8086
Russia	-	-	-	-	-
UK (England)	15993	11717	652	10770	11468
UK (Scotland)	35115	16021	14006	14373	18564
UK (N.Ireland)	638	331	-	-	17
Unallocated landings	26641	17151	-726	0	0
Total landings	387669	244823	165751	174614	218398
Discards	93	224	91	13	0
Total catch	**387762**	**245047**	**165842**	**174627**	**218398**

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	2002		2003		2004		2005		2006	
Denmark [1]	26422		48358		48128		80990		60462	
Faroe Islands	-		95		-				580	
France	10522		11237		10941		13474		18453	
Germany	15189		25796		17559		22278		18605	
Netherlands	18289		25045		43876		36619		39209	
Norway	10836		34443		36119		66232		38363	
Poland	-		-		-		458		-	
Sweden	2397		2647		2178		8261		4957	
Russia	-		-		-		99		-	
UK (England)	10142		12030		13480		15523		12031	
UK (Scotland)	30014		39970		43490		71941		47368	
UK (N. Ireland)	944		2010		2656		2912		3531	
Unallocated landings	14201	2	14115	2	28631	2	39324	2	10981	2
Misreporting from VIa North										
Total Landings	138956		215746		247058		358111		253048	
Discards	17093		4125		15794		10861		1492	
Total catch	**156049**		**219871**		**262852**		**368972**		**254540**	

Country	2007	2008	2009	2010	2011
Denmark [1]	45948	28426	16550	25092	26523
Faroe Islands	1118	2	288	1110	-
France	8570	13068	7067	6412	7885
Germany	4985	498	-	505	2642
Netherlands	42622	11634	11017	13593	15202
Norway	40279	40304	25926	38897	45200
Lithuania	-	-	-	90	-
Sweden	7658	7025	1435	2310	5121
Russia	-	-	-	-	-
UK (England)	11833	8355	578	7384	4555
UK (Scotland)	35115	14727	10249	13567	17909
UK (N. Ireland)	638	331	-	-	17
Unallocated landings	22215	14952	-977	0	0
Misreporting from VIa North					
Total Landings	220981	139322	72133	108960	125054
Discards	93	194	91	13	0
Total catch	**221074**	**139516**	**72224**	**108973**	**125054**

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

[2] May include misreported catch from VIaN and discards

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	2002	2003	2004	2005	2006
Denmark [1]	17846	7401	16278	5761	8614
Faroe Islands	1365	359	-	738	975
France	-	-	-	-	-
Germany	81	54	888	-	34
Netherlands	-	-	-	-	-
Norway [2]	63482	62306	100443	89925	90065
UK (Scotland)	-	-	-	-	83
Sweden	568	1529	1720	3510	2857
Unallocated landings	3959	9988	0	0	0
Total landings	87301	81637	119329	99934	102628
Discards	-	-	-	-	-
Total catch	**89303**	**83640**	**119329**	**99934**	**102628**
Norw. Spring Spawners [4]	4069	979	452	417	626

Country	2007	2008	2009	2010	2011
Denmark [1]	2646	1587	499	-	1590
Faroe Islands	577	400	700	719	-
France	-	-	-	-	-
Germany	-	-	-	-	-
Netherlands	263	-	-	-	-
Norway [2]	54424	17474	6981	7362	12922
UK (Scotland)	-	-	-	-	167
Sweden	640	-	1735	1505	150
Unallocated landings	-96 [3]	0	0	0	0
Total landings	58454	19461	9915	9586	14829
Discards	-	-	-	-	-
Total catch	**58454**	**19461**	**9915**	**9586**	**14829**
Norw. Spring Spawners [4]	685	2721	44560	56900	12178

[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	2002	2003	2004	2005	2006
Denmark 1	26387	22574	33857	41423	32277
Faroe Islands	48	173	402	-	200
France	4214	7918	10592	10205	17385
Germany	7577	12116	13823	14381	14222
Netherlands	13154	19115	23649	10038	13363
Norway	656	15732	1076	645	6933
Sweden	453	605	1794	1694	2715
UK (England)	317	2632	2864	3869	4924
UK (Scotland)	289	322	1841	1286	977
Unallocated landings 3	4052	-2401	8300	10233	2364
Total landings	57147	78786	98198	93774	95360
Discards 2			1265	1963	
Total catch	**57147**	**78786**	**99463**	**95737**	**95360**

Country	2007	2008	2009	2010	2011
Denmark 1	35990	32230	29164	19671	30498
Faroe Islands	1196	1612	815	1185	-
France	8421	9687	4316	2349	1687
Germany	2205	2415	1061	1994	1778
Netherlands	8550	904	3164	830	7314
Norway	5347	1543	17538	557	2537
Sweden	7150	6815	2129	580	2815
UK (England)	577	833	2	1577	4748
UK (Scotland)	-	1293	3757	805	488
Unallocated landings 3	-203	-904	-166	0	0
Total landings	69233	56428	61780	29548	51865
Discards 2		30			
Total catch	**69233**	**56458**	**61780**	**29548**	**51865**

[1] **Including any by-catches in the industrial fishery**
[2] **Discards partly included in unallocated landings**
[3] **Negative unallocated catches 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	2002	2003	2004	2005	2006
Belgium	23	5	8	6	3
Denmark	170	273	774	206	969
Faroe Islands					30
France	10686	12389	12988	15150	13637
Germany	4366	5987	9588	9896	7553
Netherlands	23814	36948	28637	34874	23743
UK (England)	3298	3977	4511	5919	5243
UK (Scotland)	623	-	-	-	-
Unallocated landings	5336	8170	9963	8231	5419
Total landings	50318	67749	68473	74282	56597
Discards 2	-	-	-	-	-
Total catch	**50318**	**67749**	**68473**	**74282**	**56597**
Coastal spring spawners included above 1	60	84	62	74	65

Country	2007	2008	2009	2010	2011
Belgium	1	-	-	-	4
Denmark	113	621	25	1106	115
France	7918	7592	6731	8984	7121
Germany	7703	5182	4307	5171	5007
Netherlands	14958	10584	10371	9449	12192
Norway	-	-	-	-	46
UK (England)	3583	2529	72	1809	2165
UK (Scotland)	-	1	-	1	-
Unallocated landings	4725	3103	417	0	0
Total landings	39001	29612	21923	26520	26650
Discards 2	-	-			
Total catch	**39001**	**29612**	**21923**	**26520**	**26650**
Coastal spring spawners included above 1	2	7	48	85	2

[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**

Table 2.1.6 ("The Wonderful Table"): Herring caught in the North Sea. Catch in thousand tonnes in Subarea IV, Division VIId and Division IIIa.

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sub-Area IV and Division VIId: TAC (IV and VIId)														
Recommended Divisions IVa, b	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]	-	-	
Expected catch of spring spawners														
Agreed Divisions IVa,b [1]	240	240	240	223	340.5	393.9	460.7	404.7	303.5	174.6	147.4	149.0	173.5	360.4
Agreed Div. IVc, VIId	25	25	25	42.7	59.5	66.1	74.3	50.0	37.5	26.7	23.6	15.3	26.5	44.6
Bycatch ceiling in the small mesh fishery	30	36	36	36	52.0	38.0	50.0	42.5	31.9	18.8	16.0	13.6	16.5	17.9
CATCH (IV and VIId)														
National landings Divisions IVa,b [2]	261	261	272	261	354.5	427.7	502.3	439.2	326.8	201.2	145.0	148.1	191.7	
Unallocated landings Divisions IVa,b	22	35	2	24	23.7	36.9	49.6	13.3	21.9	14.0	-1.1	0.0	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	0.0	
Total catch Divisions IVa,b [4]	283	296	273	303	382.3	481.6	564.6	454.0	348.8	215.4	143.9	148.1	191.7	
National landings Divisions IVc, VIId [3]	29	23	24	43	59.5	56.5	66.1	51.2	34.3	26.5	21.5	26.5	26.7	
Unallocated landings Divisions IVc,VIId	22	27	26	7	8.2	12.0	8.2	5.4	4.7	3.1	0.4	0	0	
Discard/slipping Divisions IVc, VIId [3]	-	-	-	0	-	-	-	-	-	-	-	-	-	
Total catch Divisions IVc, VIId	50	50	50	50	67.7	68.5	74.3	56.6	39.0	29.6	21.9	26.5	26.7	
Total catch IV and VIId as used by ICES [4]	**333**	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.62**	**387.8**	**245.0**	**165.8**	**174.6**	**218.4**	
CATCH BY FLEET/STOCK (IV and VIId) [7]														
North Sea autumn spawners directed fisheries (Fleet A)	313	322	296	323	434.9	529.5	610.0	487.1	379.6	236.3	152.1	164.8	209.2	
North Sea autumn spawners industrial (Fleet B)	15	18	20	22	12.3	13.6	21.8	11.9	7.1	8.6	9.8	9.1	8.9	
North Sea autumn spawners in IV and VIId total	**329**	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**	**386.7**	**244.9**	**161.9**	**173.9**	**218.1**	
Baltic-IIIa-type spring spawners in IV	5	7	6	7	2.8	7.1	7.0	11.0	1.1	0.1	3.9	0.8	0.3	
Coastal-type spring spawners	0.1	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	
Norw. Spring Spawners caught under a separate quota in IV [14]	32	26	7	4	1.0	0.5	0.4	0.6	0.7	2.7	44.6	56.9	12.2 [16]	
Division IIIa: TAC (IIIa)														
Predicted catch of autumn spawners	43	53	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended spring spawners	- [12]	- [12]	- [12]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	
Recommended mixed clupeoids	-	-	-	-	-	-	-	-	-	-	-	-		
Agreed herring TAC	80	80	80	80	80.0	70.0	96.0	81.6	69.4	51.7	37.7	33.9	30.0	45.0
Agreed mixed clupeoid TAC														
Bycatch ceiling in the small mesh fishery	19	21	21	21	21.0	21.0	24.2	20.5	15.4	11.5	8.4	7.5	6.7	6.7
CATCH (IIIa)														
National landings	86	108	90	79	76.0	61.1	90.8	88.9	47.3	38.2	38.8	37.3	20.0	
Catch as used by ICES	79	99	82	73	68.1	52.7	69.6	51.2	47.4	38.2	38.8	37.3	20.0	
CATCH BY FLEET/STOCK (IIIa) [7]														
Autumn spawners human consumption (Fleet C)	28	36	34	17	24.1	13.4	22.9	11.6	16.4	9.2	5.1	12.0	6.6	
Autumn spawners mixed clupeoid (Fleet D) [13]	8	13	12	9	8.4	10.8	9.0	3.4	3.4	3.7	1.5	1.8	1.8	
Autumn spawners other industrial landings (Fleet E)														
Autumn spawners in IIIa total	**34**	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**	**19.8**	**12.9**	**6.5**	**13.8**	**8.4**	
Spring spawners human consumption (Fleet C)	40	45	33	38	31.6	16.8	32.5	30.2	25.3	23.0	29.4	23.0	10.8	
Spring spawners mixed clupeoid (Fleet D) [13]	3	5	3	9	4.0	11.2	5.1	5.9	2.3	2.2	2.9	0.5	0.8	
Spring spawners other industrial landings (Fleet E)														
Spring spawners in IIIa total	**43**	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**	**27.6**	**25.2**	**32.3**	**23.5**	**11.6**	
North Sea autumn spawners Total as used by ICES	**363**	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**	**406.5**	**257.9**	**168.4**	**187.6**	**226.5**	

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 62ïN 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 2011. 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	203.8	0.0	0.0	0.0	24.9	550.0	0.2	0.0	574.9	0.2	778.9	575.1
1	35.4	0.0	0.0	0.0	10.9	108.5	4.7	0.0	119.4	4.7	159.5	124.1
2	61.5	12.0	0.1	11.9	218.8	70.7	1.6	3.2	301.4	4.8	367.7	306.3
3	3.2	15.4	0.4	14.9	151.8	60.9	5.7	37.6	227.6	43.3	274.1	271.4
4	0.3	22.7	0.4	22.3	100.1	41.7	3.5	50.0	164.1	53.5	217.9	218.0
5	0.2	12.1	0.2	11.9	75.9	23.4	2.2	16.2	111.1	18.4	129.7	129.7
6	0.1	3.5	0.1	3.5	38.8	12.6	1.1	6.7	54.8	7.9	62.8	62.8
7	0.1	4.0	0.1	3.9	32.8	8.0	0.2	6.9	44.7	7.0	51.9	51.9
8	0.0	3.8	0.1	3.7	38.0	13.8	0.1	4.1	55.6	4.2	59.8	59.9
9+	0.0	7.3	0.2	7.2	41.4	7.5	0.7	8.6	56.0	9.3	65.3	65.5
Sum	304.6	81.0	1.6	79.4	733.3	897.0	20.0	133.3	1709.7	153.3	2167.6	1864.7
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	13.6	0.0	0.0	0.0	0.0	4.7	3.3	0.0	4.7	3.3	21.6	8.0
2	43.2	4.7	0.0	4.7	35.6	4.0	0.0	0.0	44.3	0.0	87.6	44.4
3	2.5	3.0	0.0	3.0	23.0	1.9	0.2	1.3	27.9	1.5	31.9	29.4
4	0.2	0.8	0.0	0.8	20.0	1.6	0.3	2.5	22.3	2.8	25.3	25.1
5	0.2	2.2	0.0	2.2	30.6	3.9	0.1	0.6	36.6	0.7	37.5	37.3
6	0.1	0.1	0.0	0.1	15.7	1.2	0.1	0.9	17.0	1.0	18.0	17.9
7	0.1	0.4	0.0	0.4	8.4	0.8	0.1	1.1	9.5	1.2	10.9	10.8
8	0.0	1.3	0.0	1.3	23.6	3.8	0.1	0.7	28.6	0.8	29.4	29.4
9+	0.0	0.5	0.0	0.5	11.9	0.0	0.2	1.2	12.5	1.4	13.9	13.9
Sum	59.9	13.0	0.1	13.0	168.7	21.8	4.4	8.2	203.5	12.7	276.0	216.2
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	65.9	0.0	0.0	65.9	0.0	65.9	65.9
1	1.8	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.5	0.0	2.4	0.5
2	5.2	6.7	0.0	6.7	67.0	4.0	0.2	0.0	77.7	0.2	83.1	77.9
3	0.1	11.7	0.1	11.6	61.5	3.7	0.2	0.0	76.8	0.2	77.1	77.2
4	0.0	21.0	0.1	20.9	38.6	2.3	0.1	0.1	61.7	0.1	61.8	62.0
5	0.0	9.3	0.1	9.2	13.0	0.8	0.0	0.0	23.0	0.0	23.0	23.1
6	0.0	3.3	0.0	3.2	5.2	0.4	0.0	0.0	8.9	0.0	8.9	8.9
7	0.0	3.3	0.0	3.2	5.2	0.3	0.0	0.0	8.8	0.0	8.8	8.8
8	0.0	2.2	0.0	2.2	3.0	0.3	0.0	0.0	5.5	0.0	5.5	5.5
9+	0.0	6.2	0.0	6.2	6.8	0.2	0.0	0.0	13.2	0.0	13.2	13.3
Sum	7.1	63.6	0.4	63.2	200.4	78.4	0.5	0.2	342.0	0.7	349.8	343.1
Quarter: 3												
0	127.5	0.0	0.0	0.0	16.1	364.3	0.1	0.0	380.4	0.1	508.0	380.5
1	8.3	0.0	0.0	0.0	3.7	5.4	0.4	0.0	9.1	0.4	17.7	9.4
2	12.2	0.2	0.0	0.2	93.9	52.8	0.0	0.0	146.9	0.0	159.1	146.9
3	0.7	0.4	0.3	0.1	52.6	45.6	0.0	0.0	98.3	0.0	98.9	98.6
4	0.1	0.7	0.3	0.4	31.9	32.2	0.0	0.0	64.5	0.0	64.6	64.8
5	0.0	0.4	0.1	0.2	19.3	15.8	0.0	0.0	35.4	0.0	35.4	35.5
6	0.0	0.1	0.0	0.1	13.8	10.2	0.0	0.0	24.1	0.0	24.1	24.1
7	0.0	0.2	0.1	0.1	13.1	5.1	0.0	0.0	18.3	0.0	18.3	18.4
8	0.0	0.2	0.1	0.1	3.3	7.5	0.0	0.0	11.0	0.0	11.0	11.1
9+	0.0	0.3	0.1	0.2	10.1	5.1	0.0	0.0	15.4	0.0	15.4	15.5
Sum	148.8	2.6	1.1	1.5	257.7	544.0	0.5	0.0	803.2	0.5	952.5	804.8
Quarter: 4												
0	76.3	0.0	0.0	0.0	8.8	119.8	0.2	0.0	128.6	0.2	205.0	128.7
1	11.7	0.0	0.0	0.0	7.0	98.1	1.0	0.0	105.1	1.0	117.8	106.1
2	0.8	0.3	0.0	0.3	22.4	9.8	1.4	3.2	32.6	4.6	37.9	37.1
3	0.0	0.3	0.0	0.3	14.8	9.6	5.3	36.3	24.7	41.6	66.2	66.2
4	0.0	0.3	0.0	0.2	9.7	5.6	3.1	47.5	15.6	50.6	66.1	66.2
5	0.0	0.3	0.0	0.3	13.0	2.9	2.1	15.5	16.2	17.6	33.8	33.8
6	0.0	0.1	0.0	0.1	4.1	0.7	1.0	5.8	4.9	6.9	11.7	11.7
7	0.0	0.1	0.0	0.1	6.1	1.9	0.0	5.8	8.1	5.8	13.9	13.9
8	0.0	0.1	0.0	0.1	8.1	2.2	0.0	3.4	10.4	3.4	13.9	13.9
9+	0.0	0.3	0.0	0.3	12.6	2.2	0.5	7.3	15.0	7.8	22.9	22.9
Sum	88.8	1.8	0.1	1.7	106.5	252.8	14.6	124.8	361.1	139.4	589.3	500.6

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 2011. 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	**0.007**	**0.000**	**0.000**	**0.010**	**0.008**	**0.020**	**0.000**	**0.008**	**0.020**	**0.008**	**0.008**
1	**0.035**	**0.000**	**0.000**	**0.081**	**0.040**	**0.025**	**0.000**	**0.044**	**0.025**	**0.041**	**0.043**
2	**0.084**	**0.142**	**0.150**	**0.141**	**0.145**	**0.126**	**0.121**	**0.142**	**0.122**	**0.132**	**0.141**
3	**0.114**	**0.162**	**0.167**	**0.161**	**0.162**	**0.162**	**0.153**	**0.161**	**0.154**	**0.159**	**0.160**
4	**0.134**	**0.180**	**0.183**	**0.185**	**0.187**	**0.189**	**0.179**	**0.184**	**0.179**	**0.183**	**0.183**
5	**0.191**	**0.204**	**0.208**	**0.195**	**0.206**	**0.206**	**0.187**	**0.198**	**0.189**	**0.197**	**0.197**
6	**0.193**	**0.215**	**0.213**	**0.216**	**0.235**	**0.217**	**0.192**	**0.220**	**0.195**	**0.217**	**0.217**
7	**0.234**	**0.209**	**0.211**	**0.223**	**0.234**	**0.187**	**0.206**	**0.224**	**0.205**	**0.221**	**0.221**
8	**0.248**	**0.216**	**0.201**	**0.220**	**0.240**	**0.177**	**0.210**	**0.224**	**0.209**	**0.223**	**0.223**
9+	**0.000**	**0.222**	**0.230**	**0.243**	**0.268**	**0.196**	**0.219**	**0.243**	**0.217**	**0.240**	**0.240**
Quarter: 1											
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	**0.000**	**0.000**
1	0.010	0.000	0.000	0.000	0.015	0.015	0.000	0.015	0.015	**0.012**	**0.015**
2	0.075	0.122	0.122	0.098	0.103	0.118	0.000	0.101	0.118	**0.088**	**0.101**
3	0.106	0.139	0.139	0.137	0.136	0.126	0.124	0.137	0.124	**0.134**	**0.136**
4	0.122	0.191	0.191	0.164	0.170	0.145	0.144	0.166	0.144	**0.163**	**0.163**
5	0.191	0.189	0.189	0.168	0.172	0.155	0.154	0.170	0.154	**0.170**	**0.170**
6	0.193	0.185	0.185	0.183	0.170	0.170	0.169	0.182	0.169	**0.181**	**0.181**
7	0.234	0.279	0.279	0.188	0.188	0.187	0.187	0.192	0.187	**0.191**	**0.191**
8	0.248	0.233	0.233	0.215	0.207	0.174	0.174	0.214	0.174	**0.214**	**0.214**
9+	0.000	0.302	0.302	0.223	0.000	0.196	0.196	0.226	0.196	**0.223**	**0.223**
Quarter: 2											
0	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.006	0.000	**0.006**	**0.006**
1	0.025	0.000	0.000	0.090	0.070	0.073	0.000	0.075	0.073	**0.036**	**0.075**
2	0.082	0.156	0.156	0.133	0.133	0.118	0.000	0.135	0.118	**0.131**	**0.135**
3	0.101	0.167	0.167	0.146	0.149	0.138	0.124	0.149	0.136	**0.149**	**0.149**
4	0.000	0.179	0.179	0.171	0.174	0.162	0.144	0.174	0.154	**0.174**	**0.174**
5	0.000	0.207	0.207	0.193	0.194	0.178	0.154	0.199	0.169	**0.199**	**0.199**
6	0.000	0.215	0.215	0.222	0.225	0.187	0.169	0.219	0.173	**0.219**	**0.219**
7	0.000	0.200	0.200	0.205	0.219	0.175	0.187	0.204	0.184	**0.204**	**0.204**
8	0.000	0.208	0.208	0.193	0.244	0.183	0.174	0.202	0.175	**0.202**	**0.202**
9+	0.000	0.213	0.213	0.204	0.201	0.187	0.196	0.208	0.194	**0.208**	**0.208**
Quarter: 3											
0	0.007	0.000	0.000	0.006	0.006	0.020	0.000	0.006	0.020	**0.006**	**0.006**
1	0.055	0.000	0.000	0.162	0.081	0.047	0.000	0.114	0.047	**0.085**	**0.111**
2	0.115	0.147	0.147	0.162	0.151	0.159	0.137	0.158	0.159	**0.155**	**0.158**
3	0.142	0.167	0.167	0.187	0.164	0.167	0.161	0.177	0.165	**0.176**	**0.177**
4	0.165	0.184	0.184	0.213	0.189	0.197	0.175	0.201	0.188	**0.201**	**0.201**
5	0.000	0.212	0.212	0.235	0.216	0.230	0.188	0.227	0.214	**0.227**	**0.227**
6	0.000	0.210	0.210	0.245	0.243	0.261	0.195	0.244	0.240	**0.244**	**0.244**
7	0.000	0.207	0.207	0.246	0.247	0.258	0.221	0.246	0.241	**0.246**	**0.246**
8	0.000	0.193	0.193	0.238	0.262	0.265	0.217	0.253	0.246	**0.253**	**0.253**
9+	0.000	0.228	0.228	0.265	0.274	0.280	0.219	0.267	0.269	**0.267**	**0.267**
Quarter: 4											
0	0.008	0.000	0.000	0.016	0.016	0.020	0.000	0.016	0.020	**0.013**	**0.016**
1	0.052	0.000	0.000	0.038	0.039	0.048	0.000	0.039	0.048	**0.040**	**0.039**
2	0.084	0.143	0.143	0.143	0.133	0.127	0.121	0.140	0.123	**0.137**	**0.138**
3	0.000	0.164	0.164	0.164	0.158	0.164	0.154	0.162	0.155	**0.158**	**0.158**
4	0.000	0.186	0.186	0.188	0.183	0.194	0.181	0.186	0.181	**0.182**	**0.182**
5	0.000	0.203	0.203	0.201	0.199	0.208	0.188	0.201	0.190	**0.195**	**0.195**
6	0.000	0.242	0.242	0.237	0.230	0.222	0.195	0.236	0.199	**0.214**	**0.214**
7	0.000	0.228	0.228	0.236	0.219	0.194	0.209	0.232	0.209	**0.223**	**0.223**
8	0.000	0.227	0.227	0.237	0.222	0.184	0.217	0.233	0.217	**0.229**	**0.229**
9+	0.000	0.255	0.255	0.265	0.260	0.196	0.223	0.264	0.221	**0.249**	**0.249**

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2011. 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.**	**12.1**	**11.6**	**15.3**	**0.0**	**11.6**	**15.3**
1	**n.d.**	**0.0**	**n.d.**	**21.1**	**18.3**	**15.6**	**0.0**	**18.5**	**15.6**
2	**n.d.**	**25.6**	**n.d.**	**25.4**	**25.8**	**24.0**	**24.1**	**25.5**	**24.1**
3	**n.d.**	**26.4**	**n.d.**	**26.5**	**26.8**	**26.3**	**25.9**	**26.6**	**26.0**
4	**n.d.**	**27.1**	**n.d.**	**27.9**	**28.0**	**27.6**	**27.1**	**27.8**	**27.2**
5	**n.d.**	**28.4**	**n.d.**	**29.1**	**29.3**	**28.1**	**27.4**	**29.1**	**27.5**
6	**n.d.**	**28.6**	**n.d.**	**29.8**	**30.2**	**29.4**	**27.8**	**29.8**	**28.0**
7	**n.d.**	**28.9**	**n.d.**	**29.9**	**30.5**	**28.8**	**28.8**	**29.9**	**28.8**
8	**n.d.**	**29.5**	**n.d.**	**31.2**	**31.0**	**28.7**	**28.7**	**31.0**	**28.7**
9+	**n.d.**	**29.0**	**n.d.**	**30.3**	**31.1**	**28.2**	**29.1**	**30.2**	**29.0**
Quarter: 1									
0	n.d.	0.0	n.d.	0.0	0.0	0.0	0.0	0.0	0.0
1	n.d.	0.0	n.d.	0.0	14.1	14.1	0.0	14.1	14.1
2	n.d.	26.2	n.d.	24.0	25.0	23.6	0.0	24.3	23.6
3	n.d.	27.5	n.d.	26.6	27.5	25.6	25.6	26.8	25.6
4	n.d.	30.2	n.d.	28.6	29.5	27.2	27.2	28.7	27.2
5	n.d.	30.3	n.d.	29.1	29.8	28.0	28.0	29.2	28.0
6	n.d.	29.6	n.d.	29.6	29.9	28.4	28.4	29.7	28.4
7	n.d.	32.3	n.d.	30.1	30.8	28.9	28.9	30.3	28.9
8	n.d.	31.8	n.d.	31.5	31.6	28.8	28.8	31.5	28.8
9+	n.d.	33.4	n.d.	29.5	0.0	29.1	29.1	29.7	29.1
Quarter: 2									
0	n.d.	0.0	n.d.	0.0	10.8	0.0	0.0	10.8	0.0
1	n.d.	0.0	n.d.	21.8	20.7	20.5	0.0	21.0	20.5
2	n.d.	25.2	n.d.	24.5	24.7	23.6	0.0	24.6	23.6
3	n.d.	26.1	n.d.	25.4	25.8	25.4	25.6	25.5	25.4
4	n.d.	26.9	n.d.	26.8	27.2	26.9	27.2	26.9	27.0
5	n.d.	28.0	n.d.	28.0	28.3	27.7	28.0	28.0	27.8
6	n.d.	28.5	n.d.	28.9	29.6	28.0	28.4	28.8	28.3
7	n.d.	28.4	n.d.	28.4	29.5	28.2	28.9	28.5	28.7
8	n.d.	28.3	n.d.	28.4	30.5	28.5	28.8	28.5	28.8
9+	n.d.	28.5	n.d.	28.5	28.5	28.4	29.1	28.5	28.9
Quarter: 3									
0	n.d.	0.0	n.d.	10.8	10.8	15.3	0.0	10.8	15.3
1	n.d.	0.0	n.d.	26.7	21.8	19.0	0.0	23.8	19.0
2	n.d.	25.4	n.d.	26.3	26.0	26.1	24.8	26.2	26.1
3	n.d.	26.2	n.d.	27.4	26.8	26.5	26.1	27.1	26.4
4	n.d.	27.4	n.d.	28.5	28.0	28.0	26.8	28.3	27.5
5	n.d.	28.5	n.d.	29.7	29.2	29.6	27.4	29.5	28.7
6	n.d.	28.5	n.d.	30.0	30.3	30.5	27.7	30.1	29.6
7	n.d.	28.5	n.d.	30.0	30.7	30.4	28.8	30.1	29.7
8	n.d.	28.4	n.d.	29.7	31.1	30.7	28.7	30.6	30.0
9+	n.d.	29.0	n.d.	30.2	30.9	31.2	28.8	30.4	30.7
Quarter: 4									
0	n.d.	0.0	n.d.	14.4	14.4	15.3	0.0	14.4	15.3
1	n.d.	0.0	n.d.	18.2	18.3	19.1	0.0	18.3	19.1
2	n.d.	25.8	n.d.	26.3	25.5	24.0	24.1	26.1	24.1
3	n.d.	27.1	n.d.	27.6	27.0	26.4	25.9	27.3	26.0
4	n.d.	28.4	n.d.	29.1	28.2	27.7	27.1	28.8	27.2
5	n.d.	29.1	n.d.	29.6	29.1	28.1	27.4	29.5	27.5
6	n.d.	30.1	n.d.	30.7	29.8	29.5	27.7	30.5	28.0
7	n.d.	30.1	n.d.	30.7	29.8	28.6	28.8	30.5	28.8
8	n.d.	30.4	n.d.	31.9	30.0	28.2	28.7	31.5	28.7
9+	n.d.	31.2	n.d.	32.0	31.8	27.9	29.1	31.9	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 2011. Catches (tonnes) at-age (SOP figures), by quarter and division.

WR	IIIa NSAS	IVa(E) all	IVa(E) WBSS	IVa(E) NSAS only	IVa(W)	IVb	IVc	VIId	IVa & IVb NSAS	IVc & VIId	Total NSAS	Herring caught in the North Sea
Quarters: 1-4												
0	1.5	0.0	0.0	0.0	0.2	4.5	0.0	0.0	4.7	0.0	6.3	4.8
1	1.2	0.0	0.0	0.0	0.9	4.3	0.1	0.0	5.2	0.1	6.6	5.3
2	5.1	1.7	0.0	1.7	30.8	10.2	0.2	0.4	42.7	0.6	48.4	43.3
3	0.4	2.5	0.1	2.4	24.4	9.8	0.9	5.8	36.6	6.7	43.7	43.4
4	0.0	4.1	0.1	4.0	18.5	7.8	0.7	8.9	30.3	9.6	39.9	39.9
5	0.0	2.5	0.0	2.4	14.8	4.8	0.5	3.0	22.0	3.5	25.5	25.6
6	0.0	0.8	0.0	0.7	8.4	2.9	0.2	1.3	12.1	1.5	13.6	13.6
7	0.0	0.8	0.0	0.8	7.3	1.9	0.0	1.4	10.0	1.4	11.5	11.5
8	0.0	0.8	0.0	0.8	8.4	3.3	0.0	0.9	12.5	0.9	13.4	13.4
9+	0.0	1.6	0.0	1.6	10.0	2.0	0.1	1.9	13.6	2.0	15.7	15.7
Sum	8.4	14.8	0.3	14.5	123.6	51.7	2.8	23.5	189.8	26.3	224.5	216.4
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.3	0.1
2	3.2	0.6	0.0	0.6	3.5	0.4	0.0	0.0	4.5	0.0	7.7	4.5
3	0.3	0.4	0.0	0.4	3.1	0.3	0.0	0.2	3.8	0.2	4.3	4.0
4	0.0	0.2	0.0	0.2	3.3	0.3	0.0	0.4	3.7	0.4	4.1	4.1
5	0.0	0.4	0.0	0.4	5.1	0.7	0.0	0.1	6.2	0.1	6.4	6.3
6	0.0	0.0	0.0	0.0	2.9	0.2	0.0	0.1	3.1	0.2	3.3	3.2
7	0.0	0.1	0.0	0.1	1.6	0.1	0.0	0.2	1.8	0.2	2.1	2.1
8	0.0	0.3	0.0	0.3	5.1	0.8	0.0	0.1	6.1	0.1	6.3	6.3
9+	0.0	0.2	0.0	0.2	2.7	0.0	0.0	0.2	2.8	0.3	3.1	3.1
Sum	3.7	2.2	0.0	2.1	27.2	2.8	0.2	1.3	32.1	1.6	37.4	33.7
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.0	0.4	0.4
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
2	0.4	1.0	0.0	1.0	8.9	0.5	0.0	0.0	10.5	0.0	10.9	10.5
3	0.0	2.0	0.0	1.9	9.0	0.6	0.0	0.0	11.5	0.0	11.5	11.5
4	0.0	3.8	0.0	3.7	6.6	0.4	0.0	0.0	10.7	0.0	10.7	10.8
5	0.0	1.9	0.0	1.9	2.5	0.1	0.0	0.0	4.6	0.0	4.6	4.6
6	0.0	0.7	0.0	0.7	1.2	0.1	0.0	0.0	2.0	0.0	2.0	2.0
7	0.0	0.7	0.0	0.6	1.1	0.1	0.0	0.0	1.8	0.0	1.8	1.8
8	0.0	0.5	0.0	0.5	0.6	0.1	0.0	0.0	1.1	0.0	1.1	1.1
9+	0.0	1.3	0.0	1.3	1.4	0.0	0.0	0.0	2.7	0.0	2.8	2.8
Sum	0.5	11.8	0.1	11.7	31.2	2.4	0.1	0.0	45.2	0.1	45.8	45.4
Quarter: 3												
0	0.9	0.0	0.0	0.0	0.1	2.2	0.0	0.0	2.3	0.0	3.2	2.3
1	0.5	0.0	0.0	0.0	0.6	0.4	0.0	0.0	1.0	0.0	1.5	1.0
2	1.4	0.0	0.0	0.0	15.2	8.0	0.0	0.0	23.2	0.0	24.6	23.2
3	0.1	0.1	0.1	0.0	9.8	7.5	0.0	0.0	17.3	0.0	17.4	17.4
4	0.0	0.1	0.0	0.1	6.8	6.1	0.0	0.0	13.0	0.0	13.0	13.0
5	0.0	0.1	0.0	0.1	4.5	3.4	0.0	0.0	8.0	0.0	8.0	8.0
6	0.0	0.0	0.0	0.0	3.4	2.5	0.0	0.0	5.9	0.0	5.9	5.9
7	0.0	0.0	0.0	0.0	3.2	1.3	0.0	0.0	4.5	0.0	4.5	4.5
8	0.0	0.0	0.0	0.0	0.8	2.0	0.0	0.0	2.8	0.0	2.8	2.8
9+	0.0	0.1	0.0	0.0	2.7	1.4	0.0	0.0	4.1	0.0	4.1	4.1
Sum	2.9	0.5	0.2	0.3	47.1	34.7	0.0	0.0	82.1	0.0	85.0	82.4
Quarter: 4												
0	0.6	0.0	0.0	0.0	0.1	1.9	0.0	0.0	2.1	0.0	2.7	2.1
1	0.6	0.0	0.0	0.0	0.3	3.8	0.0	0.0	4.1	0.0	4.7	4.1
2	0.1	0.0	0.0	0.0	3.2	1.3	0.2	0.4	4.6	0.6	5.2	5.1
3	0.0	0.1	0.0	0.1	2.4	1.5	0.9	5.6	4.0	6.5	10.4	10.4
4	0.0	0.0	0.0	0.0	1.8	1.0	0.6	8.6	2.9	9.2	12.1	12.1
5	0.0	0.1	0.0	0.1	2.6	0.6	0.4	2.9	3.2	3.4	6.6	6.6
6	0.0	0.0	0.0	0.0	1.0	0.2	0.2	1.1	1.2	1.4	2.5	2.5
7	0.0	0.0	0.0	0.0	1.4	0.4	0.0	1.2	1.9	1.2	3.1	3.1
8	0.0	0.0	0.0	0.0	1.9	0.5	0.0	0.7	2.4	0.7	3.2	3.2
9+	0.0	0.1	0.0	0.1	3.3	0.6	0.1	1.6	4.0	1.7	5.7	5.7
Sum	1.3	0.4	0.0	0.3	18.1	11.8	2.5	22.2	30.3	24.6	56.2	54.9

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2011. 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	**66.9%**	**0.0%**	**0.0%**	**0.0%**	**3.4%**	**61.3%**	**1.2%**	**0.0%**	**33.6%**	**0.2%**	**35.9%**	**30.8%**
1	**11.6%**	**0.0%**	**0.0%**	**0.0%**	**1.5%**	**12.1%**	**23.3%**	**0.0%**	**7.0%**	**3.0%**	**7.4%**	**6.7%**
2	**20.2%**	**14.8%**	**3.9%**	**15.0%**	**29.8%**	**7.9%**	**8.2%**	**2.4%**	**17.6%**	**3.1%**	**17.0%**	**16.4%**
3	**1.1%**	**19.0%**	**27.4%**	**18.8%**	**20.7%**	**6.8%**	**28.3%**	**28.2%**	**13.3%**	**28.3%**	**12.6%**	**14.6%**
4	**0.1%**	**28.1%**	**24.7%**	**28.1%**	**13.7%**	**4.6%**	**17.5%**	**37.5%**	**9.6%**	**34.9%**	**10.1%**	**11.7%**
5	**0.1%**	**15.0%**	**14.6%**	**15.0%**	**10.3%**	**2.6%**	**11.0%**	**12.1%**	**6.5%**	**12.0%**	**6.0%**	**7.0%**
6	**0.0%**	**4.4%**	**4.3%**	**4.4%**	**5.3%**	**1.4%**	**5.7%**	**5.0%**	**3.2%**	**5.1%**	**2.9%**	**3.4%**
7	**0.0%**	**5.0%**	**6.8%**	**4.9%**	**4.5%**	**0.9%**	**0.8%**	**5.2%**	**2.6%**	**4.6%**	**2.4%**	**2.8%**
8	**0.0%**	**4.7%**	**7.3%**	**4.7%**	**5.2%**	**1.5%**	**0.5%**	**3.1%**	**3.3%**	**2.7%**	**2.8%**	**3.2%**
9+	**0.0%**	**9.1%**	**11.2%**	**9.0%**	**5.6%**	**0.8%**	**3.4%**	**6.5%**	**3.3%**	**6.1%**	**3.0%**	**3.5%**
Sum 3+	**1.3%**	**85.2%**	**96.1%**	**85.0%**	**65.3%**	**18.7%**	**67.3%**	**97.6%**	**41.8%**	**93.7%**	**39.7%**	**46.1%**
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	**0.0%**	**0.0%**
1	22.7%	0.0%	0.0%	0.0%	0.0%	21.6%	74.2%	0.0%	2.3%	25.9%	**7.8%**	**3.7%**
2	72.2%	36.2%	0.0%	36.4%	21.1%	18.5%	0.9%	0.0%	21.8%	0.3%	**31.7%**	**20.5%**
3	4.1%	23.0%	0.0%	23.1%	13.6%	8.8%	4.6%	16.0%	13.7%	12.0%	**11.5%**	**13.6%**
4	0.3%	6.2%	15.3%	6.2%	11.8%	7.3%	7.3%	29.8%	11.0%	21.9%	**9.2%**	**11.6%**
5	0.3%	16.9%	41.5%	16.8%	18.1%	17.7%	1.9%	7.5%	18.0%	5.5%	**13.6%**	**17.3%**
6	0.2%	0.7%	1.6%	0.6%	9.3%	5.4%	2.5%	10.3%	8.3%	7.6%	**6.5%**	**8.3%**
7	0.2%	3.1%	7.5%	3.0%	5.0%	3.6%	3.1%	13.1%	4.7%	9.6%	**3.9%**	**5.0%**
8	0.0%	9.7%	23.9%	9.7%	14.0%	17.2%	1.9%	8.1%	14.1%	6.0%	**10.7%**	**13.6%**
9+	0.0%	4.1%	10.2%	4.1%	7.1%	0.0%	3.6%	15.1%	6.1%	11.1%	**5.0%**	**6.4%**
Sum 3+	**5.1%**	**63.8%**	**100.0%**	**63.6%**	**78.9%**	**59.9%**	**24.9%**	**100.0%**	**75.9%**	**73.8%**	**60.4%**	**75.8%**
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	84.1%	0.0%	0.0%	19.3%	0.0%	**18.8%**	**19.2%**
1	25.7%	0.0%	0.0%	0.0%	0.1%	0.5%	3.0%	0.0%	0.2%	2.2%	**0.7%**	**0.2%**
2	73.2%	10.5%	4.7%	10.6%	33.4%	5.1%	39.6%	0.0%	22.7%	29.2%	**23.8%**	**22.7%**
3	1.1%	18.4%	33.9%	18.3%	30.7%	4.7%	34.6%	16.0%	22.5%	29.7%	**22.0%**	**22.5%**
4	0.0%	33.0%	28.4%	33.0%	19.2%	2.9%	13.8%	29.8%	18.0%	18.0%	**17.7%**	**18.1%**
5	0.0%	14.6%	12.6%	14.6%	6.5%	1.0%	4.4%	7.5%	6.7%	5.3%	**6.6%**	**6.7%**
6	0.0%	5.1%	4.4%	5.1%	2.6%	0.5%	1.2%	10.3%	2.6%	3.6%	**2.6%**	**2.6%**
7	0.0%	5.1%	4.4%	5.1%	2.6%	0.4%	1.5%	13.1%	2.6%	4.6%	**2.5%**	**2.6%**
8	0.0%	3.5%	3.0%	3.5%	1.5%	0.4%	0.3%	8.1%	1.6%	2.3%	**1.6%**	**1.6%**
9+	0.0%	9.7%	8.4%	9.7%	3.4%	0.3%	1.7%	15.1%	3.9%	5.2%	**3.8%**	**3.9%**
Sum 3+	**1.1%**	**89.5%**	**95.3%**	**89.4%**	**66.5%**	**10.3%**	**57.4%**	**100.0%**	**57.9%**	**68.6%**	**56.7%**	**57.9%**
Quarter: 3												
0	85.7%	0.0%	0.0%	0.0%	6.3%	67.0%	15.0%	0.0%	47.4%	14.7%	**53.3%**	**47.3%**
1	5.6%	0.0%	0.0%	0.0%	1.4%	1.0%	78.5%	0.0%	1.1%	76.8%	**1.9%**	**1.2%**
2	8.2%	8.8%	4.1%	12.2%	36.4%	9.7%	2.0%	1.5%	18.3%	1.9%	**16.7%**	**18.3%**
3	0.5%	14.9%	28.2%	5.2%	20.4%	8.4%	1.6%	20.9%	12.2%	2.1%	**10.4%**	**12.2%**
4	0.1%	27.0%	24.0%	29.2%	12.4%	5.9%	1.0%	33.6%	8.0%	1.7%	**6.8%**	**8.0%**
5	0.0%	14.9%	13.2%	16.1%	7.5%	2.9%	0.8%	21.7%	4.4%	1.3%	**3.7%**	**4.4%**
6	0.0%	4.7%	4.2%	5.1%	5.3%	1.9%	0.4%	8.2%	3.0%	0.6%	**2.5%**	**3.0%**
7	0.0%	8.1%	7.2%	8.8%	5.1%	0.9%	0.1%	5.0%	2.3%	0.2%	**1.9%**	**2.3%**
8	0.0%	8.8%	7.8%	9.5%	1.3%	1.4%	0.2%	4.8%	1.4%	0.3%	**1.2%**	**1.4%**
9+	0.0%	12.8%	11.4%	13.9%	3.9%	0.9%	0.4%	4.3%	1.9%	0.5%	**1.6%**	**1.9%**
Sum 3+	**0.5%**	**91.2%**	**95.9%**	**87.8%**	**55.9%**	**22.3%**	**4.5%**	**98.5%**	**33.2%**	**6.6%**	**28.1%**	**33.3%**
Quarter: 4												
0	86.0%	0.0%	0.0%	0.0%	8.2%	47.4%	1.2%	0.0%	35.6%	0.1%	**34.8%**	**25.7%**
1	13.2%	0.0%	0.0%	0.0%	6.6%	38.8%	6.7%	0.0%	29.1%	0.7%	**20.0%**	**21.2%**
2	0.9%	19.4%	0.0%	20.2%	21.0%	3.9%	9.5%	2.5%	9.0%	3.3%	**6.4%**	**7.4%**
3	0.0%	17.1%	0.0%	17.8%	13.9%	3.8%	36.2%	29.1%	6.8%	29.8%	**11.2%**	**13.2%**
4	0.0%	14.7%	23.2%	14.4%	9.1%	2.2%	21.2%	38.0%	4.3%	36.3%	**11.2%**	**13.2%**
5	0.0%	15.0%	23.6%	14.6%	12.2%	1.2%	14.3%	12.4%	4.5%	12.6%	**5.7%**	**6.8%**
6	0.0%	4.1%	6.4%	4.0%	3.8%	0.3%	7.0%	4.7%	1.3%	4.9%	**2.0%**	**2.3%**
7	0.0%	8.2%	13.0%	8.1%	5.7%	0.7%	0.1%	4.6%	2.2%	4.1%	**2.4%**	**2.8%**
8	0.0%	5.6%	8.8%	5.5%	7.6%	0.9%	0.1%	2.7%	2.9%	2.5%	**2.4%**	**2.8%**
9+	0.0%	15.9%	25.0%	15.5%	11.8%	0.9%	3.6%	5.9%	4.2%	5.6%	**3.9%**	**4.6%**
Sum 3+	**0.0%**	**80.6%**	**100.0%**	**79.8%**	**64.1%**	**9.9%**	**82.5%**	**97.5%**	**26.3%**	**95.9%**	**38.8%**	**45.7%**

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

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

2011	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	575.1	0.008	2.3	0.021	201.5	0.007	**778.9**	**0.008**
1	11.0	0.112	113.1	0.036	19.4	0.053	16.0	0.013	**159.5**	**0.041**
2	306.2	0.141	0.0	0.000	59.7	0.085	1.7	0.045	**367.7**	**0.132**
3	270.9	0.160	0.0	0.000	3.1	0.115	0.2	0.071	**274.1**	**0.159**
4	217.6	0.183	0.0	0.000	0.3	0.134	0.0	0.000	**217.9**	**0.183**
5	129.5	0.197	0.0	0.000	0.2	0.191	0.0	0.000	**129.7**	**0.197**
6	62.7	0.217	0.0	0.000	0.1	0.193	0.0	0.000	**62.8**	**0.217**
7	51.8	0.221	0.0	0.000	0.1	0.234	0.0	0.000	**51.9**	**0.221**
8	59.8	0.223	0.0	0.000	0.0	0.248	0.0	0.000	**59.8**	**0.223**
9+	65.3	0.240	0.0	0.000	0.0	0.000	0.0	0.000	**65.3**	**0.240**
TOTAL	1,174.8		688.3		85.1		219.5		2,167.6	
SOP catch	**207.2**		**8.8**		**6.6**		**1.8**		**224.4**	

Figures for A fleet include unsampled bycatch in the industrial fishery

Table 2.2.7: Catch at age (numbers in millions) of North Sea herring, 1996-2011. SG Rednose's revisions for 1995-2001 are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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
2011	575	124	306	271	218	130	63	52	60	66	1865

Table 2.2.8: Catch at age (numbers in millions) of WBSS Herring taken in the North Sea, and transfered to the assessment of the spring spawning stock in IIIa, 1996-2011.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
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
2011	0.0	0.0	0.1	0.4	0.4	0.2	0.1	0.1	0.1	0.2	1.6

Table 2.2.9: Catch at age (numbers in millions) of NSAS taken in IIIa, and transfered to the assessment of NSAS, 1996 - 2011. SG Rednose's revisions and revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8+		Total
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
2011	204	35	61	3	0	0	0	0	0		305

Table 2.2.10: Catch at age (numbers in millions) of the total NSAS stock 1996 - 2011. 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
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
2011	779	160	368	274	218	130	63	52	60	65	2168

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 2001 – 2011. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IIIa	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	-
	2011	0.084	0.114	0.134	0.191	0.193	0.234	0.248	-
IVa(E)	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
	2011	0.142	0.162	0.180	0.204	0.215	0.209	0.216	0.222
IVa(W)	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
	2011	0.141	0.161	0.185	0.195	0.216	0.223	0.220	0.243
IVb	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
	2011	0.145	0.162	0.187	0.206	0.235	0.234	0.240	0.268

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 2001 – 2011. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IVa & IVb	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
	2011	0.142	0.161	0.184	0.198	0.220	0.224	0.224	0.243
IVc & VIId	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
	2011	0.122	0.154	0.179	0.189	0.195	0.205	0.209	0.217
Total	2001	0.118	0.149	0.177	0.198	0.213	0.238	0.267	0.288
North Sea	2002	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252
Catch	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
	2011	0.141	0.160	0.183	0.197	0.217	0.221	0.223	0.240

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 2011 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each *reported* combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official Catch	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Denmark (A)	1	3	2	82%	15707	4	102	577	n
	2	1	0	0%	761	0	0	0	n
	3	2	2	100%	28260	13	335	1580	n
	4	3	2	100%	5070	3	79	419	n
total		9	6	93%	49798	20	516	2576	n
Denmark (B)	1	2	1	100%	118	1	7	7	y
	2	1	0	100%	409	0	0	0	n
	3	3	1	99%	2380	6	124	126	y
	4	3	2	100%	6021	15	258	260	y
total		9	4	100%	8928	22	389	393	y
England	1	2	0	0%	38	0	0	0	n
and Wales*	2	4	2	97%	618	6	200	200	y
	3	3	2	100%	8708	8	325	325	n
	4	2	0	0%	2105	0	0	0	n
total		11	4	81%	11468	14	525	525	y
France	1	2	0	0%	647	0	0	0	n
	2	4	0	0%	923	0	0	0	n
	3	3	0	0%	8690	0	0	0	n
	4	2	0	0%	6434	0	0	0	n
total		11	0	0%	16694	0	0	0	n
Germany	2	1	0	0%	115	0	0	0	n
	3	2	1	83%	3057	5	453	772	y
	4	2	2	100%	6254	15	669	3280	y
total		5	3	93%	9427	20	1122	4052	y
Netherlands	1	2	1	89%	772	9	225	1344	y
	2	3	2	99%	3168	60	1499	10156	y
	3	2	2	100%	19119	33	825	4591	y
	4	4	3	99%	11649	3	75	422	n
total		11	8	99%	34708	105	2624	16513	y
Norway	1	3	2	100%	10736	5	169	439	n
	2	3	2	97%	32019	21	783	1451	n
	3	3	2	79%	2694	6	225	283	y
	4	3	1	91%	15256	8	239	585	n
total		12	7	95%	60705	40	1416	2758	n
Scotland	1	2	1	97%	6218	2	118	447	n
	2	1	1	100%	2211	7	332	1441	y
	3	2	2	100%	9519	11	579	2287	y
	4	2	0	0%	616	0	0	0	n
total		7	4	96%	18564	20	1029	4175	y
Sweden	2	2	0	0%	5171	0	0	0	n
	3	1	0	0%	1060	0	0	0	n
	4	2	0	0%	1855	0	0	0	n
total		5	0	0%	8086	0	0	0	n
Northern Ireland	3	1	0	0%	5	0	0	0	n
	4	1	0	0%	12	0	0	0	n
total		2	0	0%	18	0	0	0	n
Belgium	4	2	0	0%	4	0	0	0	n
total		2	0	0%	4	0	0	0	n
grand total		84	36	84%	218399	241	7621	30992	y
Period total	1	16	7	89%	34235	21	621	2814	n
Period total	2	20	7	83%	45394	94	2814	13248	y
Period total	3	22	12	87%	83493	82	2866	9964	n
Period total	4	26	10	77%	55277	44	1320	4966	n
Total for stock 2011		84	36	84%	218399	241	7621	30992	y
Human Cons. only		75	32	82%	209471	219	7232	30599	y
Total for stock 2009		76	29	70%	166566	170	5444	20654	y
Total for stock 2010		85	37	81%	174628	294	9917	46589	y
Human Cons. only 2010		75	33	82%	165557	252	9428	45858	y

* majority of catches landed to Ijmuiden, the Netherlands

Table 2.3.1.1. North Sea herring. Acoustic Surveys in the North Sea (HERAS), West of Scotland VIa(N) and the Malin Shelf (MSHAS) area in June-July 2011. Vessels, areas and cruise dates.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	18 Jun – 07 July	53°-58.6°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4
Scotia (SCO)	6 July – 26 July	58°30′-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
Johan Hjort (NOR)	28 June – 25 July	56°30-62°N, 2°-5°E	42F2-F5, 43F2-F5, 44F2-F5, 45F2-F5, 46F2-F4, 47F2-F4, 48F2-F4, 49F2-F4, 50F2-F4, 51F2-F4, 52F2-F4
Tridens (NED)	27 June – 22 July	54°09– 58°16′N, 3° W–6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F1, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	28 June – 16 July	52°-56°N, Eng to Den/Ger coasts	34F2-F4, 35F2-F4, 36F3-F7, 37F2-F8, 38F3-F7, 39F3-F7, 40F6-F7
Dana (DEN) OXBH	28 June – 11 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. North Sea herring. Acoustic Surveys in the North Sea (HERAS), West of Scotland VIa(N) and the Malin Shelf (MSHAS) area in June-July 2011. 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	2,441	18	0.00	7.3	10.1
1	10,119	356	0.00	35.2	16.5
2	4,166	627	0.87	150.5	25.3
3	2,534	433	0.84	170.9	26.4
4	2,173	456	0.99	209.7	28.0
5	1,016	246	1.00	241.7	29.1
6	651	168	1.00	257.8	29.7
7	688	172	1.00	249.4	29.4
8	440	111	1.00	252.3	29.6
9+	1,297	356	1.00	274.6	30.1
Immature	13,491	511		37.9	15.9
Mature	12,033	2,431		202.0	27.5
Total	25,524	2,942	0.47	115.3	21.4

Table 2.3.2.1: North Sea herring – LAI, MLAI, and SCAI time-series of herring larval abundance <10 mm long (<11 mm for the SNS), by standard sampling area and time periods. The number of larvae are expressed as mean number per ICES rectangle * 10^9

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea			MLAI	SCAI
Period	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			3385
1973	2029	822	3	4	492	830	1213			1	12.9	3323
1974	758	421	101	284	81		1184		10		7.9	2215
1975	371	50	312			90	77	1	2		2.8	1363
1976	545	81		1	64	108			3		2.5	1207
1977	1133	221	124	32	520	262	89	1			6.1	1618
1978	3047	50		162	1406	81	269	33	3		7.3	2129
1979	2882	2362	197	10	662	131	507		111	89	13.8	3251
1980	3534	720	21	1	317	188	9	247	129	40	9.3	3548
1981	3667	277	3	12	903	235	119	1456		70	13.5	4053
1982	2353	1116	340	257	86	64	1077	710	275	54	19.9	5085
1983	2579	812	3647	768	1459	281	63	71	243	58	25.5	7785
1984	1795	1912	2327	1853	688	2404	824	523	185	39	45.8	12241
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	70.1	15294
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.5	14510
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.8	18485
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.5	26410
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	126.9	22347
1990		10144	4590	2045	19955	1239	975	2552	1204		165.0	20981
1991	1021	2397		2032	4823	2110	1249	4400	873		87.9	14340
1992	189	4917		822	10	165	163	176	1616		40.5	7395
1993		66		174		685	85	1358	1103		28.6	5015
1994	26	1179				1464	44	537	595		20.0	4300
1995		8688					43	74	230	164	20.5	5387
1996		809		184		564		337	675	691	40.6	7017
1997		3611		23				9374	918	355	53.1	10177
1998		8528		1490	205	66		1522	953	170	66.6	13334
1999		4064		185		134	181	804	1260	344	55.7	14338
2000		3352	28	83		376		7346	338	106	37.4	16375
2001		11918		164		1604		971	5531	909	123.4	21908
2002		6669		1038			3291	2008	260	925	104.5	26260
2003		3199		2263		12018	3277	12048	3109	1116	250.6	34624
2004		7055		3884		5545		7055	2052	4175	308.9	38038
2005		3380		1364		5614		498	3999	4822	183.8	32362
2006	6311	2312		280		2259		10858	2700	2106	112.8	30073
2007		1753		1304		291		4443	2439	3854	161.0	30985
2008	4978	6875		533		11201		8426	2317	4008	180.5	38571
2009		7543		4629		4219		15295	14712	1689	466.7	49554
2010		2362		1493		2317		7493	13230	8073	380.4	51364
2011		3831		2839		17766		5461	6160	1215	315.4	53595

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
2011	0.008	0.001	0.345	0.136	0.215	0.129	0.076	0.040	**68.0**

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	0.25
1980	1982	798	177	0.22	185	0.23	0.03
1981	1983	1270	192	0.15	185	0.15	0.1
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	2837	664	0.23	180	0.06	0.75
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1010	340	0.34	357	0.35	0.03
2004	2006	893	115	0.13	121	0.14	0.02
2005	2007	1321	303	0.23	304	0.23	0.07
2006	2008	1792	417	0.23	444	0.25	0.011
2007	2009	2340	734	0.31	623	0.27	0.211
2008	2010	1323	279	0.21	286	0.22	0.046
2009	2011	2937	1331	0.45	1407	0.48	0.018
2010	2012	1353	279	0.21	288	0.21	0.041

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
2011	35	86	151	155	171	176	210	201	242	227	258	244	249	246	252	253	275	267

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 2011.

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
2011	87.0	84.0	99.0	100

Table 2.6.1.1 North Sea herring. Years of duration of survey and years used in the assessment.

Survey	Age range	Years survey has been running	Years used in assessment
SCAI (Larvae survey)	SSB	1972-2011	1973-2011
IBTS 1st Quarter (Trawl survey)	1-wr	1971-2012	1984-2012
Acoustic (+trawl)	1wr	1995-2011	1997-2011
	2-9+wr	1984-2011	1989-2011
IBTS0	0wr	1977-2012	1992-2012

TABLE 2.6.3.1 North Sea Herring. CATCH IN NUMBER

Units : thousands

age	1947	1948	1949	1950	1951	1952	1953	1954	1955
0	0	0	0	0	0	0	150000	219000	164000
1	0	3000	0	0	462000	722000	1023000	1451000	2072000
2	494000	247000	478000	535000	660000	1346000	1322000	1493000	1931000
3	415000	672000	644000	1039000	959000	576000	1003000	1111000	1032000
4	638000	328000	396000	617000	1255000	610000	474000	591000	479000
5	526000	601000	287000	290000	630000	652000	386000	361000	337000
6	756000	487000	652000	254000	262000	464000	473000	330000	232000
7	431000	400000	462000	331000	142000	236000	278000	379000	120000
8	1311000	917000	1037000	597000	445000	554000	392000	511000	215000

age	1956	1957	1958	1959	1960	1961	1962	1963	1964
0	96000	279000	97000	0	194600	1269200	141800	442800	496900
1	1697000	1483000	4279000	1609000	2392700	336000	2146900	1262200	2971700
2	1860000	1644000	1029000	4934000	1142300	1889400	269600	2961200	1547500
3	1221000	736000	999000	488000	1966700	479900	797400	177200	2243100
4	516000	644000	322000	497000	165900	1455900	335100	158300	148400
5	249000	344000	461000	233000	167700	124000	1081800	80600	149000
6	194000	207000	147000	249000	112900	157900	126900	229700	95000
7	104000	147000	73000	120000	125800	61400	145100	22400	256300
8	292000	253000	118000	301000	270600	143500	173100	93000	84000

age	1965	1966	1967	1968	1969	1970	1971	1972	1973
0	157100	374500	645400	839300	112000	898100	684000	750400	289400
1	3209300	1383100	1674300	2425000	2503300	1196200	4378500	3340600	2368000
2	2217600	2569700	1171500	1795200	1883000	2002800	1146800	1440500	1344200
3	1324600	741200	1364700	1494300	296300	883600	662500	343800	659200
4	2039400	450100	371500	621400	133100	125200	208300	130600	150200
5	145100	889800	297800	157100	190800	50300	26900	32900	59300
6	151900	45300	393100	145000	49900	61000	30500	5000	30600
7	117600	64800	67900	163400	42700	7900	26800	200	3700
8	491400	331800	254400	105500	52500	24200	12500	1500	2000

age	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	996100	263800	238200	256800	NA	NA	1262700	9519700	11956700	13296900
1	846100	2460500	126600	144300	NA	NA	245100	872000	1116400	2448600
2	772600	541700	901500	44700	NA	NA	134000	284300	299400	573800
3	362000	259600	117300	186400	NA	NA	91800	56900	230100	216400
4	126000	140500	52000	10800	NA	NA	32200	39500	33700	105100
5	56100	57200	34500	7000	NA	NA	21700	28500	14400	26200
6	22300	16100	6100	4100	NA	NA	2300	22700	6800	22800
7	5000	9100	4400	1500	NA	NA	1400	18700	7800	12800
8	3100	4800	1400	700	NA	NA	500	6600	4700	23100

age	1984	1985	1986	1987	1988	1989	1990	1991	1992
0	6973300	4211000	3724700	8229200	3164800	3057800	1302800	2386600	10331300
1	1818400	3253000	4801400	6836300	7867000	3145900	3020000	2138900	2303100
2	1146200	1326300	1266700	2137200	2232500	1593700	899300	1132800	1284900
3	441400	1182400	840800	667900	1090700	1363800	779100	556700	442700
4	201500	368500	465900	467100	383700	809300	861000	548900	361500
5	81100	124500	129800	245800	255800	211800	387500	501200	360500
6	22600	43600	62100	74700	128100	123700	80200	205300	375600
7	25200	20200	20500	23800	38000	61000	54400	39300	152400
8	29700	29200	28400	16200	23800	28200	40700	38600	62500

age	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	10265400	4498900	7438469	2311226	431175	259526	1566349	1105085	1832691
1	3826800	1785200	1664874	1606393	479702	977680	303520	1171677	614469
2	1176300	1783200	1444061	642084	687920	1220105	616354	622853	842635
3	609000	489100	816703	525601	446909	537932	1058716	463170	485628
4	305500	347600	231794	172099	284920	276333	294066	646814	278884
5	215600	109000	118536	57586	109178	175817	135648	213466	321743
6	226000	91800	55128	22534	31389	88927	69299	82481	90918
7	188000	76400	41409	9264	11832	15232	27998	35706	38252
8	129000	116600	98200	21143	24467	20550	12228	17087	20602

TABLE 2.6.3.1 (cont) North Sea Herring. CATCH IN NUMBER

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	730279	369074	715597	1015554	878637	621005	798284	650043	574895	778927
1	837557	617021	206648	715547	222111	235553	235022	175923	280728	159504
2	579592	1221992	447918	355453	401087	219115	331772	259434	293887	367820
3	970577	529386	1366155	485746	310602	417452	184771	106738	236804	275016
4	292205	835552	543376	1318647	464620	285746	199069	93321	126241	218711
5	140701	244780	753231	479961	997782	309454	137529	86137	83893	130127
6	174570	107751	169324	576154	252150	629187	118349	37951	61542	62938
7	48908	123291	104945	115212	247042	147830	215542	53130	33305	52081
8	43322	46715	97142	146808	106412	156750	117258	143131	113675	125734

TABLE 2.6.3.2 North Sea Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957
0	0.015	0.015	0.0150	0.015	0.0150	0.015	0.015	0.0150	0.0150	0.015	0.0150
1	0.050	0.050	0.0500	0.050	0.0500	0.050	0.050	0.0500	0.0500	0.050	0.0500
2	0.122	0.122	0.1280	0.128	0.1340	0.137	0.137	0.1390	0.1400	0.140	0.1410
3	0.140	0.140	0.1450	0.151	0.1570	0.165	0.167	0.1690	0.1700	0.172	0.1730
4	0.156	0.156	0.1610	0.166	0.1760	0.183	0.190	0.1930	0.1950	0.197	0.1980
5	0.171	0.171	0.1760	0.180	0.1890	0.199	0.205	0.2110	0.2140	0.216	0.2180
6	0.185	0.185	0.1890	0.193	0.2010	0.210	0.218	0.2230	0.2280	0.231	0.2330
7	0.197	0.197	0.2010	0.204	0.2110	0.219	0.226	0.2330	0.2380	0.242	0.2440
8	0.242	0.242	0.2435	0.245	0.2475	0.251	0.254	0.2565	0.2595	0.261	0.2625

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
0	0.0150	0.0150	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015
1	0.0500	0.0500	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
2	0.1410	0.1430	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126
3	0.1740	0.1760	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176
4	0.1990	0.2010	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211
5	0.2190	0.2210	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243
6	0.2340	0.2360	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251
7	0.2450	0.2470	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.2635	0.2645	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age \ year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.007
1	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.049
2	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.126	0.118
3	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.176	0.142
4	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.211	0.189
5	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.243	0.211
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.222
7	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267	0.267
8	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271	0.271

age \ year	1982	1983	1984	1985	1986	1987	1988
0	0.010000	0.0100000	0.0100000	0.0090000	0.0060000	0.0110000	0.0110000
1	0.059000	0.0590000	0.0590000	0.0360000	0.0670000	0.0350000	0.0550000
2	0.118000	0.1180000	0.1180000	0.1280000	0.1210000	0.0990000	0.1110000
3	0.149000	0.1490000	0.1490000	0.1640000	0.1530000	0.1500000	0.1450000
4	0.179000	0.1790000	0.1790000	0.1940000	0.1820000	0.1800000	0.1740000
5	0.217000	0.2170000	0.2170000	0.2110000	0.2080000	0.2110000	0.1970000
6	0.238000	0.2380000	0.2380000	0.2200000	0.2210000	0.2340000	0.2160000
7	0.265000	0.2650000	0.2650000	0.2580000	0.2380000	0.2580000	0.2370000
8	0.274234	0.2745238	0.2746263	0.2821301	0.2572113	0.2881358	0.2565714

age \ year	1989	1990	1991	1992	1993	1994	1995
0	0.0170000	0.0190000	0.0170000	0.0100000	0.0100000	0.0060000	0.0090000
1	0.0430000	0.0550000	0.0580000	0.0530000	0.0330000	0.0560000	0.0420000
2	0.1150000	0.1140000	0.1300000	0.1020000	0.1150000	0.1300000	0.1300000
3	0.1530000	0.1490000	0.1660000	0.1750000	0.1450000	0.1590000	0.1690000
4	0.1730000	0.1770000	0.1840000	0.1890000	0.1890000	0.1810000	0.1980000
5	0.2080000	0.1930000	0.2030000	0.2070000	0.2040000	0.2140000	0.2070000
6	0.2310000	0.2290000	0.2170000	0.2230000	0.2280000	0.2400000	0.2430000
7	0.2470000	0.2360000	0.2350000	0.2370000	0.2440000	0.2550000	0.2470000
8	0.2631489	0.2608182	0.2630415	0.2631664	0.2734558	0.2761973	0.2809153

TABLE 2.6.3.2 (cont) North Sea Herring. WEIGHTS AT AGE IN THE CATCH

age	1996	1997	1998	1999	2000	2001	2002
0	0.0150000	0.0150000	0.0210000	0.009000	0.0150000	0.012000	0.0120000
1	0.0180000	0.0440000	0.0510000	0.045000	0.0330000	0.048000	0.0370000
2	0.1120000	0.1080000	0.1140000	0.115000	0.1130000	0.118000	0.1180000
3	0.1560000	0.1480000	0.1450000	0.151000	0.1570000	0.149000	0.1530000
4	0.1880000	0.1950000	0.1830000	0.171000	0.1790000	0.177000	0.1700000
5	0.2040000	0.2270000	0.2190000	0.207000	0.2010000	0.198000	0.1990000
6	0.2120000	0.2260000	0.2380000	0.233000	0.2160000	0.213000	0.2140000
7	0.2610000	0.2350000	0.2470000	0.245000	0.2460000	0.238000	0.2280000
8	0.2814938	0.2549437	0.2878952	0.267719	0.2731261	0.269744	0.2504017

age	2003	2004	2005	2006	2007	2008	2009
0	0.0140000	0.0140000	0.0110000	0.0100000	0.0124000	0.007900	0.0094000
1	0.0370000	0.0360000	0.0440000	0.0490000	0.0638000	0.053500	0.0514000
2	0.1040000	0.1000000	0.0990000	0.1170000	0.1214000	0.128800	0.1440000
3	0.1580000	0.1380000	0.1530000	0.1440000	0.1513000	0.179600	0.1811000
4	0.1740000	0.1830000	0.1660000	0.1720000	0.1634000	0.181200	0.2158000
5	0.1840000	0.2010000	0.2080000	0.1810000	0.1933000	0.183200	0.2162000
6	0.2050000	0.2160000	0.2230000	0.2200000	0.1900000	0.215700	0.2390000
7	0.2220000	0.2280000	0.2400000	0.2370000	0.2232000	0.216100	0.2428000
8	0.2366464	0.2545115	0.2653676	0.2460061	0.2374933	0.262076	0.2532723

age	2010	2011
0	0.0075000	0.008000
1	0.0571000	0.041300
2	0.1292000	0.131700
3	0.1669000	0.159300
4	0.1912000	0.183100
5	0.2203000	0.197000
6	0.2193000	0.216700
7	0.2160000	0.221100
8	0.2383892	0.231918

TABLE 2.6.3.3 North Sea Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

age	1947	1948	1949	1950	1951	1952	1953	1954
0	0.0150	0.0150	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500	0.0500	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1220	0.1220	0.1240000	0.1260000	0.1300000	0.1330000	0.1360000	0.1376667
3	0.1400	0.1400	0.1416667	0.1453333	0.1510000	0.1576667	0.1630000	0.1670000
4	0.1560	0.1560	0.1576667	0.1610000	0.1676667	0.1750000	0.1830000	0.1886667
5	0.1710	0.1710	0.1726667	0.1756667	0.1816667	0.1893333	0.1976667	0.2050000
6	0.1850	0.1850	0.1863333	0.1890000	0.1943333	0.2013333	0.2096667	0.2170000
7	0.1970	0.1970	0.1983333	0.2006667	0.2053333	0.2113333	0.2186667	0.2260000
8	0.2625	0.2625	0.2630000	0.2640000	0.2658333	0.2683333	0.2713333	0.2743333

age	1955	1956	1957	1958	1959	1960	1961
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1386667	0.1396667	0.1403333	0.1406667	0.1416667	0.1463333	0.1510000
3	0.1686667	0.1703333	0.1716667	0.1730000	0.1743333	0.1790000	0.1833333
4	0.1926667	0.1950000	0.1966667	0.1980000	0.1993333	0.2076667	0.2156667
5	0.2100000	0.2136667	0.2160000	0.2176667	0.2193333	0.2263333	0.2330000
6	0.2230000	0.2273333	0.2306667	0.2326667	0.2343333	0.2486667	0.2626667
7	0.2323333	0.2376667	0.2413333	0.2436667	0.2453333	0.2636667	0.2816667
8	0.2771667	0.2795000	0.2815000	0.2828333	0.2840000	0.2936240	0.3034146

age	1962	1963	1964	1965	1966	1967	1968
0	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000	0.0150000
1	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000	0.0500000
2	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000	0.1550000
3	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000	0.1870000
4	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000	0.2230000
5	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000	0.2390000
6	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000	0.2760000
7	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000	0.2990000
8	0.3090087	0.3092903	0.3101214	0.3069573	0.3102731	0.3100755	0.3112209

TABLE 2.6.3.3 (cont) North Sea Herring. WEIGHTS AT AGE IN THE STOCK

year

age	1969	1970	1971	1972	1973	1974	1975	1976	1977
0	0.0150000	0.0150000	0.015000	0.0150	0.0150	0.015000	0.01500	0.0150000	0.015
1	0.0500000	0.0500000	0.050000	0.0500	0.0500	0.050000	0.05000	0.0500000	0.050
2	0.1550000	0.1550000	0.155000	0.1550	0.1550	0.155000	0.15500	0.1550000	0.155
3	0.1870000	0.1870000	0.187000	0.1870	0.1870	0.187000	0.18700	0.1870000	0.187
4	0.2230000	0.2230000	0.223000	0.2230	0.2230	0.223000	0.22300	0.2230000	0.223
5	0.2390000	0.2390000	0.239000	0.2390	0.2390	0.239000	0.23900	0.2390000	0.239
6	0.2760000	0.2760000	0.276000	0.2760	0.2760	0.276000	0.27600	0.2760000	0.276
7	0.2990000	0.2990000	0.299000	0.2990	0.2990	0.299000	0.29900	0.2990000	0.299
8	0.3088686	0.3090248	0.311952	0.3076	0.3078	0.308129	0.30775	0.3077143	0.306

year

age	1978	1979	1980	1981	1982	1983	1984	1985
0	0.0150	0.0150000	0.0150	0.015	0.0150000	0.0150000	0.01733333	0.01566667
1	0.0500	0.0500000	0.0500	0.050	0.0500000	0.0500000	0.05666667	0.05633333
2	0.1550	0.1550000	0.1550	0.155	0.1550000	0.1550000	0.15033333	0.13800000
3	0.1870	0.1870000	0.1870	0.187	0.1870000	0.1870000	0.19033333	0.18700000
4	0.2230	0.2230000	0.2230	0.223	0.2230000	0.2230000	0.22966667	0.23233333
5	0.2390	0.2390000	0.2390	0.239	0.2390000	0.2390000	0.24333333	0.24666667
6	0.2760	0.2760000	0.2760	0.276	0.2760000	0.2760000	0.28200000	0.27466667
7	0.2990	0.2990000	0.2990	0.299	0.2990000	0.2990000	0.31066667	0.32100000
8	0.3096	0.3068571	0.3072	0.307	0.3074043	0.3091429	0.34351178	0.35438242

year

age	1986	1987	1988	1989	1990	1991
0	0.0140000	0.00900000	0.00800000	0.008666667	0.01233333	0.01133333
1	0.0610000	0.05033333	0.04833333	0.043666667	0.05200000	0.05900000
2	0.1300000	0.12166667	0.12300000	0.122333333	0.12566667	0.13900000
3	0.1833333	0.17000000	0.16633333	0.165333333	0.17433333	0.18366667
4	0.2316667	0.21233333	0.20833333	0.204666667	0.21166667	0.21200000
5	0.2520000	0.23000000	0.22900000	0.228333333	0.24366667	0.23866667
6	0.2730000	0.24200000	0.24833333	0.252333333	0.27066667	0.26533333
7	0.3146667	0.27466667	0.25866667	0.261333333	0.28366667	0.27966667
8	0.3627746	0.30562963	0.28535714	0.288595745	0.30788452	0.30953886

year

age	1992	1993	1994	1995	1996	1997
0	0.01033333	0.005666667	0.007333333	0.00600000	0.0060000	0.00500000
1	0.06366667	0.061000000	0.060000000	0.05733333	0.0540000	0.04866667
2	0.13666667	0.134000000	0.126333333	0.12933333	0.1296667	0.12333333
3	0.19400000	0.184333333	0.191666667	0.18566667	0.1993333	0.18333333
4	0.21400000	0.213000000	0.214333333	0.21066667	0.2273333	0.23033333
5	0.23433333	0.234333333	0.239666667	0.22433333	0.2343333	0.23733333
6	0.25300000	0.261666667	0.274666667	0.26800000	0.2736667	0.25666667
7	0.27166667	0.272666667	0.291333333	0.29333333	0.3006667	0.28033333
8	0.29870453	0.307936434	0.320523728	0.32614016	0.3270679	0.31004007

year

age	1998	1999	2000	2001	2002	2003
0	0.005666667	0.00600000	0.005666667	0.00600000	0.006333333	0.006666667
1	0.047333333	0.05066667	0.051333333	0.05066667	0.047333333	0.047000000
2	0.116000000	0.11600000	0.115666667	0.12166667	0.128000000	0.123000000
3	0.187333333	0.17933333	0.183666667	0.17166667	0.171666667	0.173000000
4	0.241333333	0.22633333	0.221333333	0.21000000	0.205333333	0.202333333
5	0.264333333	0.25600000	0.248333333	0.23266667	0.228333333	0.222000000
6	0.283666667	0.27333333	0.278666667	0.25533333	0.248333333	0.242333333
7	0.286666667	0.27600000	0.286000000	0.27466667	0.270333333	0.265666667
8	0.308339011	0.27811880	0.284171183	0.27449422	0.286521182	0.284946134

year

TABLE 2.6.3.3 (cont) North Sea Herring. WEIGHTS AT AGE IN THE STOCK

age	2004	2005	2006	2007	2008	2009
0	0.006666667	0.005733333	0.006766667	0.00610000	0.007933333	0.007233333
1	0.042000000	0.041433333	0.041000000	0.05133333	0.057700000	0.061433333
2	0.119333333	0.118100000	0.125666667	0.12800000	0.130366667	0.137366667
3	0.165333333	0.164433333	0.155400000	0.16073333	0.164200000	0.181000000
4	0.202666667	0.197900000	0.190900000	0.17956667	0.180766667	0.196866667
5	0.223000000	0.224500000	0.215800000	0.20680000	0.195433333	0.209966667
6	0.247666667	0.247833333	0.241900000	0.22356667	0.217700000	0.222500000
7	0.267666667	0.264866667	0.252133333	0.23780000	0.226066667	0.233633333
8	0.280490193	0.284945260	0.270223450	0.25648110	0.255556491	0.255759739

year

age	2010	2011
0	0.007133333	0.006666667
1	0.052233333	0.043166667
2	0.142266667	0.145300000
3	0.190366667	0.187433333
4	0.216266667	0.225066667
5	0.223600000	0.239366667
6	0.234200000	0.243500000
7	0.240100000	0.250766667
8	0.260682861	0.257247512

TABLE 2.6.3.4 North Sea Herring. NATURAL MORTALITY

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953
0	1.3062962	1.3063903	1.3068821	1.3072083	1.3066220	1.3043784	1.3068605
1	0.8597480	0.8597415	0.8597118	0.8596935	0.8597301	0.8598630	0.8597093
2	0.3056970	0.3056669	0.3055191	0.3054245	0.3056036	0.3062708	0.3055162
3	0.2817484	0.2817165	0.2815592	0.2814580	0.2816484	0.2823597	0.2815574
4	0.2531908	0.2531580	0.2529935	0.2528867	0.2530850	0.2538308	0.2529940
5	0.2300403	0.2300068	0.2298389	0.2297298	0.2299323	0.2306936	0.2298396
6	0.2293962	0.2293629	0.2291975	0.2290907	0.2292906	0.2300393	0.2291965
7	0.2258074	0.2257749	0.2256149	0.2255120	0.2257058	0.2264292	0.2256128
8	0.2258074	0.2257749	0.2256149	0.2255120	0.2257058	0.2264292	0.2256128

year

age	1954	1955	1956	1957	1958	1959	1960
0	1.3093415	1.3088394	1.3036901	1.2931602	1.3192712	1.3217465	1.3063292
1	0.8595631	0.8596017	0.8599133	0.8605277	0.8589407	0.8588323	0.8597945
2	0.3047803	0.3049514	0.3064994	0.3096070	0.3017431	0.3011004	0.3058071
3	0.2807726	0.2809519	0.2826002	0.2859165	0.2775460	0.2768483	0.2818484
4	0.2521708	0.2523528	0.2540767	0.2575595	0.2488103	0.2480547	0.2532628
5	0.2289991	0.2291846	0.2309444	0.2345002	0.2255694	0.2247968	0.2301122
6	0.2283702	0.2285568	0.2302904	0.2337826	0.2249822	0.2242391	0.2294894
7	0.2248147	0.2249976	0.2266746	0.2300461	0.2215312	0.2208238	0.2259122
8	0.2248147	0.2249976	0.2266746	0.2300461	0.2215312	0.2208238	0.2259122

year

age	1961	1962	1963	1964	1965	1966	1967
0	1.2779437	1.2405107	1.4498257	1.3341230	1.2292427	1.1360167	1.0533453
1	0.8614710	0.8636000	0.8510058	0.8582902	0.8646056	0.8698533	0.8742452
2	0.3142394	0.3251448	0.2624238	0.2978870	0.3293404	0.3564009	0.3796720
3	0.2908419	0.3024979	0.2356937	0.2733594	0.3068488	0.3358097	0.3607781
4	0.2626962	0.2749736	0.2050645	0.2442764	0.2793030	0.3098633	0.3363605
5	0.2397436	0.2522790	0.1809156	0.2209336	0.2566889	0.2879006	0.3149562
6	0.2389587	0.2512436	0.1809803	0.2205236	0.2557409	0.2863048	0.3126683
7	0.2350598	0.2469035	0.1789569	0.2172865	0.2513544	0.2807976	0.3061220
8	0.2350598	0.2469035	0.1789569	0.2172865	0.2513544	0.2807976	0.3061220

year

age	1968	1969	1970	1971	1972	1973	1974
0	0.9805771	0.9186008	0.8673622	0.8247947	0.7939643	0.7755027	0.7636920
1	0.8778144	0.8804017	0.8820627	0.8831532	0.8837601	0.8837618	0.8832010
2	0.3993545	0.4145945	0.4255663	0.4340132	0.4379065	0.4368385	0.4349828
3	0.3819478	0.3985622	0.4107716	0.4201306	0.4248969	0.4246783	0.4230544
4	0.3589555	0.3770431	0.3907393	0.4012868	0.4073827	0.4086825	0.4078663
5	0.3380276	0.3565578	0.3706479	0.3814567	0.3878100	0.3893628	0.3885181
6	0.3350369	0.3527903	0.3660364	0.3760727	0.3815138	0.3819820	0.3802856
7	0.3275616	0.3444648	0.3569392	0.3663576	0.3711496	0.3709273	0.3688377
8	0.3275616	0.3444648	0.3569392	0.3663576	0.3711496	0.3709273	0.3688377

TABLE 2.6.3.4 (Cont) North Sea Herring. NATURAL MORTALITY

age \ year	1975	1976	1977	1978	1979	1980	1981
0	0.7688703	0.7901108	0.8047986	0.8124459	0.8238513	0.8333298	0.8394171
1	0.8844545	0.8864425	0.8840221	0.8733575	0.8587716	0.8473594	0.8375958
2	0.4302030	0.4213890	0.4142544	0.4088044	0.4024214	0.3968846	0.3944146
3	0.4169843	0.4059054	0.3971144	0.3908862	0.3837073	0.3771918	0.3739079
4	0.4009955	0.3882011	0.3782681	0.3706733	0.3613179	0.3536230	0.3507997
5	0.3810519	0.3672796	0.3564138	0.3475373	0.3365057	0.3276900	0.3241351
6	0.3724155	0.3584487	0.3473240	0.3381604	0.3269489	0.3179354	0.3140861
7	0.3614341	0.3484669	0.3378787	0.3289188	0.3180598	0.3090793	0.3044325
8	0.3614341	0.3484669	0.3378787	0.3289188	0.3180598	0.3090793	0.3044325

age \ year	1982	1983	1984	1985	1986	1987	1988
0	0.8450021	0.8509293	0.8618818	0.8758657	0.8837108	0.8833518	0.8801386
1	0.8262204	0.8177263	0.8133933	0.8098846	0.8047687	0.8030194	0.8053149
2	0.3936631	0.3910560	0.3846764	0.3767758	0.3700325	0.3620220	0.3521287
3	0.3724725	0.3685723	0.3595125	0.3482600	0.3389950	0.3289309	0.3167563
4	0.3504278	0.3474814	0.3402310	0.3317459	0.3241989	0.3145318	0.3025221
5	0.3230039	0.3198456	0.3133267	0.3060806	0.2996061	0.2913129	0.2812120
6	0.3127191	0.3096080	0.3032829	0.2962165	0.2900961	0.2824154	0.2730801
7	0.3018394	0.2979753	0.2910907	0.2832448	0.2768250	0.2693836	0.2604610
8	0.3018394	0.2979753	0.2910907	0.2832448	0.2768250	0.2693836	0.2604610

age \ year	1989	1990	1991	1992	1993	1994	1995
0	0.8760232	0.8686097	0.8577137	0.8486048	0.8323958	0.8088519	0.7962212
1	0.8027804	0.7939753	0.7837381	0.7726129	0.7494854	0.7166964	0.6949720
2	0.3457447	0.3443718	0.3448689	0.3456637	0.3462418	0.3476941	0.3508561
3	0.3088644	0.3066102	0.3063299	0.3068890	0.3096982	0.3151729	0.3206849
4	0.2945958	0.2911509	0.2887064	0.2878693	0.2900670	0.2948533	0.3000248
5	0.2747040	0.2720989	0.2704650	0.2703406	0.2726507	0.2770603	0.2822178
6	0.2673958	0.2662294	0.2665871	0.2679837	0.2713861	0.2769124	0.2828047
7	0.2554274	0.2559625	0.2588839	0.2622695	0.2671514	0.2742681	0.2812562
8	0.2554274	0.2559625	0.2588839	0.2622695	0.2671514	0.2742681	0.2812562

age \ year	1996	1997	1998	1999	2000	2001	2002
0	0.7964933	0.8003559	0.8091044	0.8315196	0.8635228	0.8871207	0.9021687
1	0.6869137	0.6817761	0.6802653	0.6913413	0.7113333	0.7220006	0.7236466
2	0.3570840	0.3656584	0.3743015	0.3869205	0.4027811	0.4126429	0.4164810
3	0.3273645	0.3362859	0.3447364	0.3550340	0.3672442	0.3752758	0.3791293
4	0.3072634	0.3173345	0.3266605	0.3373851	0.3500588	0.3587136	0.3632873
5	0.2899977	0.3006973	0.3105983	0.3222252	0.3360710	0.3453713	0.3500951
6	0.2906329	0.3009355	0.3104069	0.3214765	0.3345297	0.3431944	0.3474571
7	0.2892593	0.2992269	0.3085044	0.3196391	0.3326829	0.3412380	0.3453142
8	0.2892593	0.2992269	0.3085044	0.3196391	0.3326829	0.3412380	0.3453142

age \ year	2003	2004	2005	2006	2007	2008	2009
0	0.9180715	0.9311605	0.9417495	0.9515479	0.9589797	0.9629198	0.9639524
1	0.7255318	0.7228521	0.7158512	0.7068146	0.6940013	0.6761454	0.6539054
2	0.4190357	0.4182149	0.4141342	0.4078147	0.3985226	0.3856549	0.3694447
3	0.3818664	0.3819880	0.3795281	0.3752508	0.3687520	0.3596482	0.3480426
4	0.3667856	0.3678416	0.3664798	0.3634001	0.3582492	0.3506907	0.3408148
5	0.3536407	0.3543872	0.3523644	0.3483950	0.3420464	0.3329287	0.3211651
6	0.3504963	0.3507288	0.3481721	0.3436320	0.3367076	0.3270346	0.3147281
7	0.3480817	0.3478837	0.3447272	0.3394611	0.3316919	0.3210542	0.3076583
8	0.3480817	0.3478837	0.3447272	0.3394611	0.3316919	0.3210542	0.3076583

age \ year	2010	2011
0	0.9630652	0.9600930
1	0.6284271	0.6718588
2	0.3504123	0.3823698
3	0.3342612	0.3571910
4	0.3289086	0.3484127
5	0.3070936	0.3303257
6	0.3001065	0.3244418
7	0.2918243	0.3183380
8	0.2918243	0.3183380

TABLE 2.6.3.5 North Sea Herring. PROPORTION MATURE

Units : NA

age	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
0	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
1	0	0	0	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00
2	1	1	1	1	1	1	1	1	1	1	0.82	0.82	0.82	0.82	0.82
3	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
4	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
5	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
6	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
7	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00
8	1	1	1	1	1	1	1	1	1	1	1.00	1.00	1.00	1.00	1.00

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00
2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.7	0.75	0.8	0.85	0.82	0.91	0.86
3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	0.93	0.94	0.97	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.0	1.00	1.0	1.00	1.00	1.00	1.00

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.50	0.47	0.73	0.67	0.61	0.64	0.64	0.69	0.67	0.77	0.87	0.43	0.70	0.76	0.66
3	0.99	0.61	0.93	0.95	0.98	0.94	0.89	0.91	0.96	0.92	0.97	0.93	0.65	0.96	0.88
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.96	0.98
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age	2007	2008	2009	2010	2011
0	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00
2	0.71	0.86	0.89	0.45	0.87
3	0.92	0.98	1.00	0.90	0.84
4	0.93	0.99	1.00	1.00	1.00
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 2.6.3.6 North Sea Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
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

age \ year	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
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

age \ year	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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

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

age \ year	2007	2008	2009	2010	2011
0	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67
8	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	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
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

age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
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

age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
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

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

age	2007	2008	2009	2010	2011
0	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67

TABLE 2.6.3.8 North Sea Herring. SURVEY INDICES

SCAI - Configuration

Spawning component abundance index

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	1972	2011	NA	NA

Index type : biomass

SCAI - Index Values

Units : NA

age \ year	1972	1973	1974	1975	1976	1977	1978	1979
all	3384.85	3322.852	2215.229	1363.273	1206.67	1618.491	2129.141	3251.282

age \ year	1980	1981	1982	1983	1984	1985	1986	1987
all	3547.903	4053.179	5084.589	7785.163	12240.83	15294.27	14510.45	18484.93

age \ year	1988	1989	1990	1991	1992	1993	1994	1995
all	26409.63	22346.76	20980.77	14339.93	7395.23	5014.908	4299.909	5387.032

age \ year	1996	1997	1998	1999	2000	2001	2002	2003
all	7016.717	10176.78	13334.14	14337.54	16375.35	21908.42	26259.78	34623.69

age \ year	2004	2005	2006	2007	2008	2009	2010	2011
all	38037.62	32361.66	30073.28	30985.21	38571.01	49553.53	51363.65	53594.87

HERAS - Configuration

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

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	8.00	8.00	1989.00	2011.00	0.54	0.56

Index type : number

HERAS - Index Values

Units : NA

age \ year	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	-1	-1	-1	-1	-1	-1	-1	-1	9361000
2	4090000	3306000	2634000	3734000	2984000	3185000	3849000	4497000	5960000
3	3903000	3521000	1700000	1378000	1637000	839000	2041000	2824000	2935000
4	1633000	3414000	1959000	1147000	902000	399000	672000	1087000	1441000
5	492000	1366000	1849000	1134000	741000	381000	299000	311000	601000
6	283000	392000	644000	1246000	777000	321000	203000	99000	215000
7	120000	210000	228000	395000	551000	326000	138000	83000	46000
8	66000	176000	145000	218000	296000	350000	212000	339000	237000

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	4449000	5087000	24736000	6837000	23055000	9829400	5183700	3114100	6822800
2	5747000	3078000	2923000	12290000	4875000	18949400	3415900	2055100	3772300
3	2520000	4725000	2156000	3083000	8220000	3081000	9191800	3648500	1997200
4	1625000	1116000	3140000	1462000	1390000	4188900	2167300	5789600	2097500
5	982000	506000	1007000	1676000	794600	675100	2590700	1212900	4175100
6	445000	314000	483000	450000	1031000	494800	317100	1174900	618200
7	170000	139000	266000	170000	244400	568300	327600	139900	562100
8	166000	141000	217000	157000	270500	323200	527650	233200	154700

age \ year	2007	2008	2009	2010	2011
1	6261000	3714000	4655000	14577000	10119000
2	2750000	2853000	5632000	4237000	4166000
3	1848000	1709000	2553000	4216000	2534000
4	898000	1485000	1023000	2453000	2173000
5	806000	809000	1077000	1246000	1016000
6	1323000	712000	674000	1332000	651000
7	243000	1749000	638000	688000	688000
8	217000	455000	1720000	2729000	1737000

TABLE 2.6.3.8 (Cont.) North Sea Herring. SURVEY INDICES

```
IBTS-Q1 - Configuration

Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from VPA
file.
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      1.00        NA   1984.00   2012.00      0.08      0.17
Index type : number

IBTS-Q1 - Index Values

Units  :  NA
   year
age     1984    1985     1986     1987     1988     1989     1990     1991
  1 1515.627 2097.28 2662.812 3692.965 4394.168 2331.566 1061.572 1286.747
   year
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
   year
age     2000     2001     2002   2003    2004     2005    2006     2007    2008
  1 3725.131 2499.391 4064.829 2836.7 979.036 1010.443 892.843 1321.279 1791.55
   year
age     2009     2010     2011     2012
  1 2339.641 1323.363 2937.234 1352.965

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   2012.00      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 2012
  0 61.3 83.1 37.2 27.8 95.8 77.1   77   68
```

TABLE 2.6.3.9 North Sea Herring. STOCK OBJECT CONFIGURATION

```
      min       max plusgroup   minyear   maxyear   minfbar   maxfbar
        0         8         8      1947      2011         2         6
```

TABLE 2.6.3.10 North Sea Herring. FLSAM CONFIGURATION SETTINGS

```
name            : Final Assessment
desc            :
range           :       min       max plusgroup   minyear   maxyear   minfbar   maxfbar
range           :         0         8         8      1947      2012         2         6
fleets          :   catch    SCAI   HERAS IBTS-Q1   IBTS0
fleets          :       0       3       2       2       2
plus.group      : TRUE
states          :          age
states          : fleet      0  1  2  3  4  5  6  7  8
states          :   catch    1  2  3  4  5  6  7  8  8
states          :   SCAI    NA NA NA NA NA NA NA NA NA
states          :   HERAS   NA NA NA NA NA NA NA NA NA
states          :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
states          :   IBTS0   NA NA NA NA NA NA NA NA NA
logN.vars       : 1 2 2 2 2 2 2 2 2
catchabilities  :          age
catchabilities  : fleet      0  1  2  3  4  5  6  7  8
catchabilities  :   catch   NA NA NA NA NA NA NA NA NA
catchabilities  :   SCAI    NA NA NA NA NA NA NA NA NA
catchabilities  :   HERAS   NA  3  3  4  4  5  5  5  5
catchabilities  :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
catchabilities  :   IBTS0    2 NA NA NA NA NA NA NA NA
power.law.exps  :          age
power.law.exps  : fleet      0  1  2  3  4  5  6  7  8
power.law.exps  :   catch   NA NA NA NA NA NA NA NA NA
power.law.exps  :   SCAI    NA NA NA NA NA NA NA NA NA
power.law.exps  :   HERAS   NA NA NA NA NA NA NA NA NA
power.law.exps  :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
power.law.exps  :   IBTS0   NA NA NA NA NA NA NA NA NA
f.vars          :          age
f.vars          : fleet      0  1  2  3  4  5  6  7  8
f.vars          :   catch    1  1  2  2  3  3  4  4  4
f.vars          :   SCAI    NA NA NA NA NA NA NA NA NA
f.vars          :   HERAS   NA NA NA NA NA NA NA NA NA
f.vars          :   IBTS-Q1 NA NA NA NA NA NA NA NA NA
f.vars          :   IBTS0   NA NA NA NA NA NA NA NA NA
obs.vars        :          age
obs.vars        : fleet      0  1  2  3  4  5  6  7  8
obs.vars        :   catch    3  4  4  4  4  4  5  5  5
obs.vars        :   SCAI    NA NA NA NA NA NA NA NA NA
obs.vars        :   HERAS   NA  6  7  7  7  7  8  8  8
obs.vars        :   IBTS-Q1 NA  1 NA NA NA NA NA NA NA
obs.vars        :   IBTS0    2 NA NA NA NA NA NA NA NA
srr             : 0
timeout         : 3600
```

TABLE 2.6.3.11 North Sea Herring. FLR, R SOFTWARE VERSIONS

```
R version 2.13.2 (2011-09-30)

Package  : FLSAM
Version  : 0.43-2
Packaged :
Built    : R 2.13.2; ; 2012-02-29 10:51:36 UTC; windows

Package  : FLCore
Version  : 2.4
Packaged :
Built    : R 2.13.2; i386-pc-mingw32; 2011-10-05 12:21:01 UTC; 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
1947	72492959	4632474	3744934	0.1745	581760	1.4609
1948	67254871	4123646	3151245	0.1723	502100	1.3326
1949	59233629	3944540	3063591	0.1858	508500	1.4502
1950	81899218	3945526	3002572	0.1956	491700	1.3073
1951	74850249	3928379	2833764	0.2341	600400	1.3238
1952	74700698	3799421	2789281	0.2460	664400	1.2720
1953	80117110	3651709	2616154	0.2611	698500	1.1979
1954	75150250	3491207	2438650	0.2919	762900	1.2509
1955	66386216	3319725	2409581	0.2893	806400	1.0598
1956	49130963	2990532	2226943	0.2921	675200	1.2712
1957	129994149	3162995	2041999	0.3065	682900	1.1575
1958	49674387	3033989	1697178	0.3152	670500	1.1674
1959	56911045	3265892	2604409	0.3291	784500	1.5186
1960	23068993	2767199	2230955	0.2871	696200	1.1830
1961	108146787	2936073	2124816	0.3219	696700	1.1348
1962	52904555	2709206	1523271	0.3460	627800	1.1705
1963	79319932	3293781	2445236	0.2440	716000	0.8602
1964	82145285	3310146	2373225	0.3240	871200	1.0656
1965	38186782	2729056	1945829	0.5013	1168800	1.1496
1966	34935009	2090135	1575346	0.5105	895500	1.0707
1967	42926504	1579753	1021819	0.6536	695500	1.1757
1968	40873807	1218666	567513	0.9482	717800	1.2551
1969	19560054	1003674	510889	0.8637	546700	0.9674
1970	36506468	971841	489435	0.9052	563100	0.9657
1971	26990621	869148	348415	1.2116	520100	1.0747
1972	17716377	772344	350224	0.6451	497500	0.9197
1973	8966446	554666	304332	0.8273	484000	0.9575
1974	16387018	440039	204454	0.8454	275100	0.9680
1975	3870909	319108	119499	0.9676	312800	0.9343
1976	4901246	270593	166619	0.7234	174800	0.9530
1977	5520616	233470	124522	0.3370	46000	1.1979
1978	5826925	278777	154857	0.2497	11000	1.2152
1979	11172880	356067	190020	0.2074	25100	1.0056
1980	17072849	479513	210696	0.1831	70764	1.0936
1981	37468083	761959	309556	0.2010	174879	1.0081
1982	59709399	1154649	431694	0.1849	275079	0.9786
1983	56232194	1569760	647799	0.2308	387202	1.0771
1984	53650428	2072988	1033501	0.3037	428631	1.0543
1985	67456938	2294619	1097551	0.3877	613780	1.0419
1986	79717524	2587889	1123644	0.3787	671488	1.1373
1987	81409294	2557352	1295112	0.3738	792058	1.0173
1988	42926504	2587829	1645490	0.3651	887686	1.1641
1989	35640743	2314082	1696497	0.3505	787899	1.0335
1990	29978769	2284550	1740614	0.3005	645229	1.0515
1991	31642129	2088169	1501737	0.3290	658008	1.0197
1992	59174425	1987326	1151701	0.3687	716799	0.9950
1993	51392356	1763310	818342	0.4223	671397	1.0231
1994	36397112	1633635	874154	0.4370	568234	1.0498
1995	46828381	1648656	921587	0.3787	579371	1.0084
1996	44233811	1903021	1057787	0.2288	275098	0.9987
1997	31108760	2104685	1216920	0.2005	264313	1.0006
1998	22098052	2232323	1467383	0.2219	391628	1.0018
1999	71128595	2257531	1536391	0.2116	363163	1.0000
2000	48496394	2791675	1531376	0.2119	388157	1.0004
2001	84901303	3229541	2085051	0.1865	374065	0.9901
2002	44278067	3723199	2397833	0.1763	394709	0.9974
2003	21274080	4060200	2455913	0.2011	482281	1.0153
2004	24865702	3387645	2419299	0.2442	587698	0.9985
2005	23277552	2742698	2295493	0.2596	663813	1.0033
2006	27480851	2281974	1797072	0.2310	514597	0.9950
2007	26245366	1980271	1444261	0.1968	406482	1.0056
2008	26192928	2095827	1525478	0.1282	257870	1.0040
2009	35039971	2513642	1900075	0.0762	168443	1.0023
2010	37095269	2977787	2003951	0.0781	187611	1.0034
2011	31139884	3031810	2343957	0.0934	226478	0.9938

TABLE 2.6.3.13 North Sea Herring. ESTIMATED FISHING MORTALITY

Units : f

age \ year	1947	1948	1949	1950	1951	1952
0	0.0035422258	0.0035432886	0.003545061	0.003540455	0.003541872	0.003541872
1	0.0002558038	0.0002558038	0.001232636	0.005939680	0.028538535	0.053874393
2	0.0698363941	0.0508182366	0.062549315	0.085434951	0.128246639	0.181209764
3	0.1418195222	0.1608955311	0.157001487	0.176435484	0.213439897	0.199987583
4	0.1474597532	0.1599810353	0.171049892	0.205152843	0.274089660	0.251679205
5	0.1905005876	0.2006285682	0.208816375	0.208315817	0.269200183	0.266308465
6	0.3229363610	0.2890660703	0.329822714	0.302522386	0.285418145	0.330912927
7	0.3330042588	0.3199789713	0.404105216	0.320844082	0.284307182	0.387120215
8	0.3330042588	0.3199789713	0.404105216	0.320844082	0.284307182	0.387120215

age \ year	1953	1954	1955	1956	1957	1958
0	0.003540809	0.004881513	0.004381343	0.003638441	0.003809718	0.003899917
1	0.077964631	0.102366067	0.162528810	0.152895591	0.193205672	0.167077083
2	0.215779117	0.250724638	0.290485970	0.363563975	0.340956628	0.367658780
3	0.249673803	0.310584274	0.310770681	0.314302305	0.324684934	0.355155343
4	0.246794320	0.257792572	0.262527353	0.271960077	0.278176354	0.268608594
5	0.264715398	0.284335614	0.257457660	0.246498345	0.302643419	0.329690811
6	0.328604625	0.355830779	0.325497662	0.264265764	0.285846593	0.254743022
7	0.375720411	0.437005281	0.248130615	0.275573748	0.283909430	0.182573947
8	0.375720411	0.437005281	0.248130615	0.275573748	0.283909430	0.182573947

age \ year	1959	1960	1961	1962	1963	1964
0	0.007404258	0.0141789	0.01704497	0.00603005	0.009880423	0.0104893
1	0.205913315	0.2248324	0.11279311	0.10520968	0.131506368	0.2550744
2	0.381265232	0.3873758	0.42269686	0.25874817	0.286046756	0.3561156
3	0.345176292	0.2857037	0.32055545	0.41716644	0.285875179	0.3561868
4	0.305623905	0.2529660	0.30122433	0.34704529	0.241641514	0.3243604
5	0.298495626	0.2254628	0.27329595	0.32193681	0.215197299	0.3057156
6	0.314711164	0.2838527	0.29188365	0.38523567	0.191034737	0.2778150
7	0.308510315	0.3319403	0.25903295	0.33763157	0.192781087	0.2255530
8	0.308510315	0.3319403	0.25903295	0.33763157	0.192781087	0.2255530

age \ year	1965	1966	1967	1968	1969	1970
0	0.008363318	0.01701942	0.02381356	0.02767848	0.01191926	0.03252976
1	0.234664135	0.20607811	0.26614873	0.27750953	0.28811372	0.26622858
2	0.534240055	0.49983862	0.49350613	0.90181128	0.70817786	0.75233017
3	0.527888601	0.55505393	0.69921290	1.28188288	0.81226389	0.94721422
4	0.507925752	0.49522157	0.66565085	0.77560648	0.75679717	0.90973585
5	0.486737654	0.60922964	0.69375944	0.85696346	0.81534821	0.81420753
6	0.449854987	0.39310442	0.71609675	0.92476928	1.22568516	1.10268928
7	0.478351242	0.56773529	0.94647947	1.13330710	0.98920074	0.92443735
8	0.478351242	0.56773529	0.94647947	1.13330710	0.98920074	0.92443735

age \ year	1971	1972	1973	1974	1975	1976	1977
0	0.03912084	0.05802392	0.05254948	0.08345898	0.0981361	0.07523791	0.07276647
1	0.51932260	0.53486548	0.59831973	0.43085227	0.5050994	0.15604669	0.10982139
2	0.70528733	0.69304524	0.79854017	0.85356806	0.9352186	0.61731861	0.17327073
3	0.87410917	0.69421748	0.92748097	0.80665436	1.0279926	0.86531645	0.47157364
4	0.88046949	0.65815159	0.73293372	0.76650811	0.8885006	0.77916691	0.30452564
5	0.70686894	0.54450399	0.72651220	0.91597336	1.1281059	0.81098153	0.43848924
6	2.89128199	0.63540671	0.95079006	0.88424598	0.8583786	0.54443321	0.29694748
7	1.27434204	0.33277124	0.56826922	0.77754015	1.3996749	0.85588436	0.34222050
8	1.27434204	0.33277124	0.56826922	0.77754015	1.3996749	0.85588436	0.34222050

age \ year	1978	1979	1980	1981	1982	1983	1984
0	0.09159304	0.10846801	0.13203345	0.3704266	0.3410930	0.3751422	0.2103253
1	0.10268389	0.09922155	0.08975245	0.1955381	0.1696700	0.2013320	0.1864858
2	0.18068502	0.19388308	0.21072528	0.1964789	0.1791915	0.1976021	0.2238901
3	0.31105050	0.27147099	0.24367985	0.2017956	0.2600712	0.2342890	0.2885174
4	0.24827954	0.19520597	0.17827999	0.1942907	0.1951474	0.2541578	0.3465251
5	0.32699840	0.27417190	0.21943483	0.2231748	0.1540004	0.2268423	0.3462480
6	0.18155439	0.10202882	0.06346923	0.1891150	0.1361361	0.2410141	0.3133921
7	0.29843593	0.22055680	0.12989875	0.3908584	0.1997477	0.3512349	0.5025651
8	0.29843593	0.22055680	0.12989875	0.3908584	0.1997477	0.3512349	0.5025651

TABLE 2.6.3.13 (Cont.) North Sea Herring. ESTIMATED FISHING MORTALITY

year

age	1985	1986	1987	1988	1989	1990	1991
0	0.1049575	0.08231516	0.1428157	0.1214200	0.1256946	0.07823016	0.1251803
1	0.2923218	0.29945234	0.3517973	0.4735868	0.3592632	0.38892452	0.2879697
2	0.2768997	0.29945234	0.3023712	0.2797105	0.2850473	0.28097207	0.3759760
3	0.3918916	0.35320735	0.3241659	0.2976610	0.2871358	0.25947368	0.2984956
4	0.4336403	0.39062393	0.3868919	0.3773697	0.3813148	0.31405096	0.3122347
5	0.4090123	0.38401257	0.4107256	0.4221604	0.3990295	0.34969288	0.3247499
6	0.4270134	0.46623289	0.4450939	0.4485837	0.3999443	0.29819728	0.3337043
7	0.5377669	0.54371504	0.4186500	0.4526211	0.4194336	0.33702438	0.2701440
8	0.5377669	0.54371504	0.4186500	0.4526211	0.4194336	0.33702438	0.2701440

year

age	1992	1993	1994	1995	1996	1997	1998
0	0.2655107	0.3198830	0.2150467	0.2156497	0.07635972	0.02387317	0.01935315
1	0.3236152	0.3278169	0.1890205	0.1916470	0.13793124	0.04152332	0.09731521
2	0.3999123	0.4349823	0.4215360	0.3086337	0.17380870	0.14567167	0.15892864
3	0.3354441	0.4302065	0.4435211	0.4038992	0.24593205	0.20478390	0.21420967
4	0.3534900	0.4447647	0.5680363	0.3961272	0.22530505	0.22275116	0.22577869
5	0.3555462	0.3809603	0.3715210	0.4268810	0.24210107	0.22157370	0.24326595
6	0.3992171	0.4205466	0.3803551	0.3581512	0.25699465	0.20773335	0.26726890
7	0.3828087	0.4628649	0.3728049	0.3245875	0.12631203	0.16393259	0.14931457
8	0.3828087	0.4628649	0.3728049	0.3245875	0.12631203	0.16393259	0.14931457

year

age	1999	2000	2001	2002	2003	2004
0	0.03080433	0.03392510	0.03205827	0.02651353	0.02857566	0.04420135
1	0.04924734	0.05287102	0.04820464	0.03412585	0.05059007	0.04023572
2	0.15254434	0.14164944	0.08428933	0.08996811	0.07992233	0.08813373
3	0.22009412	0.20353852	0.18548152	0.14487268	0.14507564	0.14106987
4	0.22324175	0.22937433	0.21675231	0.21489623	0.20844084	0.23121668
5	0.23816299	0.25392915	0.22197289	0.21720797	0.31673177	0.32873609
6	0.22375580	0.23107799	0.22420376	0.21468145	0.25520197	0.43182710
7	0.13677747	0.14156448	0.15682888	0.20000758	0.22697850	0.34058178
8	0.13677747	0.14156448	0.15682888	0.20000758	0.22697850	0.34058178

year

age	2005	2006	2007	2008	2009	2010
0	0.06325380	0.05046375	0.03930907	0.04417042	0.03038519	0.02633912
1	0.09151064	0.04106907	0.03354391	0.02957577	0.02356012	0.02736474
2	0.10983237	0.09927118	0.07925379	0.08076593	0.05693756	0.06393425
3	0.14511917	0.15621844	0.15770959	0.09934069	0.05502322	0.06700420
4	0.22146294	0.22770599	0.21275798	0.13476807	0.08839852	0.07872457
5	0.35868884	0.28739434	0.26168861	0.16939873	0.10010857	0.10072110
6	0.46273534	0.38455825	0.27234109	0.15668780	0.08066907	0.08026674
7	0.62462113	0.55889704	0.44399588	0.20653198	0.10791623	0.07874819
8	0.62462113	0.55889704	0.44399588	0.20653198	0.10791623	0.07874819

year

age	2011	2012
0	0.03737325	0.03739568
1	0.01531535	0.01532454
2	0.06819391	0.06819391
3	0.08893940	0.08893940
4	0.09014823	0.09014823
5	0.11837473	0.11837473
6	0.10110457	0.10110457
7	0.08921554	0.08921554
8	0.08921554	0.08921554

TABLE 2.6.3.14 North Sea Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

year

age	1947	1948	1949	1950	1951	1952	1953
0	72492959	67254871	59233629	81899218	74850249.3	74700698.4	80117110.2
1	15494567	19677767	18219445	15448153	22771037.5	20055219.5	20095370.0
2	7865526	6556713	9295119	7732942	6280750.3	9083771.2	7857664.6
3	3696881	5050511	5137104	7297191	5357457.1	3905904.7	5251372.3
4	5362817	2483054	2972756	3752752	5204322.0	3162900.4	2465733.8
5	3426329	3660096	1672784	1854267	2692552.0	3103372.6	1889834.8
6	2960889	2278436	2412080	1084902	1219559.2	1698065.1	1903110.1
7	1684535	1689596	1393041	1368191	641779.5	751630.4	984609.1
8	5101270	3867040	3259225	2463269	2213310.7	1778000.5	1397226.8

year

age	1954	1955	1956	1957	1958	1959	1960
0	75150250	66386215.8	49130963	129994149.0	49674386.7	56911045.4	23068993.5
1	22297832	19717162.4	18002118	12286356.8	40955636.4	12698570.7	16272709.5
2	7779480	8868356.1	6736156	6695860.1	3925483.2	16902971.6	4210112.8
3	4556202	4421546.1	5111482	3150274.0	3649132.4	1878529.8	9379152.8
4	2943177	2380925.9	2436322	2919725.0	1621723.5	1955194.0	932850.3
5	1542631	1694672.4	1365457	1429735.5	1735836.5	961259.8	1057057.9
6	1162403	911639.6	1019681	866311.7	810981.1	968012.2	545795.7
7	1104607	644351.7	514011	625933.9	516071.2	502826.3	540364.9
8	1357289	1246686.8	1218340	1054945.9	978719.1	1057057.9	927269.9

year

age	1961	1962	1963	1964	1965	1966
0	108146786.9	52904555.1	79319931.7	82145284.5	38186782.3	34935008.7
1	4995259.9	32216844.7	15494566.9	18402553.7	22275545.0	11217661.3
2	5592852.5	1624970.1	13443415.6	6064726.5	5786279.1	7633064.8
3	2074021.4	2441199.3	904375.6	8529147.7	3365206.9	2193480.3
4	6040516.0	1145097.1	997492.6	600789.6	5005260.4	1432597.8
5	573205.7	3752752.0	560172.5	643064.3	381551.1	2206680.7
6	709276.0	345932.9	1998685.0	413742.9	391210.1	185535.2
7	319336.3	443299.1	171441.9	1434031.1	272120.4	188527.7
8	799706.4	671990.8	603801.0	523347.0	1338419.5	814231.5

year

age	1967	1968	1969	1970	1971	1972
0	42926503.9	40873807.0	19560054.33	36506467.70	26990621.18	17716376.575
1	10522222.4	14709439.7	14680050.19	7889158.24	15036633.27	11628854.217
2	3953057.9	3207492.4	4652894.23	4483883.13	2655118.91	3609211.914
3	3331722.5	1871030.7	759184.42	1589611.17	1342440.79	882046.452
4	873269.9	1240468.9	323191.40	232349.97	403527.53	356111.798
5	673336.2	307429.2	400312.19	103156.24	61821.10	106830.634
6	868046.0	255505.7	87553.03	125116.43	30699.45	20140.742
7	100810.7	298343.3	73791.59	17380.43	30576.90	1088.657
8	444631.0	159532.0	103984.80	46957.58	17997.71	8851.126

year

age	1973	1974	1975	1976	1977	1978
0	8966446.485	16387018.099	3870909.305	4901245.919	5520615.966	5826925.146
1	7459507.864	3707988.113	7920778.069	1414094.564	2109581.195	2345478.523
2	2864773.937	1646232.662	986580.300	1986728.750	465096.412	810981.077
3	1191829.405	831511.161	450448.936	233748.259	639857.005	315527.146
4	319655.777	293607.758	257557.944	100207.669	59994.010	259367.175
5	129702.676	106297.814	90219.422	69424.839	26529.166	33123.557
6	45433.273	43260.705	29202.220	18403.571	20237.650	11499.973
7	8103.894	12028.090	12341.218	8369.923	7051.531	10283.542
8	5136.874	5558.591	5886.401	3026.917	3258.753	5137.901

year

age	1979	1980	1981	1982	1983	1984
0	11172880.321	17072849.310	37468082.68	59709398.81	56232194.12	53650427.75
1	2258022.527	4470451.642	6682481.78	10702629.32	18925106.79	15902708.52
2	902568.620	829020.365	1880409.26	2303637.61	3878658.87	6941302.53
3	462776.734	497325.490	416232.80	1091430.74	1314543.48	2128653.12
4	189662.224	243287.707	259886.43	238470.29	561293.94	769887.75
5	134188.392	130875.269	149044.47	144206.27	148746.68	302549.45
6	18442.259	69563.828	92318.52	81715.58	102641.74	92041.97
7	6561.011	13108.288	51844.29	58571.29	53637.30	64344.07
8	7837.694	7665.615	15257.10	34098.20	65447.27	69563.83

TABLE 2.6.3.14 (Cont.) North Sea Herring. ESTIMATED POPULATION ABUNDANCE

age	1985	1986	1987	1988	1989	1990
0	67456938.22	79717524.47	81409293.9	42926503.91	35640742.73	29978769.3
1	17930253.79	26114466.74	32249077.6	29151006.54	15494566.93	12673198.9
2	6236938.53	5774718.10	9304418.9	10821008.13	7542015.41	4671543.1
3	3890312.32	3295274.40	2841947.2	4920890.17	6052609.14	4135008.7
4	1124669.76	1744537.44	1667773.4	1429735.47	2714178.81	3745254.0
5	399512.37	491884.89	833175.8	828191.76	710695.96	1485110.9
6	146678.74	190232.06	244262.8	402318.76	401916.65	382697.4
7	52365.33	67104.07	86942.3	117125.35	190232.06	211504.2
8	66836.19	57068.07	54502.4	71324.84	91126.14	156373.1

age	1991	1992	1993	1994	1995	1996
0	31642129.4	59174425.2	51392355.8	36397112.4	46828380.6	44233810.6
1	12151947.5	11605619.8	18849557.6	15081810.9	12749466.7	16175365.6
2	4008790.0	4556202.3	3898100.7	5850279.5	6040516.0	5261885.6
3	2463269.3	1861698.9	2002686.3	1565944.9	2649814.0	3051061.1
4	2404854.6	1407041.7	992517.6	824885.6	772973.5	1167062.0
5	2111691.8	1346474.2	759184.4	431058.9	337729.3	352921.2
6	810170.5	1225672.2	735275.1	365126.8	212139.6	134726.2
7	220576.5	463239.7	608042.5	342148.5	177371.2	100408.3
8	190041.9	241832.4	365492.1	427196.8	352216.0	275681.1

age	1997	1998	1999	2000	2001	2002
0	31108759.70	22098051.6	71128595.4	48496393.9	84901303.1	44278066.5
1	18962994.88	13072221.0	9184244.3	31264693.0	18020129.6	36799690.8
2	6556713.21	9511384.4	5261885.6	5015281.0	14636076.0	7881273.0
3	3020702.57	3365206.9	6058664.8	2981687.6	3262485.9	9120179.1
4	1681169.10	1633115.3	1751529.6	3612822.9	1715131.0	1794074.8
5	666636.37	935653.0	779182.1	1053891.4	1964994.5	942225.6
6	215776.84	401113.6	459089.3	460008.4	549080.3	1125795.0
7	71253.56	133920.3	201390.3	260928.1	249197.2	301643.2
8	228890.73	172819.0	161457.9	203821.5	233281.2	292143.4

age	2003	2004	2005	2006	2007	2008
0	21274080.3	24865702.4	23277551.5	27480851.2	26245366.1	26192927.8
1	16852338.7	7944576.1	9989049.5	8040485.3	9949173.1	10951642.5
2	20297331.9	6709265.2	3813279.0	4960415.2	3700579.5	4704358.6
3	4643597.7	12534557.7	4316692.3	2488025.5	3017683.4	2251258.6
4	5443865.8	2952019.3	7889158.2	2628700.0	1551914.7	1869160.6
5	974812.1	3169232.5	1696367.9	4756392.2	1418343.2	984609.1
6	580706.1	493362.8	1641301.4	852561.0	2633962.7	868046.0
7	646287.7	346279.0	230038.0	738960.7	424216.8	1715131.0
8	333700.8	524919.4	401113.6	242074.3	409216.6	474966.7

age	2009	2010	2011	2012
0	35039971.1	37095269.0	31139884.0	27757038.3
1	10574965.3	13230032.6	15036633.3	11251364.9
2	6230704.7	5542742.7	6602771.2	7564675.4
3	2859050.1	4368804.7	3580453.4	4210112.8
4	1405635.4	2090680.1	2887784.0	2289857.2
5	1207424.3	1048635.1	1309295.8	1861698.9
6	669977.9	956465.5	710696.0	836515.2
7	600189.1	517621.7	682829.2	464631.5
8	1618483.2	1819368.5	1694672.4	1581683.0

TABLE 2.6.3.15 North Sea Herring. PREDICTED CATCH NUMBERS AT AGE

Units : NA

age \ year	1947	1948	1949	1950	1951	1952	1953
0	457851.420	656645.8	282829.6	338371.6	493017.5	158086.9	204168.3
1	427239.489	325364.1	609198.8	608711.7	708425.4	1016321.2	1465636.2
2	651739.356	596897.1	417901.1	430757.3	1302505.1	1321529.1	1496291.1
3	533012.417	513702.7	977740.9	653762.9	619457.9	1017338.0	1068536.0
4	734834.072	416857.6	546888.4	901486.2	624870.7	478829.6	594514.3
5	429896.603	953981.9	1032609.9	1108368.9	651022.8	394470.6	343245.1
6	1300943.073	486406.5	617849.4	570632.1	430068.6	479548.3	313294.8
7	3376.179	653044.1	312762.7	272066.0	217379.5	278006.6	352921.2
8	280407.730	414281.1	254613.0	142899.9	514422.4	394667.9	433653.0

age \ year	1954	1955	1956	1957	1958	1959	1960
0	161910.7	99787.68	277589.9	107387.60	1609445.1	2233320.4	359942.65
1	2006896.4	1729771.71	1467983.1	4278444.21	4672477.5	1175847.8	1672282.47
2	1940973.1	1784056.03	1678985.0	1052101.34	482579.0	2045187.4	497325.49
3	1037267.1	1209962.59	765818.1	960683.22	459089.3	185127.5	1391370.79
4	488356.0	515040.08	628694.0	340067.70	223373.4	191491.7	122504.13
5	345414.4	267560.24	334837.3	438975.99	235578.6	121115.5	160604.48
6	227817.5	212691.92	193087.7	164045.65	120427.1	137489.1	65264.27
7	127376.2	111401.94	138995.9	77528.43	253089.9	235861.5	163439.80
8	246495.7	263998.84	234169.4	146972.39	181552.5	1033539.6	182353.06

age \ year	1961	1962	1963	1964	1965	1966
0	2171220.48	1298084.14	2831451.40	3169866.40	1415650.92	1671112.28
1	318411.55	2958520.88	1584849.49	2069256.66	2563797.20	1300812.98
2	725996.16	201531.30	2253285.65	1204289.11	806291.00	1436040.17
3	295818.09	194463.55	148672.32	1760485.18	487087.96	366993.71
4	919329.61	99498.71	152832.83	130980.01	887088.47	294254.41
5	98587.52	318825.75	90508.59	126247.56	52960.41	388248.16
6	113334.62	27592.52	261319.74	92355.45	72120.96	54426.15
7	171853.90	97216.92	95415.85	454430.38	311545.29	240049.40
8	412297.31	473543.95	183212.14	352744.75	625683.54	712688.70

age \ year	1967	1968	1969	1970	1971	1972
0	2420295.02	2495251.29	1248433.346	4197501.39	3322738.997	2327022.241
1	1618159.58	1979985.34	1981371.818	1117941.94	1497937.920	1312835.684
2	1168580.12	357610.61	823813.954	658223.62	368612.044	606221.070
3	575157.96	146341.76	118266.993	200325.74	144105.363	139706.630
4	153706.47	192143.93	49227.121	26622.18	37835.383	56783.439
5	134403.27	53949.30	72330.415	26142.04	8032.491	23858.600
6	177779.62	40327.95	9057.695	19150.80	260.088	2986.418
7	95063.46	56794.80	24469.923	11268.88	2114.577	1892.928
8	151706.04	782931.12	706797.866	692040.67	320263.701	922460.652

age \ year	1973	1974	1975	1976	1977	1980
0	889397.904	2162552.943	137049.849	146840.1707	260563.0121	814964.636
1	789693.362	503430.023	762913.549	60937.2546	130888.3567	279037.093
2	385964.239	244972.197	114496.553	201571.6137	90291.6260	63869.678
3	132349.311	128579.157	46069.205	13234.8661	33634.2442	38913.636
4	54377.188	52527.914	33090.450	8025.6665	22128.0209	25616.706
5	21710.472	14423.874	6598.252	4430.0228	3669.1672	13715.612
6	5565.433	8122.880	4164.286	1750.8208	1378.2364	14596.835
7	2572.028	3874.299	1506.042	809.1222	806.0131	4297.763
8	254002.655	246668.350	267453.233	1445549.3785	8053360.3736	11920855.653

age \ year	1981	1982	1983	1984	1985	1986
0	1149341.813	2389751.63	1874589.01	3175894.87	4736457.26	6725386.81
1	314361.853	579487.86	1164380.80	1267427.74	1260097.93	2056055.71
2	210386.165	231191.12	452163.90	1077333.97	839867.99	676508.30
3	35867.971	107183.76	193068.44	340918.93	487087.96	463795.96
4	17660.398	25993.45	76733.99	116786.18	136803.38	245904.86
5	8962.549	19017.79	21529.51	44582.65	62230.47	77226.66
6	9201.299	13852.21	22310.22	19201.81	24889.47	26315.15
7	5353.629	16905.26	24141.80	24526.27	21177.19	16489.51
8	12159240.820	6921201.92	4510416.24	4208429.10	7270968.07	3292309.99

TABLE 2.6.3.15 (Cont.) North Sea Herring. PREDICTED CATCH NUMBERS AT AGE

age \ year	1987	1988	1989	1990	1991	1992	1993
0	7788820.54	3290993.33	2890384.22	2147897.47	2282084.87	3781381.6	1874589.01
1	2243617.33	1593908.92	976177.78	1074429.09	1284268.69	1176318.3	1719768.08
2	1094709.95	1308903.08	819459.29	551556.74	460606.79	608589.9	486698.44
3	391679.82	752081.52	882222.88	564558.90	367177.26	312512.6	314016.25
4	250972.84	206282.11	386620.94	516845.88	355755.86	212245.7	117830.21
5	128514.88	117336.36	87186.08	203210.97	356967.49	223239.4	101762.81
6	37903.55	58029.11	53760.81	46258.48	130705.24	199645.8	93873.18
7	23093.35	27791.90	39759.34	39850.89	68206.83	120018.4	117277.71
8	2830036.03	1515415.17	2522093.83	9476257.33	9760947.17	4900265.8	6350219.90

age \ year	1994	1995	1996	1997	1998	1999	2000
0	1620912.79	1518600.89	560340.548	883812.31	319527.94	1155218.43	605796.86
1	1364911.30	709275.99	747507.786	1171270.95	620387.77	547599.80	971697.67
2	761693.86	571145.92	477586.226	552274.23	1014493.47	462360.42	463286.07
3	220510.37	203801.14	289323.292	283197.55	299329.42	629197.20	282688.26
4	103228.47	66230.74	115058.963	174835.36	142130.37	202116.59	332867.57
5	56089.28	26659.48	35126.110	81389.37	79205.42	81178.04	93901.35
6	43165.64	10374.02	9344.563	16040.15	22114.75	29425.00	30785.53
7	85742.17	28492.61	30022.429	20699.61	17733.49	22982.77	28827.93
8	2252384.52	505751.14	290860.776	1468129.94	1085552.90	1780847.62	764517.35

age \ year	2001	2002	2003	2004	2005	2006	2007
0	880548.25	592911.2	223574.51	627061.56	232582.43	237091.2	232442.93
1	556320.59	1277480.1	463842.35	326080.64	386273.13	233164.6	303640.59
2	1028693.39	523713.5	1376837.83	487234.11	301522.52	370126.5	179297.19
3	292903.94	862939.6	513702.71	1321396.91	451892.68	251550.7	199506.08
4	156138.70	224875.0	755095.87	435434.65	1011656.86	278758.2	131150.40
5	184923.96	111146.0	147797.74	520112.29	232815.13	536971.3	107828.79
6	46495.00	111535.7	85263.35	91986.77	272528.92	131019.3	275130.28
7	45021.71	57584.0	129210.74	160379.79	89268.15	126399.1	76213.97
8	392974.50	701937.7	928940.53	876331.74	652913.54	728978.9	674346.94

age \ year	2008	2009	2010	2011
0	180936.24	265587.60	166608.16	427239.489
1	288889.63	290018.50	362543.59	651739.356
2	129430.59	241228.53	256786.43	533012.417
3	101073.17	135144.52	210701.98	734834.072
4	98666.43	86777.27	124928.89	429896.603
5	44662.97	63869.68	58524.46	1300943.073
6	52971.01	34043.69	50016.09	3376.179
7	142885.66	119670.81	124131.90	280407.730
8	620449.81	736378.84	457851.42	656645.777

TABLE 2.6.3.16 North Sea Herring. CATCH AT AGE RESIDUALS

Units : NA

age	1947	1948	1949	1950	1951	1952
0	0.47155300	0.1436320	0.09099120	-0.0786206	-0.36646400	-0.2204640000
1	-0.18045100	0.0502984	0.24301300	-0.0693490	0.11781100	0.0406535000
2	-0.13208300	0.0424816	0.35879900	0.4346130	0.20354200	0.0022256300
3	-0.08209830	-0.1907780	0.21043100	0.0588029	-0.45166900	-0.0879213000
4	0.10167800	-0.1474730	-0.13646600	0.3837570	-0.14975200	-0.0630214000
5	0.00905062	-0.1412420	0.03849760	0.7709630	0.00922333	-0.1347640000
6	0.02738910	-0.1084350	-0.00829313	0.6144640	0.27165800	-0.0492484000
7	-0.73310300	-0.0865366	-0.46911100	-0.1349910	0.29392100	0.0000635621
8	-0.78730600	-0.2803610	-0.00846700	-0.0225613	0.26517600	-0.0242404000

age	1953	1954	1955	1956	1957	1958
0	0.2948590	0.0539988	-0.1627980	0.0211252	-0.427606000	-0.00145254
1	-0.0624970	0.1979380	-0.1186190	0.0630924	0.000529766	0.33787100
2	-0.0133746	-0.0319574	0.2586960	-0.1308890	-0.137873000	0.06902470
3	0.2421300	-0.0313421	0.0562163	-0.2467600	0.242514000	0.49255100
4	-0.0366569	-0.1200370	0.0115740	0.1492440	-0.338581000	0.26206100
5	0.3129070	-0.1528500	-0.4460260	0.1676170	0.304055000	0.19828800
6	0.1856180	0.0650562	-0.3289680	0.2487880	-0.392379000	-0.01283770
7	0.2548710	-0.2133040	-0.2458140	0.2002010	-0.215140000	0.61996700
8	0.5869820	-0.4890900	0.3605290	0.2767760	-0.785226000	0.29145600

age	1959	1960	1961	1962	1963	1964	1965
0	0.427592	-0.4270990	-0.0700359	-0.17406700	0.2999710	0.0764975	-0.1445050
1	-0.179686	0.7575090	-1.0327300	0.00538616	-0.1482080	0.4295880	0.0142715
2	-0.242961	-0.2215920	0.5820550	-0.79864600	-0.0281013	0.5911110	-0.5223830
3	-0.680210	0.2813660	0.7734970	-1.27713000	-0.0112837	0.9126590	-0.4903690
4	-0.823377	0.0754948	1.0096100	-1.30725000	-0.1573260	0.6356290	0.0188439
5	-0.251288	-0.0607536	0.9030800	-1.17248000	0.1733160	0.6617060	-0.5586900
6	-0.317844	-0.2182830	0.8835310	-0.74565700	-0.0692577	0.8642910	-0.3827560
7	0.491578	-0.4652540	0.0257881	-0.15877400	-0.4556840	0.2798410	0.2252360
8	0.862970	-1.0569300	0.2998940	0.20223400	-0.6462950	0.2515480	0.1305560

age	1966	1967	1968	1969	1970	1971	1972
0	0.0116334	0.0123091	0.0198611	-0.2649730	0.2616850	0.0333357	0.108623
1	-0.6497880	0.6445780	-0.3117250	0.0666255	0.1582920	-0.2428620	0.146629
2	-0.3160910	1.5257100	-1.1671400	0.4344570	0.0400950	-0.4326010	0.520160
3	0.0755827	0.4801650	-0.5886360	0.3537360	0.2422610	-0.6106710	0.449162
4	0.0741273	0.1355130	-0.0437233	0.1335490	0.0641882	-0.8674080	0.269339
5	0.0443495	0.2712590	-0.2789630	-0.6092880	0.5514990	-1.6954900	0.890118
6	0.7911590	-0.3018150	0.2045640	-0.4890860	1.2019500	-0.9395680	0.766290
7	0.2076170	0.3727350	-0.2813100	-0.0395627	0.3708180	-1.2281700	0.196778
8	0.6873270	-1.2753100	0.5767580	-0.1378100	0.3400950	-0.4259740	0.322861

age	1973	1974	1975	1976	1977	1980	1981
0	-0.3098640	0.801117	-0.492001	-0.107986	-0.3795890	0.4196190	-0.180504
1	-0.1360200	0.454556	1.035510	-1.922940	0.1456900	0.1157530	-0.302627
2	-0.3979160	0.359733	0.150126	-0.485717	0.1026520	-0.7169500	0.556044
3	-0.3053370	0.550434	0.751304	-1.261630	-0.2704600	0.0926461	-0.386952
4	0.1933440	0.528755	0.258809	-0.848528	-0.1210630	0.6620900	-1.266520
5	0.0958336	0.393204	-0.280819	-0.276879	-1.6704400	1.8019700	-0.987586
6	-0.3831790	0.406246	0.196932	-0.553009	0.0560233	0.8859980	-0.590930
7	0.6677540	0.766275	-0.261126	-0.518129	-1.7077800	1.5342700	-0.465699
8	0.1590690	-0.146920	-0.170691	-0.568273	0.7027760	0.0124993	0.375950

age	1982	1983	1984	1985	1986	1987
0	0.1509840	-0.1889100	0.1486180	0.08430080	0.10175100	0.06213250
1	-0.0612069	-0.0975361	0.2818180	0.03236560	0.24003600	-0.03113420
2	-0.4104210	-0.1498120	0.5773270	0.00707775	-0.07953640	-0.02297860
3	-0.1216760	0.2653380	0.4830500	-0.27613600	0.04434580	-0.12746000
4	0.0488319	0.3434000	0.3972150	-0.32597200	-0.00266382	0.11847100
5	0.6487340	0.1735680	-0.0797703	-0.00766879	-0.11892700	-0.01157180
6	-0.2825300	0.4355700	0.1812590	-0.69408800	-0.35941900	0.00914603
7	1.1166200	0.7410500	0.6239660	1.04958000	-0.06333590	0.10777000
8	0.0316705	-0.2888180	-0.5129910	0.52025800	-0.16615800	0.32534600

TABLE 2.6.3.16 (Cont.) North Sea Herring. CATCH AT AGE RESIDUALS

age \ year	1988	1989	1990	1991	1992	1993
0	-0.279726	0.2724750	-0.0257613	0.05706990	0.0743931000	-0.3030230
1	-0.001098	-0.5088960	0.3285960	0.00332556	0.0000434301	0.2247190
2	0.255241	-0.3135260	0.0576338	-0.24627000	0.0039163700	0.0306678
3	0.454805	-0.1514060	-0.1744480	-0.09689240	-0.1407390000	0.6304660
4	0.163834	0.0139183	-0.1908350	0.08196580	0.0971227000	-0.4833510
5	0.188881	-0.2987390	0.0367521	0.18202600	0.0439668000	-0.3684780
6	0.178539	0.0424397	-0.5828810	0.54931700	-0.2151330000	-0.7366160
7	0.052023	0.0837126	-0.1140240	-0.31236700	0.2579870000	-0.0207437
8	-0.635251	-0.2321240	0.3628390	0.21172600	-0.3590170000	0.6647560

age \ year	1994	1995	1996	1997	1998	1999	2000
0	0.1661270	0.348974	-0.9643190	0.6262190	-0.3190820	0.0878177	0.0885034
1	0.3496720	-0.617438	-0.5157310	0.2535000	-0.0406903	0.7989230	-0.8844450
2	0.4326100	-0.515685	-0.4119840	-0.1631270	0.2645550	0.0108569	0.2922590
3	0.3093860	-1.048950	-0.0951446	-0.1521980	-0.1099720	0.1713030	-0.0837697
4	0.8581240	-0.868139	-0.3257260	0.0345182	-0.2898210	0.3393270	-0.2110470
5	-0.0619375	-0.601401	-0.4022270	0.3167090	-0.4780020	0.0568495	-0.1154380
6	-0.1485490	-0.404765	0.8441160	-0.1848960	0.8437830	0.6920720	0.7764940
7	0.4852080	-1.067050	-0.7317570	-0.0259486	-1.3294900	-1.0601600	-1.2014000
8	0.1083120	-0.670369	-0.4789610	0.2719370	0.0747615	0.1207380	-0.1925470

age \ year	2001	2002	2003	2004	2005	2006
0	-0.3108090	0.2470400	-0.4886330	0.8188690	-0.2858190	-0.0405421
1	0.2540340	-0.2754700	-0.2170990	0.5349170	0.2337850	-0.3854480
2	-0.3606080	0.0665854	-0.0482375	-0.0191619	0.1844120	0.7465130
3	-0.0145617	-0.1999310	0.3484720	-0.0127414	0.1722450	0.7908660
4	-0.6459170	0.5265960	-0.0152966	0.6040320	-0.0856958	0.6485770
5	-0.2061880	-0.1108000	0.4863020	0.3658960	0.2851970	0.5667360
6	0.1809520	0.3582140	0.7427910	0.8052130	-0.3510120	0.4316130
7	-0.1375870	-0.7481530	-1.0201600	-0.3163370	0.6284030	0.7697120
8	-0.2634730	0.0809474	0.3746830	0.0110036	-0.2106550	0.3816820

age \ year	2007	2008	2009	2010	2011
0	0.0686526	-0.17436500	0.3441390	-0.2705470	-0.18045100
1	0.5500080	-0.66737200	0.0823778	0.0897062	-0.13208300
2	0.1867760	-1.19644000	-0.1147090	0.4257420	-0.08209830
3	-0.0136463	-0.49518400	-0.4227240	0.2316530	0.10167800
4	0.2945370	-0.84286000	-0.2099120	0.2529780	0.00905062
5	0.3330980	-0.58239500	-0.1326770	0.2599850	0.02738910
6	-0.8731440	0.01062590	-0.0786071	0.1448120	-0.73310300
7	1.5407900	0.00623382	-0.1840160	0.0457816	-0.78730600
8	-0.1541080	-0.32051100	0.2359920	0.4715530	0.14363200

TABLE 2.6.3.17 North Sea Herring. PREDICTED INDEX AT AGE SCAI

Units : NA

year								
age	1972	1973	1974	1975	1976	1977	1978	1979
all	3951.063	3438.085	2315.938	1361.116	1899.337	1434.067	1792.488	2214.474
age	1980	1981	1982	1983	1984	1985	1986	1987
all	2474.813	3630.516	5061.104	7596.782	12160.28	13044.74	13451.96	15558.77
age	1988	1989	1990	1991	1992	1993	1994	1995
all	19894.73	20700.85	21393.88	18528.77	14241.85	10107.47	10664.76	11175.73
age	1996	1997	1998	1999	2000	2001	2002	2003
all	12784.39	14621.38	17522.31	18259.85	18094.98	24248.26	27931.21	28561.07
age	2004	2005	2006	2007	2008	2009	2010	2011
all	28251.45	26938.18	21183.76	17096.69	18135.38	22751.81	24313.82	27878.19

TABLE 2.6.3.18 North Sea Herring. INDEX AT AGE RESIDUALS SCAI

Units : NA

year								
age	1972	1973	1974	1975	1976	1977	1978	
all	-0.377393	-0.0831714	-0.108463	0.00387441	-1.10683	0.295175	0.419923	
age	1979	1980	1981	1982	1983	1984	1985	
all	0.936996	0.878809	0.268692	0.0113059	0.0597594	0.0161063	0.388155	
age	1986	1987	1988	1989	1990	1991	1992	1993
all	0.184804	0.42046	0.691161	0.186659	-0.0475792	-0.625272	-1.59895	-1.71
age	1994	1995	1996	1997	1998	1999	2000	
all	-2.21626	-1.7805	-1.46373	-0.884152	-0.666444	-0.590018	-0.243639	
age	2001	2002	2003	2004	2005	2006	2007	2008
all	-0.247492	-0.150611	0.469608	0.725662	0.447558	0.854933	1.45081	1.84122
age	2009	2010	2011					
all	1.89927	1.82469	1.59473					

TABLE 2.6.3.19 North Sea Herring. PREDICTED INDEX AT AGE IBTS-Q1

Units : NA

year								
age	1984	1985	1986	1987	1988	1989	1990	1991
1	1977.621	2201.667	3207.06	3931.829	3500.356	1887.805	1540.496	1498.156
age	1992	1993	1994	1995	1996	1997	1998	1999
1	1426.458	2320.76	1897.135	1608.746	2055.183	2440.773	1670.753	1179.894
age	2000	2001	2002	2003	2004	2005	2006	2007
1	4002.802	2306.485	4717.763	2155.073	1017.588	1272.26	1032.161	1280.057
age	2008	2009	2010	2011	2012			
1	1413.551	1368.896	1718.11	1945.141	1455.377			

TABLE 2.6.3.20 North Sea Herring. INDEX AT AGE RESIDUALS IBTS-Q1

Units : NA

year								
age	1984	1985	1986	1987	1988	1989	1990	
1	-0.924927	-0.168861	-0.646488	-0.217897	0.790556	0.733932	-1.29444	
age	1991	1992	1993	1994	1995	1996	1997	1998
1	-0.528811	-0.408962	0.645148	-0.276549	-0.620533	-0.289675	2.05224	1.07445
age	1999	2000	2001	2002	2003	2004	2005	
1	-1.56191	-0.249913	0.279229	-0.517856	0.955351	-0.134262	-0.800968	
age	2006	2007	2008	2009	2010	2011	2012	
1	-0.504067	0.110176	0.823817	1.8633	-0.907489	1.43272	-0.253661	

TABLE 2.6.3.21 North Sea Herring. PREDICTED INDEX AT AGE HERAS

Units : NA

age	1989	1990	1991	1992	1993	1994	1995
1	4878751.96	3231962.2	1843912.1	1127034.0	593741.9	282999.4	298134.50
2	4651033.45	2863914.6	1798026.1	1002793.3	480508.4	353557.0	3595522.93
3	1996088.35	1245689.8	687557.0	383808.9	288860.7	3847368.6	2374981.01
4	579371.98	331339.9	194677.6	200285.7	3506749.2	1898548.1	928569.03
5	329028.61	180250.0	167728.2	2321212.0	1100527.3	562136.5	310953.92
6	155034.04	133305.7	2767624.7	1421751.3	547709.3	269979.1	117747.76
7	74257.94	2469435.2	1394435.2	706515.2	356396.8	176116.3	94343.72
8	3032809.57	1883608.7	1054945.9	625746.1	300378.9	150091.4	259107.94

age	1996	1997	1998	1999	2000	2001	2002
1	11659128.58	7798952.6	5595090.1	18791214.4	10800467.7	22208818.6	10066262.1
2	4529852.79	6492122.0	3580453.4	3401748.1	10189822.6	5460768.0	14124197.2
3	2392142.58	2640291.8	4712834.1	2323534.3	2557395.7	7295001.9	3707988.1
4	1332543.39	1285296.5	1372850.8	2803278.0	1333343.2	1393180.7	4232485.6
5	590839.69	815290.7	676576.0	899685.0	1698914.4	814394.4	795956.6
6	192624.89	344655.3	401916.6	398076.7	474444.5	976373.0	491540.7
7	65205.56	122933.6	185053.5	237542.1	223843.0	263919.7	556265.0
8	209483.45	158657.0	148390.1	185535.2	209588.2	255531.3	287190.2

age	2003	2004	2005	2006	2007	2008	2009
1	4779755.7	5864337.1	4879239.9	6103665.2	6803175.2	6667796.5	8445970.3
2	4647778.9	2617682.7	3435936.2	2604626.9	3331722.5	4512672.0	4038565.0
3	10029085.7	3449707.5	1981768.1	2410874.3	1865239.5	2442908.8	3739266.4
4	2266166.1	6092688.5	2025850.2	1209478.7	1526365.5	1184699.8	1782094.6
5	2571500.1	1355119.2	3960972.0	1202363.8	882575.8	1131551.2	990237.4
6	379003.2	1240592.9	674549.3	2224627.4	785754.8	636984.1	916667.4
7	280127.5	159404.5	532532.9	327060.4	1514960.6	563825.5	498420.8
8	424513.9	277923.2	174451.1	315495.6	419659.9	1520880.5	1752230.3

age	2010	2011
1	9435596.9	4878751.96
2	4718492.9	4651033.45
3	2987358.2	1996088.35
4	2419811.0	579371.98
5	1208753.2	329028.61
6	664373.7	155034.04
7	644351.7	74257.94
8	1599177.5	3032809.57

TABLE 2.6.3.22 North Sea Herring. INDEX AT AGE RESIDUALS HERAS

Units : NA

age	1989	1990	1991	1992	1993	1994	1995
1	-0.903721	0.439008	0.3100840	0.0317994	1.113920	0.58600700	-1.41195000
2	-0.898673	0.900557	0.1430070	0.8993230	0.567092	-0.04174970	1.14647000
3	-1.028810	0.472217	-0.2712000	0.1191160	0.101320	0.00226406	0.88756100
4	-0.837702	0.696292	0.6542000	0.3511530	-0.493207	0.37090000	0.80709900
5	-0.624086	0.632763	-0.6029670	1.2871000	-1.390240	0.91464200	0.00064747
6	-1.061020	1.150680	1.5348100	0.7224050	-1.623280	0.52304900	-0.71810000
7	-0.488066	0.330412	-0.0608956	1.2516100	0.342299	0.58836500	-0.53036100
8	0.441766	-0.525569	0.4285340	0.8664210	0.275173	-0.34765200	1.11307000

age	1996	1997	1998	1999	2000	2001	2002
1	-0.5676510	-1.451150	-0.2461090	0.710488	-1.1820700	0.0966327	-0.0615664
2	1.4061700	-0.624692	-0.7747950	-0.777275	0.9603070	-0.5816570	1.5059400
3	1.0479500	-0.238811	0.0133665	-0.383355	0.9580340	0.6116310	-0.9492890
4	0.4012240	1.201910	-1.0613400	0.581049	0.4718450	-0.0116107	-0.0532506
5	0.0873234	0.953539	-1.4886200	0.577249	-0.0696622	-0.1259520	-0.8440450
6	0.4551880	1.058200	-1.0222400	0.800860	-0.2192690	0.2255660	0.0274776
7	-1.4449700	1.342310	-1.1851600	0.468790	-1.1396900	-0.3180720	0.0884901
8	0.5110530	0.187511	-0.2116970	0.648871	-1.1966900	0.2355880	0.4892530

age	2003	2004	2005	2006	2007	2008	2009
1	0.2098570	-1.636240	0.8666600	0.0657171	-1.564730	-0.928989	1.410740
2	-1.5782700	-1.240020	0.4785200	0.2780680	-0.795024	1.135560	0.245648
3	-0.4466720	0.287262	0.0399704	-1.3624700	-0.448392	0.225959	0.614888
4	-0.2286080	-0.261288	0.1781630	-1.5256900	-0.140861	-0.752260	1.637430
5	0.0379259	-0.568393	0.2700030	-2.0497500	-0.445972	-0.253257	1.177280
6	-0.7386840	-0.225534	-0.3613300	-2.1522300	-0.408170	0.233971	1.547710
7	0.6482020	-0.540562	0.2236100	-1.2302600	0.594927	0.511838	1.334830
8	0.9007770	-0.726793	-0.4974770	-1.5500800	0.334875	0.509745	1.835100

age	2010	2011
1	0.1807260	-0.903721
2	-0.6382190	-0.898673
3	-0.8434100	-1.028810
4	-0.5514250	-0.837702
5	-0.8903190	-0.624086
6	-0.0840553	-1.061020
7	0.2715430	-0.488066
8	0.3422350	0.441766

TABLE 2.6.3.23 North Sea Herring. PREDICTED INDEX AT AGE IBTS0

Units : NA

age	1992	1993	1994	1995	1996	1997	1998	1999
0	149.9422	129.5828	93.2748	120.1162	115.4491	81.69314	58.02767	185.9355

age	2000	2001	2002	2003	2004	2005	2006	2007
0	126.175	220.4608	114.7631	55.02568	64.08434	59.78113	70.62894	67.48329

age	2008	2009	2010	2011	2012
0	67.22331	90.05855	95.45453	80.03628	71.3131

TABLE 2.6.3.24 North Sea Herring. INDEX AT AGE RESIDUALS IBTS0

Units : NA

age	1992	1993	1994	1995	1996	1997	1998	1999
0	0.81564	1.07211	0.241923	0.155897	-0.225731	1.66429	-0.248258	0.76028

age	2000	2001	2002	2003	2004	2005	2006
0	0.232309	-0.0727782	0.960923	-0.0319944	-0.849584	0.0701955	0.454887

age	2007	2008	2009	2010	2011	2012
0	-1.66613	-2.47016	0.172894	-0.597396	-0.108191	-0.133085

TABLE 2.6.3.25 North Sea Herring. FIT PARAMETERS

	index	name	value	std.dev
1	1	logFpar	-8.867300	0.073463
2	2	logFpar	-12.747000	0.102680
3	3	logFpar	-0.088344	0.067555
4	4	logFpar	0.064684	0.064893
5	5	logFpar	0.166520	0.086515
6	6	logSdLogFsta	-0.531250	0.098520
7	7	logSdLogFsta	-1.128100	0.131600
8	8	logSdLogFsta	-1.191500	0.131040
9	9	logSdLogFsta	-0.675200	0.114870
10	10	logSdLogN	-0.585680	0.118510
11	11	logSdLogN	-1.886700	0.138690
12	12	logSdLogObs	-1.246000	0.167620
13	13	logSdLogObs	-1.028700	0.197670
14	14	logSdLogObs	-1.435600	0.516920
15	15	logSdLogObs	-1.825500	0.264500
16	16	logSdLogObs	-1.274400	0.176040
17	17	logSdLogObs	-0.949780	0.208450
18	18	logSdLogObs	-1.634000	0.111920
19	19	logSdLogObs	-1.421100	0.137030
20	20	logScaleSSB	-4.197400	0.080261
21	21	logSdSSB	-0.891740	0.117990

TABLE 2.6.3.26 North Sea Herring. NEGATIVE LOG-LIKELIHOOD

604.594

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

Units : kg

, , unit = A

age \ year	2009	2010	2011	2012	2013	2014
0	0.0094000	0.0075000	0.008000	0.01715547	0.01715547	0.01715547
1	0.0514000	0.0571000	0.041300	0.08707079	0.08707079	0.08707079
2	0.1440000	0.1292000	0.131700	0.14265127	0.14265127	0.14265127
3	0.1811000	0.1669000	0.159300	0.16620777	0.16620777	0.16620777
4	0.2158000	0.1912000	0.183100	0.19285176	0.19285176	0.19285176
5	0.2162000	0.2203000	0.197000	0.20949120	0.20949120	0.20949120
6	0.2390000	0.2193000	0.216700	0.22409936	0.22409936	0.22409936
7	0.2428000	0.2160000	0.221100	0.22899797	0.22899797	0.22899797
8	0.2532723	0.2383892	0.231918	0.24252540	0.24252540	0.24252540

, , unit = B

age \ year	2009	2010	2011	2012	2013	2014
0	0.0094000	0.0075000	0.008000	0.007913819	0.007913819	0.007913819
1	0.0514000	0.0571000	0.041300	0.038652364	0.038652364	0.038652364
2	0.1440000	0.1292000	0.131700	0.085720610	0.085720610	0.085720610
3	0.1811000	0.1669000	0.159300	0.180660674	0.180660674	0.180660674
4	0.2158000	0.1912000	0.183100	0.142500000	0.142500000	0.142500000
5	0.2162000	0.2203000	0.197000	0.205400000	0.205400000	0.205400000
6	0.2390000	0.2193000	0.216700	0.195196580	0.195196580	0.195196580
7	0.2428000	0.2160000	0.221100	0.000000000	0.000000000	0.000000000
8	0.2532723	0.2383892	0.231918	0.000000000	0.000000000	0.000000000

, , unit = C

age \ year	2009	2010	2011	2012	2013	2014
0	0.0094000	0.0075000	0.008000	0.02055517	0.02055517	0.02055517
1	0.0514000	0.0571000	0.041300	0.07401483	0.07401483	0.07401483
2	0.1440000	0.1292000	0.131700	0.08418275	0.08418275	0.08418275
3	0.1811000	0.1669000	0.159300	0.11283348	0.11283348	0.11283348
4	0.2158000	0.1912000	0.183100	0.16307359	0.16307359	0.16307359
5	0.2162000	0.2203000	0.197000	0.19139556	0.19139556	0.19139556
6	0.2390000	0.2193000	0.216700	0.19317161	0.19317161	0.19317161
7	0.2428000	0.2160000	0.221100	0.22503486	0.22503486	0.22503486
8	0.2532723	0.2383892	0.231918	0.26536723	0.26536723	0.26536723

, , unit = D

age \ year	2009	2010	2011	2012	2013	2014
0	0.0094000	0.0075000	0.008000	0.007970067	0.007970067	0.007970067
1	0.0514000	0.0571000	0.041300	0.015174290	0.015174290	0.015174290
2	0.1440000	0.1292000	0.131700	0.045924766	0.045924766	0.045924766
3	0.1811000	0.1669000	0.159300	0.072456757	0.072456757	0.072456757
4	0.2158000	0.1912000	0.183100	0.186378831	0.186378831	0.186378831
5	0.2162000	0.2203000	0.197000	0.000000000	0.000000000	0.000000000
6	0.2390000	0.2193000	0.216700	0.000000000	0.000000000	0.000000000
7	0.2428000	0.2160000	0.221100	0.000000000	0.000000000	0.000000000
8	0.2532723	0.2383892	0.231918	0.263000000	0.263000000	0.263000000

Table 2.7.2 NORTH SEA HERRING. WEIGHTS AT AGE IN THE STOCK

Units : kg

, , unit = A

age \ year	2009	2010	2011	2012	2013	2014
0	0.007233333	0.007133333	0.006666667	0.006666667	0.006666667	0.006666667
1	0.061433333	0.052233333	0.043166667	0.043166667	0.043166667	0.043166667
2	0.137366667	0.142266667	0.145300000	0.145300000	0.145300000	0.145300000
3	0.181000000	0.190366667	0.187433333	0.187433333	0.187433333	0.187433333
4	0.196866667	0.216266667	0.225066667	0.225066667	0.225066667	0.225066667
5	0.209966667	0.223600000	0.239366667	0.239366667	0.239366667	0.239366667
6	0.222500000	0.234200000	0.243500000	0.243500000	0.243500000	0.243500000
7	0.233633333	0.240100000	0.250766667	0.250766667	0.250766667	0.250766667
8	0.255759739	0.260682861	0.257247512	0.257247512	0.257247512	0.257247512

, , unit = B

age \ year	2009	2010	2011	2012	2013	2014
0	0.007233333	0.007133333	0.006666667	0.006666667	0.006666667	0.006666667
1	0.061433333	0.052233333	0.043166667	0.043166667	0.043166667	0.043166667
2	0.137366667	0.142266667	0.145300000	0.145300000	0.145300000	0.145300000
3	0.181000000	0.190366667	0.187433333	0.187433333	0.187433333	0.187433333
4	0.196866667	0.216266667	0.225066667	0.225066667	0.225066667	0.225066667
5	0.209966667	0.223600000	0.239366667	0.239366667	0.239366667	0.239366667
6	0.222500000	0.234200000	0.243500000	0.243500000	0.243500000	0.243500000
7	0.233633333	0.240100000	0.250766667	0.250766667	0.250766667	0.250766667
8	0.255759739	0.260682861	0.257247512	0.257247512	0.257247512	0.257247512

, , unit = C

age \ year	2009	2010	2011	2012	2013	2014
0	0.007233333	0.007133333	0.006666667	0.006666667	0.006666667	0.006666667
1	0.061433333	0.052233333	0.043166667	0.043166667	0.043166667	0.043166667
2	0.137366667	0.142266667	0.145300000	0.145300000	0.145300000	0.145300000
3	0.181000000	0.190366667	0.187433333	0.187433333	0.187433333	0.187433333
4	0.196866667	0.216266667	0.225066667	0.225066667	0.225066667	0.225066667
5	0.209966667	0.223600000	0.239366667	0.239366667	0.239366667	0.239366667
6	0.222500000	0.234200000	0.243500000	0.243500000	0.243500000	0.243500000
7	0.233633333	0.240100000	0.250766667	0.250766667	0.250766667	0.250766667
8	0.255759739	0.260682861	0.257247512	0.257247512	0.257247512	0.257247512

, , unit = D

age \ year	2009	2010	2011	2012	2013	2014
0	0.007233333	0.007133333	0.006666667	0.006666667	0.006666667	0.006666667
1	0.061433333	0.052233333	0.043166667	0.043166667	0.043166667	0.043166667
2	0.137366667	0.142266667	0.145300000	0.145300000	0.145300000	0.145300000
3	0.181000000	0.190366667	0.187433333	0.187433333	0.187433333	0.187433333
4	0.196866667	0.216266667	0.225066667	0.225066667	0.225066667	0.225066667
5	0.209966667	0.223600000	0.239366667	0.239366667	0.239366667	0.239366667
6	0.222500000	0.234200000	0.243500000	0.243500000	0.243500000	0.243500000
7	0.233633333	0.240100000	0.250766667	0.250766667	0.250766667	0.250766667
8	0.255759739	0.260682861	0.257247512	0.257247512	0.257247512	0.257247512

Table 2.7.3 NORTH SEA HERRING. STOCK IN NUMBER

Units : NA

, , unit = A

age \ year	2009	2010	2011	2012
0	35039971.1259143	37095269.0285397	31139884.0233303	27757038.3435818
1	10574965.2834253	13230032.5975544	15036633.2745304	11251364.8583707
2	6230704.71039642	5542742.65334218	6602771.21544981	7564675.4290902
3	2859050.1149798	4368804.67540453	3580453.40572017	4210112.80568872
4	1405635.39927993	2090680.14660904	2887784.04633736	2289857.1644901
5	1207424.33497633	1048635.1296106	1309295.8086548	1861698.87039527
6	669977.89614863	956465.501711716	710695.964077649	836515.22493291
7	600189.069264095	517621.728181463	682829.176733983	464631.547727694
8	1618483.24481079	1819368.46212039	1694672.39020392	1581682.95576922

, , unit = B

age \ year	2009	2010	2011	2012
0	35039971.1259143	37095269.0285397	31139884.0233303	27757038.3435818
1	10574965.2834253	13230032.5975544	15036633.2745304	11251364.8583707
2	6230704.71039642	5542742.65334218	6602771.21544981	7564675.4290902
3	2859050.1149798	4368804.67540453	3580453.40572017	4210112.80568872
4	1405635.39927993	2090680.14660904	2887784.04633736	2289857.1644901
5	1207424.33497633	1048635.1296106	1309295.8086548	1861698.87039527
6	669977.89614863	956465.501711716	710695.964077649	836515.22493291
7	600189.069264095	517621.728181463	682829.176733983	464631.547727694
8	1618483.24481079	1819368.46212039	1694672.39020392	1581682.95576922

, , unit = C

age \ year	2009	2010	2011	2012
0	35039971.1259143	37095269.0285397	31139884.0233303	27757038.3435818
1	10574965.2834253	13230032.5975544	15036633.2745304	11251364.8583707
2	6230704.71039642	5542742.65334218	6602771.21544981	7564675.4290902
3	2859050.1149798	4368804.67540453	3580453.40572017	4210112.80568872
4	1405635.39927993	2090680.14660904	2887784.04633736	2289857.1644901
5	1207424.33497633	1048635.1296106	1309295.8086548	1861698.87039527
6	669977.89614863	956465.501711716	710695.964077649	836515.22493291
7	600189.069264095	517621.728181463	682829.176733983	464631.547727694
8	1618483.24481079	1819368.46212039	1694672.39020392	1581682.95576922

, , unit = D

age \ year	2009	2010	2011	2012
0	35039971.1259143	37095269.0285397	31139884.0233303	27757038.3435818
1	10574965.2834253	13230032.5975544	15036633.2745304	11251364.8583707
2	6230704.71039642	5542742.65334218	6602771.21544981	7564675.4290902
3	2859050.1149798	4368804.67540453	3580453.40572017	4210112.80568872
4	1405635.39927993	2090680.14660904	2887784.04633736	2289857.1644901
5	1207424.33497633	1048635.1296106	1309295.8086548	1861698.87039527
6	669977.89614863	956465.501711716	710695.964077649	836515.22493291
7	600189.069264095	517621.728181463	682829.176733983	464631.547727694
8	1618483.24481079	1819368.46212039	1694672.39020392	1581682.95576922

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

Units : f

, , unit = A

age \ year	2009	2010	2011
0	0.0303851887945881	0.0263391198021559	0.0373732526576112
1	0.0235601159201677	0.0273647387855266	0.0153153451840406
2	0.0569375628568688	0.0639342543124782	0.0681939109756875
3	0.0550232200564072	0.0670041983241397	0.0889394035614291
4	0.08839852455784	0.0787245679579957	0.0901482267067939
5	0.100108568192044	0.100721096770833	0.118374730990265
6	0.0806690739163983	0.0802667352317332	0.101104565066885
7	0.107916230105405	0.078748188871343	0.0892155435082451
8	0.107916230105405	0.078748188871343	0.0892155435082451

age \ year	2012
0	0.0000000000958227081566232
1	0.00210052905048813
2	0.113426017194483
3	0.175539286539656
4	0.17980745770001
5	0.236096464307403
6	0.201540941291915
7	0.177852321389597
8	0.178147265346174

, , unit = B

age \ year	2009	2010	2011	2012
0	0.0303851887945881	0.0263391198021559	0.0373732526576112	0.0368343712417058
1	0.0235601159201677	0.0273647387855266	0.0153153451840406	0.0144980524010145
2	0.0569375628568688	0.0639342543124782	0.0681939109756875	0
3	0.0550232200564072	0.0670041983241397	0.0889394035614291	0
4	0.08839852455784	0.0787245679579957	0.0901482267067939	0
5	0.100108568192044	0.100721096770833	0.118374730990265	0
6	0.0806690739163983	0.0802667352317332	0.101104565066885	0
7	0.107916230105405	0.078748188871343	0.0892155435082451	0
8	0.107916230105405	0.078748188871343	0.0892155435082451	0

, , unit = C

age \ year	2009	2010	2011
0	0.0303851887945881	0.0263391198021559	0.0373732526576112
1	0.0235601159201677	0.0273647387855266	0.0153153451840406
2	0.0569375628568688	0.0639342543124782	0.0681939109756875
3	0.0550232200564072	0.0670041983241397	0.0889394035614291
4	0.08839852455784	0.0787245679579957	0.0901482267067939
5	0.100108568192044	0.100721096770833	0.118374730990265
6	0.0806690739163983	0.0802667352317332	0.101104565066885
7	0.107916230105405	0.078748188871343	0.0892155435082451
8	0.107916230105405	0.078748188871343	0.0892155435082451

age \ year	2012
0	0.000114270545856896
1	0.00196272430943602
2	0.0116612854822408
3	0.00104466116543772
4	0.000120991644629099
5	0.000164617820419363
6	0.000198837841137813
7	0.000169735874918212
8	0.000142348483600322

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

, , unit = D

age	2009	2010	2011
0	0.0303851887945881	0.0263391198021559	0.0373732526576112
1	0.0235601159201677	0.0273647387855266	0.0153153451840406
2	0.0569375628568688	0.0639342543124782	0.0681939109756875
3	0.0550232200564072	0.0670041983241397	0.0889394035614291
4	0.08839852455784	0.0787245679579957	0.0901482267067939
5	0.100108568192044	0.100721096770833	0.118374730990265
6	0.0806690739163983	0.0802667352317332	0.101104565066885
7	0.107916230105405	0.078748188871343	0.0892155435082451
8	0.107916230105405	0.078748188871343	0.0892155435082451

age	2012
0	0.00955028573111538
1	0.0015190592764886
2	0.000320041618101867
3	0.0000504678366004659
4	0
5	0
6	0
7	0
8	0

Table 2.7.5 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA

, , unit = A

age \ year	2009	2010	2011	2012	2013	2014
0	0.9639524	0.9630652	0.9600930	0.9618020	0.9618020	0.9618020
1	0.6539054	0.6284271	0.6718588	0.6648676	0.6648676	0.6648676
2	0.3694447	0.3504123	0.3823698	0.3772809	0.3772809	0.3772809
3	0.3480426	0.3342612	0.3571910	0.3535790	0.3535790	0.3535790
4	0.3408148	0.3289086	0.3484127	0.3454152	0.3454152	0.3454152
5	0.3211651	0.3070936	0.3303257	0.3267119	0.3267119	0.3267119
6	0.3147281	0.3001065	0.3244418	0.3206037	0.3206037	0.3206037
7	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134
8	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134

, , unit = B

age \ year	2009	2010	2011	2012	2013	2014
0	0.9639524	0.9630652	0.9600930	0.9618020	0.9618020	0.9618020
1	0.6539054	0.6284271	0.6718588	0.6648676	0.6648676	0.6648676
2	0.3694447	0.3504123	0.3823698	0.3772809	0.3772809	0.3772809
3	0.3480426	0.3342612	0.3571910	0.3535790	0.3535790	0.3535790
4	0.3408148	0.3289086	0.3484127	0.3454152	0.3454152	0.3454152
5	0.3211651	0.3070936	0.3303257	0.3267119	0.3267119	0.3267119
6	0.3147281	0.3001065	0.3244418	0.3206037	0.3206037	0.3206037
7	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134
8	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134

, , unit = C

age \ year	2009	2010	2011	2012	2013	2014
0	0.9639524	0.9630652	0.9600930	0.9618020	0.9618020	0.9618020
1	0.6539054	0.6284271	0.6718588	0.6648676	0.6648676	0.6648676
2	0.3694447	0.3504123	0.3823698	0.3772809	0.3772809	0.3772809
3	0.3480426	0.3342612	0.3571910	0.3535790	0.3535790	0.3535790
4	0.3408148	0.3289086	0.3484127	0.3454152	0.3454152	0.3454152
5	0.3211651	0.3070936	0.3303257	0.3267119	0.3267119	0.3267119
6	0.3147281	0.3001065	0.3244418	0.3206037	0.3206037	0.3206037
7	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134
8	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134

, , unit = D

age \ year	2009	2010	2011	2012	2013	2014
0	0.9639524	0.9630652	0.9600930	0.9618020	0.9618020	0.9618020
1	0.6539054	0.6284271	0.6718588	0.6648676	0.6648676	0.6648676
2	0.3694447	0.3504123	0.3823698	0.3772809	0.3772809	0.3772809
3	0.3480426	0.3342612	0.3571910	0.3535790	0.3535790	0.3535790
4	0.3408148	0.3289086	0.3484127	0.3454152	0.3454152	0.3454152
5	0.3211651	0.3070936	0.3303257	0.3267119	0.3267119	0.3267119
6	0.3147281	0.3001065	0.3244418	0.3206037	0.3206037	0.3206037
7	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134
8	0.3076583	0.2918243	0.3183380	0.3141134	0.3141134	0.3141134

Table 2.7.6 NORTH SEA HERRING. PROPORTION MATURE

```
Units  :  NA
, , unit = A

   year
age 2009 2010 2011      2012      2013      2014
  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 0.89 0.45 0.87 0.7366667 0.7366667 0.7366667
  3 1.00 0.90 0.84 0.9133333 0.9133333 0.9133333
  4 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  5 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  6 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  7 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  8 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000

, , unit = B

   year
age 2009 2010 2011      2012      2013      2014
  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 0.89 0.45 0.87 0.7366667 0.7366667 0.7366667
  3 1.00 0.90 0.84 0.9133333 0.9133333 0.9133333
  4 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  5 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  6 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  7 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  8 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000

, , unit = C

   year
age 2009 2010 2011      2012      2013      2014
  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 0.89 0.45 0.87 0.7366667 0.7366667 0.7366667
  3 1.00 0.90 0.84 0.9133333 0.9133333 0.9133333
  4 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  5 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  6 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  7 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  8 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000

, , unit = D

   year
age 2009 2010 2011      2012      2013      2014
  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 0.89 0.45 0.87 0.7366667 0.7366667 0.7366667
  3 1.00 0.90 0.84 0.9133333 0.9133333 0.9133333
  4 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  5 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  6 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  7 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
  8 1.00 1.00 1.00 1.0000000 1.0000000 1.0000000
```

Table 2.7.7 NORTH SEA HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

, , unit = A

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

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

Units : NA

, , unit = A

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

age \ year	2009	2010	2011	2012	2013	2014
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67

Table 2.7.9 NORTH SEA HERRING. Recruitment in 2013

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28662492
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Table 2.7.10 NORTH SEA HERRING. Recruitment in 2014

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28662492
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Table 2.7.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

```
R version 2.13.2 (2011-09-30)

Package  : FLSAM
Version  : 0.43-2
Packaged :
Built    : R 2.13.2; ; 2012-02-29 10:51:36 UTC; windows

Package  : FLCore
Version  : 2.4
Packaged :
Built    : R 2.13.2; i386-pc-mingw32; 2011-10-05 12:21:01 UTC; windows
```

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

Outlook assuming a TAC constraint for fleet A in 2012, proportion of 2011 by-catch ceiling taken applied to 2012 for fleet B

Basis: Intermediate year (2012) 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 2012
0.181	0.026	0.001	0.006	0.033	0.184	423.5[1]	9.7	7.6	1.6	2271

[1]Includes a transfer of 308 tonnes of the Norwegian quota and 41.9% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2013)

	F-values by fleet and total						Catches by fleet				Biomass			
	FLEET A	FLEET B	FLEET C	FLEET D	F_{0-1}	F_{2-6}	FLEET A	FLEET B	FLEET C	FLEET D	**SSB 2013[1)]**	**SSB 2014**	**%SSB CHANGE [2)]**	**%TAC CHANGE FLEET A [3)]**
A	0	0	0	0	0	0	0	0	0	0	2362	2484	+4%	-100%
B	0.246	0.040	0.002	0.007	0.05	0.25	514737	14421	9634	2059	2013	1742	-11%	+27%
C	0.188	0.040	0.002	0.007	0.05	0.193	405000	14421	9634	2059	2088	1884	-8%	0%
D	0.220	0.040	0.002	0.007	0.05	0.224	465750	14421	9634	2059	2047	1805	-10%	+15%
E	0.158	0.040	0.002	0.007	0.05	0.162	344250	14421	9634	2059	2129	1965	-6%	-15%
F	0.296	0.040	0.002	0.007	0.05	0.30	606154	14421	9634	2059	1950	1628	-14%	+50%

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 (2013) relative to SSB (2012).

3) Calculated landings (2013) relative to TAC 2012 for the A fleet.

Table 2.7.3.1. North Sea herring. Exploratory short term forecast management options for North Sea herring.

Outlook assuming a TAC constraint for fleet A in 2012, proportion of 2011 by-catch ceiling taken applied to 2012 for fleet B

Basis: Intermediate year (2012) with catch constraint (95% CI between '[ ]')

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 2012
0.181 [0.142, 0.229]	0.026 [0.019, 0.038]	0.001 [0.001, 0.002]	0.006 [0.004, 0.008]	0.033 [0.025, 0.048]	0.184 [0.144, 0.232]	423.5[1]	9.7	7.6	1.6	2271 [1738, 2686]

[1]Includes a transfer of 308 tonnes of the Norwegian quota and 41.9% of IIIa TAC from the C-fleet to the A-fleet

Scenarios for prediction year (2013) (95% CI between '[ ]')

	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 20131)	SSB 2014	%SSB change 2)	%TAC change fleet A 3)
A	0	0	0	0	0	0	0	0	0	0	2305 [1827, 2748]	2425 [1945, 2953]	+5% [+5%, +2%]	-100%
B	0.246 [0.224, 0.247]	0.040 [0.037, 0.041]	0.002 [0.001, 0.003]	0.007 [0.006, 0.008]	0.05	0.25	521636 [401190, 633092]	13697 [11030, 18736]	9634	2059	1962 [1563, 2358]	1678 [1372, 2118]	-11% [-10%, -12%]	+29% [+0%, +56%]
C	0.189 [0.149, 0.246]	0.039 [0.035, 0.044]	0.002 [0.001, 0.003]	0.007 [0.006, 0.008]	0.049 [0.045, 0.055]	0.193 [0.152, 0.251]	405000	13697 [11030, 18736]	9634	2058	2046 [1555, 2502]	1818 [1375, 2351]	-7% [-10%, -7%]	0%
D	0.220 [0.173, 0.288]	0.039 [0.035, 0.044]	0.002 [0.001, 0.003]	0.007 [0.006, 0.008]	0.05 [0.045, 0.055]	0.224 [0.176, 0.293]	465750	13697 [11030, 18736]	9634	2058	2006 [1514, 2465]	1741 [1302, 2270]	-9% [-13%, -8%]	+15%
E	0.158 [0.125, 0.205]	0.039 [0.035, 0.044]	0.002 [0.001, 0.003]	0.007 [0.006, 0.008]	0.049 [0.045, 0.054]	0.162 [0.128, 0.210]	344250	13697 [11030, 18736]	9634	2058	2087 [1596, 2539]	1900 [1453, 2434]	-5% [-8%, -5%]	-15%
F	0.295 [0.294, 0.297]	0.039 [0.035, 0.044]	0.002 [0.001, 0.003]	0.007 [0.006, 0.008]	0.05 [0.046, 0.055]	0.3	604641 [475334, 754857]	13697 [11030, 18736]	9634	2058	1897 [1498, 2275]	1571 [1270, 2005]	-14% [-14%, -15%]	+49% [+17%, +86%]

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 (2013) relative to SSB (2012).

3) Calculated landings (2013) relative to TAC 2012 for the A fleet.

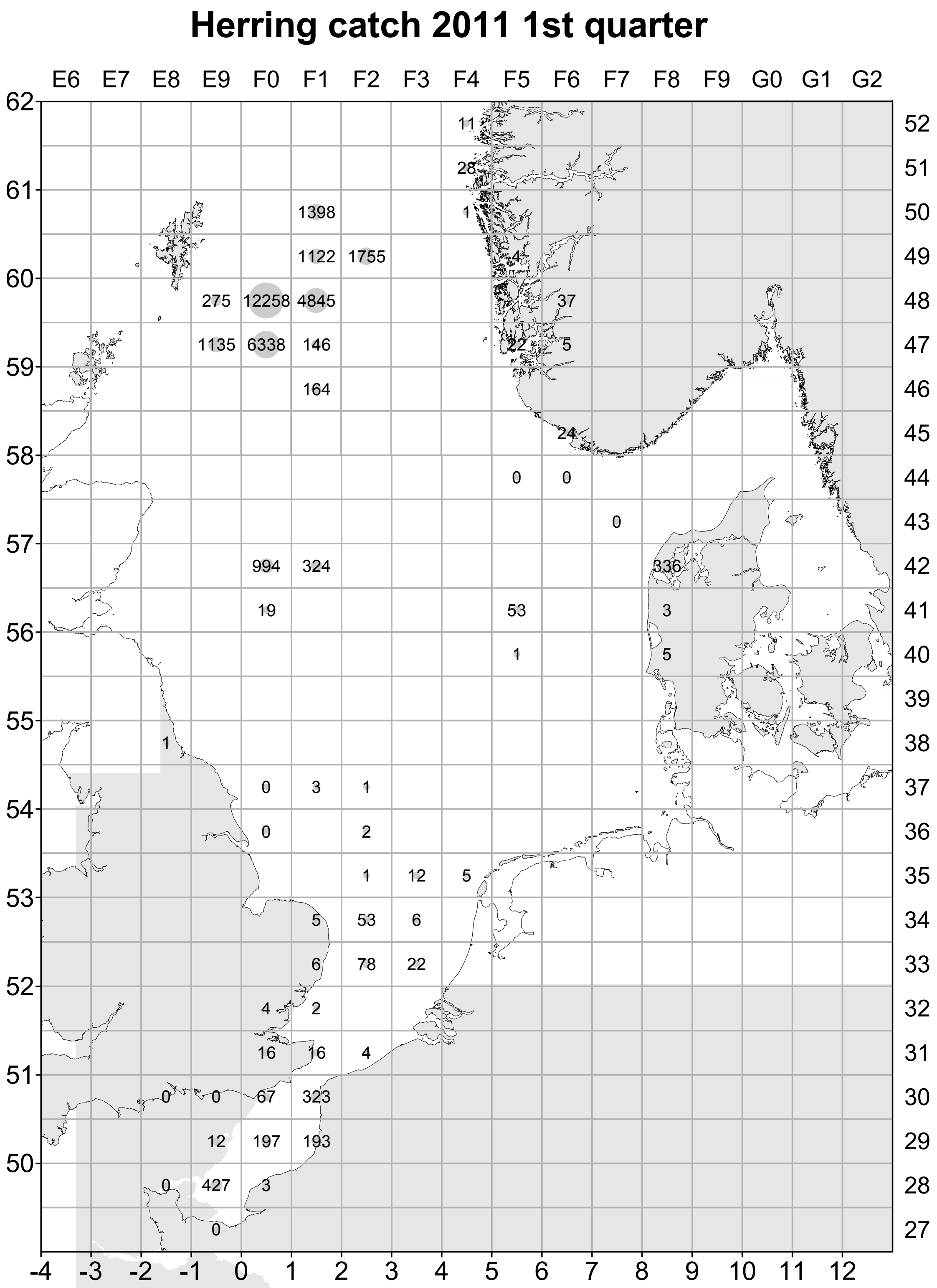


Figure 2.1.1a: Herring catches in the North Sea in the 1st quarter of 2011 (in tonnes) by statistical rectangle. Note that catches in Division IIIa are not included in this figure.

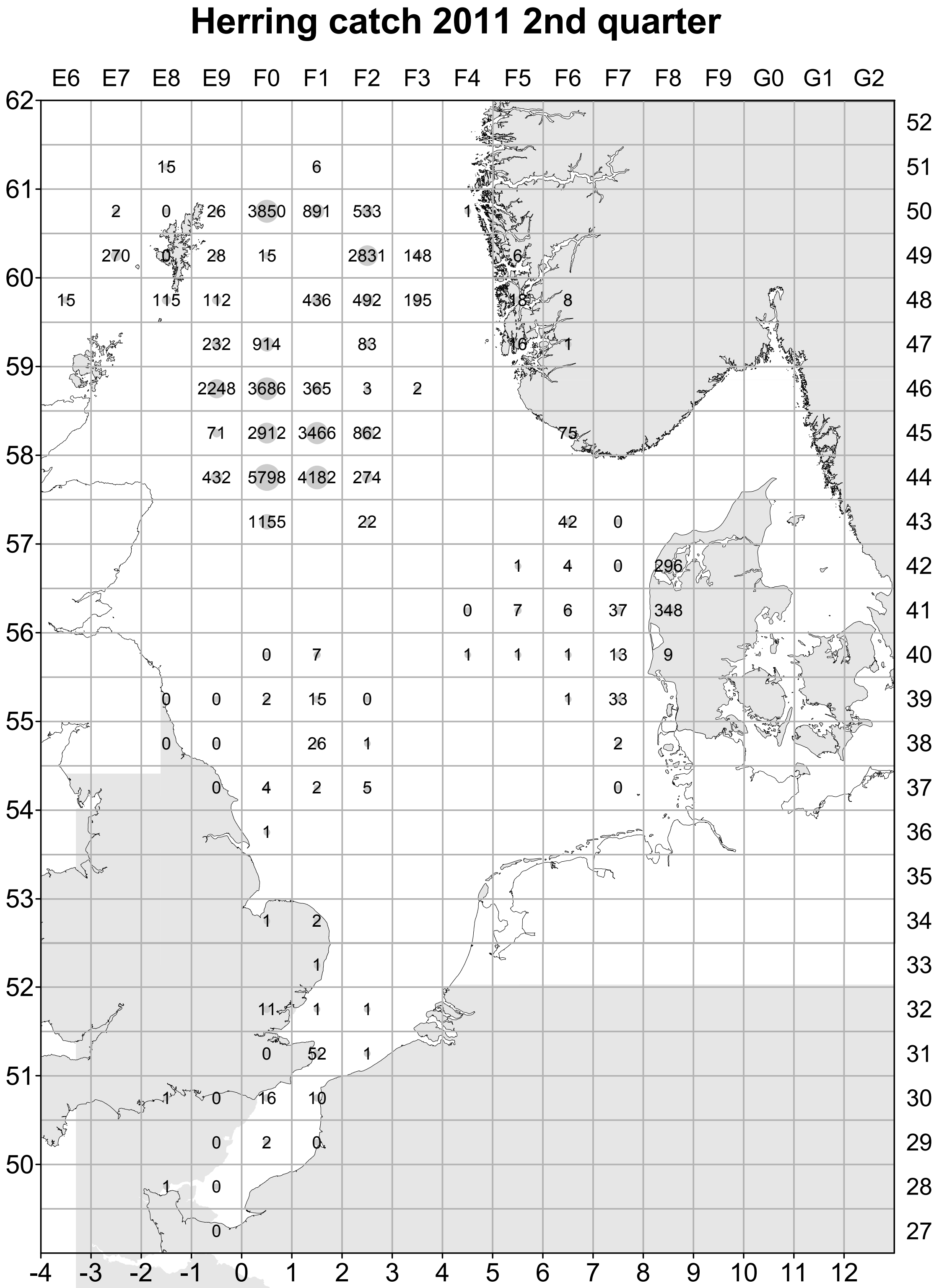


Figure 2.1.1b: Herring catches in the North Sea in the 2nd quarter of 2011 (in tonnes) by statistical rectangle. Note that catches in Division IIIa are not included in this figure.

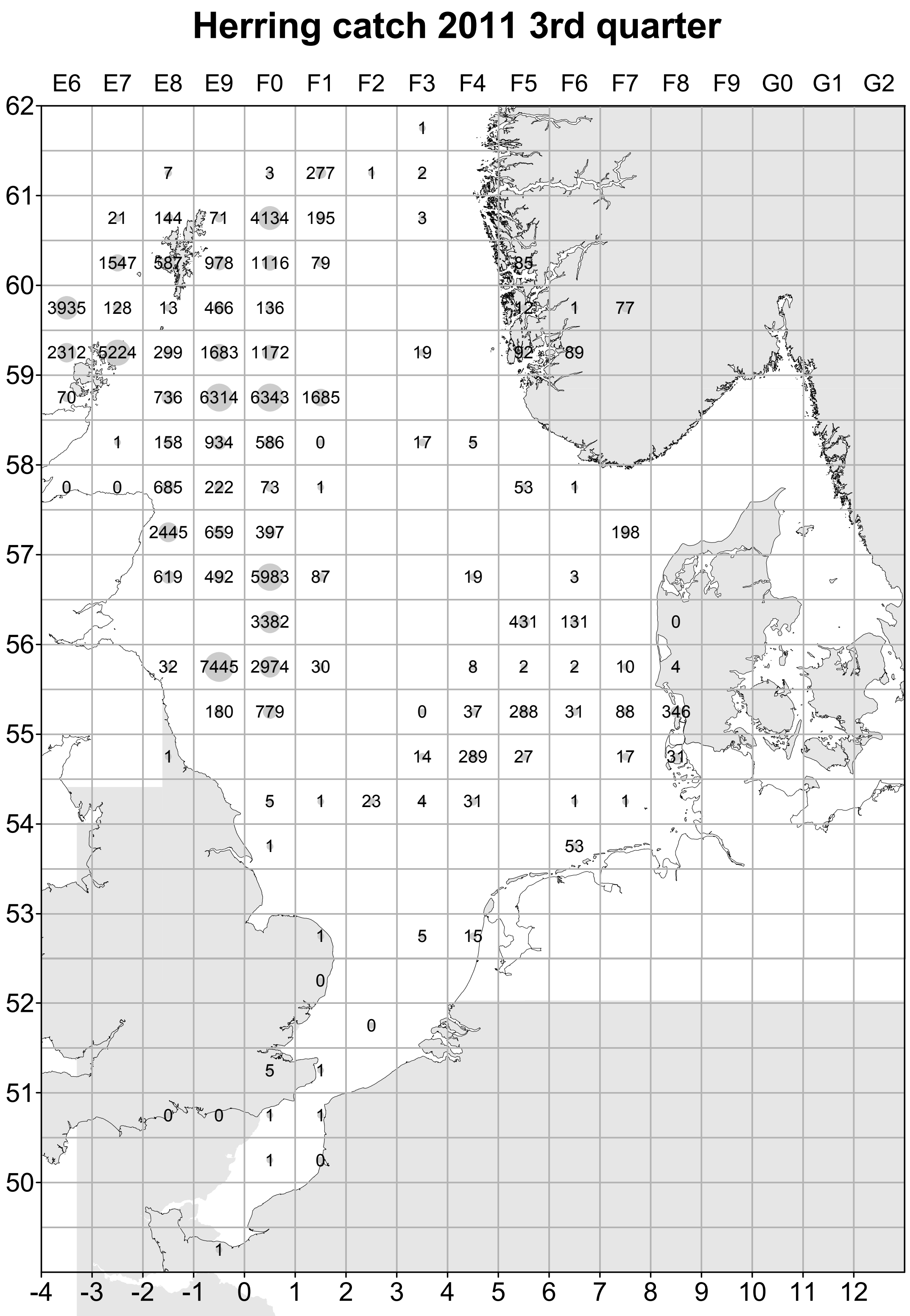


Figure 2.1.1c: Herring catches in theNorth Sea in the 3rd quarter of 2011 (in tonnes) by statistical rectangle. Note that catches in Division IIIa are not included in this figure.

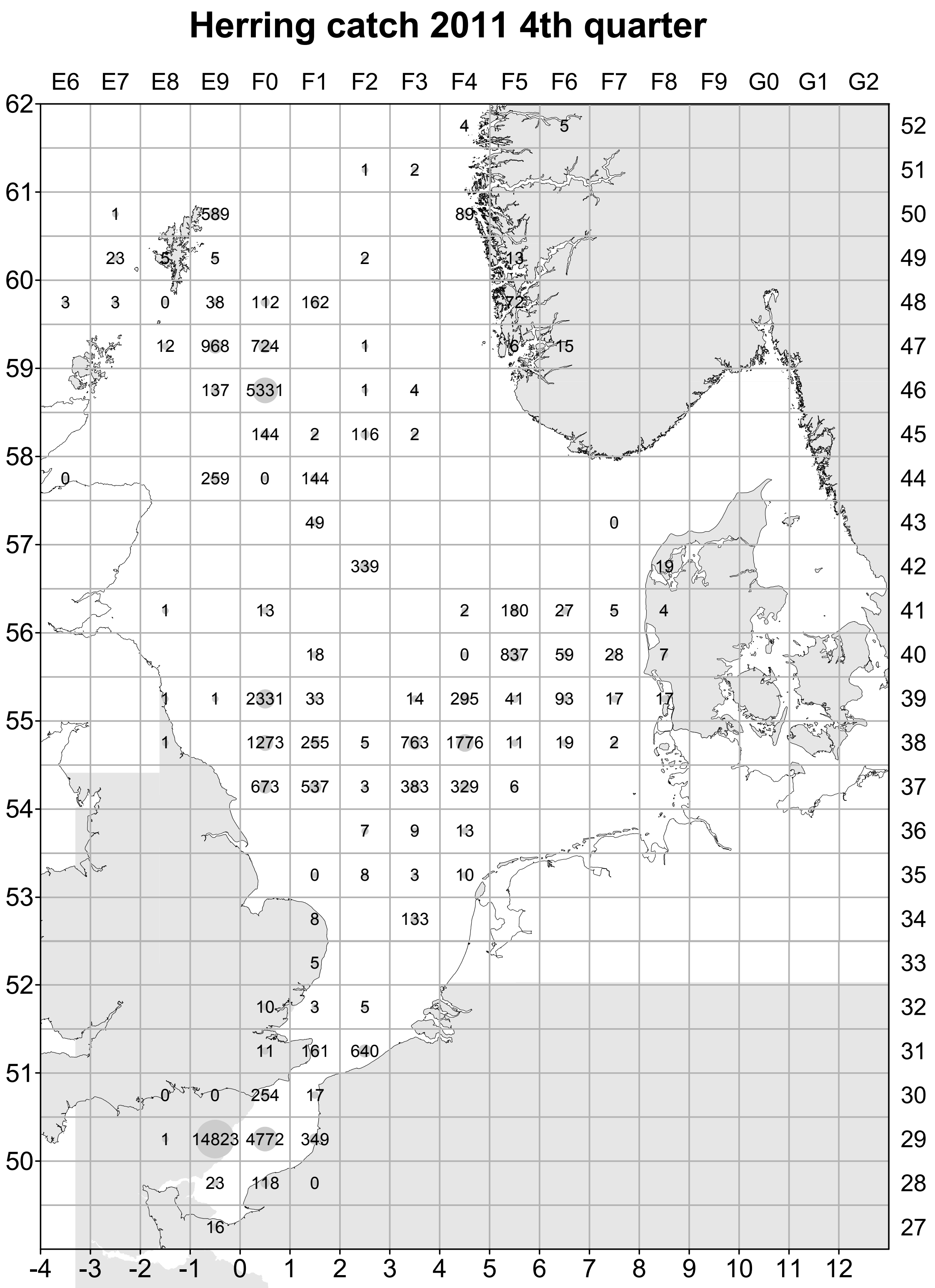


Figure 2.1.1d: Herring catches in the North Sea in the 4th quarter of 2011 (in tonnes) by statistical rectangle. Note that catches in Division IIIa are not included in this figure.

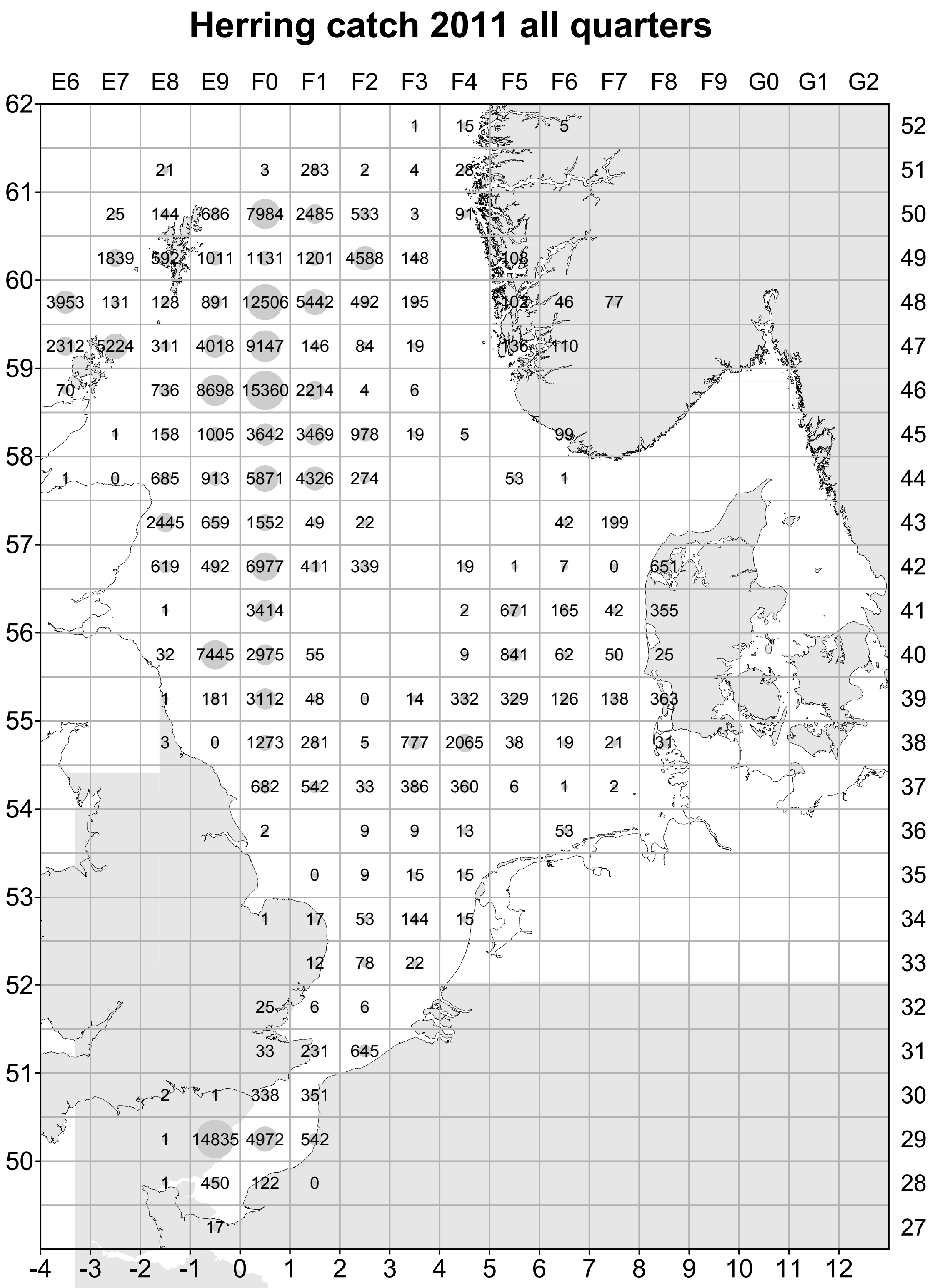
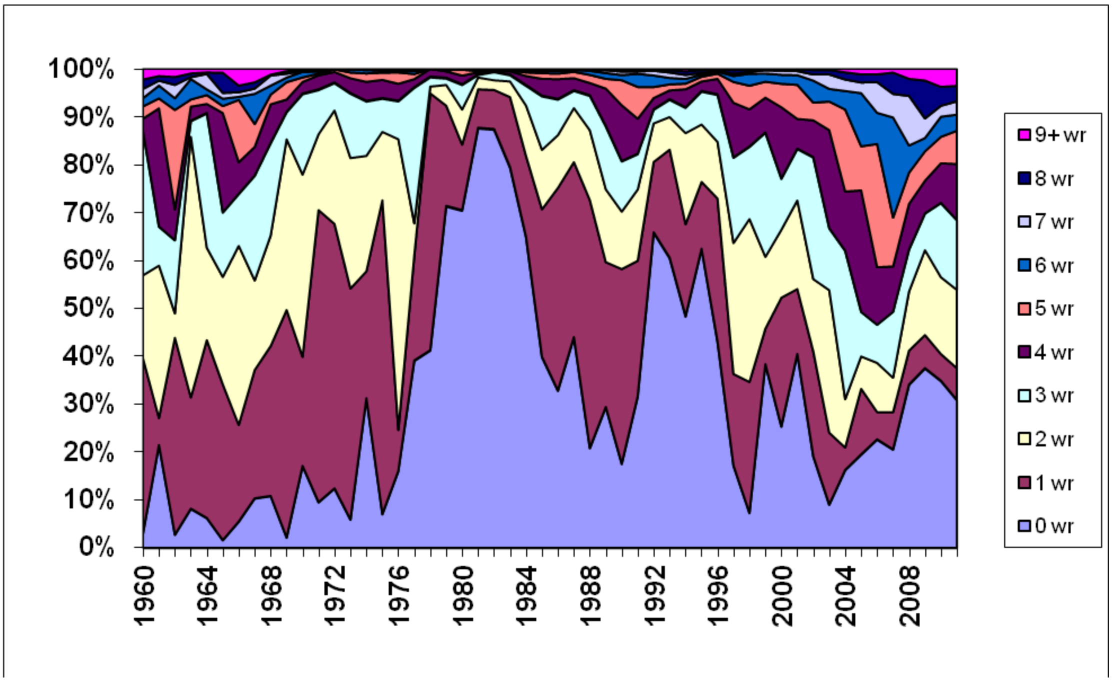


Figure 2.1.1e: Herring catches in the North Sea in all quarters of 2011 (in tonnes) by statistical rectangle. Note that catches in Division IIIa are not included in this figure.



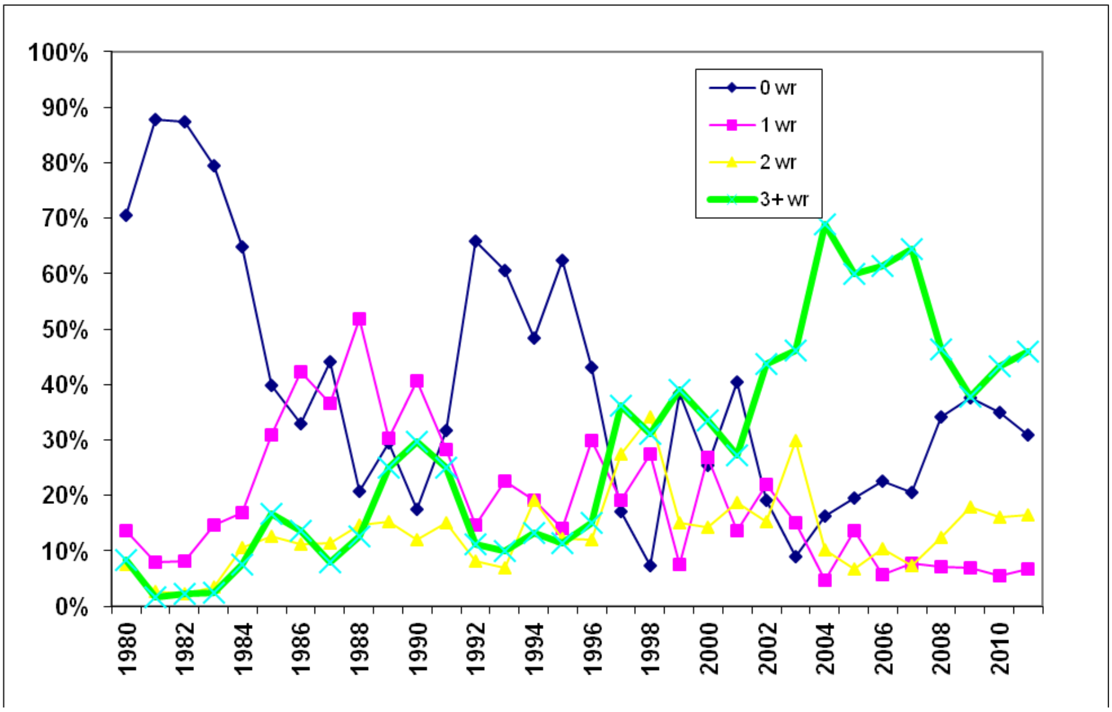


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring caught in the North Sea (upper, 1960-2011, and lower panel, 1980-2011).

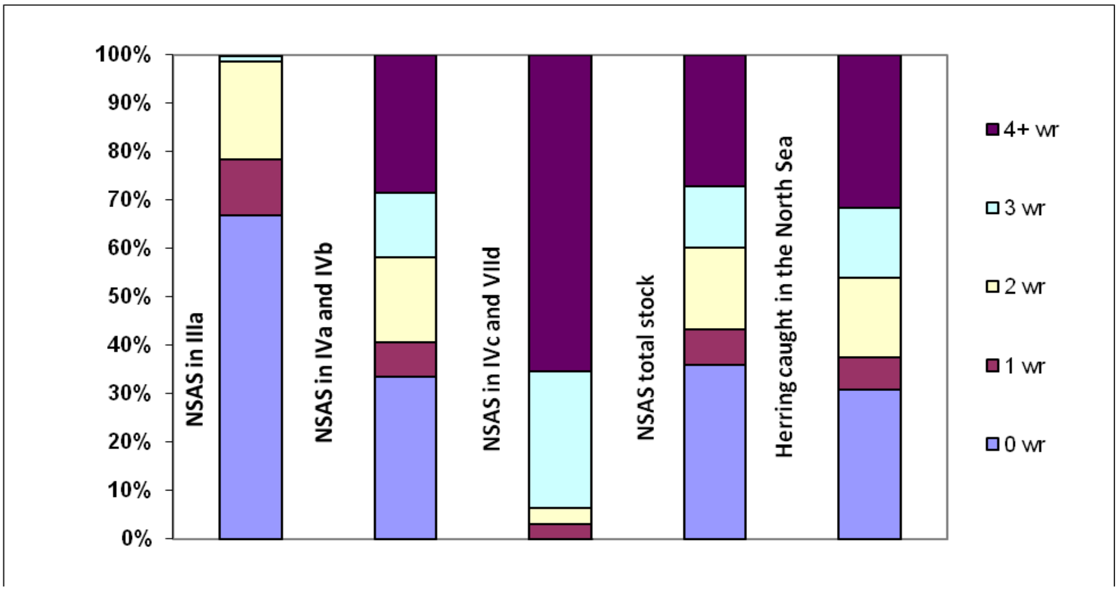


Figure 2.2.2: Proportion of age groups (numbers) in the total catch of NSAS and herring caught in the North Sea in 2011.

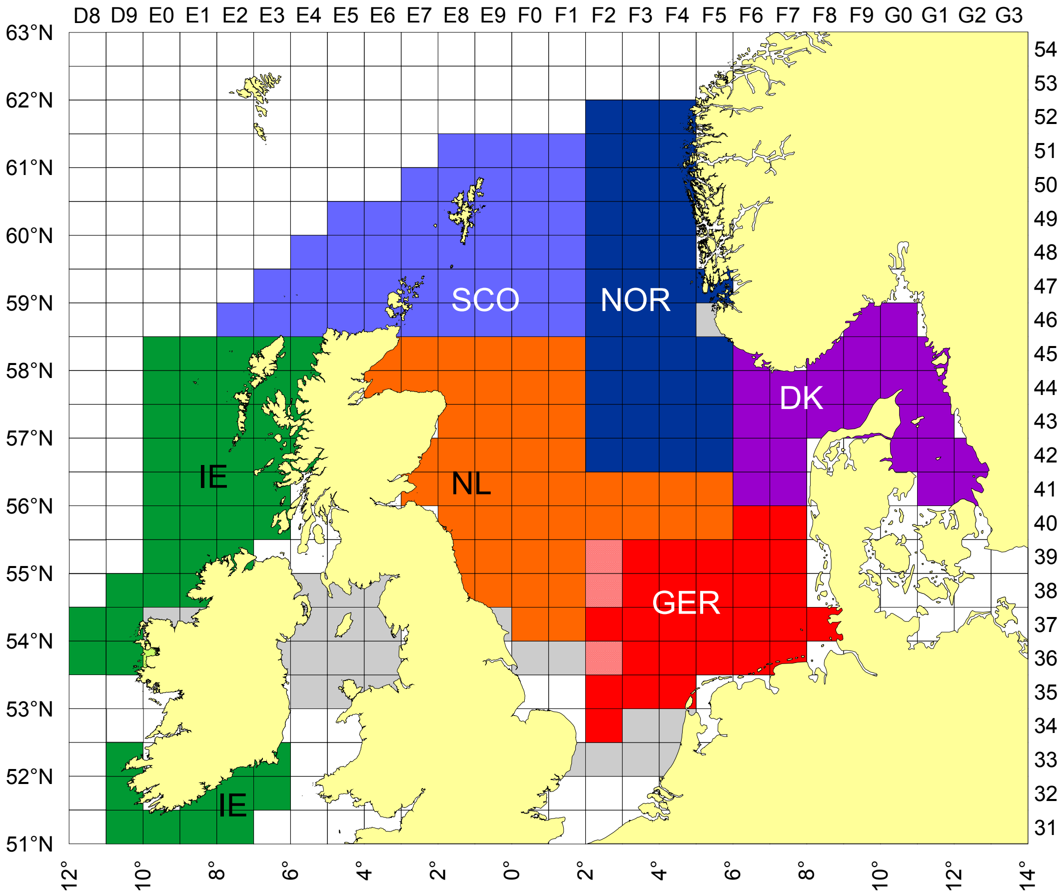


Figure 2.3.1.1. Survey area coverage in the combined acoustic surveys in 2011, by rectangle and nation (IR = Celtic Explorer; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Rectangles 36F2, 38F2 and 39F2 were interpolated from surrounding ones. Rectangles in light grey were left uncovered.

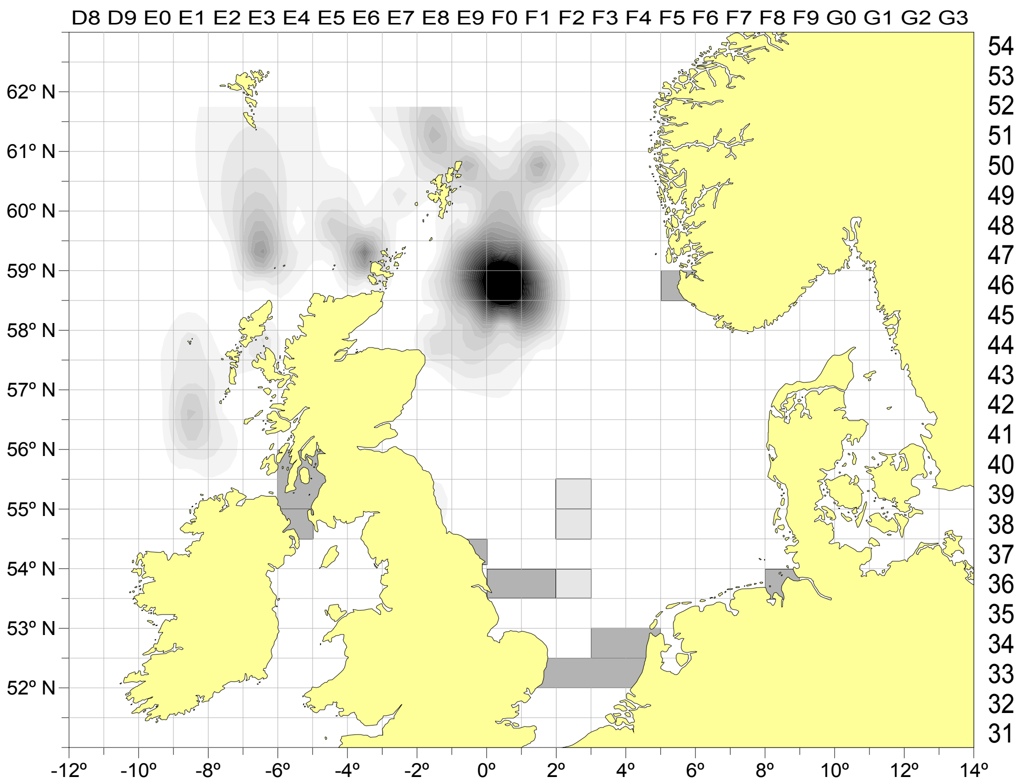


Figure 2.3.1.2. Biomass of mature autumn spawning herring from the combined acoustic surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June – July 2011 (maximum value = 220 000). Rectangles 36F2, 38F2 and 39F2 (light grey) were interpolated from surrounding ones. Rectangles in dark grey were left uncovered.

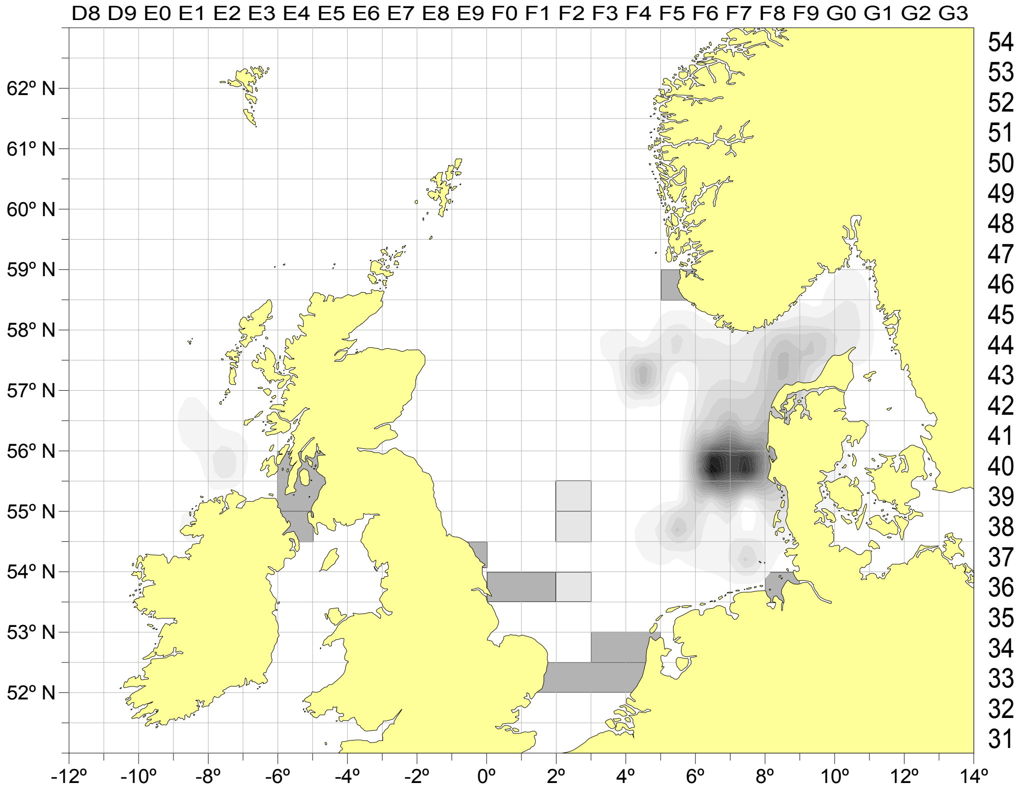


Figure 2.3.1.3. North Sea herring. Biomass of immature autumn spawning herring from the combined acoustic surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June – July 2011 (maximum value = 57 500). Rectangles 36F2, 38F2 and 39F2 (light grey) were interpolated from surrounding ones. Rectangles in dark grey were left uncovered.

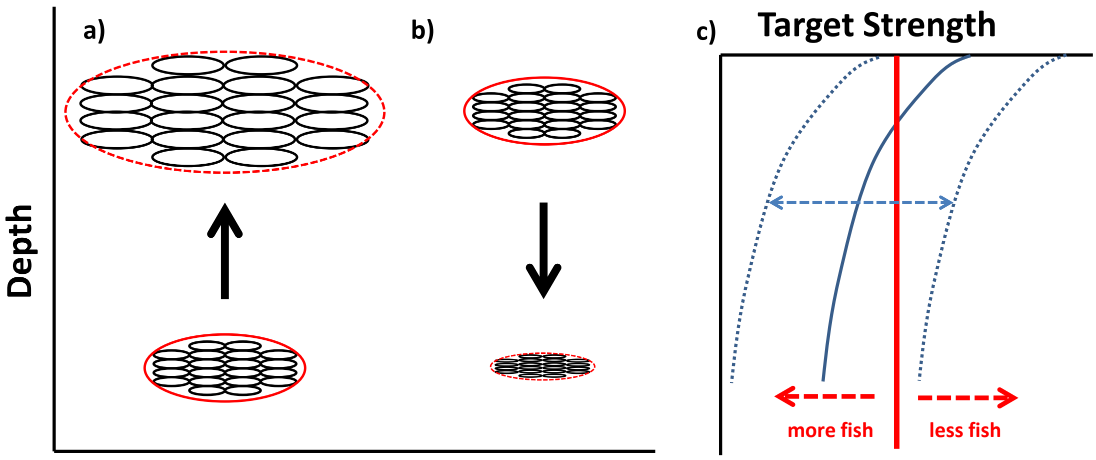


Figure 2.3.1.4. North Sea herring. Schematic description of the effect of changes in vertical distribution of physostomous fish on acoustic abundance estimates. a) If a given number of fish migrate to shallower depths, their bladders (black ellipses) will expand, causing an increase in sound reflection potential (red ellipses) and a perceived increase in fish numbers. b) The opposite is true if these fish migrate to deeper depths. c) A depth-dependent target strength (blue curve) can take this effect into account. However, depending on assumptions about swimbladder size, this curve may be below, above or intersecting the currently used depth-independent target strength (red line), resulting in different perceptions of stock size.

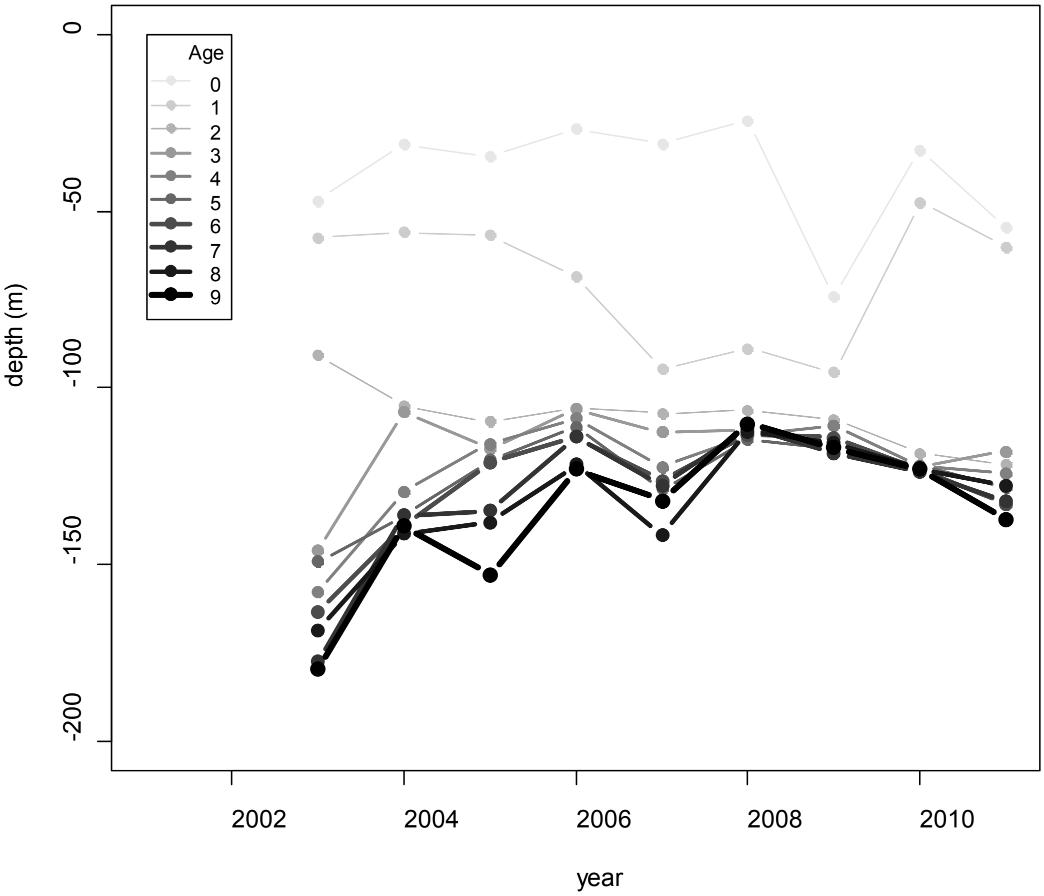


Figure 2.3.1.5. North Sea herring. Changes in mean depth distributions of North Sea herring at age, weighted by abundance per ICES rectangle. The mean ICES rectangle sea bed depth was used for simplicity reasons.

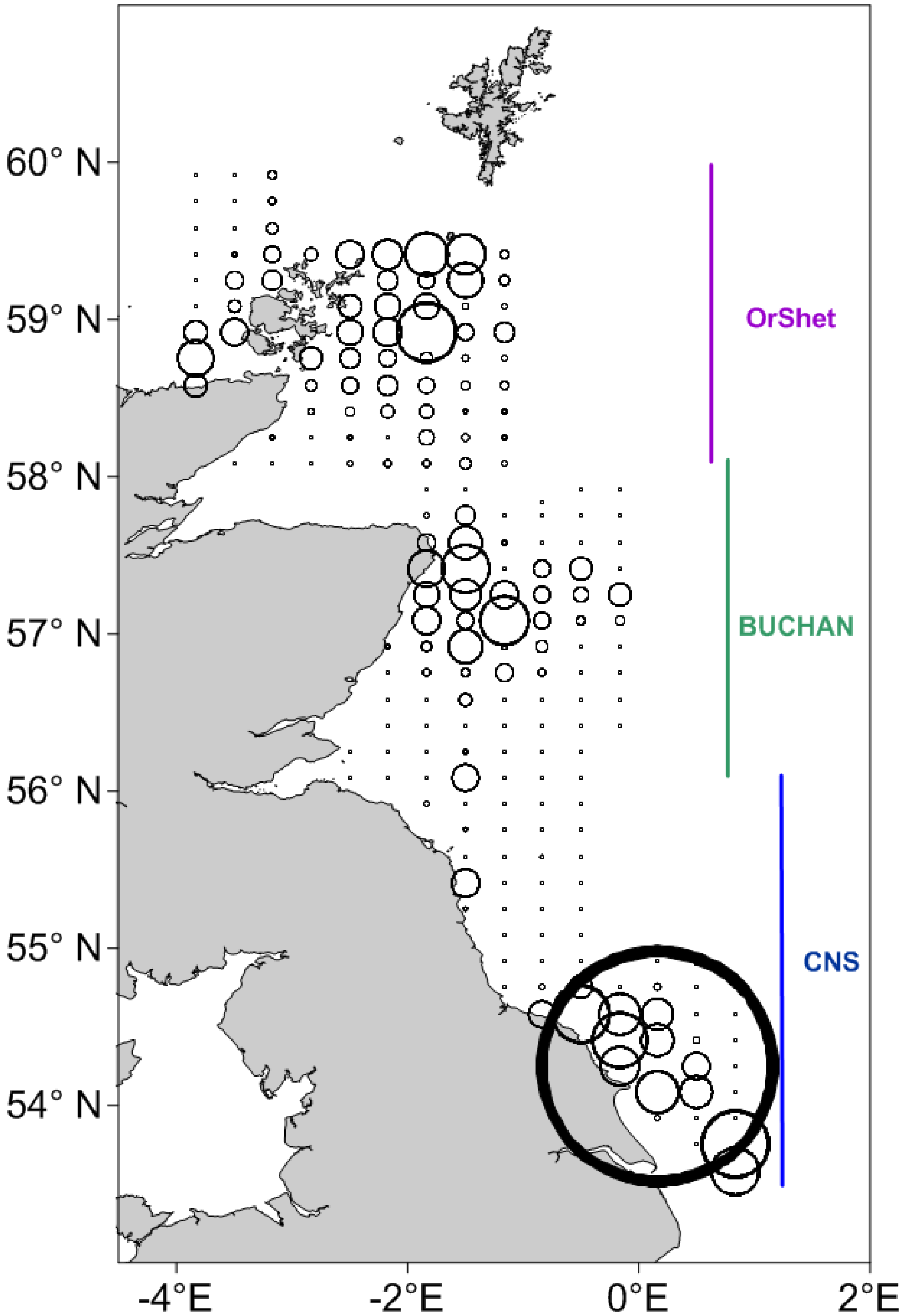


Figure 2.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetland, Buchan and Central North Sea area (16-30 September 2011, scale 0.64 cm =4 000 n/m²).

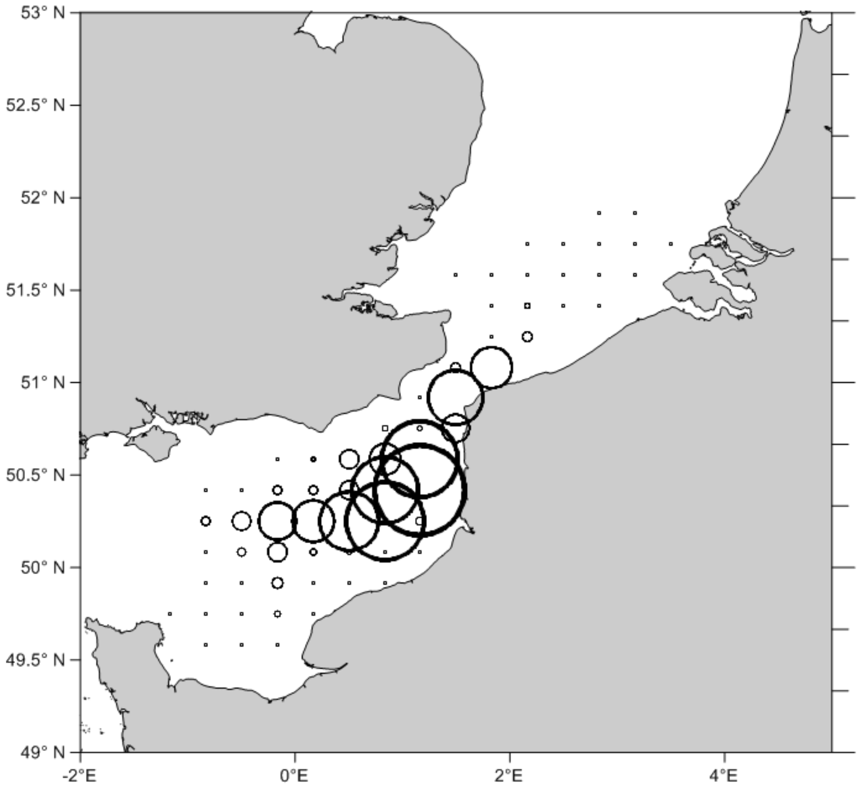


Figure 2.3.2.2. North Sea herring - Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 December 2011, scale 0.64 cm = 2 000 n/m²).

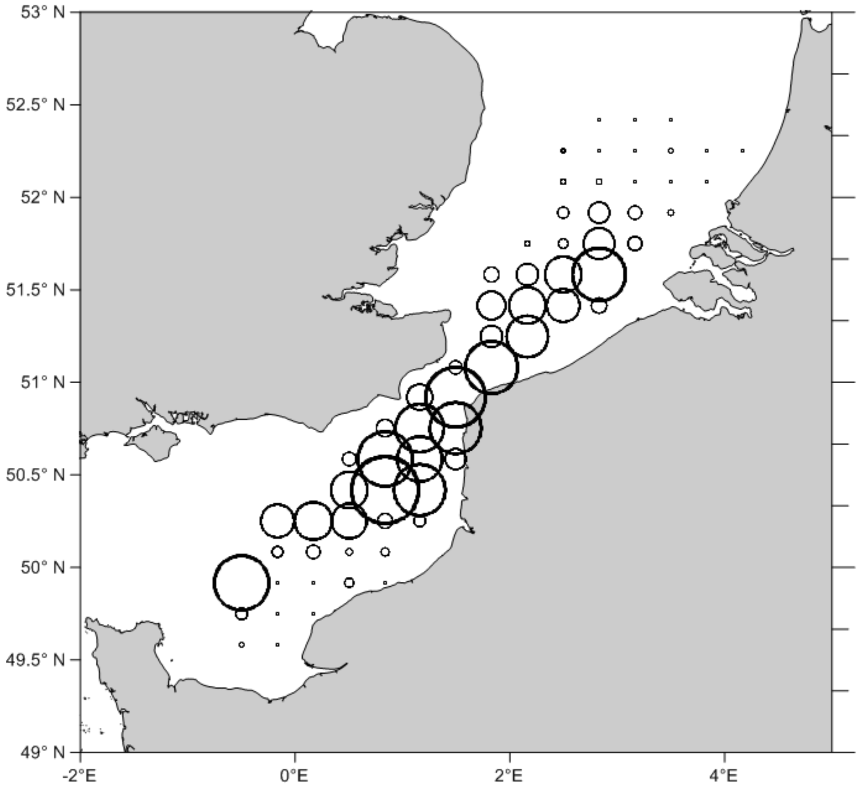


Figure 2.3.2.3. North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (01-15 January 2012, scale 0.64 cm = 2 000 n/m²).

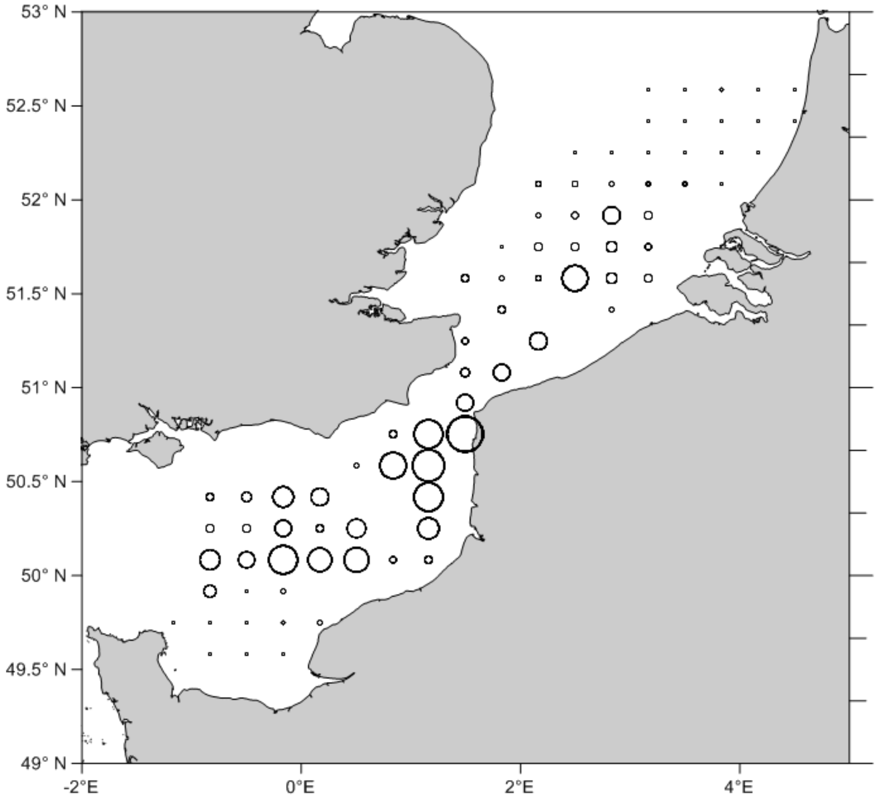


Figure2.3.2.4. North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 January 2012, scale 0.64 cm = 2 000 n/m²).

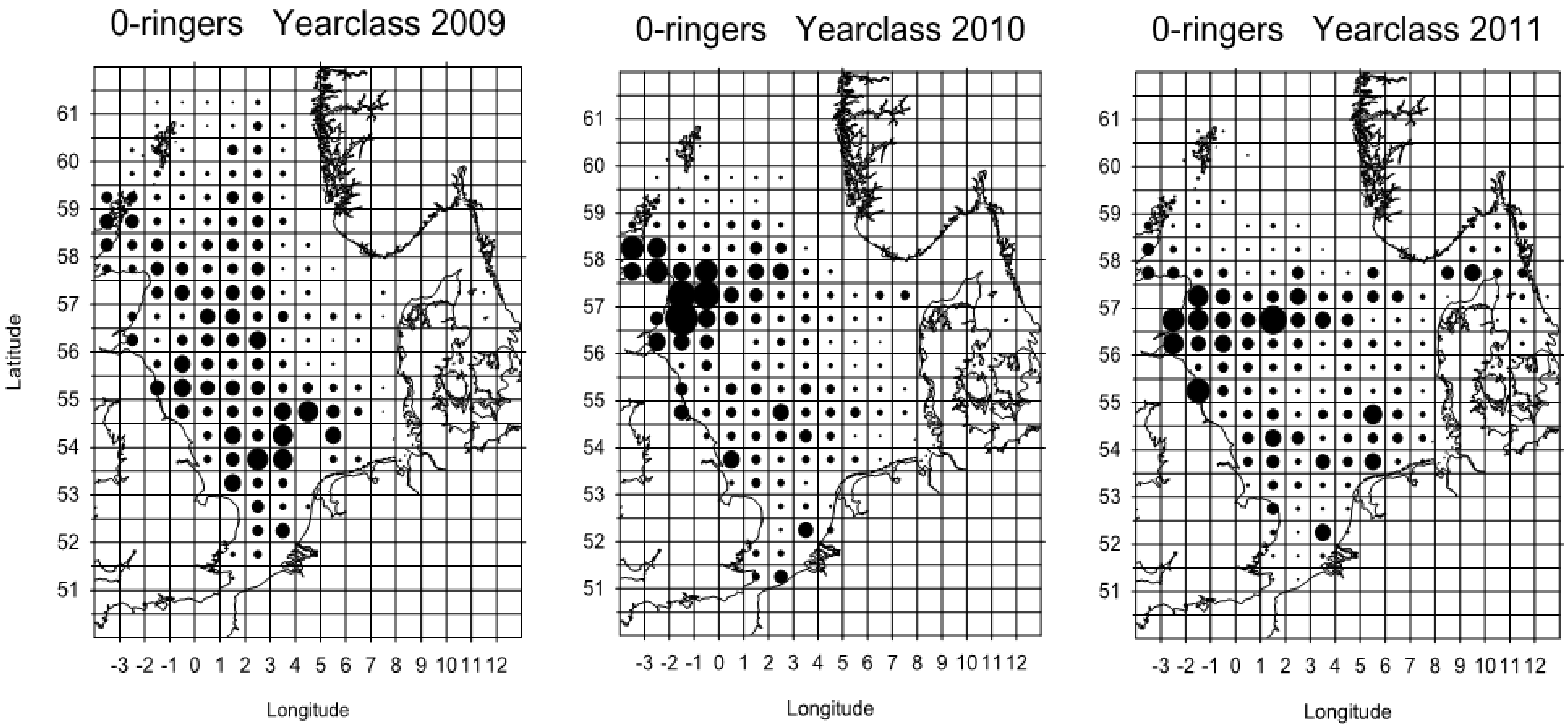


Figure 2.3.3.1. North Sea herring. Distribution of 0-ringer herring, year classes 2009-2011. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2010-2012. Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1 m^{-2}.

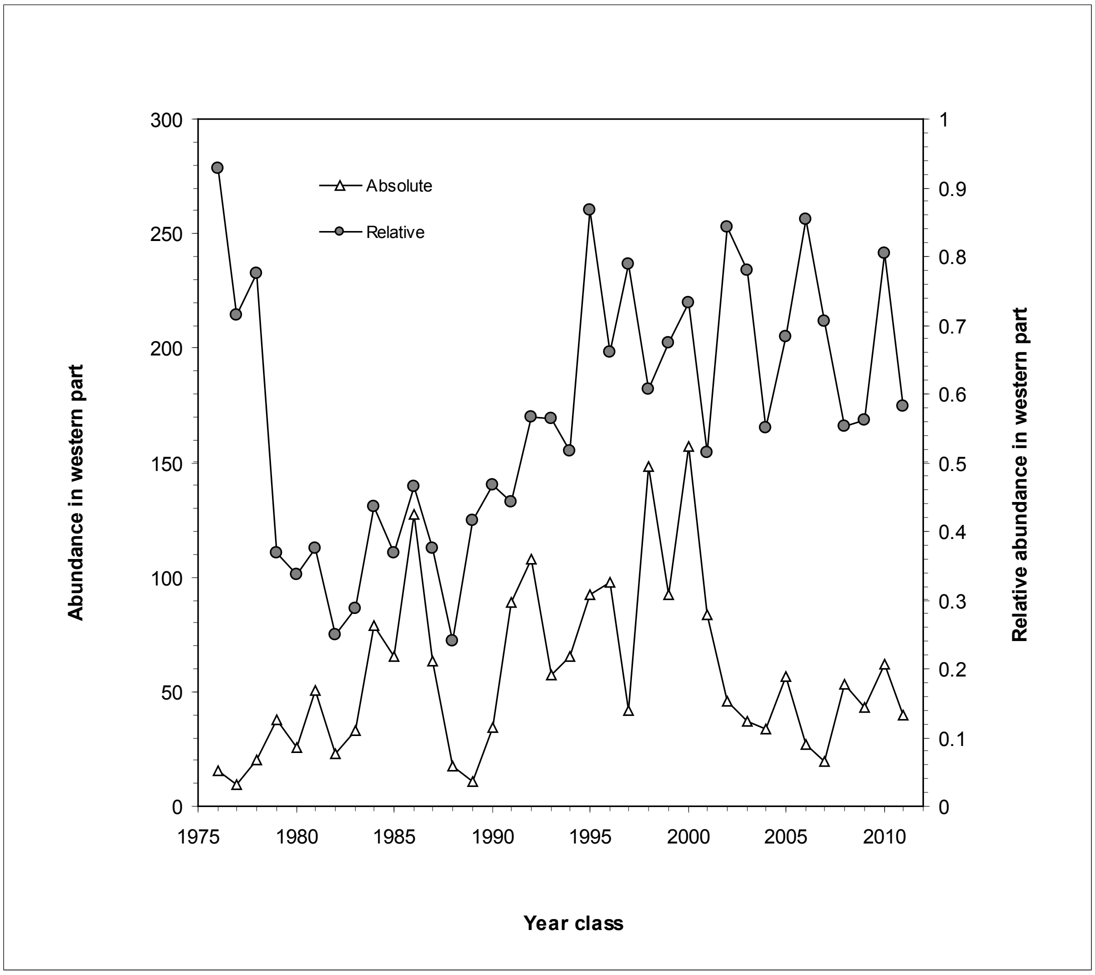


Figure 2.3.3.2. North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS, the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number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

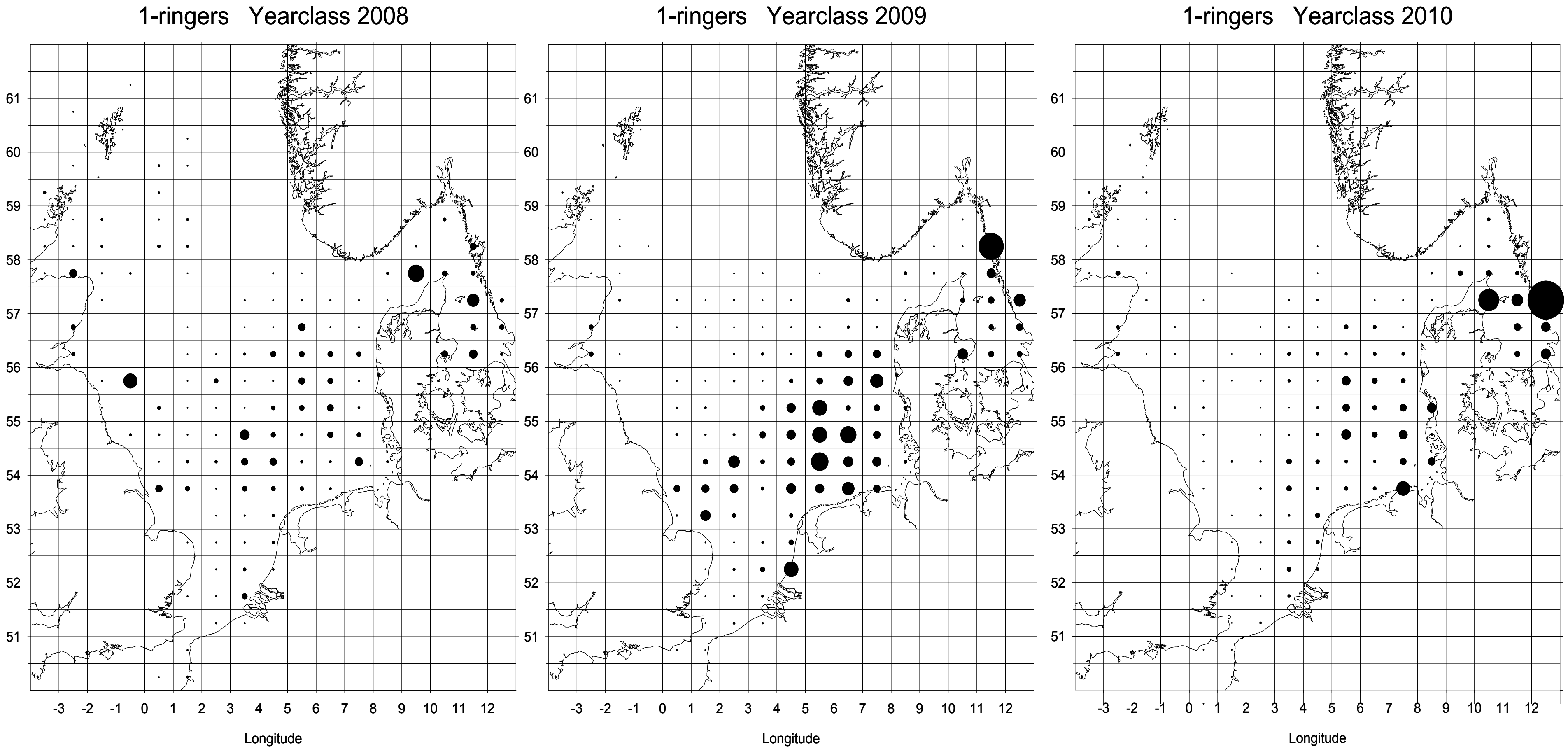
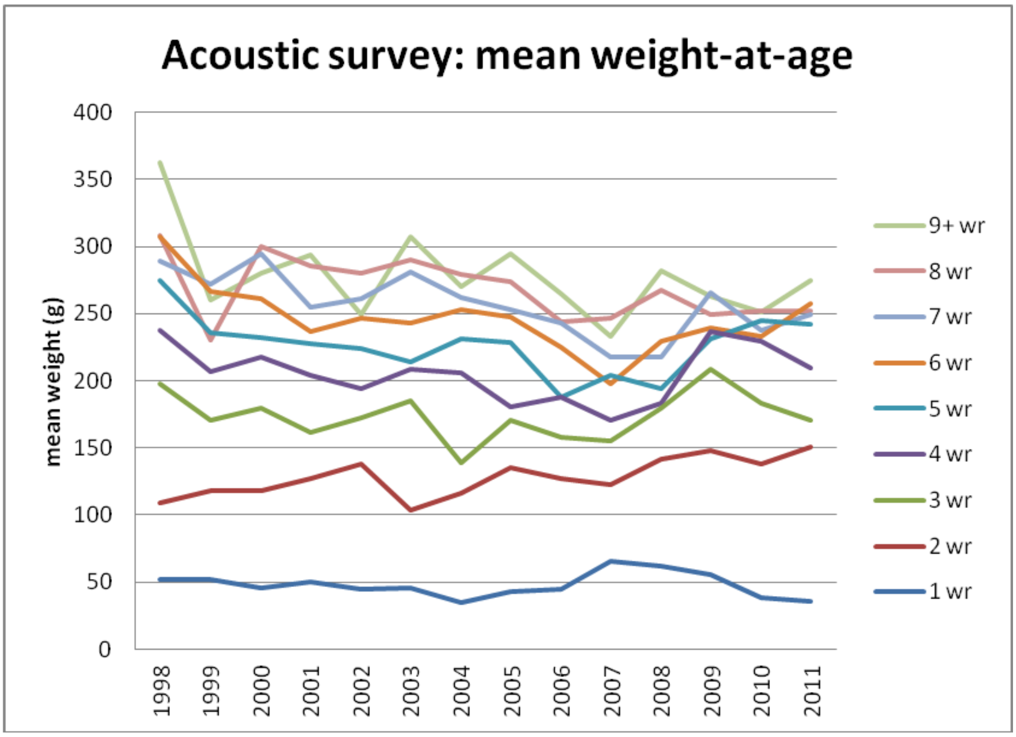


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2008-2010. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in February 2010-2012. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.



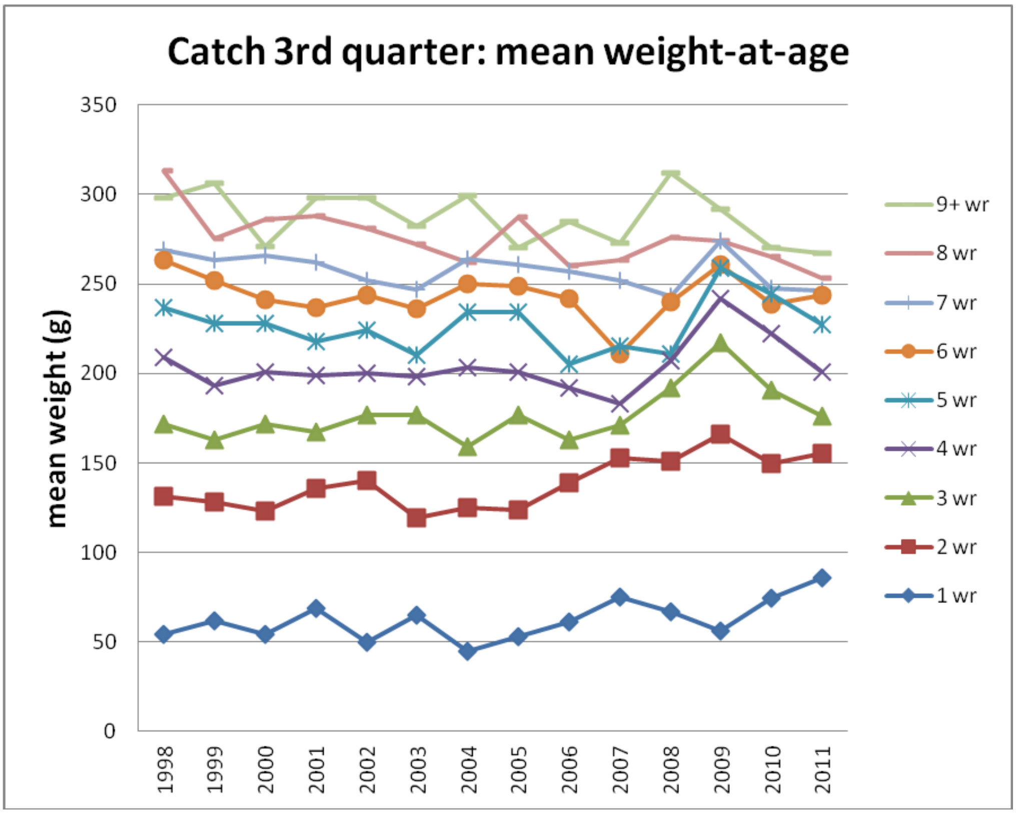


Figure 2.4.1.1. North Sea Herring. Mean weights-at-age for the 3rd quarter in Divisions IV and IIIa from the acoustic survey and mean weights-in-the-catch for comparison.

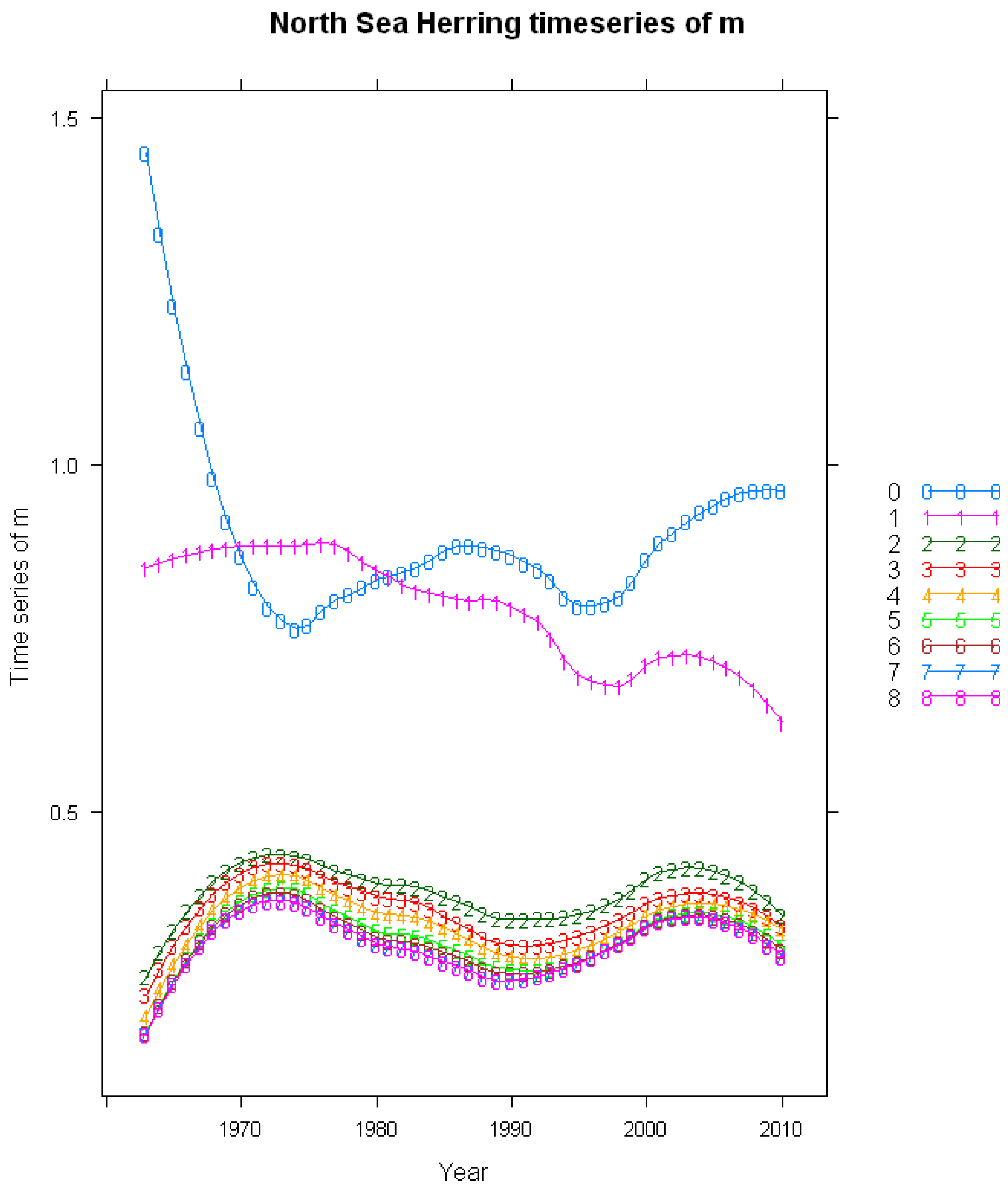


Figure 2.4.3.1 North Sea herring. Smoothed time varying natural mortality estimates at age for North Sea herring derived from the SMS model for the time period 1963-2010.

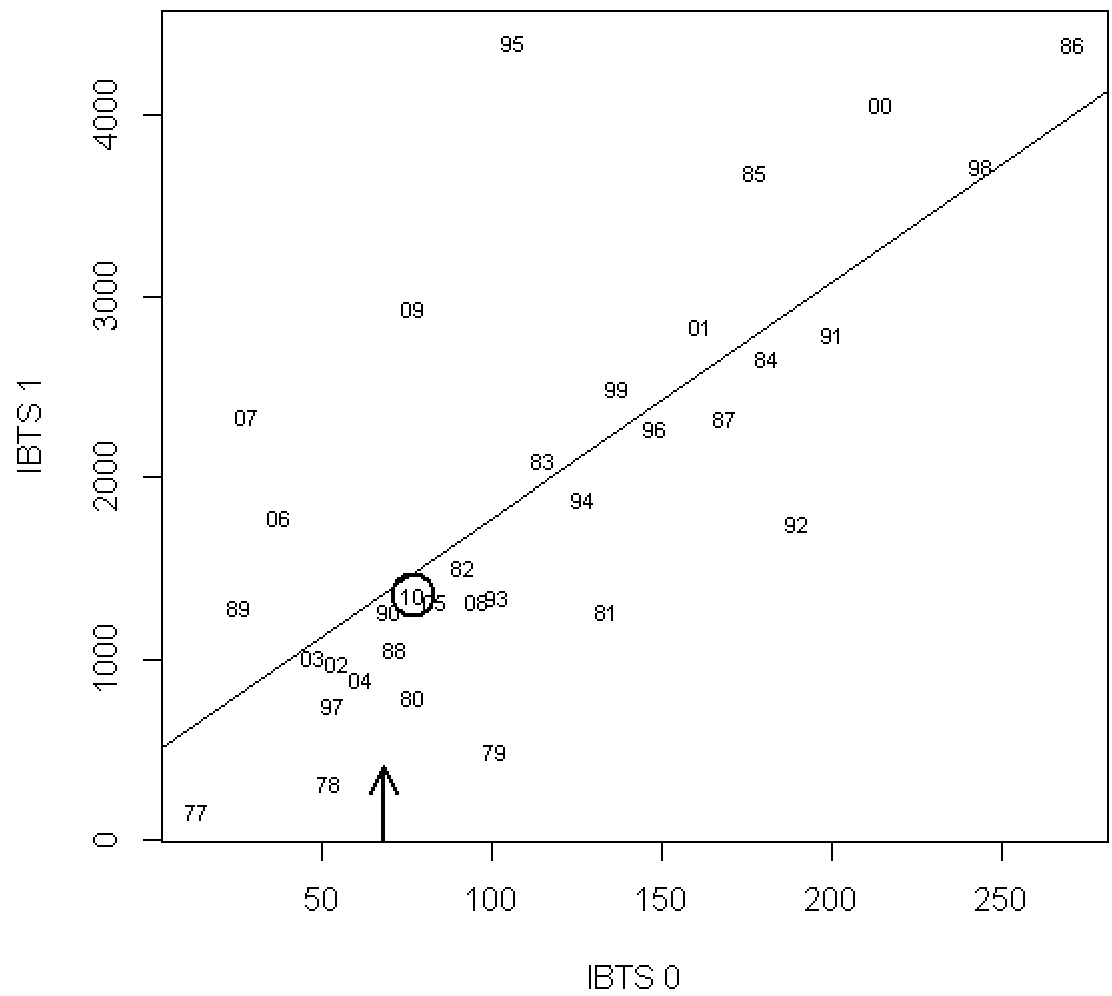


Figure 2.5.1. North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2010. The 2010 year class relation is circled; the present 0-ringer index for year class 2012 is indicated by an arrow.

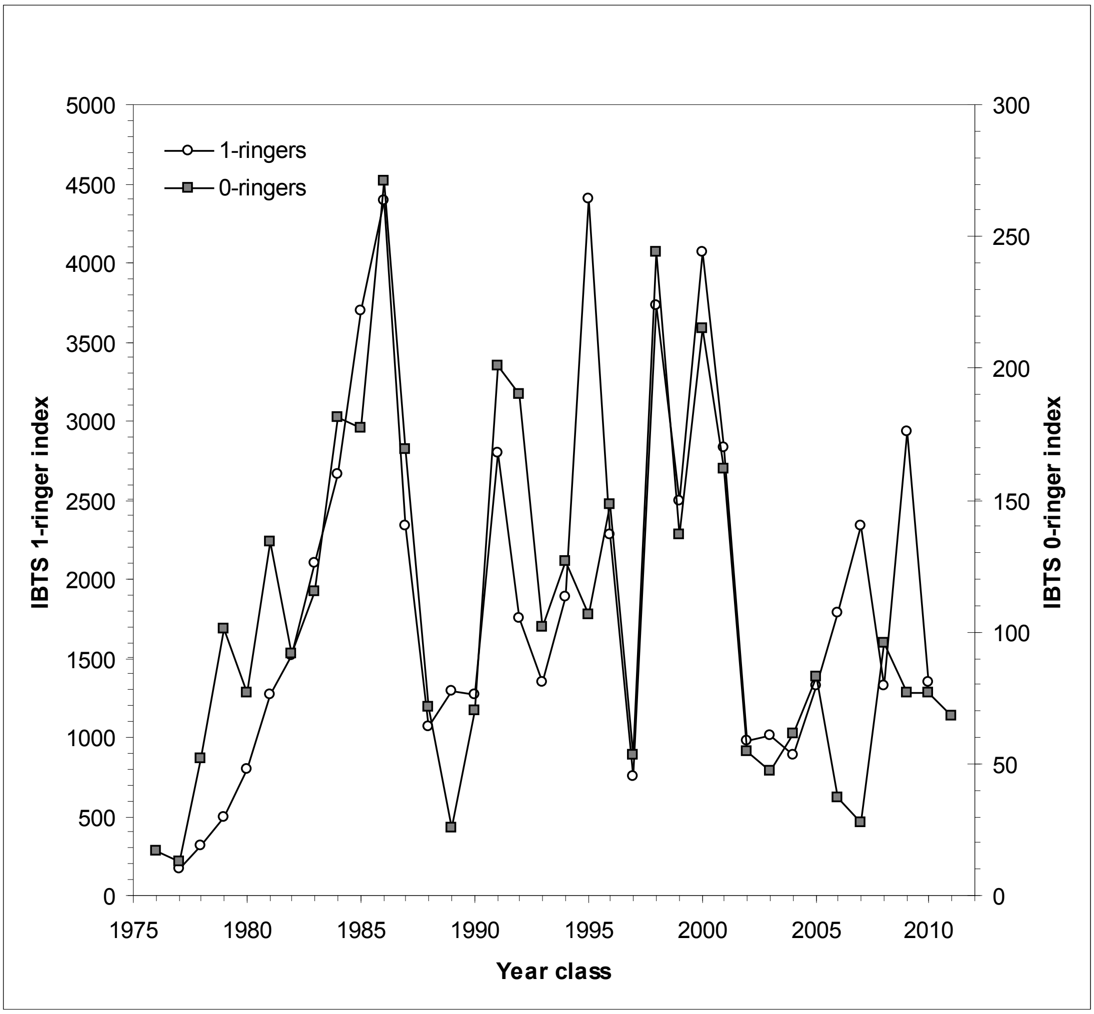


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2011 for 0-ringers, year classes 1977-2010 for 1-ringers.

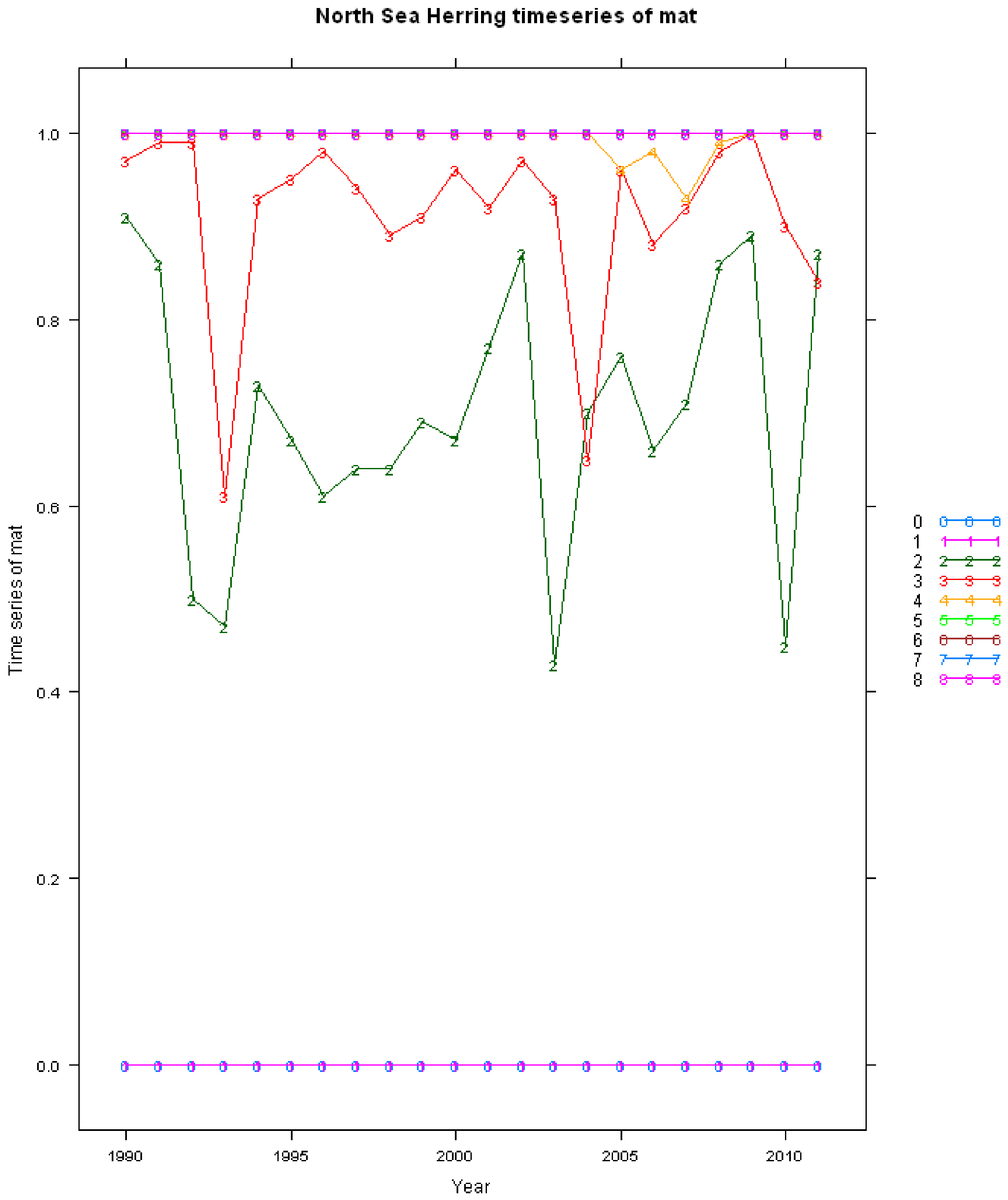


Figure 2.6.1.1 North Sea Herring. Time series of proportion mature at ages 0 to 8+ as used in the North Sea herring assessment.

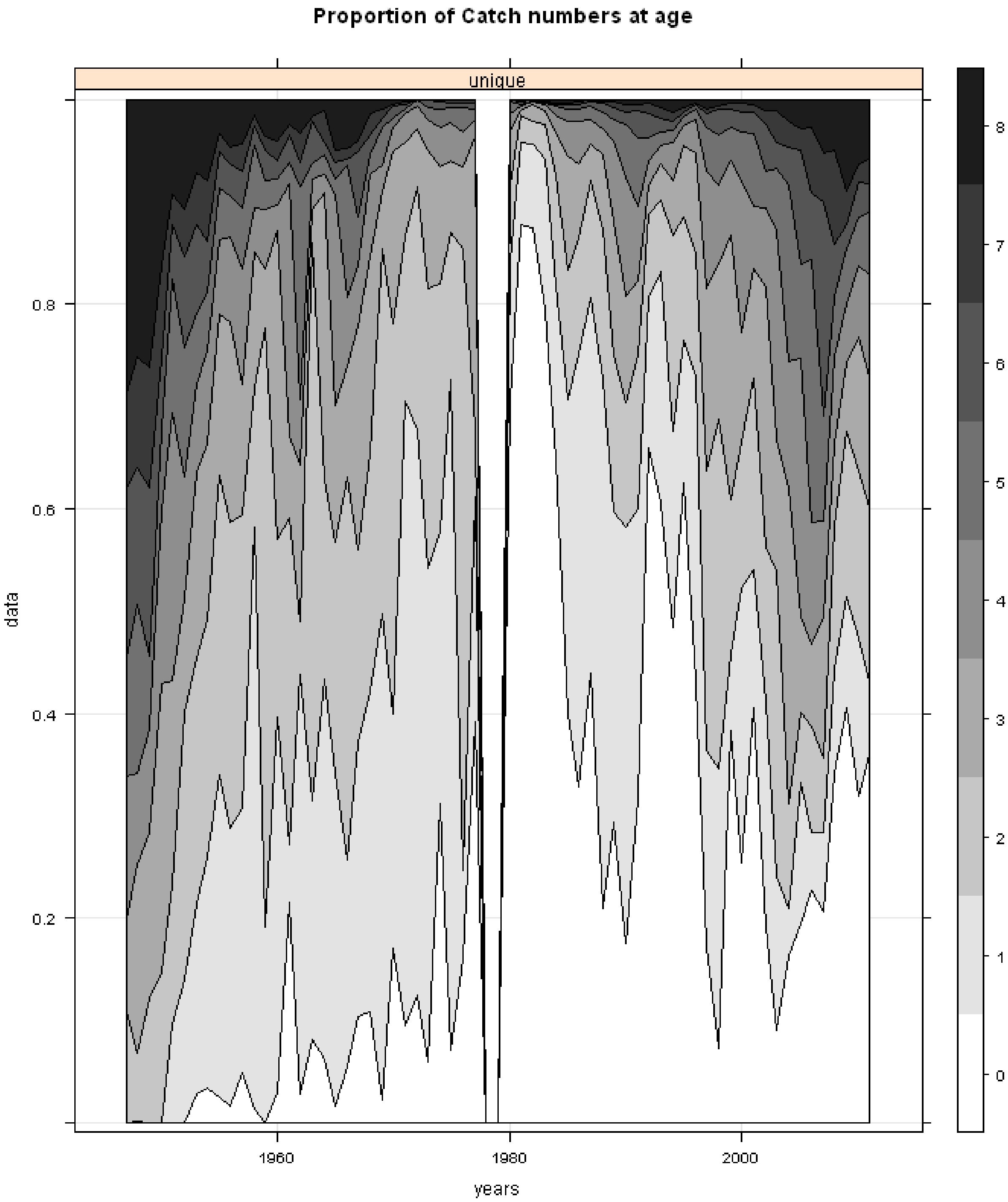


Figure 2.6.1.2. North Sea Herring. Time series of catch-at-age proportion at ages 0-8+ as used in the North Sea herring assessment.

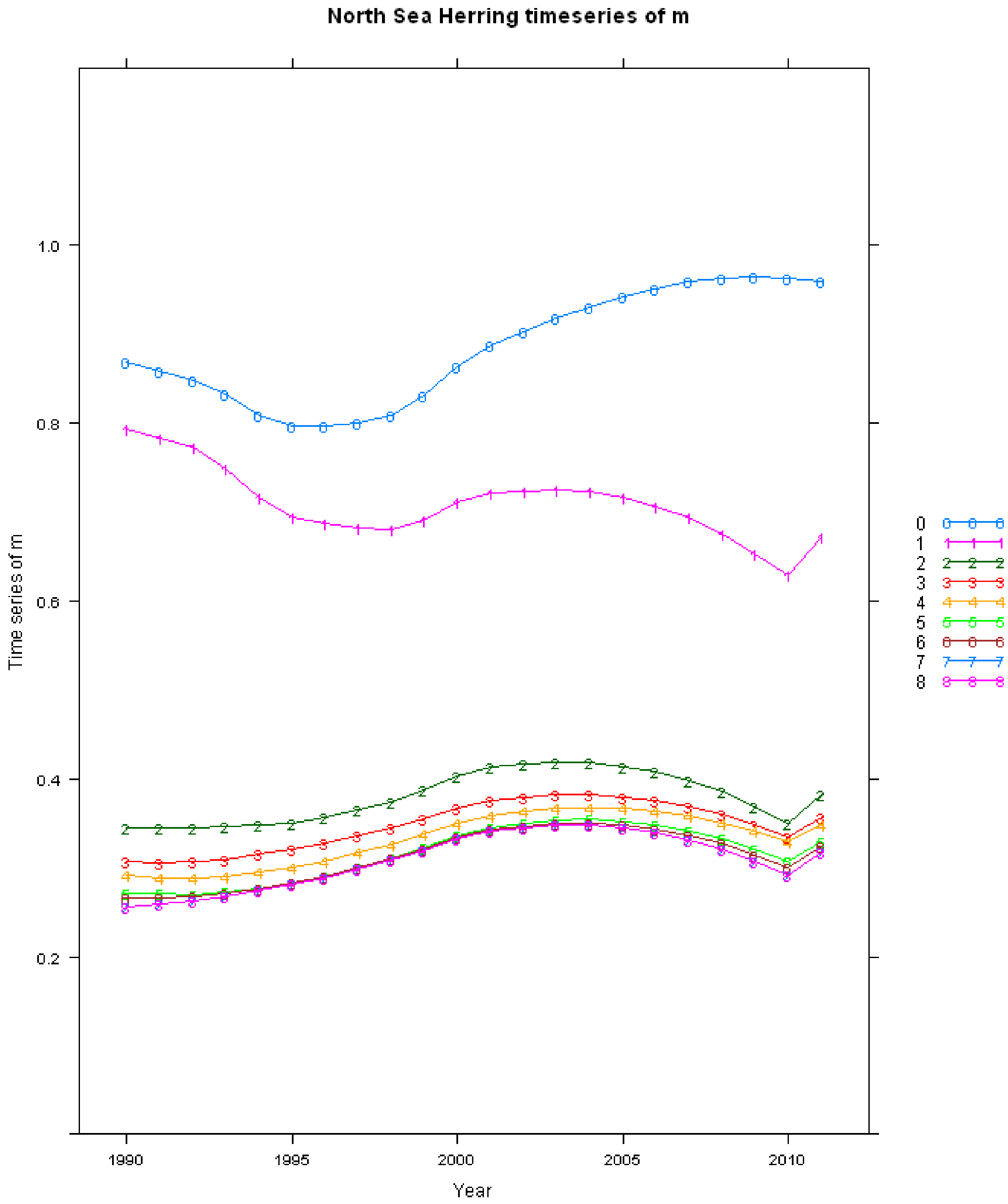


Figure 2.6.1.3. North Sea Herring. Time series of absolute natural mortality values at age 0-8+ as used in the North Sea herring assessment.

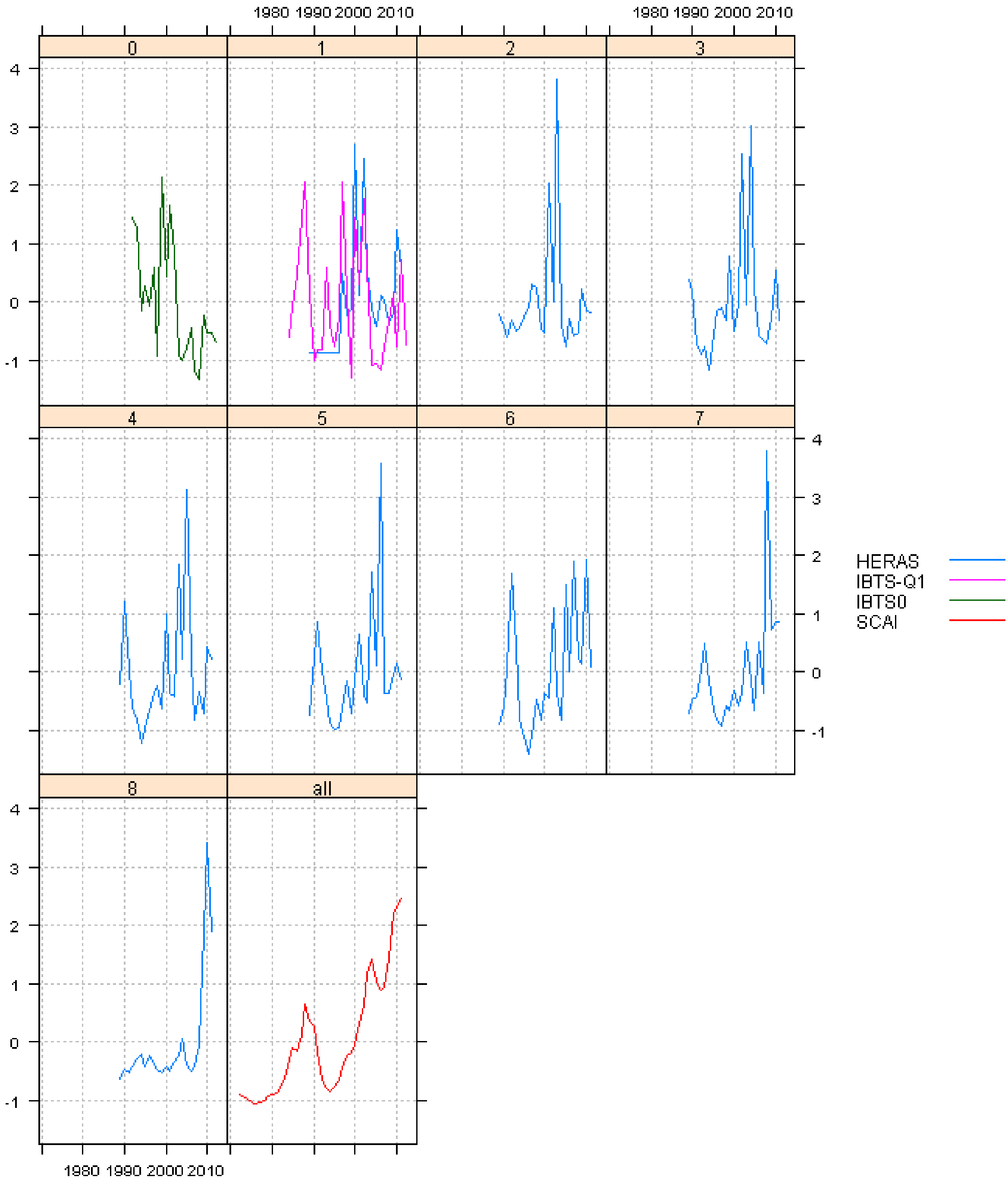


Figure 2.6.1.4. North Sea Herring. Time series of the standardized tuning series by ages 0-8+ (Acoustic survey: HERAS, IBTS quarter 1 survey: IBTS-Q1 and IBTS MIK net survey in quarter 1: IBTS0) and SSB tuning series (IHLS survey: SCAI).

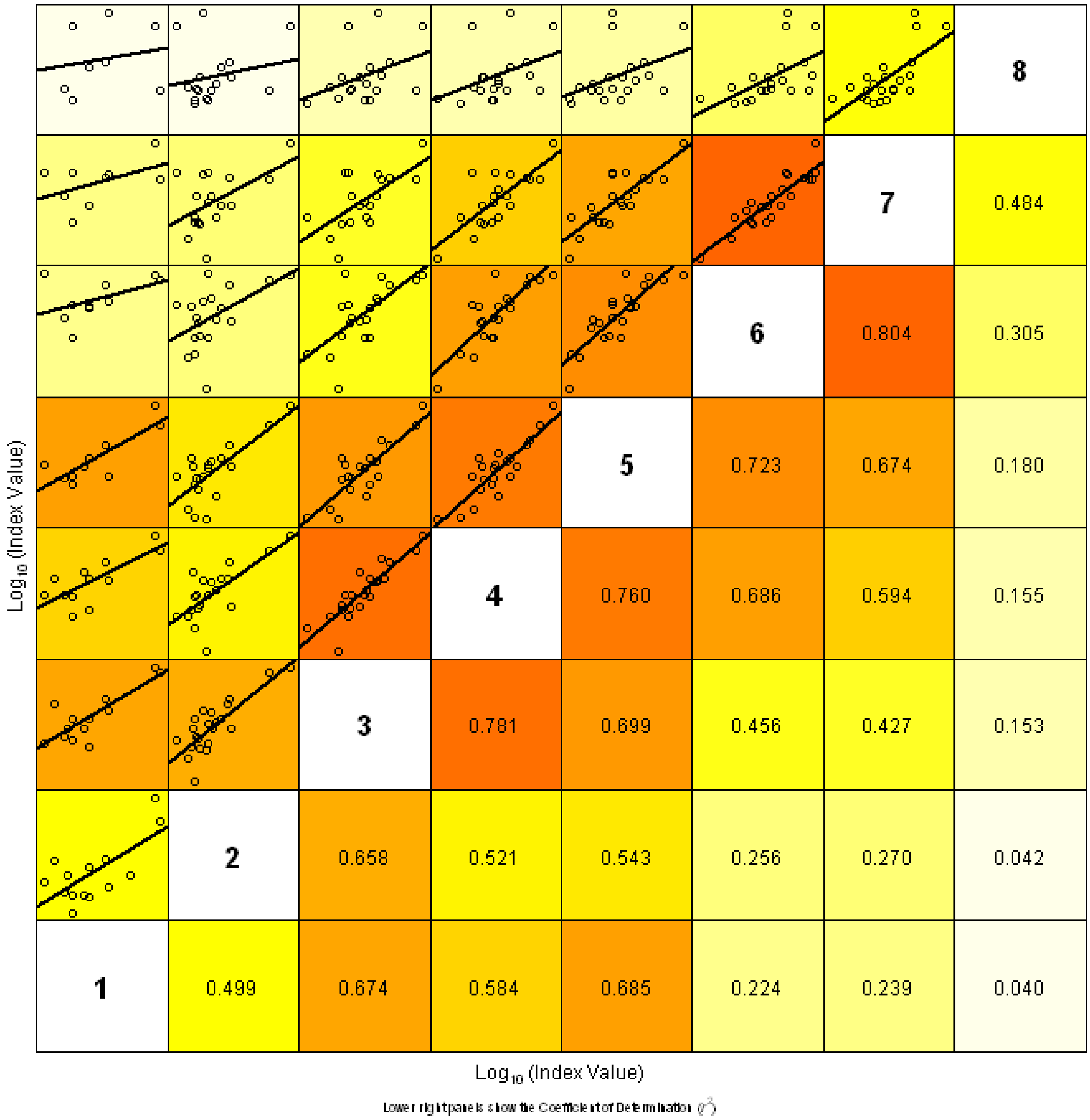


Figure 2.6.1.5. North Sea herring. Internal consistency plot of the acoustic survey (HERAS). Above the diagonal the linear regression is shown including the observations (in points) while under the diagonal the R2 value that is associated with the linear regression is given.

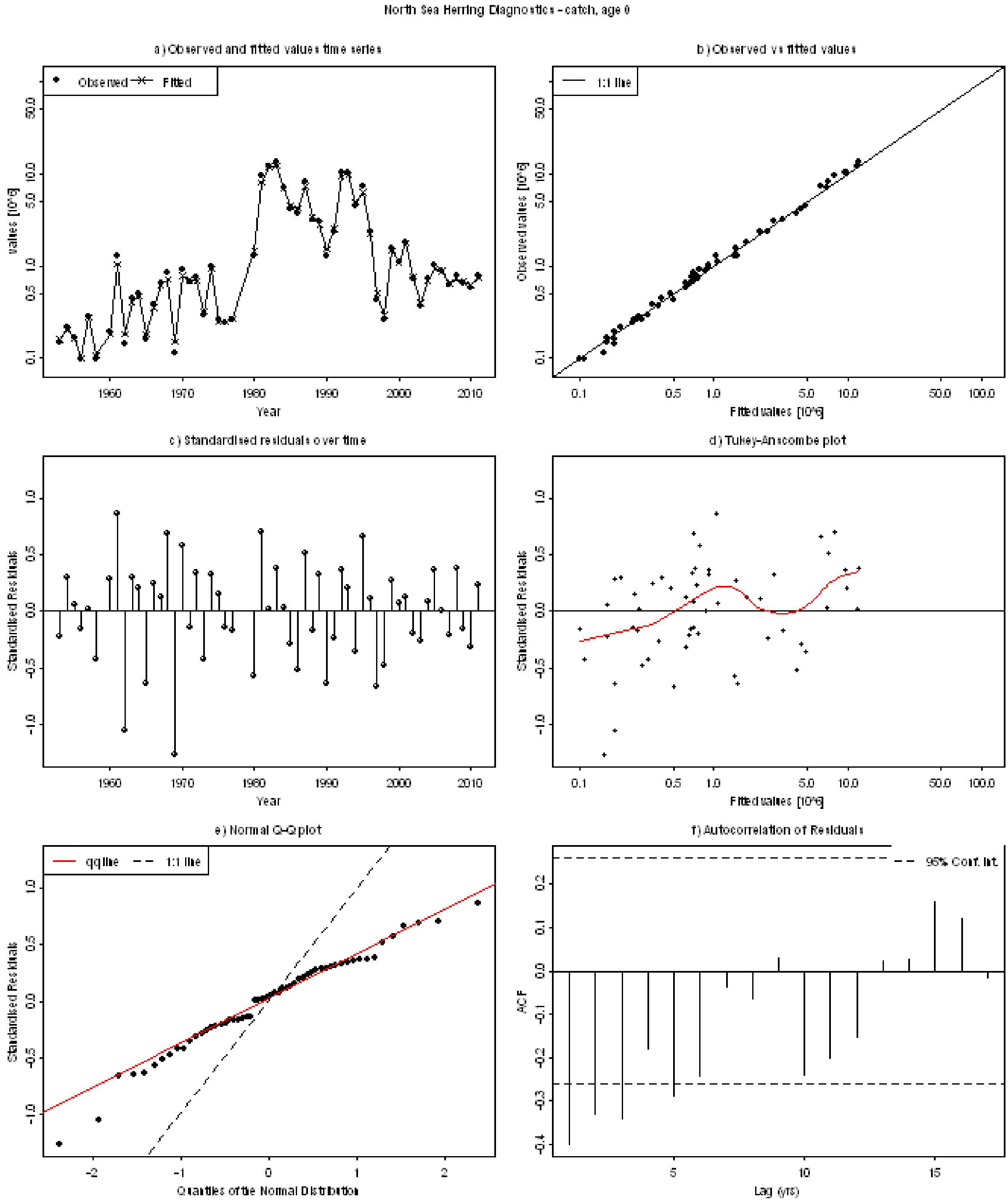


Figure 2.6.1.6 North Sea herring. Diagnostics of the assessment model fit to the catch at age 0 time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from catch abundance at 0 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the catch at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

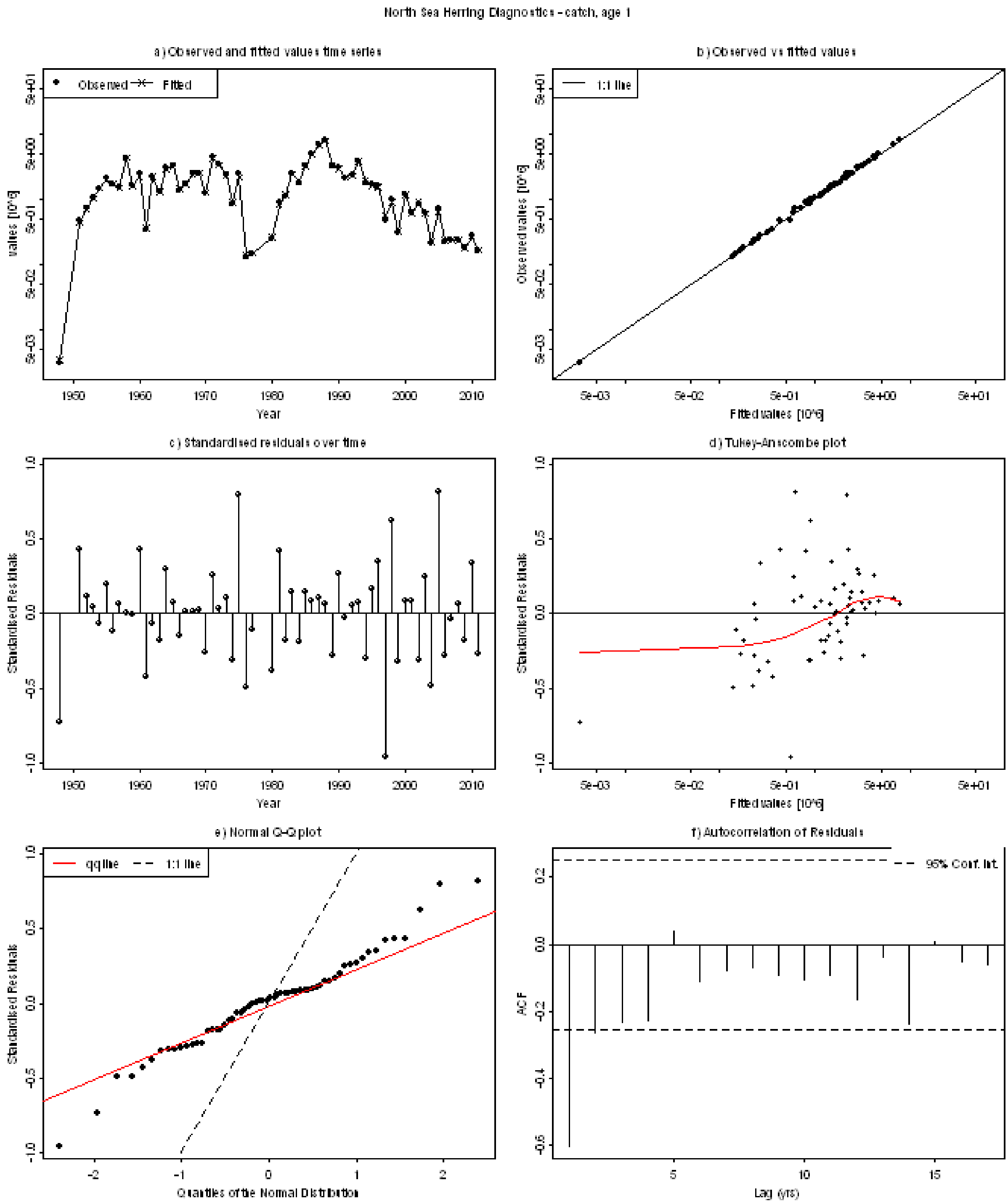


Figure 2.6.1.7 North Sea herring. Diagnostics of the assessment model fit to the catch at age 1 time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from catch abundance at 1 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the catch at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

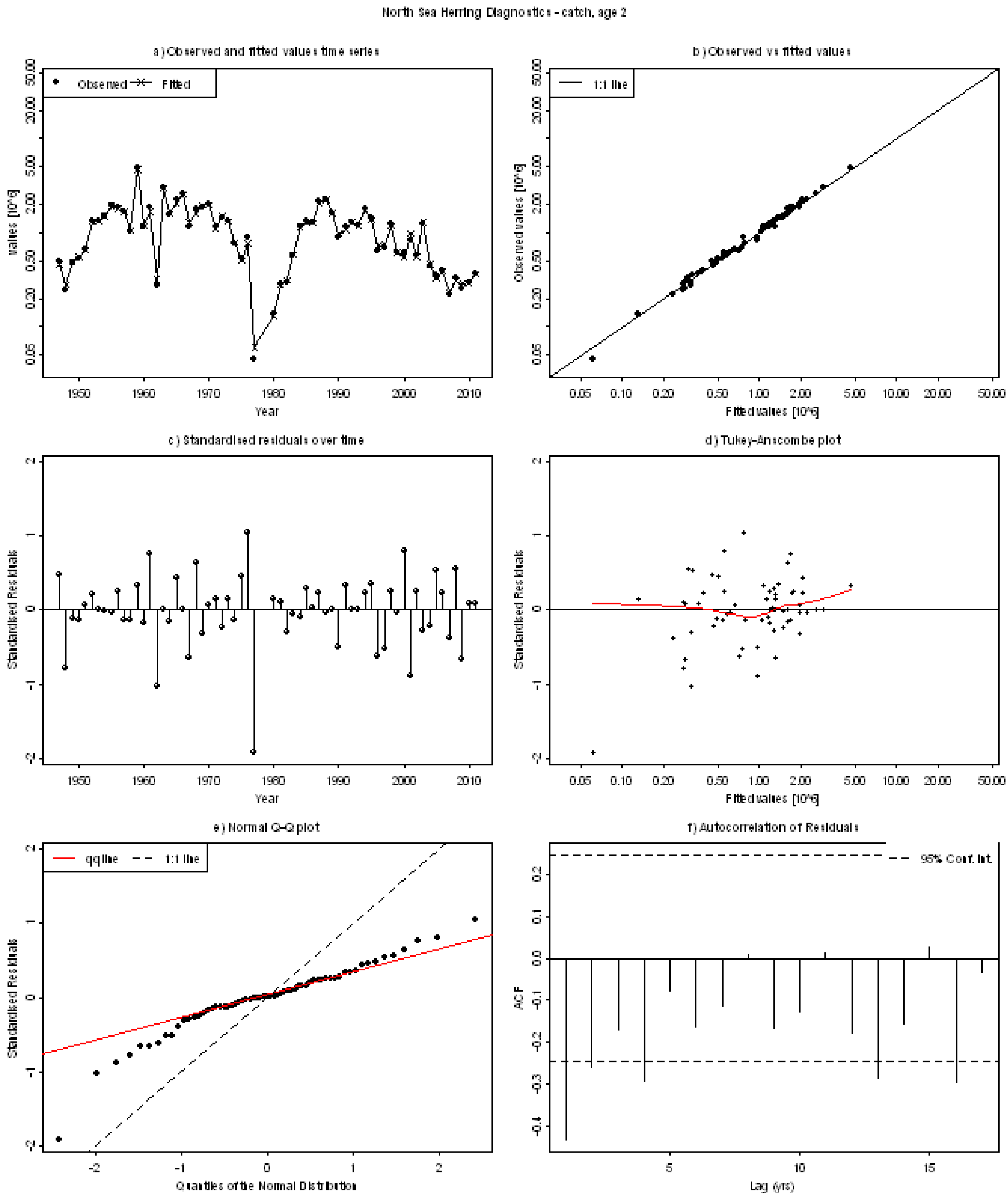


Figure 2.6.1.8 North Sea herring. Diagnostics of the assessment model fit to the catch at age 2 time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from catch abundance at 2 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the catch at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

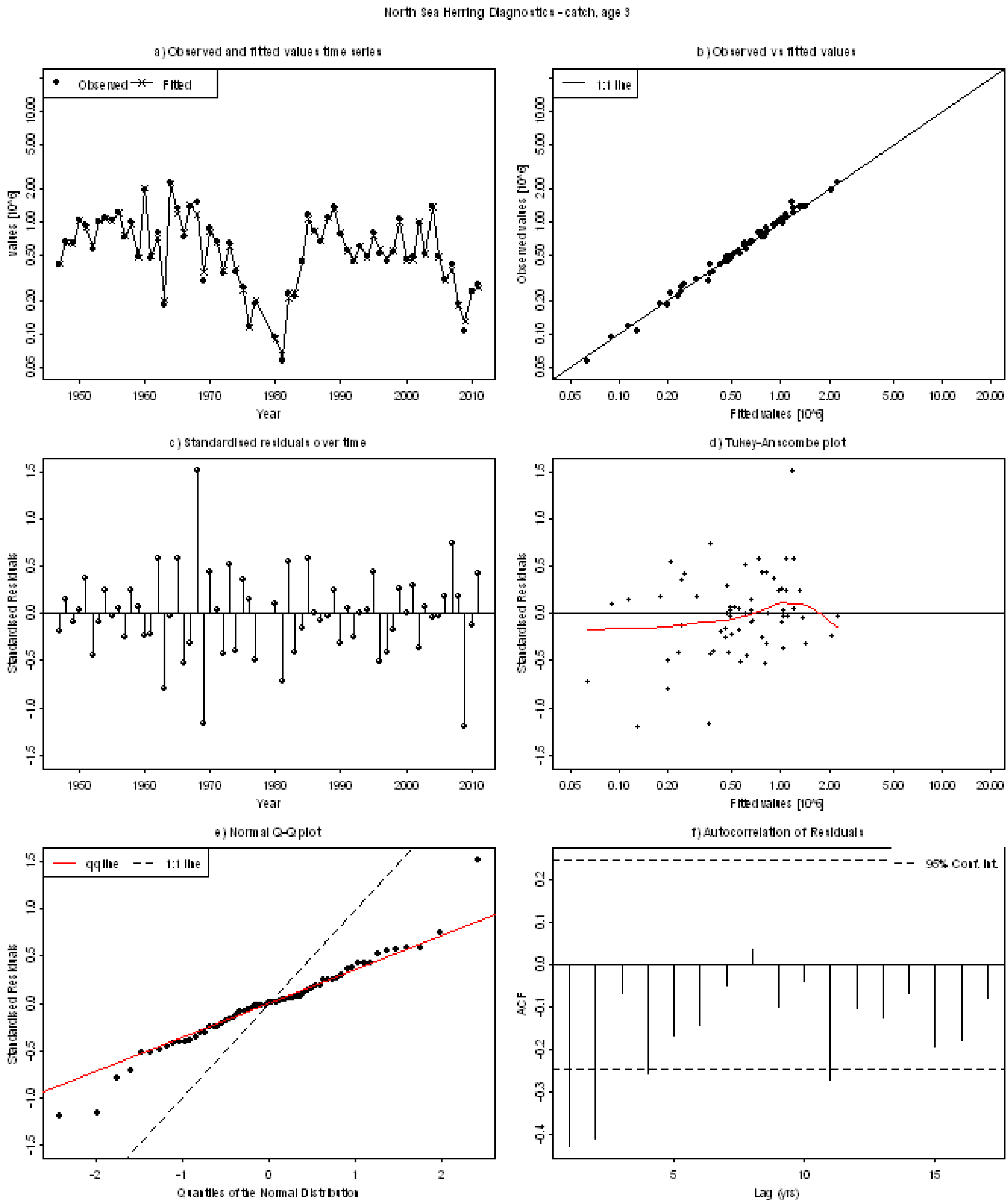


Figure 2.6.1.9 North Sea herring. Diagnostics of the assessment model fit to the catch at age 3 time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from catch abundance at 3 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the catch at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

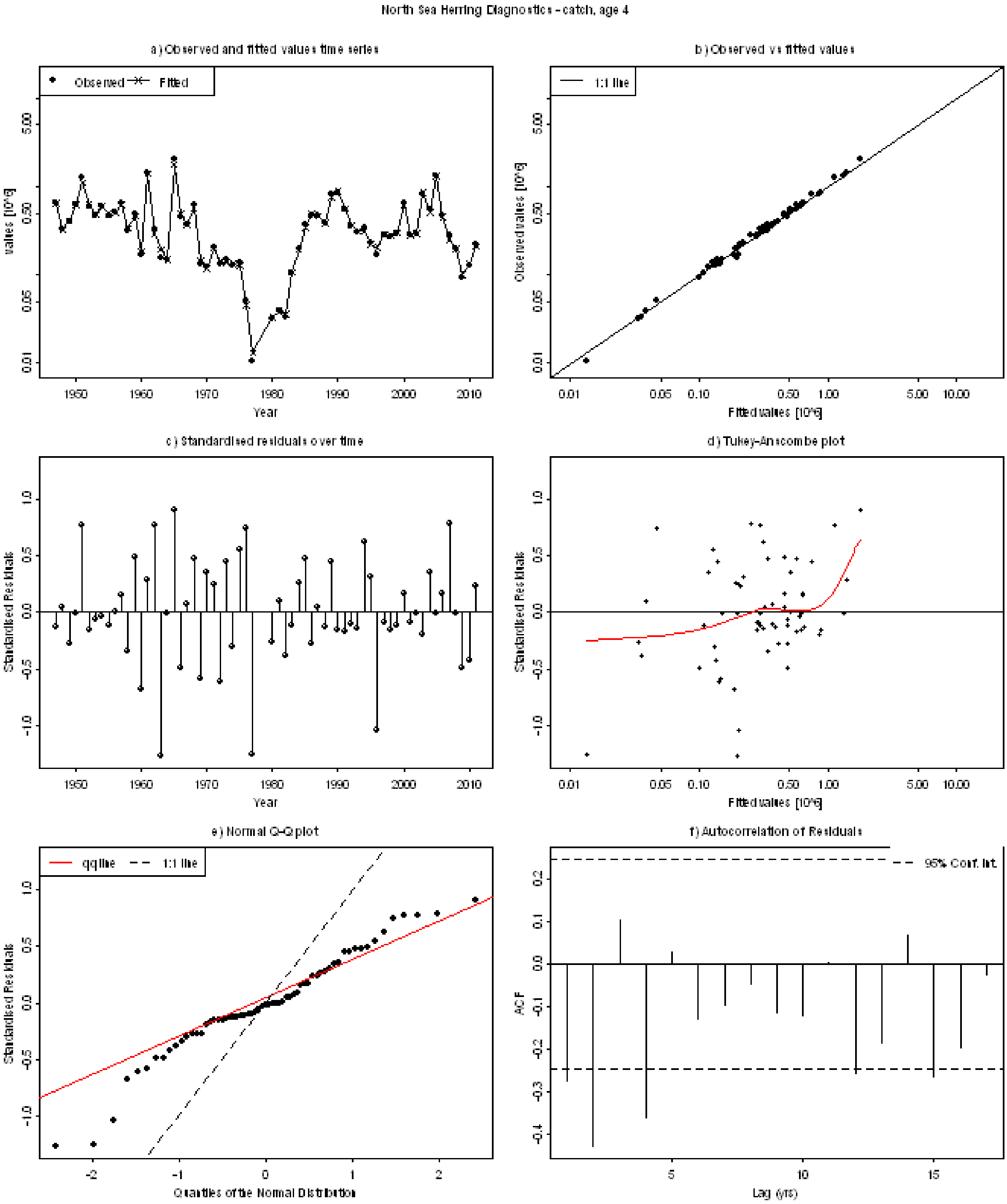


Figure 2.6.1.10 North Sea herring. Diagnostics of the assessment model fit to the catch at age 4 time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from catch abundance at 4 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the catch at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

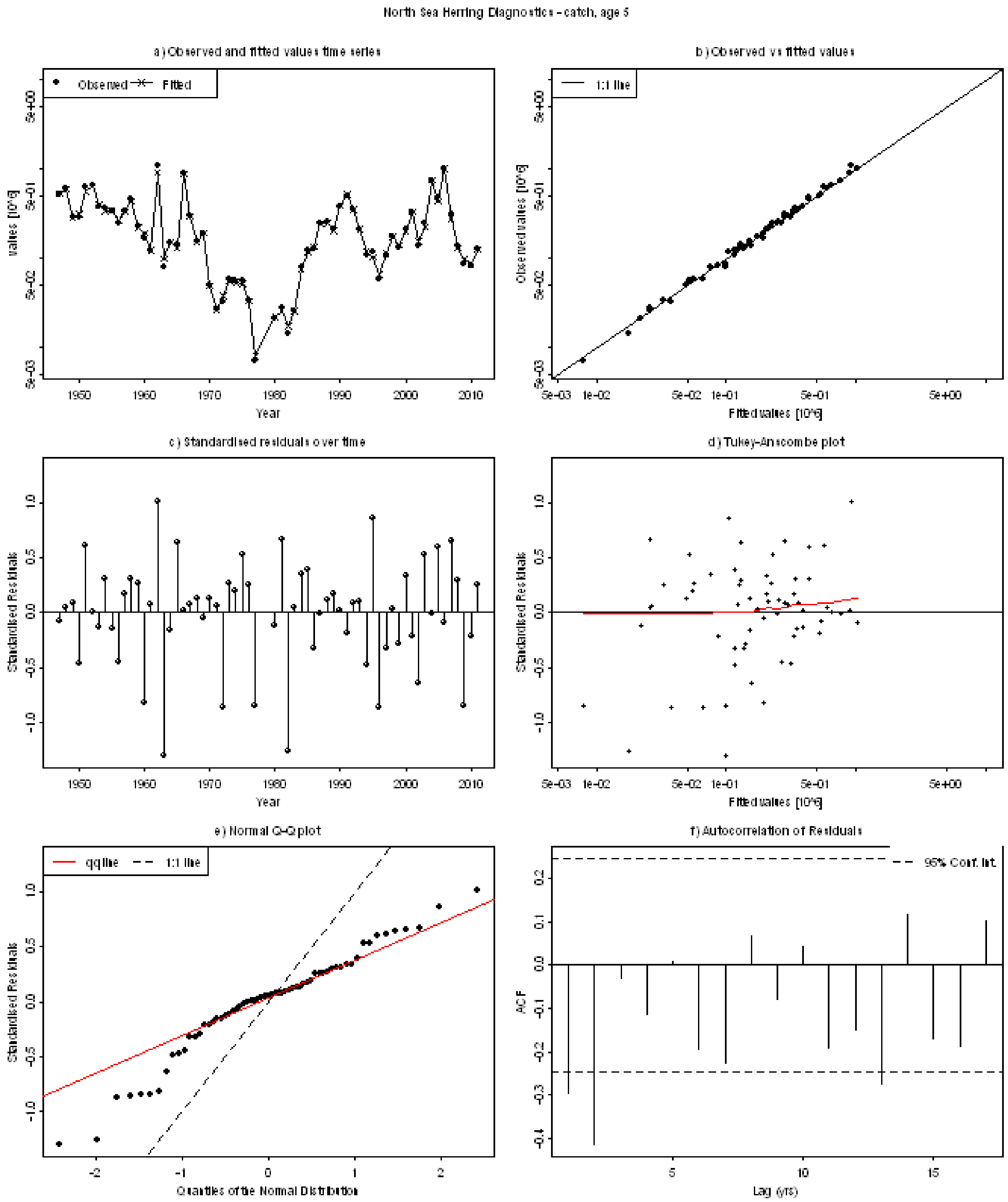


Figure 2.6.1.11 North Sea herring. Diagnostics of the assessment model fit to the catch at age 5 time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from catch abundance at 5 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the catch at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

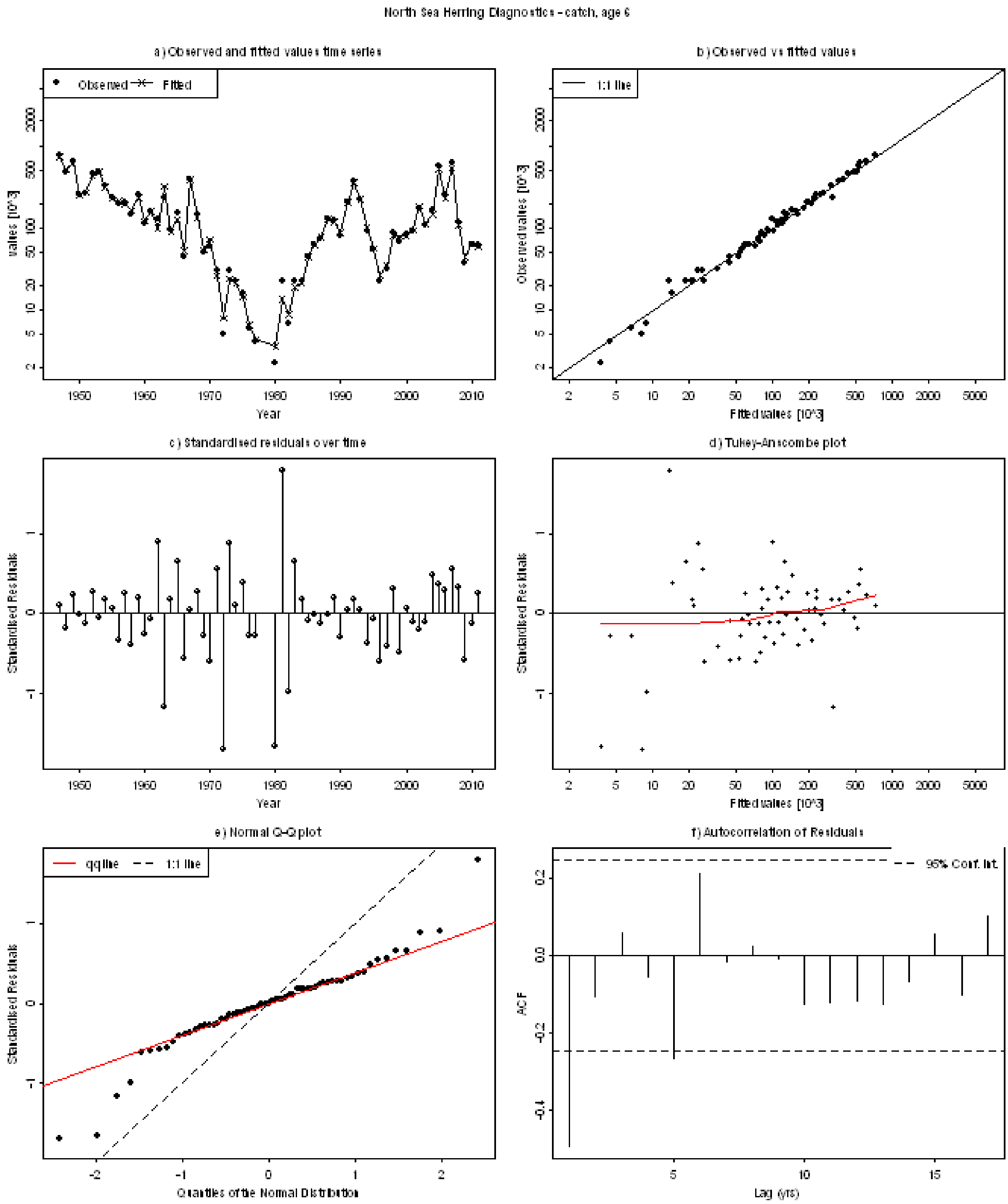


Figure 2.6.1.12 North Sea herring. Diagnostics of the assessment model fit to the catch at age 6 time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from catch abundance at 6 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the catch at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

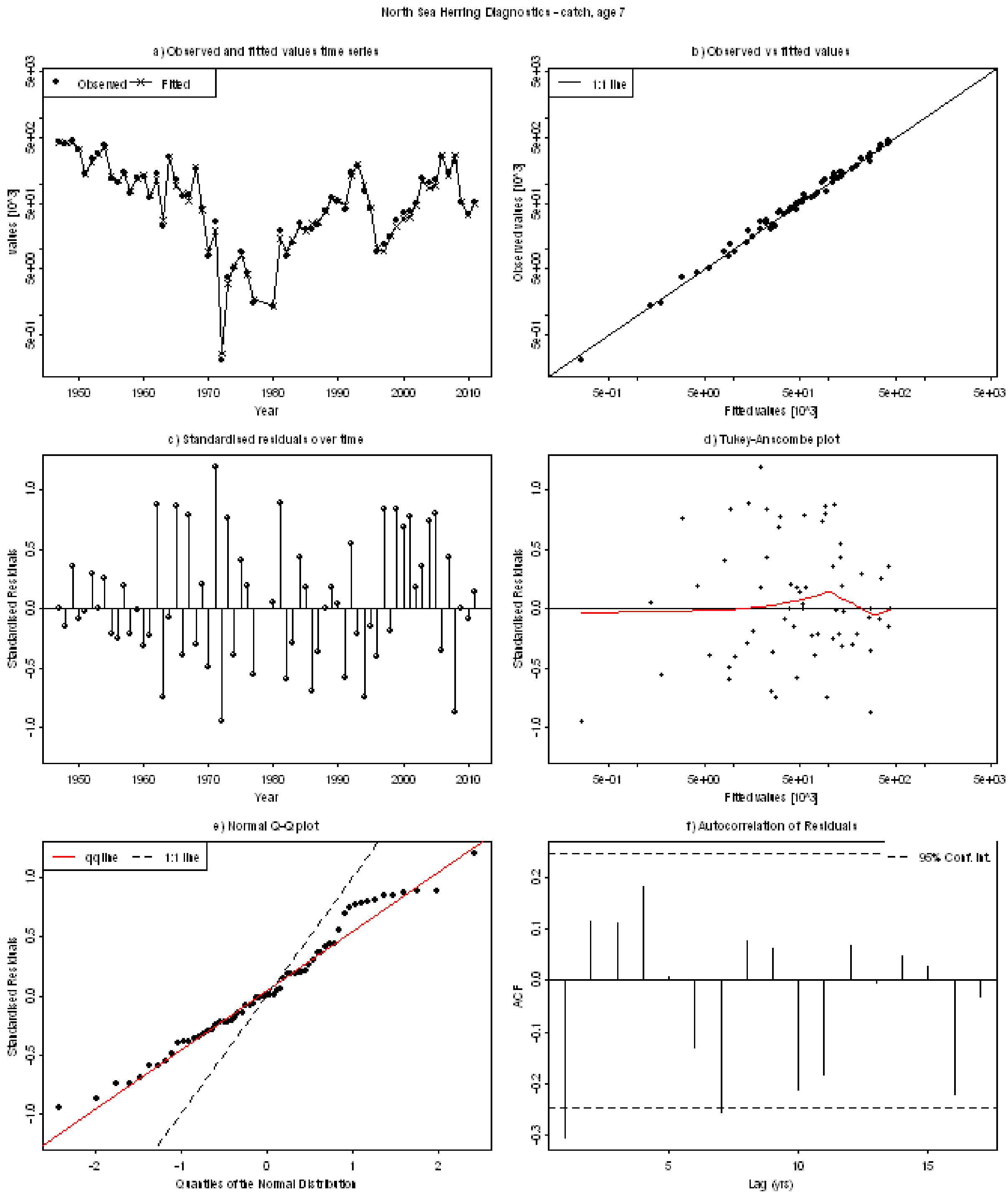


Figure 2.6.1.13 North Sea herring. Diagnostics of the assessment model fit to the catch at age 7 time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from catch abundance at 7 wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the catch at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

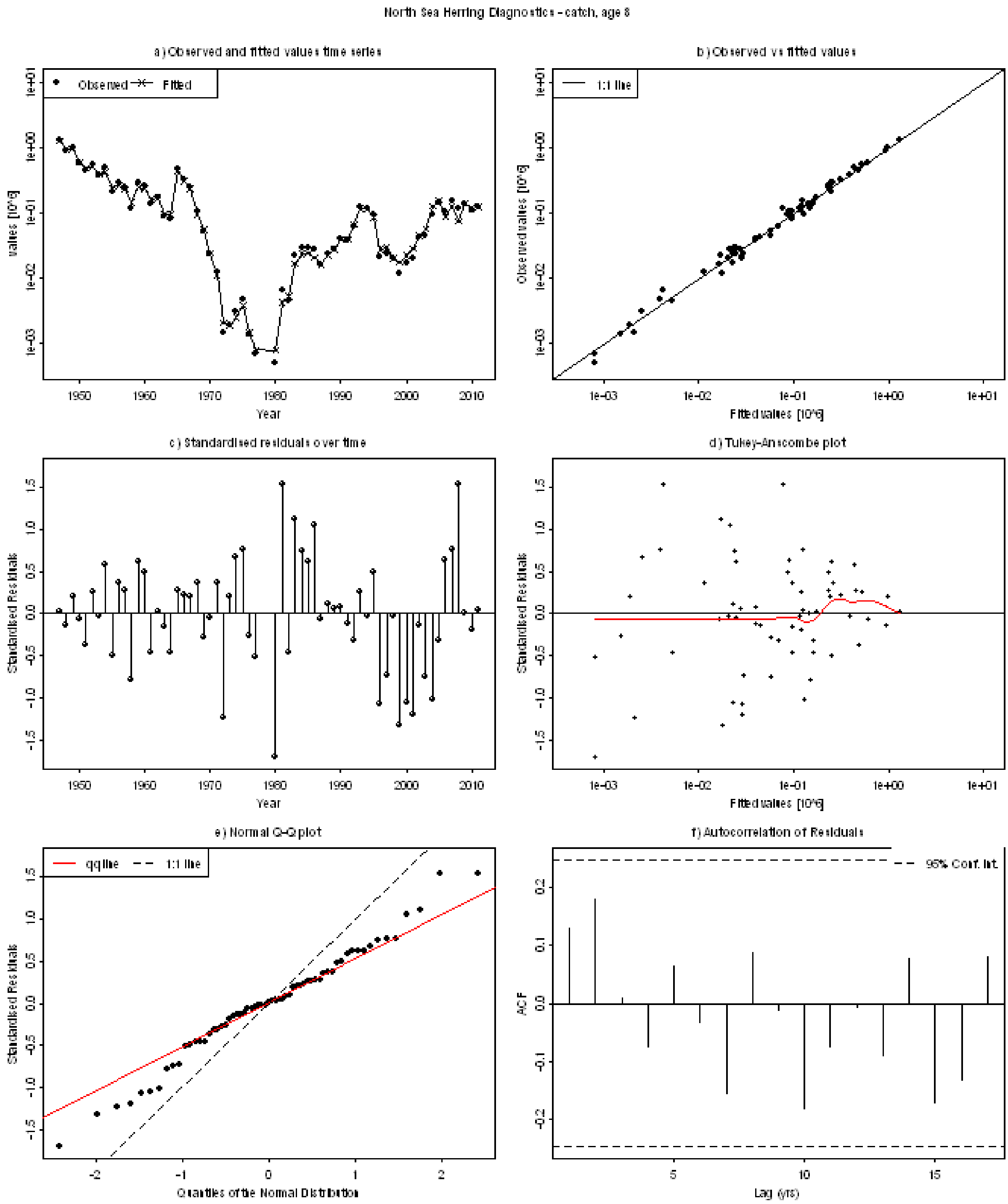


Figure 2.6.1.14. North Sea herring. Diagnostics of the assessment model fit to the catch at age 8+ time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from catch abundance at 8+ wr. Top right: scatterplot of catch observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: catch observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the catch at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

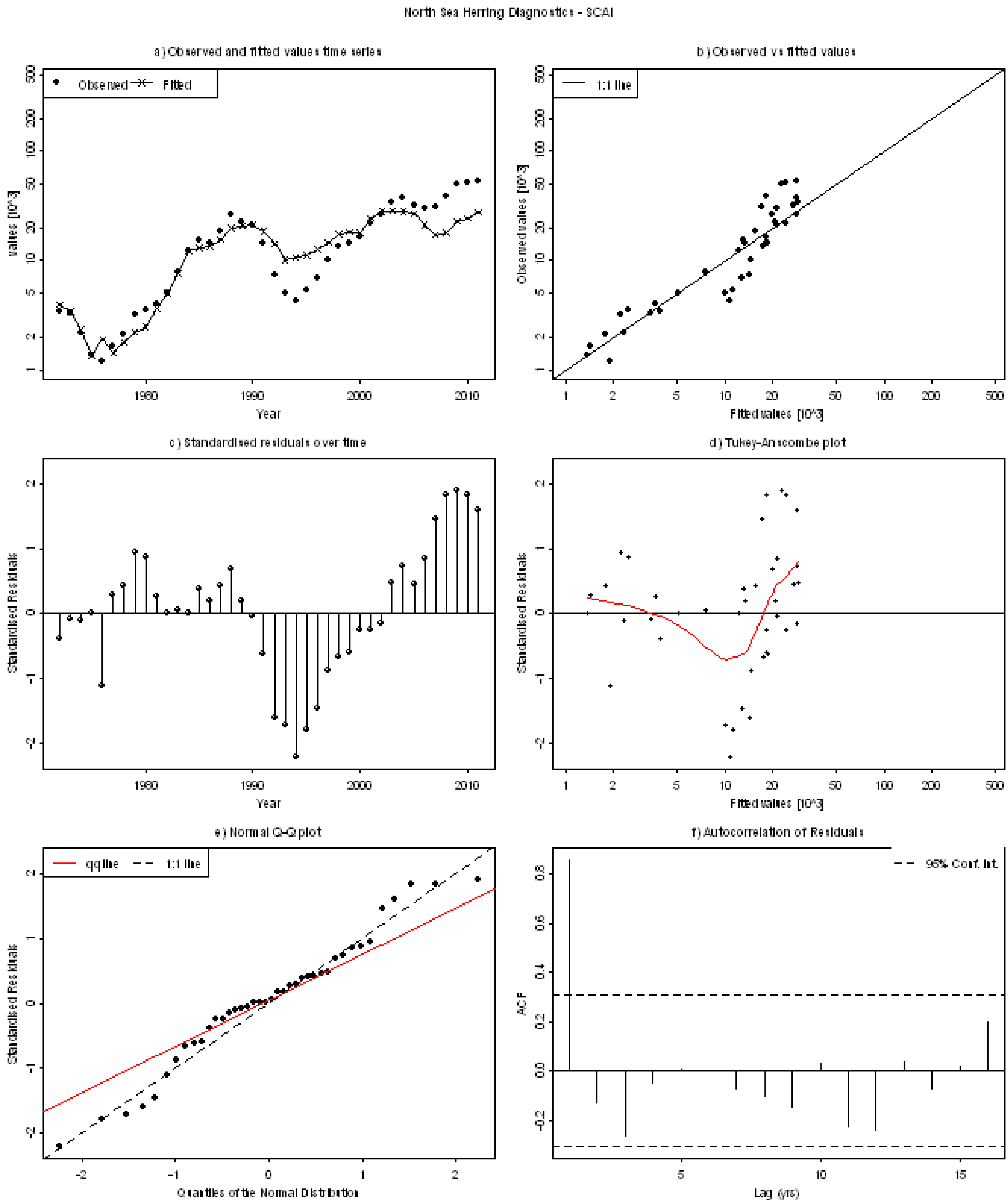


Figure 2.6.1.15. North Sea herring. Diagnostics of the assessment model fit to the SCAI SSB index time series. Top left: Estimates of SSB (line) and SSB predicted from assessment model. Top right: scatterplot of SSB observations versus assessment model estimates with the best-fit catchability model (linear function). Middle right: SSB observation versus standardized residuals. Middle left: Time series of standardized residuals of the SSB. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

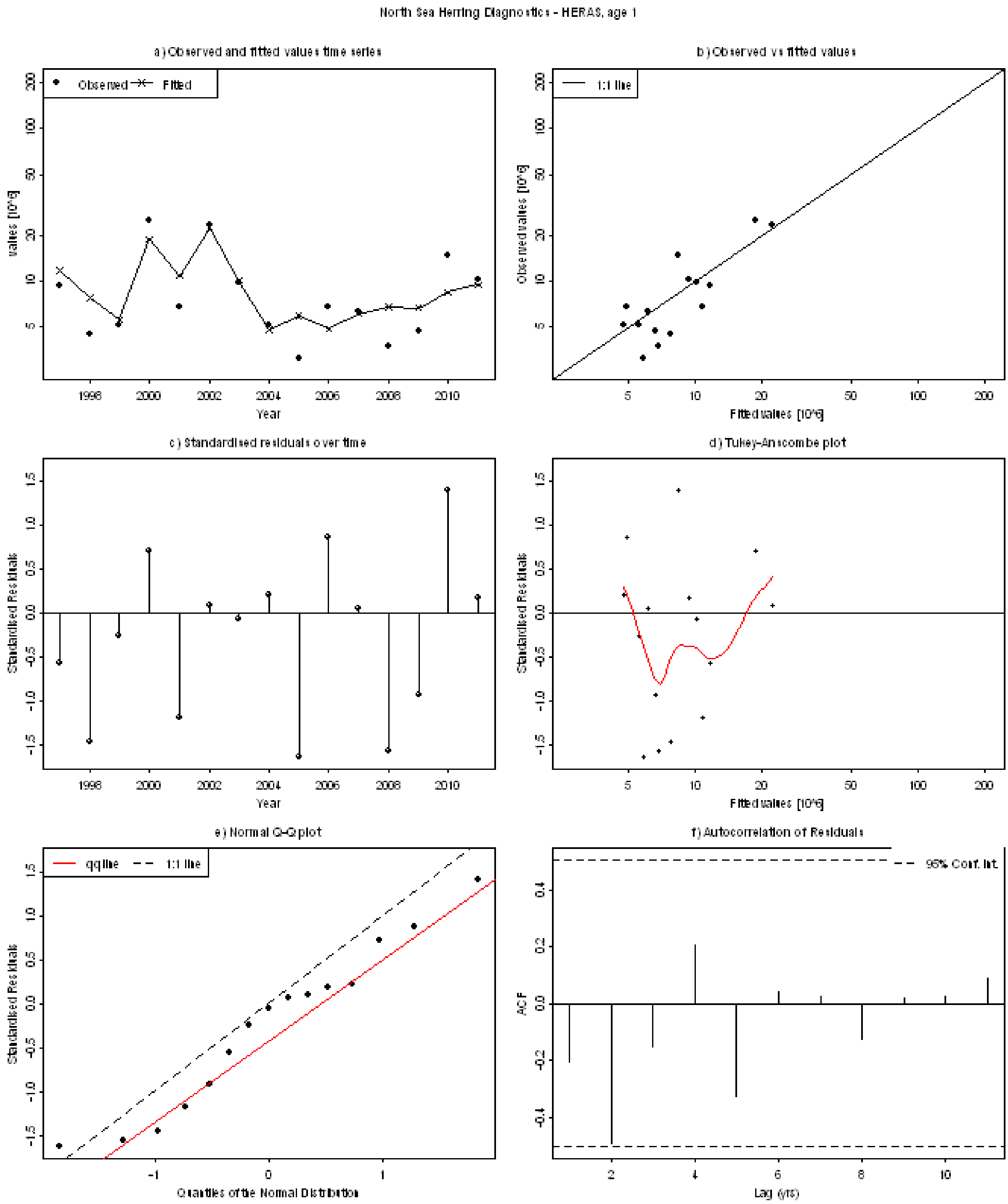


Figure 2.6.1.16. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

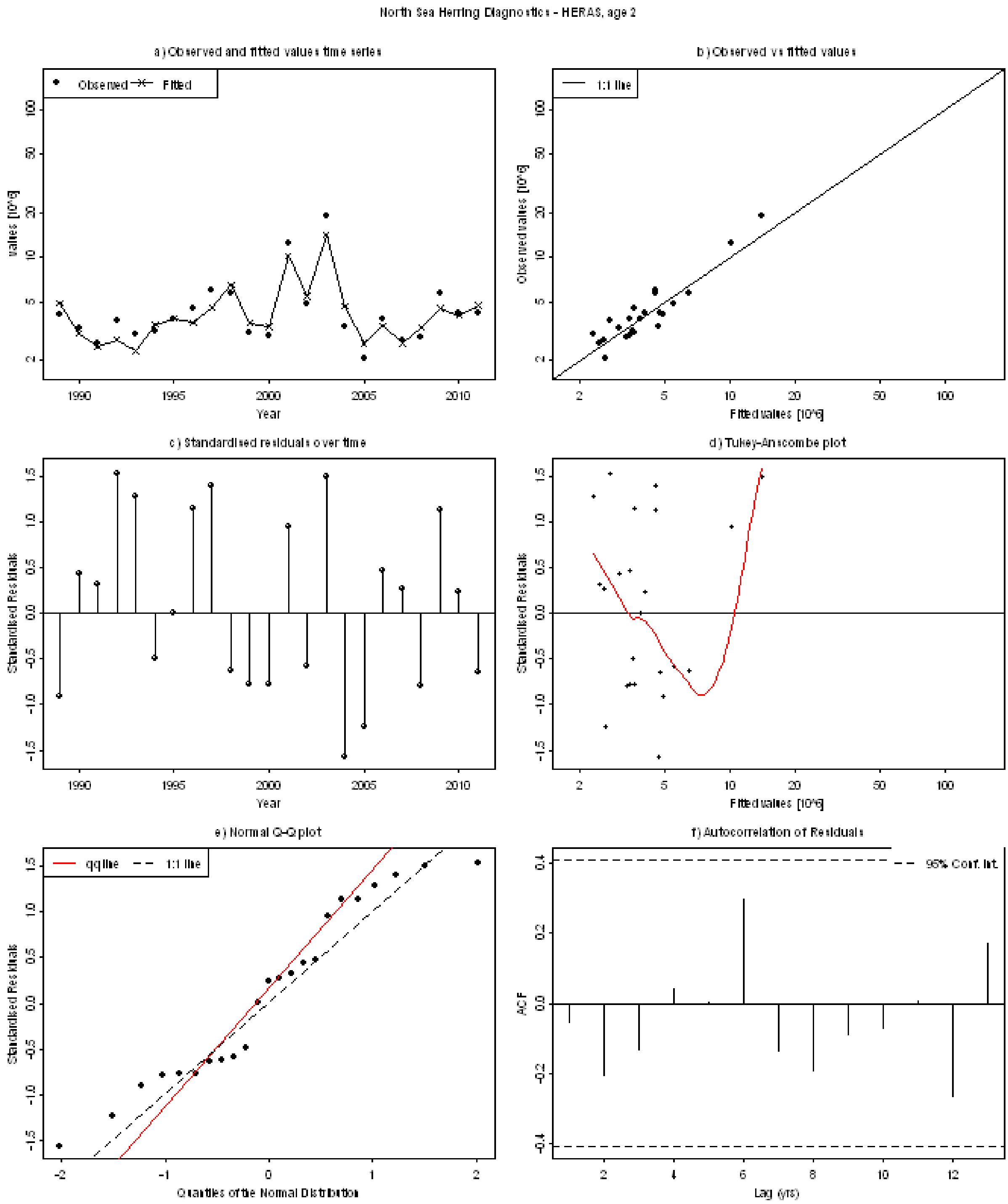


Figure 2.6.1.17. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 2 wr time series. Top left: Estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 2 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 2 wr. Middle left: Time series of standardized residuals of the index at 2 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

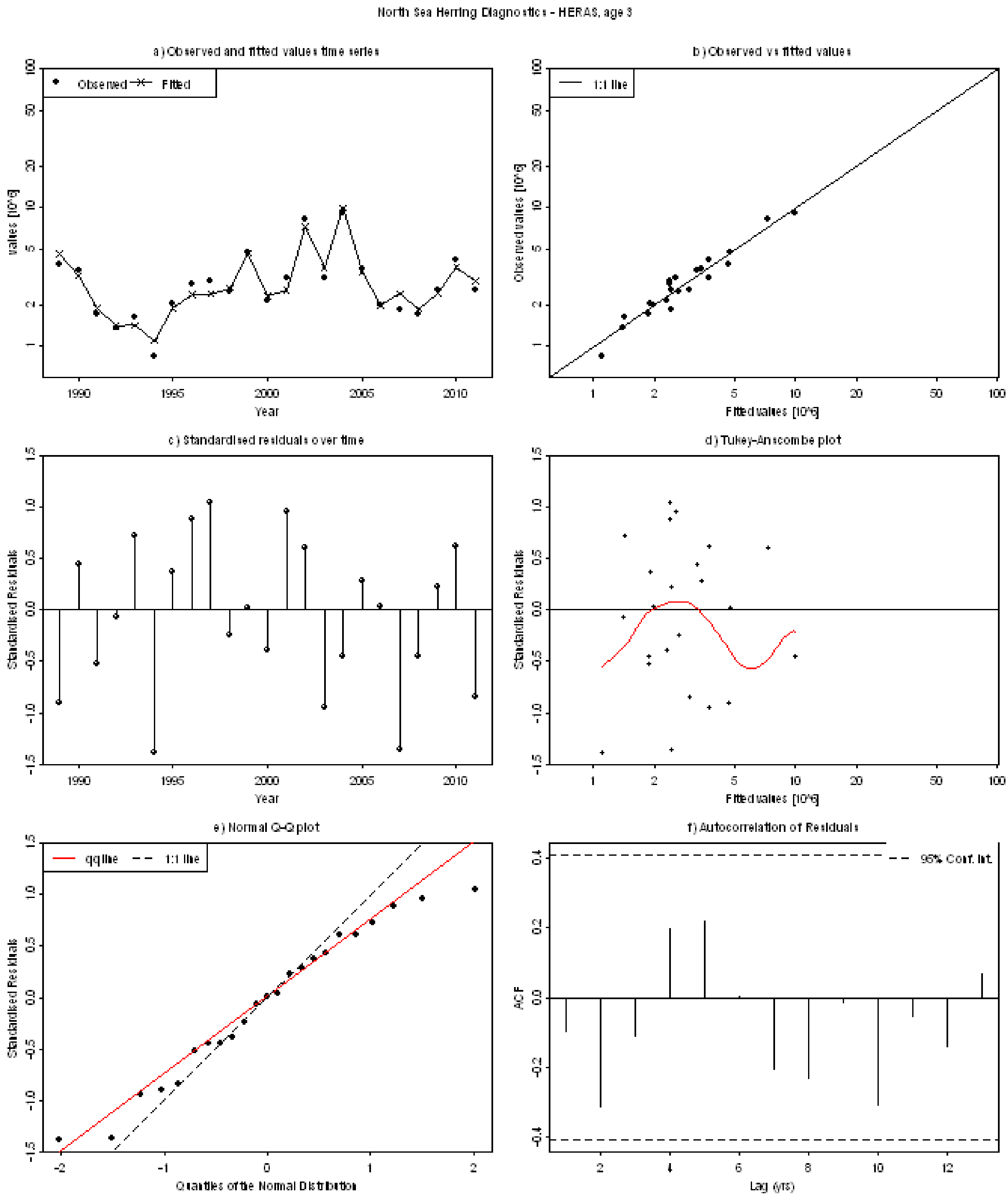


Figure 2.6.1.18. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 3 wr time series. Top left: Estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 3 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 3 wr. Middle left: Time series of standardized residuals of the index at 3 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

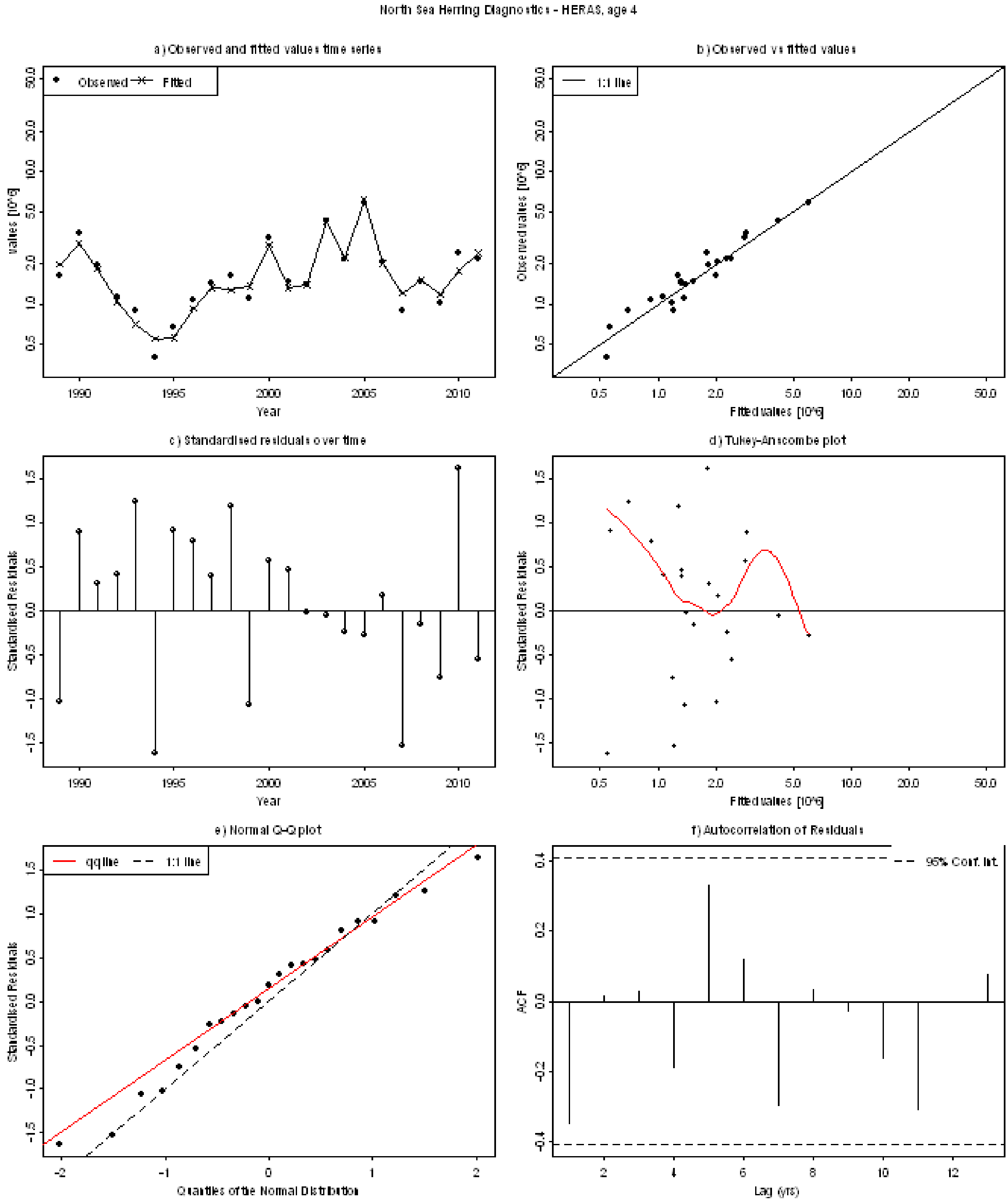


Figure 2.6.1.19. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 4 wr time series. Top left: Estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 4 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 4 wr. Middle left: Time series of standardized residuals of the index at 4 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

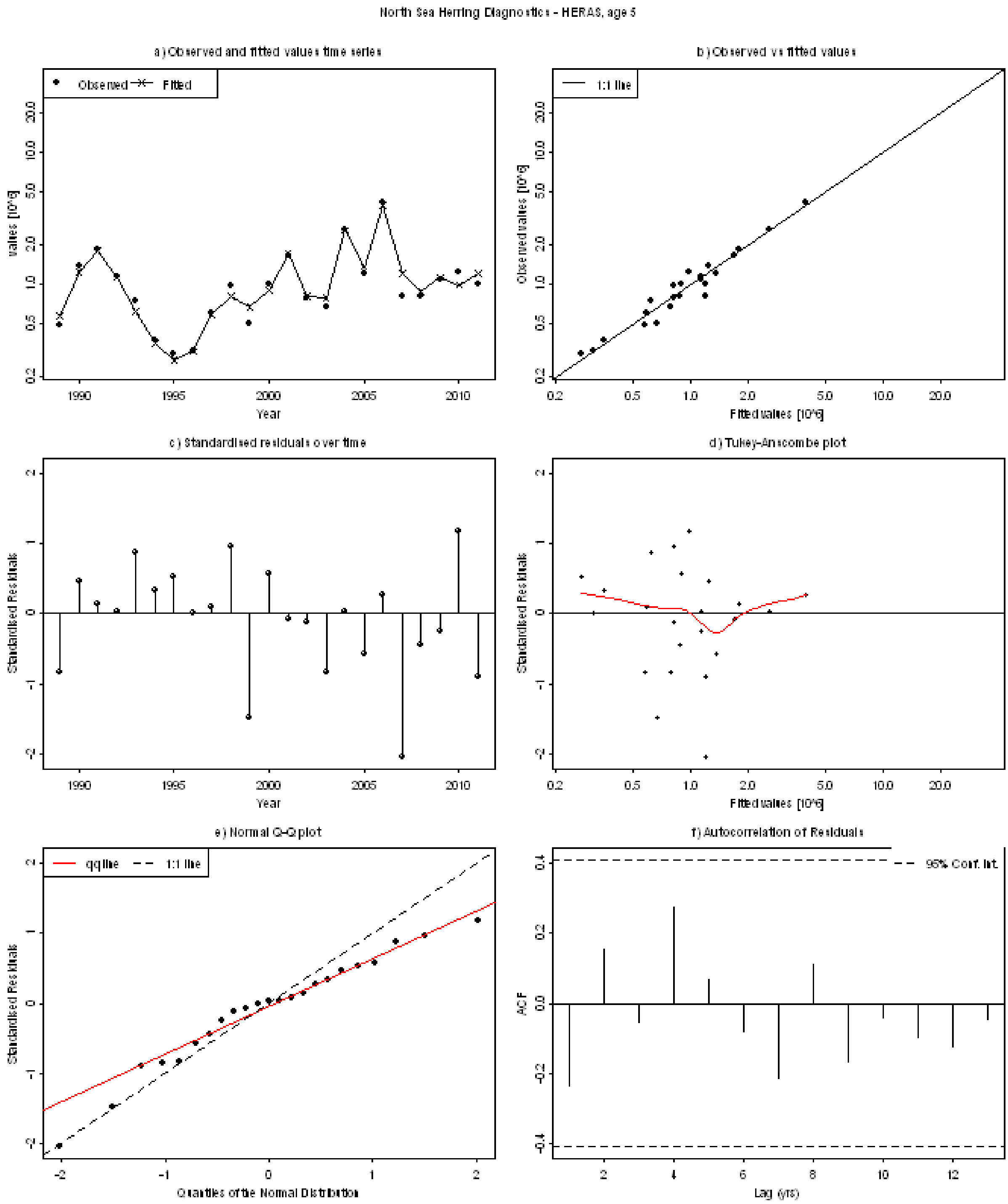


Figure 2.6.1.20. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 5 wr time series. Top left: Estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 5 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 5 wr. Middle left: Time series of standardized residuals of the index at 5 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

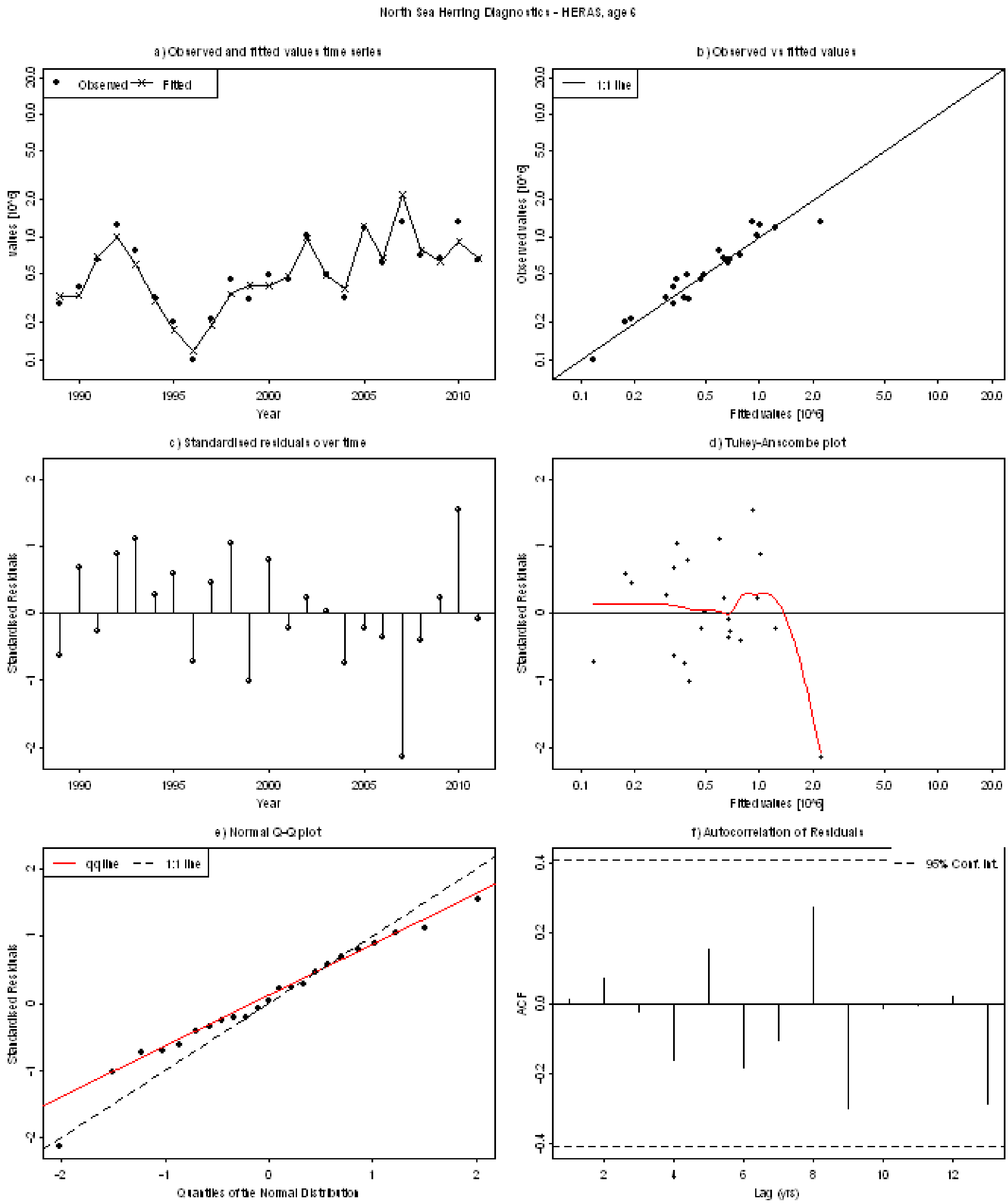


Figure 2.6.1.21. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 6 wr time series. Top left: Estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 6 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 6 wr. Middle left: Time series of standardized residuals of the index at 6 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

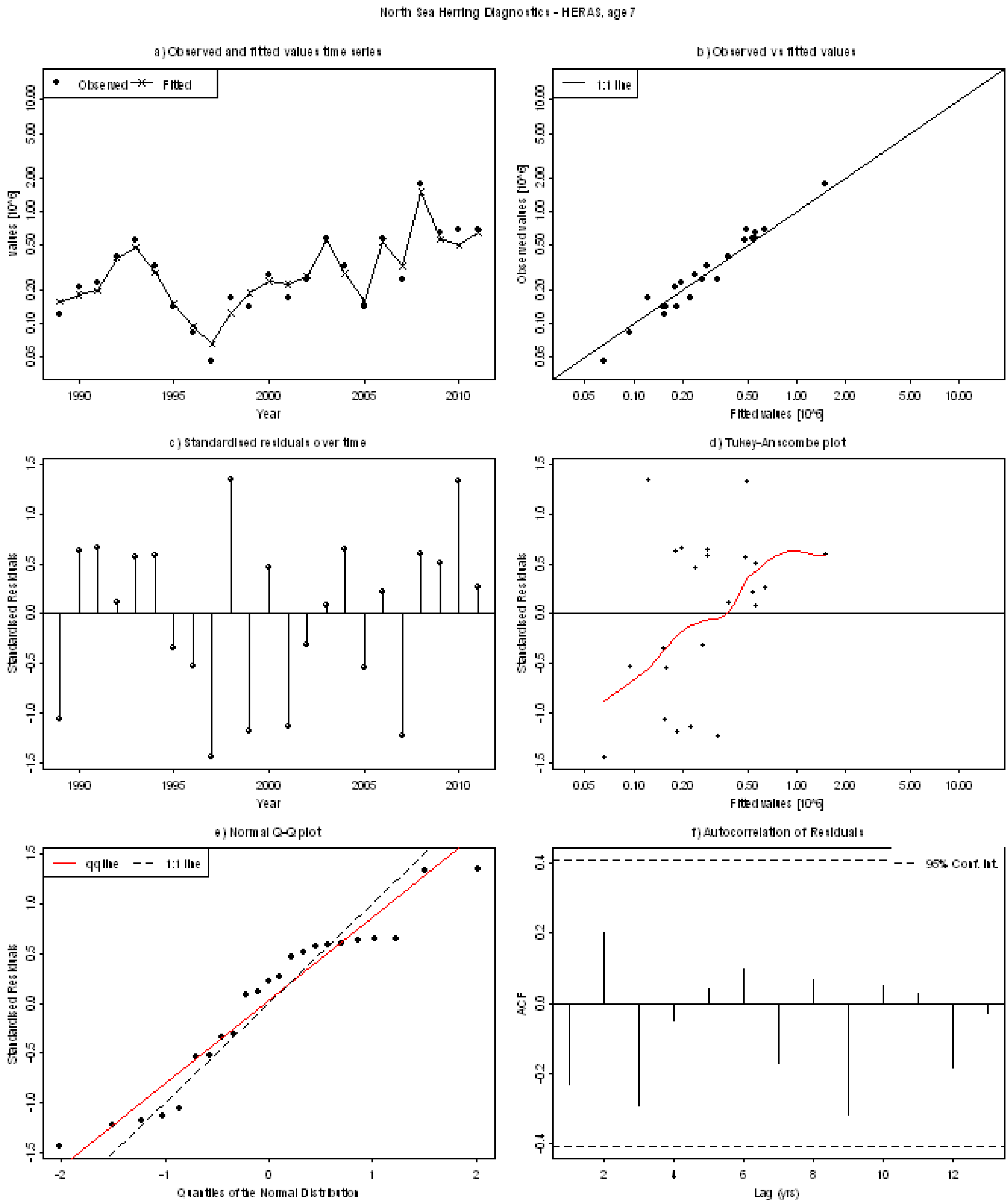


Figure 2.6.1.22. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 7 wr time series. Top left: Estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 7 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 7 wr. Middle left: Time series of standardized residuals of the index at 7 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

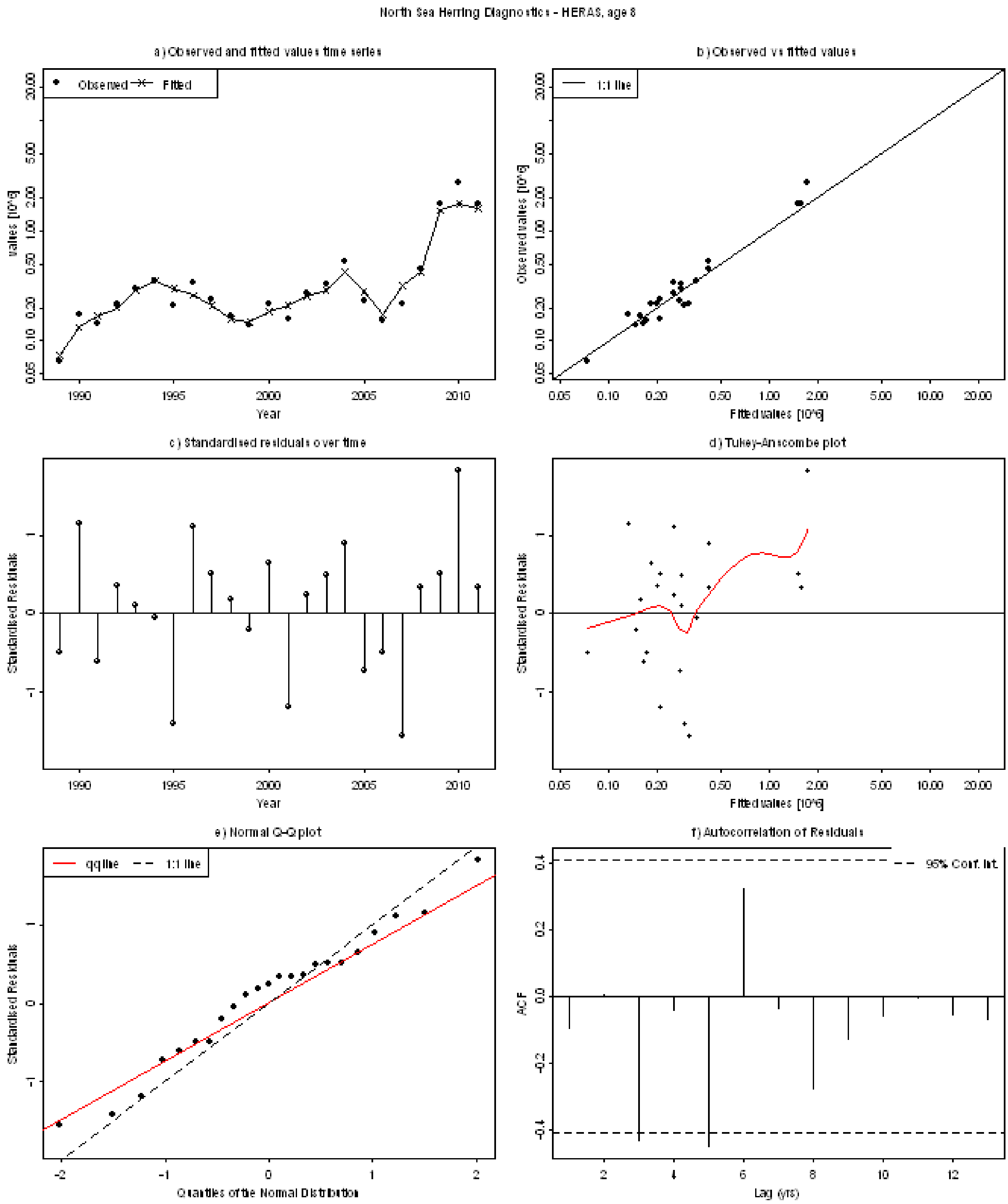


Figure 2.6.1.23. North Sea herring. Diagnostics of the assessment model fit to the HERAS index at age 8+ wr time series. Top left: Estimates of numbers at 8+ wr (line) and numbers predicted from index abundance at 8+ wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 8+ wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 8+ wr. Middle left: Time series of standardized residuals of the index at 8+ wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

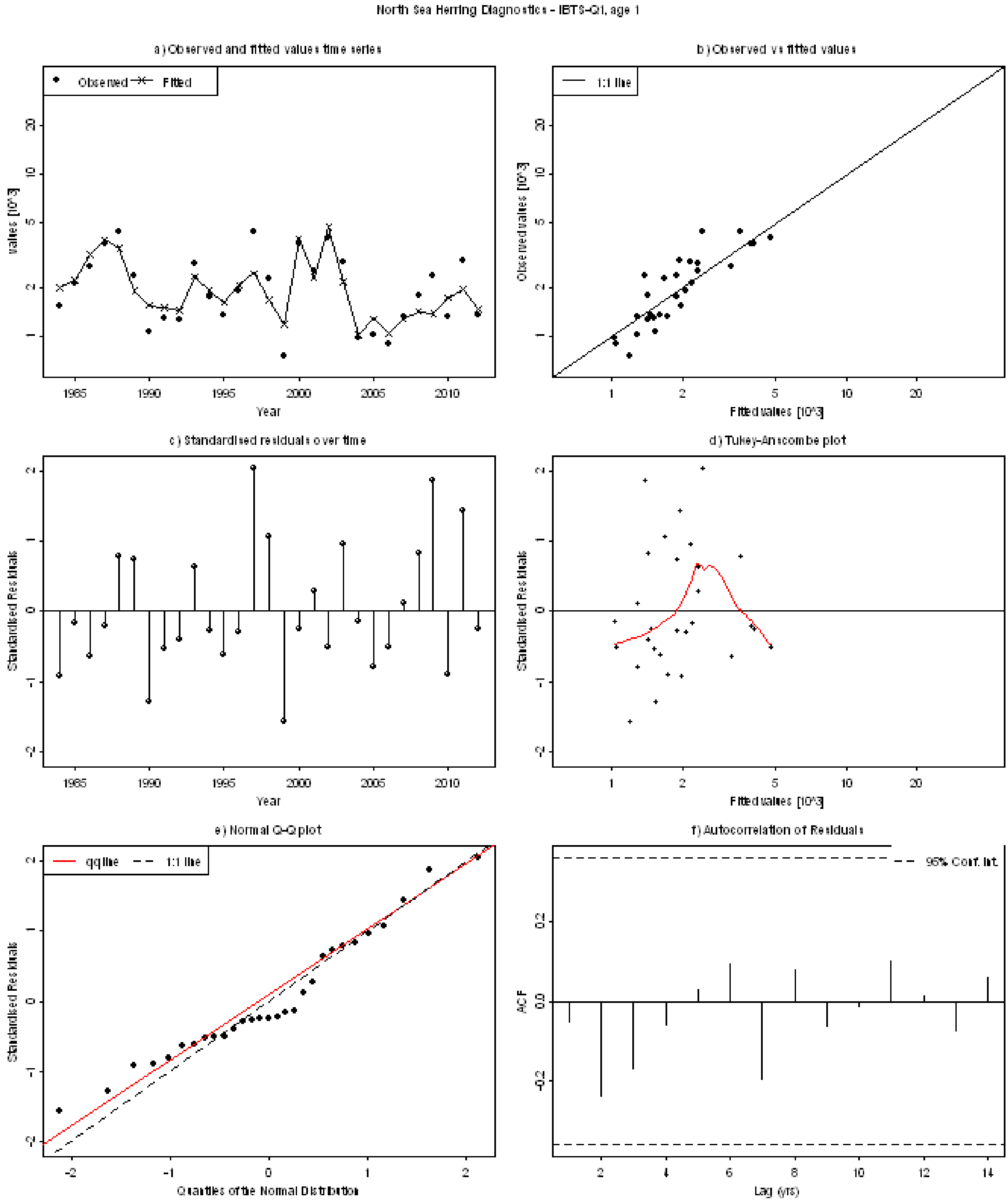


Figure 2.6.1.24. North Sea herring. Diagnostics of the assessment model fit to the IBTS-Q1 index at age 1 wr time series. Top left: Estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 1 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 1 wr. Middle left: Time series of standardized residuals of the index at 1 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

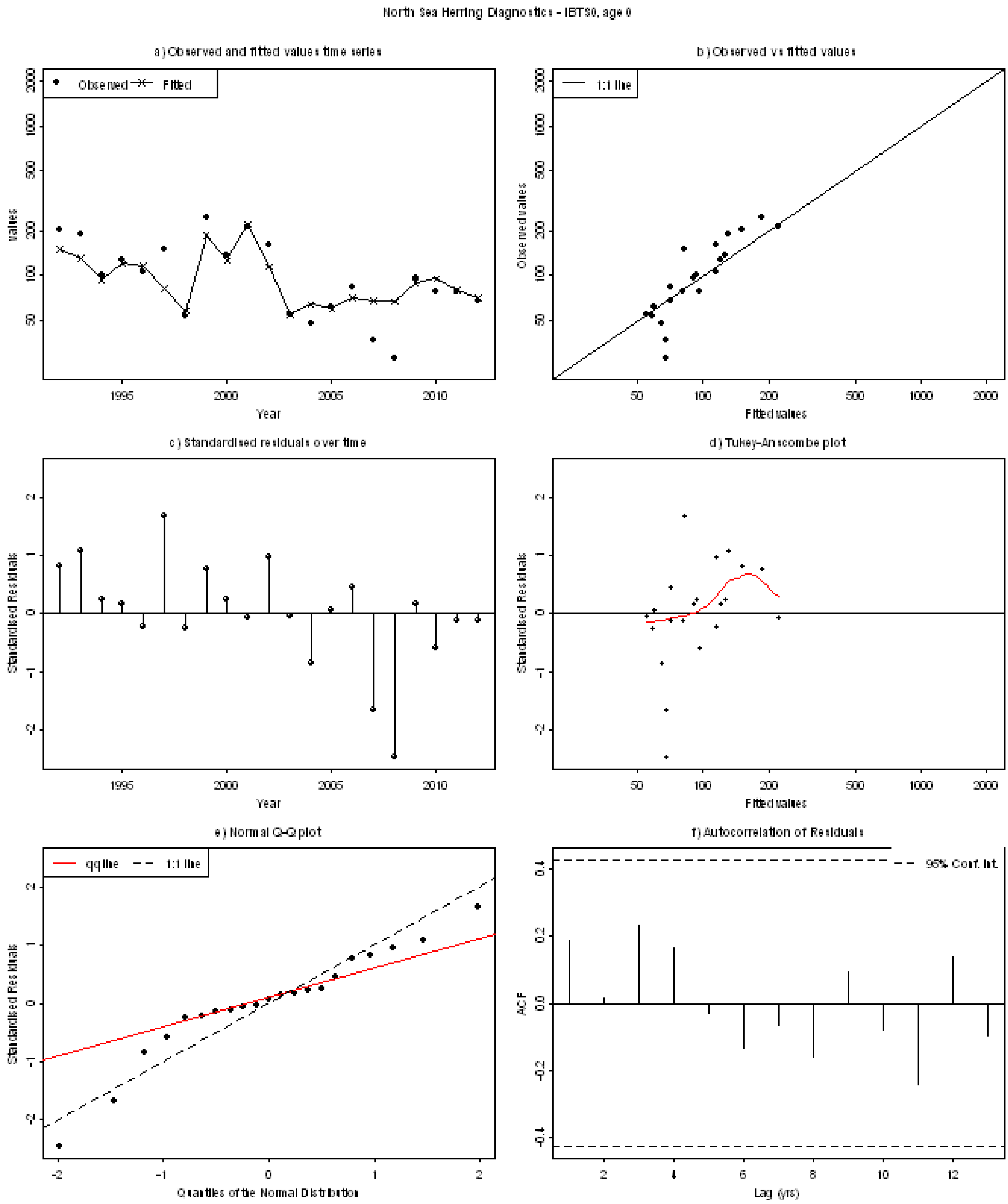


Figure 2.6.1.25. North Sea herring. Diagnostics of the assessment model fit to the IBTS0 index at age 0 wr time series. Top left: Estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus assessment model estimates of numbers at 0 wr with the best-fit catchability model (linear function). Middle right: index observation versus standardized residuals at 0 wr. Middle left: Time series of standardized residuals of the index at 0 wr. Bottom left: normal Q-Q plot of standardized residuals. Bottom right: Autocorrelation plot.

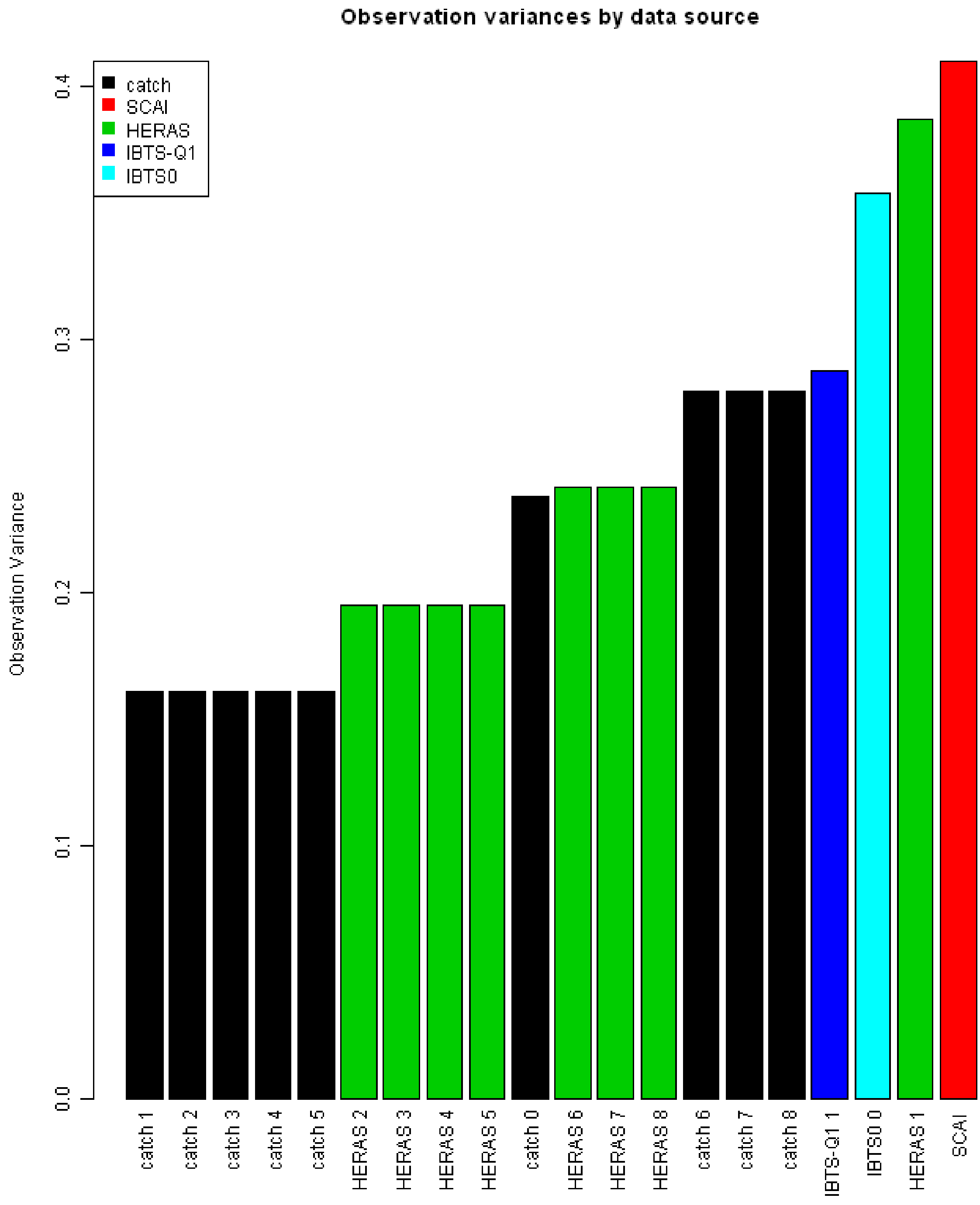


Figure 2.6.1.26. North Sea herring. Observation variance by data source as estimated by the assessment model. Observation variance is ordered from least (left) to most (right). Colours indicate the different data sources. Observation variance is not individually estimated for each data source individually thereby reducing the parameters needed to be estimated in the assessment model. In these cases of parameter bindings, observation variances have equal values.

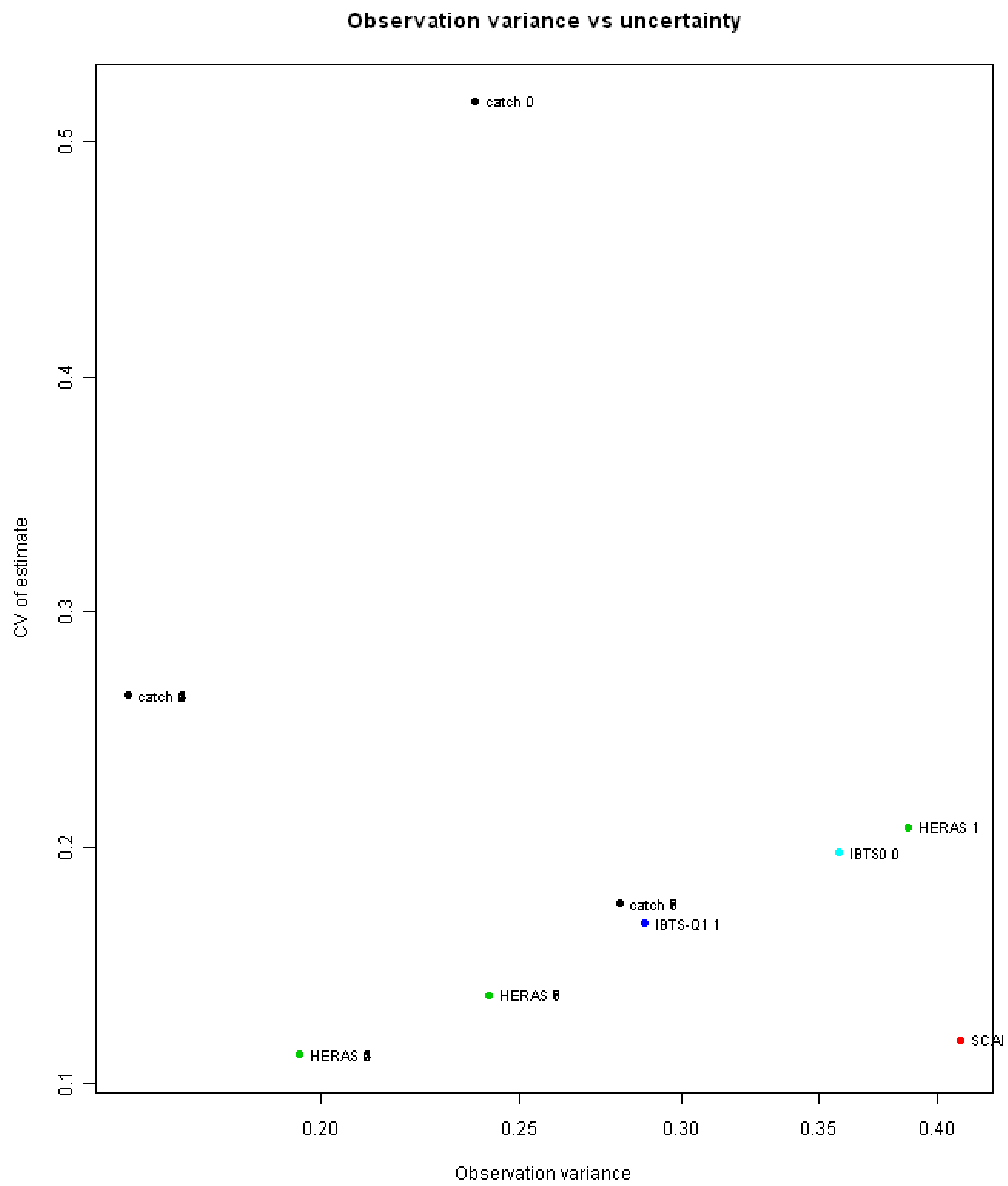


Figure 2.6.1.27. North Sea herring. Observation variance by data source as estimated by the assessment model plotted against the CV estimate of the observation variance parameter.

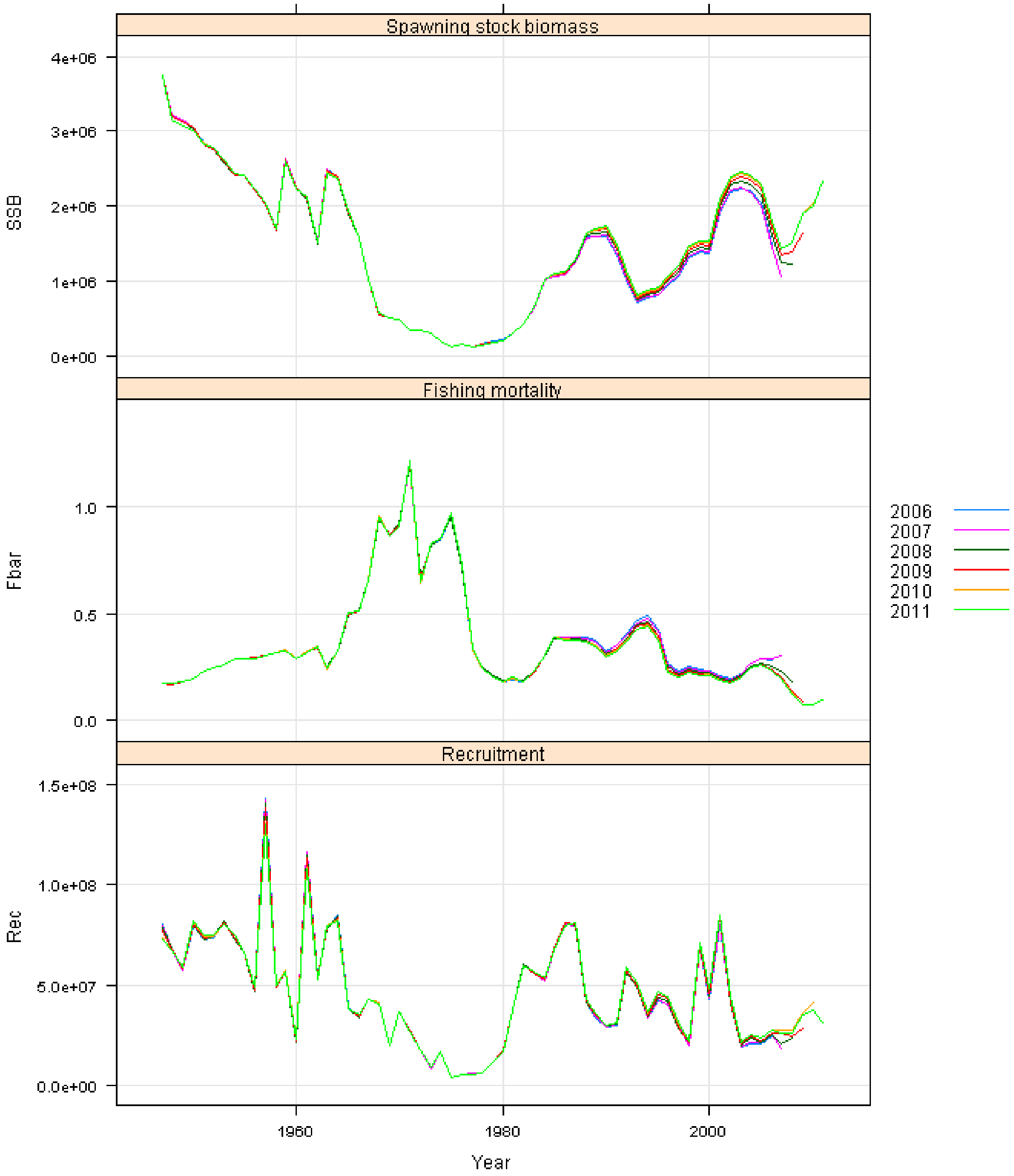


Figure 2.6.1.28. North Sea herring. Retrospective pattern of SSB (top panel) F (middle panel) and recruitment (bottom panel) for the assessments with respectively terminal years in 2011 to 2006.

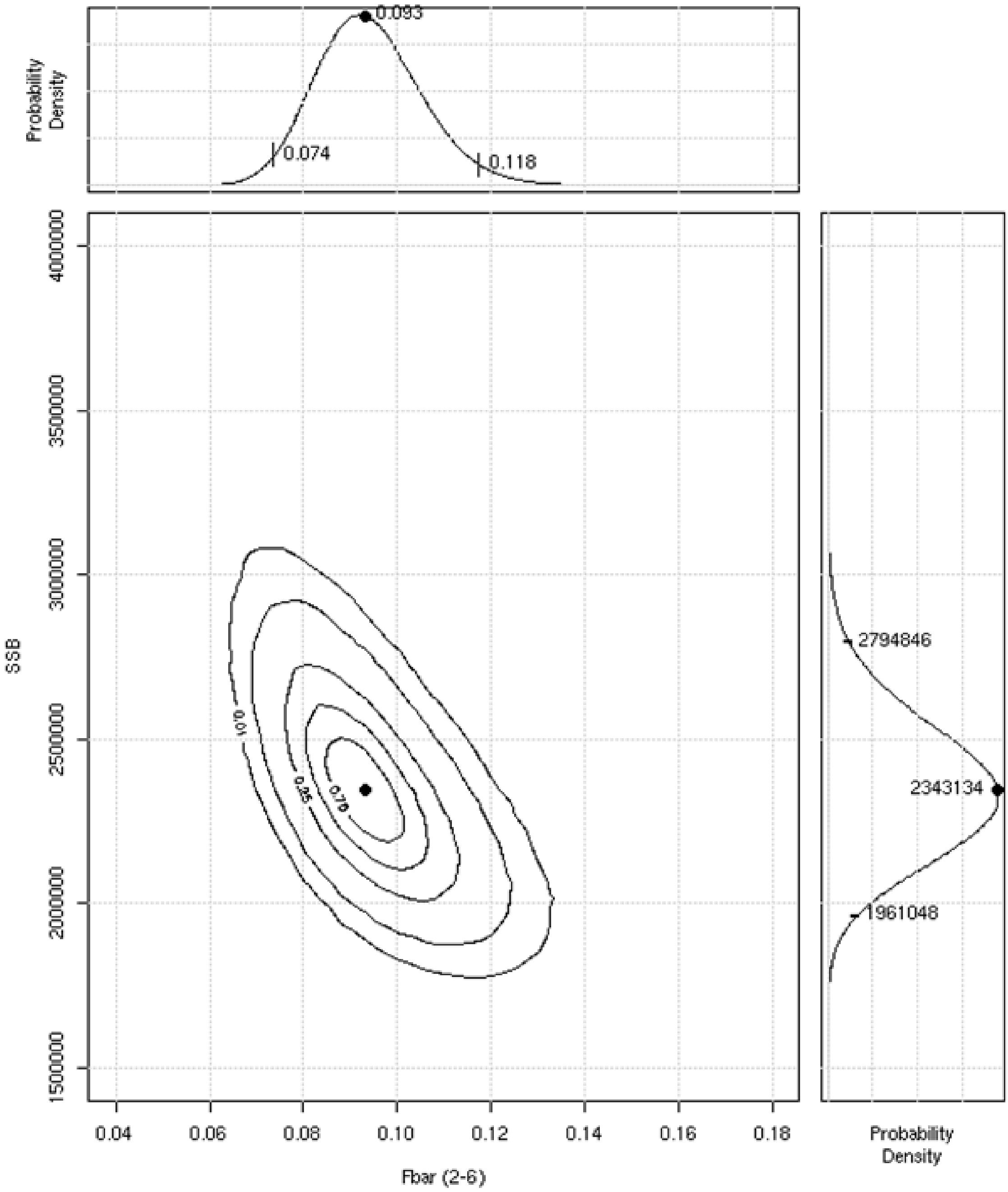


Figure 2.6.1.29. North Sea herring. Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLSAM estimated variance / covariance estimates from the model.

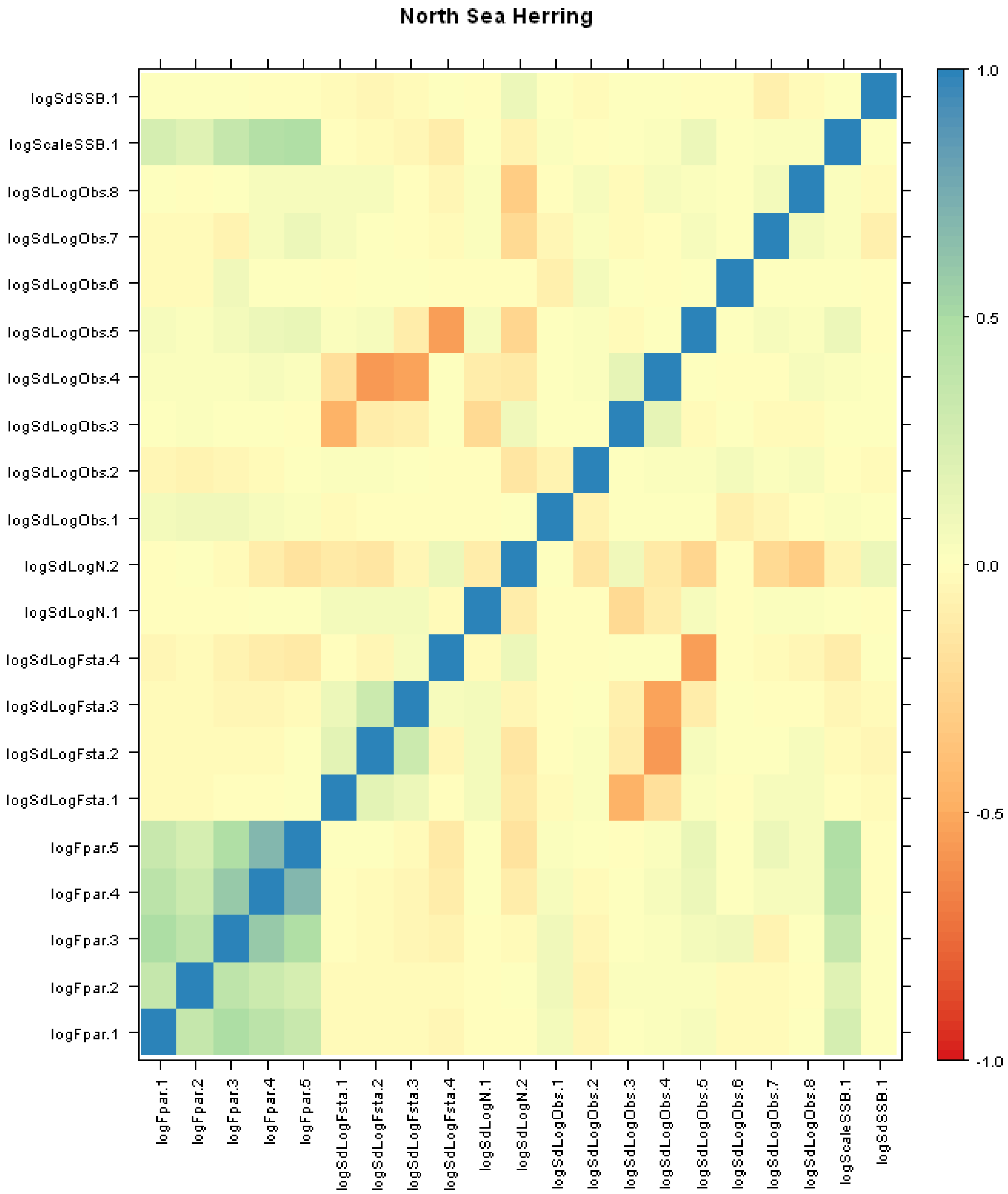


Figure 2.6.1.30. North Sea herring. Correlation plot of the FLSAM assessment model with the final set of parameters estimated in the model. The diagonal represents the correlation with the data source itself.

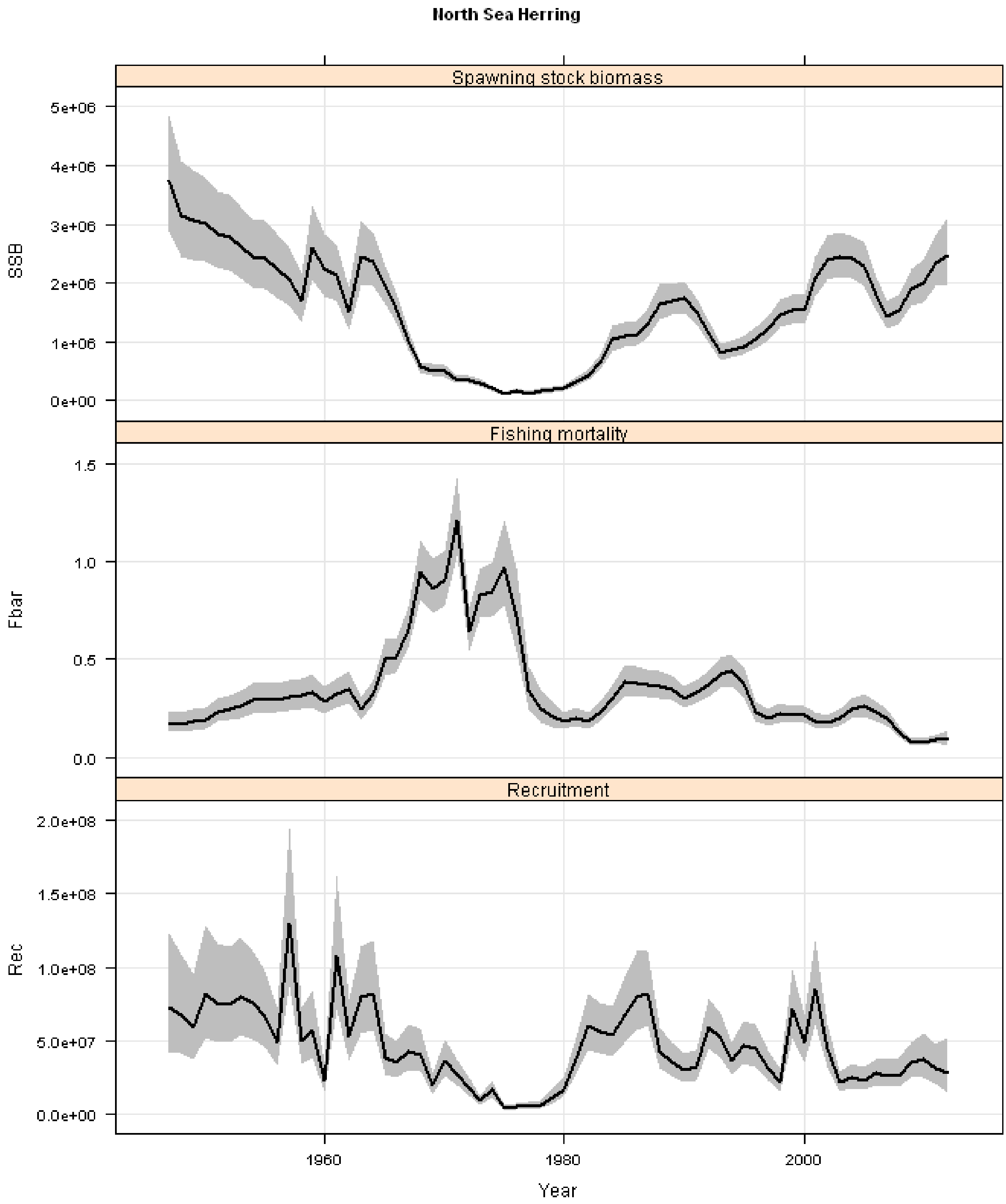


Figure 2.6.3.1 North Sea herring. Stock summary plot of North Sea herring with associated uncertainty for SSB (top panel), F ages 2-6 (middle panel) and recruitment (bottom panel).

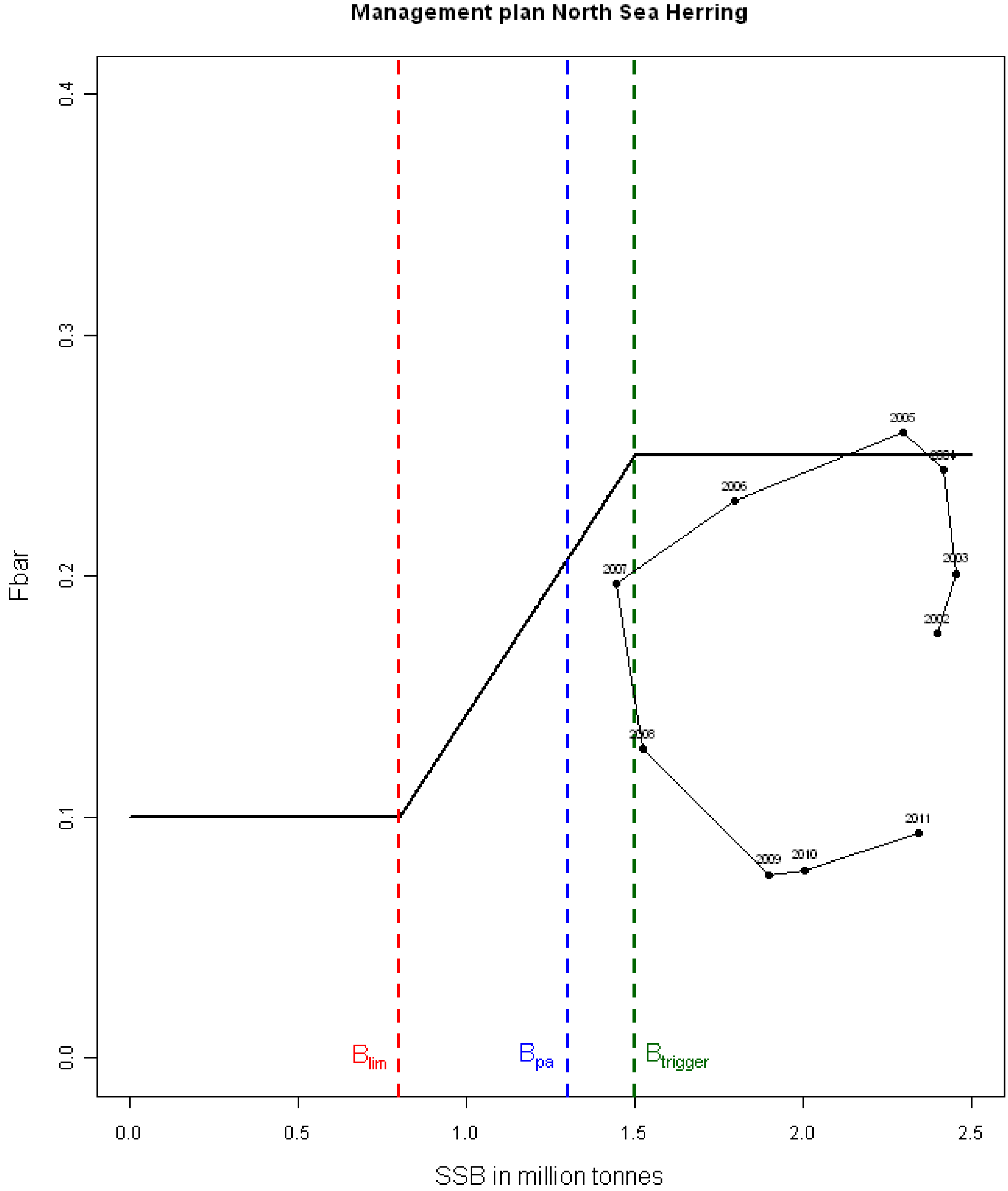


Figure 2.6.3.2. North Sea herring. Agreed management plan for North Sea herring including the most recent 10 years of SSB and F as estimated within the assessment in relation with the management plan.

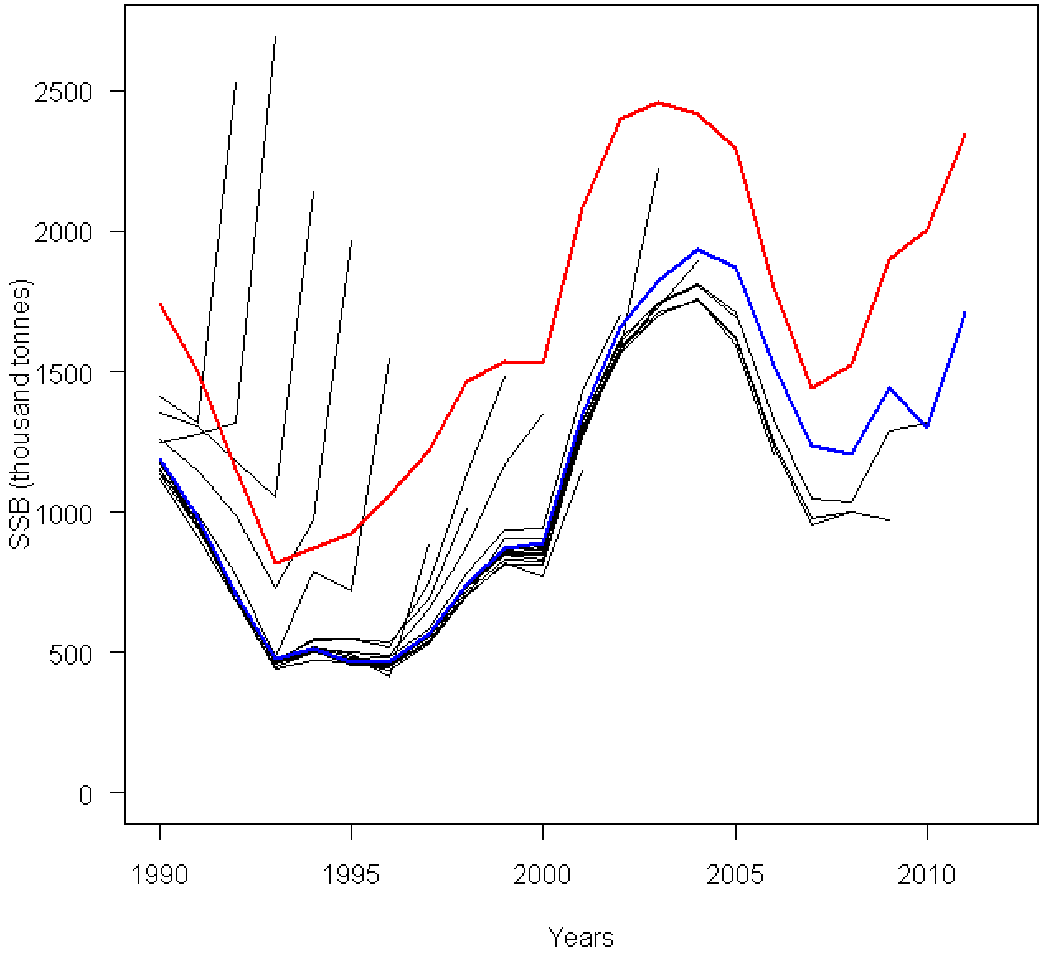


Figure 2.10.1 North Sea Autumn Spawning Herring. Historic retrospective of the estimated spawning stock biomass showing the results of the WKPELA benchmark assessment (red line) and the results of the HAWG 2011 assessment (blue line). Assessments from HAWG work groups prior to 2011 are shown in black.

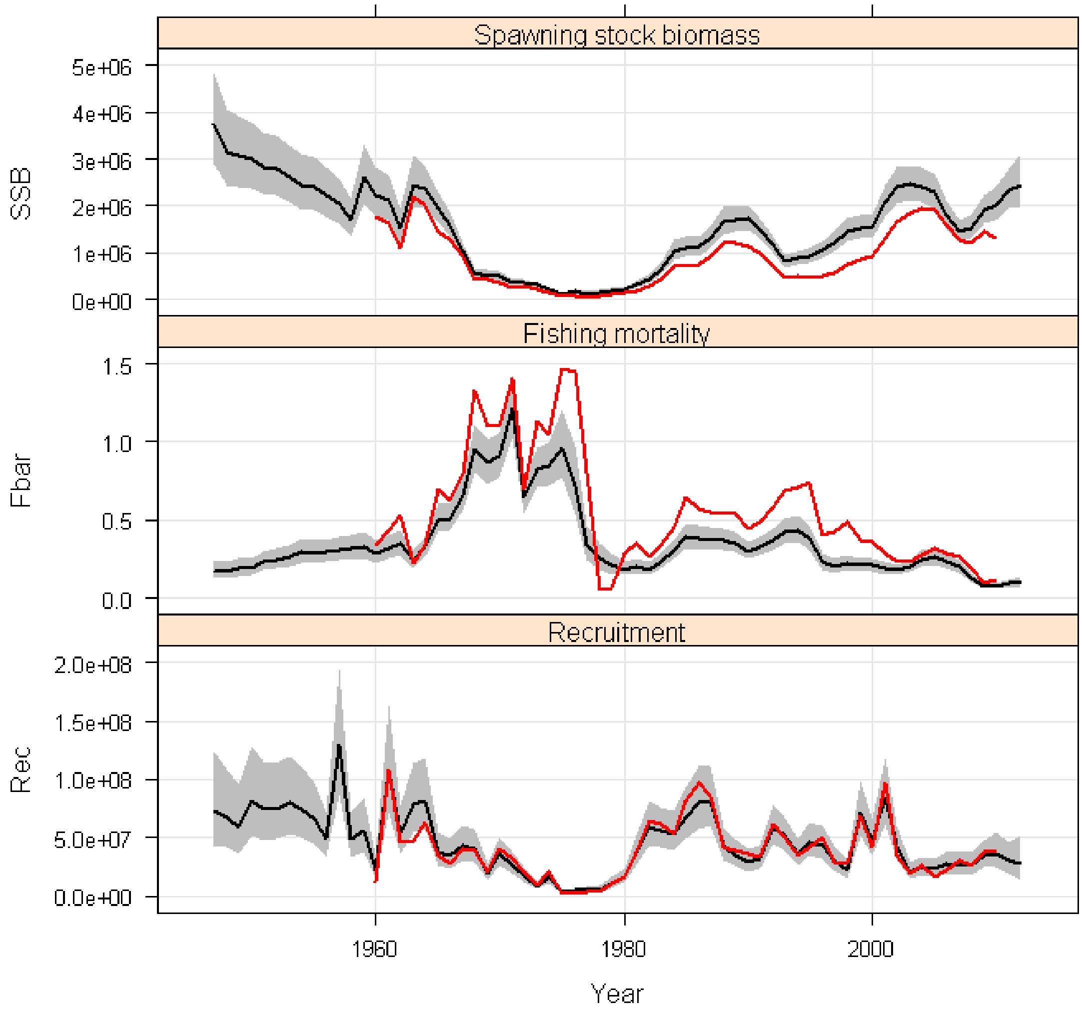


Figure 2.10.2 North Sea Autumn Spawning herring. Historic retrospective showing the results of the HAWG 2012 FLSAM assessment of the stock (black line) with 95% confidence intervals (grey area) and the HAWG 2011 FLICA assessment.

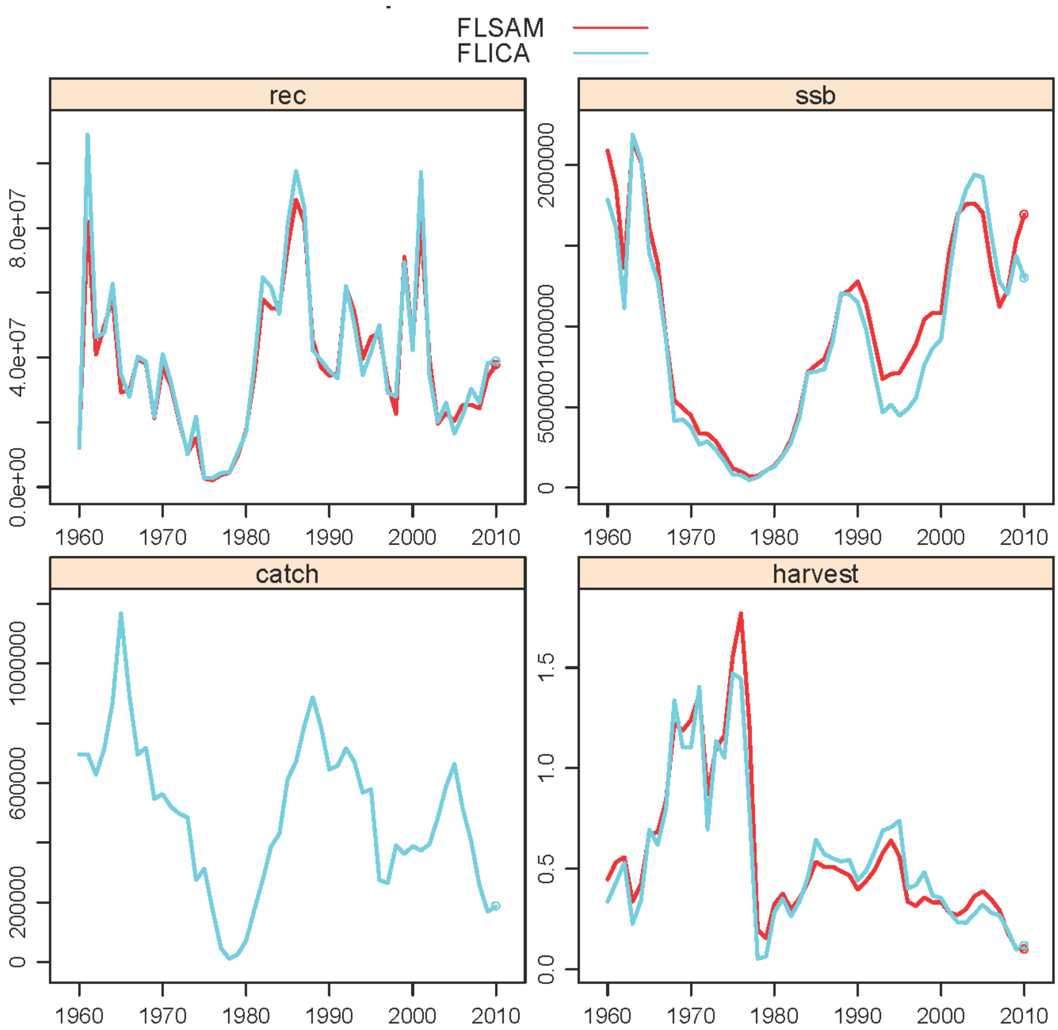


Figure 2.10.3 North Sea Autumn Spawning Herring. Comparison of the results of the HAWG 2011 FLICA assessment (blue line) with an FLSAM assessment (red line) performed under a similar set of input data (from ICES WKPELA 2012). Confidence intervals about the FLSAM model are not shown but generally encapsulate the FLICA time series. Furthermore, the FLSAM assessment shown here has not been statistically validated and a direct comparison between these output results should therefore be interpreted as being indicative in nature.

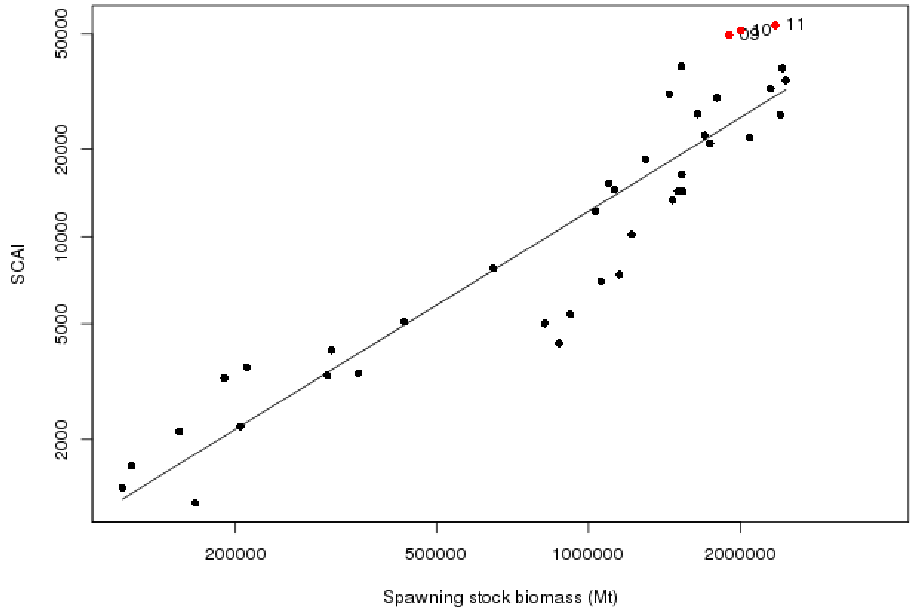


Figure 2.11.0 : North Sea herring. Relationship between the SCAI index (Payne 2010) and the spawning stock biomass . Note the logarithmic scales on both axes. The most recent three years (2009-2011) are plotted with red points and labelled with the last two digits of the years. A linear regression line between the log values is also plotted. Note that because the SSB is derived from the stock-assessment model here, which incorporates the SCAI as a tuning index, the two axes cannot be considered independent – the relationship shown here is there only indicative.

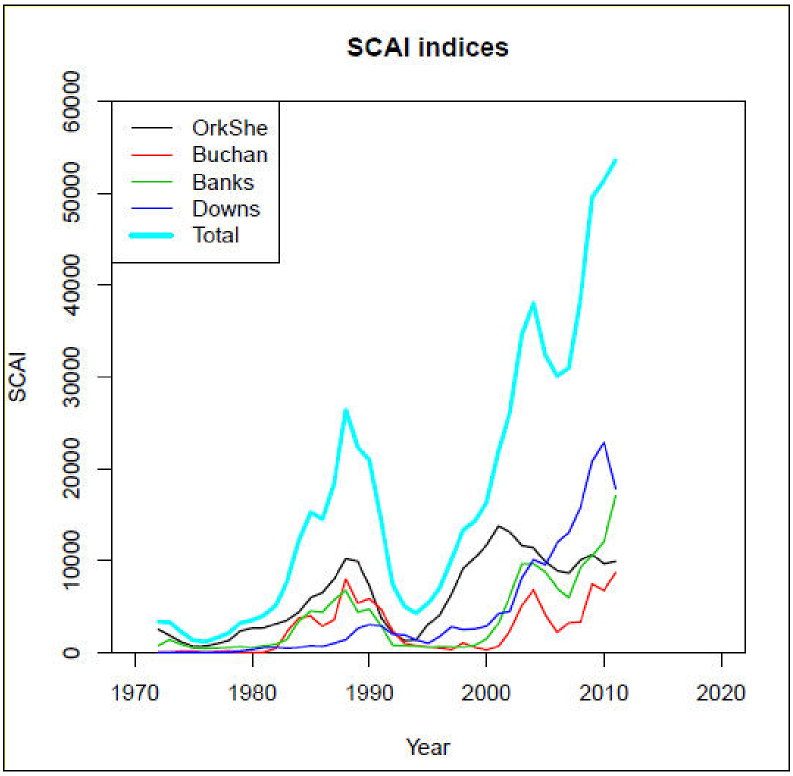


Figure 2.11.1 : North Sea herring. Relative dynamics of the individual North Sea spawning components.

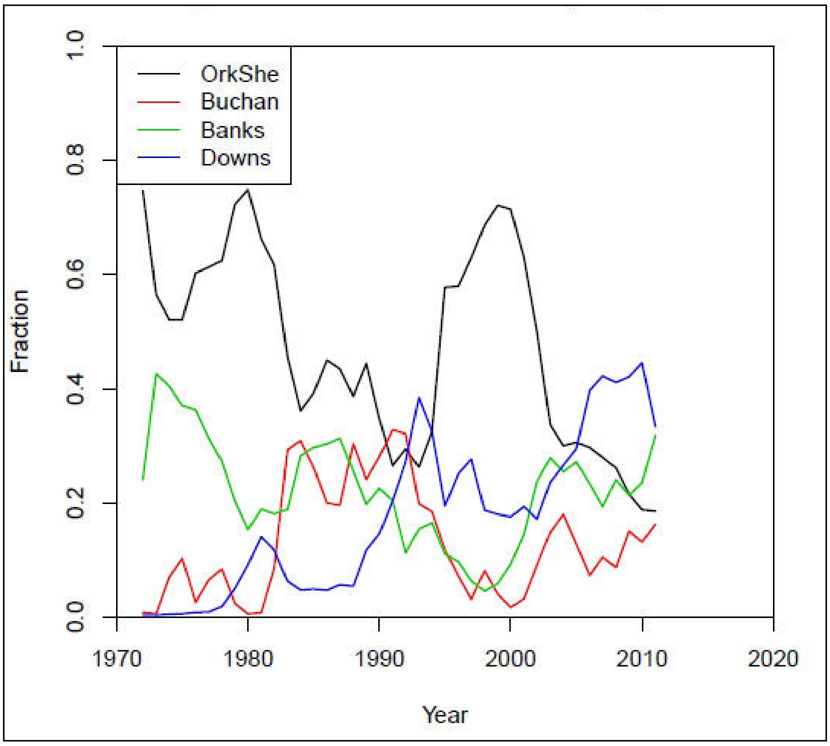


Figure 2.11.2 : North Sea herring. Proportion of spawning components.

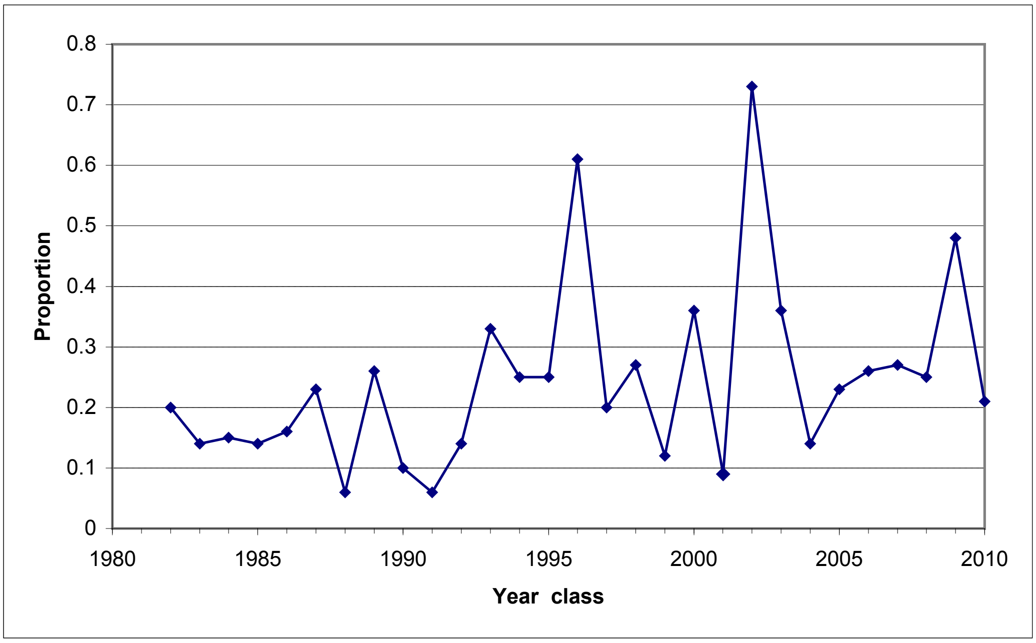


Figure 2.11.3. North Sea herring. Proportion of small 1-ringers versus all sizes in the North sea (from Table 2.3.3.2).

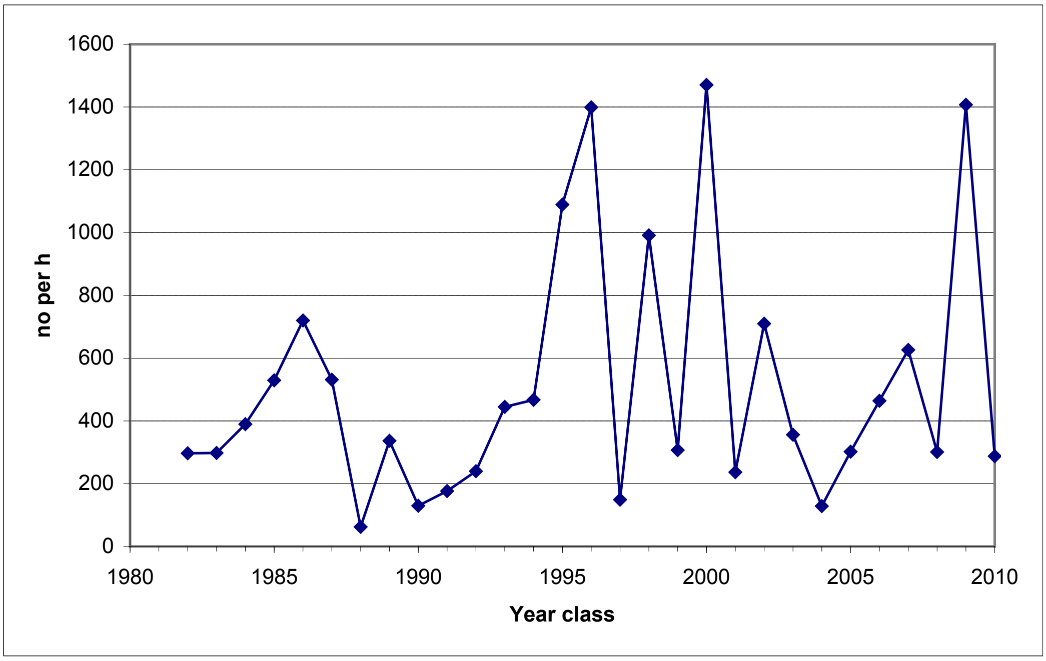


Figure 2.11.4. North Sea herring. Index (Numbers per hr) of small (<13cm) 1-ringers in the North from Table 2.3.3.2).

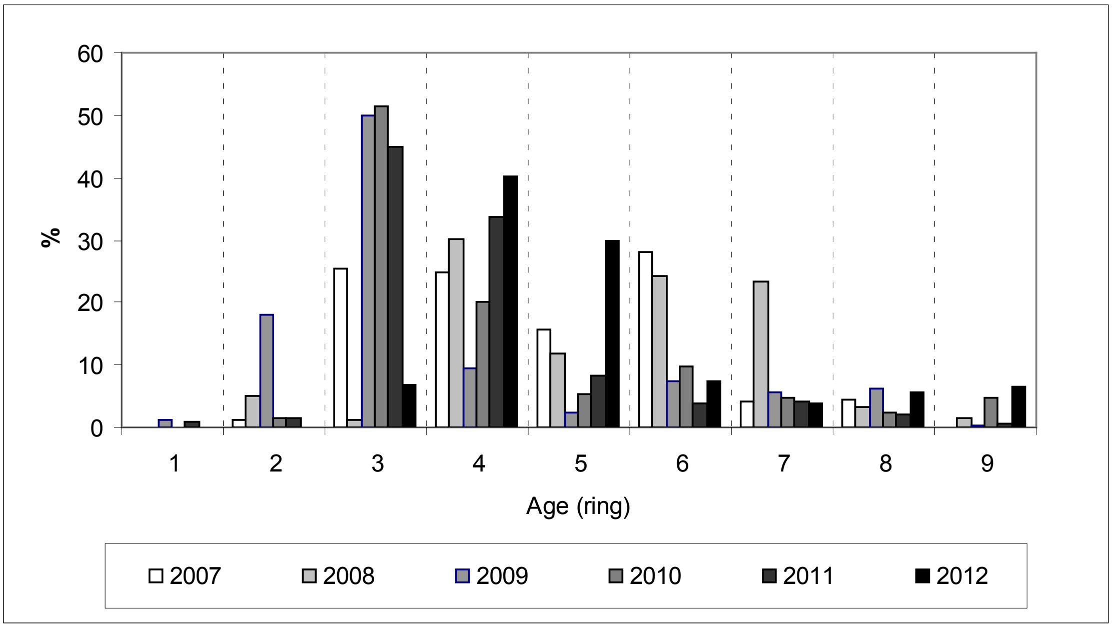


Figure 2.11.5. North Sea herring. Catch composition (percentage by age) from pelagic hauls in the Eastern English Channel during IBTS 2007 to 2011.

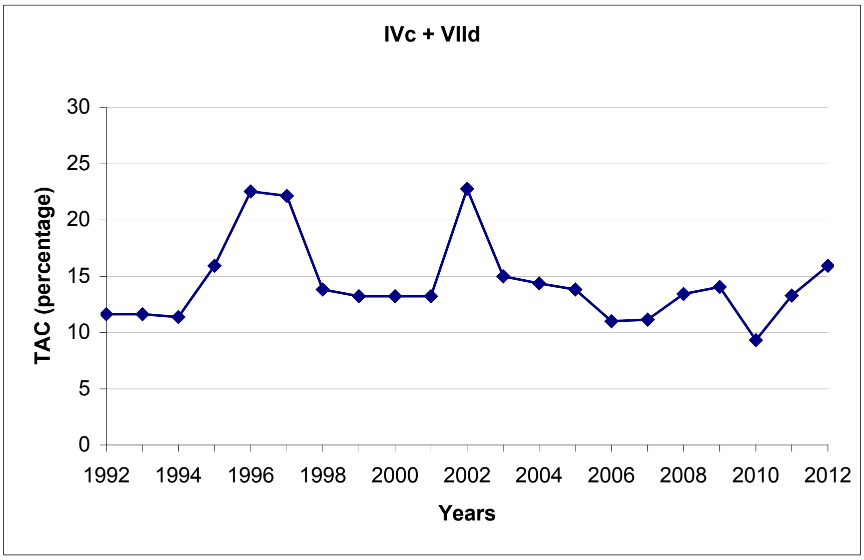


Figure 2.11.6. North Sea herring. TACs (percentage) for divisions IVc and VIId

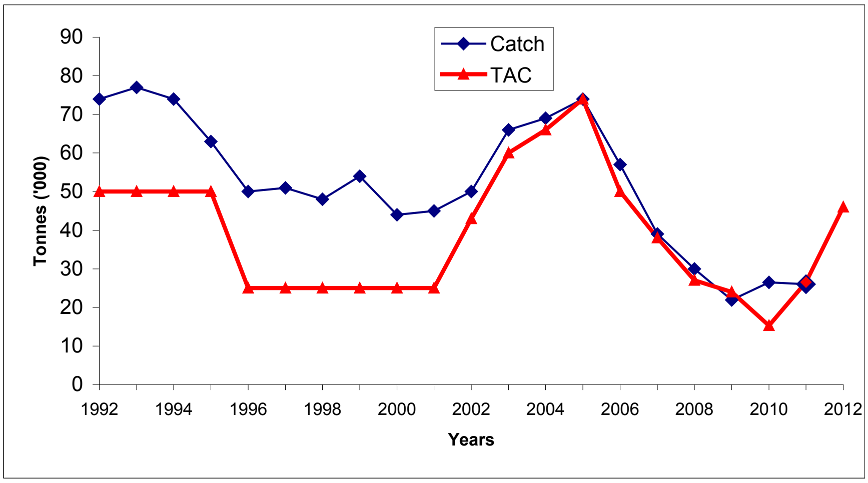


Figure 2.11.7. North Sea herring. Downs herring in IVc and VIId. Comparison of historical catches and TACs.

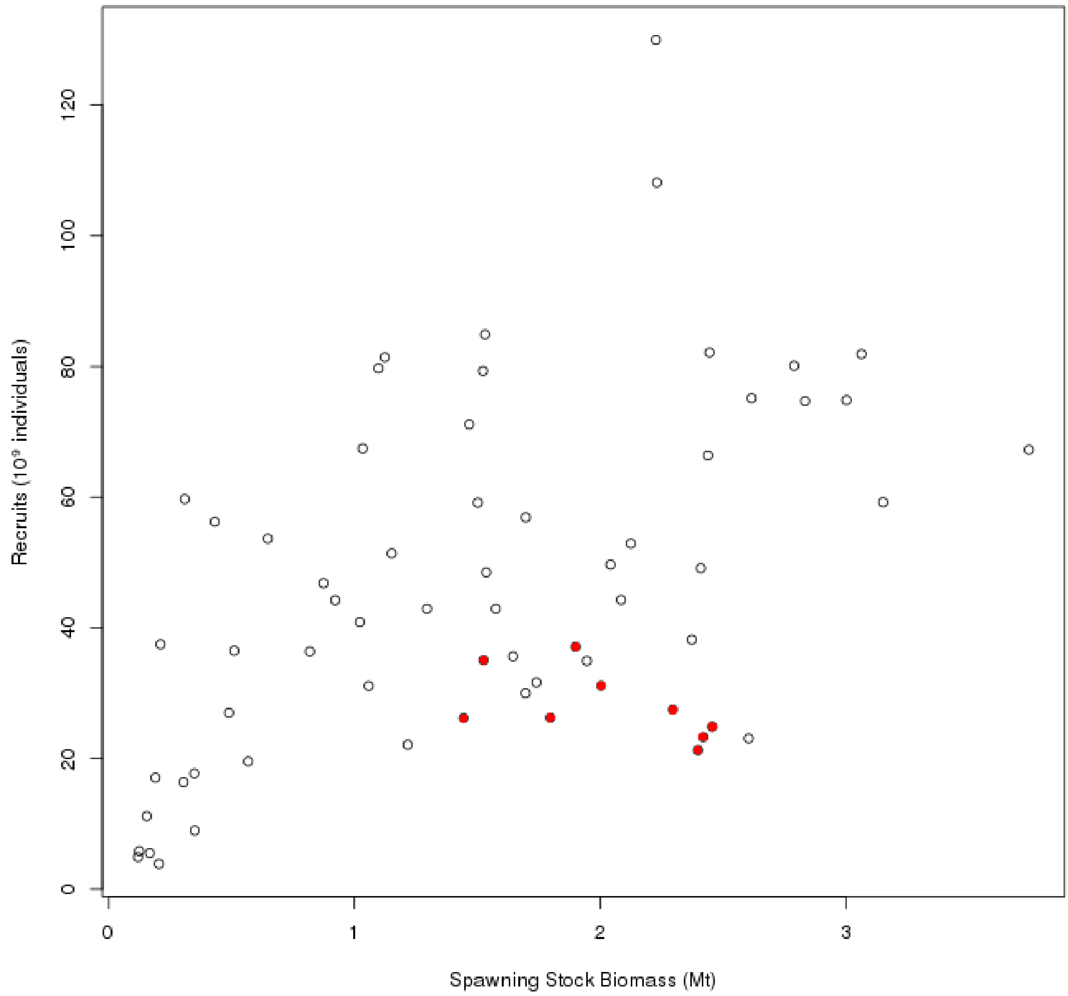


Figure 2.14.1. North Sea Autumn Spawning Herring. Stock recruitment curve, plotting estimated spawning stock biomass against the resulting recruitment. Year classes spawned after 2001 are plotted with fill red circles, to highlight the years of recent poor recruitment.

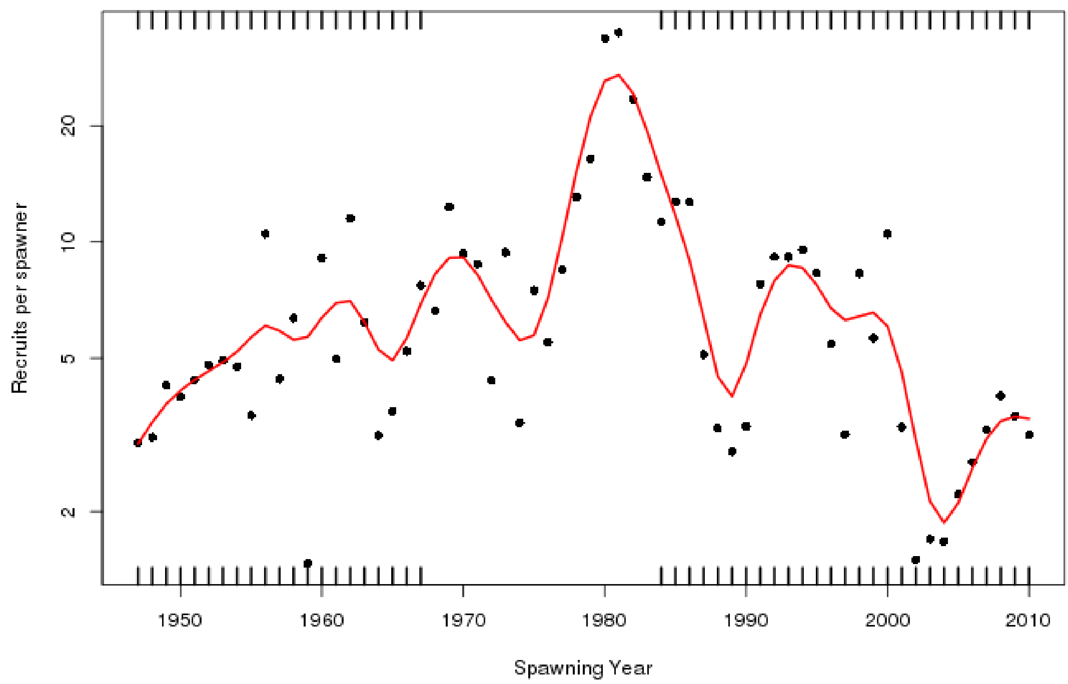


Figure 2.14.2. North Sea Autumn Spawning Herring. Time series of recruits per spawner (RPS). RPS is calculated as the estimated number of recruits from the assessment divided by the estimated number of mature fish at the time of spawning and is plotted against the year in which spawning occurred.. Black points: RPS in a given year. Red line: Spline smoother to aid visual interpretation. Internal tick marks on the horizontal axes indicate years when the spawning stock biomass is estimated as being above B_{lim} (800 000 tonnes). Note the logarithmic scale on the vertical axis.

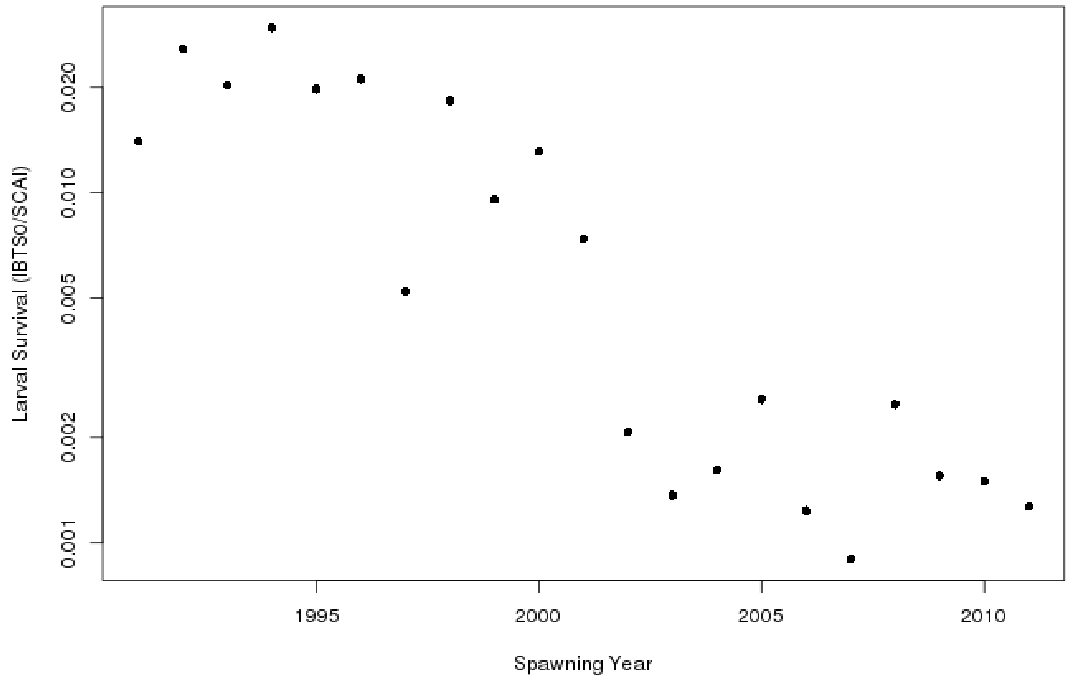


Figure 2.14.3. North Sea Autumn Spawning Herring. Time series of larval survival ratio (Dickey-Collas & Nash 2005; Payne et al 2009), defined as the ratio of the SCAI index (representing larvae less than 10-11mm) and the IBTS0 index (representing the late larvae, of approximately 20-30mm). Survival ratio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

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

3.1 The Fishery

3.1.1 Advice and management applicable to 2011 and 2012

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 42 700 t in 2012 as estimated by the last year assessment (ICES CM 2011/ACOM:06).

The EU and Norway agreement on a herring TAC for 2011 was 30 000 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 6 659 t to be taken in the small mesh fishery. For 2012, the EU and Norway agreement on herring TACs in Division IIIa was 45 000 t for the human consumption fleet and a by-catch ceiling of 6,659 t to be taken in the small mesh fishery.

Prior to 2006 no separate TAC for Subdivisions 22-24 was set. In 2011, a TAC of 15 884 t was set on the Western Baltic stock component. The TAC for 2012 was set at 20 900 t.

3.1.2 Catches in 2011

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 2011 are given in Table 3.1.1 and Figure 3.1.1. In 2011 the total landings in Division IIIa and Subdivisions 22–24 have decreased to 35 900 t, which is the lowest value of the time series (1986-2011). The decrease in landings in 2011 is particularly evident in the Skagerrak, however all areas did have a major reduction in catches. As in previous years the 2011 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 2011 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 unalike 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 gives 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
	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 fleet-C can be taken in IV EU waters							-50%		
% of IIIa fleet-C can be taken in IV Norwigian waters								-50 %	
	2012								
Div. IIIa fleet-C	45,000	18,912	303			19,783	38,998	6,002	
Div. IIIa fleet-D	6,659	5,692	51			916	6,659		
SD 22-24 fleet-F	20,900	2,930	11,532	1	2,719	3,718	20,900		
% of IIIa fleet-C can be taken in IV EU waters							-50%		
% of IIIa fleet-C can be taken in IV Norwigian waters								-50 %	

*2011: 495 t 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 Area IV. These catches have been allocated to the North Sea stock and accounted for under the A-fleet. Misreported catches have been moved to the appropriate stock for the assessment. However, from 2009 and on onwards, information from both the industry and VMS estimates suggest that this pattern of misreporting of catches into Division IIIa does not . Thus no catches were moved out of Division IIIa to the North Sea for catches taken in 2011.

Regulations allowing quota transfers from Division IIIa to the North Sea were introduced as an incentive to decrease misreporting of the fishery, and the percentage has gradually been reduced until 2010. In 2011 the EU – Norway agreement allowed 50% of the Division IIIa quotas for human consumption (Fleet C) to be taken in the North Sea. The optional transfer of quotas from one management area to another introduces uncertainty for catch predictions and thus influence the quality of the stock projections. ICES dealt with this in a pragmatic way assuming that this transfer was fully implemented in 2011, which proved to be the case. Assuming the same transfer rule for 2012, ICES will take the same approach.

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

3.1.3.1 Changes in fishing technology and fishing patterns

There have been no significant changes 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 within the directions set by the DCF, however, as the landings were minor, the regulation of 1 sample pr. 1 000 t landed resulted in few samples being taken. This resulted in unsampled Subdivisions, despite a total catch of 500 t (Table 3.2.4). Where sampling was missing in areas and quarters on national landings, sampling from either other nations or adjacent areas and quarters were used to estimate catch in numbers and mean weight-at-age (Table 3.2.5).

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

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

The total catch, expressed as SOP, of the WBSS taken in the North Sea + Division IIIa in 2011 was estimated to be 11 941 t, which is the lowest value 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, were estimated for 2011 (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 1993–2011, are presented in Tables 3.2.15 and 3.2.16.

The total catch of NSAS in Division IIIa amounted to 8 388 t in 2011, which is the second lowest value of the time series (Table 3.2.17).

The transfer of WBSS from Subarea IVaE into Division IIIa and the transfer of NSAS from Division IIIa into Area IV in 2011 are shown in the text table below:

Year	Stock	Transfer route	Tonnes
2011	WBSS	IVaE to IIIa	308
2011	NSAS	IIIa to IV	8 388

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 2011 is assumed to be insignificant, as in previous years.

Table 3.2.4 shows the number of fish aged by country, area, fishery and quarter. The overall sampling in 2011 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. Fortunately occasional lack of national sampling of catches by quarter and area has been covered by similar fisheries in other countries

Splitting of catches into WBSS 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 2 433 with 48% of the samples in Division IIIa North and 52% in IIIa South.

Sampling for split of catches in the transfer area in Division IVa East in 2011 was based on 356 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 2011 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 2012/SSGESST:21). 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.

Results from 2010 indicated a strong immigration of Central Baltic herring (CBH) in the western part of the survey area (SD 24). In 2011, a less pronounced immigration rate may be assumed based on observations of mean-weght and number-at-age. An updated method for the quantification and separation of the CBH component was presented at this meeting, at WGIPS in 2012 and it will also be presented to WGBFAS in 2012.

The results for 2011, which still includes CBH, are presented in Table 3.3.1. The Western Baltic spring spawning herring stock in 2011 was estimated to be 5.4 x 10^9 fish or about 206 x 10^3 tonnes in Subdivisions 21–24. Estimates of total biomass are comparable to levels of abundance and biomass observed in 2005.

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

The Herring acoustic survey (HERAS) was conducted from 28 June to 11 July 2011 and covered the Skagerrak and the Kattegat. Details of the survey are given in the WGIPS report (ICES CM 2012/SSGESST:21). The 1999 survey was excluded from the assessment due to different survey area coverage. The estimates of Western Baltic spring spawning herring SSB were 230 000 tonnes and 4.1 x 10^9 herring. The stock is dominated by 1 ring and, to a lesser extent, 2 ring fish. This year's estimated abundance of 1 ringers is considerably larger than the previous two years. 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 2011 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 recruitment index N20 derived from the survey is with 4.4 x 10^9, lower than 2010 but more than two times higher than that calculated for the low-recruitment year 2008 (Table 3.3.3). Unlike in recent years 2009 and 2010 the current index is located below the range of the arithmetic mean of the time series (7.3 x 10^9) but only slightly below the median (5.2 x 10^9).

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 and Table 3.6.3).

The maturity ogive of WBSS applied in HAWG has been assumed constant between years and has been the same since 1991 (ICES 1992/Assess:13), although large year-to-year variations in the percentage mature have been observed (Gröhsler and Müller, 2004). A Workshop on Sexual Maturity Staging of Herring and Sprat took place during 2011 (WKMSHS, ICES CM 2011/in press) 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 2011/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 2011 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 2011 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 3.6.1.3) 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

According to 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 (2007-2011)
- 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 Final run

The results of the assessment are given in Tables 3.6.8-21. The estimated SSB for 2011 is 107 342 [82 248, 143 023 (95% CI)] t. The mean fishing mortality (ages 3-6) is estimated as 0.20 [0.14, 0.30 (95% CI)] yr^{-1} (Figure 3.6.4.1).

After a marked decline from over 300 000 t in the early 1990s to a low of 120 000 t in the late 1990s, the SSB of this stock recovered somewhat, reaching a secondary peak of around 200 000 tonnes in the early 2000s (Figure 3.6.4.2). After a small peak in 2006 coinciding with the maturing of the 2003 year-class, the SSB has declined up to 2011 with the lowest SSB observed in the time series. This year assessment slightly revised upward the most recent SSB estimates.

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 has been decreasing for the last years, and 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 2006-2009 lows. The 2010 year class has been slightly revised downward after this assessment, but it is still perceived as a good recruitment year compared to the previous low recruitment period. The recruitment in 2011 is slightly lower than in 2010 but appears higher than the low estimates that characterized the mid 2000s.

The catch residuals are generally free from patterns (Figure 3.6.4.3).

The individual diagnostics for the three surveys generally show acceptable fits (Figures 3.6.4.4 – 3.6.4.11). No major pattern is observed in the residuals, and the assumption of normal distribution is generally held up. Most survey-ages appear to have at least one significant outlier. The general 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 3.6.4.12): this is not surprising as the FLICA method fits many more parameters to the catch data than the survey data.

Some patterns are apparent in the residuals (Figures 3.6.4.13). Both the HERAS and German acoustic surveys show appreciable year effects, with some years showing either positive or negative residuals across all ages. 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 few outlying points exist. No cohort or age effects are apparent.

Retrospective analysis suggests the assessment method gives a relatively consistent perception of the stock and its dynamics (Figure 3.6.4.14). 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 3.6.4.15), especially in the most recent years covered by the separable period. Such a result suggests that the assumption of a constant selectivity in the fishery, a key criterion for the application of the FLICA method, is valid.

The stock-recruitment plot for this stock (Figure 3.6.4.16) does not show any clear relationship between stock-size and recruitment.

The Taylor diagram (Taylor 2001; Payne 2011) for WBSS herring (Figure 3.6.4.17) 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 generally poorer agreement with the model, and especially 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).

3.6.5 State of the stock

The stock has decreased systematically and consistently during the second half of the 2000s. SSB has been slightly reduced from the last year, recording a new minimum over the time period of this assessment. Fishing mortality was drastically reduced in 2010, and it further decreased in 2011. The estimate of F3-6 for 2011 is 0.20 yr^{-1} and it is now below the F_{msy} (0.25 yr^{-1}).

Recruitment has declined consistently from 2003 to 2009, causing the following progressive reduction of SSB. This assessment slightly revised downward the 2010 year class. However, the 2010 year class is still above the low recruitment period of the mid 2000s. Thus, it may be expected that the 2010 year class will lead to an increase of the SSB for the next year. The recruitment in 2011 is slightly lower than in 2010, but it still appears to be higher than the low estimates that characterized the mid 2000s.

3.6.6 Comparison with previous years perception of the stock

This year's assessment is an update assessment, and employs the same methodology as 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 some downwards revision of recruitment to the 2010 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 2011	Assessment in 2012	Diff. 12-11 (+/-) %
ICA results	SSB (t) 2009	105 222	116 377	+10%
	F(3-6) 2009	0.52	0.46	-12%
	Recr. ('000) 2009	2 159 680	1 695 931	-21%
	SSB (t) 2010	95 152	108427	+14%
	F(3-6) 2010	0.30	0.27	-10%
	Recr. ('000) 2010	3 961 260	3 072 854	-22%

3.6.7 Short term predictions

Short term predictions were made with the MFDP package.

3.6.8 Input data

Stock numbers at age at the beginning of 2012 were taken from the ICA assessment, except for age 0. For age 0 in 2011 - 2014, the geometric mean recruitment (2006-2010) was used considering both the recent low recruitment period (2006-2009) and the higher recruitment in 2010. Age 1 in 2012 was calculated according to the adjusted geometric mean recruitment in 2011. The fishing mortality at age was taken from the ICA assessment (average of 2009-2011). Arithmetic averages over the years 2009-2011 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 3.6.22.

3.6.9 Intermediate year 2012

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

1) Catch constraint applying a TAC transfer from IIIa to IV as in 2011.

   a. The EU – Norway agreement allows an optional transfer of 50% of the TAC for herring in Division IIIa into the Area IV in the North Sea. Based on the behaviour of the fishing fleet in 2011 41.9 % was subtracted from the TAC for human consumption in Division IIIa as the basis for the catch constraint in 2012. This choice influences the perception of the stock development in 2012 and 2013. There is no information on how much of this TAC transfer is actually utilised in Area IV.

   b. 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.

   c. The catch by the F-fleet fishing for human consumption in Subdivisions 22-24 in 2011 was close to the TAC and utilisation of 100% is assumed for the intermediate year. The TAC utilisation for the C-fleet is assumed to follow the pattern in 2011 and according to 1) set to 58.1%. 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 40.7% is assumed for the intermediate year.

d. 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 2012 and 2013 as the average of 2009-2011 in Division IIIa (71% and 40% of WBSS in the C- and the D-fleet respectively).

e. 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, according to 1c) are assumed to be equal to the utilised TAC in the respective areas times the proportion of WBSS in the catches for the intermediate year 2012.

f. A constant amount of 308 t of WBSS taken in Division IVaE by the A-fleet in 2011 is assumed in 2012.

g. 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.

h. Summarising: predicted catches of WBSS and NSAS by fleet in IIIa are based on 1) the fraction of WBSS catches taken by the C-fleet in 2011 and the 2009-2011 average fraction in the D-fleet plus a constant catch of WBSS in IVaE (2011 catch) and 2) the 2009-2011 average proportion of the two stocks in the catches of the different fleets. These assumptions give the expected catch by fleet in 2012.

2) We explored an alternative catch constraint assuming that the total IIIa TAC in 2012 is taken in IIIa with no utilisation of the optional quota transfer to area IV.

a. The EU – Norway agreement allows an optional transfer of 50% of the TAC for herring in Division IIIa into the Area IV in the North Sea. no catches were subtracted from the TAC for human consumption in Division IIIa as a basis for the catch constraint in 2012.

b. No misreporting assumed (as in 1b).

c. The TAC utilisation for the C-, D- and F-fleets is assumed to be 100% (changed in relation to 1c).

d. WBSS proportions in the catch of each fleet in 2012 and 2013 assumed equal to the recent 3-years average in Division IIIa (71% and 40% of WBSS in the C- and the D-fleet respectively) (as in 1d).

e. 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, according to 1c) are assumed to be equal to the utilised TAC in the respective areas times the proportion of WBSS in the catches for the intermediate year 2012 (as in 1e).

f. A constant amount of 308 t of WBSS taken in Division IVaE by the A-fleet in 2011 is assumed in 2012(as in 1f).

g. 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(as in 1g).

h. Summarising: predicted catches of WBSS and NSAS by fleet in IIIa are based on the 2012 total TAC for the C- and the D-fleets plus a constant catch of WBSS in IVaE (2011 catch) and 2) the 2009-2011 average proportion of the two stocks in the catches of the different fleets. These assumptions give the expected catch by fleet in 2012.

The resulting expected catch of WBSS in 2012 following scenario 1) was 40 876 t and scenario 2) was 55 555 t.

	2011				2012				
Calculation of Intermediate year catch constraint (2012)	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 2012 *	Proportion of WBSS in catch	catch of WBSS in 2012
A-fleet	308						308	100%	308
C-fleet 1)	10 816	6 608	30 000	17 424	0.581	45 000	26 145	71.0%	18 575
C-fleet 2)	-	-	-	-	1	45 000	45 000	71.0%	31 972
D-fleet 1)	818	1 780	6 659	2 598	0.407	6 659	2 710	40.3%	1 092
D-fleet 2)	-	-	-	-	1	6 659	6 659	40.3%	2 683
F-fleet	15 830		15 884	15 830	1	20 900	20 900	100%	20 900
Scenario 1) Total (Div. IIIa, SD 22-24 and IVaE) 1)	27 772	8 388	52 543	35 852			50 063		40 876
Scenario 2) Total (Div. IIIa, SD 22-24 and IVaE) 2)	-	-	-	-			72 559		55 555

* Based on the observed pattern following the EU-Norway agreed transfer of quota of Fleet C from Division IIIa to the North Sea (19 855 t in 2012).

**The D-fleet is calculated as the average utilisation of the by-catch ceiling over the years 2009-2011

3.6.10 Catch options for 2013

The output of the short-term prediction, based on a catch constraint in the intermediate year 2012 of 40 876 t scenario (1), is given in Table 3.6.23 and in Figure 3.6.10.1. The output of scenario (2) is given in Table 3.6.24.

The following catch options for 2013 were explored:

1) Zero catch.

2) F_{2013} = 0.25, which is F_{MSY}.

3) A 15% reduction of all fleet-wise TACs for 2013, 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 recently observed pattern.

4) As for option 3, but with no change in the TAC.

5) As for option 3, but with a 15% increase in the TAC.

6) As for option 2, but with a 2012 catch constraint assuming that the total IIIa TAC is taken (scenario 2).

3.6.11 Exploring a range of total WBSS catches for 2013 (advice year)

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

The selection pattern is assumed to be invariant among the fleets.

A constant catch of 308 t of WBSS caught in the A-fleet in Division IVa East.

This constant amount is subtracted from each of the TAC options presented and thereafter the observed allocation between Division IIIa and Subdivisions 22-24 of the remaining TAC is assumed.

The C-fleet follows the 2011 pattern and the D-fleet takes a constant share of the WBSS based upon the mean of the recent three years 2009-2011.

There will not be any transfer of quotas from the C-fleet to the A-fleet.

The total TAC is taken

The average 2009-2011 proportions of WBSS by fleet is the same for 2013. (The proportions of WBSS in catches were 71.0% in the C-fleet, 40.3% in the D-fleet and 100% in the F-fleet).

For catch option 6) a 50:50 share of the total WBSS catches (minus a constant catch of 308 t in IVaE) is allocated to Division IIIa and Subdivisions 22-24.

The table below gives the 2013 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)** $F_{-15\%TAC}$=0.243, **4)** F_{TAC}=0.291, **5)** $F_{+15\%TAC}$=0.342 and **6**) F_{MSY}=0.25**

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	51 939	308	23 641	1 390	26 600	9 634	2 059	33 275	3 449	26 600	63 632	-12%
3	50 586	308	23 026	1 354	25 907	9 383	2 006	32 409	3 360	25 907	61 983	-15%
4	59 513	308	27 089	1 593	30 479	11 039	2 360	38 128	3 952	30 479	72 867	0%
5	68 440	308	31 152	1 831	35 051	12 695	2 714	43 847	4 545	35 051	83 751	15%
**6	*48 807*	*308*	*22 903*	*1 346*	*24 250*	*9 333*	*1 995*	*32 236*	*3 342*	*24 250*	*60 135*	*-17%*

*** total catches of WBSS herring include a constant catch of 308 t WBSS taken by the A-fleet in Div. IVa East**

**** Alternative basis for intermediate year (2012) where the total C-fleet TAC of 45 000 t is assumed taken in IIIa, and a 50:50 allocation of WBSS catches in 2013 between [DivIIIa]:[SD22-24]**

Scenario (1):

1) Zero catch not shown in the table. After an increase of SSB to 171 809 t in 2013 the SSB further increases to 229 784 t in 2014.
2) The F_{MSY} option will give a yield of 51 942 t in 2013 with an increase in SSB from 167 777 t in 2013 to 179 845 t in 2014.
3) 15% reduced TAC option gives a yield in 2013 of 50 600 t. This option is very similar to option 2) based on F_{MSY} with an increase from a SSB of 167 892 t in 2013 to 181 107 t in 2014.
4) A TAC roll over option gives a catch in 2013 of 59 500 t and a SSB of 167 123 t. With this assumption the SSB increases in 2014 to 172 762 t
5) A 15% increased TAC gives a catch in 2013 of 68 500 t. With this assumption the SSB increases to 166 317 t in 2013 with levelling out at 164 396 t in 2014 both above the breakpoint of 110 000 t.

Scenario (2):

6) This alternative scenario** is a F_{MSY} based catch option that leads to a 17% decreased TAC and gives a WBSS catch in 2013 of 48 807 t. With this assumption the SSB increase to 155 764 t in 2013 and to 168 861 t in 2014.

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.

3.8 Quality of the Assessment

The limited level of sampling for the splitting of NSAS and WBSS is mostly unchanged from the last year. The issue will be fully addressed with the benchmark in 2013.

The assessment this year was classified as an update assessment following the procedures and settings specified in the Stock Annex 4. In 2011 the assessment of WBSS was regarded reliable and consistent, and the diagnostics indicate a similar classification for this year.

Variability in the retrospective perception of the stock 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). The WBSS-CBH stock mixing was highlighted and initially analysed during the last year assessment (HAWG 2011) and this year new data confirmed the relevance of the issue (Gröhsler et al. WD06 2012). The WG recommended further investigation of this relevant issue within the next benchmark in 2013.

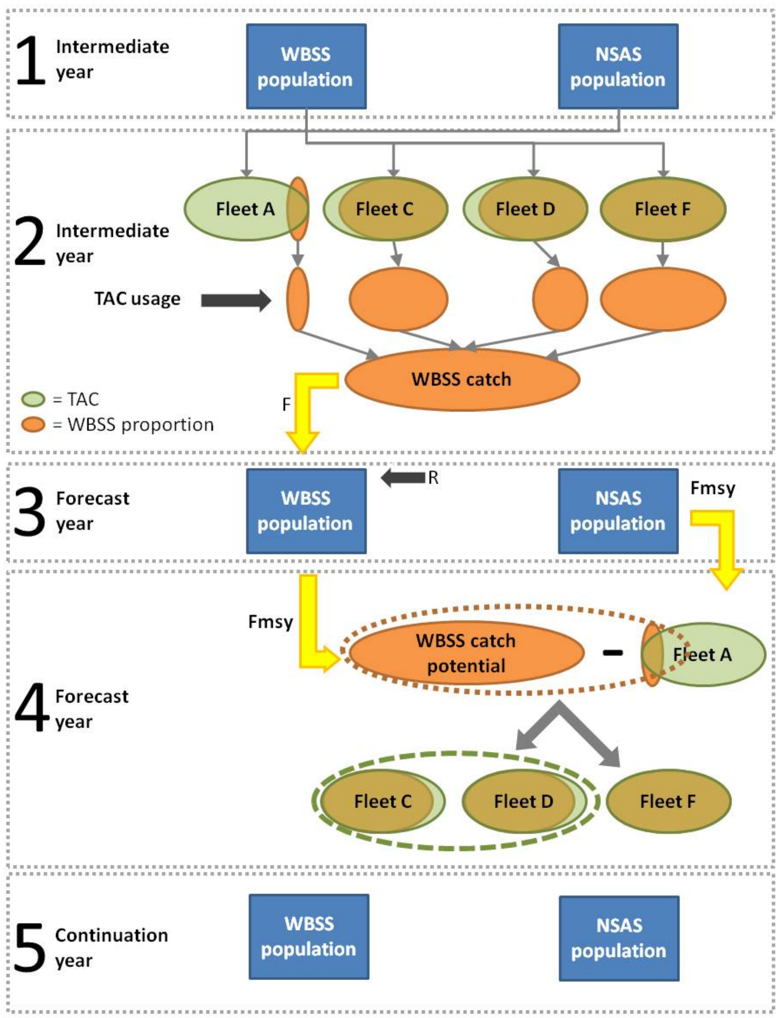
3.9 Management Considerations

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 Area IV as NSAS in 2011. ICES assumes that a transfer of 41.9% will be effected in 2012. However ICES has also explored an option based on a catch constraint in the intermediate year where the total TAC is taken in Division IIIa.

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 is presented:



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 get all stocks exploited at Fmsy by the year 2015. From now until 2015 there is an Fmsy transition period. For 2011 F was estimated below Fmsy, consequently catch options for the forecast year are assumed to be at Fmsy. 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), and also to split the remainder between the F and the C & D fleet according to the recent observed pattern e.g. 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.

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 simulations 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 at the time of calculation by WKHMP (ICES 2008) 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 includes a sloping change in F at SSB below a breakpoint.

Data used for catch options for 2013 (prediction 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 2013 are based on the average share by fleet based on area TACs and the stock composition in catches for the most recent years 2009-2011.

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 and 2012 managers decided an optional transfer of 50% of the quotas for human consumption in Division IIIa to the North Sea, of which 41.9% was effected, this has increased the SSB from 107 342 t in 2011 to 132 290 t in 2012. The maturation of the improved 2010 year-class has now a profound effect on stock development and dependent on effected TAC transfer from IIIa to IV, SSB will further increase to the range between 156 000 and 168 000 t in 2013. For options 2-5 HAWG assumes that a similar TAC utilisation of the C-fleet is effected in 2012 as in 2011 and thus bases the catch options on a fishing mortality that will continue to be below F_{MSY} in 2012 (F=0.21).

Applying the F_{MSY} framework for WBSS herring (F_{MSY}=0.25) in the situation when SSB in the advice year (2013) 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 51 939 t in 2013 with an increase in SSB from 167 777 t in 2013 to 179 845 t in 2014. The fishing mortality corresponding to a 15% TAC reduction is very similar to F_{MSY} with an increase in SSB from 167 892 t in 2013 to 181 107 t in 2014.

For the alternative option 6 (scenario 2) with no utilised TAC transfer from IIIa to IV in the intermediate year, fishing mortality is above F_{MSY} in 2012 (F=0.30) and SSB equal to 131 199 t, above the $B_{trigger}$. Here applying the F_{MSY} framework when SSB in the advice year (2013) is above the $B_{trigger}$ and F is close to F_{MSY} means applying a fishing mortality equal to F_{MSY}. A F_{MSY} of 0.25 give a catch in 2013 of 48 807 t, somewhat lower than the yield with the comparable option 2 (scenario 1). With this assumption the increase in SSB is weaker than with the other options, estimated to 155 764 t in 2013 and to 168 861 t in 2014.

The catches of WBSS in the C- and D-fleets comprise 48% of the total out-take of the WBSS stock whereas the catches of NSAS by the same fleets only comprise 2.3% of the total out-take of the NSAS stock. The NSAS has experienced a decline in fishing mortality and subsequent increase in SSB and there is an indication of an on going similar development for WBSS. With the maturation of the improved 2010 year-class there is now a possibility for a consolidated fishing mortality at Fmsy on the WBSS. Therefore a reduced uncertainty about the realised outtake, by eliminating the optional TAC transfer between IIIa and IV, should to be considered in the management of both stocks.

The resulting catch option 2 (scenario 1) with the above assumptions was also used as constraint 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 (Podolska et al. 2006). Herring in Division IIIa and Subdivisions 22–24 migrate back to Rügen area (SD 24) at the beginning of the winter for spawning. Moreover, there are recent indications that Central Baltic herring perform migrations into Subdivision 24.

Similarly to the North Sea herring, the Western Baltic herring has produced several poor year classes in the last decade. The recruitment in 2011 is slightly lower than the year-class estimated in 2010, but appears still higher than the low estimates that characterized the late 2000s.

A recent analysis on different Baltic herring stocks, the Baltic Sea Index (BSI) reflecting Sea Surface Temperature (SST) was the main predictor for the recruitment of 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. The low recruitment phase appears to have been initiated before the observed occurrence of *Mnemiopsis leidyi* (Ctenophore) in the Western Baltic (Kube et al., 2007). The specific reasons for this low recruitment are unknown. Further investigation of the causes of the poor recruitment will require targeted research projects.

3.11 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. There are indications that higher SST observed in the last decades might affect recruitment negatively, although 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 1989-2011 (1000 tonnes).
(Data provided by Working Group members 2012).

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	2011[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	3.6
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	0.1
Lithuania											0.4	
Norway	9.7							3.5	4.0	3.3	3.3	0.1
Sweden	45.8	30.8	26.4	25.8	21.8	32.5	26.0	19.4	16.5	12.9	17.4	9.5
Total	71.5	47.0	52.3	42.0	34.1	48.5	31.8	26.9	26.0	29.7	27.0	13.2
Kattegat												
Denmark	18.9	18.8	18.6	16.0	7.6	11.1	8.6	9.2	7.0	4.9	7.6	5.2
Sweden	17.3	16.2	7.2	10.2	9.6	10.0	10.8	11.2	5.2	3.6	2.7	1.7
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	6.8
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	3.1
Germany	9.3	11.4	22.4	18.8	18.5	21.0	22.9	24.6	**22.8**	16.0	12.2	8.2
Poland	6.6	9.3		4.4	5.5	6.3	5.5	2.9	5.5	5.2	1.8	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	2.2
Total	53.3	62.9	46.2	38.7	41.2	41.8	39.4	37.6	38.5	27.4	16.8	15.3
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[6]	0.03
Sweden	0.1	0.2		0.2	0.3	0.4	0.7		0.3	0.8	0.9	0.5
Total	1.0	0.8	4.6	2.6	0.4	2.2	2.5	2.9	5.7	3.6	1.0	0.6
Grand Total	**162.0**	**145.7**	**128.9**	**109.5**	**92.8**	**113.6**	**93.0**	**87.7**	**82.3**	**69.9**	**55.2**	**35.9**

[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 Skagerrak.

[6] Official reported catches: 3,103 tonnes, see text section 3.2.1 (HAWG 2011)

Table 3.1.2 **WESTERN BALTIC HERRING.**
Landings (SOP) in 2003-2011 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
2011	1	7.0	0.5	7.8	15.3
	2	0.5	0.2	4.1	4.8
	3	6.5	1.0	0.8	8.3
	4	3.4	0.9	3.2	7.4
	Total	17.4	2.6	15.8	35.9

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: 2011 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.75	27	3.24	9	3.99	12
	2	43.33	77	0.23	45	43.57	77
	3	4.03	103	0.06	71	4.09	103
	4	1.53	136			1.53	136
	5	0.47	191			0.47	191
	6	0.32	193			0.32	193
	7	0.26	234			0.26	234
	8+	0.05	248			0.05	248
	Total	50.75		3.54		54.29	
	SOP		4,209		44		4,252
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.12	25	1.51	25	1.63	25
	2	5.78	82	0.02	51	5.79	82
	3	0.29	101			0.29	101
	4	0.12	129			0.12	129
	5	0.00	180			0.00	180
	6	0.03	174			0.03	174
	7	0.00	224			0.00	224
	8+	0.00	248			0.00	248
	Total	6.34		1.53		7.87	
	SOP		527		39		566
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.09	18	111.05	6	111.13	6
	1	5.32	69	0.33	27	5.65	66
	2	17.55	116			17.55	116
	3	7.29	146			7.29	146
	4	4.29	165			4.29	165
	5	2.64	186			2.64	186
	6	0.92	198			0.92	198
	7	0.55	217			0.55	217
	8+	0.49	215			0.49	215
	Total	39.13		111.38		150.51	
	SOP		5,075		695		5,770
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	1.66	23	60.71	6	62.38	7
	1	29.30	54	0.18	27	29.49	54
	2	3.61	107			3.61	107
	3	0.92	125			0.92	125
	4	0.41	167			0.41	167
	5	0.14	190			0.14	190
	6	0.04	206			0.04	206
	7	0.02	222			0.02	222
	8+	0.04	213			0.04	213
	Total	36.15		60.90		97.05	
	SOP		2,236		380		2,616
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	1.75	23	171.76	6	173.51	6
	1	35.49	55	5.27	15	40.77	50
	2	70.27	89	0.25	45	70.52	89
	3	12.53	130	0.06	71	12.59	130
	4	6.36	157			6.36	157
	5	3.25	187			3.25	187
	6	1.31	196			1.31	196
	7	0.83	222			0.83	222
	8+	0.58	218			0.58	218
	Total	132.37		177.34		309.71	
	SOP		12,047		1,158		13,205

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: 2011 Country: ALL

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.11	16	37.07	9	38.18	9
	2	6.12	65	2.67	45	8.79	59
	3	8.33	110	0.69	71	9.02	107
	4	6.09	122			6.09	122
	5	2.47	148			2.47	148
	6	1.68	178			1.68	178
	7	0.13	207			0.13	207
	8+	0.21	198			0.21	198
	Total	26.16		40.42		66.58	
	SOP		2,802		498		3,300
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00	14	5.79	25	5.79	25
	2	0.00	60	0.07	51	0.07	51
	3	0.01	110			0.01	110
	4	0.01	122			0.01	122
	5	0.00	148			0.00	148
	6	0.00	177			0.00	177
	7	0.00	207			0.00	207
	8+	0.00	199			0.00	199
	Total	0.03		5.86		5.89	
	SOP		4		150		154
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.29	16	18.76	11	19.05	11
	1	11.19	47	1.63	37	12.82	46
	2	6.79	88			6.79	88
	3	1.38	108			1.38	108
	4	0.62	131			0.62	131
	5	0.16	155			0.16	155
	6	0.04	172			0.04	172
	7	0.05	185			0.05	185
	8+	0.05	171			0.05	171
	Total	20.58		20.39		40.97	
	SOP		1,417		274		1,691
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.31	20	17.09	15	17.40	15
	1	13.47	48	7.46	36	20.93	43
	2	5.01	83	0.07	45	5.09	82
	3	0.73	93			0.73	93
	4	0.19	97			0.19	97
	5	0.04	115			0.04	115
	6						
	7						
	8+						
	Total	19.75		24.63		44.37	
	SOP		1,154		518		1,672
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.60	18	35.85	13	36.46	13
	1	25.78	46	51.95	15	77.72	26
	2	17.94	79	2.81	45	20.75	74
	3	10.45	108	0.69	71	11.14	106
	4	6.91	122			6.91	122
	5	2.67	148			2.67	148
	6	1.72	177			1.72	177
	7	0.18	202			0.18	202
	8+	0.26	193			0.26	193
	Total	66.52		91.30		157.81	
	SOP		5,377		1,440		6,817

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: 2011 Country: ALL

		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	1.06	10	0.01	27	4.21	12	5.29	11
	2	0.82	43	0.42	46	6.24	44	7.48	44
	3	0.74	87	0.63	77	6.85	83	8.21	83
	4	1.67	131	0.74	119	13.32	127	15.73	127
	5	1.08	160	0.32	152	8.47	156	9.86	156
	6	1.00	171	0.23	170	7.52	172	8.76	172
	7	0.59	184	0.07	180	4.40	182	5.06	182
	8+	0.41	196	0.09	186	3.34	191	3.84	191
	Total	7.35		2.51		54.36		64.22	
	SOP		860		273		6,629		7,761
		Sub-division 22		Sub-division 23		Sub-division 24		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	2.59	11	0.13	11	15.02	11	17.75	11
	2	0.23	41	0.02	43	1.79	44	2.04	44
	3	0.12	71	0.02	74	1.69	80	1.83	79
	4	0.16	133	0.02	119	6.89	130	7.07	130
	5	0.08	154	0.01	152	4.82	160	4.91	160
	6	0.15	178	0.01	170	4.94	176	5.09	176
	7	0.14	184	0.00	180	3.05	182	3.20	182
	8+	0.10	200	0.00	186	2.27	192	2.37	193
	Total	3.58		0.21		40.47		44.25	
	SOP		152		9		3,905		4,066
		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	0.09	14	0.62	15	0.01	14	0.72	15
	1	0.02	29	0.72	37	0.17	33	0.91	36
	2	0.00	48	0.60	81	1.77	47	2.37	55
	3	0.00	68	0.64	88	1.47	52	2.12	63
	4	0.00	106	0.52	102	3.26	48	3.79	56
	5	0.00	163	0.23	118	1.53	56	1.76	64
	6	0.00	180	0.12	115	1.42	54	1.54	59
	7	0.00	196	0.04	112	0.91	57	0.95	60
	8+	0.00	198	0.06	121	1.01	61	1.07	65
	Total	0.13		3.56		11.54		15.23	
	SOP		4		247		595		846
		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	0.39	12	0.64	14	3.89	12	4.92	12
	1	0.30	37	0.21	32	5.78	37	6.29	37
	2	0.31	67	0.08	81	5.29	70	5.67	70
	3	0.24	82	0.08	88	5.72	75	6.05	75
	4	0.45	134	0.07	102	8.28	97	8.79	99
	5	0.28	126	0.03	118	4.60	97	4.90	99
	6	0.16	144	0.02	115	3.81	89	3.98	91
	7	0.09	168	0.01	112	1.57	109	1.67	112
	8+	0.05	162	0.01	121	0.82	121	0.88	123
	Total	2.27		1.14		39.74		43.15	
	SOP		198		43		2,915		3,157
		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	0.48	12	1.26	15	3.90	12	5.64	12
	1	3.97	13	1.08	32	10.41	26	15.46	23
	2	1.36	48	1.12	67	13.93	55	16.41	55
	3	1.10	84	1.37	83	15.36	77	17.83	78
	4	2.28	132	1.34	111	32.32	112	35.93	113
	5	1.44	153	0.58	137	19.62	135	21.64	137
	6	1.31	169	0.37	150	17.96	146	19.65	148
	7	0.82	182	0.12	152	10.27	160	11.21	161
	8+	0.56	193	0.17	159	7.49	166	8.21	168
	Total	13.32		7.41		131.26		151.99	
	SOP		1,214		571		14,045		15,830

Table 3.2.4 HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2011 available to the Working Group.

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	Denmark	1	0.7	4	498	209
		2	0.0	No data available		
		3	2.4	11	1050	225
		4	0.5	No data available		
	Total		3.6	15	1,548	434
	Germany	1	-			
		2	-			
		3	-			
		4	0.1	No data available		
	Total		0.1			
	Norway	1	0.0	No data available		
		2	0.0	No data available		
		3	0.0	No data available		
		4	0.1	No data available		
	Total		0.1	0	0	0
	Sweden	1	3.5	14	700	700
		2	0.5	4	458	458
		3	3.4	11	666	666
		4	2.0	9	675	675
	Total		9.4	38	2,499	2,499
Kattegat	Denmark	1	2.7	6	724	323
		2	0.2	2	91	
		3	0.9	1	50	
		4	1.1	5	522	179
	Total		4.9	14	1,387	502
	Sweden	1	0.2	5	612	612
		2	-			
		3	0.8	6	662	662
		4	0.6	4	469	469
	Total		1.6	15	1,743	1,274

Table 3.2.4 (cont.) HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2011

	Country	Quarter	Landings ('000 tons)	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	Denmark	1	0.0	5	299	130
		2	0.0	2	68	68
		3	0.0	No data available		
		4	0.0	4	39	39
	Total		0.047	11	406	237
	Germany	1	0.9	No data available		
		2	0.1	4	1,434	253
		3	0.0	No data available		
		4	0.2	2	1377	254
	Total		1.2	6	2,811	507
Subdivision 23	Denmark	1	0.0	No data available		
		2	0.0	No data available		
		3	0.0	No data available		
		4	0.0	No data available		
	Total		0.028	0	0	0
	Sweden	1	0.3	No data available		
		2	0.0	No data available		
		3	0.2	No data available		
		4	0.0	No data available		
	Total		0.5	0	0	0
Subdivision 24	Denmark	1	1.6	No data available		
		2	0.2	No data available		
		3	0.0	No data available		
		4	1.2	No data available		
	Total		3.0	0	0	0
	Germany	1	3.7	16	7,410	1,674
		2	2.9	11	4,047	796
		3	0.0	No data available		
		4	0.4	4	2,068	479
	Total		7.0	31	13,525	2,949
	Poland	1	0.2	2	284	122
		2	0.6	5	912	184
		3	0.6	1	245	63
		4	0	11	1,753	85
	Total		1.8	19	3194	454
	Sweden	1	1.19	11	814	814
		2	0.13	No data available		
		3	0.03	No data available		
		4	0.83	3	512	512
	Total		2.17	14	1,326	1,326
Total	**Skagerrak**	**1-4**	**13.2**	**53.0**	**4047.0**	**2933.0**
	Kattegat	**1-4**	**6.5**	**29.0**	**3130.0**	**1776.0**
	Subdivision 22	**1-4**	**1.2**	**17**	**3,217**	**744**
	Subdivision 23	**1-4**	**0.6**	**0**	**0**	**0**
	Subdivision 24	**1-4**	**14.0**	**64**	**18,045**	**4,729**
	Total	**1-4**	**35.5**	**163**	**28,439**	**10,182**

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 2011

	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 2011

	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: 2011

		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
1	1	100.00%	0.00%	12	25.16%	74.84%	155
	2	88.24%	11.76%	221	54.43%	45.57%	79
	3	11.94%	88.06%	67	21.88%	78.13%	96
	4	0.00%	100.00%	26	3.28%	96.72%	61
	5	36.36%	63.64%	9	0.00%	100.00%	23
	6	36.36%	63.64%	5	0.00%	100.00%	17
	7	36.36%	63.64%	4	0.00%	100.00%	2
	8	36.36%	63.64%	4	0.00%	100.00%	3
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
2	1	100.00%	0.00%	8	3.45%	96.55%	29
	2	88.89%	11.11%	45	88.89%	11.11%	1
	3	25.00%	75.00%	20	25.00%	75.00%	0
	4	0.00%	100.00%	9	0.00%	100.00%	0
	5	0.00%	100.00%	0	0.00%	100.00%	0
	6	0.00%	100.00%	1	0.00%	100.00%	0
	7	0.00%	100.00%	0	0.00%	100.00%	0
	8	0.00%	100.00%	0	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
3	0	97.92%	2.08%	192	98.08%	1.92%	52
	1	67.21%	32.79%	61	35.19%	64.81%	54
	2	67.33%	32.67%	150	6.25%	93.75%	48
	3	8.14%	91.86%	86	6.12%	93.88%	49
	4	1.82%	98.18%	55	0.00%	100.00%	31
	5	0.00%	100.00%	31	0.00%	100.00%	10
	6	0.00%	100.00%	11	0.00%	100.00%	3
	7	0.00%	100.00%	5	0.00%	100.00%	3
	8	0.00%	100.00%	6	0.00%	100.00%	2
		Skagerrak			Kattegat		
Quarter	W-rings	NSAS	WBSS	n	NSAS	WBSS	n
4	0	96.43%	3.57%	28	92.76%	7.24%	221
	1	31.25%	68.75%	48	11.82%	88.18%	220
	2	2.00%	98.00%	50	13.89%	86.11%	72
	3	0.00%	100.00%	12	0.00%	100.00%	29
	4	0.00%	100.00%	2	0.00%	100.00%	4
	5	0.00%	100.00%	0	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%	0
	8	0.00%	100.00%	0	0.00%	100.00%	0

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: 2011 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	0.28	16	9.33	9	9.61	9
	2	3.33	65	1.45	45	4.79	59
	3	1.82	110	0.15	71	1.97	107
	4	0.20	122			0.20	122
	5						
	6						
	7						
	8+						
	Total	5.64		10.93		16.57	
	SOP		444		159		603
2	1	0.00	14	0.20	25	0.20	25
	2	0.00	60	0.06	51	0.07	51
	3	0.00	110			0.00	110
	4						
	5						
	6						
	7						
	8+						
	Total	0.01		0.26		0.27	
	SOP		1		8		9
3	0	0.29	16	18.40	11	18.69	11
	1	3.94	47	0.57	37	4.51	46
	2	0.42	88			0.42	88
	3	0.08	108			0.08	108
	4						
	5						
	6						
	7						
	8+						
	Total	4.73		18.97		23.71	
	SOP		238		231		469
4	0	0.29	20	15.85	15	16.14	15
	1	1.59	48	0.88	36	2.47	43
	2	0.70	83	0.01	45	0.71	82
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	2.58		16.75		19.32	
	SOP		139		264		403
Total	0	0.57	18	34.25	13	34.83	13
	1	5.81	46	10.98	13	16.79	24
	2	4.46	70	1.52	45	5.98	63
	3	1.91	109	0.15	71	2.06	107
	4	0.20	122			0.20	122
	5						
	6						
	7						
	8+						
	Total	12.95		46.91		59.86	
	SOP		822		661		1,483

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: 2011 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	0.75	27	3.24	9	3.99	12
	2	38.24	77	0.21	45	38.44	77
	3	0.48	103	0.01	71	0.49	103
	4						
	5	0.17	191			0.17	191
	6	0.12	193			0.12	193
	7	0.09	234			0.09	234
	8+	0.02	248			0.02	248
	Total	39.87		3.46		43.33	
	SOP		3,098		39		3,136
2	1	0.12	25	1.51	25	1.63	25
	2	5.13	82	0.02	51	5.15	82
	3	0.07	101			0.07	101
	4						
	5						
	6						
	7						
	8+						
	Total	5.33		1.53		6.86	
	SOP		431		39		471
3	0	0.08	18	108.73	6	108.82	6
	1	3.57	69	0.22	27	3.80	66
	2	11.81	116			11.81	116
	3	0.59	146			0.59	146
	4	0.08	165			0.08	165
	5						
	6						
	7						
	8+						
	Total	16.15		108.96		125.10	
	SOP		1,719		678		2,397
4	0	1.60	23	58.55	6	60.15	7
	1	9.16	54	0.06	27	9.21	54
	2	0.07	107			0.07	107
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	10.83		58.60		69.44	
	SOP		538		363		901
Total	0	1.69	23	167.28	6	168.97	6
	1	13.60	56	5.04	15	18.64	45
	2	55.26	86	0.22	45	55.48	86
	3	1.15	125	0.01	71	1.16	125
	4	0.08	165			0.08	165
	5	0.17	191			0.17	191
	6	0.12	193			0.12	193
	7	0.09	234			0.09	234
	8+	0.02	248			0.02	248
	Total	72.18		172.54		244.72	
	SOP		5,786		1,119		6,905

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: 2011 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	0.83	16	27.74	9	28.57	9
	2	2.79	65	1.22	45	4.01	59
	3	6.51	110	0.54	71	7.05	107
	4	5.89	122			5.89	122
	5	2.47	148			2.47	148
	6	1.68	178			1.68	178
	7	0.13	207			0.13	207
	8+	0.21	198			0.21	198
	Total	20.52		29.49		50.01	
	SOP		2,358		339		2,698
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00	14	5.59	25	5.59	25
	2	0.00	60	0.01	51	0.01	51
	3	0.01	110			0.01	110
	4	0.01	122			0.01	122
	5	0.00	148			0.00	148
	6	0.00	177			0.00	177
	7	0.00	207			0.00	207
	8+	0.00	199			0.00	199
	Total	0.02		5.60		5.62	
	SOP		3		142		145
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.01	16	0.36	11	0.37	11
	1	7.25	47	1.06	37	8.31	46
	2	6.37	88			6.37	88
	3	1.29	108			1.29	108
	4	0.62	131			0.62	131
	5	0.16	155			0.16	155
	6	0.04	172			0.04	172
	7	0.05	185			0.05	185
	8+	0.05	171			0.05	171
	Total	15.85		1.42		17.26	
	SOP		1,179		43		1,222
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.02	20	1.24	15	1.26	15
	1	11.88	48	6.58	36	18.46	43
	2	4.32	83	0.06	45	4.38	82
	3	0.73	93			0.73	93
	4	0.19	97			0.19	97
	5	0.04	115			0.04	115
	6						
	7						
	8+						
	Total	17.17		7.88		25.05	
	SOP		1,015		255		1,269
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.03	19	1.60	14	1.63	14
	1	19.97	46	40.96	16	60.93	26
	2	13.48	82	1.29	45	14.77	78
	3	8.54	108	0.54	71	9.08	106
	4	6.71	122			6.71	122
	5	2.67	148			2.67	148
	6	1.72	177			1.72	177
	7	0.18	202			0.18	202
	8+	0.26	193			0.26	193
	Total	53.56		44.39		97.95	
	SOP		4,555		779		5,333

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: 2011 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						
	2	5.10	77	0.03	45	5.13	77
	3	3.55	103	0.05	71	3.60	103
	4	1.53	136			1.53	136
	5	0.30	191			0.30	191
	6	0.21	193			0.21	193
	7	0.16	234			0.16	234
	8+	0.03	248			0.03	248
	Total	10.88		0.08		10.96	
	SOP		1,111		5		1,116
2	1						
	2	0.64	82	0.00	51	0.64	82
	3	0.22	101			0.22	101
	4	0.12	129			0.12	129
	5	0.00	180			0.00	180
	6	0.03	174			0.03	174
	7	0.00	224			0.00	224
	8+	0.00	248			0.00	248
	Total	1.01		0.00		1.01	
	SOP		96		0		96
3	0	0.00	18	2.31	6	2.32	6
	1	1.74	69	0.11	27	1.85	66
	2	5.73	116			5.73	116
	3	6.70	146			6.70	146
	4	4.22	165			4.22	165
	5	2.64	186			2.64	186
	6	0.92	198			0.92	198
	7	0.55	217			0.55	217
	8+	0.49	215			0.49	215
	Total	22.98		2.42		25.41	
	SOP		3,356		17		3,373
4	0	0.06	23	2.17	6	2.23	7
	1	20.15	54	0.13	27	20.27	54
	2	3.54	107			3.54	107
	3	0.92	125			0.92	125
	4	0.41	167			0.41	167
	5	0.14	190			0.14	190
	6	0.04	206			0.04	206
	7	0.02	222			0.02	222
	8+	0.04	213			0.04	213
	Total	25.32		2.29		27.61	
	SOP		1,698		17		1,715
Total	0	0.06	23	4.48	6	4.54	6
	1	21.89	55	0.24	27	22.13	55
	2	15.01	99	0.03	45	15.04	99
	3	11.38	130	0.05	71	11.44	130
	4	6.28	157			6.28	157
	5	3.08	187			3.08	187
	6	1.19	197			1.19	197
	7	0.73	221			0.73	221
	8+	0.56	217			0.56	217
	Total	60.19		4.80		64.99	
	SOP		6,261		39		6,300

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: 2011 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	1.03	24	12.57	9	13.60	10
	2	41.57	76	1.66	45	43.23	75
	3	2.30	108	0.16	71	2.46	106
	4	0.20	122			0.20	122
1	5	0.17	191			0.17	191
	6	0.12	193			0.12	193
	7	0.09	234			0.09	234
	8+	0.02	248			0.02	248
	Total	45.50		14.39		59.89	
	SOP		3,542		197		3,739
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	1	0.12	25	1.71	25	1.83	25
	2	5.14	82	0.08	51	5.22	82
	3	0.08	101			0.08	101
	4						
2	5						
	6						
	7						
	8+						
	Total	5.34		1.79		7.12	
	SOP		432		47		479
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	0.37	16	127.13	7	127.50	7
	1	7.51	58	0.80	34	8.31	55
	2	12.24	115			12.24	115
	3	0.68	142			0.68	142
	4	0.08	165			0.08	165
3	5						
	6						
	7						
	8+						
	Total	20.88		127.93		148.81	
	SOP		1,957		909		2,866
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	1.89	22	74.40	8	76.29	8
	1	10.75	53	0.94	35	11.69	52
	2	0.77	85	0.01	45	0.78	84
	3						
	4						
4	5						
	6						
	7						
	8+						
	Total	13.41		75.35		88.76	
	SOP		677		627		1,304
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
	0	2.26	21	201.53	7	203.80	7
	1	19.41	53	16.02	13	35.43	35
	2	59.72	85	1.75	45	61.46	84
	3	3.06	115	0.16	71	3.22	113
	4	0.28	134			0.28	134
Total	5	0.17	191			0.17	191
	6	0.12	193			0.12	193
	7	0.09	234			0.09	234
	8+	0.02	248			0.02	248
	Total	85.13		219.46		304.58	
	SOP		6,608		1,780		8,388

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: 2011** **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	0.83	16	27.74	9	28.57	9
	2	7.89	73	1.24	45	9.13	69
	3	10.06	107	0.59	71	10.65	105
	4	7.42	125			7.42	125
	5	2.77	153			2.77	153
	6	1.88	179			1.88	179
	7	0.30	222			0.30	222
	8+	0.25	205			0.25	205
	Total	31.40		29.57		60.98	
	SOP		3,469		344		3,814
2	1	0.00	14	5.59	25	5.59	25
	2	0.64	82	0.01	51	0.65	82
	3	0.23	101			0.23	101
	4	0.13	128			0.13	128
	5	0.00	153			0.00	153
	6	0.03	174			0.03	174
	7	0.00	213			0.00	213
	8+	0.00	228			0.00	228
	Total	1.04		5.60		6.63	
	SOP		99		142		241
3	0	0.01	16	2.67	7	2.68	7
	1	9.00	52	1.17	36	10.17	50
	2	12.10	102			12.10	102
	3	7.99	140			7.99	140
	4	4.84	160			4.84	160
	5	2.80	184			2.80	184
	6	0.96	197			0.96	197
	7	0.59	214			0.59	214
	8+	0.54	211			0.54	211
	Total	38.83		3.84		42.67	
	SOP		4,535		60		4,595
4	0	0.08	22	3.41	9	3.49	10
	1	32.02	52	6.71	35	38.73	49
	2	7.86	94	0.06	45	7.92	93
	3	1.65	111			1.65	111
	4	0.60	145			0.60	145
	5	0.18	175			0.18	175
	6	0.04	206			0.04	206
	7	0.02	222			0.02	222
	8+	0.04	213			0.04	213
	Total	42.49		10.18		52.66	
	SOP		2,713		271		2,984
Total	0	0.09	22	6.08	8	6.17	8
	1	41.86	51	41.20	16	83.06	34
	2	28.49	91	1.32	45	29.81	89
	3	19.92	121	0.59	71	20.51	119
	4	12.99	139			12.99	139
	5	5.76	169			5.76	169
	6	2.91	185			2.91	185
	7	0.91	217			0.91	217
	8+	0.82	209			0.82	209
	Total	113.76		49.19		162.94	
	SOP		10,816		818		11,633

Table 3.3.1 **WESTERN BALTIC HERRING. German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1993-2011 (September/October).**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001[1]	2002[2]	2003	2004	2005	2006	2007	2008	2009	2010[3]	2011
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	2,929
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	1,207
2	437	884	329	590	738	679	287	454	1,227	421	223	592	640	274	278	214	135	339	383
3	530	560	358	434	395	394	233	329	845	575	217	346	401	376	149	209	92	483	314
4	403	444	354	295	162	237	156	202	367	341	260	163	192	353	136	150	61	336	280
5	125	189	254	306	119	100	52	79	132	64	97	143	105	183	88	166	32	182	161
6	55	60	127	119	99	51	8	39	86	25	38	79	90	131	25	102	34	76	86
7	28	24	46	47	33	24	1	6	20	10	9	23	26	85	23	42	16	88	52
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	30	11	19	4	27	41
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	5,453
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	934
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	**37.5**	35.8
1	19.5	14.5	58.6	46.6	76.4	39.9	51.1	57.5	48.2	34.2	44.8	35.9	30.1	38.8	23.0	17.7	10.3	**20.9**	46.8
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	**25.8**	30.8
3	33.8	40.7	30.1	31.0	35.9	35.3	27.5	27.7	77.2	56.8	22.0	27.7	36.2	35.9	12.6	17.7	6.3	**33.5**	29.0
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	**24.9**	24.7
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	**19.6**	15.9
6	7.1	12.3	14.9	16.1	14.0	6.2	0.9	5.6	13.3	3.5	5.7	12.2	14.5	19.9	2.9	8.8	2.2	**10.6**	10.7
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	**7.8**	6.9
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	**3.8**	4.9
Total	137.3	248.5	266.3	206.8	253.3	200.5	197.5	168.4	308.1	215.0	174.2	174.6	208.3	243.9	111.0	118.0	65.0	**184.4**	205.6
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	**100.2**	92.2
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	**8.2**	12.2
1	39.7	34.8	35.0	32.4	39.1	49.8	38.2	40.2	42.8	40.8	36.2	37.0	40.0	40.8	41.0	45.0	38.1	**39.1**	38.8
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	**76.2**	80.5
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	**69.4**	92.2
4	63.6	97.0	113.3	71.7	137.2	118.4	106.9	119.4	103.4	118.3	131.2	112.6	118.3	106.2	92.0	95.5	62.4	**74.0**	88.3
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	**108.0**	98.8
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	**139.0**	123.9
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	**87.9**	134.6
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	**140.3**	119.4
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	**27.8**	37.7

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

[2]incl. mean for Sub-division 21, which was not covered by RV SOLEA

[3]Revision of 2010 mean weights/biomass during HAWG 2012

Table 3.3.2 WESTERN BALTIC HERRING. Acoustic surveys on the Western Baltic Spring Spawning Herring in the North Sea/Division IIIa in 1991-2011 (July).

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	1999**	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
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	2,980
2	1,864	2,092	2,768	413	1,887	1,005	715	1,682	1,143	1,891	641	1,577	1,110	930	1,342	2,217	3,621	1,160	398	511	473
3	1,927	1,799	1,274	935	1,022	247	787	901	523	674	452	1,393	395	726	464	1,780	933	843	205	254	259
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490	499	333	161	115	163
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274	82	65	70
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176	86	24	53
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45	39	28	22
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44	65	34	46
Total	**5,177**	**10,509**	**5,779**	**3,339**	**6,867**	**2,673**	**2,088**	**3,248**	**3,201**	**4,696**	**1,481**	**7,002**	**3,807**	**3,926**	**4,939**	**6,786**	**9,199**	**8,839**	**1,601**	**2,030**	**4,066**
+ group	**5,177**	**4,287**	**2,536**	**1,957**	**2,781**	**577**	**1,245**	**1,428**	**691**	**1,295**	**774**	**2,079**	**864**	**1,328**	**910**	**2,487**	**1,660**	**1,715**	**638**	**520**	**613**
Biomass ('000 tonnnes)																					
W-rings																					
0		34.3	1	8.7																	
1		26.8	7	0.4	77.4	52.9	4.7	7.1	74.8	61.4	3.5	137.2	79.0	63.9	105.9	112.6	193.2	284.4	26.8	53.0	90.0
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	47.0
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	31.0
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	25.0
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	12.0
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	10.0
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	5.0
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	10.0
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	230.0
+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3	244.4	178.2	243.2	129.3	75.0	93.0
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	30.2
2	95.0	80.8	50.1	80.3	57.7	86.6	73.0	80.9	88.9	73.1	87.0	68.0	82.5	81.3	74.6	72.4	75.5	87.0	122.7	65.8	98.8
3	114.0	114.7	87.9	122.7	100.4	111.9	103.0	94.1	113.8	102.2	113.2	91.1	104.9	123.2	100.5	89.1	97.4	120.8	149.1	111.4	121.2
4	134.0	128.5	116.2	153.0	114.6	126.8	129.6	124.7	109.1	124.4	140.5	106.6	128.8	135.2	143.7	114.8	119.5	141.4	182.9	150.9	150.6
5	146.0	149.8	149.9	175.1	132.9	149.4	145.0	118.7	120.0	135.4	185.2	145.8	134.2	159.4	160.9	131.6	120.0	165.5	213.3	175.6	168.7
6	216.0	185.7	169.6	205.0	157.2	157.3	143.1	135.8	179.9	179.2	182.6	186.5	165.4	162.9	177.7	153.2	136.6	175.6	248.3	198.0	190.8
7	181.0	199.7	256.9	212.0	172.9	166.8	185.6	156.4	179.9	208.8	206.3	198.7	167.2	191.6	202.3	169.2	101.5	208.5	272.1	215.9	211.0
8+	200.0	252.0	164.2	230.3	183.1	212.9	178.0	168.0	181.7	135.2	226.9	183.4	170.3	178.0	229.2	178.0	138.3	196.7	304.7	234.8	228.5
Total	115.6	123.9	75.8	100.2	73.7	80.5	99.4	91.4	78.5	74.8	110.9	64.8	72.1	81.2	65.9	76.3	70.1	71.1	128.0	79.8	56.6

* revised in 1997

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

Table 3.3.3WESTERN BALTIC HERRING.

N20 Larval Abundance Index.

Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters (March/April to June).

Year	N20 (millions)
1992	1,060
1993	3,044
1994	12,515
1995	7,930
1996	21,012
1997	4,872
1998	16,743
1999	20,364
2000	3,026
2001	4,845
2002	11,324
2003	5,507
2004	5,640
2005	3,887
2006	3,774
2007*	1,829
2008*	1,622
2009	6,464
2010	7,037
2011	4,444

*** small revision during HAWG 2010**

TABLE 3.6.1 WBSS HERRING. CATCH IN NUMBER

Units : thousands

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

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	756285	150271	53489	243554	106906	7946	10721	9610	20734	12394	11813
1	523163	659130	126876	457754	305171	148909	172044	149436	181083	75083	98516
2	488816	281840	264855	197812	319225	187674	184735	136988	243007	136419	46282
3	257837	321311	161251	164766	177833	233214	143904	135753	101330	82970	38787
4	108097	172285	189432	93214	130394	150654	126861	92305	69937	46833	49324
5	68376	57160	103648	91242	60639	98751	64996	89436	48091	29979	27630
6	39092	38532	29117	48957	65695	42459	30199	45930	39750	18589	22632
7	18307	13842	17452	14876	31231	32418	21256	17216	20907	10996	12236
8+	6687	8329	8819	11013	12620	17312	14759	17410	12529	11262	9335

TABLE 3.6.2 WBSS HERRING. WEIGHTS AT AGE IN THE CATCH

Units : kg

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

age	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.0123	0.0105	0.0132	0.00618	0.0140	0.0170	0.0139	0.0178	0.0126	0.00928	0.0103
1	0.0243	0.0213	0.0315	0.02754	0.0272	0.0360	0.0506	0.0647	0.0479	0.04619	0.0320
2	0.0593	0.0700	0.0671	0.06419	0.0721	0.0728	0.0709	0.0788	0.0711	0.07688	0.0770
3	0.0862	0.0968	0.0907	0.10017	0.0938	0.0982	0.0854	0.0960	0.1032	0.10873	0.1009
4	0.1089	0.1196	0.1079	0.10596	0.1106	0.1153	0.1141	0.1153	0.1390	0.13535	0.1205
5	0.1567	0.1400	0.1223	0.13139	0.1228	0.1535	0.1288	0.1404	0.1534	0.16464	0.1439
6	0.1560	0.1876	0.1319	0.15228	0.1493	0.1581	0.1564	0.1481	0.1709	0.18078	0.1526
7	0.1556	0.1814	0.1603	0.16768	0.1619	0.1865	0.1673	0.1667	0.1924	0.19751	0.1658
8+	0.1713	0.1717	0.1625	0.15295	0.1736	0.1848	0.1903	0.1704	0.2146	0.20551	0.1733

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	2011
0	0.0001	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	0.0090
2	0.0509	0.0637	0.0445	0.0456	0.0514	0.0621	0.0550	0.0680	0.0520	0.0626	0.0580
3	0.0783	0.0905	0.0793	0.0811	0.0800	0.0953	0.0800	0.0860	0.0900	0.0974	0.0950
4	0.1159	0.1239	0.1051	0.1092	0.1066	0.1174	0.1140	0.1100	0.1300	0.1283	0.1260
5	0.1690	0.1736	0.1268	0.1440	0.1322	0.1659	0.1430	0.1390	0.1560	0.1618	0.1560
6	0.1763	0.1983	0.1506	0.1628	0.1573	0.1710	0.1710	0.1430	0.1740	0.1813	0.1730
7	0.1681	0.1980	0.1729	0.1932	0.1677	0.1858	0.1750	0.1410	0.1850	0.2023	0.1850
8+	0.1805	0.2036	0.1847	0.2076	0.1820	0.1871	0.1880	0.1580	0.1990	0.2045	0.1920

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	2011
0	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
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
4	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
6	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
8+	0.2	0.2	0.2	0.2	0.2	0.2

TABLE 3.6.5 WBSS HERRING. PROPORTION MATURE

Units : NA

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

age	2006	2007	2008	2009	2010	2011
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	0.20	0.20	0.20	0.20	0.20	0.20
3	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
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

TABLE 3.6.6 WBSS HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

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

age	2006	2007	2008	2009	2010	2011
0	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
2	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
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

TABLE 3.6.7 WBSS HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

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

age	2006	2007	2008	2009	2010	2011
0	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
2	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
4	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
6	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
8+	0.25	0.25	0.25	0.25	0.25	0.25

TABLE 3.6.8 WBSS HERRING. SURVEY INDICES

HERAS 3-6 wr - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
3.00	6.00	NA	1993.00	2011.00	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	2011
3	933000000	843000000	205000000	254000000	259000000
4	499000000	333000000	161000000	115000000	163000000
5	154000000	274000000	82000000	65000000	70000000
6	34000000	176000000	86000000	24000000	53000000

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	2011
3	1	1	1	1
4	1	1	1	1
5	1	1	1	1
6	1	1	1	1

GerAS 1-3 wr - Configuration

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	3.00	NA	1994.00	2011.00	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    2011
  1 968860 752980 950450 560000 392780 270930 535760 1206820
  2 592360 640060 274460 278000 213500 134670 338780  382800
  3 346230 401070 376480 149000 209000  92270 482880  314080
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 2011
  1    1    1    1
  2    1    1    1
  3    1    1    1

N20 - Configuration
      min       max plusgroup   minyear   maxyear    startf      endf
      0.0       0.0        NA    1992.0    2011.0       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 2011
  0 3774 1829 1622 6464 7037 4444
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 2011
  0    1    1    1    1    1
```

TABLE 3.6.9 WBSS HERRING. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	8	8	1991	2011	3	6

TABLE 3.6.10 WBSS HERRING. FLICA CONFIGURATION SETTINGS

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

TABLE 3.6.11 WBSS HERRING. FLR, R SOFTWARE VERSIONS

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

Package  : FLICA
Version  : 1.4-12
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. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 3-6) f	Landings tonnes	Landings SOP
1991	4990766	611865	306843	0.363	191573	1.000
1992	3644301	536747	317845	0.484	194411	1.000
1993	3097516	459051	290995	0.552	185010	1.000
1994	6167290	373402	228122	0.705	172438	1.000
1995	4038064	314542	179570	0.522	150831	1.000
1996	4469355	270538	132151	0.715	121266	1.000
1997	3976489	272015	147601	0.522	115588	1.000
1998	5599813	270090	119440	0.503	107032	1.000
1999	6432009	287720	126726	0.380	97240	1.000
2000	3487574	293020	140102	0.475	109914	1.000
2001	4486001	318722	161426	0.462	105803	1.000
2002	2940297	352190	201125	0.413	106191	1.000
2003	3789452	266978	162782	0.395	78309	1.000
2004	2672576	279072	168338	0.339	76815	1.000
2005	2112904	278409	166503	0.386	88406	1.000
2006	1568541	296520	184317	0.486	90549	1.000
2007	1697020	224088	143326	0.409	68997	0.988
2008	1429294	204422	123711	0.440	68484	1.015
2009	1695931	190334	116377	0.457	67262	1.000
2010	3072854	173231	108427	0.270	42214	1.000
2011	2563268	178914	107342	0.202	27772	1.000

TABLE 3.6.13 **WBSS HERRING. ESTIMATED FISHING MORTALITY**

Units : f

age	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
0	0.0280	0.0471	0.080	0.0506	0.168	0.0453	0.116	0.120	0.108	0.0519	0.216
1	0.2599	0.1747	0.299	0.1609	0.641	0.3798	0.308	0.353	0.237	0.3202	0.311
2	0.3210	0.3731	0.353	0.4236	0.576	0.3806	0.360	0.408	0.397	0.3698	0.335
3	0.4236	0.3730	0.478	0.5063	0.510	0.5682	0.495	0.407	0.432	0.4040	0.334
4	0.4010	0.4794	0.501	0.6538	0.527	0.7239	0.435	0.534	0.361	0.4236	0.434
5	0.3793	0.5007	0.639	0.7138	0.441	0.8289	0.494	0.512	0.400	0.5463	0.419
6	0.2464	0.5842	0.588	0.9468	0.608	0.7383	0.664	0.561	0.328	0.5274	0.660
7	0.4396	0.4863	0.585	0.6363	0.769	0.7362	0.571	0.588	0.457	0.5463	0.521
8	0.4396	0.4863	0.585	0.6363	0.769	0.7362	0.571	0.588	0.457	0.5463	0.521

age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
0	0.0609	0.0165	0.111	0.0603	0.00588	0.0088	0.00945	0.0098	0.00579	0.00434
1	0.3682	0.0816	0.234	0.2442	0.13659	0.1550	0.16654	0.1728	0.10201	0.07648
2	0.3338	0.2993	0.211	0.3070	0.28086	0.3049	0.32764	0.3399	0.20068	0.15046
3	0.3846	0.3242	0.308	0.2970	0.38605	0.3400	0.36542	0.3791	0.22382	0.16781
4	0.3908	0.4119	0.315	0.4277	0.44148	0.4133	0.44421	0.4609	0.27208	0.20399
5	0.4322	0.4325	0.357	0.3487	0.67665	0.4181	0.44939	0.4663	0.27526	0.20637
6	0.4438	0.4102	0.375	0.4723	0.44046	0.4662	0.50103	0.5198	0.30689	0.23008
7	0.5189	0.3701	0.381	0.4366	0.45254	0.4133	0.44421	0.4609	0.27208	0.20399
8	0.5189	0.3701	0.381	0.4366	0.45254	0.4133	0.44421	0.4609	0.27208	0.20399

TABLE 3.6.14 WBSS HERRING. ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	4990766	3644301	3097516	6167290	4038064	4469355	3976489	5599813	6432009
1	4536626	3595317	2575497	2118318	4343433	2529248	3164391	2623690	3678430
2	2163407	2121789	1831199	1158099	1093878	1387578	1049299	1410476	1118056
3	1790788	1284922	1196164	1053865	620780	503556	776468	599284	768174
4	928207	959873	724445	607310	520055	305089	233584	387609	326580
5	616435	508904	486556	359348	258590	251281	121108	123726	186007
6	233892	345371	252531	210204	144095	136277	89808	60521	60703
7	40770	149673	157661	114818	66773	64230	53322	37863	28286
8	15189	64161	60515	76743	41551	52529	60670	34696	18157

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3487574	4486001	2940297	3789452	2672576	2112904	1568541	1697020	1429294
1	4277836	2452991	2678281	2049565	2761448	1771626	1473744	1155191	1246177
2	1760828	1883794	1089736	1124088	1145665	1325486	841698	779747	600080
3	615350	995976	1103206	639012	682260	759926	798317	520382	470652
4	408105	336356	583812	614824	378298	410508	462323	444281	303250
5	186335	218750	178437	323360	333420	225961	219139	243419	240602
6	102110	88347	117758	94826	171785	191046	130540	91200	131190
7	35791	49337	37401	61860	51513	96695	97533	68801	46846
8	27768	18021	22505	31260	38136	39073	52085	47772	53164

age	2009	2010	2011
0	1695931	3072854	2563268
1	1048887	1244117	2263287
2	639889	535230	681416
3	354046	372921	358531
4	267388	198403	244091
5	159230	138080	123744
6	125681	81785	85847
7	65080	61186	49265
8	37151	51928	55627

TABLE 3.6.15 WBSS HERRING. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	year 2012
0	NA
1	1890692
2	1271681
3	479966
4	248193
5	162968
6	82421
7	55840
8	70031

TABLE 3.6.16 WBSS HERRING. FITTED SELECTION PATTERN

Units : NA

age	2007	2008	2009	2010	2011
0	0.0213	0.0213	0.0213	0.0213	0.0213
1	0.3749	0.3749	0.3749	0.3749	0.3749
2	0.7376	0.7376	0.7376	0.7376	0.7376
3	0.8226	0.8226	0.8226	0.8226	0.8226
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0117	1.0117	1.0117	1.0117	1.0117
6	1.1279	1.1279	1.1279	1.1279	1.1279
7	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000

TABLE 3.6.17 WBSS HERRING. PREDICTED CATCH IN NUMBERS

Units : NA

age	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	2011
0	756285	150271	53489	243554	106906	7946	12839	11618	14300	15326	9591
1	523163	659130	126876	457754	305171	148909	131335	151486	131919	95348	131551
2	488816	281840	264855	197812	319225	187674	186645	152775	168078	88500	86486
3	257837	321311	161251	164766	177833	233214	136713	131365	101892	68036	50340
4	108097	172285	189432	93214	130394	150654	137260	99308	90176	43029	40962
5	68376	57160	103648	91242	60639	98751	75917	79528	54197	30252	20985
6	39092	38532	29117	48957	65695	42459	31038	47249	46576	19689	16053
7	18307	13842	17452	14876	31231	32418	21256	15341	21948	13270	8267
8	6687	8329	8819	11013	12620	17312	14759	17410	12529	11262	9335

TABLE 3.6.18 WBSS HERRING. CATCH RESIDUALS

Units : thousands NA

age	2007	2008	2009	2010	2011
0	-0.1803	-0.1897	0.37152	-0.21232	0.208
1	0.2700	-0.0136	0.31676	-0.23894	-0.289
2	-0.0103	-0.1091	0.36866	0.43272	-0.625
3	0.0513	0.0328	-0.00553	0.19844	-0.261
4	-0.0788	-0.0731	-0.25417	0.08471	0.186
5	-0.1553	0.1174	-0.11953	-0.00906	0.275
6	-0.0274	-0.0283	-0.15847	-0.05750	0.343
7	0.0000	0.1153	-0.04859	-0.18797	0.392
8	0.0000	0.0000	0.00000	0.00000	0.000

TABLE 3.6.19 WBSS HERRING. PREDICTED INDEX VALUES

HERAS 3-6 wr (Units : NA NA)

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
3	1094874974	947624740	556775074	435618312	703240065	573346799	NA	589836626
4	539281195	410939731	380833216	197587711	181163236	282631069	NA	318876602
5	273983137	193139933	164870570	125683762	74693088	75435465	NA	111206017
6	123993990	82488482	69880726	60918986	42063354	30232565	NA	52078919

age \ year	2001	2002	2003	2004	2005	2006	2007
3	997299392	1070352044	643833204	694414382	778827768	773861527	519167789
4	261122663	465610635	483913095	316282021	319934713	357225688	349381874
5	141334681	114362920	207203180	223991206	152580828	120548925	157387023
6	41485973	63282032	52038113	96388079	100849091	70295443	48327310

age \ year	2008	2009	2010	2011
3	462155147	344687930	400071817	398338545
4	233914880	204115356	170421632	218782582
5	152556272	99903356	97617070	91331421
6	68020767	64403670	47875551	52724523

GerAS 1-3 wr (Units : NA NA)

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	902285	1259920	904249	1198177	958349	1474607	1604138	NA	966456	930141
2	423893	354478	525663	404058	522875	417972	672821	NA	428577	454441
3	490100	287751	222870	364442	301722	378964	310565	NA	565484	343762

age \ year	2004	2005	2006	2007	2008	2009	2010	2011
1	1109425	705943	640056	494389	528409	442536	555485	1031385
2	497263	532565	345339	313840	237163	250422	234146	310319
3	371823	417829	408743	276435	244987	182280	217397	218588

N20 (Units : NA NA)

age \ year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	6342	5320	10717	6696	7783	6732	9464	10924	6057	7297	5089	6676	4533	3658

age \ year	2006	2007	2008	2009	2010	2011
0	2775	2999	2525	2996	5436	4538

TABLE 3.6.20 WBSS HERRING. INDEX RESIDUALS

HERAS 3-6 wr (Units : NA)

age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	0.152	-0.0134	0.607	-0.5674	0.1125	0.45201	NA	0.1328	-0.7907	0.263
4	0.103	0.1982	1.204	-0.3374	-0.0874	-0.00224	NA	0.1321	-0.5339	0.119
5	0.460	0.2130	0.436	-0.0546	-0.1087	0.38625	NA	0.5127	-0.3826	-0.268
6	0.217	0.8131	0.912	-0.4986	0.4949	0.52291	NA	0.0654	-0.0984	-0.471

age	2003	2004	2005	2006	2007	2008	2009	2010	2011
3	-0.490	0.0445	-0.519	0.833	0.5862	0.601	-0.520	-0.454	-0.43047
4	-0.403	-0.0301	-0.463	0.316	0.3564	0.353	-0.237	-0.393	-0.29433
5	-0.695	-0.1983	-0.398	0.403	-0.0218	0.586	-0.197	-0.407	-0.26600
6	-0.725	-0.2903	-0.188	-0.957	-0.3516	0.951	0.289	-0.691	0.00521

GerAS 1-3 wr (Units : NA)

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.775	0.2850	0.465	0.4898	-0.179	-0.0967	-0.1150	NA	-0.1432	0.286
2	0.735	-0.0758	0.115	0.6026	0.261	-0.3751	-0.3934	NA	-0.0169	-0.714
3	0.133	0.2183	0.667	0.0793	0.267	-0.4885	0.0575	NA	0.0173	-0.459

age	2004	2005	2006	2007	2008	2009	2010	2011
1	-0.1355	0.0645	0.3954	0.125	-0.297	-0.491	-0.0362	0.157
2	0.1750	0.1839	-0.2297	-0.121	-0.105	-0.620	0.3694	0.210
3	-0.0713	-0.0409	-0.0822	-0.618	-0.159	-0.681	0.7980	0.362

N20 (Units : NA)

age	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
0	-1.79	-0.558	0.155	0.169	0.993	-0.323	0.57	0.623	-0.694	-0.410	0.8	-0.192

age	2004	2005	2006	2007	2008	2009	2010	2011
0	0.218	0.0608	0.307	-0.494	-0.443	0.769	0.258	-0.0208

TABLE 3.6.21 WBSS HERRING. FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2007	0.4133	0.1959	0.28154	0.60677
F, 2008	0.4442	0.1958	0.30262	0.65203
F, 2009	0.4609	0.2039	0.30902	0.68735
F, 2010	0.2721	0.2177	0.17758	0.41689
F, 2011	0.2040	0.2218	0.13208	0.31505
Selectivity at age 0	0.0213	0.4936	0.00809	0.05598
Selectivity at age 1	0.3749	0.2216	0.24283	0.57885
Selectivity at age 2	0.7376	0.2095	0.48915	1.11218
Selectivity at age 3	0.8226	0.2045	0.55101	1.22815
Selectivity at age 5	1.0117	0.1813	0.70914	1.44328
Selectivity at age 6	1.1279	0.1734	0.80286	1.58460
Terminal year pop, age 0	2563266.6052	0.3208	1366781.13983	4807160.04768
Terminal year pop, age 1	2263285.7096	0.2362	1424700.09143	3595467.02783
Terminal year pop, age 2	681414.9348	0.2003	460157.21846	1009060.15333
Terminal year pop, age 3	358529.6364	0.1794	252223.02303	509642.21528
Terminal year pop, age 4	244090.3477	0.1754	173073.55383	344247.26681
Terminal year pop, age 5	123743.1028	0.1877	85659.68996	178758.00743
Terminal year pop, age 6	85846.1812	0.2091	56979.96126	129336.11504
Terminal year pop, age 7	49263.6404	0.2444	30511.12536	79541.68323
Last true age pop, 2007	68800.2265	0.3608	33918.62186	139553.75862
Last true age pop, 2008	46844.8447	0.2737	27394.77461	80104.30828
Last true age pop, 2009	65078.6055	0.2498	39885.51596	106184.53329
Last true age pop, 2010	61185.1144	0.2631	36532.96208	102472.34317
Index 1, age 3 numbers, Q	1398.1744	0.1550	1031.95090	1894.36486
Index 1, age 4 numbers, Q	1153.7625	0.1556	850.50549	1565.14924
Index 1, age 5 numbers, Q	951.4773	0.1570	699.39139	1294.42413
Index 1, age 6 numbers, Q	803.5742	0.1601	587.17890	1099.71850
Index 2, age 1 numbers, Q	0.7227	0.1394	0.54997	0.94974
Index 2, age 2 numbers, Q	0.6028	0.1391	0.45889	0.79178
Index 2, age 3 numbers, Q	0.8183	0.1392	0.62284	1.07497
Index 3, age 0 numbers, Q	0.0020	0.0778	0.00172	0.00233

Table 3.6.22 WESTERN BALTIC HERRING. Input table for short term predictions

MFDP version 1a
Run: WBSS 2012
Time and date: 16:19 18/03/2012
Fbar age range: 3-6

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1817402	0.3	0.00	0.1	0.25	0.000	0.007	0.011
1	1340534	0.5	0.00	0.1	0.25	0.015	0.117	0.042
2	1271681	0.2	0.20	0.1	0.25	0.058	0.230	0.075
3	479966	0.2	0.75	0.1	0.25	0.094	0.257	0.104
4	248193	0.2	0.90	0.1	0.25	0.128	0.312	0.132
5	162968	0.2	1.00	0.1	0.25	0.158	0.316	0.154
6	82421	0.2	1.00	0.1	0.25	0.176	0.352	0.168
7	55840	0.2	1.00	0.1	0.25	0.191	0.312	0.185
8	70031	0.2	1.00	0.1	0.25	0.198	0.312	0.198

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1817402	0.3	0.00	0.1	0.25	0.000	0.007	0.011
1		0.5	0.00	0.1	0.25	0.015	0.117	0.042
2		0.2	0.20	0.1	0.25	0.058	0.230	0.075
3		0.2	0.75	0.1	0.25	0.094	0.257	0.104
4		0.2	0.90	0.1	0.25	0.128	0.312	0.132
5		0.2	1.00	0.1	0.25	0.158	0.316	0.154
6		0.2	1.00	0.1	0.25	0.176	0.352	0.168
7		0.2	1.00	0.1	0.25	0.191	0.312	0.185
8		0.2	1.00	0.1	0.25	0.198	0.312	0.198

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1817402	0.3	0.00	0.1	0.25	0.000	0.007	0.011
1		0.5	0.00	0.1	0.25	0.015	0.117	0.042
2		0.2	0.20	0.1	0.25	0.058	0.230	0.075
3		0.2	0.75	0.1	0.25	0.094	0.257	0.104
4		0.2	0.90	0.1	0.25	0.128	0.312	0.132
5		0.2	1.00	0.1	0.25	0.158	0.316	0.154
6		0.2	1.00	0.1	0.25	0.176	0.352	0.168
7		0.2	1.00	0.1	0.25	0.191	0.312	0.185
8		0.2	1.00	0.1	0.25	0.198	0.312	0.198

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)

$N_{2011/2012/2013/2014}$ Age 0:	Geometric Mean from ICA of age 0 (Table 3.6.14) for the years 2006-2010
N_{2012} Age 1	= N_{2011} Age 0 * EXP(-(F_{2011} Age 0+ M_{2011} Age 0))
N_{2012} Age 2-8+	Output from ICA (Table 3.6.15)
Natural Mortality (M):	Average for 2009-2011
Weight in the Catch/Stock (CWt/SWt):	Average for 2009-2011
Expoitation pattern (Sel):	Average for 2009-2011

Table 3.6.23 WESTERN BALTIC HERRING.
Short-term prediction multiple option table, Catch constraint

MFDP version 1a
Run: WBSS 2012
Western Baltic Herring (combined sex; plus group)
Time and date: 16:19 18/03/2012
Fbar age range: 3-6

2012 Biomass	SSB	FMult	FBar	Landings
235712	132290	0.6901	0.2135	40876

2013 Biomass	SSB	FMult	FBar	Landings	2014 Biomass	SSB
261009	171809	0.0000	0.0000	0	323597	229784
	171304	0.1000	0.0309	7035	316057	222899
	170802	0.2000	0.0619	13890	308718	216227
	170301	0.3000	0.0928	20567	301573	209759
	169801	0.4000	0.1238	27074	294618	203490
	169303	0.5000	0.1547	33413	287846	197414
	168806	0.6000	0.1856	39591	281254	191525
	168311	0.7000	0.2166	45610	274836	185816
	167817	0.8000	0.2475	51476	268587	180283
	167325	0.9000	0.2784	57193	262502	174919
	166834	1.0000	0.3094	62765	256578	169719
	166345	1.1000	0.3403	68195	250809	164678
	165857	1.2000	0.3713	73488	245191	159791
	165370	1.3000	0.4022	78647	239721	155054
	164885	1.4000	0.4331	83676	234393	150462
	164402	1.5000	0.4641	88579	229205	146009
	163920	1.6000	0.4950	93359	224152	141692
	163439	1.7000	0.5259	98018	219231	137507
	162960	1.8000	0.5569	102562	214438	133450
	162482	1.9000	0.5878	106991	209769	129515
	162005	2.0000	0.6188	111311	205222	125701

Input units are thousands and kg - output in tonnes

Table 3.6.24 WESTERN BALTIC HERRING.
Short-term prediction multiple option table, TAC constraint.

MFDP version 1a
Run: WBSS_TAC constraint
Western Baltic Herring (combined sex; plus group)
Time and date: 09:53 22/03/2012
Fbar age range: 3-6

2012				
Biomass	SSB	FMult	FBar	Landings
235712	131199	0.9704	0.3002	55555

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
245317	159501	0.0000	0.0000	0	307520	215555
	159034	0.1000	0.0309	6608	300433	209119
	158568	0.2000	0.0619	13047	293533	202881
	158103	0.3000	0.0928	19321	286815	196834
	157640	0.4000	0.1238	25434	280275	190973
	157178	0.5000	0.1547	31392	273906	185291
	156718	0.6000	0.1856	37198	267705	179783
	156258	0.7000	0.2166	42857	261667	174444
	155801	0.8000	0.2475	48372	255788	169267
	155344	0.9000	0.2784	53748	250062	164250
	154889	1.0000	0.3094	58988	244486	159385
	154436	1.1000	0.3403	64095	239056	154669
	153983	1.2000	0.3713	69075	233767	150096
	153532	1.3000	0.4022	73929	228616	145663
	153083	1.4000	0.4331	78661	223599	141365
	152634	1.5000	0.4641	83275	218713	137198
	152187	1.6000	0.4950	87774	213953	133157
	151742	1.7000	0.5259	92161	209317	129239
	151297	1.8000	0.5569	96439	204800	125440
	150854	1.9000	0.5878	100611	200400	121757
	150413	2.0000	0.6188	104679	196114	118185

Input units are thousands and kg - output in tonnes

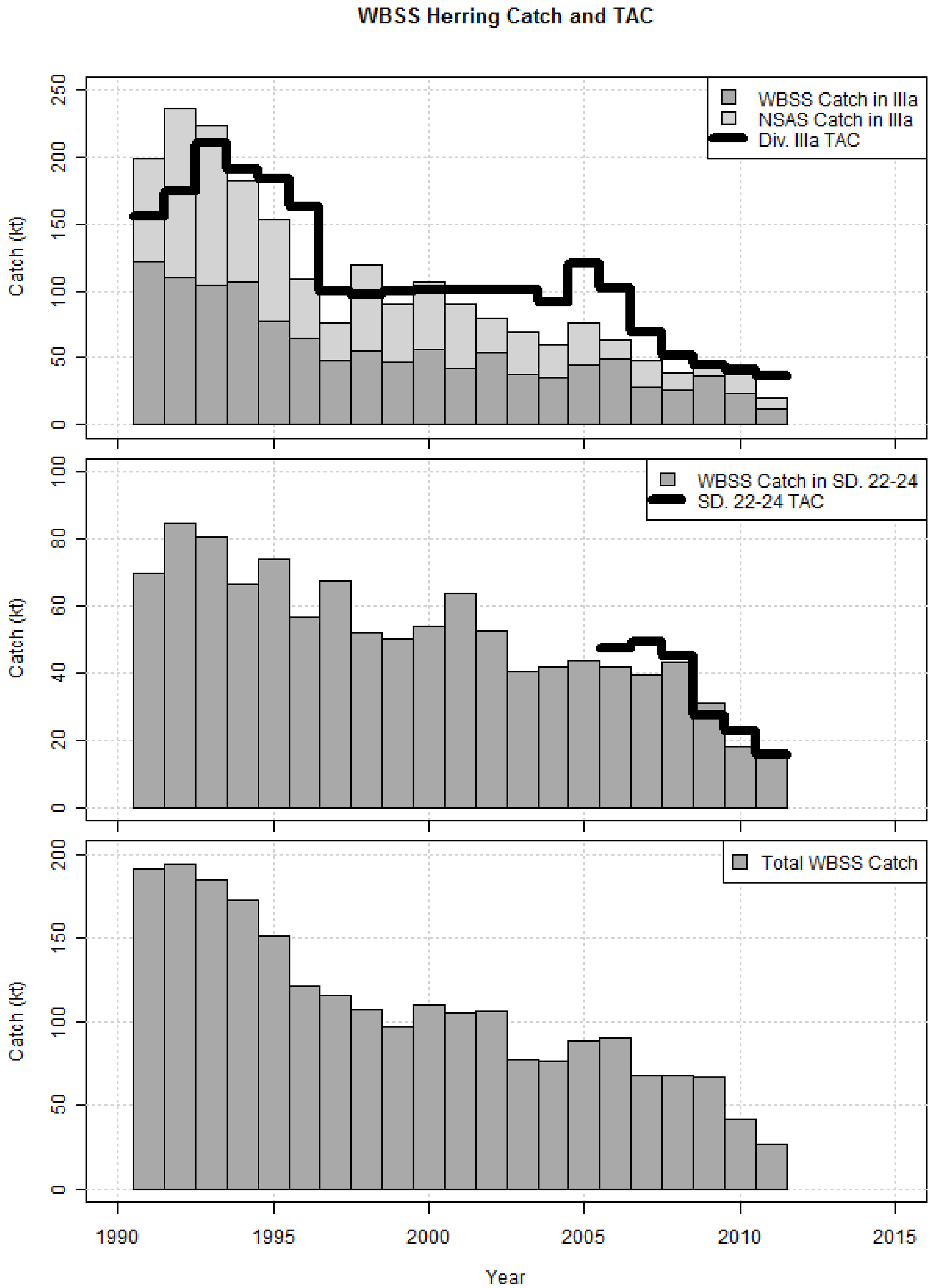


Figure 3.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Catches and TACs by area. Top panel) Catches of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in division IIIa, and the total TAC for both stocks. Middle panel) Catches and TACs of WBSS herring in subdivisions 22-24.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

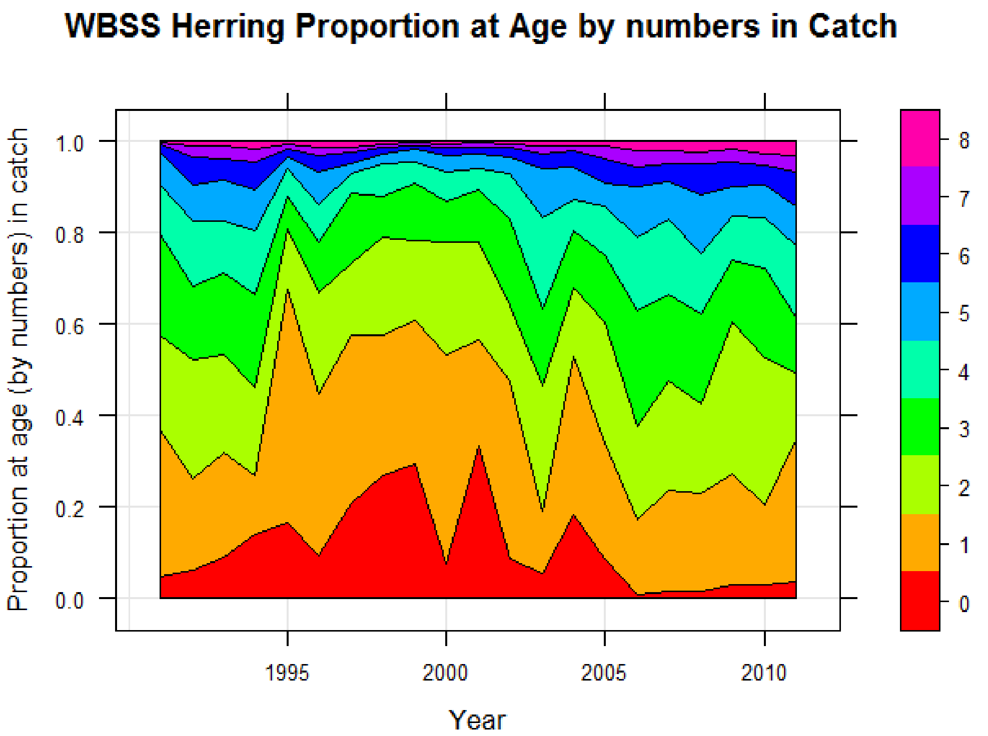


Figure 3.6.1.1 WESTERN BALTIC SPRING SPAWNING HERRING. Proportion (by numbers) of a given age (in winter rings) in the catch.

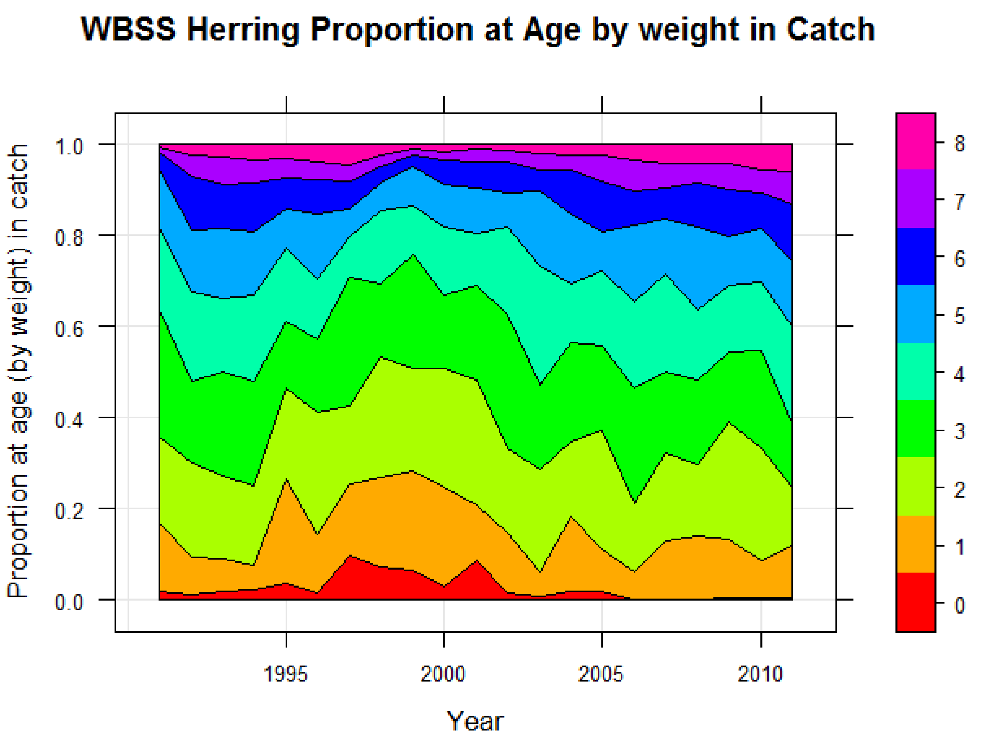


Figure 3.6.1.2 WESTERN BALTIC SPRING SPAWNING HERRING. Proportion (by weight) of a given age (in winter rings) in the catch.

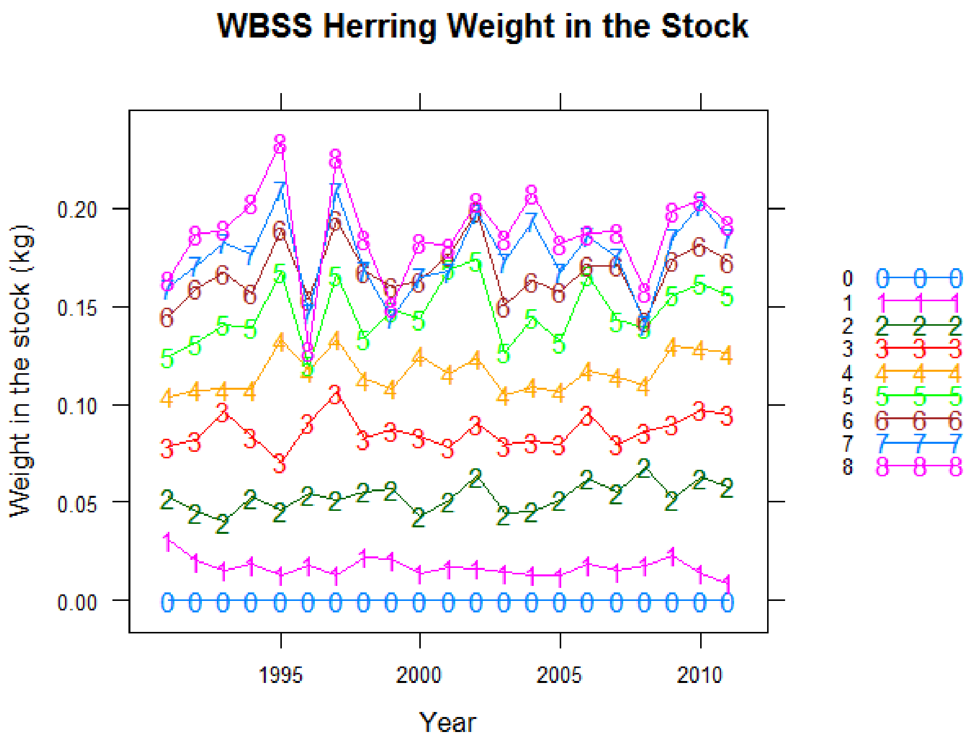


Figure 3.6.1.3 WESTERN BALTIC SPRING SPAWNING HERRING. Weight at age (in winter rings) in the stock.

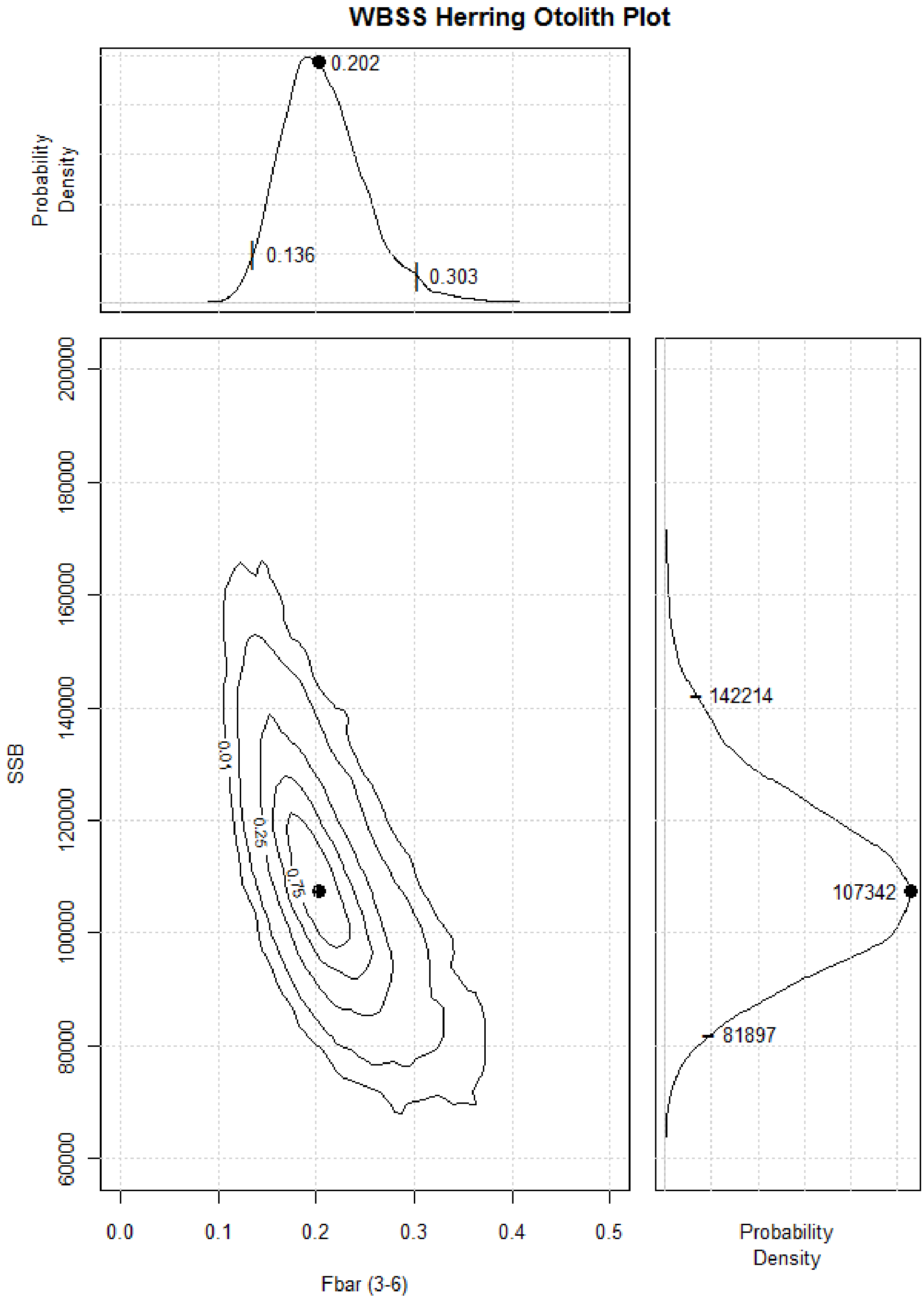


Figure 3.6.4.1 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. "Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated 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.

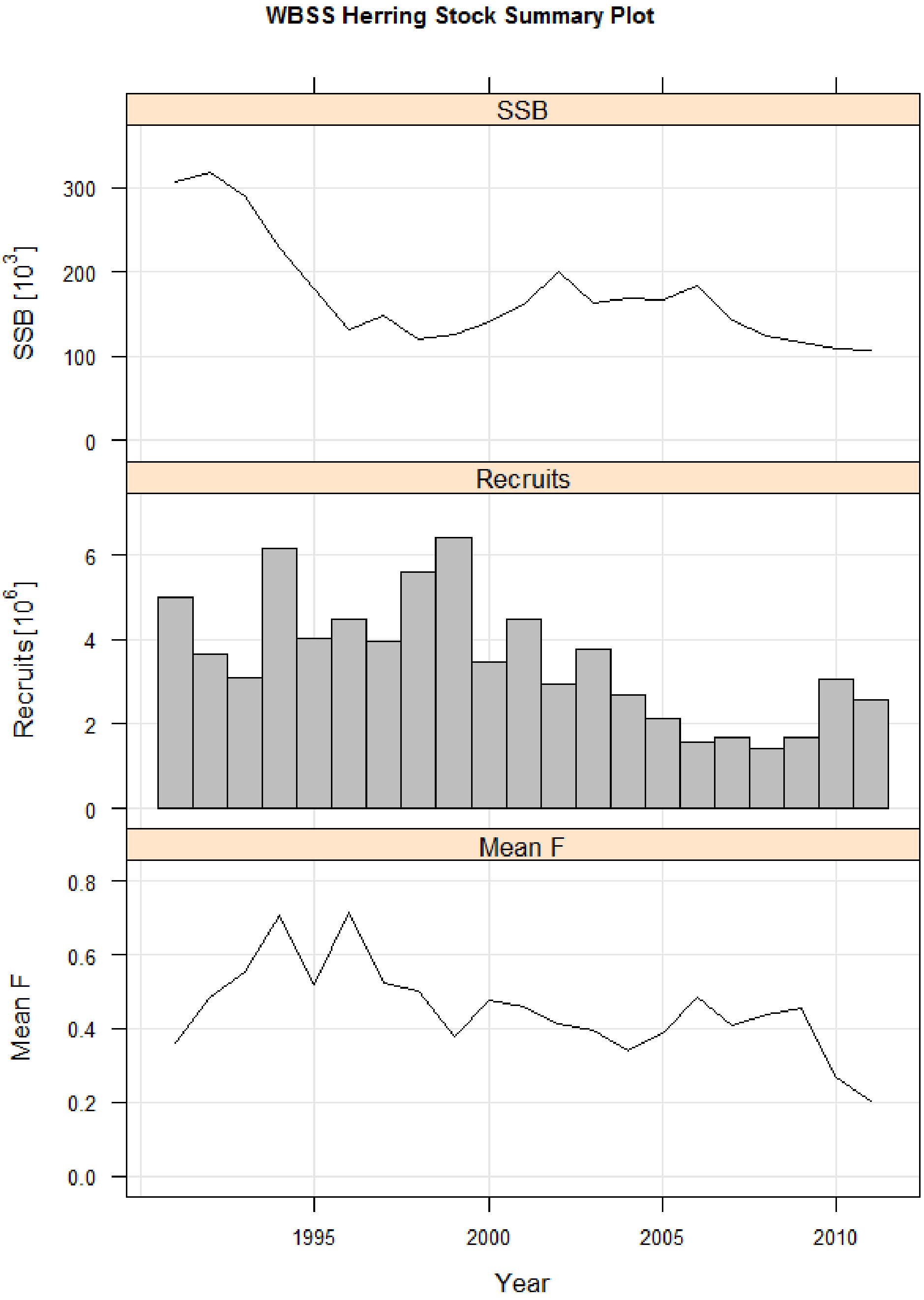


Figure 3.6.4.2 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age 0-wr) as a function of time. Bottom panel:: Mean annual fishing mortality on ages 3-6 ringers as a function of time.

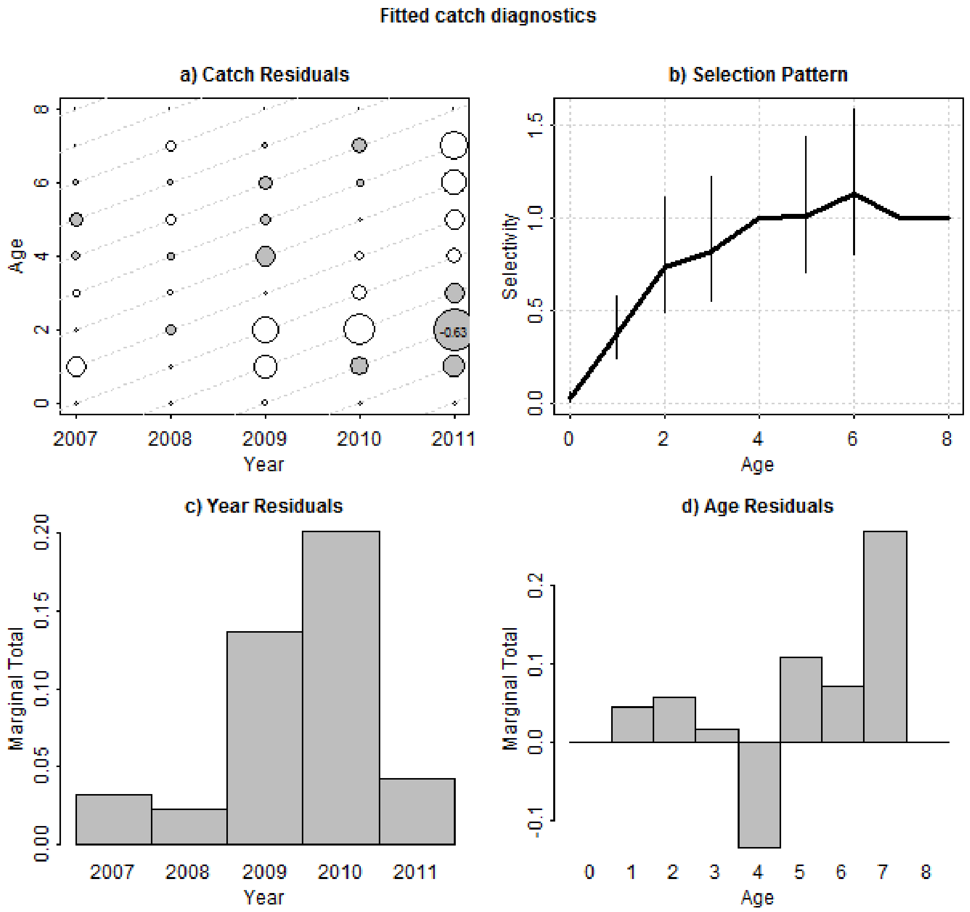


Figure 3.6.4.3 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of selection pattern. a) Bubbles plot of log catch residuals by age (weighting applied) and year. Grey bubbles correspond to negative log residuals. The largest residual is given. b) Estimated selection parameters (relative to 4 wr) with 95% confidence intervals. c): Marginal totals of residuals by year. d). Marginal totals of residuals by age (wr).

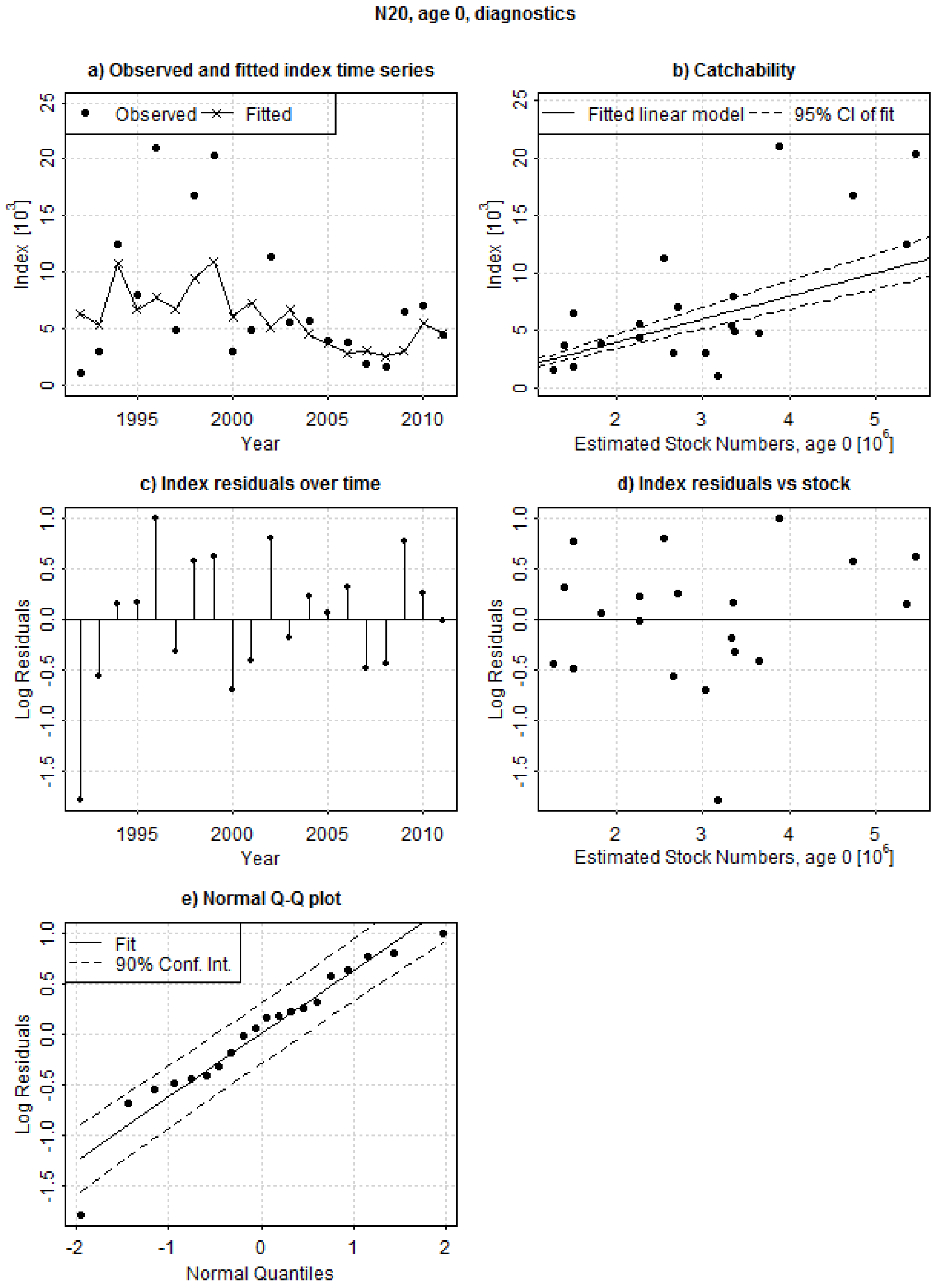


Figure 3.6.4.4 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the N20 larval index. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), 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).

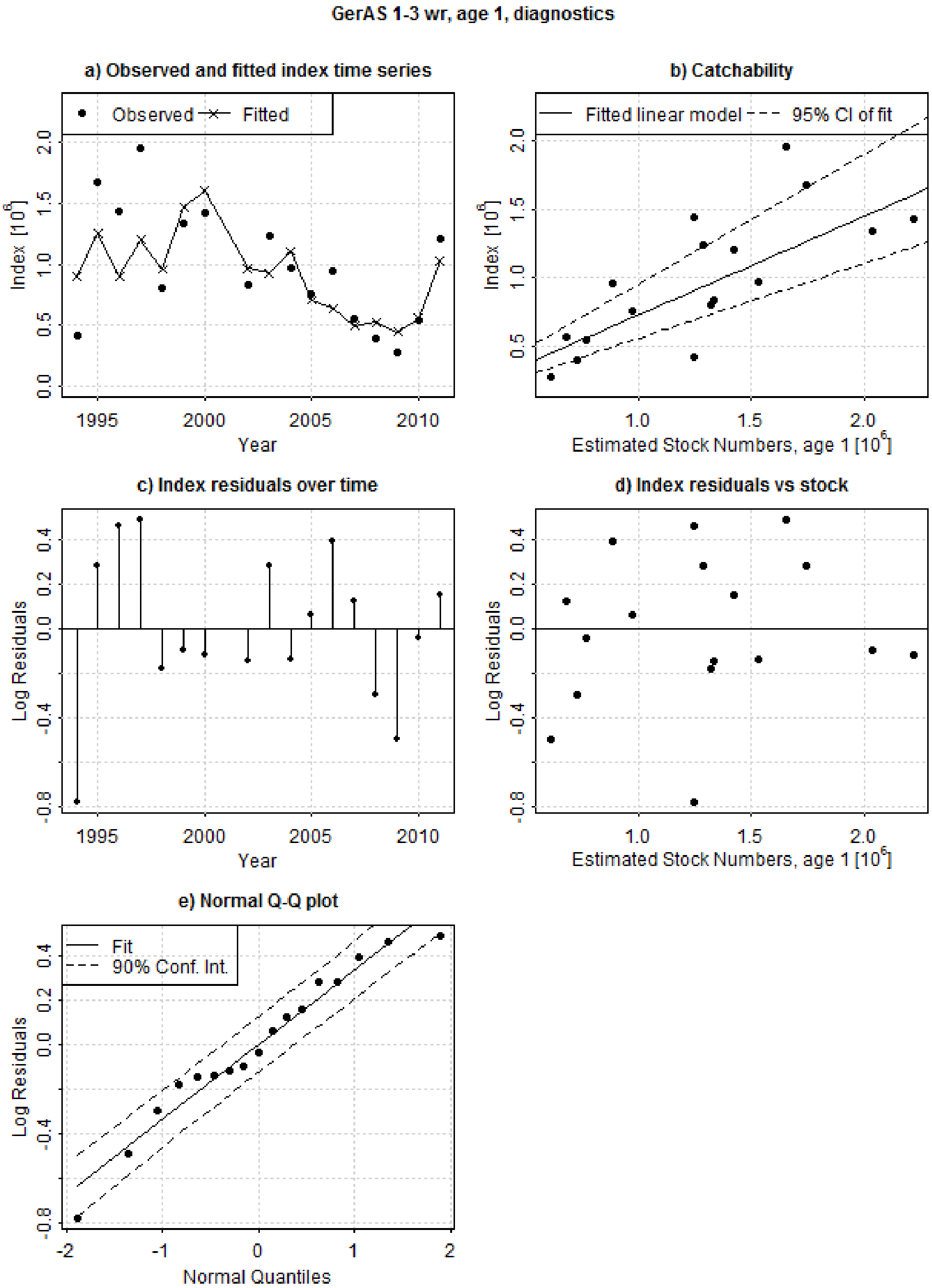


Figure 3.6.4.5 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates 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).

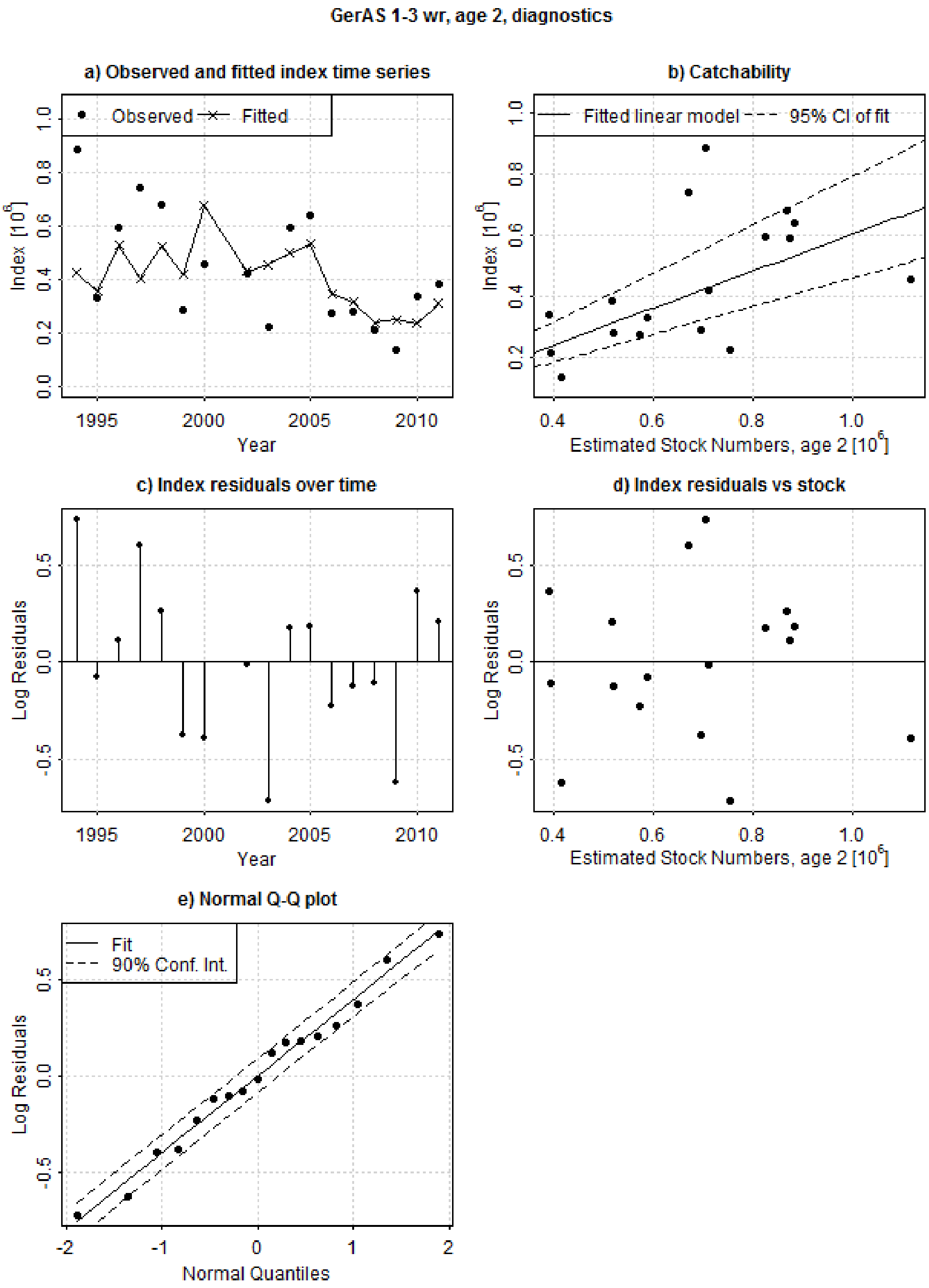


Figure 3.6.4.6 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates 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).

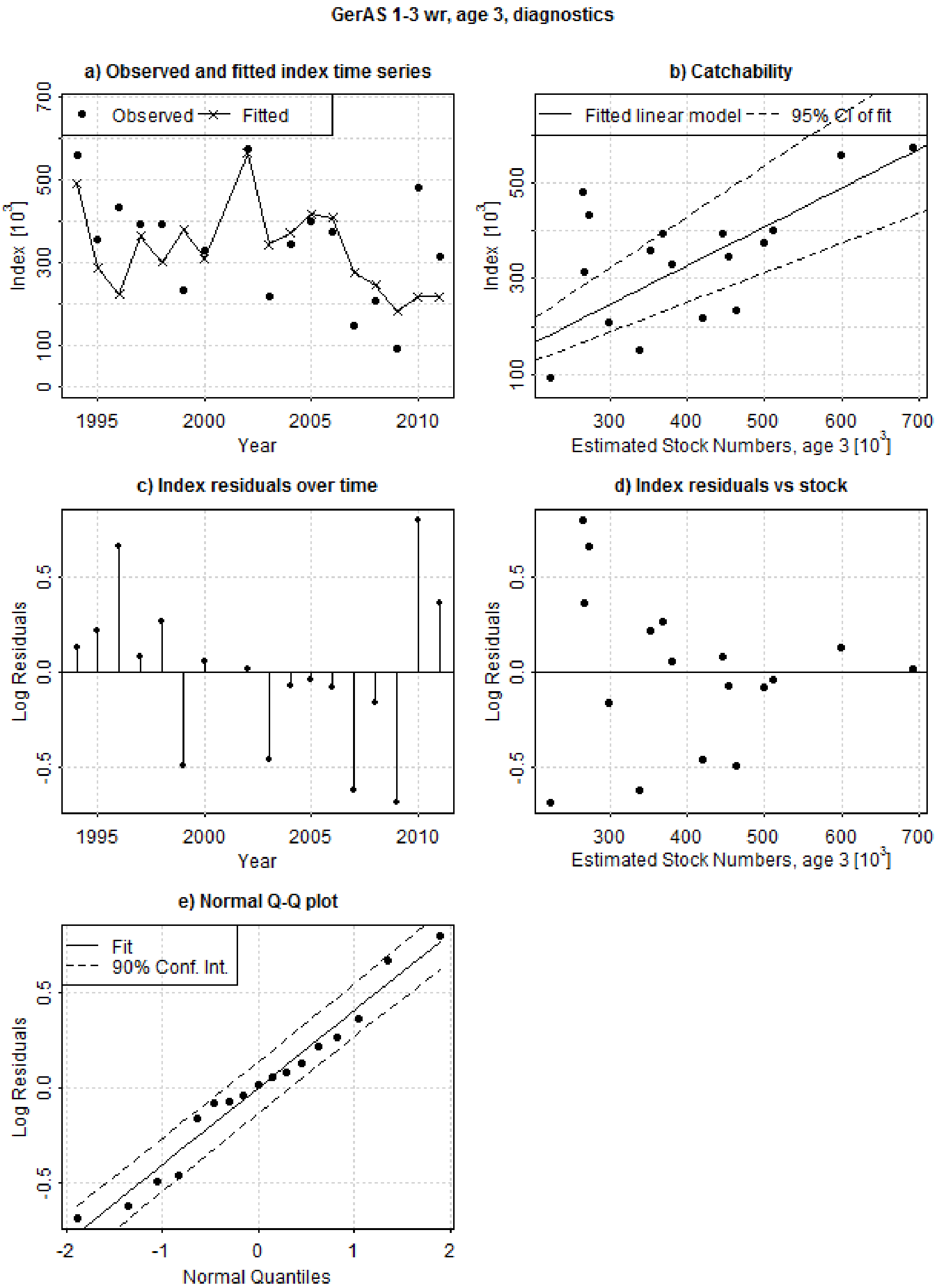


Figure 3.6.4.7 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates 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).

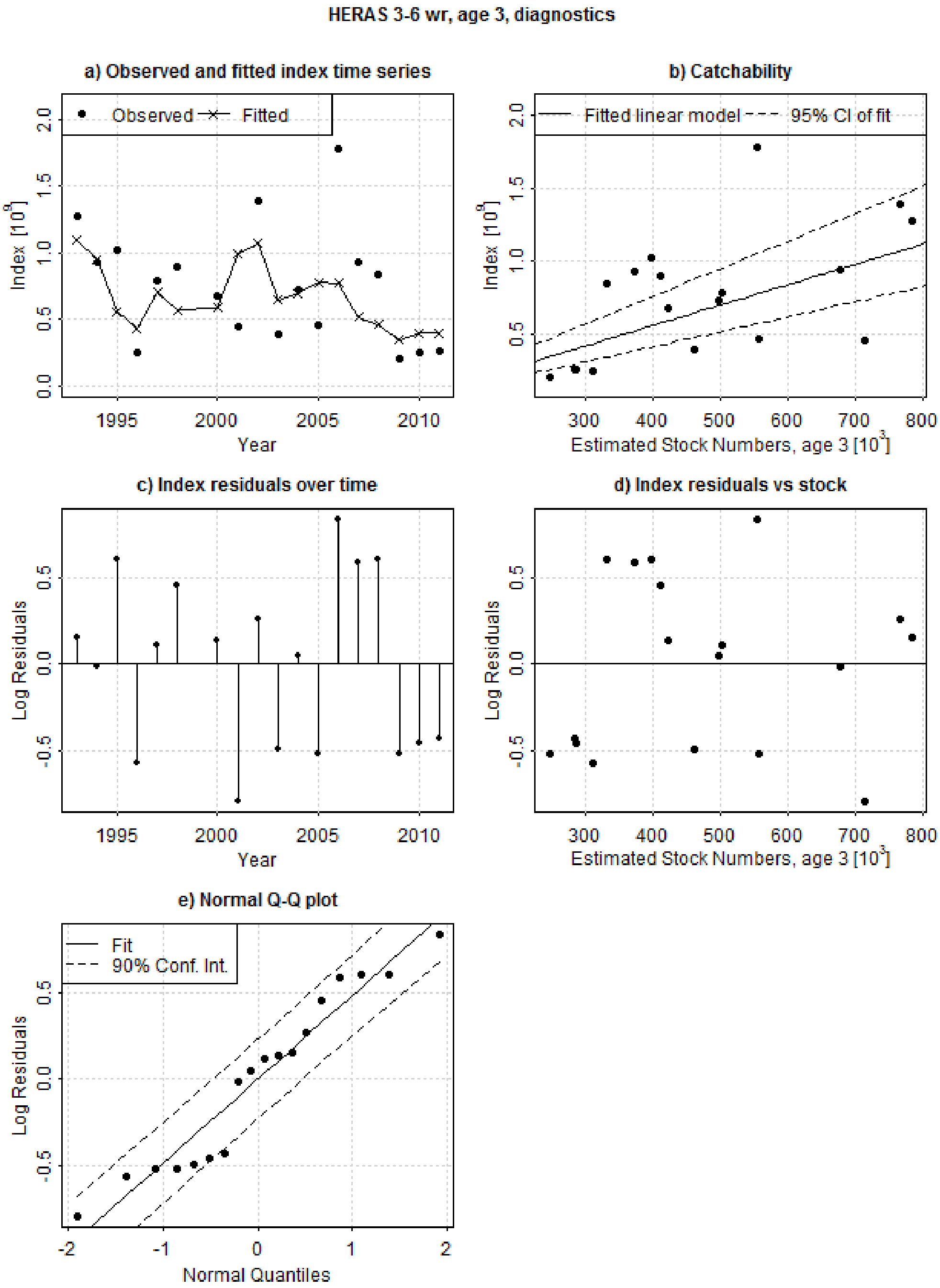


Figure 3.6.4.8 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus 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).

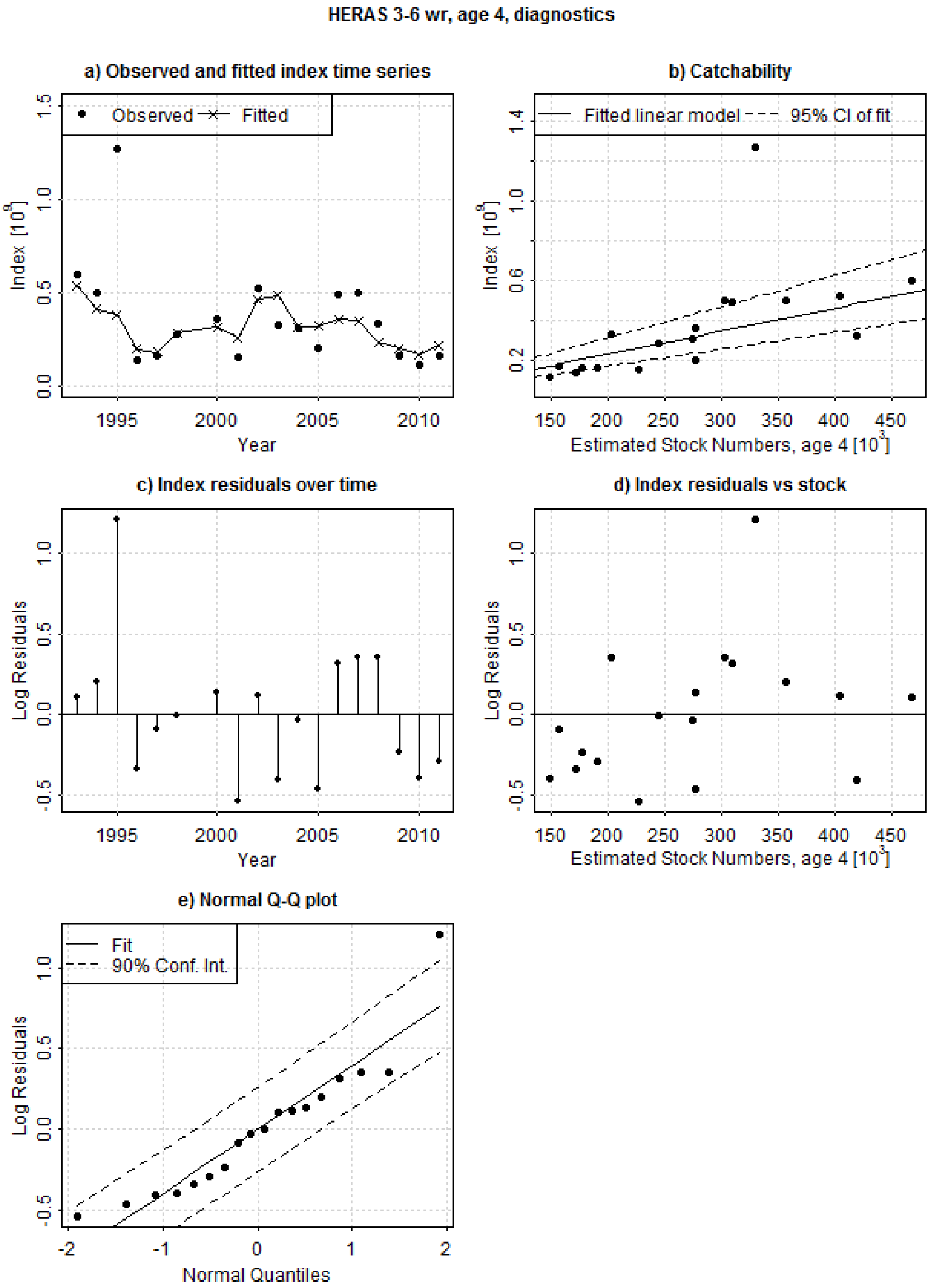


Figure 3.6.4.9 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus 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).

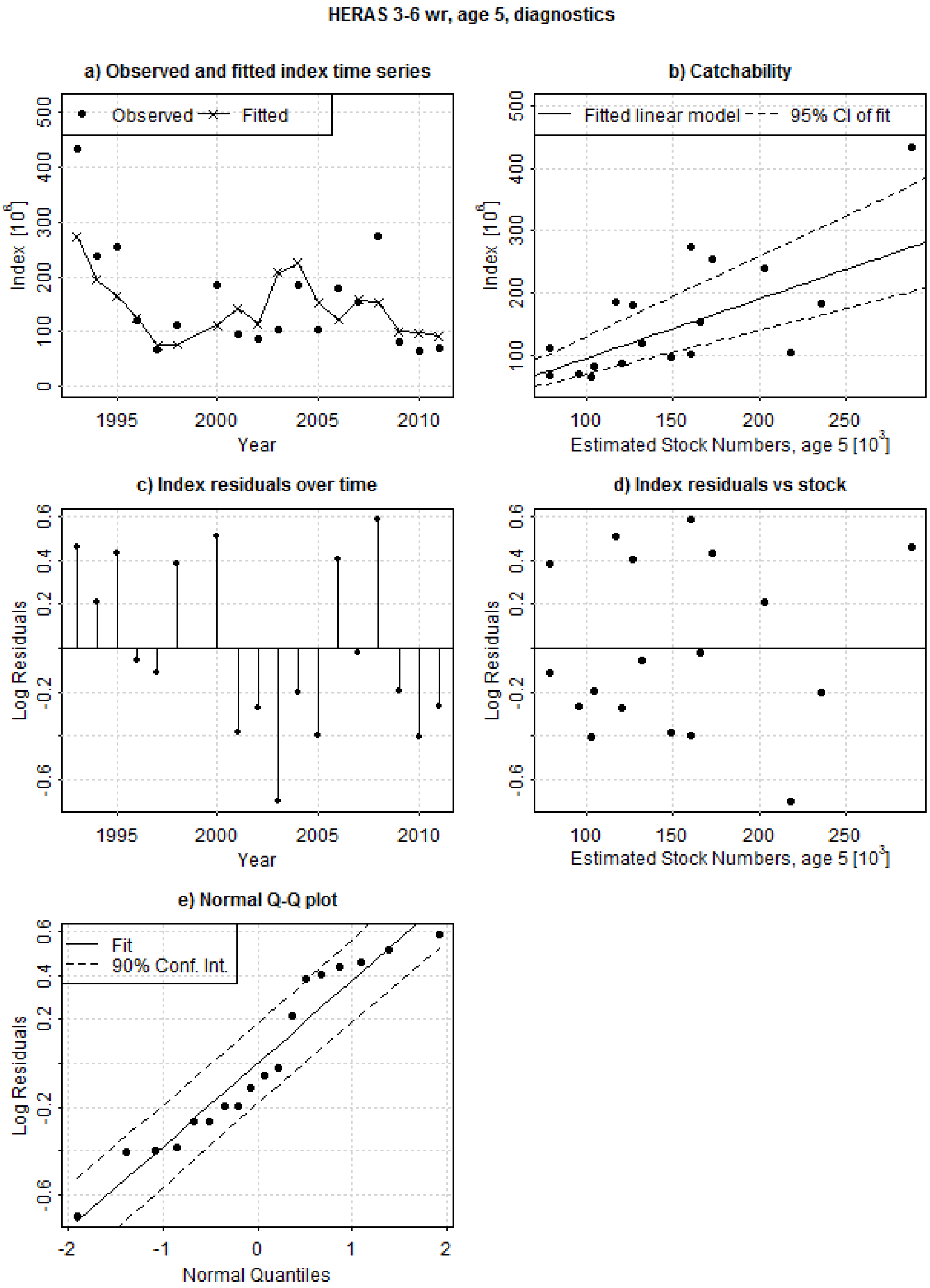


Figure 3.6.4.10 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus 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).

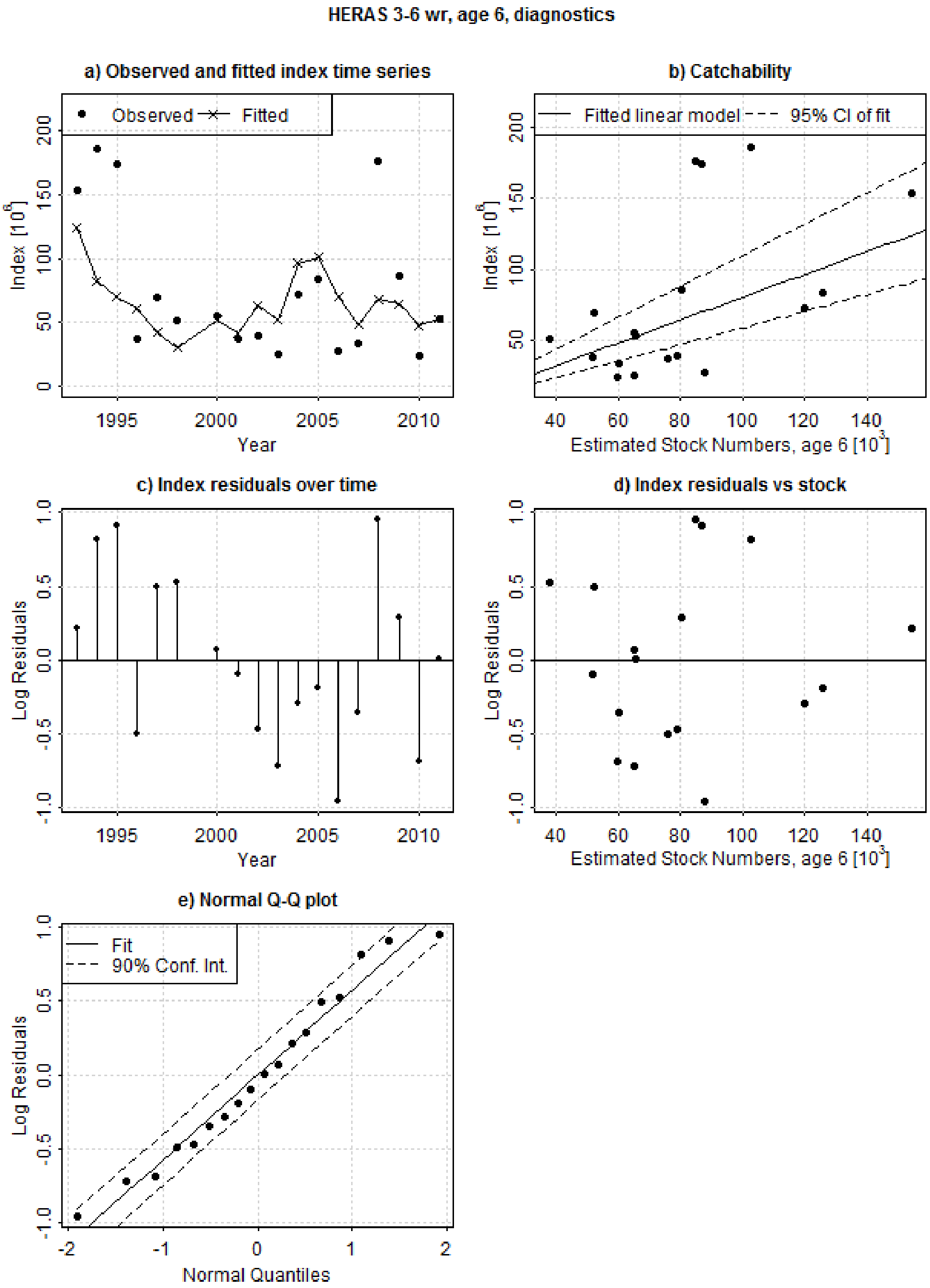


Figure 3.6.4.11 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus 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).

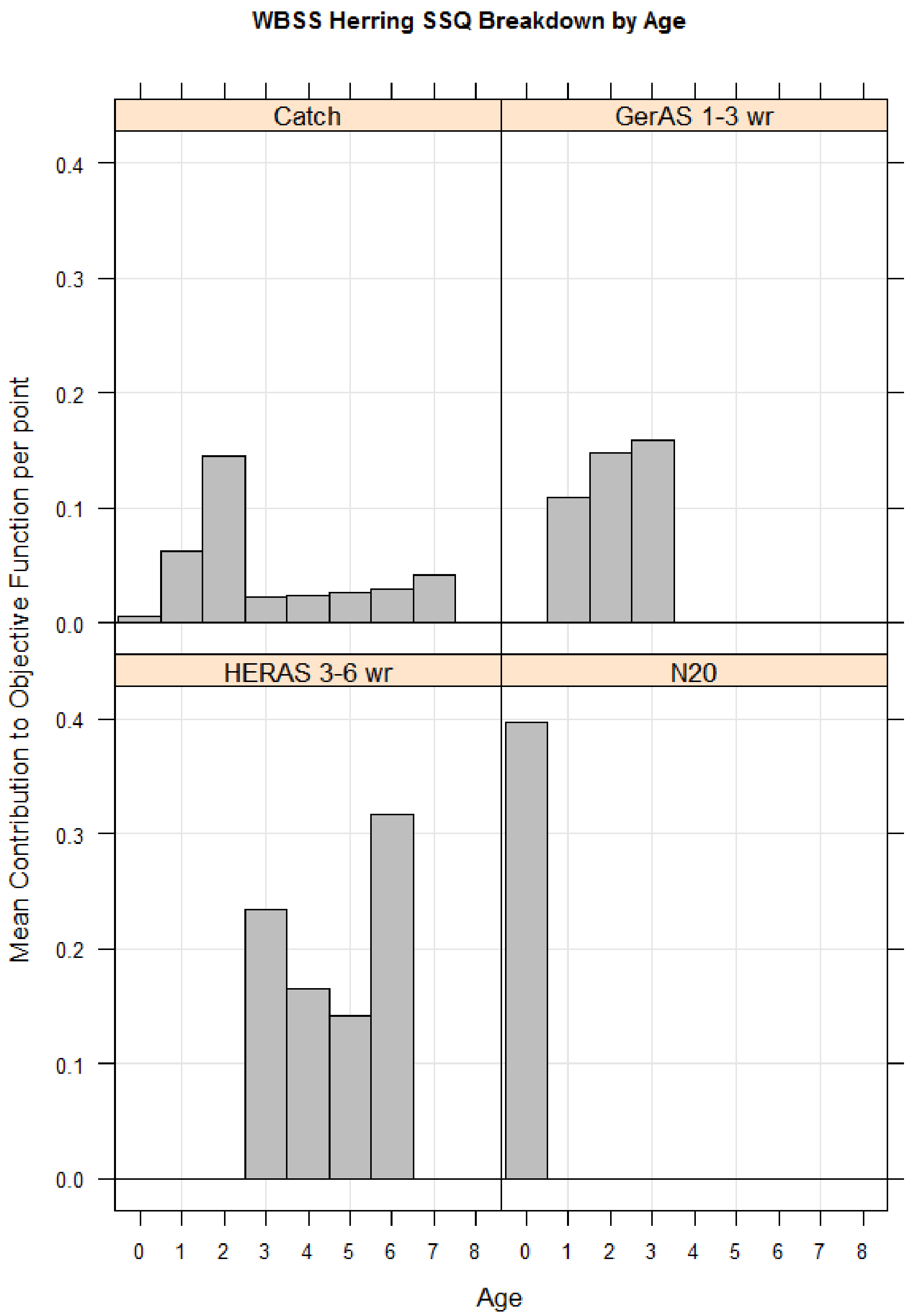


Figure 3.6.4.12 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Mean contribution of a data point individual information groups (ages in each survey) to the FLICA objective function. The contribution is calculated from the mean of the squared residuals in the corresponding class, and weighted according to the appropriate value employed by the optimiser.

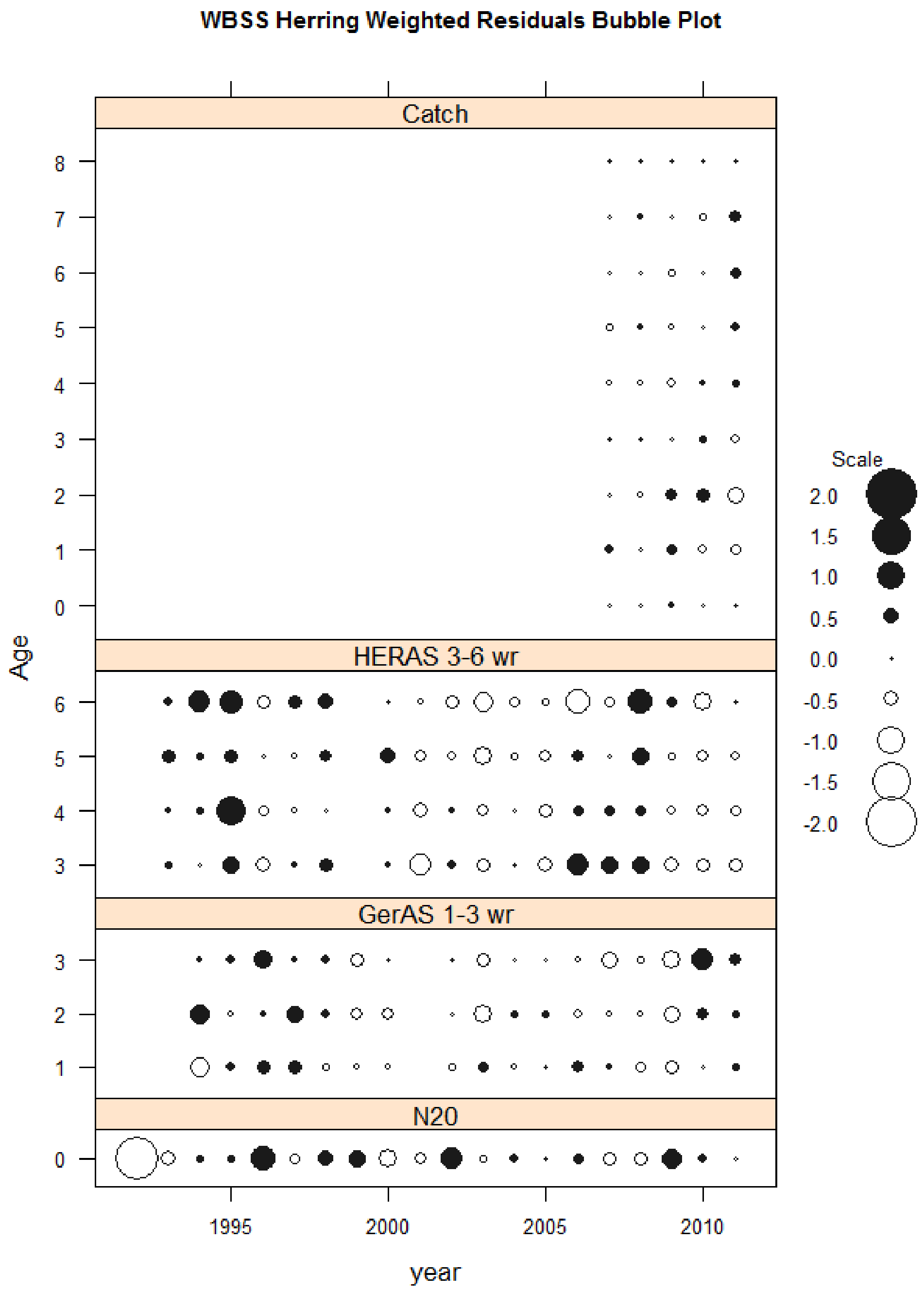


Figure 3.6.4.13 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with FLICA in calculating the objective function. The bubble scale is consistent between all panels.

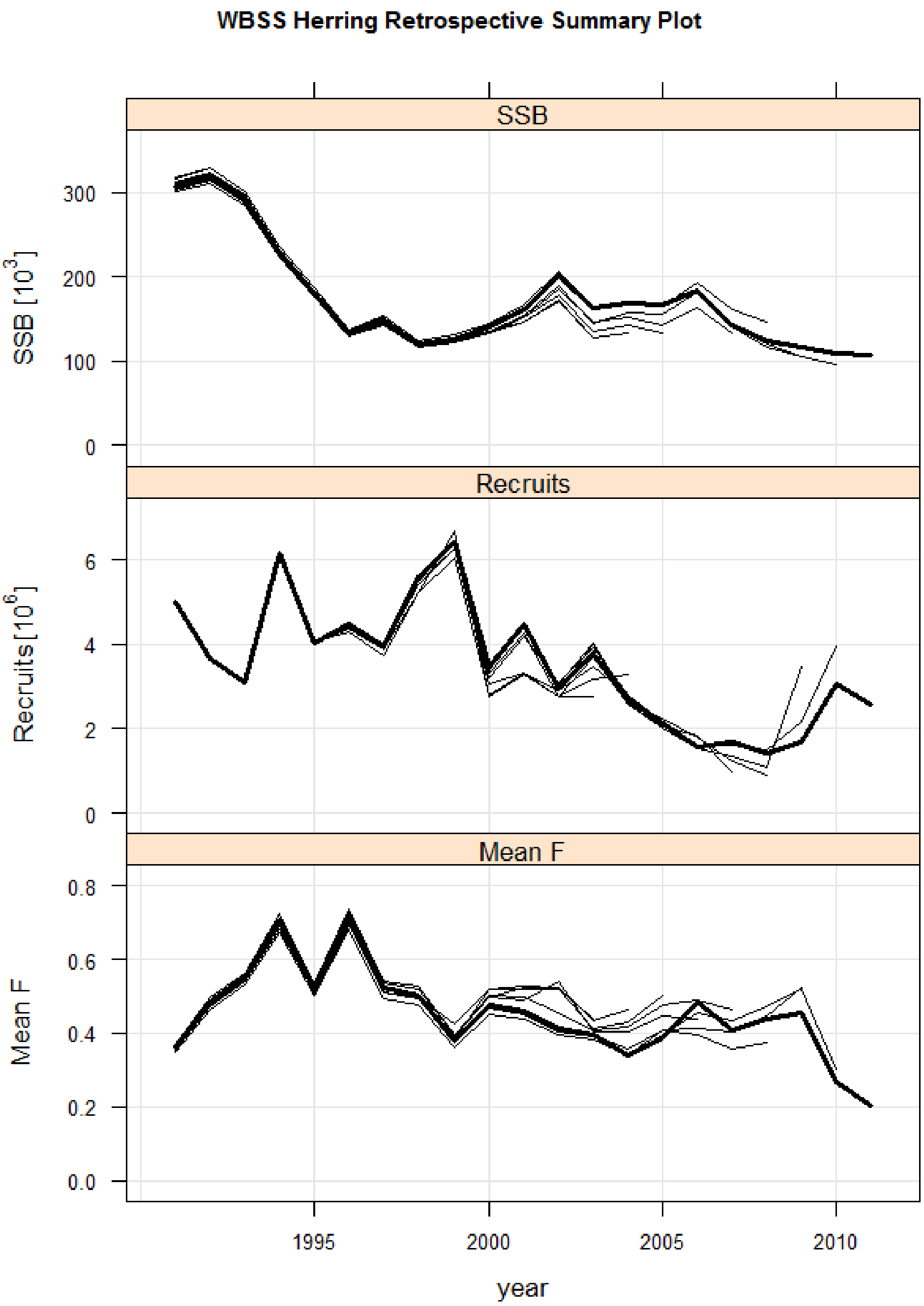


Figure 3.6.4.14 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Analytical retrospective pattern in the assessment. Top panel: Spawning stock biomass. Middle panel: Recruitment at age 0 wr. Bottom panel: Mean fishing mortality in the ages 3-6 ringer. The heavy black line shows the current assessment

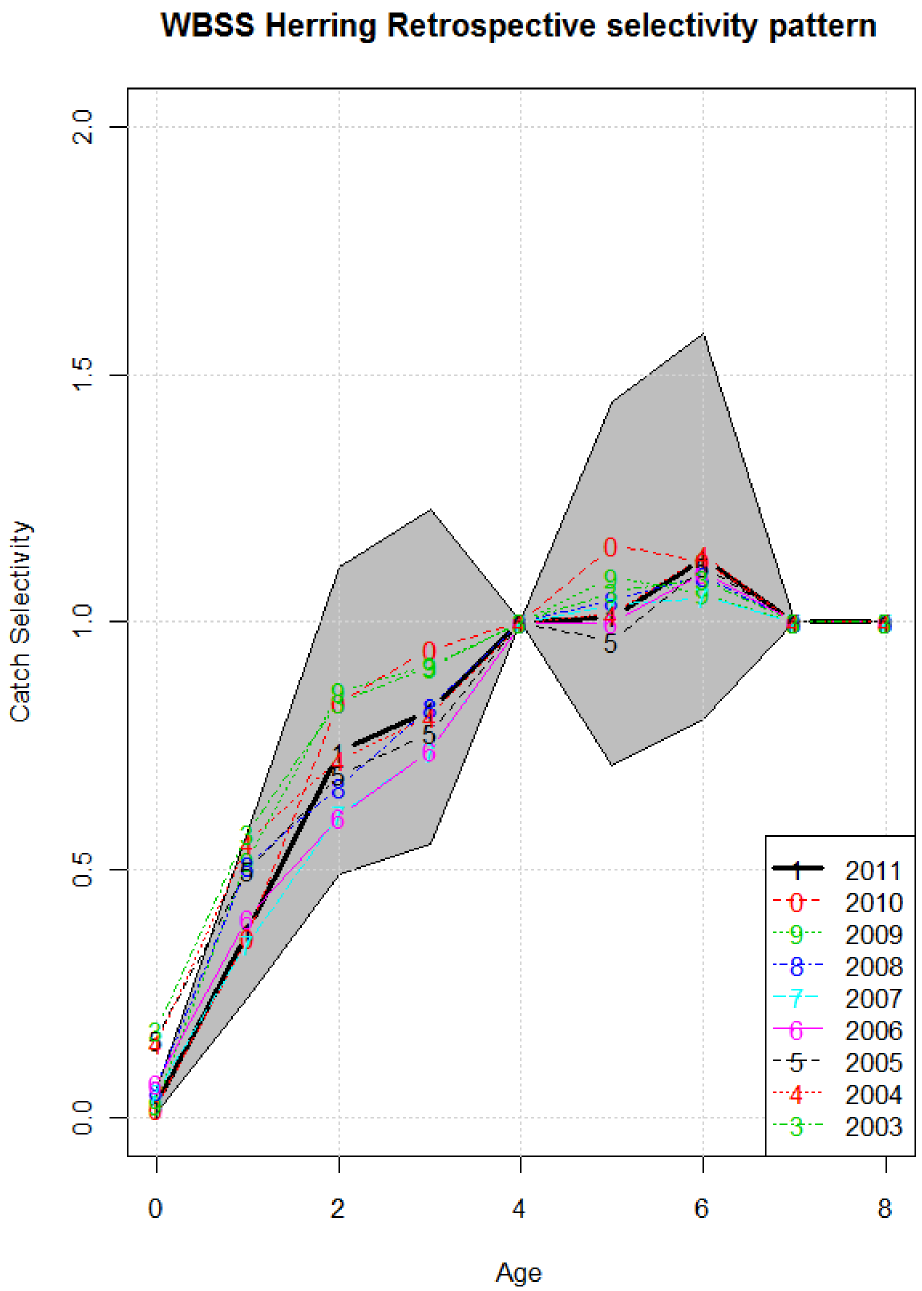


Figure 3.6.4.15 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Retrospective selectivity pattern

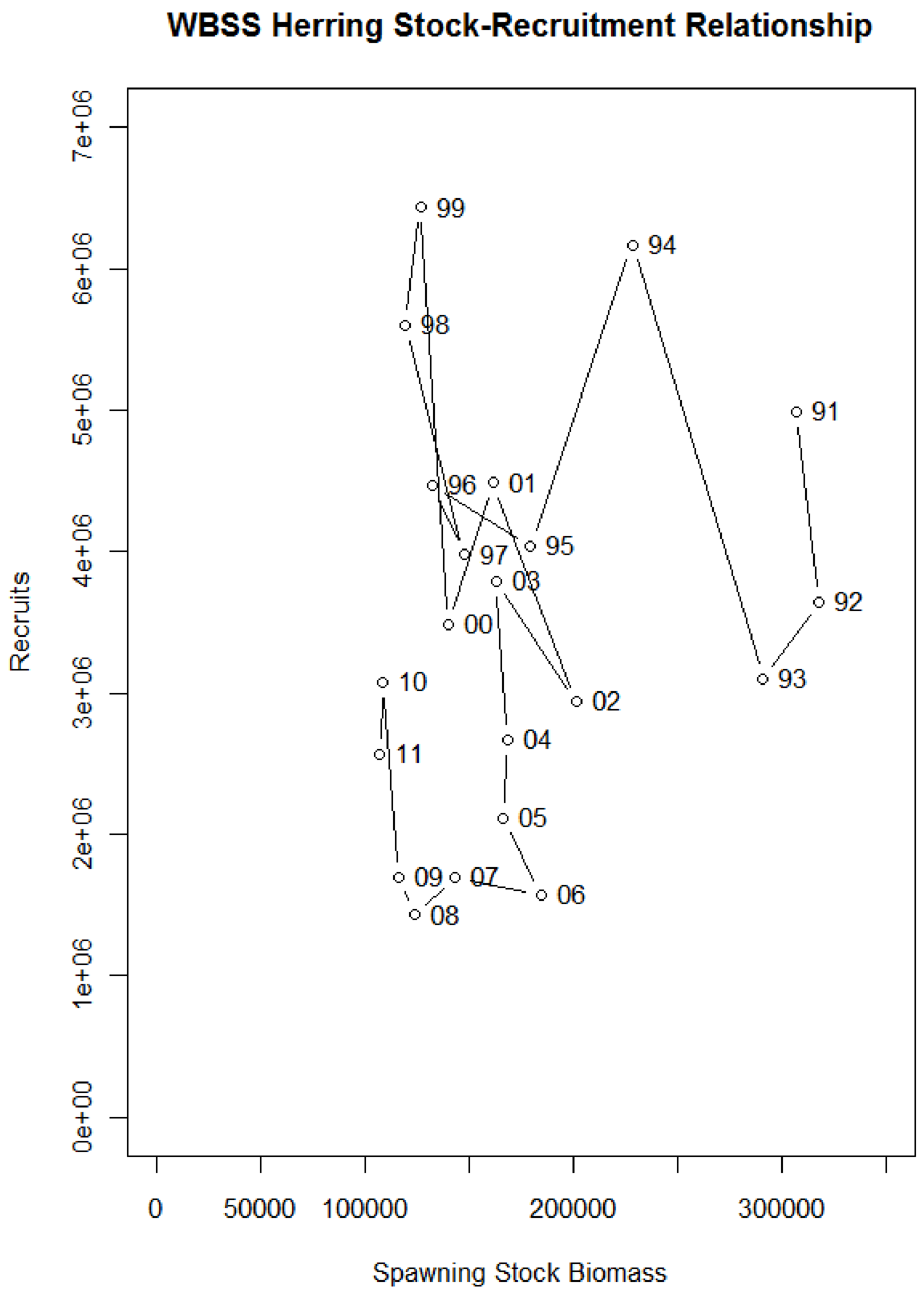


Figure 3.6.4.16 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN. Stock-recruitment relationship. Recruitment at age 0-wr (in thousands) is plotted as a function of spawning stock biomass (tonnes) estimated by the assessment. Successive years are joined by the line. Individual data points are labelled with the two-digit year.

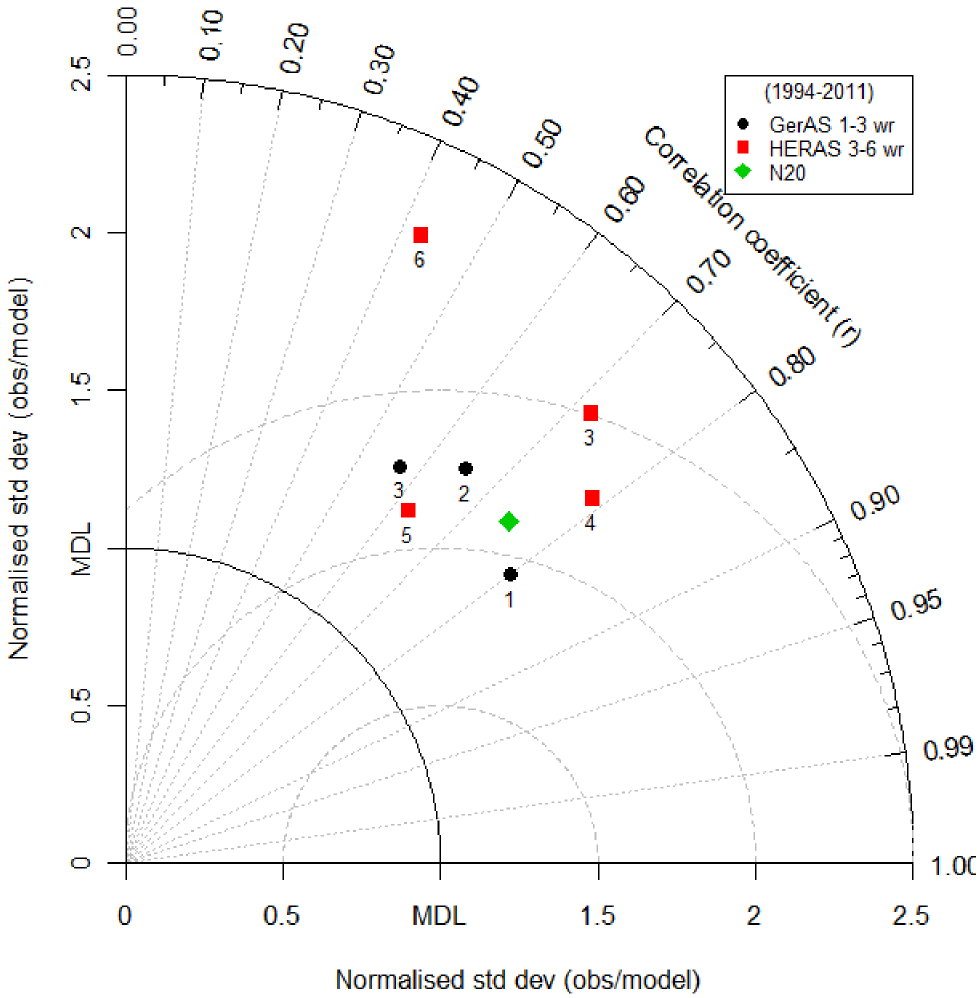
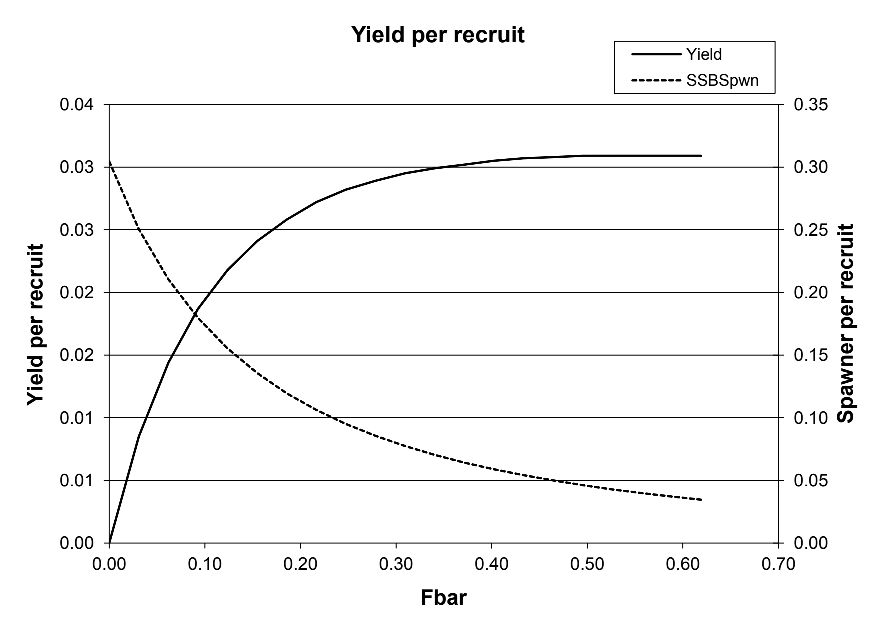
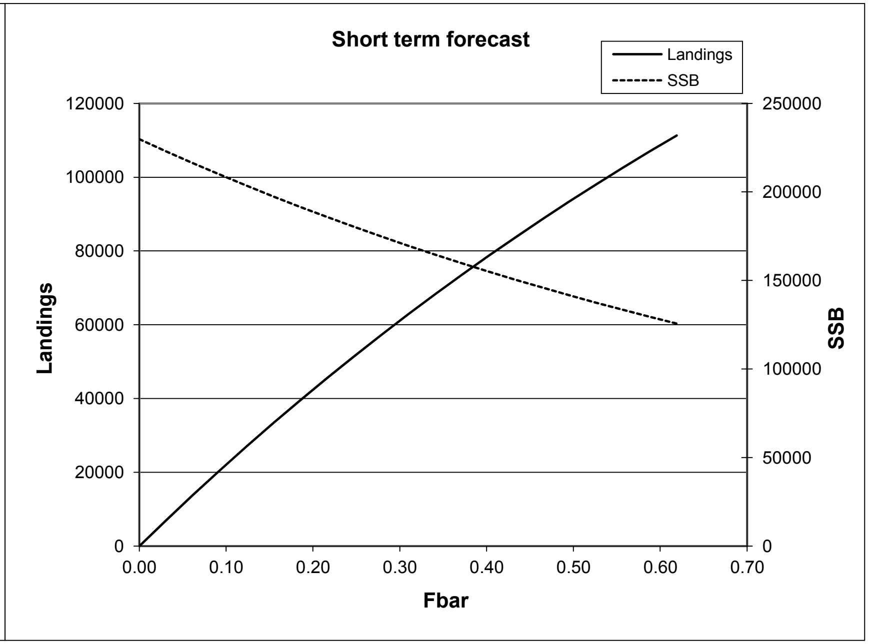


Figure 3.6.4.17 WESTERN BALTIC SPRING SPAWNING HERRING. FINAL RUN Taylor diagram (Taylor 2001, Payne 2011). The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard deviation of the 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: WBSS 2012_MFYPR2a
Time and date: 18:04 18/03/2012

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.3094
FMax	1.8103	0.5600
F0.1	0.7390	0.2286
F35%SPR	0.6970	0.2156

Weights in kilograms

MFDP version 1a
Run: WBSS 2012
Western Baltic Herring (combined sex; plus group)
Time and date: 16:19 18/03/2012
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 3.6.10.1 **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 2011 – 2012

The TAC is set by calendar year and in 2011 was 13 200 t and for 2012 is 21 100 t (based on the rebuilding plan). In 2011 ICES advised that the TAC for 2011 should be 26 900 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 came to completion at the end of 2011, however the HCR within it was used as the basis of the TAC set in 2012.

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 was adopted by the Pelagic RAC, but has not yet been evaluated by ICES or STECF. The plan was adopted as the basis for the 2012 TAC, by the Pelagic RAC and Irish fisheries administration. In 2012, the LTMP would have implied a TAC of 17 200 t.

4.1.2 The fishery in 2011/2012

In 2011/2012, 66 vessels took part in the Irish fishery. These are categorised as follows:

- 25 vessels less than 65ft in length
- 12 vessels between 65 and 80ft in length
- 29 vessels over 80ft in length

The fishery took place entirely in the third and fourth quarter of 2011 as there was no fishery in the first quarter of 2012. In the third quarter, fishing took place in VIIg and VIIj and in the fourth quarter it occurred in VIIj, VIIg and VIIaS. On average, vessels under 65ft reported landings of about 60 t for the season, while the vessels over 80ft reported mean landings of around 250 t.

The third quarter fishery took place in VIIg and VIIj, landing a total of 1 656 t from late August and September. The fourth quarter 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 2nd of October, and lasted until the 21st of December.

The fishery was not opened in the first quarter of 2012. This was partly because of the EC rotational box closure in VIIaS and also lack of demand from processors for the lower yielding fish caught at this time of year.

The distribution of the total landings is presented in Figure 4.1.2.1.

4.1.3 The catches in 2011/2012

The estimated national catches from 1988–2011 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 2011 season has increased to around 11 500 t, the largest since 2004 and double that in 2009, which was the lowest estimate in the series (Figure 4.1.3.1). Catches considered to be area-misreported are subtracted as unallocated catches.

The catch data include discards until 1997; however there are no recent estimates of discards for this fishery. Statements from fishermen suggest that discarding has become a feature of this fishery since 2010 (see section 4.1.6).

4.1.4 Regulations and their effects

The closure of Sub Division VIIaS from the 2007-2011, except for a sentinel fishery, meant 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. This has led to a mismatch in the age structure of catches. Catches in the main fishery are dominated by older fish than in those from the sentinel fishery in the Closed Box.

There is evidence that closure of Sub Division VIIaS, under the rebuilding plan, has helped to reduce fishing mortality substantially (HAWG 2011). This area has been the dominant spawning area, and before the closure a large proportion of the catch was taken from it. Closing this area seems to have had a positive effect of keeping fishing mortality down. This has served to reduce the efficiency of the fleets.

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 (8% of the Irish quota).

The rebuilding plan is now complete, and the sentinel fishery has ended. However, closed box area is subject to an exclusion of vessels >50 feet length. Vessels under 50 feet are restricted to 12% of the Irish quota. The abundance of herring in the closed box has attracted more vessels to target herring in this area and it can be expected that this trend may continue.

The overall increases in the TAC in the past 3 years have attracted more Irish vessels to fish this stock. Irish quota is allocated to vessels on a weekly basis. The large number of vessels involved has led to individual quotas being reduced. This has led to increased discarding due to vessels being unable to catch their small allocations without extra-quota catches that are often slipped.

4.1.6 Discarding

Discarding has become a more important feature in the past two seasons. TAC increases over the past 3 years have attracted an increased number of vessels to the fishery, in particular larger RSW vessels from the NW of Ireland. The management regime allocates quotas to individual vessels on a weekly basis and, as a result of the increased numbers, quotas have fallen to 52 t per boat per week for the large RSW vessels in 2011/2012. This is substantially lower than the mean catch per haul for these vessels (95 t per vessel in the VIaS fishery). It is expected that this mismatch in quota and capacity leads to increased slippage, though the effect may be reduced to some extent by sharing of catch between neighbouring vessels. A submission by an industry representative the management advisory committee notes the problem and suggested that discarding of 15 t per week was on the conservative side.

In order to estimate discarding in the past two seasons, two scenarios were considered:

- 30 t per boat per week discarded
- 40 t per boat per week discarded

These rates were applied to the total number of vessels over 80 ft in each season resulting in the following estimated discarded quantities.

Season	30 t per vessel per week	40 t per vessel per week
2010/2011	6,510 t	8,680 t
2011/2012	6,960 t	9,280 t

The catch numbers at age for VIIg, in quarters 3 and 4 (main fishery) were raised by the appropriate factors to produce input files for assessment.

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 2011. In 2011, the most abundant age classes were 3-ringers (2007 year class, 38%), 5-ringers (2005 year class, 15%), and 2-ringers (2008 year class, 19%). Two of these cohorts were also strong in the previous season as 2- and 4-ringers respectively (Table 4.2.1.1). The yearly mean standardised catch numbers-at-age for 6+ and 7+ are shown in Figures 4.2.1.1 and 4.2.1.2 and clearly show the 2007 year class as the strongest cohort in 2011. The weak 2001/2002 year class has now disappeared from the catches. The strong 2003 year class is now 7-ringer and is a significant component of the plus group in the SALY assessment.

The overall proportions-at-age were similar in all sampled metiers (division*quarter, Figure 4.2.1.3). A slightly different age profile can be seen in the sentinel fishery (quarter 4 from Division VIIaS) with more 2-ringers and fewer 3-ringers. To a much greater extent than in 2011, the survey and the commercial fishery did not agree in terms of proportions-at-age (Figure 4.2.1.3). As expected the survey caught greater amounts of 1-ring fish. The survey also recorded a higher percentage of 2-ringers and slightly lower percentages of all other age groups compared to the commercial catch. The 2008 year class is less strongly represented in the commercial catch in the most recent season (2 ring in 2011/2012). However this year class appears dominant in acoustic survey and in the sentinel fishery in the Closed Area of VIIaS (Figure 4.2.1.3). In 2011 the age structure in the survey and the commercial fishery differed for the first time, in the current series. This is probably due to the exclusion of the main fleet from the Closed Area. The closed area is dominated by recruits to the spawning stock.

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 in quarter 4, where the only fish over 29.5cm were recorded.

4.2.2 Quality of catch and biological data

Biological sampling of the catches was comprehensive throughout the area exploited by the Irish fishery (Table 4.2.2.1). Under the Data Collection Framework the sampling of this stock is well above that required by the Minimum Programme (Section 1.5).

The quality of catch data has varied over time. A rudimentary history of the Irish fishery since 1958 is presented in the Stock Annex. In 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 2002-2011 is presented in Table 4.3.1.1.

The acoustic survey of the 2011/2012 season was carried out in October 2011, on the *Celtic Explorer* (O'Donnell, *et al* in WGIPS (ICES 2012)). 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.

The survey takes place during the height of the fishing season. A fishing industry representative was onboard the research vessel for the duration of the survey and maintained regular contact with fishing vessels targeting herring. During the 2011 survey it became apparent that the majority of the fleet were targeting offshore aggregations of herring in an area outwith the predetermined survey track. The survey track was adapted to include an additional broad scale parallel track stratum (#20) covering this area. This additional stratum covered approximately 260 nautical miles. In order for this stratum 20 to be covered, survey effort was reallocated from the southwest broad scale area, which has historically contributed very little to the overall estimate of biomass.

Two sets of survey results were processed. The first covered the traditional survey track (i.e. not including stratum 20) and the second the entire survey track. Both sets of results show that, as observed in previous years, the bulk of the herring is located within 20 nautical miles of the coast. When stratum 20 is included, the total SSB estimate was 122kt, the same as in 2010/2011. Excluding stratum 20 from the processing gives a result of 112kt such that stratum 20 contributed approximately 7% of the total biomass. The CV on the estimates have increased from 20% in 2010/11 to 31% (including stratum 20) and 28% (excluding stratum 20). This is as a result of a greater proportion of the biomass being detected in fewer, but relatively larger, 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 Figures 4.4.1.1-2 and Tables 4.6.1.2-3. There has been an overall downward trend in mean weights-at-age in the catch since the mid-1980s (with a slight increase around 2008 in the main age groups 2-8). The 2011/2012 mean weights-at-age have continued the downward trend, having decreased slightly for most age groups except 6, 7 and 8.

Mean weights in the stock at spawning time were calculated from biological samples from the fourth quarter (Figure 4.4.1.2). Small increases in mean weight can be seen in all age groups with the exception of 1- and 5-ringers, where a slight decrease 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.*, WD to HAWG 2008 (ICES 2008)).

4.5 Recruitment

At present there are no independent recruitment estimates for this stock.

4.6 Assessment

In 2012, this stock is scheduled as an update assessment. However some data exploration was conducted to examine the following:

- Effect of excluding the additional area covered by the acoustic survey
- Effect of extending the plus group from 6+ to 7+
- Sensitivity analysis of possible levels of discarding in the past two seasons.

4.6.1 Data Exploration

Exploratory analyses were performed to investigate the effect of including biomass detected in stratum 20 of the acoustic survey in the tuning series. Following the same procedure as in 2011 (SALY), assessments were run using acoustic tuning data with and without the additional stratum. The age structure of the acoustic abundance estimate was almost identical whether the stratum was included or not (Figure 4.6.1.1) and the inclusion of stratum 20 in the assessment had little discernable change in the assessment diagnostics. Stratum 20 accounted for approximately 5% of the total survey SSB and consequently the primary effect of using it in the assessment is to change the overall SSB and mean F estimates. Including stratum 20 increased SSB by approximately 4 000 t (5%) and decreased mean F by 0.01 y^{-1} (6%). As discussed in Section 4.3, the inclusion of stratum 20 within the survey was considered appropriate as it was consistent with the behaviour of the fishing fleet and captured aggregations of the stock that would otherwise have been missed as they would have been beyond the previous extent of offshore transects (O'Donnell, *et al* in WGIPS (ICES 2012)).

Based on this *a priori* information, and the lack of any significant change in the behaviour of the assessment model, it was decided to include stratum 20 in the tuning time series.

Additional exploratory assessments were conducted to explore the effects of increasing the plus group from age 6 to 7. In 2009 HAWG reduced the plus group (ICES 2009) used in the assessment to 6+. This improved the model diagnostics appreciably. Furthermore, at that time, there was significant truncation in the age structure, with few fish older than 6 ring in catches. In 2011, HAWG re-examined the question of whether the plus group should be extended, given that the strong 2003 year class had entered the plus group. HAWG decided, based on model diagnostics, not to extend the plus group at that time. In the 2012/2012 season the plus group accounts for 13% of catch numbers at age and so the comparison between assessments with 6+ and 7+ was repeated. Furthermore, the relatively strong 2005 year class will be in the plus group when HAWG next meets.

Catch diagnostics for the 6+ and 7+ assessments are shown in Figures 4.6.1.2-3. There are slightly differing residual patterns between the runs, with the 7+ showing larger residuals at age 6, both negative and positive. Larger positive residuals at 6 winter rings in 2010 and 2011, evident in the 7+ run may indicate an increased targeting of older fish as the stock abundance and TACs increased, and as the closed area reduced targeting of younger fish. The 6+ run displays a slightly more balanced residual pattern. A comparison of the tuning index residuals showed slightly smaller residuals at the oldest survey age (5) in the early years of the time series for the 7+ run. Otherwise, there were no significant differences.

A comparison of the stock summaries from the 6+ and 7+ runs is shown in Figure 4.6.1.4. The 7+ run is associated with lower SSB (approx 10%) and higher F (approx 0.2) in recent years. The 7+ assessment also has narrower confidence intervals than the SALY run.

HAWG decided to proceed on the basis of maintaining the plus group at 6+. It was felt that the model diagnostics did not appreciably alter with an increase to 7+. The proportion of the catch allocated to the current (6+) plus group is not currently detrimental to the performance of the assessment model and it was felt the most appropriate time to consider changing the plus group would be during a future benchmark exercise.

As described in section 4.1.6, anecdotal information has become available suggesting that discarding has become a feature of this fishery in 2010 and 2011, primarily due to the management regime leading to over-quota discarding. Figure 4.6.1.5 shows the results of the SALY assessment and two additional runs: one assuming a discard rate of 30 t per boat per week for the main VIIg fishery and one for a rate of 40 t per boat per week. The results for the recent period are summarised in the text table below.

	SSB			FBar		
Season	Final assessment	+ 30 t per week	+ 40 t per week	Final assessment	+ 30 t per week	+ 40 t per week
2010/11	84 263	88 647	90 653	0.139	0.224	0.250
2011/12	85 366	83 105	83 147	0.152	0.250	0.282

The increases in fishing mortality associated with the extra removals due to discarding are substantial and in all cases, above the various management options (0.25 for MST, 0.19 for the rebuilding plan and 0.23 for the proposed long term management plan) for the most recent year. SSB is commensurately decreased although it remains above B_{pa} (44 000t).

4.6.2 Stock Assessment

This update assessment was carried out using FLICA. The same settings as the 2011 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 are shown in Figure 4.6.1.2. Catch residuals are smaller than those in the 2011 assessment and show no discernible pattern.

The survey diagnostics at-age are presented in Figures 4.6.2.1 – 4.6.2.4 and are similar to last year. The model fit overestimates the quantity of 3 winter ring fish and underestimates the 2 ringers as a result of the mismatch between the commercial catch (where 3 ringers were the largest component) and the acoustic data.

The catch and survey residual patterns are shown in Figure 4.6.2.5. 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.

A plot which depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality is presented in Figure 4.6.2.6. 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 show 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 4.6.2.8. All cohorts have been revised down from 2011 due to a downward revision in SSB. The analytical retrospective pattern is displayed in Figure 4.6.2.9. There is a significant downward revision in SSB this year due primarily to an overestimation of the size of the 2007 year class in last year's assessment (at which point it was the largest in the time series). Although the commercial catch data indicates that the 2007 year class (3 ringers) is the largest component of the catch by number, the acoustic survey detected a greater number of 2 ringers. This has contributed to the downward revision in the size of the 2007 year class. A corresponding upward revision can be seen in fishing mortality. A historical retrospective is presented in Figure 4.6.2.10. This compares the final assessments in 2010, 2011 and 2012. The downward revision in SSB can be seen here also.

4.6.3 State of the stock

The stock has increased considerably in size in recent years (85 366 t in 2011) and is well above B_{pa} (44 000 t). Fishing mortality declined substantially between 2003 and 2009 and although it has started to rise due to increased catches in 2010 and 2011, it is estimated (0.152) to be below $F_{0.1}$ (0.17). Several strong cohorts have recruited to the stock in recent years.

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 1981-2009. 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 (2012) were calculated by the degradation of geometric mean recruitment (1981-2009) 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. There was no quarter 1 fishery in 2012 and it is assumed this will also be the case in 2013. Thus, the interim catch was taken as the 2012 Irish quota (18 236 t). The use of Irish catch estimates in the interim year assumes that the freezer trawler fleet does not partake (which has been the case in recent years).

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 management plan (F=0.23) implies catches of 17 151 t in 2013. All scenarios show SSB will be above B_{pa} in 2014.

4.7.2 Yield Per Recruit

No yield per recruit analysis was conducted at HAWG 2012.

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 to HAWG 2011).

4.9 Precautionary and yield based reference points

Reference points are defined for this stock, $\mathbf{B}_{pa}$ is currently at 44 000 t (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 to HAWG 2011) 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. 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 2011 assessment. A significant downward revision of the perception of SSB is a feature of the 2012 assessment. 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 4.6.2.10.

2011 Report				2012 Assessment				Percentage change in Estimates	
Year	SSB	Catch	F 2-5	Year	SSB	Catch	F 2-5	SSB	F 2-5
2009	105903	5745	0.07	2009	69145	5745	0.10	-35%	+43%
2010	114319	8370	0.09	2010	84263	8370	0.13	-26%	+40%
2011*	118399	16193	0.14	2011	85366	11470	0.15	-28%	+7%

* From Intermediate year in STF

Assessment outputs are sensitive to discarding which is difficult to quantify but understood to have taken place in 2010 and 2011.

The review group comments (ICES HAWG 2011) mainly related to better estimation of the mixing of this stock with herring in the Irish Sea. This matter remains to be addressed, and hopefully can be dealt with at the next benchmark. The recent benchmark of Irish Sea herring did not fully account for the contamination by Celtic Sea fish (mainly younger ages) of Irish Sea data.

4.11 Management Considerations

Fishing mortality on this stock was high for many years, well above $\mathbf{F}_{MSY}$ = 0.25. F was reduced substantially from 2004 to 2009. It has risen slightly since 2009 but is still below $\mathbf{F}_{MSY}$ and $F_{0.1}$. The current estimate of F is 0.15. SSB is well above $\mathbf{B}_{pa}$ (44 000 t).

The advice for 2012 was based on the harvest rule contained within the rebuilding plan and led to a 60% 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 was adopted by the Pelagic RAC, but has not yet been evaluated by ICES or STECF.

The closure of the Sub Division 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 was considered to have recovered by 2011 and this area was reopened in January 2012.

Discarding has become again, a feature for this stock since the TAC increased. Efforts should be made to both quantify and reduce the quantity of fish discarded. Review of the current management scheme may aid in the reduction of discarding.

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), 1988–2011. (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	-	-	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	8,406	325		-1239	-	8,406
2011	241		11,503	7	4	-252	-	11,503

Table 4.1.3.2. Herring in the Celtic Sea. Landings (t) by assessment year (1st April–31st March) 1988/1989-2011/2012. (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
2011/2012	241	-	11,470	7	4	-252	-	11,470

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 1967-2011.

	1	2	3	4	5	6	7	8	9
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	4%	33%	13%	25%	8%	16%	1%	0%	0%
2011	7%	19%	38%	8%	15%	6%	6%	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 2011/2012 season in the Celtic Sea and VIIj fishery.

	VIIg Q3	VIIg Q4	VIIj Q3	VIIj Q4	VIIaS Q4	Total
15.5					2	2
16						
16.5						
17		19				19
17.5						
18	13	75				88
18.5	13	75			9	97
19	13	393			9	415
19.5	39	581		4	31	655
20	91	1,368		8	68	1,535
20.5	26	1,162		8	61	1,257
21	78	1,630			113	1,821
21.5	117	1,405	22	8	100	1,652
22	117	1,780	9	12	220	2,138
22.5	117	2,267	13	31	182	2,610
23	299	4,103	13	59	356	4,831
23.5	338	4,103	40	90	340	4,912
24	768	6,313	53	216	498	7,848
24.5	1,054	8,018	53	204	400	9,730
25	1,614	9,255	35	196	447	11,547
25.5	1,471	7,644	58	275	372	9,819
26	2,017	7,700	58	259	409	10,442
26.5	1,614	5,976	75	165	274	8,104
27	976	4,271	31	141	234	5,654
27.5	338	1,799	18	130	101	2,385
28	182	824		86	37	1,130
28.5		150		98	10	259
29	39			71		110
29.5		19		16		34
30				16		16
30.5				12		12

Table 4.2.2.1 Herring in the Celtic Sea. Sampling intensity of Irish commercial catches (2011/2012). Only Ireland provides samples of this stock.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIIg	2011	3	1589	4	200	871	125.87
VIIg	2011	4	9004	16	785	3786	87.18
Sub-total			**10593**	**20**	**985**	**4657**	
VIIaS	2011	4	490	10	492	2447	1004.55
Sub-total			**490**	**10**	**492**	**2447**	
VIIj	2011	3	67	4	50	108	746.27
VIIj	2011	4	320	5	243	536	759
Sub-total			**387**	**9**	**293**	**644**	
Total Celtic Sea			**11470**	**39**	**1770**	**7748**	

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 abundances are used in tuning.

	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009	2009 2010	2010 2011	2011 2012	2011° 2012
0	0	24	-	2	-	1	99	239	5	0	0
1	42	13	-	65	21	106	64	381	346	111	110
2	185	62	-	137	211	70	295	112	549	433	418
3	151	60	-	28	48	220	111	210	156	298	272
4	30	17	-	54	14	31	162	57	193	47	41
5	7	5	-	22	11	9	27	125	65	71	60
6	7	1	-	5	1	13	6	12	91	24	20
7	3	0	-	1	-	4	5	4	7	33	26
8	0	0	-	0	-	1		6	3	4	3
9	0	0	-	0	-	0		1		2	1
							-				
Abd	423	183	-	312	305	454	769	1,147	1,414	1,022	951
SSB	41	20	-	33	36	46	90	91	122	122	112
CV (%)	49	34	-	48	35	25	20	24	20	28	31
Design	AR	AR		R	R	R	R	R	R	AR	R

*AR Adaptive random; R random

°Excluding stratum 20

TABLE 4.6.1.1 Celtic Sea and Division VIIj Herring. 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	2011
1	1460	8043	1306	10171	2468	6384
2	33894	11028	12638	4465	20929	17151
3	10914	36223	8255	12859	8183	33453
4	2469	5509	15777	4887	15917	7301
5	6261	1365	2360	8458	4846	13087
6	2997	2509	921	1578	11592	11738

TABLE 4.6.1.2 Celtic Sea and Division VIIj Herring. WEIGHTS AT AGE IN THE CATCH

Units : kg

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.214	0.219	0.205	0.211

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.089	0.080	0.077
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.102	0.130	0.102
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.128	0.134	0.142
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.146	0.151	0.147
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.185	0.165	0.159	0.158
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.191	0.186	0.174

age	2006	2007	2008	2009	2010	2011
1	0.093	0.074	0.091	0.078	0.075	0.070
2	0.105	0.106	0.120	0.122	0.108	0.104
3	0.127	0.123	0.144	0.146	0.129	0.127
4	0.151	0.141	0.156	0.160	0.142	0.141
5	0.155	0.166	0.172	0.169	0.155	0.154
6	0.168	0.164	0.193	0.188	0.159	0.165

TABLE 4.6.1.3 Celtic Sea and Division VIIj Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

year

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

year

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.213	0.219	0.205	0.211

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.078	0.077	0.074
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.100	0.127	0.103
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.130	0.133	0.145
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.141	0.151	0.143
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.184	0.156	0.156	0.155
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.168	0.187	0.167

year

age	2006	2007	2008	2009	2010	2011
1	0.085	0.066	0.083	0.076	0.076	0.067
2	0.104	0.102	0.117	0.117	0.106	0.108
3	0.123	0.116	0.140	0.142	0.127	0.127
4	0.153	0.135	0.156	0.158	0.139	0.138
5	0.150	0.151	0.170	0.168	0.152	0.148
6	0.159	0.160	0.180	0.178	0.159	0.167

TABLE 4.6.1.4 Celtic Sea and Division VIIj Herring. NATURAL MORTALITY

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age	2003	2004	2005	2006	2007	2008	2009	2010	2011
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

TABLE 4.6.1.5 Celtic Sea and Division VIIj Herring. PROPORTION MATURE

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	1.0	1.0	1.0	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	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	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	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	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
3	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
5	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

TABLE 4.6.1.6 Celtic Sea and Division VIIj Herring. 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	2011
1	0.551	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	0.551
3	0.551	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	0.551
5	0.551	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	0.551

TABLE 4.6.1.7 Celtic Sea and Division VIIj Herring. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
6	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

age	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	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
3	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
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

TABLE 4.6.1.8 Celtic Sea and Division VIIj Herring. SURVEY INDICES

FLT02: Celtic revised acoustic - Configuration

"Celtic Sea and Division VIIj herring . Imported from VPA file."

min	max	plusgroup	minyear	maxyear	startf	endf
2	5	NA	2002	2011	1	1

Index type : number

FLT02: Celtic revised acoustic - Index Values

Units : NA

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	185200	61700	-1	137100	210500	70000	295000	112000	549000	479000
3	150600	60400	-1	28200	47800	220000	111000	210000	156000	299000
4	29700	17200	-1	54200	13500	31000	162000	57000	193000	47000
5	6600	5400	-1	21600	11000	9000	27000	125000	65000	71000

FLT02: Celtic revised acoustic - Index Variance (Inverse Weights)

Units : NA

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1

TABLE 4.6.1.9 Celtic Sea and Division VIIj Herring. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	6	6	1958	2011	2	5

TABLE 4.6.1.10 Celtic Sea and Division VIIj Herring. FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1
lambda.sr   : 0
index.model : linear
index.cor   : 1
sep.nyr     : 6
sep.age     : 3
sep.sel     : 1
```

TABLE 4.6.1.11 Celtic Sea and Division VIIj 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 4.6.1.12 Celtic Sea and Division VIIj Herring. STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 2-5) f	Landings tonnes	Landings SOP
1958	286622	101832	71927	0.4055	22978	1.1144
1959	830660	126714	68519	0.3476	15086	1.1238
1960	184682	81647	57878	0.5039	18283	1.1314
1961	208247	70235	48985	0.3157	15372	0.7759
1962	531941	107917	58223	0.6692	21552	1.0137
1963	266394	81043	52392	0.4642	17349	1.0017
1964	1036046	157607	75047	0.2859	10599	1.0234
1965	325446	139161	100370	0.2605	19126	1.1620
1966	675316	180763	109178	0.3064	27030	0.9617
1967	699244	189155	114876	0.3847	27658	1.1093
1968	827891	205614	119957	0.3553	30236	0.9937
1969	437470	170041	110764	0.5505	44389	1.0062
1970	212444	118789	84182	0.4818	31727	1.0041
1971	851386	164070	81208	0.7238	31396	1.0385
1972	262343	112506	69844	0.7642	38203	0.9936
1973	289768	87666	50487	0.7666	26936	1.0461
1974	128146	56664	35020	0.8486	19940	1.0226
1975	142607	45583	26069	0.7798	15588	0.9298
1976	173161	44981	24152	0.6725	9771	1.0604
1977	167703	43074	23500	0.5829	7833	0.9983
1978	133648	40467	24282	0.5404	7559	1.0882
1979	236556	51625	26206	0.6861	10321	0.9954
1980	146590	43203	25512	0.7216	13130	0.9302
1981	402166	68172	29806	1.0338	17103	0.9861
1982	663810	104311	44913	0.7348	13000	0.9865
1983	731882	129433	61894	0.7290	24981	0.9551
1984	563104	112020	61842	0.9170	26779	1.0089
1985	506486	108222	60969	0.5304	20426	0.9760
1986	527669	118670	65131	0.6874	25024	0.9992
1987	953073	148078	71712	0.7928	26200	1.0043
1988	387774	109278	70091	0.4415	20447	0.9962
1989	470429	110310	64149	0.5706	23254	0.9984
1990	424832	98090	59116	0.4786	18404	1.0102
1991	176486	70206	47279	0.7239	25562	0.9873
1992	935404	124931	53243	1.0523	21127	1.0467
1993	322727	86599	54581	0.6253	18618	0.9993
1994	692030	119549	62996	0.4648	19300	1.0049
1995	674689	119386	66336	0.5841	23305	0.9979
1996	339057	90854	59374	0.4224	18816	0.9981
1997	370002	83320	49644	0.6427	20496	1.0037
1998	239756	65385	40456	0.6620	18041	1.0016
1999	500937	77284	38068	0.9072	18485	1.0024
2000	434916	72424	36511	0.9260	17191	1.0001
2001	383353	61215	32130	0.8406	15269	1.0064
2002	488667	76094	38575	0.3443	7465	0.9994
2003	99458	45139	29223	0.4644	11536	0.9977
2004	254265	46721	22819	0.6757	12743	1.0080
2005	740249	75795	30274	0.5693	9494	0.9983
2006	265977	61142	36930	0.3005	6944	0.9976
2007	576876	73035	39072	0.2422	7636	0.9998
2008	256275	74525	51306	0.1392	5872	0.9995
2009	974482	128240	69145	0.1036	5745	0.9963
2010	735244	135432	84263	0.1338	8370	0.9983
2011	440602*	162519	84232	0.1519	11470	0.9992

***Geometric Mean 1995 - 2009**

TABLE 4.6.1.13 Celtic Sea and Division VIIj Herring. ESTIMATED FISHING MORTALITY

Units : f

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	0.0091	0.00229	0.0246	0.0163	0.0023	0.00177	0.0116	0.000277	0.0167	0.0173
2	0.1825	0.33205	0.3176	0.3259	0.3324	0.36402	0.1952	0.241463	0.2085	0.2089
3	0.4274	0.17054	0.6627	0.2410	0.9420	0.44077	0.2091	0.189653	0.3562	0.3648
4	0.5593	0.44979	0.4450	0.2902	0.6443	0.48862	0.4012	0.284278	0.2979	0.5255
5	0.4527	0.43811	0.5904	0.4057	0.7583	0.56345	0.3380	0.326649	0.3631	0.4397
6	0.4527	0.43811	0.5904	0.4057	0.7583	0.56345	0.3380	0.326649	0.3631	0.4397

age	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.0235	0.0348	0.00986	0.0238	0.0519	0.136	0.070	0.151	0.128	0.0795	0.0336
2	0.2864	0.4447	0.32192	0.4232	0.7174	0.643	0.740	0.513	0.332	0.2966	0.3144
3	0.3507	0.5583	0.49105	0.6755	0.7306	0.798	0.744	0.887	0.525	0.4991	0.5505
4	0.3504	0.5268	0.54546	0.9603	0.6466	0.683	0.859	0.801	1.074	0.8759	0.6726
5	0.4336	0.6723	0.56864	0.8361	0.9623	0.943	1.051	0.919	0.758	0.6600	0.6242
6	0.4336	0.6723	0.56864	0.8361	0.9623	0.943	1.051	0.919	0.758	0.6600	0.6242

age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
1	0.0783	0.0799	0.166	0.0371	0.0296	0.0561	0.0573	0.0125	0.00996	0.00945
2	0.4085	0.5568	0.667	0.4939	0.6882	0.5210	0.4062	0.4606	0.50994	0.31658
3	0.5792	0.7887	1.180	0.6990	0.7324	0.7173	0.4238	0.6620	0.84390	0.50620
4	0.9625	0.6668	1.074	0.8787	0.5759	1.3762	0.6515	0.8157	0.88713	0.41537
5	0.7941	0.8740	1.214	0.8678	0.9193	1.0538	0.6403	0.8114	0.93022	0.52789
6	0.7941	0.8740	1.214	0.8678	0.9193	1.0538	0.6403	0.8114	0.93022	0.52789

age	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1	0.0281	0.0101	0.0173	0.0177	0.00791	0.0281	0.0224	0.0163	0.0166	0.039
2	0.4213	0.3353	0.6354	0.6492	0.38418	0.4274	0.4557	0.3464	0.4299	0.439
3	0.5098	0.4982	0.6341	0.9842	0.53606	0.5043	0.5689	0.4467	0.6081	0.693
4	0.6669	0.5115	0.7278	1.3504	0.85348	0.3443	0.6034	0.3789	0.7746	0.736
5	0.6847	0.5695	0.8981	1.2255	0.72734	0.5831	0.7084	0.5175	0.7583	0.780
6	0.6847	0.5695	0.8981	1.2255	0.72734	0.5831	0.7084	0.5175	0.7583	0.780

age	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.0459	0.0368	0.0667	0.0114	0.0439	0.0269	0.0334	0.0189	0.0152	0.00875
2	0.6124	0.6936	0.6152	0.2623	0.2736	0.3713	0.4873	0.1610	0.1297	0.07455
3	0.9489	0.9279	0.9100	0.3988	0.4402	0.7003	0.4353	0.3433	0.2767	0.15899
4	0.9947	0.9676	0.8289	0.2999	0.6068	0.8571	0.6525	0.3544	0.2857	0.16416
5	1.0728	1.1148	1.0083	0.4163	0.5371	0.7741	0.7022	0.3433	0.2767	0.15899
6	1.0728	1.1148	1.0083	0.4163	0.5371	0.7741	0.7022	0.3433	0.2767	0.15899

age	2009	2010	2011
1	0.00652	0.00842	0.00955
2	0.05552	0.07170	0.08135
3	0.11841	0.15291	0.17350
4	0.12225	0.15787	0.17913
5	0.11841	0.15291	0.17350
6	0.11841	0.15291	0.17350

TABLE 4.6.1.14 Celtic Sea and Division VIIj Herring. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	286622	830660	184682	208247	531941	266394	1036046	325446	675316	699244
2	25851	104488	304883	66291	75372	195241	97828	376763	119692	244313
3	104252	15957	55535	164400	35451	40047	100505	59623	219237	71985
4	62860	55670	11016	23436	105769	11315	21100	66758	40382	125711
5	36086	32511	32126	6387	15865	50248	6281	12783	45459	27127
6	158160	102558	44694	45105	41855	22710	46734	96035	74930	78426

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	827891	437470	212444	851386	262343	289768	128146	142607	173161	167703
2	252821	297479	155439	77387	305855	91630	93047	43956	45122	56033
3	146877	140646	141270	83457	37548	110582	35697	32886	19500	23977
4	40923	84685	65890	70783	34772	14805	40783	13892	11092	9440
5	67253	26084	45248	34554	24515	16481	6766	15630	5643	3429
6	45666	60299	47619	40339	18644	20861	13525	13006	19211	8207

age \ year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	133648	236556	146590	402166	663810	731882	563104	506486	527669	953073
2	56977	47541	80470	49787	125349	235302	261384	195848	175948	191701
3	30857	30822	23410	34162	18929	56670	87589	115005	96655	82238
4	11917	14568	14141	8710	8595	7704	22306	35002	61634	40819
5	3558	5503	5035	6568	2692	3230	3919	5097	16509	24667
6	7557	7210	9337	8007	8079	3364	2994	1366	2378	8010

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	387774	470429	424832	176486	935404	322727	692030	674689	339057	370002
2	347141	141312	168265	154716	63814	338066	117790	247540	242714	122712
3	85285	187382	68696	89146	60714	24700	170555	56913	116267	127164
4	28954	42089	92148	34174	38711	18579	11831	84333	26380	60899
5	15211	17294	19549	49996	14934	9077	7160	7587	41736	16341
6	10966	16598	15984	15848	41324	20383	20510	18055	16045	17131

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	239756	500937	434916	383353	488667	99458	254265	740249	265977	576876
2	133879	84826	176009	154222	131926	177739	35016	91056	263373	96016
3	59143	63971	34063	65164	61758	75182	100155	17895	41438	166104
4	56679	24218	20279	11026	21476	33933	39633	40706	9480	24069
5	25398	24564	8104	6972	4355	14397	16737	15219	19180	6018
6	14272	21065	15166	6188	6339	16685	4168	5167	10808	10882

age \ year	2008	2009	2010	2011
1	256275	974482	735244	384525
2	209013	93457	356163	268214
3	62475	143717	65495	245597
4	103122	43631	104526	46020
5	16367	79182	34936	80767
6	6575	14835	85801	77329

TABLE 4.6.1.15 Celtic Sea and Division VIIj Herring. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age \ year	2012
1	NA
2	140114
3	183174
4	169050
5	34811
6	120265

TABLE 4.6.1.16 Celtic Sea and Division VIIj Herring. FITTED SELECTION PATTERN

Units : NA

age \ year	2006	2007	2008	2009	2010	2011
1	0.055	0.055	0.055	0.055	0.055	0.055
2	0.469	0.469	0.469	0.469	0.469	0.469
3	1.000	1.000	1.000	1.000	1.000	1.000
4	1.032	1.032	1.032	1.032	1.032	1.032
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 Celtic Sea and Division VIIj Herring. PREDICTED CATCH IN NUMBERS

Units : NA

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	2011
1	3152	5518	1412	4004	3898	6384
2	33965	10126	12997	4367	21327	18141
3	10975	36558	8346	14574	8438	35557
4	2700	5706	14877	4783	14546	7193
5	5318	1387	2293	8423	4720	12260
6	2997	2509	921	1578	11592	11738

TABLE 4.6.1.18 Celtic Sea and Division VIIj Herring. CATCH RESIDUALS

Units : thousands NA

age \ year	2006	2007	2008	2009	2010	2011
1	-0.7695	0.3767	-0.0784	0.9324	-0.4570	0.0000
2	-0.0021	0.0853	-0.0280	0.0223	-0.0188	-0.0562
3	-0.0056	-0.0092	-0.0109	-0.1252	-0.0307	-0.0611
4	-0.0895	-0.0350	0.0587	0.0215	0.0901	0.0149
5	0.1632	-0.0163	0.0290	0.0042	0.0264	0.0653
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE 4.6.1.19 Celtic Sea and Division VIIj Herring. PREDICTED INDEX VALUES

Celtic Sea Herring Acoustic
Units : NA NA

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	130824	174280	NA	72107	289038	108714	250082	113969	427364	318741
3	81338	95000	NA	22724	57694	247183	104584	250549	110309	405213
4	26863	31230	NA	35787	11229	30538	147745	65187	150701	64954
5	4460	13065	NA	11710	21128	7086	21678	109221	46556	105435

TABLE 4.6.1.20 Celtic Sea and Division VIIj Herring. INDEX RESIDUALS

Celtic Sea Herring Acoustic
Units : NA

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
2	0.348	-1.038	NA	0.643	-0.317	-0.440	0.1652	-0.0174	0.250	0.407
3	0.616	-0.453	NA	0.216	-0.188	-0.117	0.0595	-0.1765	0.347	-0.304
4	0.100	-0.596	NA	0.415	0.184	0.015	0.0921	-0.1342	0.247	-0.324
5	0.392	-0.884	NA	0.612	-0.653	0.239	0.2196	0.1349	0.334	-0.395

TABLE 4.6.1.21 Celtic Sea and Division VIIj Herring. FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2006	0.343	0.161	0.250	0.470
F, 2007	0.277	0.169	0.199	0.385
F, 2008	0.159	0.175	0.113	0.224
F, 2009	0.118	0.175	0.084	0.167
F, 2010	0.153	0.183	0.107	0.219
F, 2011	0.173	0.207	0.116	0.260
Selectivity at age 1	0.055	0.309	0.030	0.101
Selectivity at age 2	0.469	0.125	0.367	0.599
Selectivity at age 4	1.032	0.102	0.845	1.262
Terminal year pop, age 1	1061835.943	0.746	246008.219	4583162.187
Terminal year pop, age 2	268213.295	0.261	160809.310	447352.032
Terminal year pop, age 3	245595.915	0.200	165943.750	363480.718
Terminal year pop, age 4	46018.804	0.183	32172.272	65824.706
Terminal year pop, age 5	80765.611	0.177	57070.524	114298.653
Last true age pop, 2006	19178.609	0.216	12564.029	29275.566
Last true age pop, 2007	6016.998	0.185	4190.445	8639.719
Last true age pop, 2008	16365.590	0.184	11419.594	23453.771
Last true age pop, 2009	79181.183	0.171	56612.764	110746.399
Last true age pop, 2010	34935.179	0.168	25123.229	48579.214
Index 1, age 2 numbers, Q	1.740	0.161	1.269	2.386
Index 1, age 3 numbers, Q	2.397	0.162	1.746	3.290
Index 1, age 4 numbers, Q	1.866	0.166	1.347	2.584
Index 1, age 5 numbers, Q	1.716	0.173	1.222	2.411

Table 4.7.1.1. Herring in the Celtic Sea. Inputs to the Short Term Forecast.

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	440602	1	0.5	0.55	0.5	0.073	0.008	0.074
2	160548	0.3	1	0.55	0.5	0.110	0.070	0.111
3	183174	0.2	1	0.55	0.5	0.132	0.148	0.134
4	169050	0.1	1	0.55	0.5	0.145	0.153	0.148
5	34811	0.1	1	0.55	0.5	0.156	0.148	0.159
6	120265	0.1	1	0.55	0.5	0.168	0.148	0.171

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	440602	1	0.5	0.55	0.5	0.073	0.008	0.074
2	-	0.3	1	0.55	0.5	0.110	0.070	0.111
3	-	0.2	1	0.55	0.5	0.132	0.148	0.134
4	-	0.1	1	0.55	0.5	0.145	0.153	0.148
5	-	0.1	1	0.55	0.5	0.156	0.148	0.159
6	-	0.1	1	0.55	0.5	0.168	0.148	0.171

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	440602	1	0.5	0.55	0.5	0.073	0.008	0.074
2	-	0.3	1	0.55	0.5	0.110	0.070	0.111
3	-	0.2	1	0.55	0.5	0.132	0.148	0.134
4	-	0.1	1	0.55	0.5	0.145	0.153	0.148
5	-	0.1	1	0.55	0.5	0.156	0.148	0.159
6	-	0.1	1	0.55	0.5	0.168	0.148	0.171

Population vector (N) in 2012 is taken from the final assessment with 1 ringers replaced by geometric mean recruitment from 1981 to 2009. Numbers of 2 ringers are derived from geometric mean reduced by natural and fishing mortality at age 1 from the assessment. Mean weights in the catch (CWt) and stock (SWt), natural mortality (M) and mortality proportions (PM, PF) are means over the last 3 years. The selection vector (Sel) is that from the assessment.

Table 4.7.1.2. Herring in the Celtic Sea. Single Option Tables from the Short Term Forecast.

a). Catch(2013) = Zero

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.000	0.000
2	160548	159820	162089	0.120	0.000	0.000
3	183174	105482	118398	0.256	0.000	0.000
4	169050	116093	86361	0.264	0.000	0.000
5	34811	117429	105045	0.256	0.000	0.000
6	120265	108622	204540	0.256	0.000	0.000

b). Catch(2013) = 2012 TAC -15% (17 935 t)

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.015	0.015
2	160548	159820	159641	0.120	0.130	0.130
3	183174	105482	104006	0.256	0.276	0.276
4	169050	116093	65506	0.264	0.285	0.285
5	34811	117429	78966	0.256	0.276	0.276
6	120265	108622	155146	0.256	0.276	0.276

c). Catch(2013) = 2012 TAC status quo (21 100 t)

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.018	0.018
2	160548	159820	159142	0.120	0.156	0.156
3	183174	105482	101267	0.256	0.333	0.333
4	169050	116093	61882	0.264	0.344	0.344
5	34811	117429	74460	0.256	0.333	0.333
6	120265	108622	146563	0.256	0.333	0.333

d). Catch(2013) = 2012 TAC +15% (24 265 t)

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.022	0.022
2	160548	159820	158617	0.120	0.184	0.184
3	183174	105482	98458	0.256	0.393	0.393
4	169050	116093	58279	0.264	0.406	0.406
5	34811	117429	69987	0.256	0.393	0.393
6	120265	108622	138029	0.256	0.393	0.393

e). Catch(2013) = 2012 TAC + 25% (26 375 t)

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.024	0.024
2	160548	159820	158252	0.120	0.204	0.204
3	183174	105482	96544	0.256	0.435	0.435
4	169050	116093	55889	0.264	0.449	0.449
5	34811	117429	67026	0.256	0.435	0.435
6	120265	108622	132368	0.256	0.435	0.435

f). Catch(2013) = 2012 TAC + 30% (27430 t)

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.025	0.025
2	160548	159820	158065	0.120	0.214	0.214
3	183174	105482	95574	0.256	0.457	0.457
4	169050	116093	54697	0.264	0.472	0.472
5	34811	117429	65552	0.256	0.457	0.457
6	120265	108622	129547	0.256	0.457	0.457

g). Fbar(2013) = 0.25

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.016	0.016
2	160548	159820	159561	0.120	0.134	0.134
3	183174	105482	103558	0.256	0.286	0.286
4	169050	116093	64906	0.264	0.295	0.295
5	34811	117429	78219	0.256	0.286	0.286
6	120265	108622	153725	0.256	0.286	0.286

h). Fbar(2013) = 0.23

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.014	0.014
2	160548	159820	159761	0.120	0.123	0.123
3	183174	105482	104674	0.256	0.263	0.263
4	169050	116093	66406	0.264	0.271	0.271
5	34811	117429	80086	0.256	0.263	0.263
6	120265	108622	157277	0.256	0.263	0.263

i). Fbar(2013) = 0.19

Age	N(2012)	N(2013)	N(2014)	F(2012)	F(2013)	F(2014)
1	440602	440602	440602	0.014	0.012	0.012
2	160548	159820	160164	0.120	0.102	0.102
3	183174	105482	106941	0.256	0.217	0.217
4	169050	116093	69511	0.264	0.224	0.224
5	34811	117429	83955	0.256	0.217	0.217
6	120265	108622	164631	0.256	0.217	0.217

Table 4.7.1.3. Herring in the Celtic Sea. Catch option table from the Short Term Forecast.

Rationale	Fbar (2012)	Catch (2012)	SSB (2012)	Fbar (2013)	Catch (2013)	SSB (2013)	SSB (2014)
Catch(2013) = Zero	0.224	18236	84281	0.000	0	88327	99475
Catch(2013) = 2012 TAC -15% (17935 t)	0.224	18236	84281	0.242	17935	78176	73530
Catch(2013) = 2012 TAC sq (21100 t)	0.224	18236	84281	0.292	21100	76261	69337
Catch(2013) = 2012 TAC +15% (24265 t)	0.224	18236	84281	0.344	24265	74303	65264
Catch(2013) = 2012 TAC + 25% (26375 t)	0.224	18236	84281	0.381	26375	72971	62616
Catch(2013) = 2012 TAC + 30% (27430 t)	0.224	18236	84281	0.400	27430	72297	61313
Fbar(2013) = 0.25	0.224	18236	84281	0.250	18458	77862	72829
Fbar(2013) = 0.23	0.224	18236	84281	0.230	17152	78643	74586
Fbar(2013) = 0.19	0.224	18236	84281	0.190	14456	80234	78275

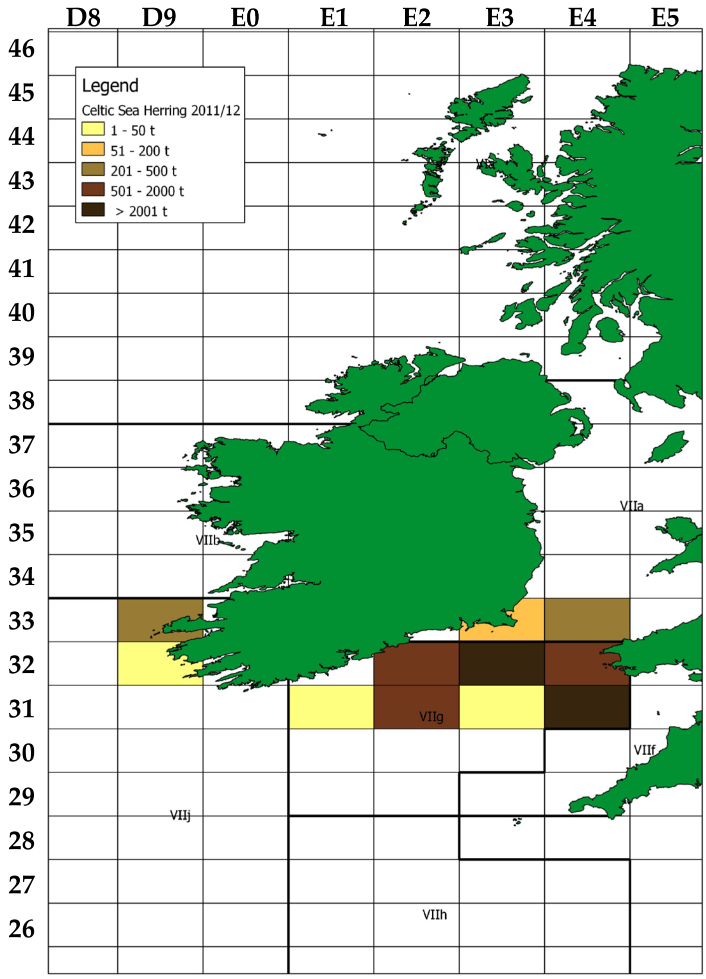


Figure 4.1.2.1. Herring in the Celtic Sea. Irish official herring catches by statistical rectangle in 2011/2012.

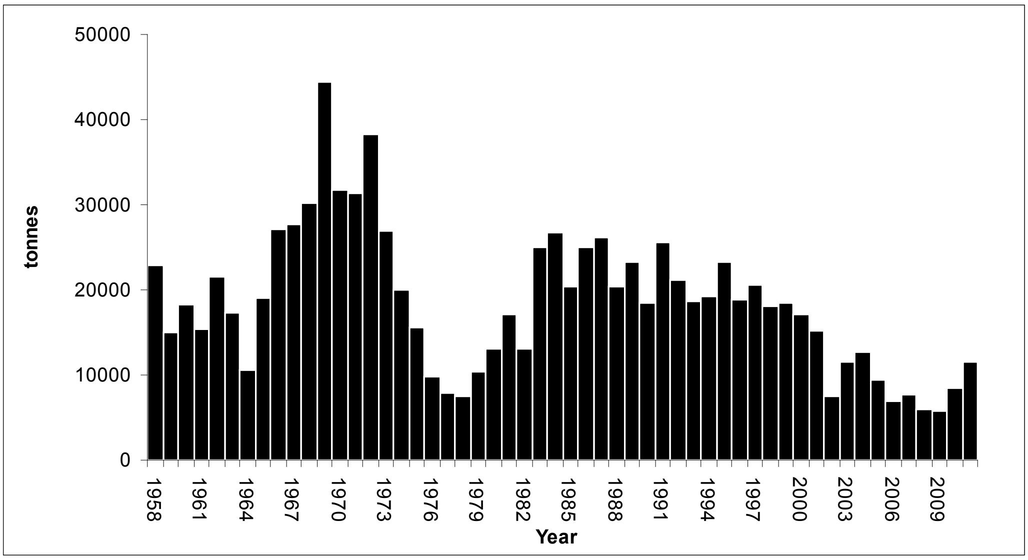


Figure 4.1.3.1. Herring in the Celtic Sea. Working Group estimates of herring landings per season.

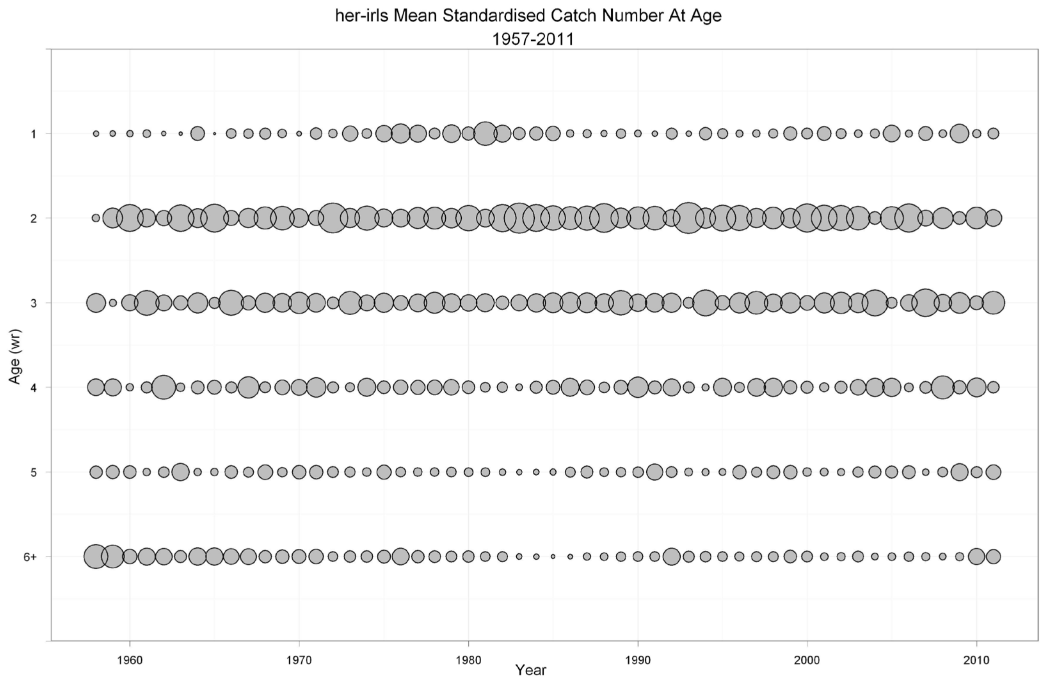


Figure 4.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 6-ringer is the plus group.

Figure 4.2.1.2. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 7-ringer is the plus group.

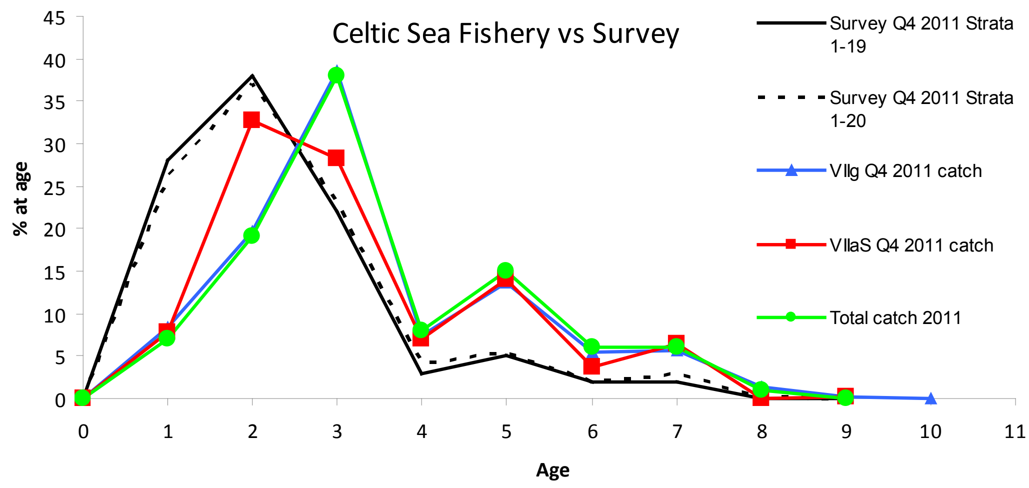


Figure 4.2.1.3. Herring in the Celtic Sea. The percentage age composition in the survey and the commercial fishery 2011/2012.

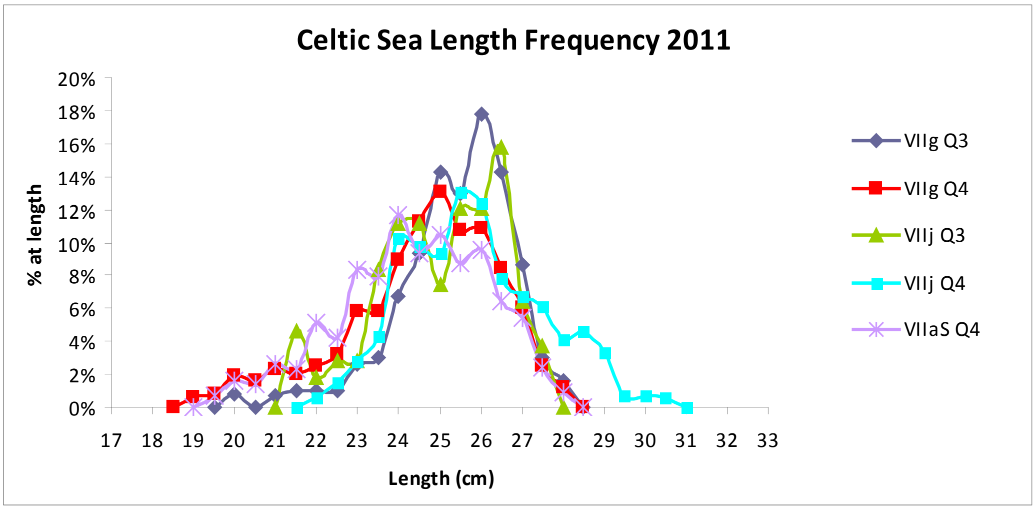


Figure 4.2.1.4. Herring in the Celtic Sea. Length-frequency data from sampling in 2011/2012.

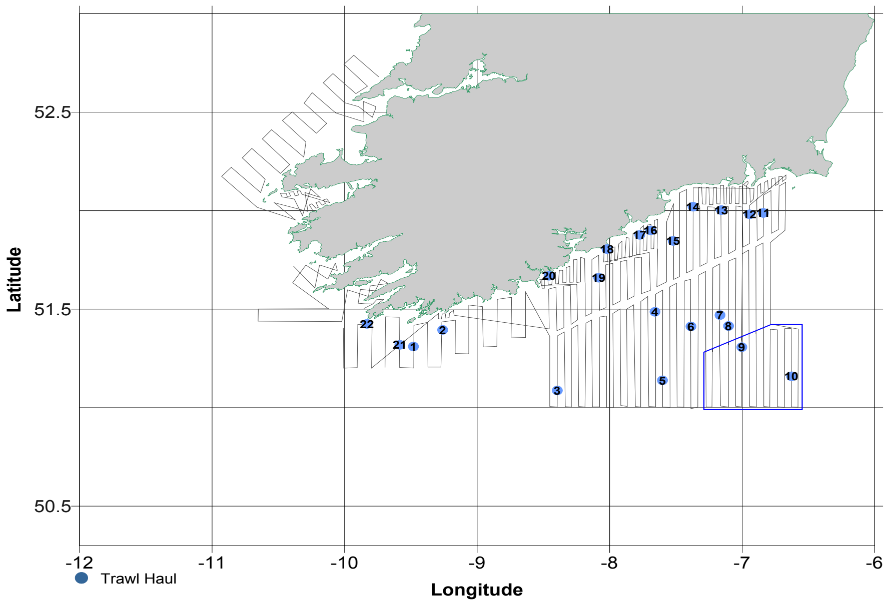


Figure 4.3.1.1a. Herring in the Celtic Sea. Acoustic survey track and haul positions from acoustic survey, October 2011. The blue box indicates the location of the additional strata (strata 20).

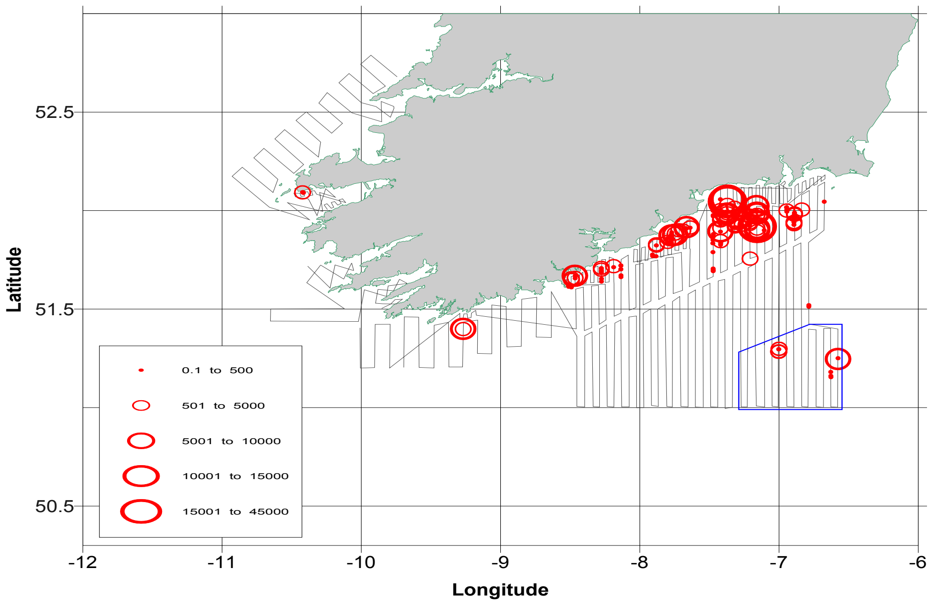


Figure 4.3.1.1b. Herring in the Celtic Sea. Acoustic survey total Sa values attributed to herring in the acoustic survey, October 2011. The blue box indicates the location of the additional strata (strata 20).

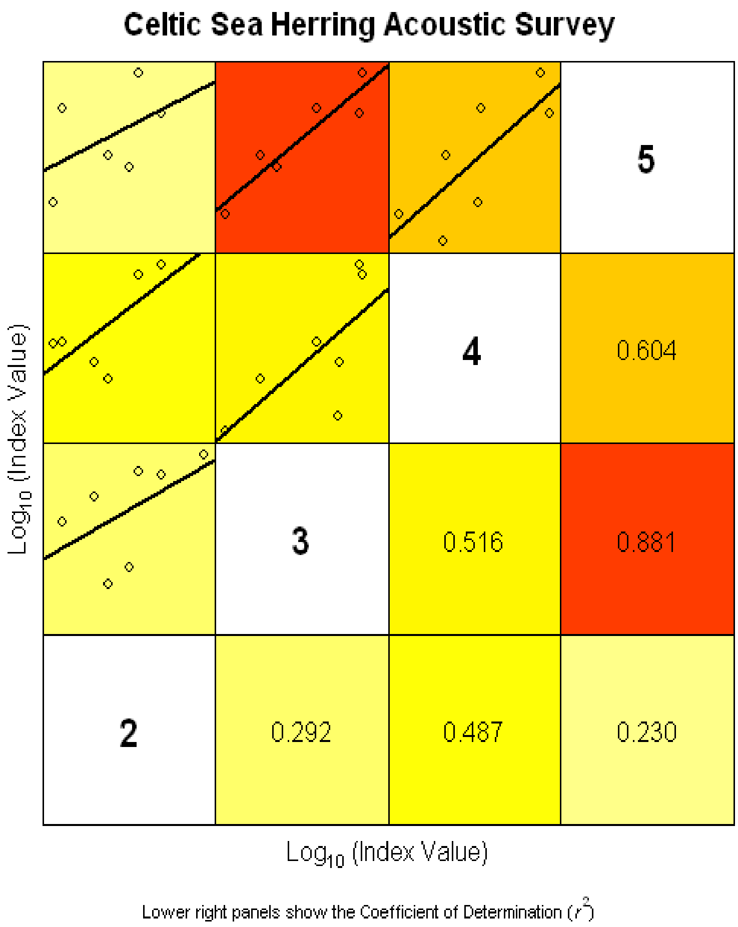


Figure 4.3.1.2. Herring in the Celtic Sea. Internal consistency between ages in the Celtic Sea Herring Acoustic survey time series.

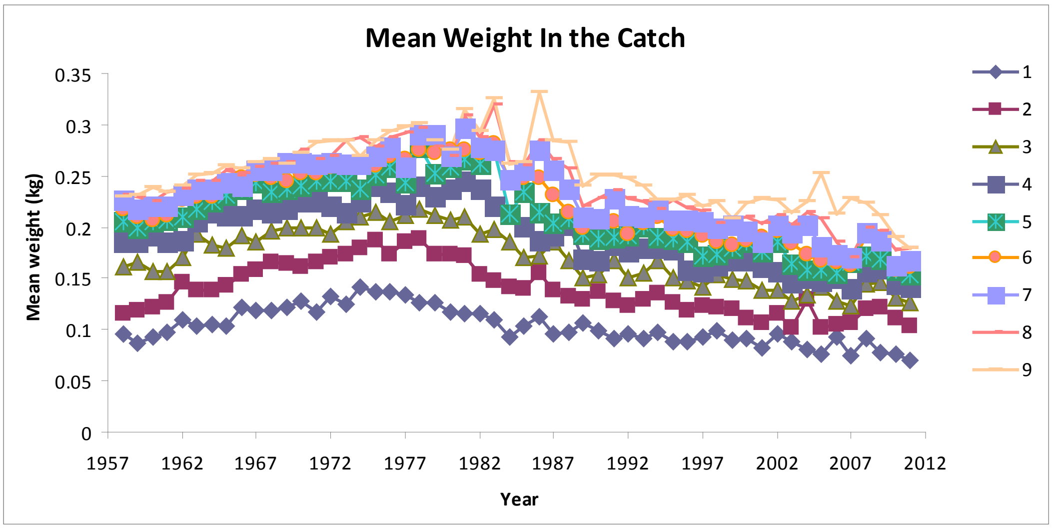


Figure 4.4.1.1. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the catch from 1-9+.

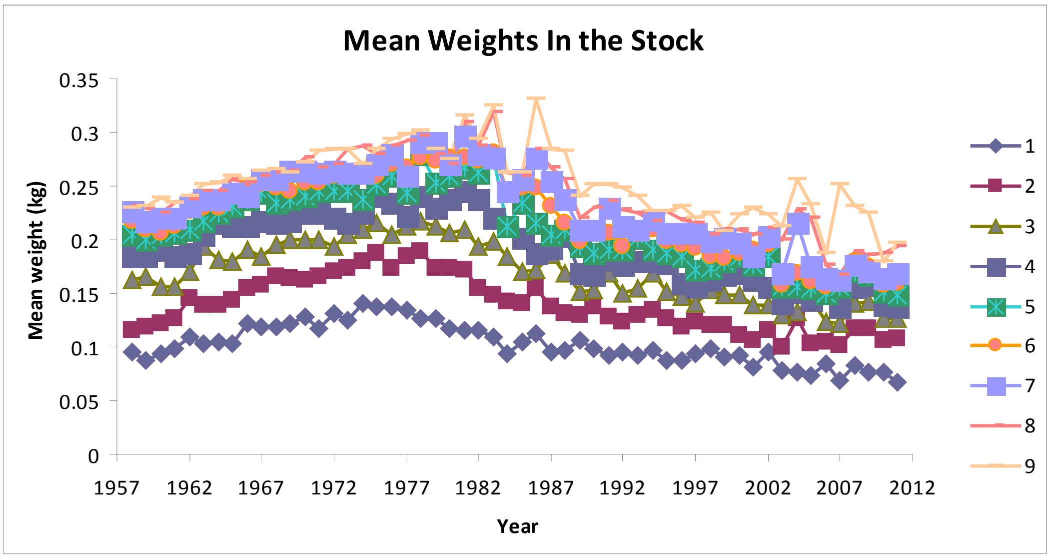


Figure 4.4.1.2. Herring in the Celtic Sea. Trends over time in mean weight-at-age in the stock at spawning time from 1-9+.

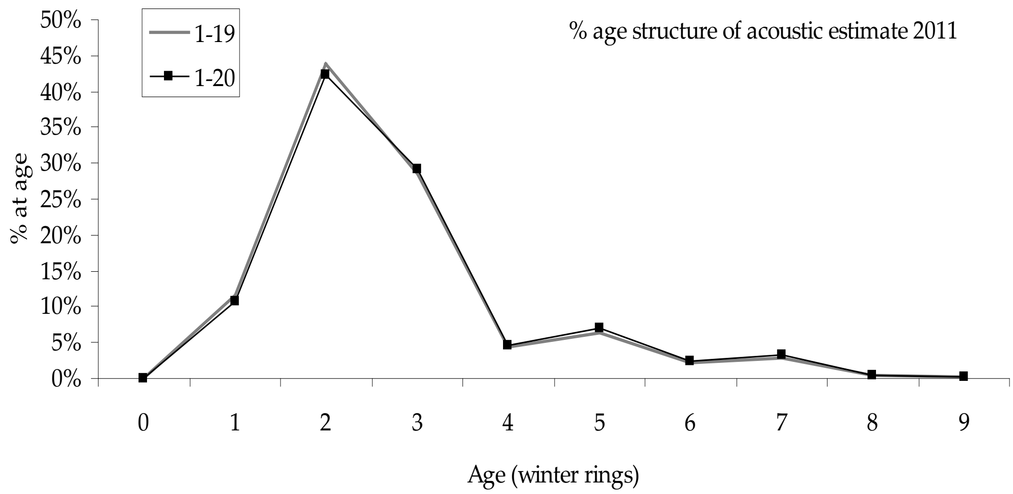


Figure 4.6.1.1. Herring in the Celtic Sea. Comparison of age structure of acoustic abundance estimates, including/excluding the additional stratum (20).

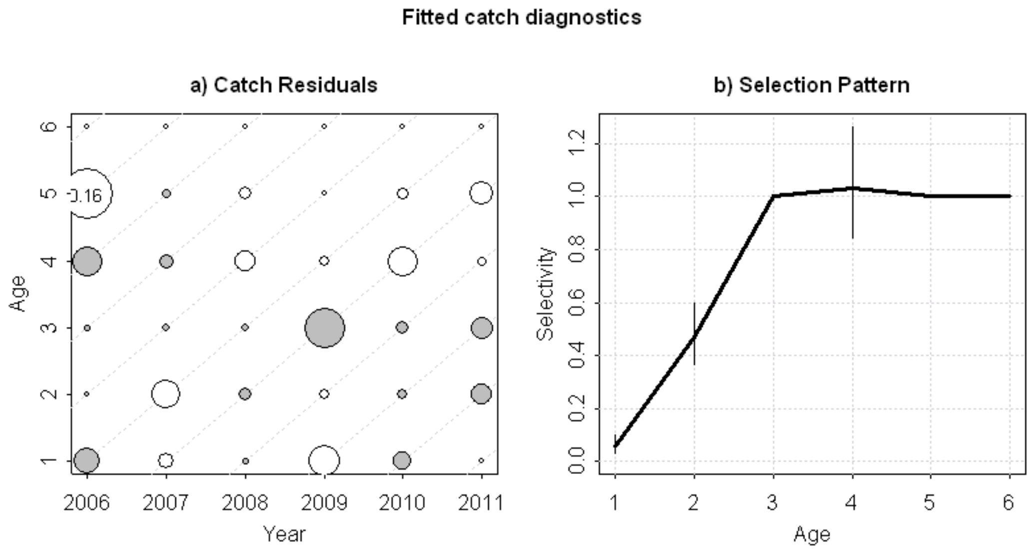


Figure 4.6.1.2. Herring in the Celtic Sea. Illustration of model diagnostics for 6+ run (including stratum 20) a) bubble plot of catch residuals in separable period; b) estimated selection relative to 3-ringers with 95% confidence intervals.

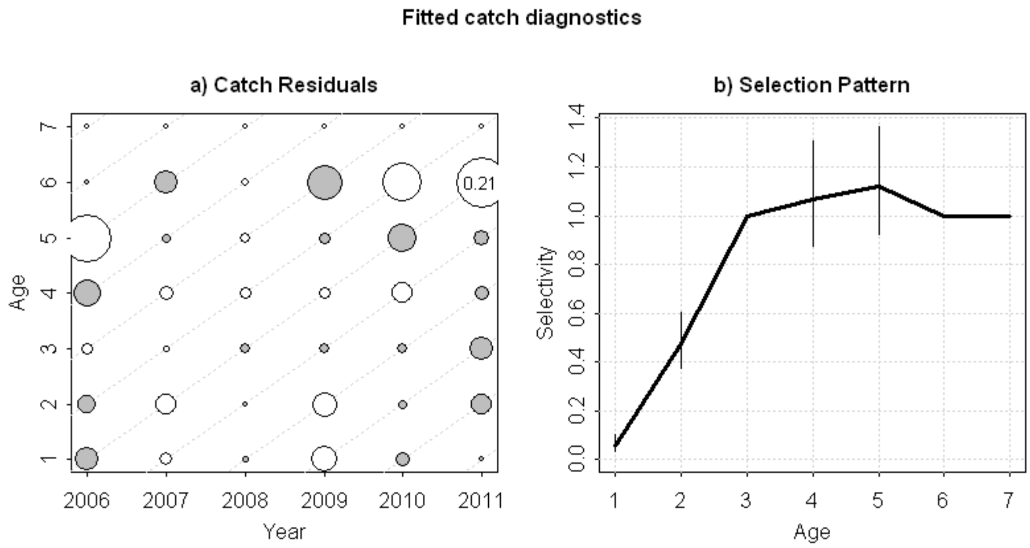


Figure 4.6.1.3. Herring in the Celtic Sea. Illustration of model diagnostics for 7+ run (including stratum 20) a) bubble plot of catch residuals in separable period; b) estimated selection relative to 3-ringers with 95% confidence intervals.

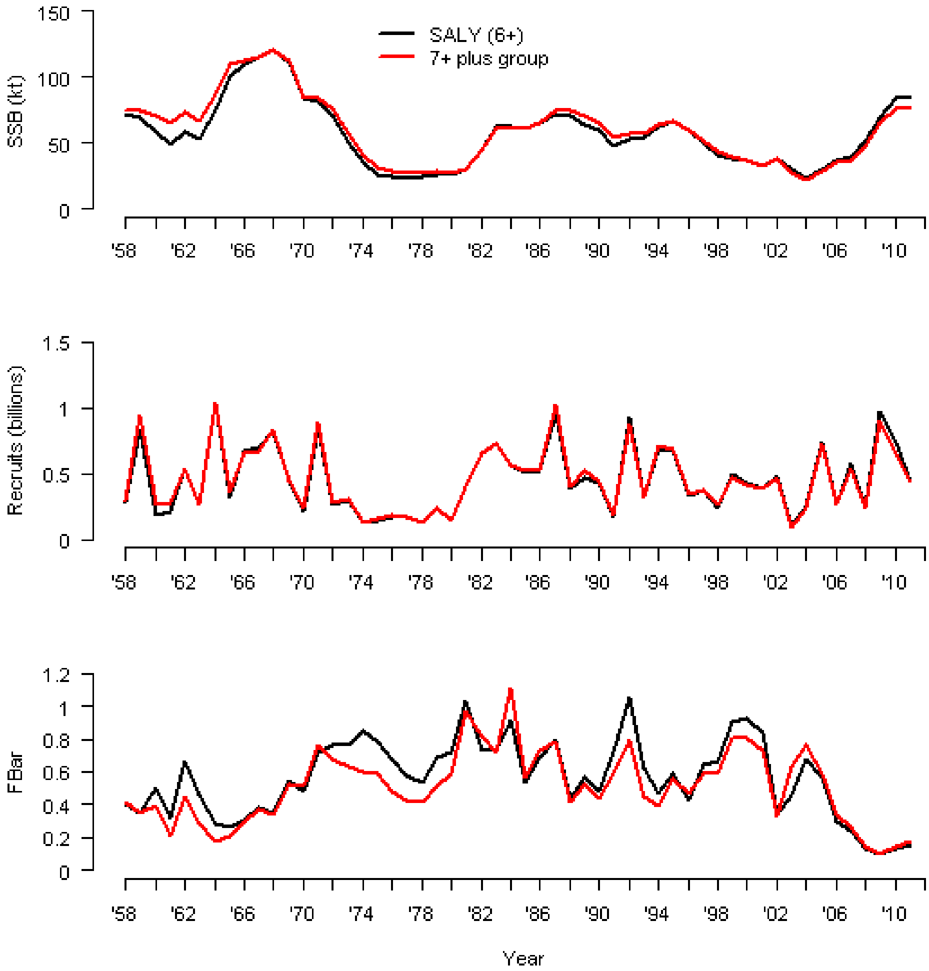


Figure 4.6.1.4. Herring in the Celtic Sea. Stock summary plots for the SALY (6+) assessment (black line) and with extended plus group, 7+ (red).

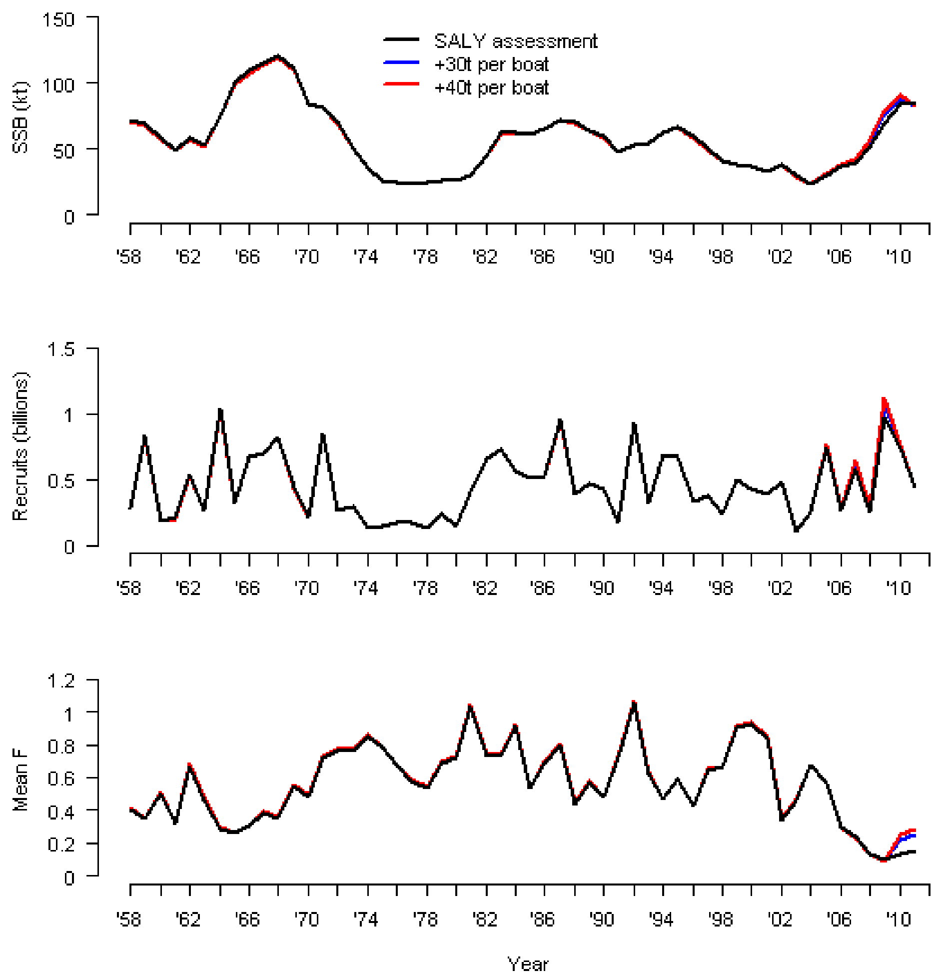


Figure 4.6.1.5. Herring in the Celtic Sea. SALY assessment (black line) and assessments with an additional 30t per boat, per week in 2010 and 2011 (blue line) and 40t per boat per week in 2010 and 2011 (red line).

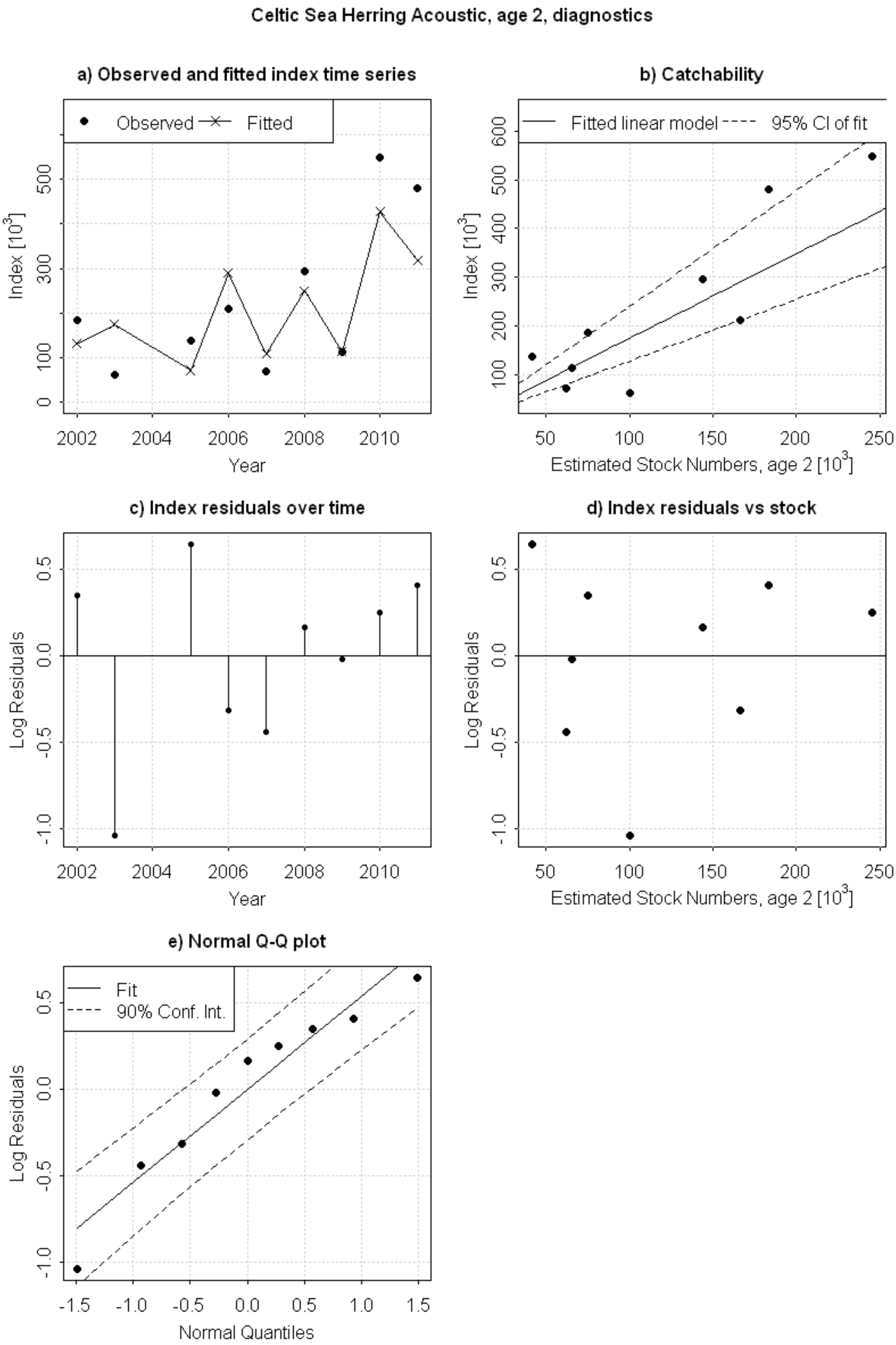


Figure 4.6.2.1. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 2 from the 6+ run.

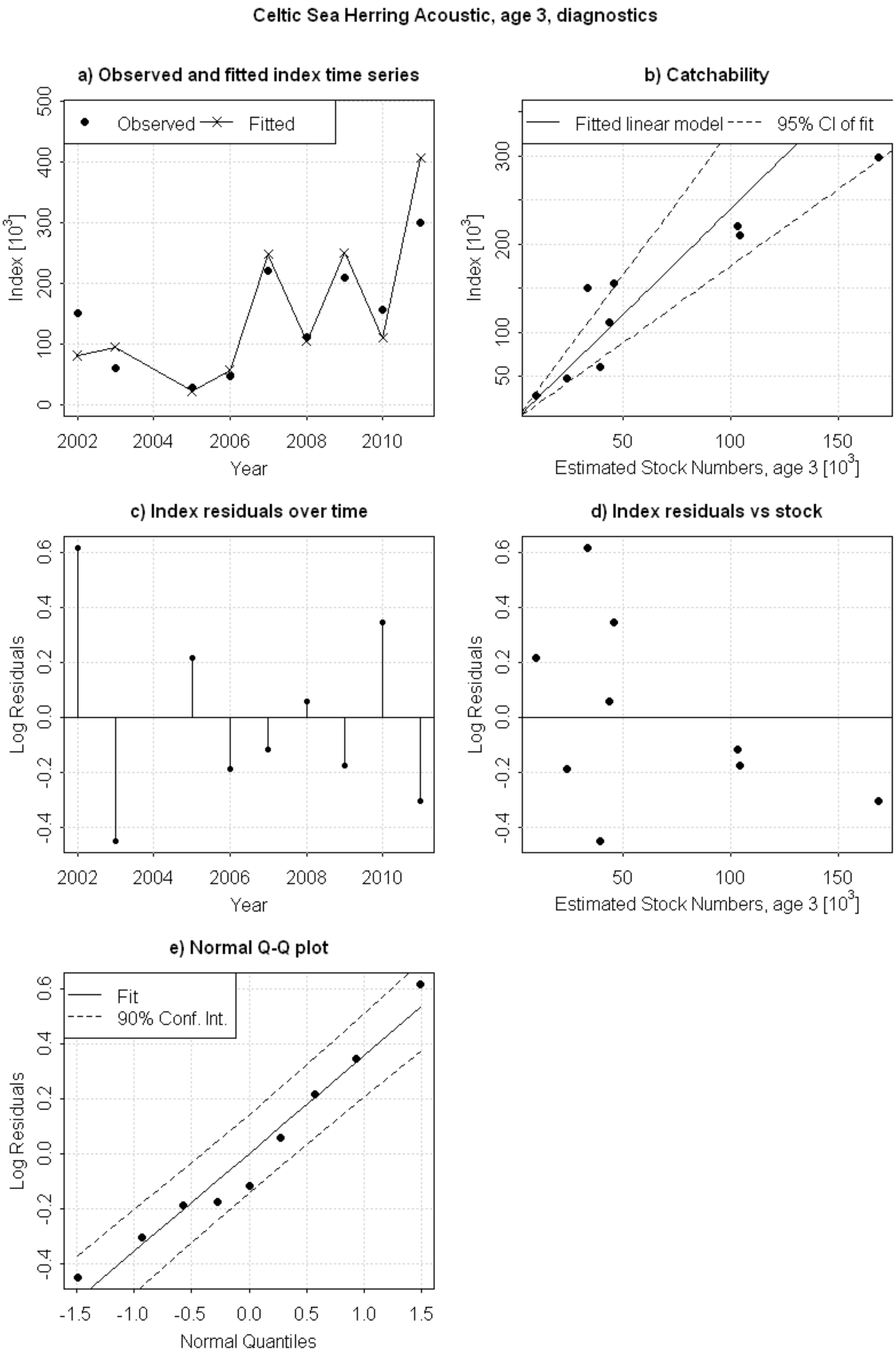


Figure 4.6.2.2. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 3 from the 6+ run.

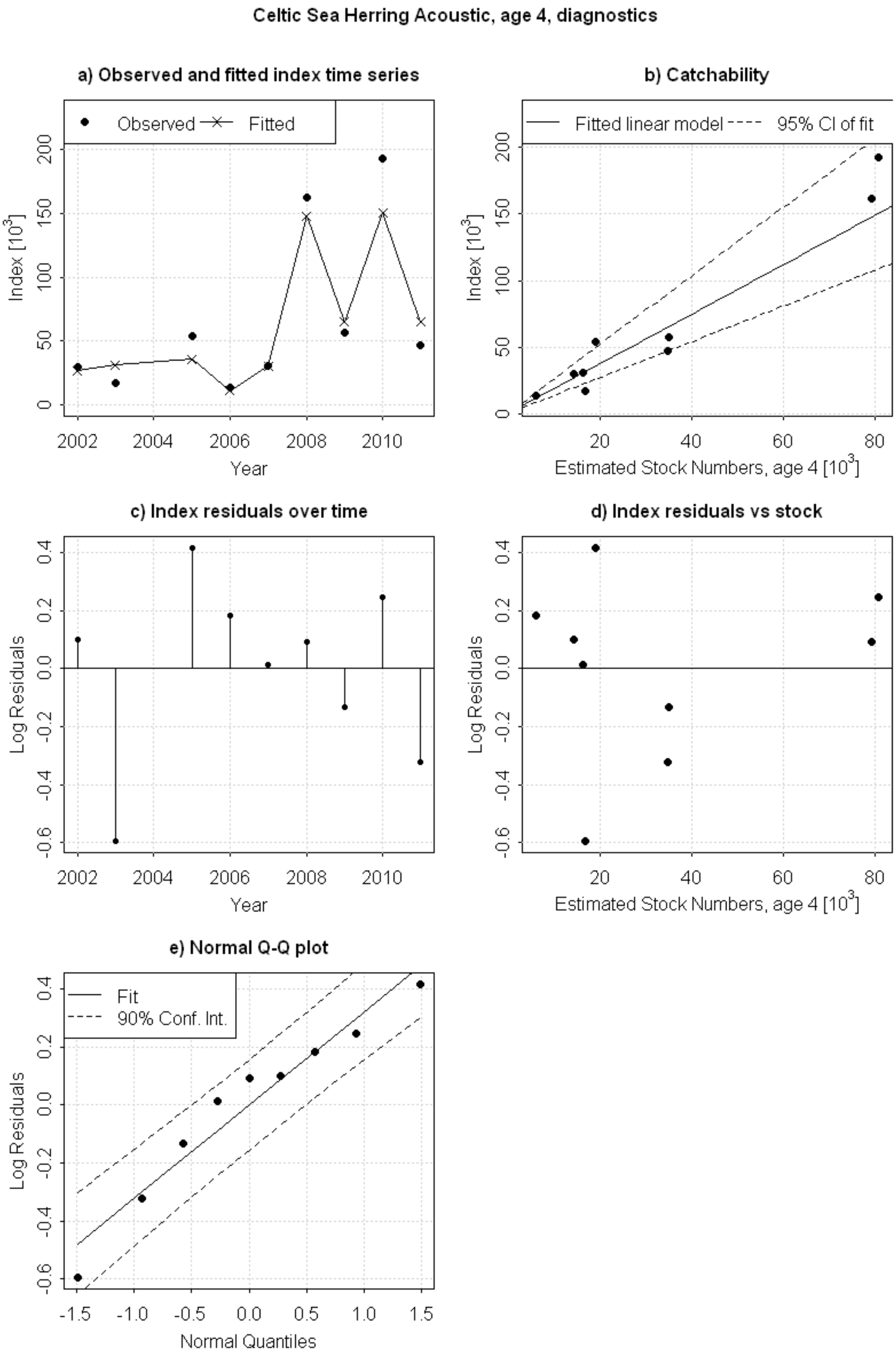


Figure 4.6.2.3. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 4 from the 6+ run.

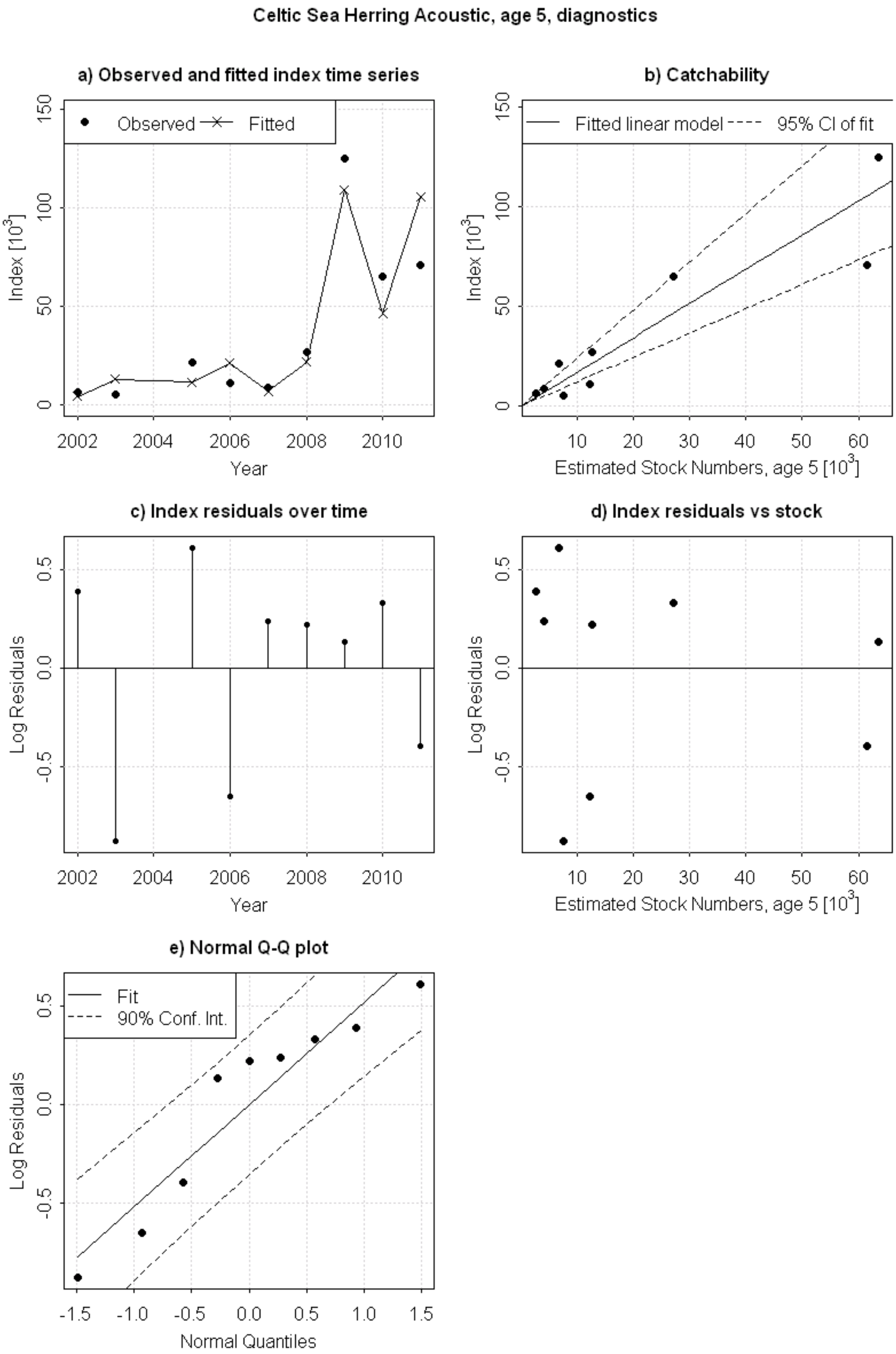


Figure 4.6.2.4. Herring in the Celtic Sea. Diagnostics from the Celtic Sea Herring Acoustic survey age 5 from the 6+ run.

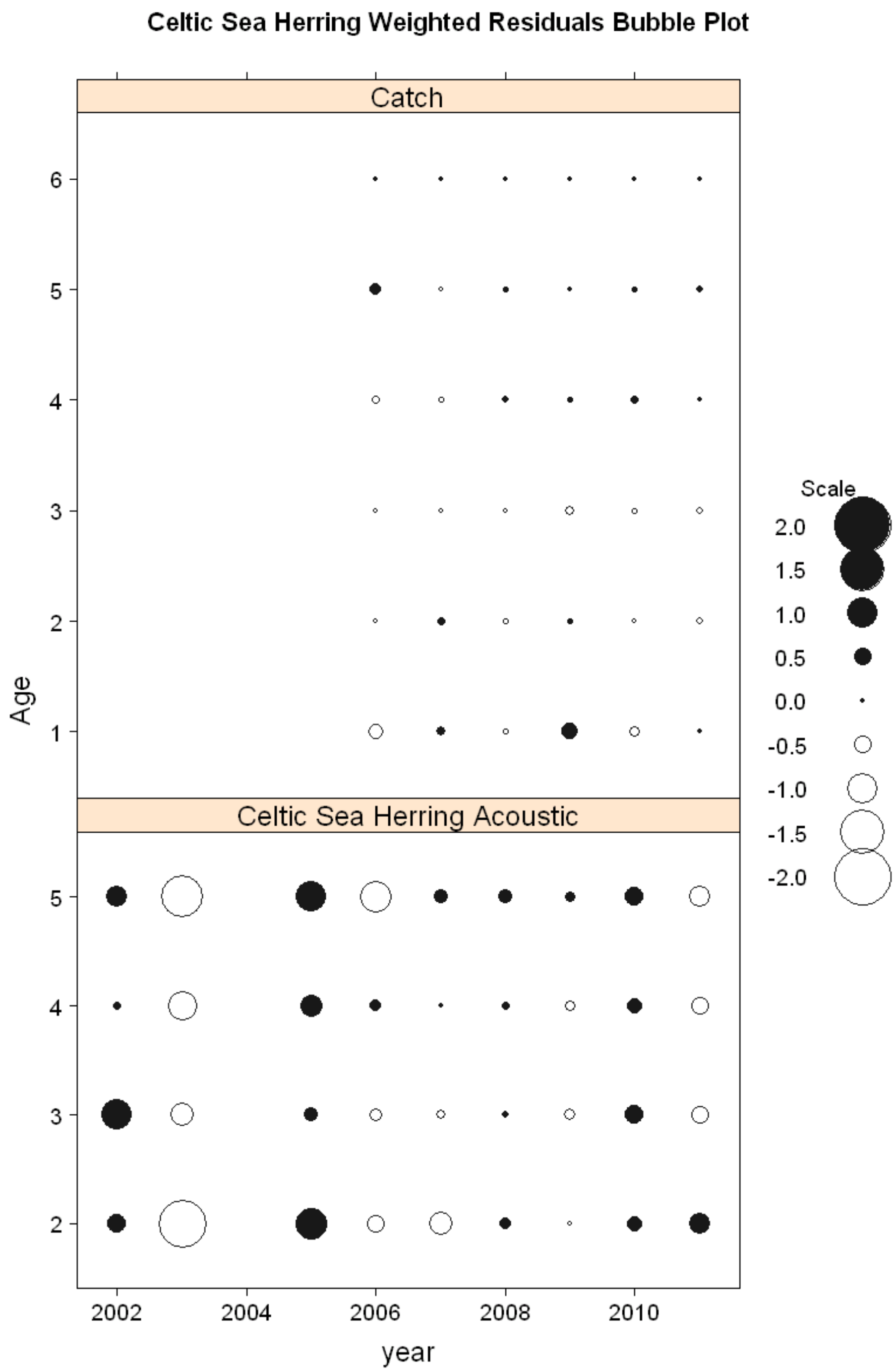


Figure 4.6.2.5 Herring in the Celtic Sea. Weighted catch and survey residuals from the final assessment.

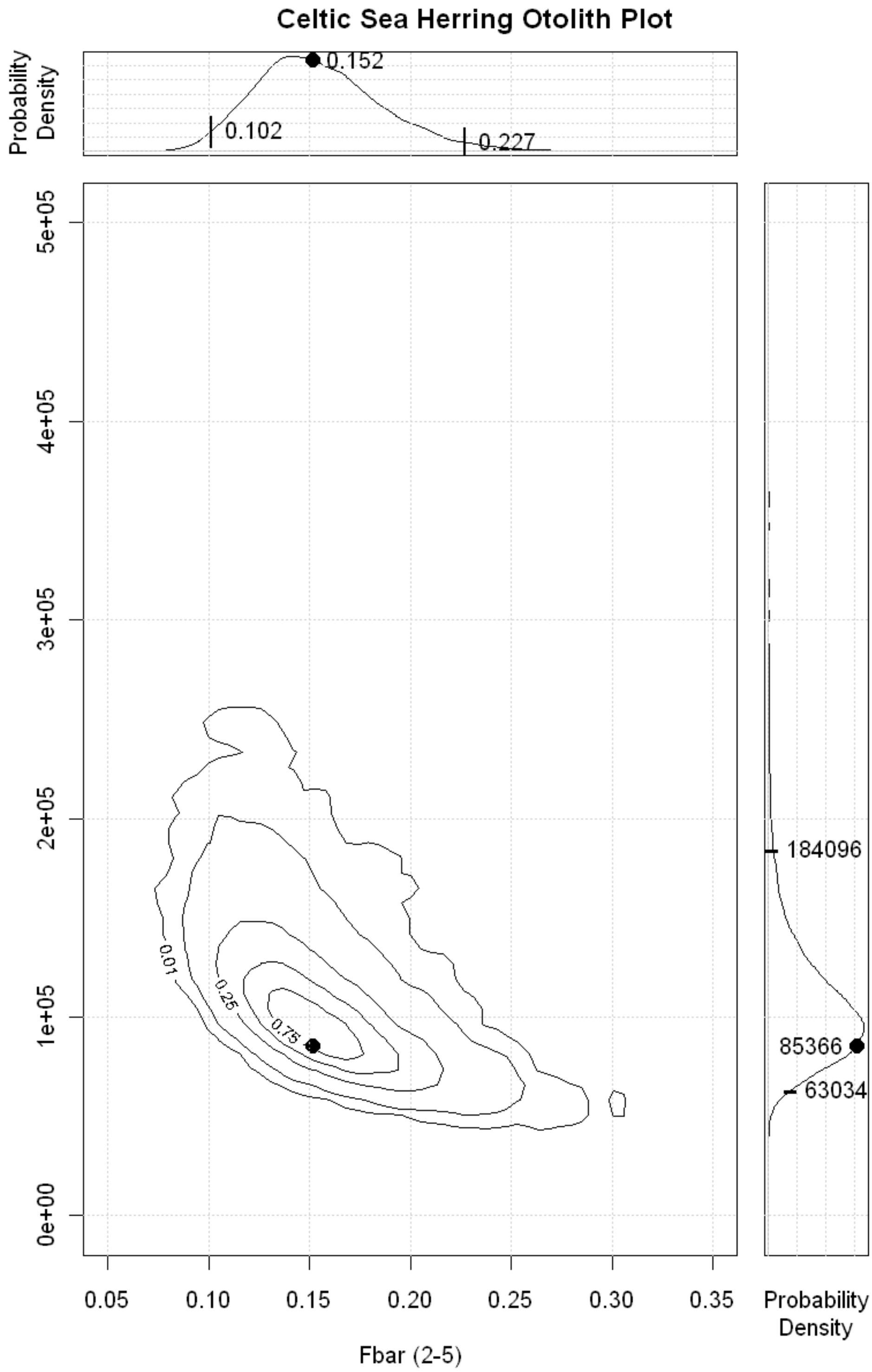


Figure 4.6.2.6. Herring in the Celtic Sea. Uncertainty plot showing the results of parametric bootstrapping from FLICA.

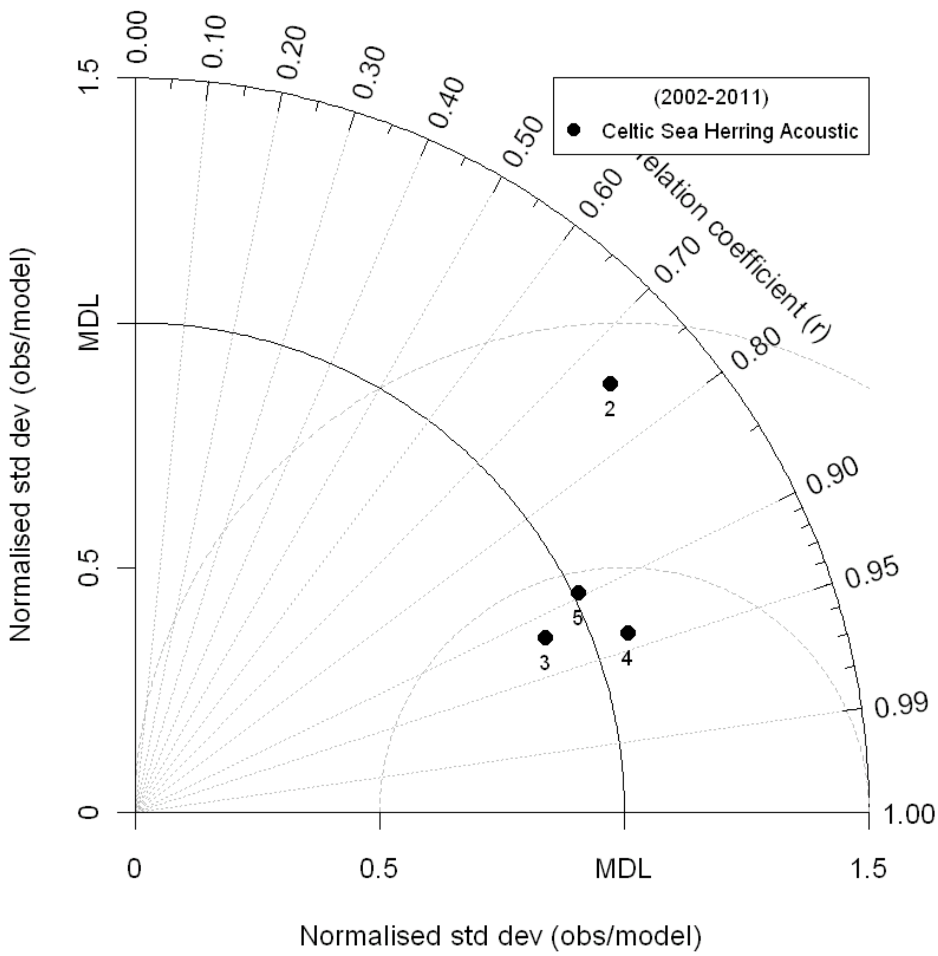


Figure 4.6.2.7. Herring in the Celtic Sea. Taylor Diagram. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modelled values. The radial axis represents the standard deviation of the observations normalized by the standard 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.

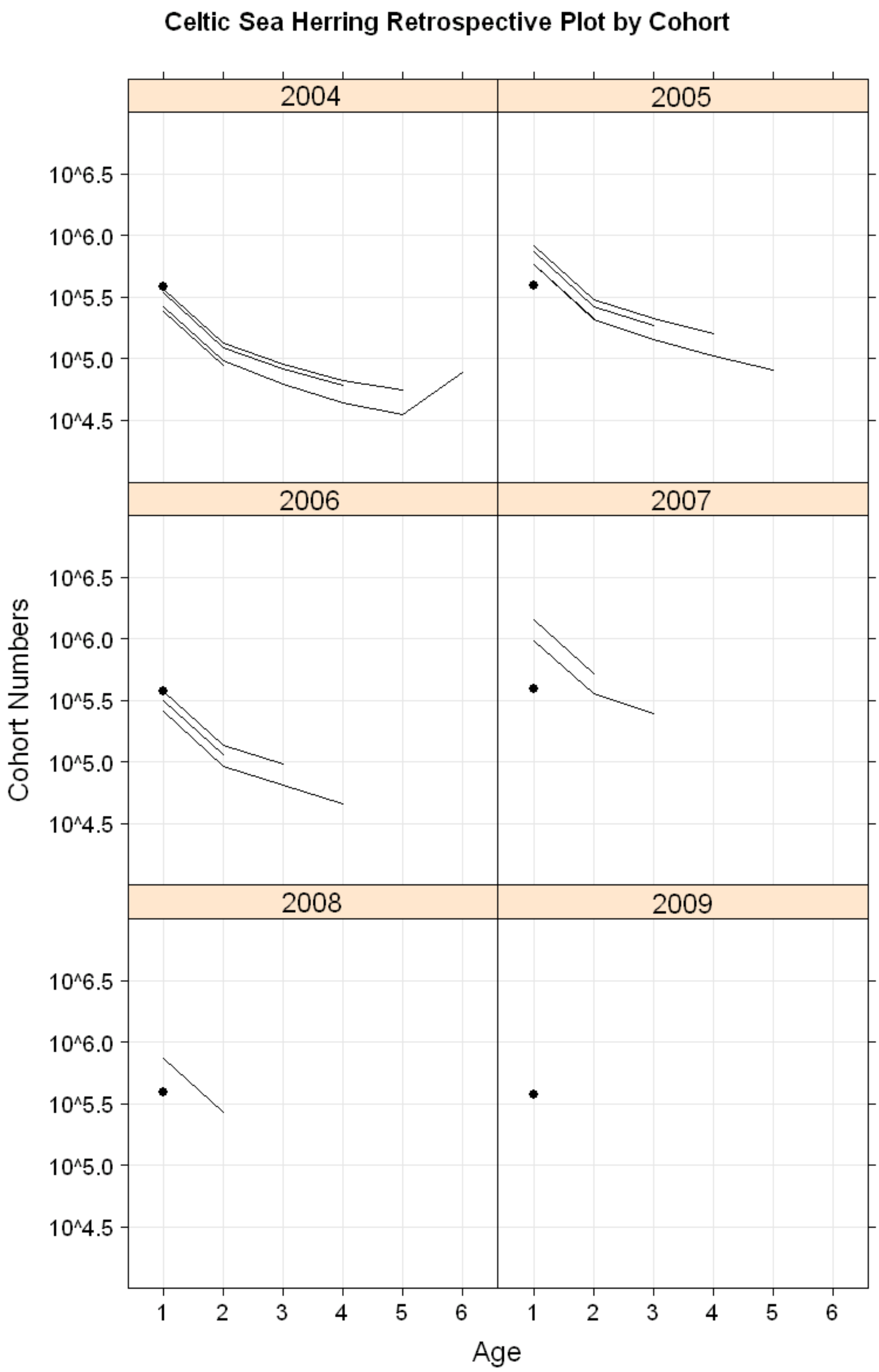


Figure 4.6.2.8. Herring in the Celtic Sea. Retrospectives by cohort

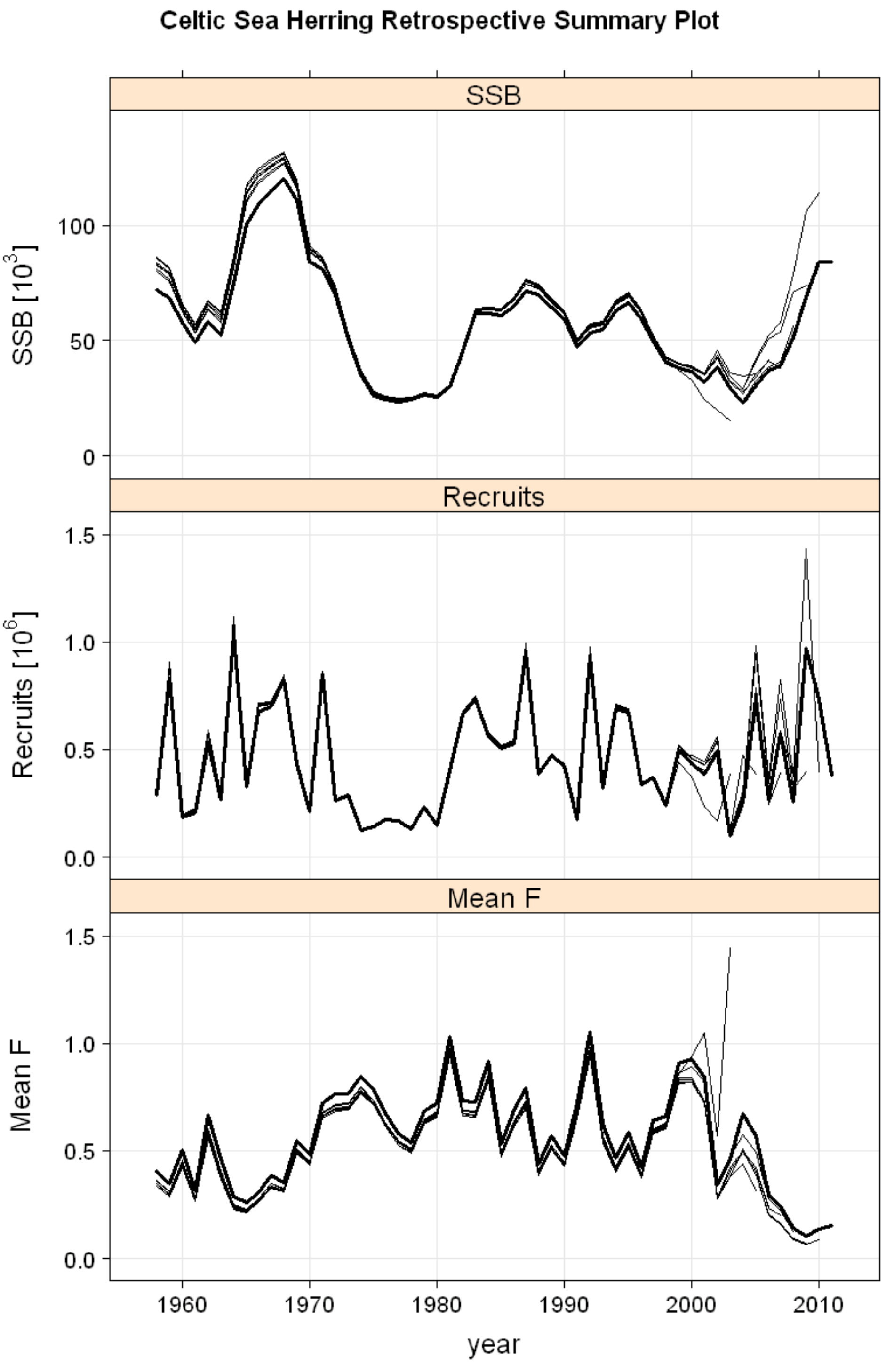


Figure 4.6.2.9. Herring in Celtic Sea. Analytical retrospective pattern. This retrospective includes 2003 and 2005-2011. 2004 data are excluded.

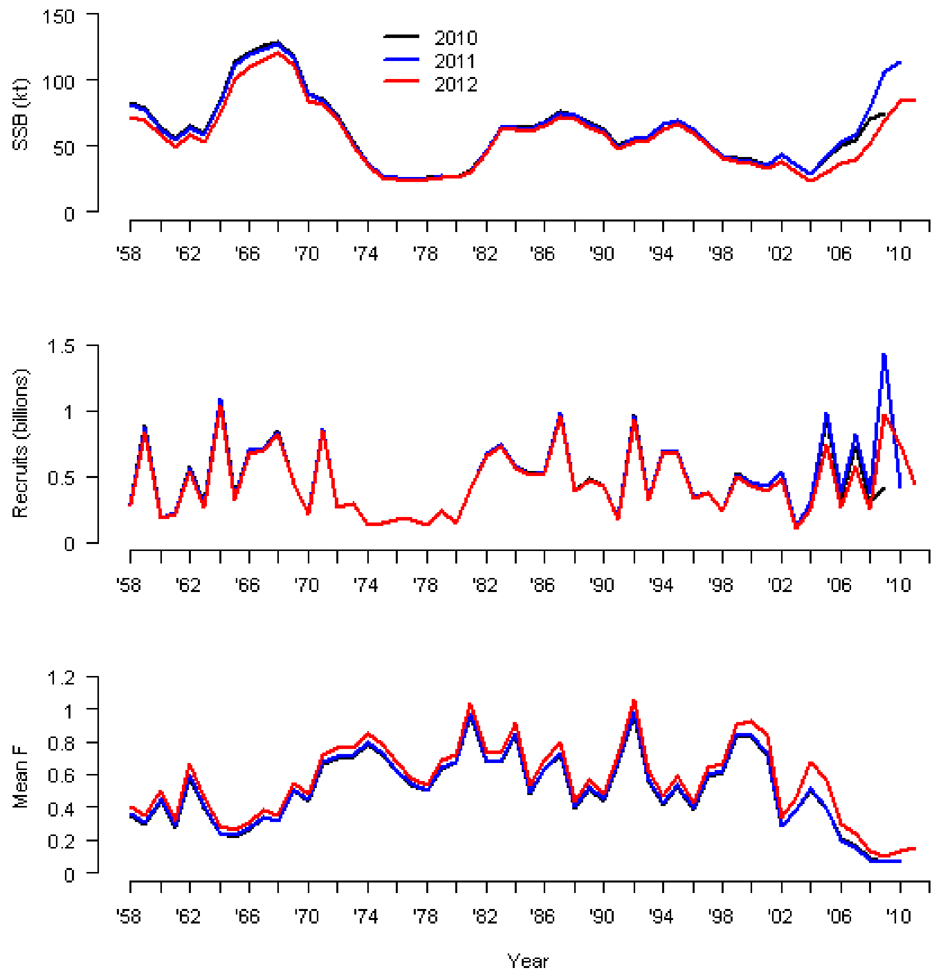


Figure 4.6.2.10. Herring in the Celtic Sea. Historical Retrospective based on the final assessments in 2010, 2011 and 2012.

5 Herring in Division VIa (North)

The location of the area occupied by the stock is shown in Figure 5.1.1.

5.1 The Fishery

5.1.1 Advice applicable to 2011 and 2012

ACOM reported in 2011 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 2012 is 22 900 t, which is in accordance with the agreed plan (see Section I.1 in the Stock Annex). The International TAC in 2011 was 22 481 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 fisheries prosecuted by these latter two fleets have become more similar both temporally and spatially.

In 2011, 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) (Figure 5.1.2). Recently (since 2006) the majority of the fishery has been prosecuted in quarter 3. This pattern has continued in 2011, with 78% 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 2011, with around 90% 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 2011 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 2011 the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 21 358 t, compared with the TAC of 22 481 t. The Working Group's estimates of area misreported and unallocated catches are 3 599 t. Various observer programs suggest that discarding is not a problem (see, for example, Van Helmond & Van Overzee WD to HAWG 2012). In 2011, there was no reported discarding.

The Working Group’s best estimate of removals from the stock in 2011 is 17 759 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 had increased markedly from the low level seen over the last few years (except in 2006) but declined again in 2011. There were 19 samples available in 2011, obtained from the Scottish (10), German (3), English (2), Irish (2), Dutch (1) and Northern Irish (1) fleets. The English fleet catch was sampled by the Dutch. However, the samples were raised to the English reported catch. 49% of the catch was taken by the Scottish and Northern Irish RSW fleet; 49% was taken by the international freezer trawler fleet; the remaining 2% was caught by the Irish fleet. 16 of the 19 samples obtained came from quarter 3; 10 from the RSW fleet and 6 from the freezer trawler fleet. The available samples were used to allocate a mean age- distribution (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 distributions to unsampled catches, and the calculation of total international catch-at-age and mean weight-at-age in the catches were made using the 'sallocl' programme (Patterson 1998a).

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). One large year class (2008) dominates (43% of the catch) the catch-at-age bubble plot in 2011 (Figure 5.2.1); at 2-rings in 2011. Two other year classes (2006 and 2007 at 4- and 3-ringers respectively in 2011) comprise an additional 30% of the catch. The plus group remains larger than normal as this group contains the large 2000 year class, at 10-ringer in 2011. The 2002 and 2003 year classes still appear relatively weak, with the 2002 year class the weaker of the two. 1-ring herring in the catch are observed intermittently and are rarely representative of year class strength.

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 2011 survey values are in Table 5.3.1.

The 2011 acoustic survey was carried out on three separate vessels (see text table below), with Celtic Explorer surveying the area south from 58°30′ N to 56°N, part of the area usually surveyed by Scotland. Further details are available in the Report of the Working Group for International Pelagic Surveys (ICES 2012/ SSGESST:21).

VESSEL	DATES	AREA SURVEYED	RECTANGLES
R/V Scotia (UK Scotland)	6 July – 26 July	58°30′-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
M/V Sunbeam (UK Scotland)	6 July – 26 July	58°30′-62°N, 4°W-2°E	46E2-F1, 47E3-F1, 48E4-F1, 49E5-F1, 50E7-F1, 51E8-F1
R/V Celtic Explorer (Ireland)	18 June – 07 July	53°-58°30′N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2,41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4

The combined spawning stock biomass estimate for VIa (North) from the acoustic survey (Table 5.3.2) has increased by approximately 49% from 2010 (from 308 055 tonnes to 457 900 tonnes), to give an average time series estimate.

In 2011 there were different patterns in year class proportions seen in the catch and the survey (Figure 5.3.1). The catch showed higher proportions of 2-ringers, whereas the survey showed higher proportions of 3-ringers. 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.

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 in 2011are similar for all ages to those in 2010. The weights-at-age in the stock have increased for all ages in 2011, except 3-ringers (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 1992 to 2011 (cf. Table 5.6.5). In 2011, 46% of the 2-ring fish were mature, compared to 79% in 2010. It is not unusual for 2-ringer maturity to be variable for this stock.

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 2011, using the revised catch data, post HAWG 2010, with the 8 year separable period moved forward one year to 2004 – 2011. However, it is tuned using the revised survey time series (1991-2011) – see Stock Annex. The assessment uses catch data from 1957 to 2011 giving an estimate of fishing mortality from 1957 to 2011 and numbers-at-age from 1 Jan 1957 to 2012. 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 2011 (in the plus group as 10-ringers). Two additional year classes are also reasonably abundant (2007, 3-ringers in 2011, in the survey and 2008, 2-ringers in 2011, in the catch).

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 downweighting of this index. The best fits are to middle ages 3-5.

The assessment shows continuing low levels of recruitment (the 2002, 2003, 2005 and 2006 year classes are 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 has been noisy but is perceived to be more stable over the last four years. 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 quite variable year-on-year SSB estimates. 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 2011 of around 82 000 t and a mean fishing mortality (3 to 6-ringers) of 0.18. SSB has returned to around the same level as in 2009, around 20% below the average of the previous 20 years. SSB in 2011 is around 33% higher than in 2010. F decreased in 2011, to F=0.18 (compared to F=0.27 in 2010, F=0.22 in 2009 and F=0.16 in 2008). Catch in 2011 decreased by 11% compared to 2010 (which had increased by 7% compared to 2009). The 2008 year class appears to be bigger than the last reasonable year class in 2000. This is driven very strongly by the catch data. 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 2009 to 2011 was considered to be appropriate again.

HAWG DATA YEAR	TAC	CATON	% BELOW TAC
2009	21760	18508	15
2010	24420	19877	19
2011	22481	17759	21

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_{3-6} 2009 to 2011). Input data are stock numbers on 1st January in 2012 from the 2012 ICA assessment (Section 5.6.1, Table 5.7.1.1). Geometric mean recruitment of 1-ringers (1989-2010) replaced recruitment for 1-ringers in both 2011 and 2012. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period. Population numbers of 2-ringers in the intermediate year (2012) were calculated by the degradation of geometric mean recruitment (1989-2010) using the equation below:

$$N_{t+1} = N_t * e^{-Ft+Mt}$$

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 the last 8 years. It is not 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., 2009 - 2011). An F constraint of 0.22 in 2012 (average F_{3-6} for the years 2009 to 2011) is used for the basis for the intermediate year in the projection, this implies an SSB in 2012 of 101 300 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 implies a TAC increase of 20%. This is consistent with an SSB in 2013 of ~ 104 000 t and a catch of ~27 500 t. This is coherent with a biomass in 2013 above $B_{trigger}$. The SSB is expected to fall to ~ 103 000 t in 2014.

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 0.16.

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 2010 is around 64 000 t, compared with some 62 000 t in last year's final assessment run, an increase of 3.5%.

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. 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.

	2011 Assessment		**2012 Assessment**		**Percentage change in estimate 2011-2012**	
Year	**SSB**	F_{3-6}	**SSB**	F_{3-6}	**SSB**	F_{3-6}
2009	74800	0.238	79721	0.218	6.58	-8.4
2010	61649	0.266	63785	0.252	3.46	-5.26
2011*	80998	0.219	82158	0.178	1.43	-18.72

*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 2011 to 2007 (Figure 5.9.2) support the perception of an uncertain but fairly well balanced assessment.

The Review Group comments were evaluated by the HAWG. For this stock, the HAWG found that many of the concerns raised are answered in the section below. As noted by the Review Group, the survey time series estimates are variable, leading to annual revisions of SSB and F. The HAWG believes much of this variability is due to mixing of fish from three separate stocks. Discarding and misreporting are now believed to be low within the stock. The management plan should be continued because it is designed to cope with the annual assessment revisions by applying a constraint on TAC changes.

5.10 Management Considerations

The forecast shows that SSB (in 2012) is approx. 1.7 times B_{lim}. ICES considers that the stock is currently fluctuating at a low level and is currently being exploited below F_{MSY}. Recruitment has been low since 1998, and the 2002, 2003, 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 some of the fleets. Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish discard observer program have recorded occasional catches of seals and zero catches of cetaceans in the past. Unfortunately the Scottish discard observer program is no longer active.

5.12 Changes in the Environment

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, 1988-2011. These figures 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**
Denmark								
Faroes			326	482			274	
France	44	1342	1287	1168	119	818	5087	3672
Germany	1860	4290	7096	6450	5640	4693	7938	3733
Ireland	6740	8000	10000	8000	7985	8236	6093	3548
Netherlands	6131	5860	7693	7979	8000	6132	8183	7808
Norway	456		1607	3318	2389	7447	30676	4840
UK	26894	29874	38253	32628	32730	32602	-4287	42661
Unallocated	5229	2123	2397	-10597	-5485	-3753	700	-4541
Discards		1550	1300	1180	200			
Total	47354	53039	69959	50608	51578	56175	54664	61271
Area-Misreported	-11763	-19013	-25266	-22079	-22593	-24397	-30234	-32146
WG Estimate	35591	34026	44693	28529	28985	31778	24430	29575
Source (WG)	1990	1991	1993	1993	1994	1995	1996	1997

Country	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**
Faroes							800	400
France	2297	3093	1903	463	870	760	1340	1370
Germany	7836	8873	8253	6752	4615	3944	3810	2935
Ireland	9721	1875	11199	7915	4841	4311	4239	3581
Netherlands	9396	9873	8483	7244	4647	4534	4612	3609
Norway	6223	4962	5317	2695				
UK	46639	44273	42302	36446	22816	21862	20604	16947
Unallocated	-17753	-8015	-11748	-8155			878	-7
Discards		62	90					
Total	64359	64995	65799	61514	37789	35411	36283	28835
Area-Misreported	-38254	-29766	-32446	-23623	-19467	-11132	-8735	-3581
WG Estimate	26105	35233*	33353	29736	18322$	24556$	32914$	28081$
Source (WG)	1997	1998	1999	2000	2001	2002	2003	2004

Country	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Faroes	228	1810	570	484	927	1544	70	
France	625	613	701	703	564	1049	511	504
Germany	1046	2691	3152	1749	2526	27	3583	3518
Ireland	1894	2880	4352	5129	3103	1935	2728	3956
Netherlands	8232	5132	7008	8052	4133	5675	3600	1684
Norway								
UK	17706	17494	18284	17618	13963	11076	12018	11696
Unallocated								
Discards	123	772	163				95	
Total	29854	31392	34230	33735	25216	21306	22510	21358
Area-Misreported	-7218	-17263	-6884	-4119	-9162	-2798	-2728	-3599
WG Estimate	25021$	14129$	27346	29616	16054	18508	19877	17759
Source (WG)	2005	2006	2007	2008	2009	2010	2011	2012

$Revised at HAWG 2007

Table 5.2.1. Herring in VIa (North). Catch and sampling effort by nations participating in the fishery in 2011.

Summary of Sampling by Country

AREA : VIa(N)

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	2771.00	3011.00	2	75	75	99.99
France	0.00	504.00	0	0	0	0.00
Germany	2309.00	3518.00	3	433	254	100.02
Ireland	224.00	3956.00	1	212	60	100.01
N. Ireland	499.00	499.00	2	240	98	99.98
Netherlands	1680.00	1684.00	1	148	25	100.01
Scotland	6325.00	8186.00	10	1477	462	100.00
Total VIa(N)	13808.00	21358.00	19	2585	974	100.00

Sum of Offical Catches : 21358.00
Unallocated Catch : -3599.00
Working Group Catch : 17759.00

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Ireland	0.00	3013.00	0	0	0	0.00
Scotland	0.00	1189.00	0	0	0	0.00
Period Total	0.00	4202.00	0	0	0	0.00

Sum of Offical Catches : 4202.00
Unallocated Catch : -2880.00
Working Group Catch : 1322.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	230.00	0	0	0	0.00
France	0.00	460.00	0	0	0	0.00
Germany	0.00	1151.00	0	0	0	0.00
Period Total	0.00	1841.00	0	0	0	0.00

Sum of Offical Catches : 1841.00
Unallocated Catch : 0.00
Working Group Catch : 1841.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	2771.00	2781.00	2	75	75	99.99
France	0.00	44.00	0	0	0	0.00
Germany	2309.00	2354.00	3	433	254	100.02
Netherlands	1680.00	1680.00	1	148	25	100.01
Scotland	6325.00	6938.00	10	1477	462	100.00
Period Total	13085.00	13797.00	16	2133	816	100.00

Sum of Offical Catches : 13797.00
Unallocated Catch : 0.00
Working Group Catch : 13797.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Germany	0.00	13.00	0	0	0	0.00
Ireland	224.00	943.00	1	212	60	100.01
N. Ireland	499.00	499.00	2	240	98	99.98
Netherlands	0.00	4.00	0	0	0	0.00
Scotland	0.00	59.00	0	0	0	0.00
Period Total	723.00	1518.00	3	452	158	99.99

Sum of Offical Catches : 1518.00
Unallocated Catch : -719.00
Working Group Catch : 799.00

Table 5.3.1. Herring in VIa (North). Estimates of abundance, biomass, maturity, weight- and length-at-age from the 2011 acoustic survey in VIa (North). 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 combined surveys by Scotland and Ireland in VIaN, within the original survey boundaries, to retain consistency with previous year's survey results.

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
1	22	1	0.00	56.8	19.2
2	185	24	0.46	132.3	24.2
3	733	117	0.92	159.7	25.9
4	451	94	1.00	207.8	28.1
5	204	48	1.00	235.6	29.2
6	220	54	1.00	244.7	29.6
7	199	47	1.00	237.9	29.7
8	113	25	1.00	222.4	29.5
9+	263	66	1.00	252.6	29.4
Immature	177	20		110.4	15.9
Mature	2214	458		206.8	27.5
Total	2319	477	0.93	199.7	27.6

Table 5.3.2. Herring in VIa (North). Estimates of abundance and SSB for the time series of acoustic surveys in the historically surveyed area of VIa (N), not including Clyde and North Channel. Thousands of fish at age and spawning biomass (SSB, tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year/Age	1	2	3	4	5	6	7	8	9+	SSB
1991	338312	294484	327902	367830	488288	176348	98741	89830	58043	410 000
1992	74310	503430	210980	258090	414750	240110	105670	56710	63440	351 460
1993	2357	579320	689510	688740	564850	900410	295610	157870	161450	845 452
1994	494150	542080	607720	285610	306760	268130	406840	173740	131880	533 740
1995	441200	1103400	473300	450300	153000	187200	169200	236700	201700	452 300
1996	41220	576460	802530	329110	95360	60600	77380	78190	114810	370 300
1997	792320	641860	286170	167040	66100	49520	16280	28990	24440	175 000
1998	1221700	794630	666780	471070	179050	79270	28050	13850	36770	375 890
1999	534200	322400	1388000	432000	308000	138700	86500	27600	35400	460 200
2000	447600	316200	337100	899500	393400	247600	199500	95000	65000	444 900
2001	313100	1062000	217700	172800	437500	132600	102800	52400	34700	359 200
2002	424700	436000	1436900	199800	161700	424300	152300	67500	59500	548 800
2003	438800	1039400	932500	1471800	181300	129200	346700	114300	75200	739 200
2004	564000	274500	760200	442300	577200	55700	61800	82200	76300	395 900
2005	50200	243400	230300	423100	245100	152800	12600	39000	26800	222 960
2006	112300	835200	387900	284500	582200	414700	227000	21700	59300	471 700
2007	-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
2011	22239	184919	733384	451487	204324	219863	198768	112646	263185	457 900

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 (N). CATCH IN NUMBER
Units : Thousands

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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	2011
1	1923.62	10074.12	1667.19
2	11508.54	20339.85	40587.92
3	10475.63	16331.31	15782.93
4	16586.96	9957.96	10333.90
5	8332.17	14608.15	7190.29
6	5688.68	6322.33	5071.43
7	7514.70	4322.24	3164.16
8	11793.98	5388.91	2611.38
9	9443.85	13199.28	7225.68

TABLE 5.6.2 HERRING in VIa (N). WEIGHTS AT AGE IN THE CATCH

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082	0.079	0.084	0.091
2	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142	0.129	0.118	0.119
3	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145	0.173	0.160	0.183
4	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191	0.182	0.203	0.196
5	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190	0.209	0.211	0.227
6	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213	0.224	0.229	0.219
7	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216	0.228	0.236	0.244
8	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204	0.237	0.261	0.256
9	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243	0.247	0.271	0.256

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834	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	2011
1	0.1084	0.0908	0.1152	NaN	0.1121	0.0818	0.0613
2	0.1327	0.1580	0.1667	0.1705	0.1726	0.1549	0.1550
3	0.1632	0.1676	0.1881	0.2060	0.2141	0.1883	0.1894
4	0.1845	0.1929	0.1968	0.2310	0.2379	0.2129	0.2178
5	0.2108	0.2076	0.2105	0.2309	0.2457	0.2337	0.2340
6	0.2258	0.2251	0.2214	0.2489	0.2535	0.2394	0.2388
7	0.2341	0.2443	0.2161	0.2529	0.2599	0.2369	0.2470
8	0.2556	0.2615	0.2618	0.2840	0.2549	0.2400	0.2463
9	0.2496	0.2750	0.3030	0.2877	0.2730	0.2549	0.2522

TABLE 5.6.3 HERRING in VIa (N). WEIGHTS AT AGE IN THE STOCK

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

TABLE 5.6.3 continued. HERRING in VIa (N). WEIGHTS AT AGE IN THE STOCK

	year											
age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.000	0.000

	year											
age	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.253
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.273
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.299
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.302

	year											
age	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.073	0.052	0.042	0.045	0.054	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.164	0.150	0.144	0.140	0.142	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.180	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.199	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.225	0.221	0.225	0.219	0.213	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.222	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.253	0.241	0.247	0.229	0.231	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.259	0.270	0.260	0.242	0.242	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.263	0.249	0.245	0.230	0.254	0.259	0.228	0.206

	year						
age	2005	2006	2007	2008	2009	2010	2011
1	0.0751	0.075	0.0750	0.0546	0.1013	0.0642	0.0570
2	0.1296	0.135	0.1675	0.1721	0.1734	0.0923	0.1323
3	0.1538	0.166	0.1830	0.1913	0.2064	0.1677	0.1597
4	0.1665	0.185	0.1914	0.2083	0.2233	0.1983	0.2078
5	0.1802	0.192	0.1951	0.2143	0.2331	0.2114	0.2356
6	0.1911	0.204	0.1951	0.2139	0.2313	0.2148	0.2447
7	0.2125	0.211	0.2021	0.2206	0.2318	0.2091	0.2379
8	0.2030	0.224	0.2034	0.2242	0.2323	0.2193	0.2224
9	0.2284	0.231	0.2138	0.2385	0.2382	0.2153	0.2526

TABLE 5.6.4 HERRING in VIa (N). NATURAL MORTALITY

Units : NA

	year														
age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

	year														
age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 5.6.4 continued. HERRING in VIa (N). NATURAL MORTALITY

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	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
3	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
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	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 (N). PROPORTION MATURE

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	0.21	0.76	0.55	0.85	0.57	0.45	0.93
3	0.96	0.96	0.96	0.96	0.96	1.00	0.96	0.93	0.98	0.94	0.95	0.97	0.98	0.92	0.99
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.0	0.00	0.00
2	0.92	0.76	0.83	0.84	0.81	1	0.98	0.7	0.79	0.46
3	1.00	1.00	0.97	1.00	0.97	1	1.00	1.0	1.00	0.92
4	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0	1.00	1.00

TABLE 5.6.6 HERRING in VIa (N). FRACTION OF HARVEST BEFORE SPAWNING
Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age \ year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
1	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
3	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
5	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
7	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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.7 HERRING in VIa (N). 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

TABLE 5.6.7 continued. HERRING in VIa (N). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

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	2011
1	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
3	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
5	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
7	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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.8 HERRING in VIa (N). 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	2011.00	0.52	0.57

Index type : number

West of Scotland Summer Acoustic Survey - Index Values

Units : number

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	338312	74310	2357	494150	441200	41220	792320	1221700	534200	447600
2	294484	503430	579320	542080	1103400	576460	641860	794630	322400	316200
3	327902	210980	689510	607720	473300	802530	286170	666780	1388000	337100
4	367830	258090	688740	285610	450300	329110	167040	471070	432000	899500
5	488288	414750	564850	306760	153000	95360	66100	179050	308000	393400
6	176348	240110	900410	268130	187200	60600	49520	79270	138700	247600
7	98741	105670	295610	406840	169200	77380	16280	28050	86500	199500
8	89830	56710	157870	173740	236700	78190	28990	13850	27600	95000
9	58043	63440	161450	131880	201700	114810	24440	36770	35400	65000

age \ year	2001	2002	2003	2004	2005	2006	2007	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

age \ year	2011
1	22239
2	184919
3	733384
4	451487
5	204324
6	219863
7	198768
8	112646
9	263185

TABLE 5.6.8 continued. HERRING in VIa (N). SURVEY INDICES

West of Scotland Summer Acoustic Survey - Index Variance (Inverse Weights)
Units : NA

age \ year	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

age \ year	2006	2007	2008	2009	2010	2011
1	10	10	10	10	10	10
2	1	1	1	1	1	1
3	1	1	1	1	1	1
4	1	1	1	1	1	1
5	1	1	1	1	1	1
6	1	1	1	1	1	1
7	1	1	1	1	1	1
8	1	1	1	1	1	1
9	1	1	1	1	1	1

TABLE 5.6.9 HERRING in VIa (N). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2011	3	6

TABLE 5.6.10 HERRING in VIa (N). FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1 1 1
lambda.sr   : 0.01
index.model : linear
index.cor   : 1
sep.nyr     : 8
sep.age     : 4
sep.sel     : 1
```

TABLE 5.6.11 HERRING in VIa (N). 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 (N). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings Tonnes	Landings SOP
1957	1031284	386838	174428	0.2989	43438	0.7258
1958	2004997	471073	187847	0.3529	59669	0.7470
1959	2055467	505860	197797	0.3280	65221	0.7248
1960	604949	403504	229141	0.2128	63759	0.5679
1961	1250113	411187	229156	0.1396	46353	0.5846
1962	2234720	514027	218335	0.2217	58195	0.7727
1963	2067704	545998	240549	0.1955	49030	0.6970
1964	962524	498431	285226	0.1634	64234	0.5774
1965	7744999	1086122	293381	0.1674	68669	0.8586
1966	1058606	824984	407499	0.2025	100619	1.0136
1967	2485451	810242	440554	0.1964	90400	0.8072
1968	4091898	936437	420874	0.1473	84614	0.7964
1969	2996425	966104	459283	0.2477	107170	0.7573
1970	3438053	989940	432592	0.3647	165930	0.7343
1971	9564422	1506702	307931	0.7982	207167	1.0162
1972	2674750	1108405	436679	0.3688	164756	1.0239
1973	1073144	798402	382106	0.6093	210270	1.0438
1974	1669599	574002	201852	0.9623	178160	1.1255
1975	2088191	431861	105645	0.9154	114001	1.0108
1976	598870	260996	71898	1.0802	93642	0.9984
1977	614804	160345	50290	1.0180	41341	0.9154
1978	906699	167857	46614	0.7156	22156	1.0056
1979	1214143	213564	70605	0.0008	60	1.0011
1980	877315	249379	120274	0.0004	306	1.0007
1981	1653259	361280	129728	0.3681	51420	0.9698
1982	762971	302170	107112	0.6863	92360	1.0347
1983	2915338	418513	78697	0.7293	63523	1.0277
1984	1110832	345697	116402	0.5326	56012	0.9494
1985	1186008	340875	142548	0.3290	39142	1.0058
1986	876435	306587	127453	0.5501	70764	1.0479
1987	2051987	368931	116953	0.3637	44360	0.9725
1988	877858	323393	140785	0.2996	35591	1.0236
1989	807846	305169	155721	0.2588	34026	1.0199
1990	426615	258301	145218	0.3670	44693	0.9889
1991	376264	199412	118280	0.2756	28529	1.0693
1992	789219	185164	91338	0.3014	28985	1.0018
1993	575424	176359	93058	0.2596	31778	0.9912
1994	843278	170392	85194	0.2356	24430	0.9984
1995	603900	152177	67987	0.2720	29575	1.0001
1996	922140	186769	106239	0.1756	26105	1.0477
1997	1477822	204985	69092	0.5277	35233	1.0079
1998	497762	184848	98641	0.5173	33353	0.9992
1999	305656	142607	82770	0.3183	29736	1.0015
2000	1659950	202026	70735	0.2476	18322	0.9997
2001	1112447	225225	115407	0.1982	24556	1.0049
2002	1167155	259767	135005	0.3464	32914	1.0021
2003	462012	217532	134388	0.2498	28081	1.0074
2004	287165	171091	118908	0.1943	25021	1.0172
2005	313993	143136	99572	0.1158	14129	1.0021
2006	508373	162049	95588	0.2165	27346	0.9997
2007	299363	144274	92895	0.2681	29616	1.0004
2008	381607	134805	93734	0.1440	16054	1.0022
2009	565534	165386	79721	0.2180	18508	1.0492
2010	1412631	177289	63785	0.2520	19877	0.9951
2011	618751	211196	82158	0.1777	17759	1.0008

TABLE 5.6.13 HERRING in VIa (N). ESTIMATED FISHING MORTALITY

Units : f

age	1957	1958	1959	1960	1961	1962
1	0.01000651	0.01238517	0.04157544	0.00934865	0.01666914	0.0396172
2	0.10303632	0.10007506	0.11394085	0.17702855	0.26877979	0.2690830
3	0.33198018	0.31657648	0.16736488	0.14825421	0.16323616	0.2183823
4	0.22716702	0.36936250	0.42679705	0.14749033	0.10791943	0.2560962
5	0.31687571	0.31788525	0.37872593	0.28418843	0.19045298	0.1845724
6	0.31966059	0.40766938	0.33930056	0.27109933	0.09693099	0.2275838
7	0.20805017	0.45234814	0.41883943	0.31005080	0.17231491	0.2465378
8	0.26519741	0.33305129	0.31206267	0.24198973	0.20710255	0.2728778
9	0.26519741	0.33305129	0.31206267	0.24198973	0.20710255	0.2728778

age	1963	1964	1965	1966	1967	1968	1969
1	0.009059198	0.04444493	0.06278879	0.3668086	0.1402394	0.08832889	0.02007449
2	0.121347581	0.13516090	0.06981653	0.2425189	0.1246890	0.14739246	0.08076442
3	0.260554934	0.16101750	0.15235726	0.1711481	0.1680567	0.14037787	0.16927293
4	0.164256450	0.19030562	0.18921088	0.2046443	0.2753990	0.16855506	0.21661232
5	0.215452043	0.12919606	0.21479088	0.1727188	0.1777339	0.14199057	0.31339640
6	0.141813776	0.17308643	0.11335327	0.2613297	0.1645885	0.13835337	0.29162585
7	0.132700003	0.12775428	0.21971171	0.1555757	0.2242601	0.10991428	0.35216425
8	0.192322950	0.17288393	0.16591835	0.2373237	0.2045124	0.16323475	0.23949606
9	0.192322950	0.17288393	0.16591835	0.2373237	0.2045124	0.16323475	0.23949606

age	1970	1971	1972	1973	1974	1975	1976
1	0.1149527	0.03485847	0.3669125	0.07791078	0.3353829	0.1386818	0.1978317
2	0.1118057	0.41623968	0.2363080	0.50267350	0.4962183	0.7401923	0.7823447
3	0.3503357	0.98415221	0.4281872	0.58763800	0.7732931	0.8867388	1.2298975
4	0.4060153	0.86882301	0.3003300	0.63046499	0.9135426	0.8575533	1.0950901
5	0.3821687	0.69940794	0.4139019	0.59669647	0.9350556	0.9117916	0.8992826
6	0.3204670	0.64038555	0.3328208	0.62232659	1.2273548	1.0057123	1.0965668
7	0.4849148	0.60095976	0.5136125	0.37032623	0.9242040	1.0805266	1.1485707
8	0.3500897	0.76685384	0.3994842	0.62791335	0.9348667	1.0106262	1.1527353
9	0.3500897	0.76685384	0.3994842	0.62791335	0.9348667	1.0106262	1.1527353

age	1977	1978	1979	1980	1981	1982
1	0.09316583	0.03996033	0.0003218737	0.0048640968	0.03568243	0.02790793
2	0.36090297	0.29850473	0.0005129760	0.0007234934	0.32668397	0.66374889
3	0.61980110	0.27735766	0.0007504138	0.0004417936	0.43074461	0.61494940
4	0.96948674	0.55594526	0.0003448106	0.0005785741	0.40169380	0.80985154
5	0.98086698	0.82826457	0.0002637857	0.0002608145	0.31279782	0.73232247
6	1.50168726	1.20080382	0.0016698452	0.0002018744	0.32734104	0.58821963
7	0.93424792	1.09434518	0.0027087575	0.0018487111	0.33738034	0.49418657
8	0.92213607	0.71670894	0.0010557366	0.0007497177	0.40571275	0.74889987
9	0.92213607	0.71670894	0.0010557366	0.0007497177	0.40571275	0.74889987

age	1983	1984	1985	1986	1987	1988
1	0.0453008	0.003147207	0.05568848	0.0625569	0.01509985	0.003081932
2	0.3956144	0.238156182	0.21637129	0.5597907	0.28802700	0.204425294
3	0.6024888	0.511521766	0.31769104	0.4902684	0.33629041	0.317854817
4	0.5158715	0.454397862	0.31465492	0.4292768	0.32208855	0.344599121
5	0.9836929	0.480044079	0.32375797	0.5908978	0.28787154	0.300012645
6	0.8151122	0.684471219	0.36006589	0.6901353	0.50864171	0.235896780
7	0.8009620	0.643413265	1.07281356	0.2063673	0.59113046	0.332843374
8	0.7267888	0.526397337	0.44186156	0.5815129	0.42171173	0.316763649
9	0.7267888	0.526397337	0.44186156	0.5815129	0.42171173	0.316763649

age	1989	1990	1991	1992	1993	1994
1	0.01223492	0.05421381	0.1164541	0.01057616	0.04973214	0.003246101
2	0.14122558	0.17486148	0.1963888	0.25929711	0.47708716	0.234260988
3	0.31154477	0.24382853	0.1649077	0.35960925	0.34454382	0.405731513
4	0.22069339	0.34124992	0.2518764	0.21862065	0.25182655	0.167586030
5	0.34210041	0.48071167	0.2577099	0.28070137	0.16376351	0.241191800
6	0.16095423	0.40204224	0.4280824	0.34682846	0.27835550	0.127940542
7	0.16801870	0.28893965	0.3735321	0.32484343	0.30062525	0.290312905
8	0.24571164	0.34049729	0.2988145	0.33559899	0.37761851	0.281896821
9	0.24571164	0.34049729	0.2988145	0.33559899	0.37761851	0.281896821

TABLE 5.6.13 continued. HERRING in VIa (N). ESTIMATED FISHING MORTALITY

age	1995	1996	1997	1998	1999	2000
1	0.0006970164	0.003353447	0.001277763	0.02925048	0.04018311	0.003405797
2	0.3636137089	0.218516269	0.210801496	0.17130428	0.25873335	0.215152694
3	0.3320459808	0.239824350	0.342776472	0.20748553	0.36225106	0.206568522
4	0.3699140896	0.150277465	0.390461534	0.56986838	0.21678444	0.249513564
5	0.1989480400	0.192199519	0.593764813	0.47984906	0.43993038	0.140320669
6	0.1870699328	0.120188287	0.783599631	0.81211350	0.25419189	0.393833356
7	0.1789814083	0.292876912	0.866222102	1.04322901	0.37727264	0.140531289
8	0.3314368284	0.233170748	0.538315661	0.54045219	0.35269319	0.256745206
9	0.3314368284	0.233170748	0.538315661	0.54045219	0.35269319	0.256745206

age	2001	2002	2003	2004	2005	2006
1	0.0002033447	0.001345597	0.0001921763	0.001743864	0.001039513	0.001943559
2	0.1666168091	0.114905685	0.0940529640	0.098724662	0.058849521	0.110029932
3	0.2933688475	0.315060892	0.2115726217	0.167698087	0.099964405	0.186901720
4	0.1557048046	0.274275185	0.2839473151	0.195256785	0.116392075	0.217616251
5	0.2089805171	0.448723089	0.3404976121	0.210548451	0.125507399	0.234659013
6	0.1346635885	0.347579299	0.1630715032	0.203539821	0.121329572	0.226847803
7	0.6833903134	0.168582360	0.2361821723	0.234567947	0.139825359	0.261429057
8	0.2864441876	0.293044793	0.2308516232	0.195256785	0.116392075	0.217616251
9	0.2864441876	0.293044793	0.2308516232	0.195256785	0.116392075	0.217616251

age	2007	2008	2009	2010	2011
1	0.002407060	0.001292644	0.001956596	0.002262462	0.001594966
2	0.136269907	0.073179946	0.110767973	0.128083856	0.090295194
3	0.231474105	0.124306700	0.188155389	0.217568916	0.153379419
4	0.269513447	0.144734666	0.219075942	0.253323147	0.178585056
5	0.290620574	0.156069659	0.236233022	0.273162319	0.192571065
6	0.280946544	0.150874491	0.228369417	0.264069430	0.186160857
7	0.323774746	0.173874181	0.263182629	0.304324843	0.214539689
8	0.269513447	0.144734666	0.219075942	0.253323147	0.178585056
9	0.269513447	0.144734666	0.219075942	0.253323147	0.178585056

TABLE 5.6.14 HERRING in VIa (N). ESTIMATED POPULATION ABUNDANCE

Units : NA

age	1957	1958	1959	1960	1961	1962
1	1031284.412	2004997.22	2055466.60	604949.17	1250112.63	2234720.46
2	879952.665	375610.91	728518.33	725370.62	220477.53	452288.29
3	225615.148	588061.65	251760.62	481579.79	450183.00	124837.89
4	132966.587	132535.49	350813.70	174358.56	339956.52	313067.25
5	131130.840	95864.03	82887.81	207153.13	136131.80	276137.32
6	76188.879	86428.71	63120.50	51354.99	141071.92	101816.33
7	49621.030	50076.65	52021.16	40680.34	35433.68	115854.94
8	6423.113	36465.43	28823.95	30963.56	26996.15	26986.80
9	19908.501	26484.32	33605.79	22527.38	14479.45	31091.67

age	1963	1964	1965	1966	1967	1968	1969
1	2067703.90	962524.48	7744999.32	1058606.20	2485451.27	4091897.91	2996425.06
2	790174.83	753805.85	338699.94	2675827.28	269859.07	794704.31	1378064.55
3	256015.20	518482.69	487833.40	233994.60	1555410.73	176480.58	508048.87
4	82157.14	161528.55	361365.22	342960.98	161442.64	1076465.48	125566.18
5	219273.93	63078.33	120828.99	270609.89	252894.51	110913.53	822939.91
6	207748.02	159951.35	50158.16	88198.10	206017.16	191567.18	87074.18
7	73375.26	163124.24	121727.30	40521.31	61451.95	158122.64	150940.42
8	81924.74	58141.91	129899.08	88417.65	31382.56	44433.58	128182.71
9	36506.94	99820.08	134058.60	134445.86	146329.04	75349.66	129049.38

age	1970	1971	1972	1973	1974	1975
1	3438052.58	9564422.32	2674749.93	1073144.01	1669599.24	2088190.76
2	1080415.23	1127443.32	3398016.01	681774.33	365197.09	439200.50
3	941685.05	715724.28	550853.08	1987512.33	305523.04	164715.36
4	351182.04	543122.67	219015.56	293912.14	904155.22	115437.82
5	91489.17	211725.24	206131.06	146762.08	141573.06	328145.94
6	544292.50	56489.34	95190.63	123298.75	73121.05	50287.69
7	58858.40	357458.67	26941.46	61747.94	59876.48	19390.08
8	96035.79	32793.15	177338.44	14585.88	38580.02	21500.58
9	85425.85	62394.34	52890.19	72241.13	36128.20	22446.07

TABLE 5.6.14 continued. HERRING in VIa (N). ESTIMATED POPULATION ABUNDANCE

age	1976	1977	1978	1979	1980	1981
1	598869.762	614803.685	906698.672	1214143.2424	877315.044	1653259.171
2	668724.071	180767.631	206053.774	320489.6052	446514.593	321180.111
3	155207.620	226563.860	93345.665	113253.9281	237302.777	330546.911
4	55560.920	37146.374	99805.745	57913.5730	92654.918	194201.266
5	44308.597	16816.995	12748.064	51794.3197	52384.302	83789.145
6	119303.039	16311.920	5706.027	5038.5325	46853.078	47386.916
7	16643.971	36056.962	3287.768	1553.8243	4551.446	42385.860
8	5955.022	4775.398	12818.020	995.8722	1402.155	4110.712
9	18278.906	2572.967	3152.441	7057.0838	7278.927	4164.098

age	1982	1983	1984	1985	1986	1987
1	762970.537	2915337.95	1110831.903	1186008.038	876435.337	2051987.00
2	586880.633	272956.24	1024992.143	407368.128	412674.799	302870.72
3	171626.068	223871.57	136141.813	598414.731	243069.152	174664.87
4	175915.538	75972.29	100341.943	66831.553	356592.260	121884.95
5	117589.679	70820.78	41037.948	57638.222	44146.798	210043.83
6	55451.327	51155.95	23961.767	22976.067	37728.959	22123.11
7	30907.693	27862.62	20486.509	10935.215	14503.460	17120.77
8	27369.643	17061.40	11317.204	9741.093	3384.394	10676.23
9	7978.685	17156.44	5007.997	6416.868	4674.590	18208.63

age	1988	1989	1990	1991	1992	1993	1994
1	877858.009	807846.233	426614.52	376263.73	789219.19	575424.34	843278.30
2	743570.827	321952.149	293576.08	148660.77	123203.35	287283.04	201416.64
3	168221.074	449007.113	207094.94	182595.87	90493.52	70424.35	132076.43
4	102163.934	100225.657	269210.60	132867.03	126769.14	51710.92	40853.61
5	79917.037	65495.379	72728.32	173164.85	93454.29	92180.35	36373.57
6	142514.634	53569.314	42092.90	40691.50	121090.01	63864.97	70808.81
7	12036.948	101854.763	41265.31	25478.55	23997.19	77455.66	43746.67
8	8577.669	7807.911	77908.04	27968.60	15868.01	15691.09	51887.63
9	9110.395	16872.213	20050.72	18083.01	20256.79	12456.95	43556.93

age	1995	1996	1997	1998	1999	2000	2001
1	603900.32	922140.48	1477822.25	497762.35	305655.930	1659949.584	1112447.425
2	309219.36	222007.71	338100.82	542966.20	177837.865	108015.739	608585.075
3	118050.75	159243.94	132184.13	202865.39	338912.778	101711.351	64529.614
4	72070.82	69343.24	102576.91	76816.49	134970.617	193154.758	67732.789
5	31262.19	45048.30	53989.59	62812.33	39312.833	98324.443	136180.085
6	25858.79	23183.97	33633.94	26978.13	35173.828	22911.080	77319.948
7	56375.97	19405.97	18602.07	13900.66	10836.422	24682.892	13982.230
8	29609.72	42651.46	13101.20	7078.42	4431.362	6723.711	19405.938
9	36355.58	156869.43	24837.74	8336.25	3839.104	2111.356	4211.205

age	2002	2003	2004	2005	2006	2007	2008
1	1167155.335	462011.512	287165.00	313992.99	508373.30	299363.50	381606.74
2	409163.327	428795.079	169931.88	105458.03	115391.55	186656.95	109864.91
3	381656.086	270212.510	289144.39	114054.11	73660.27	76577.34	120663.12
4	39399.590	228025.853	179044.81	200182.23	84496.37	50026.95	49740.88
5	52450.275	27098.550	155323.76	133270.29	161230.66	61503.39	34572.15
6	99982.747	30299.842	17443.77	113859.27	106364.50	115373.77	41615.46
7	61147.465	63906.325	23291.09	12877.00	91252.80	76709.39	78825.02
8	6387.845	46744.941	45660.62	16668.21	10131.18	63574.00	50211.77
9	5871.241	7163.445	23706.12	13670.53	27295.17	18828.79	69857.37

age	2009	2010	2011
1	565534.12	1412631.32	618750.70
2	140203.92	207641.71	518503.60
3	75646.53	92974.94	135331.89
4	87242.87	51311.56	61237.58
5	38942.74	63409.89	36038.69
6	26761.89	27822.90	43661.10
7	32381.82	19271.15	19332.55
8	59940.73	22520.24	12862.09
9	50350.07	61850.31	46357.94

TABLE 5.6.15 HERRING in VIa (N). SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2012
1	NA
2	450523.10
3	350952.81
4	95045.03
5	46347.90
6	26897.19
7	32795.68
8	14115.17
9	44820.91

TABLE 5.6.16 HERRING in VIa (N). FITTED SELECTION PATTERN

Units : NA

age	2004	2005	2006	2007	2008	2009
1	0.00893113	0.00893113	0.00893113	0.00893113	0.00893113	0.00893113
2	0.50561450	0.50561450	0.50561450	0.50561450	0.50561450	0.50561450
3	0.85885920	0.85885920	0.85885920	0.85885920	0.85885920	0.85885920
4	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
5	1.07831567	1.07831567	1.07831567	1.07831567	1.07831567	1.07831567
6	1.04242125	1.04242125	1.04242125	1.04242125	1.04242125	1.04242125
7	1.20133058	1.20133058	1.20133058	1.20133058	1.20133058	1.20133058
8	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000
9	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000	1.00000000

age	2010	2011
1	0.00893113	0.00893113
2	0.50561450	0.50561450
3	0.85885920	0.85885920
4	1.00000000	1.00000000
5	1.07831567	1.07831567
6	1.04242125	1.04242125
7	1.20133058	1.20133058
8	1.00000000	1.00000000
9	1.00000000	1.00000000

TABLE 5.6.17 HERRING in VIa (N). 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

TABLE 5.6.17 continued. HERRING in VIa (N). PREDICTED CATCH IN NUMBERS

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
1	142.98	992.20	56.12	316.3206	206.2344	624.0618	455.0391
2	81030.48	38481.61	33331.97	13835.3965	5214.6739	10415.6424	20613.3246
3	14942.91	93975.06	46865.58	40573.4611	9850.2414	11416.6156	14397.0307
4	9305.89	9014.41	53766.66	30271.2281	20951.1077	15753.7458	11272.3278
5	24482.25	18113.71	7462.99	28112.4662	14974.5643	32154.3213	14796.5629
6	9280.71	28016.08	4344.55	3062.2660	12392.5321	20582.0500	26954.5534
7	6624.96	9040.10	12818.38	4643.3528	1600.8975	20020.6424	20244.8624
8	4610.61	1547.86	9187.62	7719.8718	1744.4974	1888.8856	14324.8188
9	1000.53	1422.68	1407.96	4008.0100	1430.7600	5088.9900	4242.6000

age \ year	2008	2009	2010	2011
1	311.6451	698.8834	2018.364	1235.851
2	6710.1652	12735.8004	21635.296	38763.047
3	12809.9765	11796.1895	16536.343	17485.950
4	6385.9552	16363.6025	10950.240	9544.928
5	4760.2082	7812.6597	14456.513	6016.956
6	5553.0569	5209.5427	6158.284	7068.460
7	11989.0455	7146.2570	4823.934	3558.640
8	6446.4096	11242.7101	4805.975	2004.778
9	8968.6000	9443.8500	13199.280	7225.680

TABLE 5.6.18 HERRING in VIa (N). CATCH RESIDUALS

Units : Thousands NA

age \ year	2004	2005	2006	2007
1	-Inf	-0.12226299	-1.54996874	-1.2470962944888144274813
2	-0.7038710673618114865846	0.61368805	-0.44247218	0.5099653906073098319496
3	-0.6019773981953959740565	0.85823739	-0.21738159	0.2096356085821550196968
4	-0.0846139808864900255791	-0.01678443	-0.14371380	-0.5421013841127926280450
5	0.4876872791624904945884	-0.38025360	0.24467726	-0.0365866305643367459299
6	0.2459410989686551529676	-0.23642946	0.29996396	0.1257412750804116630121
7	0.4981912613021419744541	-0.45567874	0.04647108	0.0609455210488490869980
8	0.0940317838875921740982	-0.37835377	0.47643283	-0.0529942488168435796303
9	0.00000000000000002220446	0.00000000	0.00000000	-0.00000000000000002220446

age \ year	2008	2009	2010	2011
1	-Inf	1.0124802458018264950113	1.60768269	0.2993796366533767461249
2	0.16304043	-0.1013275864536878206890	-0.06174402	0.0460030964343158751961
3	0.01772672	-0.1187249467423410198563	-0.01247642	-0.1024687322435217096128
4	-0.16260587	0.0135573338024086529480	-0.09498915	0.0794198415015049813404
5	-0.39105912	0.0643784675916293513964	0.01043456	0.1781500263156265140285
6	0.02410857	0.0879861622280477956304	0.02628962	-0.3320198553136166075284
7	0.21281185	0.0502723766834401175618	-0.10981589	-0.1174909202844708067115
8	0.23355060	0.0478693070991284899685	0.11448328	0.2643454907779174689608
9	0.00000000	-0.00000000000000002220446	0.00000000	-0.00000000000000001110223

TABLE 5.6.19 HERRING in VIa (N). PREDICTED INDEX VALUES

WoS Summer Acoustic Survey

Units : NA NA

age \ year	1991	1992	1993	1994	1995	1996	1997
1	94817.31	210694.51	150375.11	226027.6	162091.1	247150.92	396532.36
2	286753.00	229638.28	475535.49	380577.4	544499.8	423099.28	647062.83
3	719828.26	320827.38	251734.44	456628.0	424860.8	602655.04	472952.37
4	572268.95	555991.09	222729.14	184231.6	291074.4	315670.92	409666.82
5	693999.79	369876.70	388842.90	147094.1	129368.1	187104.25	180164.24
6	146050.22	454295.99	248714.00	299313.7	105840.6	98415.16	99455.49
7	98429.70	95199.78	311358.67	176845.4	242155.2	78338.83	54941.14
8	110924.43	61683.96	59615.27	207694.3	115363.7	175318.44	45601.58
9	78381.37	86060.99	51725.15	190547.7	154807.4	704721.86	94485.82

age \ year	1998	1999	2000	2001	2002	2003
1	131539.93	80293.56	444884.878	298669.06	313161.98	124041.26
2	1061748.46	331573.22	206232.632	1193107.63	825077.15	874547.27
3	781390.50	1199821.37	391964.422	237187.33	1386341.76	1038480.28
4	278209.38	592554.26	833005.045	307428.99	167638.24	965108.56
5	223031.52	142660.61	420093.540	560463.03	189424.59	103812.72
6	78544.14	138795.83	83781.964	325641.36	374953.96	125650.57
7	37279.99	41778.42	108267.112	45623.37	264143.26	266075.38
8	24609.31	17066.37	27284.931	77485.24	25414.20	192387.66
9	31675.21	16159.18	9363.993	18377.08	25529.23	32221.83

age \ year	2004	2005	2006	2007	2008	2009	2010
1	77033.14	84262.20	136358.30	NA	102392.7	151689.2	378836.83
2	345702.57	219252.97	233306.01	372036.31	226638.1	283359.2	415712.71
3	1138131.00	465822.37	286923.08	291127.07	486320.3	294458.7	356155.33
4	795327.53	928274.30	370791.75	213408.87	227120.2	382539.7	220828.84
5	638704.75	574016.01	654339.51	242107.93	146447.9	157910.0	251999.21
6	70759.71	483028.15	426015.69	448674.39	173726.4	107099.0	109199.65
7	97058.32	56504.40	374741.12	304492.81	339525.7	132853.0	77310.74
8	191606.10	73016.82	41998.63	256195.36	216586.4	248285.8	91558.12
9	108721.09	65449.32	123665.01	82927.76	329324.2	227937.4	274821.93

age \ year	2011
1	329067.95
2	1059679.91
3	536867.01
4	274503.80
5	149653.30
6	178794.35
7	81446.51
8	54465.97
9	214547.49

TABLE 5.6.20 HERRING in VIa (N). INDEX RESIDUALS

WoS Summer Acoustic Survey

Units : NA

age \ year	1991	1992	1993	1994	1995	1996
1	1.272016521	-1.04216375	-4.15574331	0.7821820	1.0013398	-1.79107557
2	0.026603440	0.78493931	0.19741349	0.3537241	0.7062841	0.30929911
3	-0.786297877	-0.41913989	1.00760648	0.2858451	0.1079679	0.28642428
4	-0.441988192	-0.76744390	1.12890744	0.4384335	0.4363351	0.04169175
5	-0.351566264	0.11450621	0.37338481	0.7349932	0.1677759	-0.67400674
6	0.188508771	-0.63765180	1.28654657	-0.1100203	0.5702437	-0.48490000
7	0.003157687	0.10434336	-0.05190452	0.8331443	-0.3584972	-0.01231507
8	-0.210930140	-0.08407335	0.97386021	-0.1785072	0.7187034	-0.80746220
9	-0.300402152	-0.30496166	1.13825144	-0.3680101	0.2645994	-1.81452461

TABLE 5.6.20 continued. HERRING in VIa (N). INDEX RESIDUALS

age	1997	1998	1999	2000	2001	2002
1	0.692207704	2.228688179	1.895080840	0.006084428	0.04718650	0.30466246
2	-0.008073187	-0.289795718	-0.028055659	0.427370112	-0.11640743	-0.63783465
3	-0.502408652	-0.158614871	0.145691175	-0.150791453	-0.08573227	0.03581957
4	-0.897110898	0.526632717	-0.316016856	0.076799355	-0.57610928	0.17550857
5	-1.002700117	-0.219648013	0.769631326	-0.065650495	-0.24768658	-0.15824824
6	-0.697333533	0.009198929	-0.000690678	1.083596785	-0.89845956	0.12363752
7	-1.216325111	-0.284468184	0.727764533	0.611212801	0.81236520	-0.55063936
8	-0.452991321	-0.574839618	0.480706063	1.247542320	-0.39118091	0.97681957
9	-1.352228682	0.149147864	0.784223249	1.937515446	0.63563555	0.84615225

age	2003	2004	2005	2006	2007	2008
1	1.26342946	1.9908185	-0.5179183	-0.19411212	NA	-0.76095321
2	0.17269255	-0.2306275	0.1044800	1.27532029	-1.08270954	0.02583676
3	-0.10764450	-0.4035612	-0.7044216	0.30153342	0.01117954	0.62871775
4	0.42200083	-0.5867656	-0.7857187	-0.26490732	-0.05247001	1.08011013
5	0.55756459	-0.1012535	-0.8509910	-0.11681232	-0.51058304	0.84204034
6	0.02785676	-0.2393096	-1.1509451	-0.02692081	-0.25726088	0.44916584
7	0.26468019	-0.4514087	-1.5006218	-0.50128542	-0.22599765	0.75289532
8	-0.52068582	-0.8462864	-0.6271282	-0.66032479	-0.44912728	0.52434328
9	0.84750697	-0.3541128	-0.8928742	-0.73496705	-0.94911386	-0.22207891

age	2009	2010	2011
1	0.8240878	-1.1513821	-2.6944167
2	-0.4169929	0.1723548	-1.7458043
3	-0.1090383	0.3049644	0.3119190
4	0.1176340	-0.2530846	0.4975815
5	0.8608904	-0.4330045	0.3113857
6	0.7154687	-0.1574757	0.2067684
7	0.3394989	-0.1877630	0.8921918
8	0.6994175	-0.5444958	0.7266740
9	0.6935072	-0.2075579	0.2043261

TABLE 5.6.21 HERRING in VIa (N). FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL
F, 2004	0.19525579	0.1496913	0.145607631
F, 2005	0.11639108	0.1457371	0.087471340
F, 2006	0.21761525	0.1417209	0.164836766
F, 2007	0.26951245	0.1452783	0.202728796
F, 2008	0.14473367	0.1544212	0.106935906
F, 2009	0.21907494	0.1630347	0.159152984
F, 2010	0.25332215	0.1858745	0.175976070
F, 2011	0.17858406	0.2193306	0.116183579
Selectivity at age 1	0.00893013	0.3798975	0.004241139
Selectivity at age 2	0.50561350	0.1401316	0.384181321
Selectivity at age 3	0.85885820	0.1279059	0.668414408
Selectivity at age 5	1.07831467	0.1149945	0.860716750
Selectivity at age 6	1.04242025	0.1119480	0.837048728
Selectivity at age 7	1.20132958	0.1120344	0.964487322
Terminal year pop, age 1	1226602.57908280	0.8642531	225442.993370395
Terminal year pop, age 2	518502.59941849	0.3201271	276855.558122705
Terminal year pop, age 3	135330.88602036	0.2537817	82295.027488875
Terminal year pop, age 4	61236.58158859	0.2249886	39400.052321676
Terminal year pop, age 5	36037.68705221	0.2089750	23926.204185143
Terminal year pop, age 6	43660.10210359	0.2032841	29312.025540412
Terminal year pop, age 7	19331.54610225	0.1990449	13086.880842634
Terminal year pop, age 8	12861.09346229	0.2041911	8619.199729890
Last true age pop, 2004	45659.61785276	0.2711960	26834.010601069
Last true age pop, 2005	16667.20552856	0.2142607	10951.671042374
Last true age pop, 2006	10130.17626258	0.1830653	7076.014517112
Last true age pop, 2007	63573.00223919	0.1722380	45358.714934681
Last true age pop, 2008	50210.76543355	0.1782904	35402.426248028
Last true age pop, 2009	59939.73168605	0.1682028	43105.994791538
Last true age pop, 2010	22519.24361009	0.1770383	15916.800580235

TABLE 5.6.21 continued. HERRING in VIa (N). FIT PARAMETERS

Index 1, age 1 numbers, Q	0.46307289	0.5415961	0.160189266
Index 1, age 2 numbers, Q	2.52814564	0.1718927	1.805028593
Index 1, age 3 numbers, Q	4.80959081	0.1708375	3.441028806
Index 1, age 4 numbers, Q	5.21757568	0.1705278	3.735188670
Index 1, age 5 numbers, Q	4.87041675	0.1707785	3.484950052
Index 1, age 6 numbers, Q	4.78619776	0.1714552	3.420148757
Index 1, age 7 numbers, Q	5.00071351	0.1729168	3.563216912
Index 1, age 8 numbers, Q	4.92892289	0.1747999	3.499124336
Index 1, age 9 numbers, Q	5.38688573	0.1726961	3.840040869

	Upper.95.pct.CL
F, 2004	0.26183258
F, 2005	0.15487224
F, 2006	0.28729269
F, 2007	0.35829621
F, 2008	0.19589149
F, 2009	0.30155784
F, 2010	0.36466384
F, 2011	0.27449891
Selectivity at age 1	0.01880326
Selectivity at age 2	0.66542801
Selectivity at age 3	1.10356301
Selectivity at age 5	1.35092355
Selectivity at age 6	1.29818006
Selectivity at age 7	1.49633150
Terminal year pop, age 1	6673766.45651894
Terminal year pop, age 2	971065.73343411
Terminal year pop, age 3	222546.23723811
Terminal year pop, age 4	95175.48083540
Terminal year pop, age 5	54280.02193843
Terminal year pop, age 6	65031.48385524
Terminal year pop, age 7	28555.97748594
Terminal year pop, age 8	19190.61284449
Last true age pop, 2004	77692.47517465
Last true age pop, 2005	25365.60302593
Last true age pop, 2006	14502.58063530
Last true age pop, 2007	89101.43551299
Last true age pop, 2008	71213.22555013
Last true age pop, 2009	83347.37318952
Last true age pop, 2010	31860.44395130
Index 1, age 1 numbers, Q	1.33864465
Index 1, age 2 numbers, Q	3.54095242
Index 1, age 3 numbers, Q	6.72245571
Index 1, age 4 numbers, Q	7.28827870
Index 1, age 5 numbers, Q	6.80668559
Index 1, age 6 numbers, Q	6.69786335
Index 1, age 7 numbers, Q	7.01813452
Index 1, age 8 numbers, Q	6.94296016
Index 1, age 9 numbers, Q	7.55683048

Table 5.7.1.1. Herring in VIa (North). Input data for short-term predictions, numbers-at-age from the assessment with age 1-ring in 2011 and 2012 replaced by geometric mean values (1989-2010) and age 2-ring in 2012 replaced by a the value calculated by the exponential degradation of geometric mean recruitment (1989-2010); natural mortality (M), proportion mature (Mat), proportion of fishing mortality prior to spawning (PF), proportion of natural mortality prior to spawning (PM), mean weights at age in the stock (SWt), selection pattern (Sel), mean weights at age in the catch (CWt). All biological data are taken as mean of the last 3 years. VIa (N) herring appears to have considerable annual variability in mean weights and in fraction mature. The last year's values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	618751	1	0	0.67	0.67	0.074167	0.001938	0.085067
2	227263	0.3	0.46	0.67	0.67	0.132667	0.109716	0.160833
3	350952.8	0.2	0.92	0.67	0.67	0.177933	0.186368	0.197267
4	95045.03	0.1	1	0.67	0.67	0.209800	0.216995	0.222867
5	46347.9	0.1	1	0.67	0.67	0.226700	0.233989	0.237800
6	26897.19	0.1	1	0.67	0.67	0.230267	0.226200	0.243900
7	32795.68	0.1	1	0.67	0.67	0.226267	0.260682	0.247933
8	14115.17	0.1	1	0.67	0.67	0.224667	0.216995	0.247067
9	44820.91	0.1	1	0.67	0.67	0.235367	0.216995	0.260033

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	618751	1	0	0.67	0.67	0.074167	0.001938	0.085067
2	.	0.3	0.46	0.67	0.67	0.132667	0.109716	0.160833
3	.	0.2	0.92	0.67	0.67	0.177933	0.186368	0.197267
4	.	0.1	1	0.67	0.67	0.209800	0.216995	0.222867
5	.	0.1	1	0.67	0.67	0.226700	0.233989	0.237800
6	.	0.1	1	0.67	0.67	0.230267	0.226200	0.243900
7	.	0.1	1	0.67	0.67	0.226267	0.260682	0.247933
8	.	0.1	1	0.67	0.67	0.224667	0.216995	0.247067
9	.	0.1	1	0.67	0.67	0.235367	0.216995	0.260033

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	618751	1	0	0.67	0.67	0.074167	0.001938	0.085067
2	.	0.3	0.46	0.67	0.67	0.132667	0.109716	0.160833
3	.	0.2	0.92	0.67	0.67	0.177933	0.186368	0.197267
4	.	0.1	1	0.67	0.67	0.209800	0.216995	0.222867
5	.	0.1	1	0.67	0.67	0.226700	0.233989	0.237800
6	.	0.1	1	0.67	0.67	0.230267	0.226200	0.243900
7	.	0.1	1	0.67	0.67	0.226267	0.260682	0.247933
8	.	0.1	1	0.67	0.67	0.224667	0.216995	0.247067
9	.	0.1	1	0.67	0.67	0.235367	0.216995	0.260033

Table 5.7.1.2. Herring in VIa (North). Short-term prediction single option table, with F constraint (Fsq (avg 2009-2011)). Fbar is $F_{3\text{-}6}$ N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year:	2012	F multiplier:	1	Fbar:	0.2159				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	757	64	618751	45891	0	0	0	0
2	0.1097	20458	3290	227263	30150	104541	13869	79445	10540
3	0.1864	54252	10702	350953	62446	322877	57451	249237	44348
4	0.217	17675	3939	95045	19940	95045	19940	76858	16125
5	0.234	9220	2192	46348	10507	46348	10507	37055	8400
6	0.2262	5191	1266	26897	6194	26897	6194	21617	4978
7	0.2607	7177	1779	32796	7421	32796	7421	25755	5828
8	0.217	2625	649	14115	3171	14115	3171	11414	2564
9	0.217	8335	2167	44821	10549	44821	10549	36245	8531
Total		125691	26050	1456989	196269	687439	129102	537626	101313

Year:	2013	F multiplier:	1	Fbar:	0.2159				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	757	64	618751	45891	0	0	0	0
2	0.1097	20451	3289	227185	30140	104505	13864	79418	10536
3	0.1864	23322	4601	150866	26844	138797	24697	107141	19064
4	0.217	44349	9884	238480	50033	238480	50033	192847	40459
5	0.234	13770	3275	69225	15693	69225	15693	55345	12547
6	0.2262	6406	1562	33188	7642	33188	7642	26673	6142
7	0.2607	4248	1053	19411	4392	19411	4392	15244	3449
8	0.217	4252	1051	22865	5137	22865	5137	18490	4154
9	0.217	7983	2076	42925	10103	42925	10103	34712	8170
Total		125538	26855	1422895	195875	669395	131561	529869	104521

Year:	2014	F multiplier:	1	Fbar:	0.2159				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0019	757	64	618751	45891	0	0	0	0
2	0.1097	20451	3289	227185	30140	104505	13864	79418	10536
3	0.1864	23314	4599	150814	26835	138749	24688	107104	19057
4	0.217	19065	4249	102517	21508	102517	21508	82900	17392
5	0.234	34552	8216	173693	39376	173693	39376	138867	31481
6	0.2262	9567	2333	49569	11414	49569	11414	39838	9173
7	0.2607	5242	1300	23950	5419	23950	5419	18809	4256
8	0.217	2517	622	13533	3040	13533	3040	10944	2459
9	0.217	8911	2317	47917	11278	47917	11278	38748	9120
Total		124375	26990	1407930	194902	654434	130589	516628	103475

Table 5.7.1.3. Herring in VIa (North). Short-term prediction multiple option table, with F constraint (Fsq (avg 2009-2011)). Fbar is $F_{3\text{-}6}$

2012				
Biomass	SSB	FMult	FBar	Landings
196269	101313	1	0.2159	26050

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
195875	119913	0	0	0	220044	142077
.	118274	0.1	0.0216	2931	217295	137591
.	116658	0.2	0.0432	5805	214601	133257
.	115065	0.3	0.0648	8622	211961	129071
.	113494	0.4	0.0864	11383	209374	125026
.	111945	0.5	0.1079	14091	206838	121119
.	110418	0.6	0.1295	16745	204354	117343
.	108912	0.7	0.1511	19348	201919	113696
.	107428	0.8	0.1727	21900	199532	110171
.	105964	0.9	0.1943	24402	197194	106766
.	104521	1	0.2159	26855	194902	103475
.	103098	1.1	0.2375	29260	192655	100295
.	101695	1.2	0.2591	31618	190453	97222
.	100312	1.3	0.2807	33931	188295	94252
.	98948	1.4	0.3022	36199	186180	91381
.	97604	1.5	0.3238	38422	184107	88607
.	96278	1.6	0.3454	40603	182075	85925
.	94970	1.7	0.367	42741	180083	83333
.	93681	1.8	0.3886	44838	178130	80827
.	92410	1.9	0.4102	46895	176217	78405
.	91157	2	0.4318	48912	174341	76063

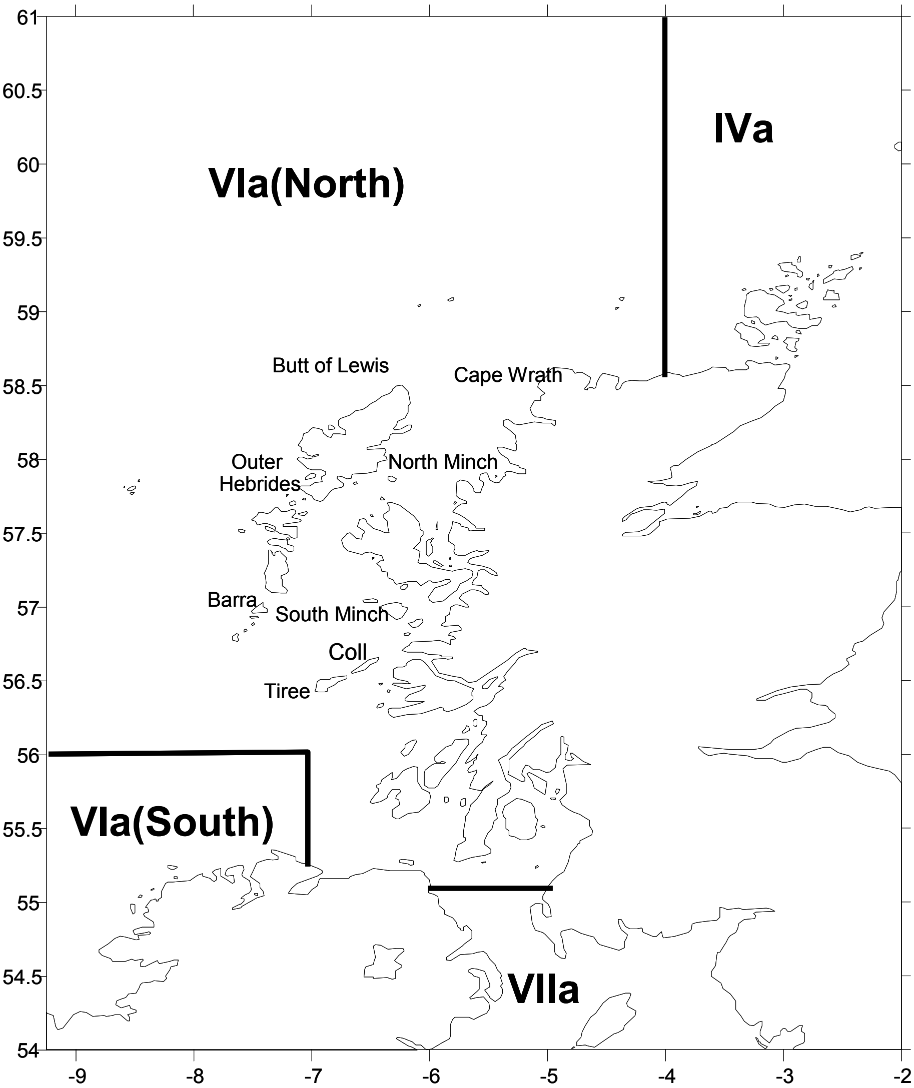


Figure 5.1.1. Location of ICES area VIa (North) and adjacent areas, with place names.

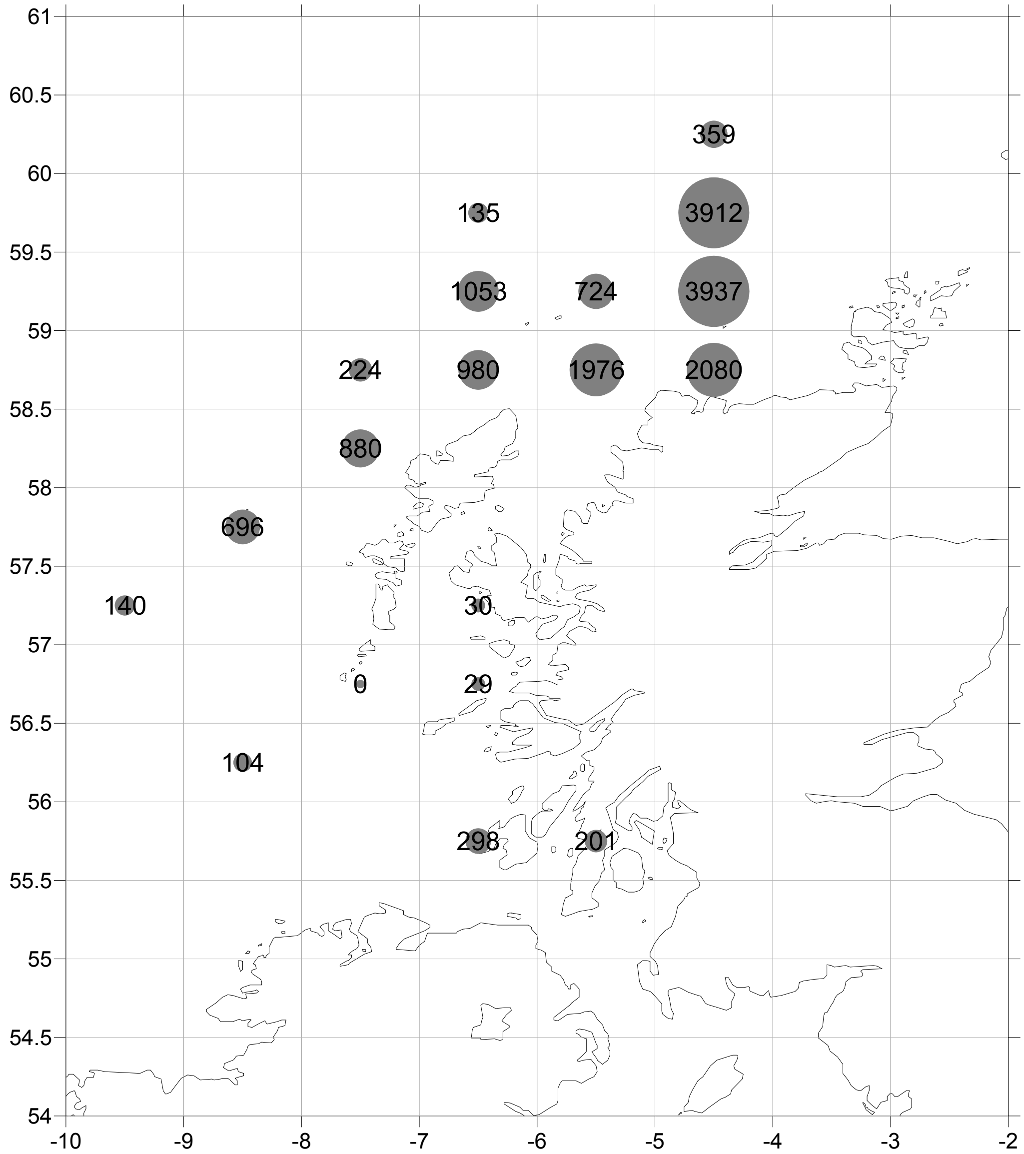


Figure 5.1.2. Herring in VIa (North).Herring catches in tonnes) in all quarters in 2011 by statistical rectangle. WG estimates (if available).

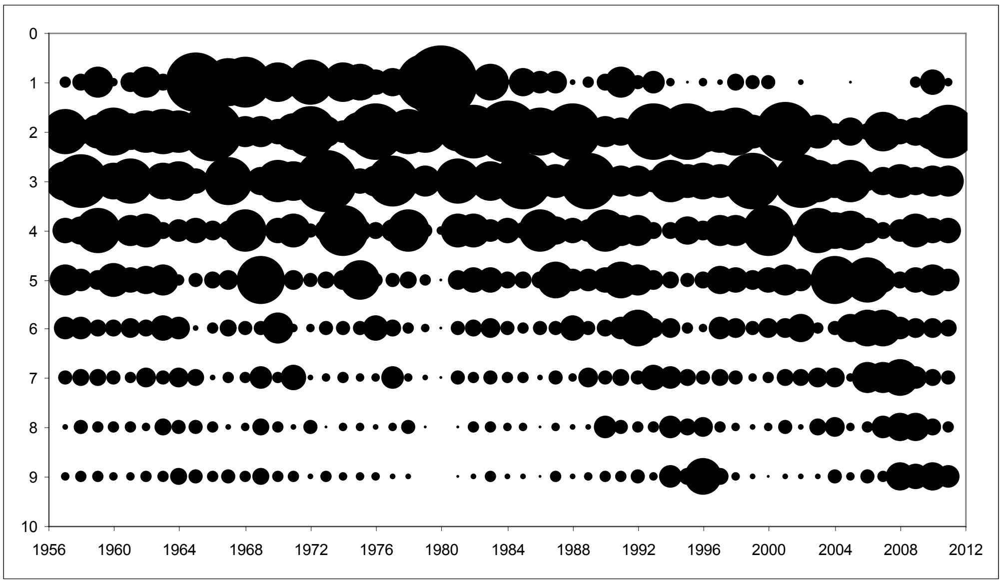


Figure 5.2.1. Herring in VIa (North). Mean standardised catch numbers-at-age standardised by year for the fishery, 1957 to 2011.

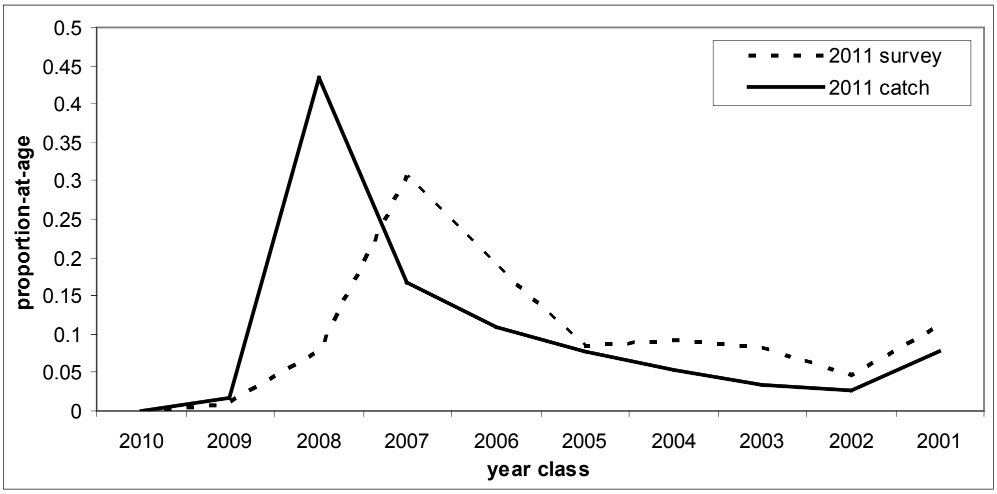


Figure 5.3.1. Herring in VIa (North). Comparison of the proportions-at-age, by year class, in the 2011 acoustic survey (MSHAS_N) and the catch.

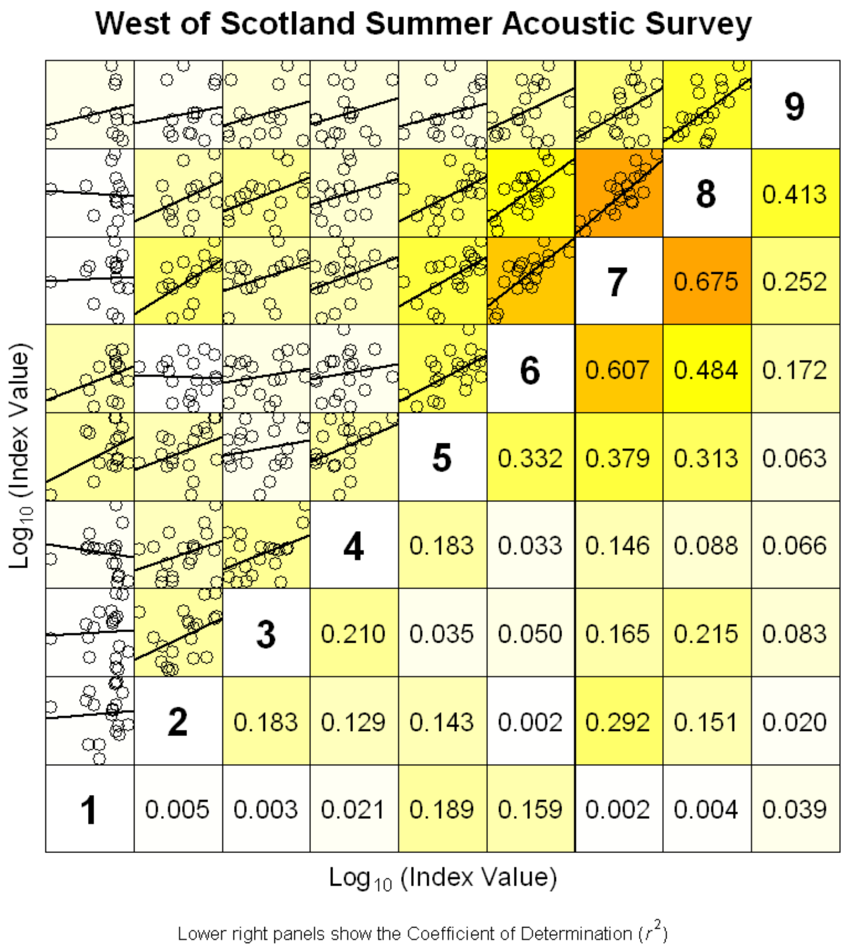


Figure 5.3.2. Herring in VIa (North). Internal consistency between ages in the West of Scotland acoustic survey time series.

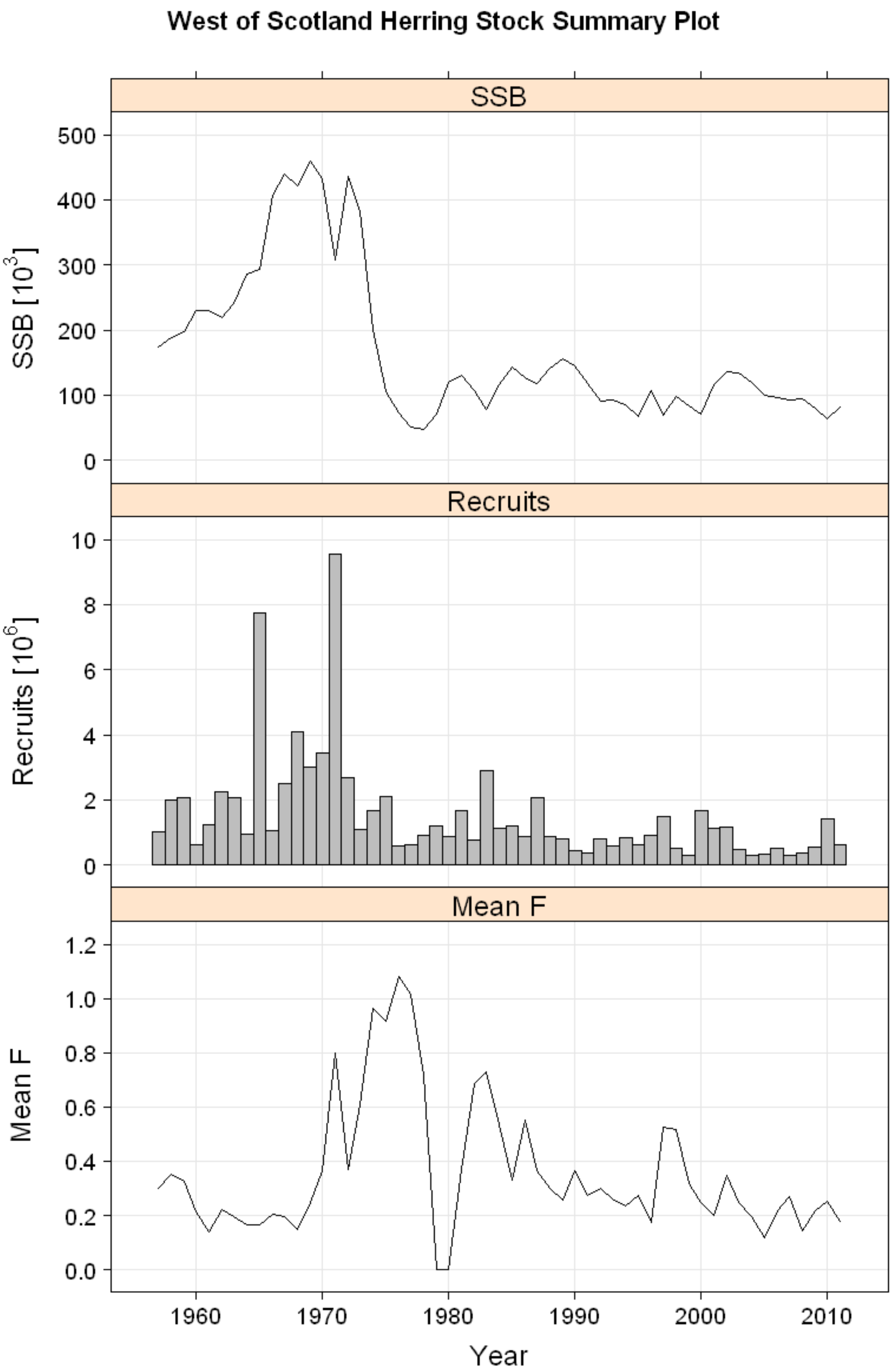


Figure 5.6.1. Herring in VIa (North). Illustration of stock trends from the assessment (8 year separable period) 1957-2011. Summary of estimates of landings, spawning stock biomass at spawning time, fishing mortality at $F_{3\text{-}6}$, recruitment at 1-ring, in the final assessment run. The 2011 estimate for recruitment is given as geometric mean (1989-2010) because there are no data to support its estimation.

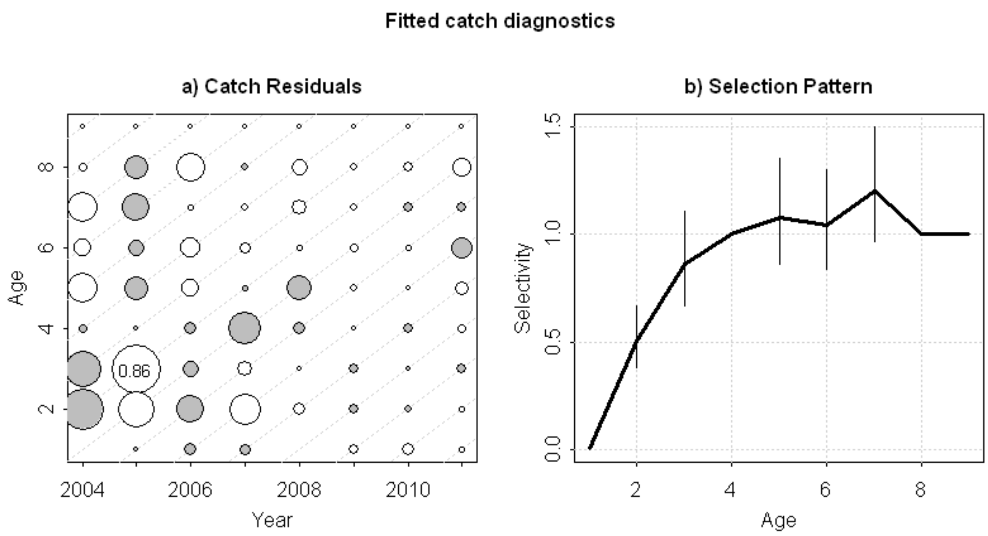


Figure 5.6.2. Herring in VIa (North). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation.

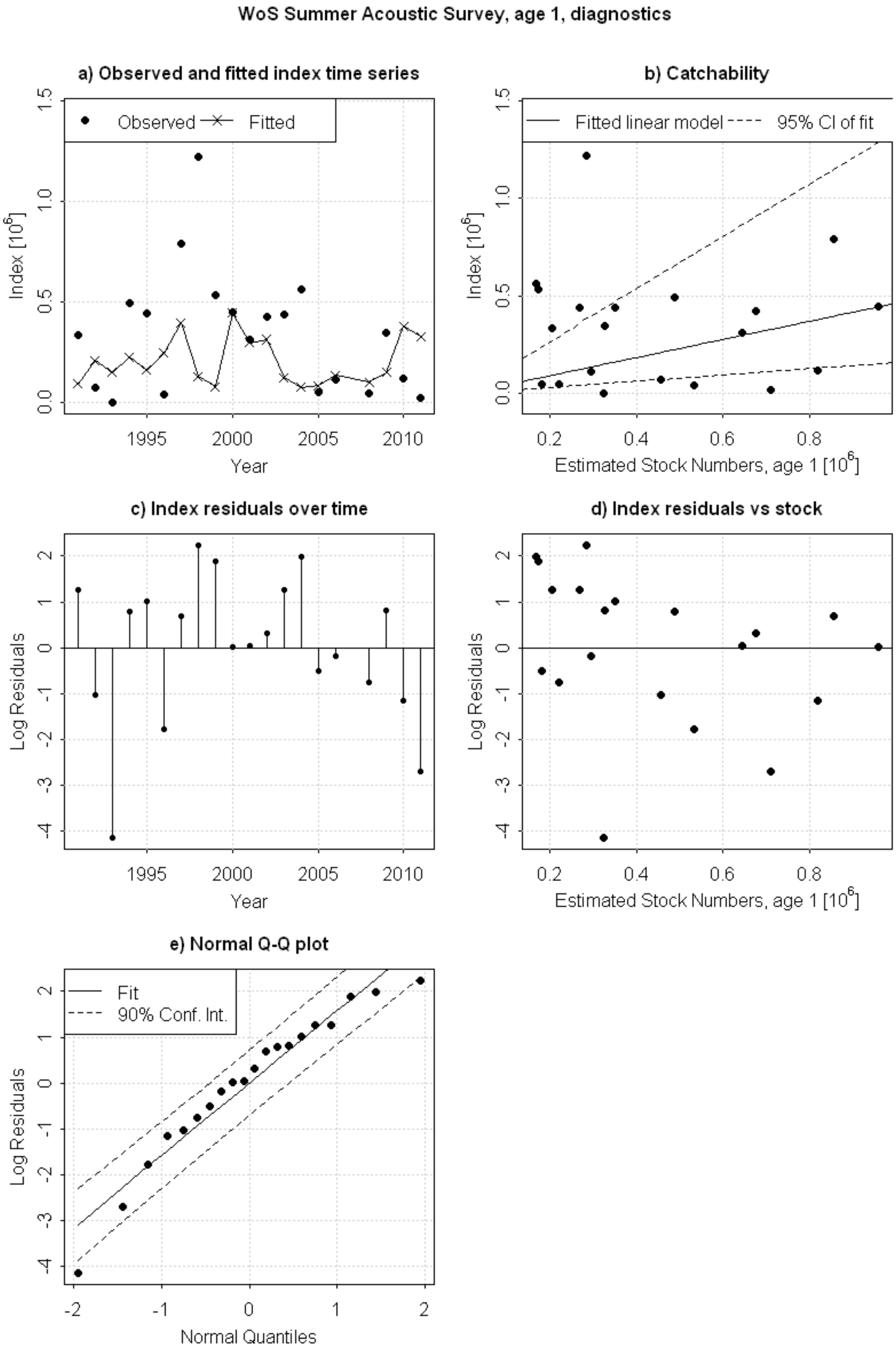


Figure 5.6.3. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 1 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

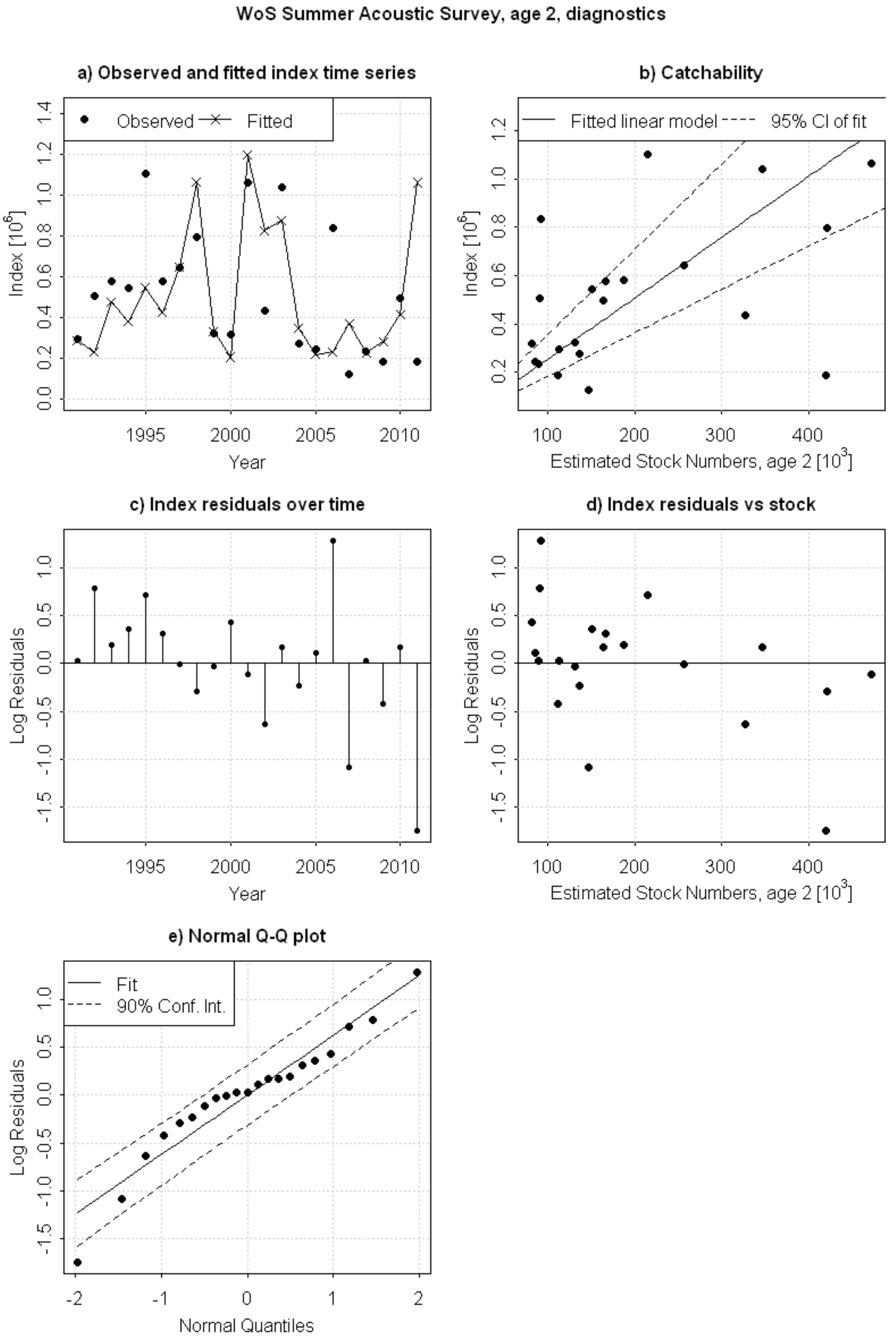


Figure 5.6.4. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 2 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

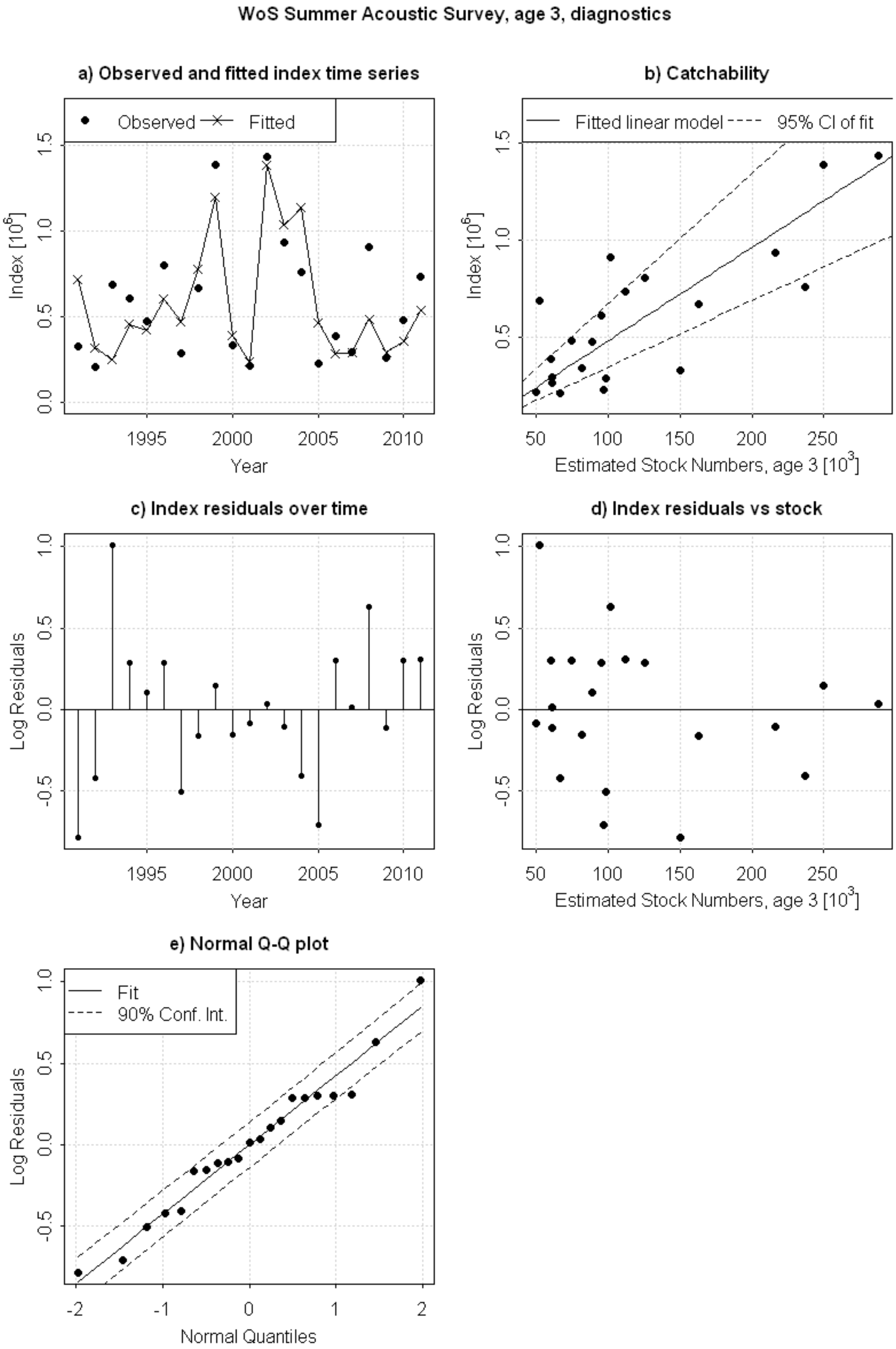


Figure 5.6.5. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 3 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

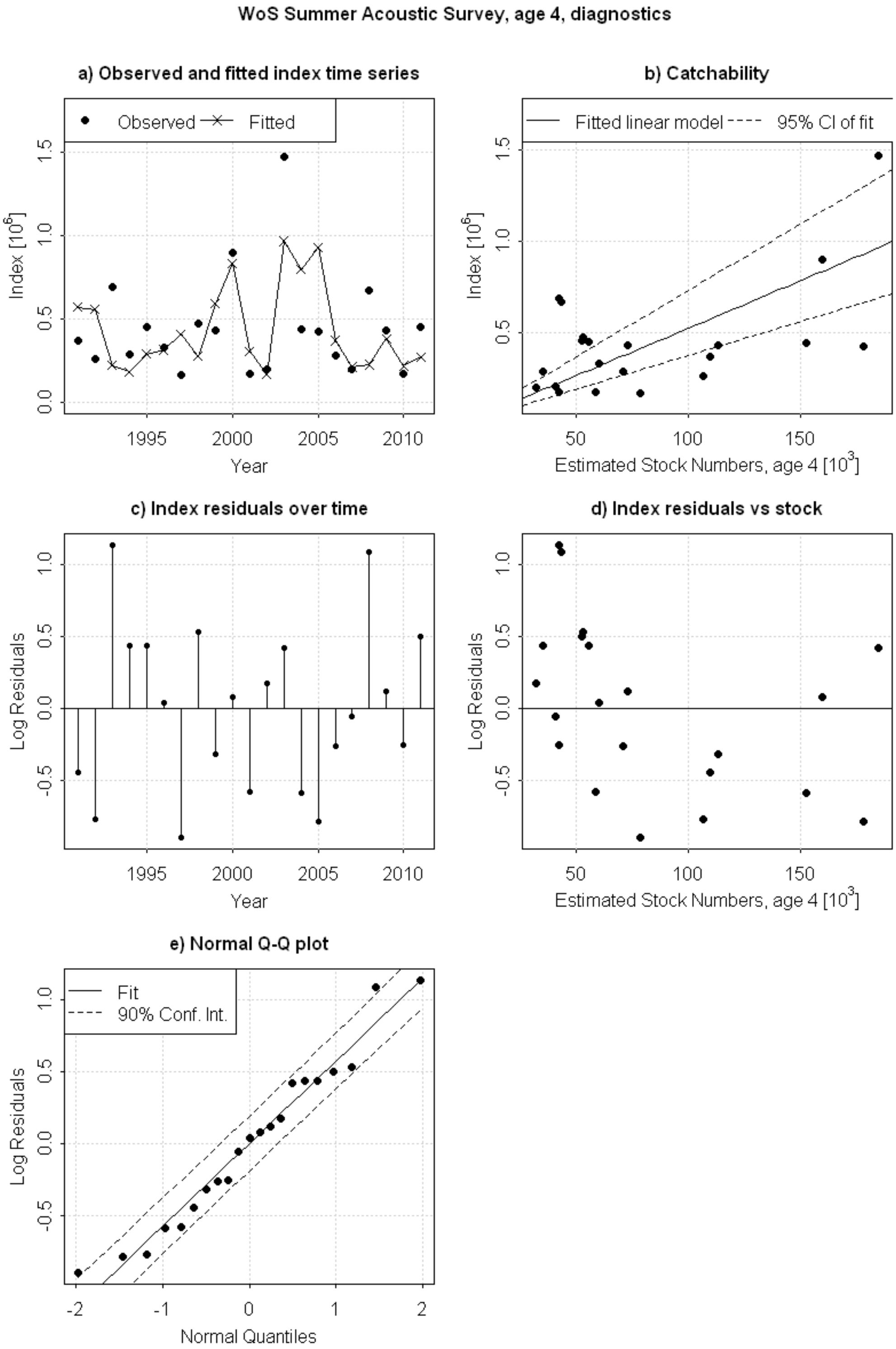


Figure 5.6.6. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 4 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

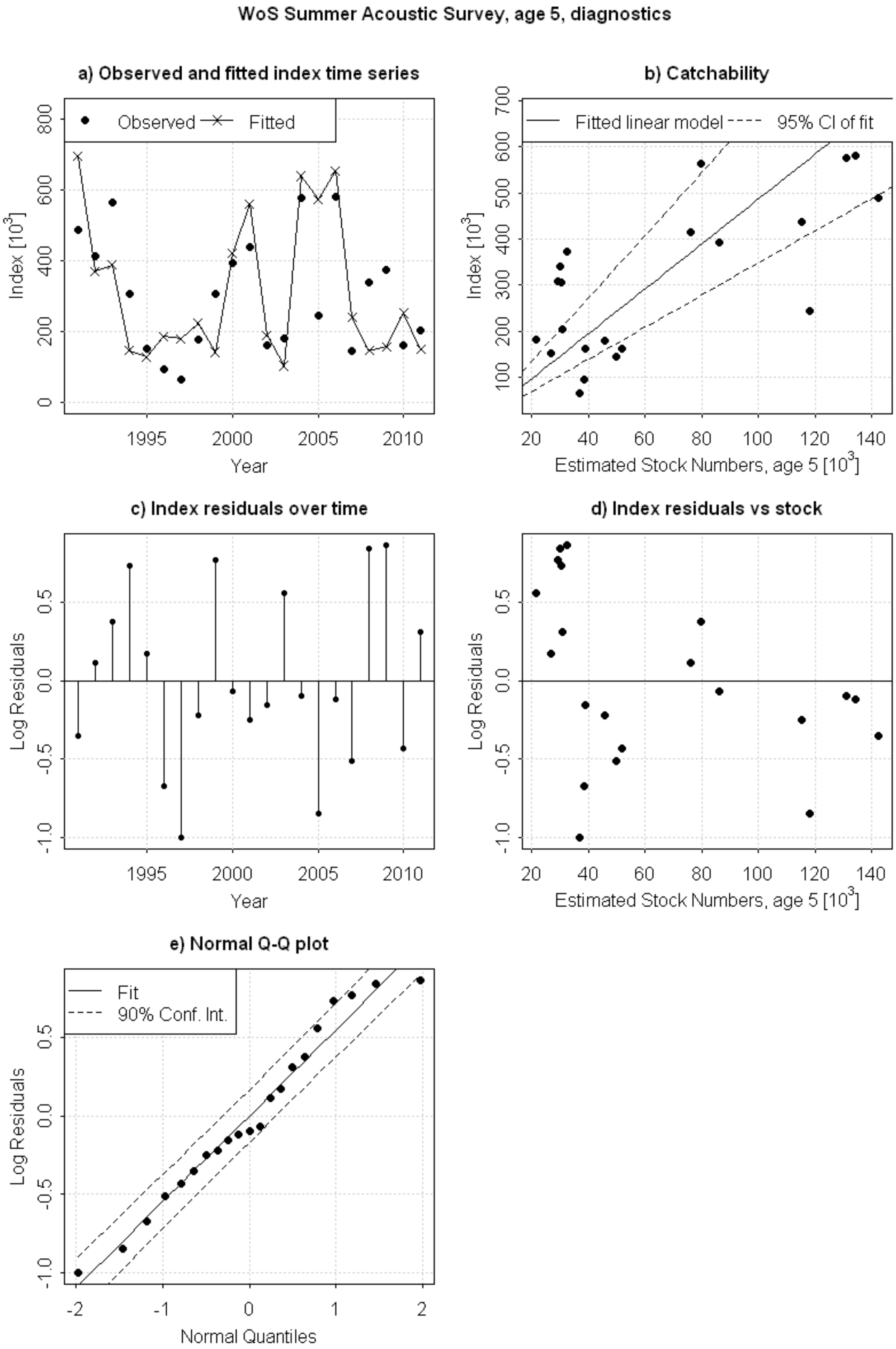


Figure 5.6.7. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 5 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

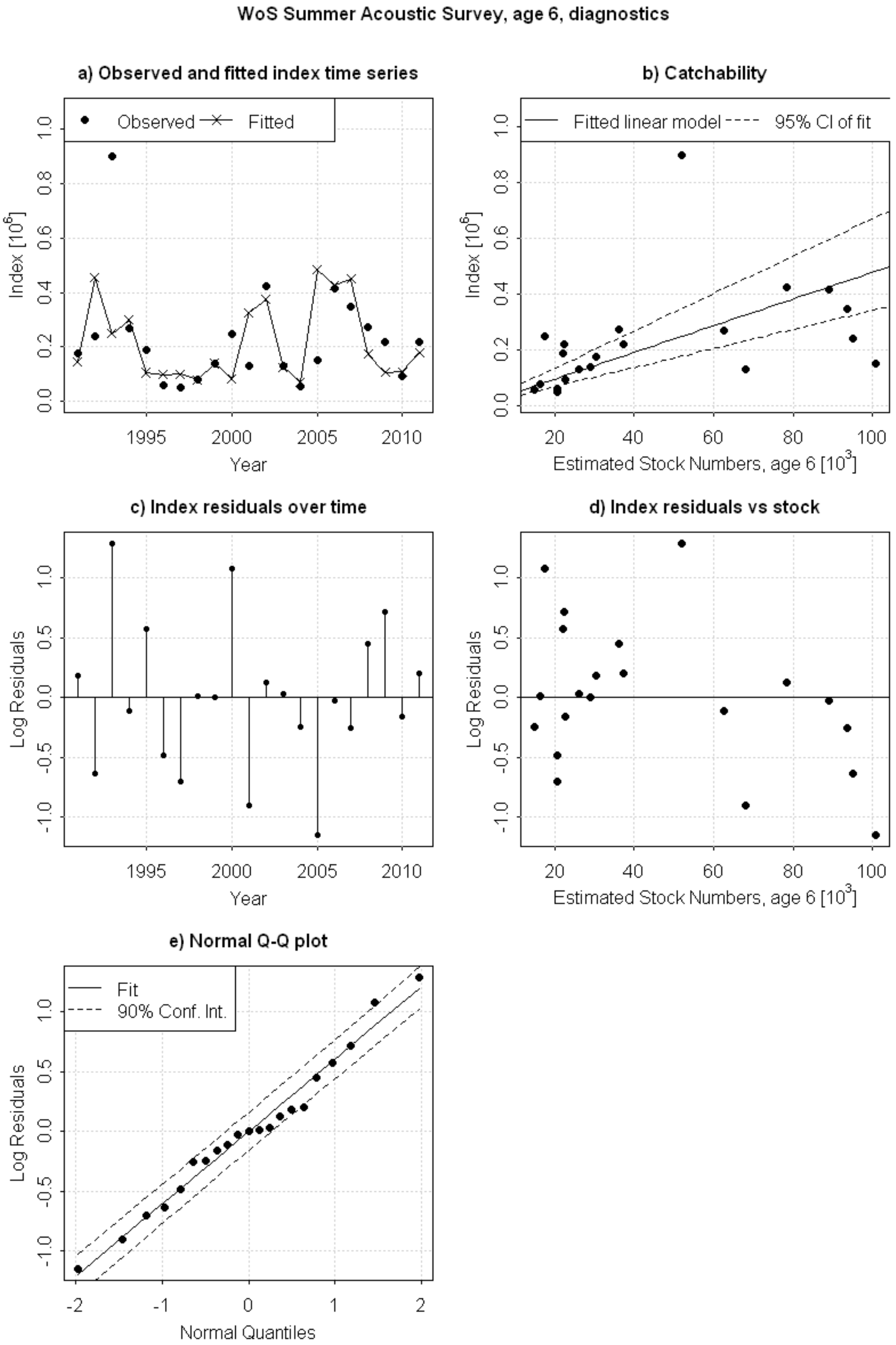


Figure 5.6.8. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 6 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

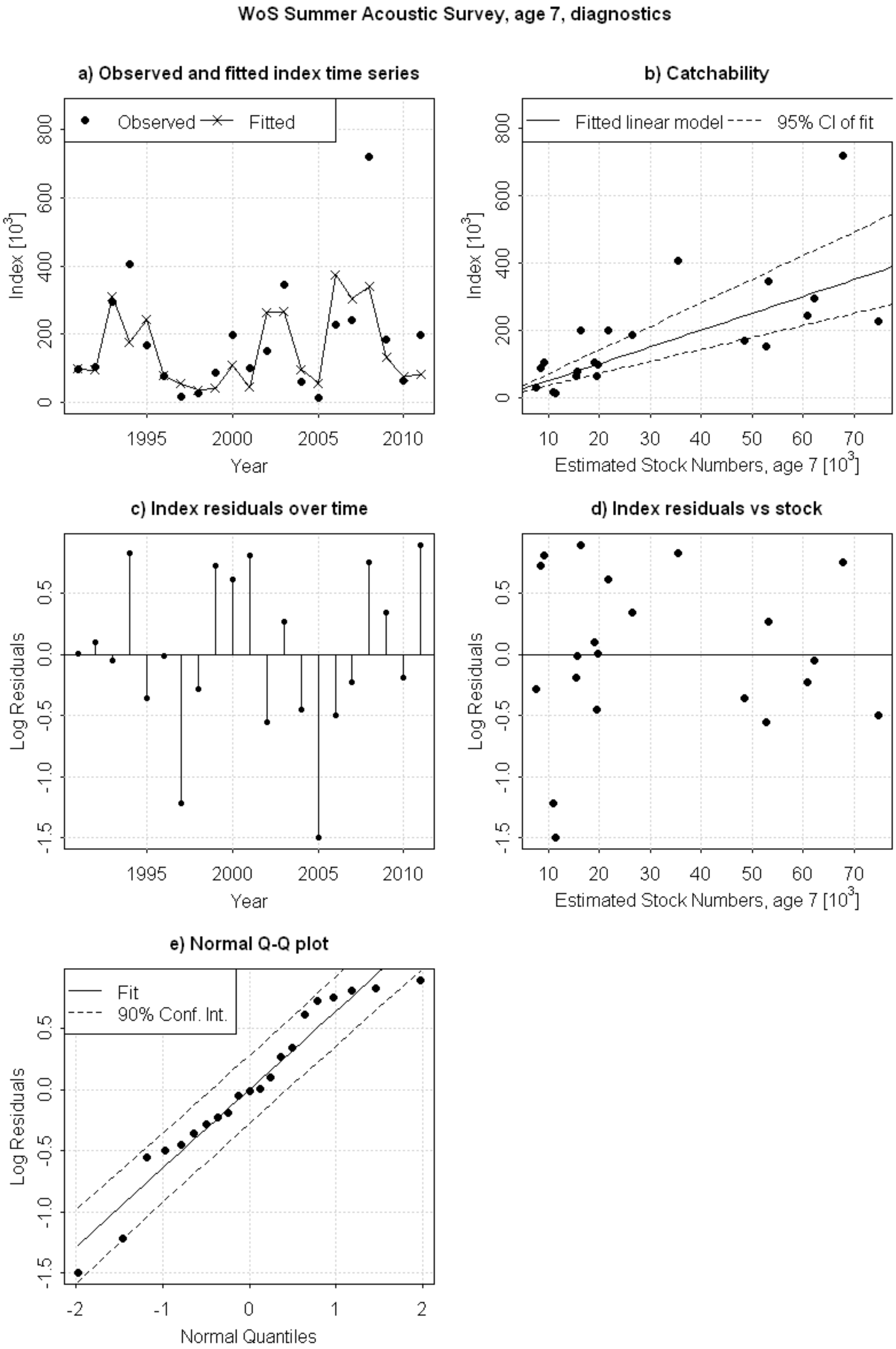


Figure 5.6.9. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 7 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

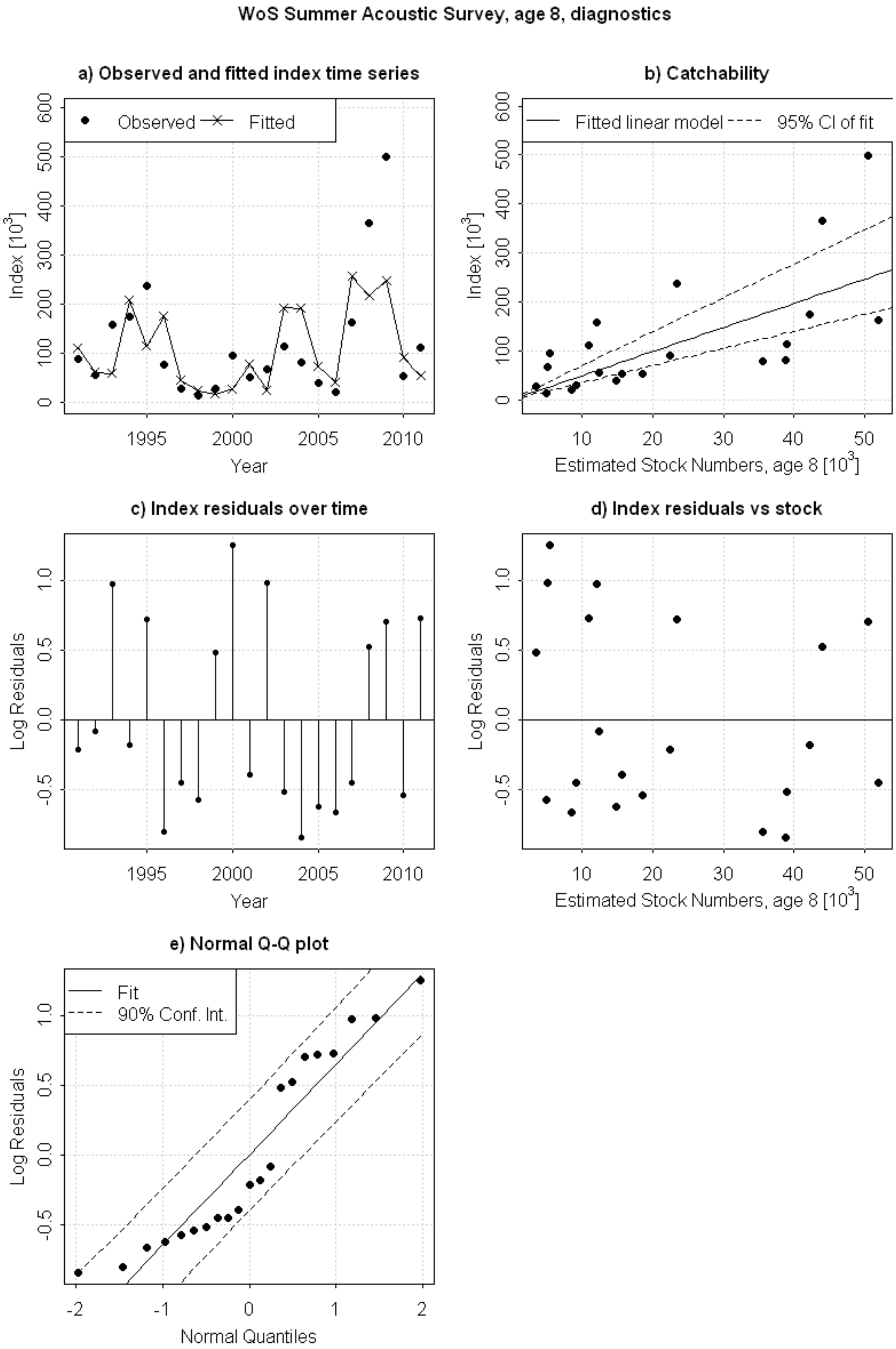


Figure 5.6.10. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 8 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

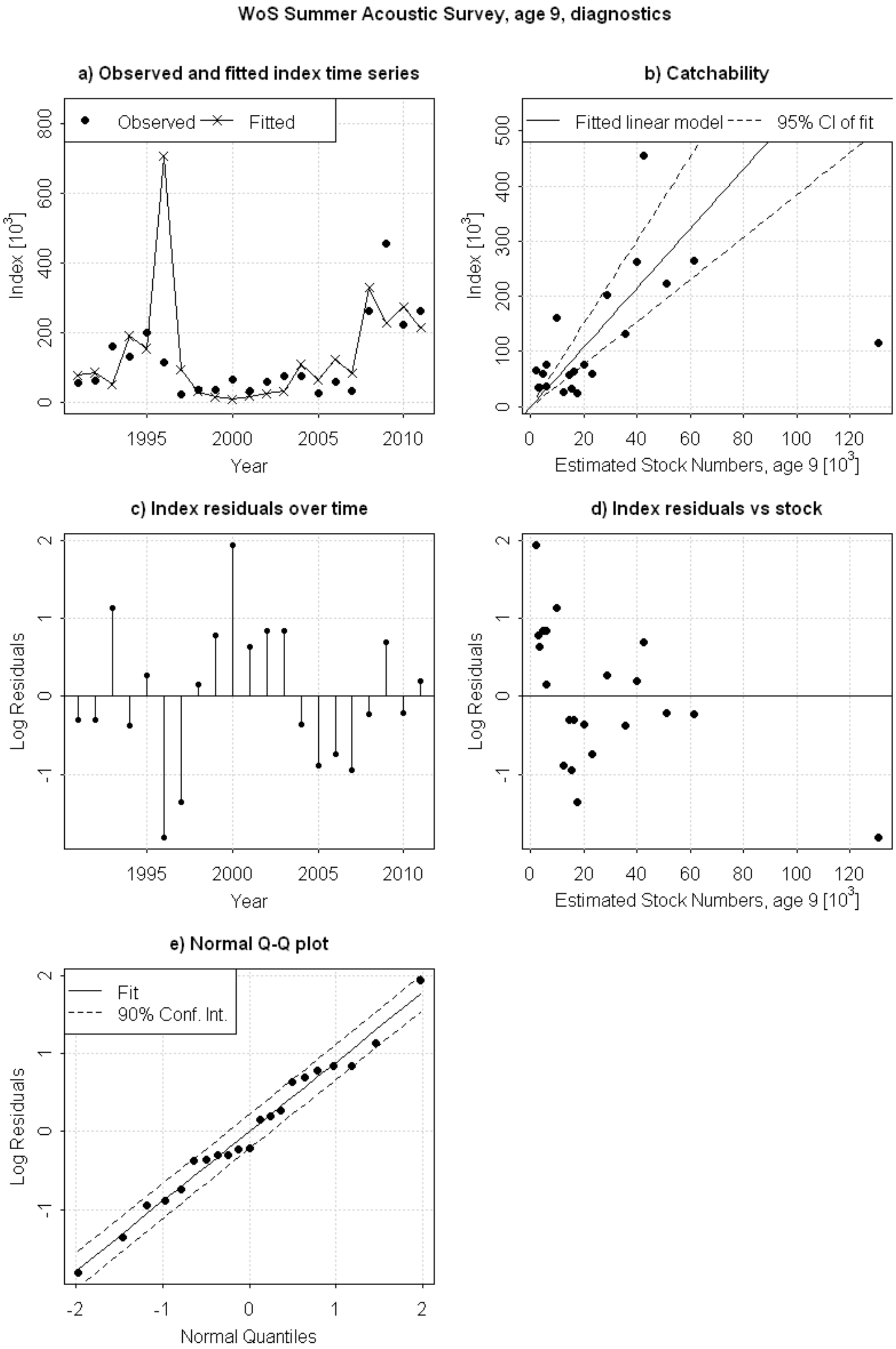


Figure 5.6.11. Herring in VIa (North). Diagnostics of the VIaN acoustic survey fit at 9 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

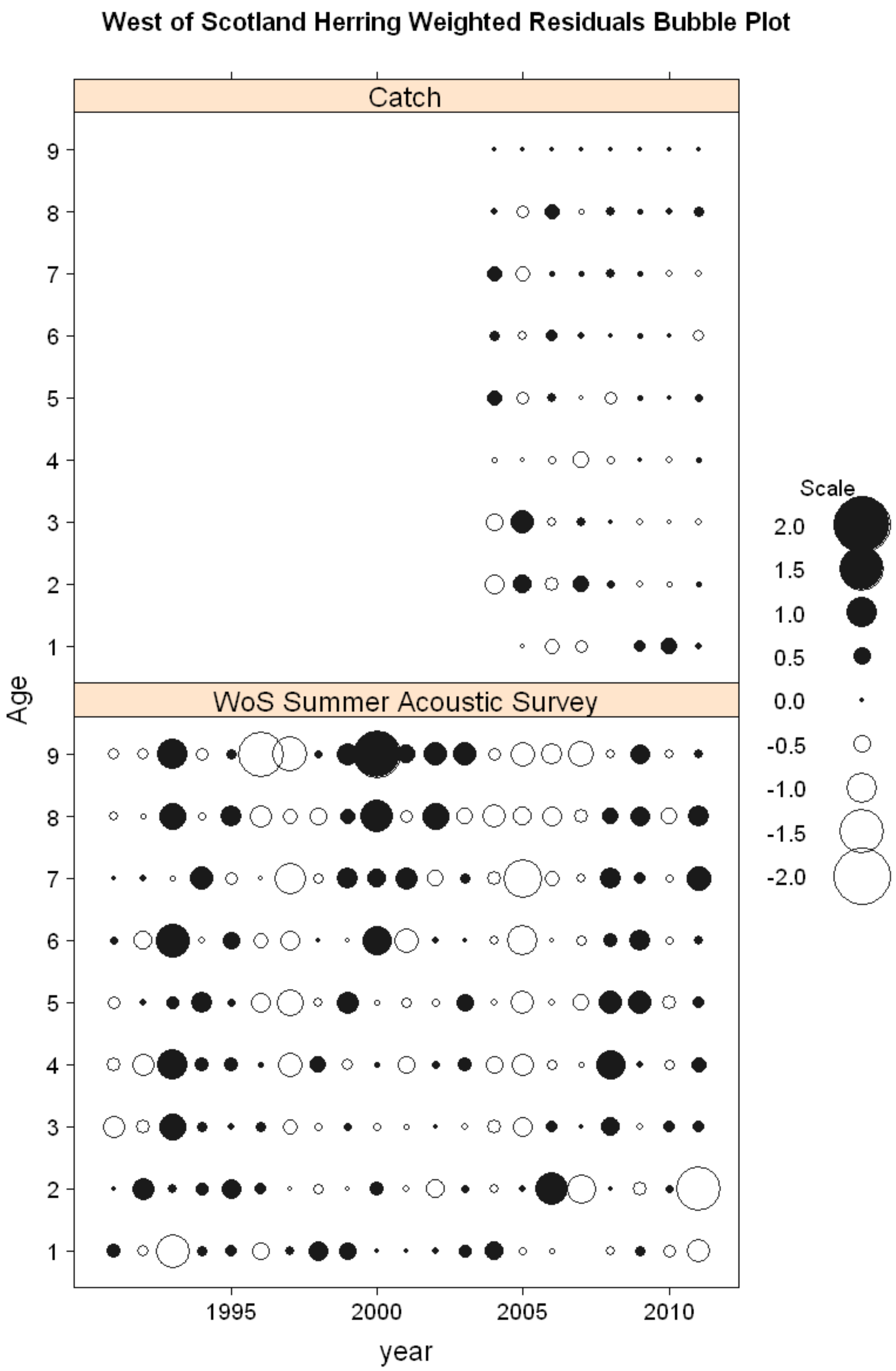


Figure 5.6.12. Herring in VIa (North). Comparison of residuals in the catch (top) and survey (bottom) Note the year effects in the survey, particularly in 2005, 2008 and 2009. The assessment effectively smoothes an otherwise noisy survey.

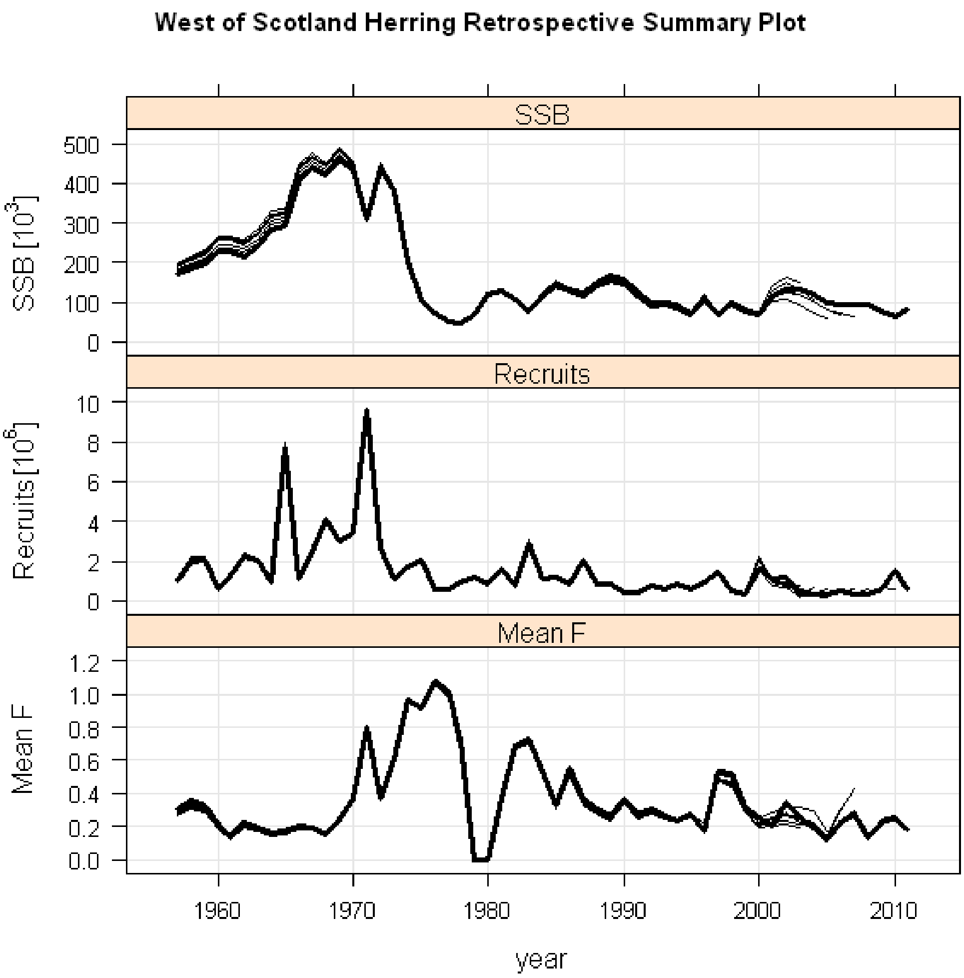


Figure 5.6.13. Herring in VIa (North). Analytical retrospective patterns (2011 to 2007) of SSB, recruitment and mean $F_{3\text{-}6}$ from the final assessment. The terminal estimates for recruitment are given as geometric mean (1989 to one year prior to the last data year) because there are no data to support its estimation.

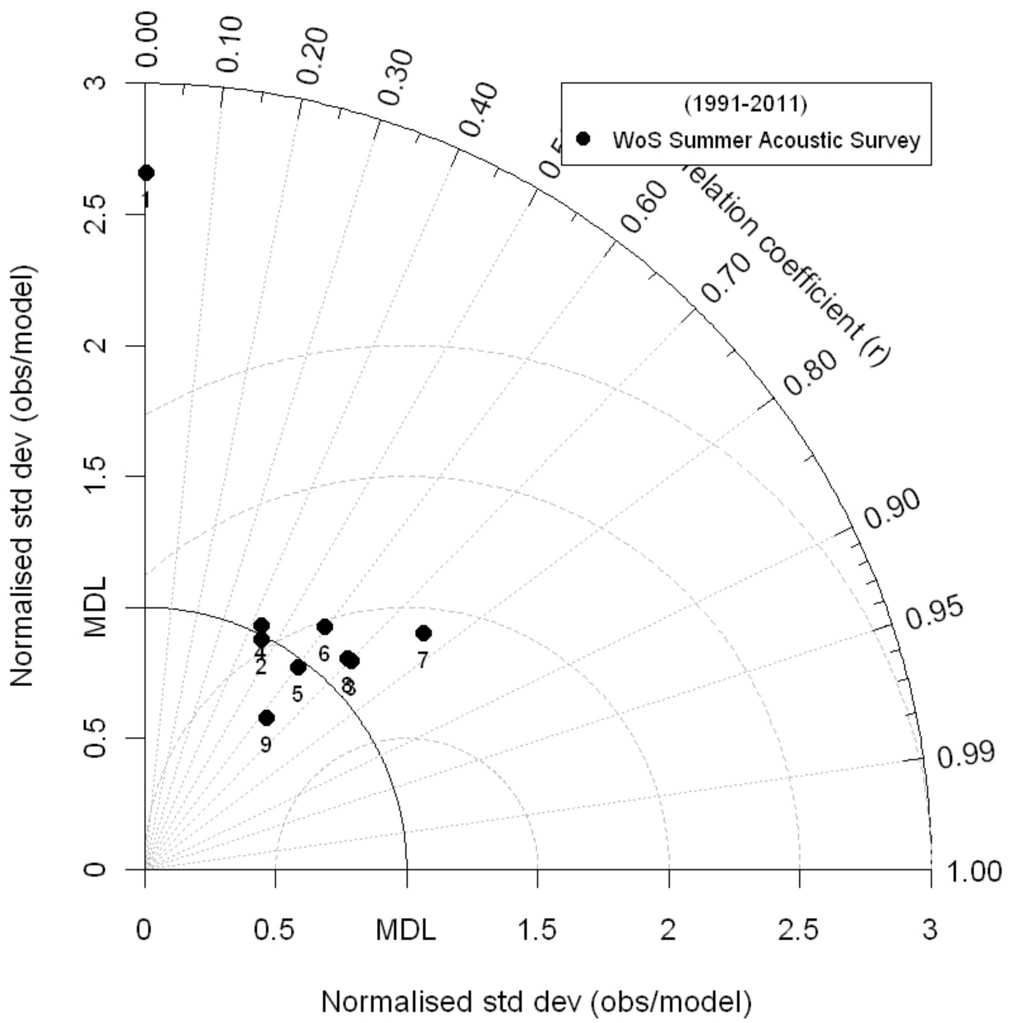
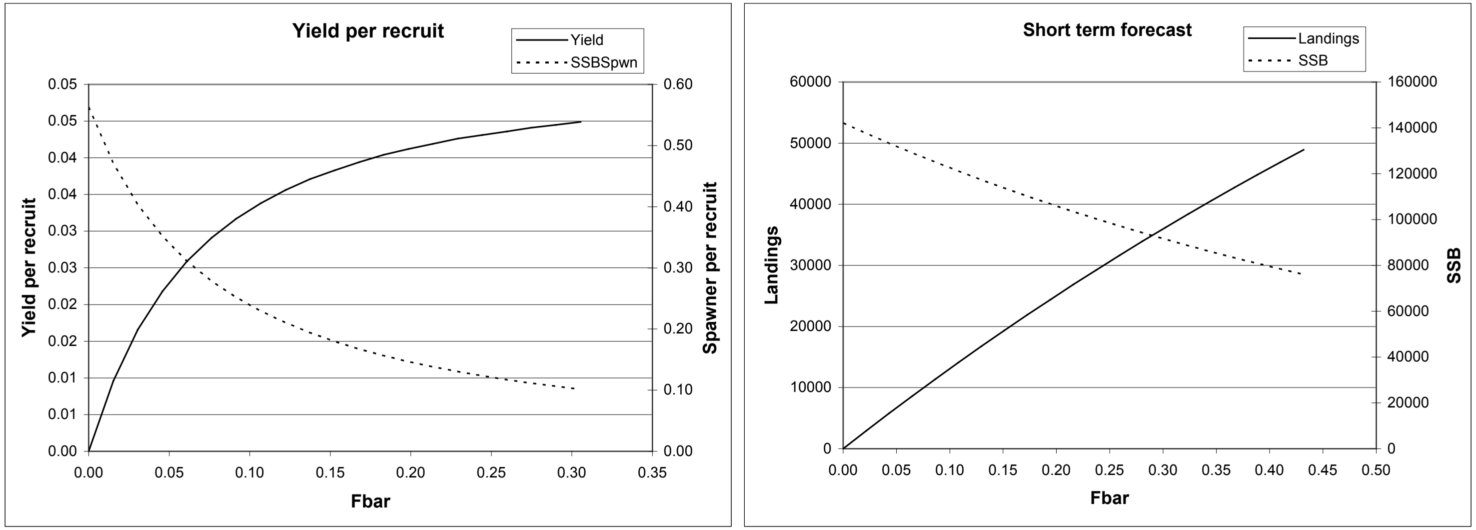


Figure 5.6.14. Herring in VIa (North). Taylor diagram. The plot is not Cartesian but rather polar in nature: the angular axis plots the correlation coefficient between observations and the modeled values. The radial axis represents the standard deviation of the observations normalized by the standard 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: hervian
Time and date: 15:43 18/03/2012

Reference point	F multiplier	Absolute F
Fbar(1-9)	1.0000	0.1527
FMax	>=1000000	
F0.1	1.0158	0.1551
F35%SPR	0.8795	0.1343

Weights in kilograms

MFDP version 1a
Run: Favsq09to11 no scaling
Herring VIaN
Time and date: 13:02 19/03/2012
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.

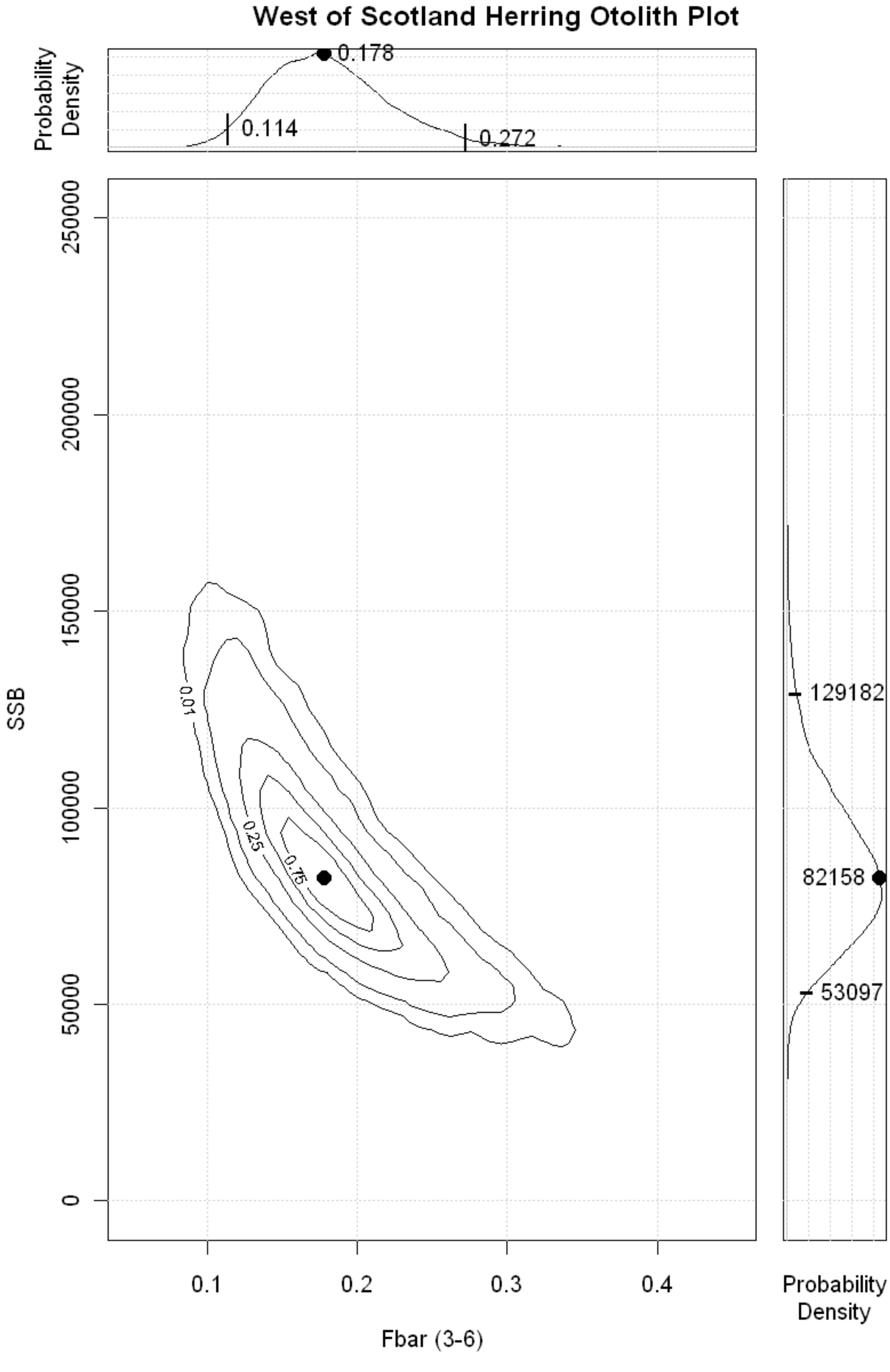


Figure 5.9.1. Herring in VIa (North). Results of parametric bootstrapping from FLICA. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two 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.

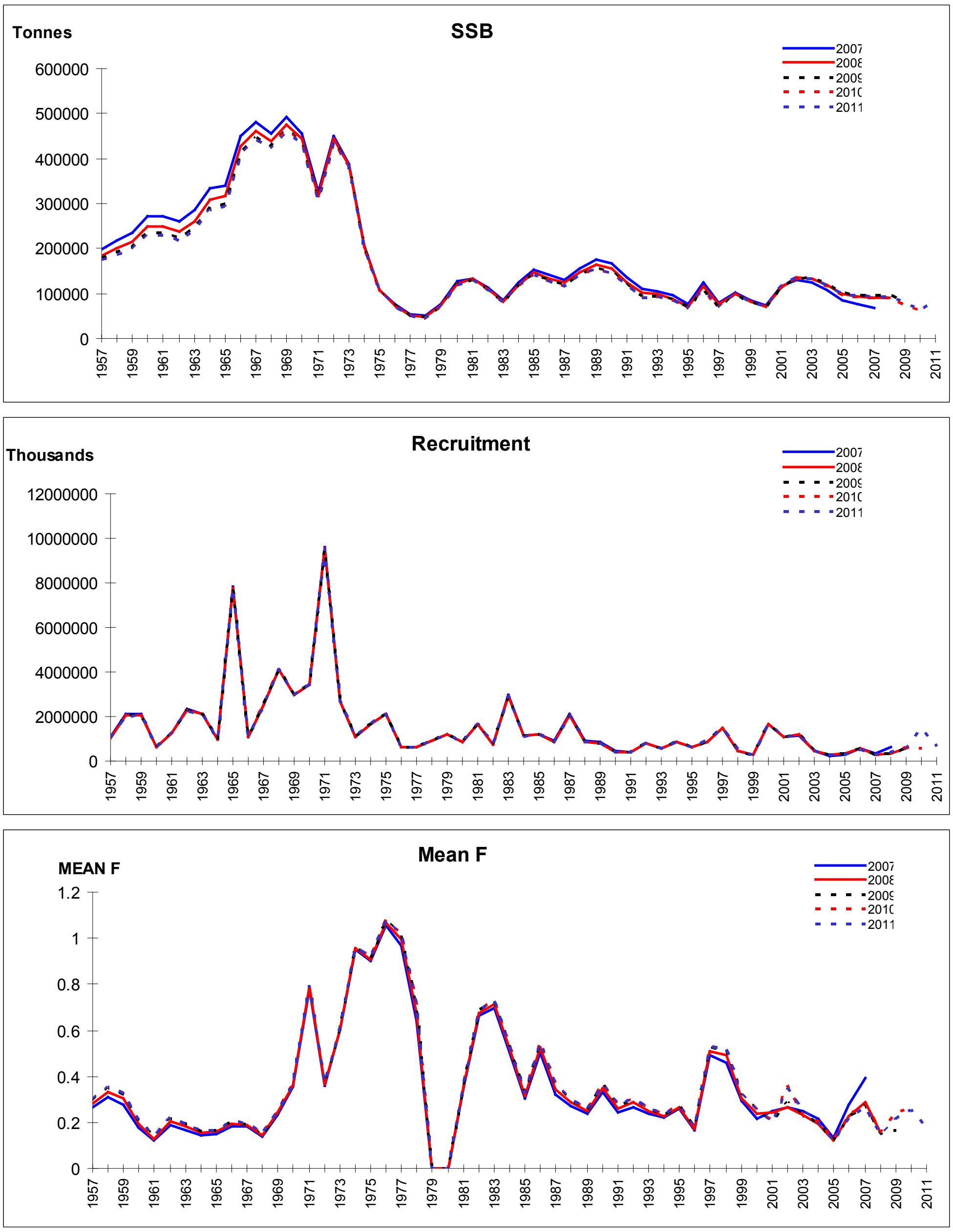


Figure 5.9.2. Herring in VIa (North). Historical retrospective patterns (2011 to 2007 assessments) of SSB, recruitment and mean $F_{3\text{-}6}$ from the final assessment. The final estimate for recruitment in each year is given as geometric mean (1989 to one year prior to the last data year) because 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.

6.1 The Fishery

6.1.1 Advice and management applicable to 2011–2012

The TAC for this area in 2011 was 4 471 t with a decrease of 5% to 4 247 t in 2012. For 2012, ICES advised that, based on precautionary considerations, catches should be reduced.

Rebuilding plan

A rebuilding plan was developed by the Federation of Irish Fishermens' Organisations and the Pelagic RAC in 2011. The plan was for *status quo* TAC in 2012, and, in subsequent years a TAC set at $F_{0.1}$ (0.2). However, if the stock was considered by ICES to be at risk of recruitment impairment, a TAC lower than $F_{0.1}$ (F = 0.2) would apply. This plan was not approved by STECF as a basis for TAC setting in 2012, and was not applied. It has not been evaluated by ICES.

6.1.2 Catches in 2011

The Working Group estimates of landings recorded by each country from this fishery from 1988 – 2011 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 2011 was 4 247 t, compared with 7 513 t, in 2010. The total working group estimates of catches in these areas from 1957 – 2011 are shown in Figure 6.1.2.1. The working group estimates of catch have declined from about 19 000 t in 2006 to about 7 000 t in 2011. The Irish official catch was close to the quota.

There were no estimates of discards available for 2011, and discarding is not considered to be a major feature of the Irish fishery at present. Information from the Dutch freezer trawlers in this area showed that some discarding took place (van Helmond and van Oversee 2012 WD).

The assessment period runs concurrently with the annual quota. In recent years Ireland has been the only country participating in this fishery. In 2011 all of the catches were reported from quarters 1 and 4 in VIaS. Only one catch was reported from VIIb, in quarter 4, amounting to 130 t. 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 early November and closed in late December. 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 56 boats categorised as follows caught greater than 5 t of herring in VIaS, VIIb,c in 2011:

- 11 vessels less than 65ft in length
- 10 vessels between 65 and 80ft in length
- 35 vessels over 80ft in length

6.1.3 Regulations and their effects

The reduction in quotas in recent years 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.

23 of the large (RSW) vessels are not permitted 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.

6.2 Biological composition of the catch

6.2.1 Catch in numbers-at-age

The time series was extended in 2011 to include data from 1957 (Clarke WD to HAWG 2011), with details of the extension included in an adjunct to the stock annex. Catch-at-age data for this fishery are shown in Table 6.2.1.1 with percentages since 1994 shown in Table 6.2.1.2. In 2011 the fishery was dominated by 2-, 3- and 4-ringers accounting for 32%, 21% and 21% respectively. Two of these were the dominant age groups in the previous year as 2- and 3- ringers. 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 seven years of the time series, with the exception of 2010 when 1-ringers accounted for 2% of the total catch numbers at age. The strong 2006, 2007 and 2008 year classes are also evident in the mean standardised catch numbers at age, which are depicted in Figure 6.2.1.1.

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 2011, 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.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

The stock area is covered by a constituent survey of the Malin Shelf Survey (Figure 2.3.1.2), the "MSHAS_S" survey. However this survey component does not contain the stock at time of year of the survey. The entire Malin Shelf Survey (MSHAS) is considered likely to contain this stock, but also covers the VIaN stock. Currently it is not possible to determine the level of mixing of these two stocks in the MSHAS survey. This survey is described in the WGIPS report (ICES 2012) and in Section 1.

Table 6.3.1.1 shows the abundance at age and biomass estimates, from surveys of this stock, south of 56°N boundary, from 1999 to 2011. The surveys have been conducted at different times (Table 6.3.1.2). The current series of summer-feeding phase surveys (2008-2011) is comparable with those conducted from 1994-1996. From 1999-2001 surveys were conducted in autumn and from 2002-2007 in winter.

Comparing the numbers at age from VIIb and VIaS (MSHAS-S) only, the 2011 age structure shows high numbers of 3-ringers. This follows on from the high proportions of 1-ringers in 2009 (2007 year class) and 2-ringers in 2010 (Figure 6.3.1.1). This suggests that there may be a stronger year class entering the fishery. The proportions-at-age in the catch and survey data from 2008-2011 are presented in Figure 6.3.1.2 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 are 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.

For the purposes of tuning the FLICA assessment, the Malin Shelf Survey was used for the period 2008-2011, over ages 3-6 (Section 6.6).

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 2011 are based on Irish catches (Figure 6.4.1.1). In 2011 there were slight decreases in the mean weights of all age groups except 9-ringers. 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). Similar to the mean weights in the catch, the mean weights in the stock all decreased slightly and the same overall trends can be seen.

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 of the recent years. Since the mid 1990s recruitment has been uniformly low, based on exploratory assessments. However there is evidence from surveys that the 2007 and 2008 year classes were stronger than those in the previous 10 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 evidence to suggest that the 2007 cohort is strong in the acoustic survey (Figure 6.3.1.3).

6.6 Stock Assessment

6.6.1 Data Exploration

Separable VPAs

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). The reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to 3 winter rings.

Four exploratory assessments using the separable VPA were performed, based on the four initial values for terminal F. Recruitment, SSB and mean F from each run are shown in Figure 6.6.1.1. Outputs from separable VPAs with terminal Fs of 0.2, 0.4, 0.5 and 0.6 are presented in Tables 6.6.1.1-4. Residual plots for the four trial assessments are presented in Figure 6.6.1.2. Large residuals can be seen in 1-ringers, reflecting the poor estimation of this age group. These residuals are also presented in Tables 6.6.1.3 – 6.6.1.6. There is little pattern in these residuals.

Fishing mortality was estimated to be highest in 1998. From 1998 to 2004 F is estimated to have declined, but increased again and even the lowest estimate of F is above F_{msy}. There was a sharp rise in F in 2006, associated with an increased catch in that year.

Recruitment has been stable at a very low level or declining in recent years. In 2011, the assessments suggested there was an increase in recruitment, though this was replaced with geometric mean. There was no evidence from the catch at age data or the survey data for such a strong cohort, and it has been retrospectively downgraded in the 2012 assessments, though it dominates the modelled abundance in all the runs.

All of the runs with starting F values greater than 0.2, show that SSB is at the lowest level in the series. All runs show the stock to be considerably lower than B_{pa} (110 000 t) and B_{lim} (81 000 t).

Historical retrospective analyses were performed for each of the terminal F initial values. Using a terminal F = 0.2 as a starting value (Figure 6.6.1.4) shows a bias towards underestimation of SSB and overestimation of F. Using a terminal F = 0.4 (Figure 6.6.1.5) displays a more stable estimation of F with a slight overestimation of SSB. The retrospective assessment using F=0.5 (Figures 6.6.1.6) shows stability in SSB estimation, with a slight underestimation in F. The scenario for F=0.6 (Figure 6.6.1.7) shows a bias towards a slight overestimation of SSB and an underestimation of F.

The results of the retrospective analysis suggest that using an initial terminal F of 0.5 produces more stable estimates of SSB and F. The mean F generated by this "best-estimate" run is 0.65 in 2011, and mean F in the non converged VPA (2006-2010) is

0.61-0.86. This suggests that recent F has been well above $F_{0.1}$ and F_{msy}, estimated to be around 0.2 and 0.25 respectively (ICES 2010 ACFM:06).

Historical retrospective analyses of the "best-estimate" separable VPA assessments for 2008-2012 WGs are presented in Figure 6.6.1.7. The estimation of SSB and F appears balanced and without bias. Retrospective analyses of recruitment using geometric mean leads to overestimation of terminal recruitment. These analyses reinforce the perception of a stock that is over exploited and well outside safe biological limits.

Further sensitivity analyses were performed using separable VPAs, to examine the effect of some settings, see text table below.

Run ID	Term F	Term S	Ref age	Tuning	Shrinkage	F and M Prop
1	0.5	0.9	4	-	-	Invariant
2	0.5	1.1	4	-	-	Invariant
3	0.5	1.2	4	-	-	Invariant
4	-	-	-	VIaN*		Invariant
5	-	-	-	VIaN*	Yes	Invariant
6	0.5	1	3	-	-	Variant
8	0.5	0.9	3	-	-	Invariant
9	0.5	1.1	3	-	-	Invariant
10	0.5	1.2	3	-	-	Invariant

*The VIaN component of the Malin Shelf survey

Residual patterns were not very different in any of the runs. Stock trajectories are presented in Figure 6.6.1.8, and are very similar in all cases. Using a varying proportion of F and M before spawning scaled up SSB in through most of the series. This was attempted to examine the effect on changes in the proportions of autumn and spring spawning, known to occur (Dransfeld *et al.* 2010). *Ad hoc* VPA tuning (Darby and Flatman 1994), using the VIaN acoustic survey (because the Malin Shelf survey series is too short), led to lower estimates of F and slightly elevated recruitments in the most recent years. Many of these runs estimated recruitment in 2010 (2008 cohort) to be above than the recent average.

ICA Assessment of VIaS and VIIbc

Given that 4 years of the Malin Shelf Survey are now available for tuning, it was considered appropriate to attempt an ICA (Patterson and Melvin 1996) assessment. The last attempt at an ICA assessment was in 2006. However, poor diagnostics and the uncertainties in the previous (winter-spawning time) survey meant that the 2006 assessment was not acceptable.

In 2012, HAWG ran a series of exploratory ICA assessments using FLICA (Kell *et al.* 2007). A number of combinations of catch and tuning data configurations were investigated. The following components of the Malin Shelf survey time series were investigated as possible tuning series

- VIaS/VIIbc (2008-2011)
- VIa/VIIbc (2008-2022)

- VIaN (1991-2011)

The runs using the VIaN survey displayed very poor diagnostics, with strong year effects in the catch residuals and large retrospective revisions of F and SSB. Consequently no further work was conducted with the VIaN acoustic survey.

Tuning using the VIaS/VIIbc component of the Malin Shelf survey was considered appropriate, though it was recognised that the entire population of VIaS/VIIbc fish is unlikely to be contained within these spatial boundaries. Tuning with the entire Malin Shelf survey (2008-2011) will necessarily contain fish that belong to the VIaN stock. Optimal FLICA performance was achieved with the VIa/VIIbc tuning series, comprising thelowing:

- VIaN area, north of 56°N, as used for tuning the VIaN assessment (Section 5)
- VIaS and VIIbc
- Two rectangles (39E3 and 40E3) in VIaN, south of 56°N.

Moving north of the 56°N boundary, the age structure becomes more coherent with the age structure seen in the VIaS catches. Commercial sampling for VIaN and VIaS components is geographically distinct. Further work will investigate the age structure, latitude and allocation of samples taken by trawl during the acoustic surveys in VIa to quantify the relative proportions of the VIaS and VIaN components within the survey. This may result in a more appropriate tuning index for the assessment of the VIaS stock.

Further model refinements were made in reducing the plus group from 9+ to 7+. The model was forcing up selection at the oldest ages as a result of sparse numbers in the catch data at these ages. Reducing the plus group to 7+ in the catch data permitted an accumulation of fish in the plus group and an improved model selection pattern. Further runs investigated the effects of altering the terminal selection (0.9,1.0 and 1.1) on the older ages and also increasing the reference age from 4 to 5 to reflect that stronger year classes do not fully recruit to the fishery until age 5. The final exploratory assessment used the following configuration

- Catch data with a 7+ plus group. Age 1 down-weighted to 0.1
- Ages 3-6 from the VIa,VIIbc survey data (2008-2011)
- Reference age 4
- Terminal selection on plus group and oldest true age = 1.0

The stock summary, catch and survey diagnostics are shown in Figures 6.6.1.9-11. There are no obvious year or age effects in the catch residuals. There are year effects throughout the survey series. The uncertainty plot (Figure 6.6.1.12) shows a wide range of possible values for SSB, with over 95% below B_{lim}. A comparison between the FLICA and VPA outputs (terminal F = 0.5) are shown in Figure 6.6.1.13. There is good agreement between the two approaches except in the most recent years where ICA predicts higher SSB and recruitment and lower F than the VPA. However, this period corresponds to the non-converged part of the VPA where confidence in the result is low.

ICA Aggregate assessment of VIa (total) and VIIbc

It is recognised that this stock mixes with VIaN at certain times of the year, and that the VIaN acoustic survey contains fish from this stock (SGHERWAY: ICES CM 2010/SSGSUE:08). The lack of coherence in the catch at age matrix for VIaS and VIIbc may in part be explained by variability in straying. In particular, strong year classes have been shown to recruit to the VIaS/VIIbc fishery later than weaker ones (Farran 1930; 1937). It is also known that the summer feeding grounds of this stock straddle the 56°N boundary with VIaN (Le Gall 1932).

In an attempt to deal with this complexity, an approach was taken to conduct a combined assessment for both stocks, and then subtract the population numbers for VIaN (SPALY assessment, Chapter 5). The remaining population numbers would be an estimate of stock abundance of VIaS.

Catch numbers at age and catch in tonnes were summed for both stock areas. Mean weights in the catch were averages from both stocks, re-weighted by the combined catch numbers at age. Weights in the stock at spawning time, and maturity at age were as per VIaN, whilst natural mortality was assumed to be the same in both stocks and this was carried forward to the combined assessment. Proportions of F and M before spawning were taken to be 0.3, to account for greater spring spawning in the combined stock. However these values were not used in population abundance estimation. Tuning was conducted using the VIaN acoustic survey (Chapter 5). Settings for the combined assessment were as per the VIaN SPALY accepted assessment, and were considered appropriate.

Using the difference between the two assessment abundance vectors to derive the VIaS/VIIbc stock numbers leads to negative population numbers in some older ages in recent years so that when calculating fishing mortality on the basis of abundance ratio this leads to gaps in the fishing mortality matrix. To overcome this, an alternative approach of calculating fishing mortality as a partial F was taken. In this case, the fishing mortality is calculated as a fraction of the fishing mortality on the Malin meta-population, based on the relative fraction of catches *i.e.*

$$F_{y,a} = (F_{y,a,\ VIa/VIIbc}) * (C_{y,a,VIaS/VIIbc} / C_{y,a,VIa/VIIbc})$$

The comparison of all the methods used (separable VPA, ICA and the aggregate assessment) are shown in Figure 6.6.1.14. The SSB calculated from the aggregate assessment has been increasing since 2000 whereas the separable VPA and FLICA both show a general downward trend. It should be noted that the SSB results for VIaS/VIIbc are derived from two separate ICA assessments each of which are associated with high uncertainty, especially in recent years, making interpretation of these results highly uncertain.

6.6.2 State of the Stock

The results of the exploratory assessments continue to suggest that SSB has been low since the mid 1990s. The absolute level is uncertain but is very likely to be below B_{lim}.

F is estimated to remain high (separable VPAs) or reducing somewhat in recent years (ICA assessment).

Recruitment has been poor in recent years, though there is evidence from surveys and the ICA assessment that the 2008 year class was above the recent average.

6.7 Short term projections

In 2012, the working group conducted a series of exploratory short term deterministic forecasts from separable VPA and FLICA output. These forecasts were used to explore possible reactions of the stock in the short term.

For the forecasts based on the VPA output, recruitment was based on the geometric mean of the recruitment from 1957-2005. More recent years were not considered as the VPA is not converged and the strong year classes of 1963, 1981, 1983 and 1985 were also removed. Thus the forecasts were based on a low recruitment regime. A similar approach was taken with the FLICA output except that the recruitment time series was extended to 2009. The other parameters required for the forecast were derived from the appropriate assessment output or available data. Inputs to the forecasts based on the separable VPA runs are shown in Table 6.7.1. and those for the FLICA forecast in Table 6.7.2.

The interim catch used in each forecast consisted of the Irish quota for VIaS/VIIbc in 2012 plus the quota for VIaN which is traditionally taken on the boundary of the two areas (56°N) and is considered to be the southern stock. The catch was calculated as 7 607 t.

Results of the separable VPA forecasts are shown in Table 6.7.3. Assuming the terminal populations from the separable VPAs are indicative of stock status, fishing at $F_{0.1}$ (0.2) implies catches in 2013 of between 5 000 t and 10 000 t. Fishing at F_{MSY} (0.25) implies catches in 2013 of between 6 000 t and 13 000 t. Only the most optimistic of the separable VPA assessments (terminal F = 0.2) is associated with recovery to above B_{lim} in 2014 (fishing at F=0.1). None of the tested scenarios imply recovery to B_{pa} in 2014.

The FLICA forecasts were used to test the effect of implementing two proposed harvest rules: the generic ICES rule that reduces fishing mortality from F_{MSY} when below B_{pa} and a proposed rule from the Pelagic RAC which uses F=0.2 and B_{lim} (Table 6.7.4). The RAC proposed HCR is not specific on the F to be applied when the stock is judged to be below B_{lim}, but HAWG considers that a linear transition towards the origin is the most appropriate option. The ICES rule implies a fishing mortality of 0.110 in 2013 whereas the HAWG implementation of the Pelagic RAC rule implies 0.119. These HCRs imply catches of approximately 5 500 t with an SSB in 2013 of 59 000t.

6.8 Medium term simulations

No yield per recruit was performed in 2012.

6.9 Long term simulations

Work was conducted on simulating the long term dynamics of this stock for HAWG 2011. This work focused on using the converged part of the separable VPA exploratory assessments and projecting forward. The analysis aimed to define a range of target F, $B_{trigger}$ and percentage TAC constraints that would be appropriate for this stock. 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 76 000 t. When all of the data, including the periods of low and high productivity are used the breakpoint is 79 000 t which is in general agreement with the existing B_{lim} (81 000 t) (Clarke et al. WD02). HAWG considers that 76 000 t may be a better basis for B_{lim} for this stock.

In 2010, HAWG estimated $F_{0.1}$ as 0.2 and 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

In the 2009 acoustic survey, 1-ringer abundance was high and there are corresponding peaks at 2 and 3-ring in the 2010 and 2011 surveys suggesting that a strong year class may be 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 and underlies the lack of coherence in the catch-at-age matrix from year to year, which has been an ongoing feature of this assessment.

The various assessments presented are more indicative of the general state of the stock, but cannot provide precise estimates of current stock size. The separable VPAs rely on the catch data only, and the incoherence in cohort tracking in the catches is reflected in these assessments. The VPAs were 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. The retrospective analysis of the assessment suggests that an F of 0.2 underestimates mean F and SSB. Using the terminal F= 0.5 produces the most stable retrospective pattern implying that F may have been in the region of 0.5. There are however, concerns about the underlying assumptions of the separable VPA. The assumption of a constant selection pattern throughout the series is invalid.

The ICA assessments are quite uncertain, with wide confidence intervals for F and SSB. However the entire confidence interval for SSB is below B_{lim}. The survey used for tuning (VIa and VIIbc combined acoustic 2008-2011) is known to contain VIaN fish also, and therefore is not a good tuning index. However, if it is possible to segregate the index according to stock, then it could provide a basis for an assessment. The ICA assessments are considered to be the best indicator of stock development, because they include fisheries independent information.

The aggregate VIa/VIIbc assessment is not considered a basis for stock status, but it does underline the difficulty that arises by mixing with VIaN. It is likely that the VIaN assessment overestimates abundance of that stock because it is tuned using acoustic data comprising this stock.

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 low level of SSB ($<B_{lim}$) is clear and is unlikely due to such methodological issues.

The review group (ICES HAWG 2011) suggested that further work be carried out in relation to the acoustic survey time series. This data series now contains 4 data points and the exploratory assessments presented have investigated their utility within an ICA assessment. With regard to the mixing of different stock components during the survey and commercial fishery, further examination of the full Malin acoustic series as discussed in section 6.6.1 will be carried out. The stock annex will be revisited during a subsequent benchmark exercise when a full review of the available data will take place.

6.12 Management Considerations

Since 2000, reported landings have been much lower than previously. In recent years landings have been reduced each year. However SSB is estimated to remain below B_{lim}. This implies that a rebuilding plan is urgently required and should aim to keep catches at a low level until stock recovery can be confirmed. The rebuilding plan proposed by the Pelagic RAC can form the basis of a rebuilding plan, and HAWG presents an interpretation of the action to take when $SSB<B_{lim}$ linear reduction in F.

Evidence from the survey of a good incoming year class needs to be further corroborated in the next years. Strong year classes often do not fully recruit to the fishery until 4 or 5 ring. Until a better basis for assessing the stock is found, and until there is firm evidence of good recruiting year classes, rebuilding measures should be developed and implemented. These should include restrictions on catch. Such measures should apply in all areas where the stock is being caught.

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 instead feel that herring abundance is high.

6.13 Environment

6.13.1 Ecosystem Considerations

Grainger (1978; 1980) found significant negative correlations between sea surface temperature (SST) and catches from the west of Ireland component of this stock at a time lag of 3-4 years later. This indicates that recruitment responds favourably to cooler temperatures. Cannaby and Hosrevoglu (2009) present long time series of sea surface temperature for this stock area. In Figure 6.13.1 these data are combined with periods of good recruitment. It can be seen that strong historic herring recruitments/fisheries (Clarke *et al*., 2012 WD) correspond with cooler temperatures.

6.13.2 Changes in the Environment

Since the mid 1990s the AMO has been in a positive phase, indicating warmer sea temperatures in this area. However since 2010, there is some evidence that AMO may be entering a negative phase again, see http://www.esrl.noaa.gov/psd/data/timeseries/AMO/ (Figure, 6.13.2). Colder temperatures implied by such a negative phase may be associated with improved recruitment in this stock.

Table 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Estimated Herring catches in tonnes, 1988–2011. 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
France	-	-	+	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	250	-	-	11
Ireland	15,000	18,200	25,000	22,500	26,000	27,600	24,400	25,450
Netherlands	300	2,900	2,533	600	900	2,500	2,500	1,207
UK (N.Ireland)	-	-	80	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	50	24
UK Scotland	-	+	-	+	-	200	-	-
Total landings	15,300	21,100	27,613	23,100	27,150	30,300	26,950	26,692
Unallocated/ area mis-reported	13,800	7,100	13,826	11,200	4,600	6,250	6,250	1,100
Discards	-	1,000	2,530	3,400	100	250	700	-
WG catch	29,100	29,200	43,969	37,700	31,850	36,800	33,900	27,792

Country	1996	1997	1998	1999	2000	2001	2002	2003
France	-	-	-	-	-	-	515	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-
Ireland	23,800	24,400	25,200	16,325	10,164	11,278	13,072	12,921
Netherlands	1,800	3,400	2,500	1,868	1,234	2,088	366	-
UK (N.Ireland)	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	-	-
Total landings	25,600	27,800	27,700	18,193	11,398	13,366	13,953	12,921
Area misreported	6,900	-700	11,200	7,916	8,448	1,390	3,873	3,581
Unallocated	-	50		-				
Discards	32,500	27,150	38,900	26,109	-	-	-	-
WG catch					19,846	14,756	17,826	16,502

Country	2004	2005	2006	2007	2008	2009	2010	2011
France	-	-	-	-	-	-		
Germany, Fed.Rep.	-	-	-	-	-	-		
Ireland	10,950	13,351	14,840	12,662	10,237	8,533	7,513	4,247
Netherlands	64	-	353	13				
UK (N.Ireland)	-	-	-	-	-	-		
UK (England + Wales)	-	-	-	-	-	-		
UK Scotland	-	-	6	-	-			
Total landings	11,014	13,351	15,199	12,675	10,237	8,533	7,513	4,247
Area misreported	2,813	2,880	4,353	5,129	3,103	1,935	2,728	2,672
Unallocated			-353	-13				
Discards	-	-	-	-	-			
WG catch	13,827	16,231	19,193	17,791	13,340	10,468	10,241	6,919

Table 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Catch in numbers-at-age (winter rings) from 1957 to 2011.

	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
2011	121	14207	9315	9114	3386	3780	2871	980	95

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
2011	0	32	21	21	8	9	7	2	0

Table 6.2.2.1. Herring in Divisions VIa(S) and VIIb,c. Sampling intensity of catches in 2011

ICES area	Year	Qrt	Ldg (t)	No. Samples	No. Aged	No. Measured	Aged/ 1000 t
VIaS	2011	1	4071	12	936	3176	230
VIaS	2011	4	2718	11	744	2380	274
Total			6789	23	1680	5556	247

Table 6.2.2.2. Herring in Divisions VIa(S) and VIIb,c. Length distribution of Irish catches/quarter (thousands) 2011.

Length (cm)	Quarter 1 VIa South	Quarter 4 VIa South
21		30
21.5	31	30
22	353	53
22.5	746	53
23	989	243
23.5	1,029	456
24	1,107	926
24.5	919	1,245
25	730	1,731
25.5	738	2,210
26	903	2,650
26.5	950	2,392
27	1,413	1,670
27.5	1,829	1,238
28	2,167	1,192
28.5	2,670	881
29	2,897	600
29.5	2,301	334
30	1,680	114
30.5	769	8
31	416	15
31.5	188	
32	55	
32.5	24	
33	8	
33.5	24	
34		
Total	24,937	18,072

Table 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Time series of acoustic surveys since 1999-2007 (upper table). The 2008-2011 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^	2011*
0	-	-	-	-
1	12	416	17	45
2	83	81	293	86
3	65	11	85	147
4	38	15	63	29
5	22	8	43	6
6	29	7	27	4
7	9	7	19	5
8	5	0	13	2
9	2	1	6	1
10	2	0	0	1
Abundance (millions)	267	548	565	326
Total Biomass (t)	44,611	46,460	82,100	40,700
SSB (t)	43,006	20,906	81,400	28,600
CV	34%	38%	25%**	22%**

^ Survey coverage: VIaS & VIIb

* Survey coverage: VIaS, VIaN (to 56°N) &VIIb

** CV represents an area north of 56°N also

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	82,100	81,400
2011**	Feeding Phase	40,700	28,600

Table 6.3.1.3. Herring in Divisions VIa(S) and VIIb,c. Abundance at age (millions) in the Malin Shelf Survey, 2008-2011. This survey is thought to contain the VIaS/VIIbc stock, but also covers the VIaN stock.

	1	2	3	4	5	6	7	8	9
2008	55	295	996	715	365	299	727	371	265
2009	773	265	274	444	380	225	193	500	456
2010	442	844	398	193	157	108	78	109	187
2011	63	257	913	485	213	228	205	113	264

Table 6.6.1.1. Herring in Divisions VIa(S) and VIIb,c. VPA run with a terminal F value of 0.2.

Year	Recruitment	SSB	Landings	Mean F 3-6
1957	164054	27755	5070	0.2382
1958	312807	26990	6825	0.3468
1959	455623	35356	5226	0.2218
1960	249984	47456	5401	0.1035
1961	197893	48348	6182	0.1289
1962	274755	52001	7399	0.1446
1963	300418	62680	5059	0.0906
1964	286410	64684	6169	0.0958
1965	2330764	70249	8016	0.1325
1966	162377	177018	12215	0.2075
1967	459377	106354	18881	0.2437
1968	537358	147380	20731	0.1776
1969	347749	135910	19607	0.1761
1970	403100	125763	20306	0.1975
1971	813689	110638	15044	0.1726
1972	731245	114109	23474	0.2073
1973	531788	130566	36719	0.2888
1974	585886	91056	36589	0.4537
1975	405051	85810	38764	0.4424
1976	682710	63949	32767	0.5054
1977	572508	70401	20567	0.3227
1978	1042649	70221	19715	0.2661
1979	966066	96868	22608	0.2762
1980	526926	102412	30124	0.399
1981	668150	96364	24922	0.3198
1982	692469	106676	19209	0.2308
1983	2283692	104552	32988	0.3697
1984	948428	184351	27450	0.2102
1985	1215215	186039	23343	0.1757
1986	935892	220866	28785	0.1856
1987	3196100	199305	48600	0.3524
1988	475755	294607	29100	0.2773
1989	710261	219579	29210	0.186
1990	806182	189521	43969	0.2652
1991	501550	164335	37700	0.2488
1992	414982	131635	31856	0.2785
1993	615422	111722	36763	0.3593
1994	801783	93783	33908	0.3659
1995	457153	78912	27792	0.4716
1996	831051	62243	32534	0.5857
1997	819762	63491	27225	0.5388
1998	526148	52040	38895	1.0409
1999	385993	44251	26109	0.7112
2000	437429	36769	19846	0.5338
2001	446689	34167	14756	0.643
2002	548705	32753	17826	0.7135
2003	454679	37644	16502	0.6535
2004	479516	39800	13727	0.5929
2005	546617	40169	16231	0.591
2006	325630	39321	19193	0.8217
2007	188214	32886	17791	0.6058
2008	322575	25965	13340	0.5689
2009	273029	30346	10468	0.4527
2010	636553	28958	10241	0.4032
2011	243742	41241	6919	0.2647
Mean	531979*	92514	21830	0.361

***Geometric Mean recruitment 1957- 2010**

Table 6.6.1.2. 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	169171	28646	5070	0.231
1958	322991	28084	6825	0.3328
1959	468669	36910	5226	0.2114
1960	256163	49444	5401	0.0989
1961	202487	50378	6182	0.1236
1962	280461	54345	7399	0.1385
1963	305696	65523	5059	0.0872
1964	290867	67321	6169	0.0927
1965	2362330	73068	8016	0.1289
1966	164124	181414	12215	0.2015
1967	463140	108985	18881	0.2364
1968	540811	150840	20731	0.1731
1969	349268	138885	19607	0.1724
1970	404746	128423	20306	0.1947
1971	817385	112946	15044	0.1702
1972	734997	116268	23474	0.2052
1973	534815	133307	36719	0.2862
1974	589474	92451	36589	0.4492
1975	408422	87251	38764	0.4364
1976	688415	65165	32767	0.4972
1977	577921	71730	20567	0.3167
1978	1054691	71601	19715	0.2615
1979	978991	98687	22608	0.2708
1980	533643	104574	30124	0.3904
1981	675753	98789	24922	0.3113
1982	701147	109252	19209	0.2248
1983	2310315	107530	32988	0.3604
1984	959327	188457	27450	0.2048
1985	1226511	189914	23343	0.1715
1986	943176	225121	28785	0.1816
1987	3217341	203572	48600	0.345
1988	478310	299286	29100	0.2716
1989	712952	223102	29210	0.1827
1990	807939	192629	43969	0.2612
1991	502188	166691	37700	0.2454
1992	415276	133531	31856	0.2761
1993	615779	113286	36763	0.3569
1994	802285	95035	33908	0.364
1995	457432	79394	27792	0.4695
1996	831428	62548	32534	0.5841
1997	820137	63719	27225	0.5373
1998	526297	52162	38895	1.0364
1999	385613	44349	26109	0.7074
2000	437045	36854	19846	0.5323
2001	445136	34202	14756	0.6409
2002	545132	32711	17826	0.7124
2003	448708	37450	16502	0.6549
2004	467367	39366	13727	0.5983
2005	519637	39280	16231	0.5996
2006	295651	37442	19193	0.8511
2007	158201	29945	17791	0.6503
2008	235415	21886	13340	0.6534
2009	168753	22292	10468	0.5795
2010	317201	17433	10241	0.6176
2011	104850	19644	6919	0.5213
Mean	517847*	93329	21830	0.3711

***Geometric mean recruitment: 1957-2010**

Table 6.6.1.3. 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	170808	28933	5070	0.2288
1958	326238	28437	6825	0.3285
1959	472817	37409	5226	0.2083
1960	258125	50082	5401	0.0976
1961	203944	51027	6182	0.1219
1962	282268	55094	7399	0.1367
1963	307363	66429	5059	0.0862
1964	292271	68160	6169	0.0917
1965	2372256	73963	8016	0.1278
1966	164671	182805	12215	0.1997
1967	464322	109816	18881	0.2343
1968	541900	151932	20731	0.1718
1969	349751	139822	19607	0.1712
1970	405272	129260	20306	0.1938
1971	818568	113672	15044	0.1695
1972	736194	116947	23474	0.2046
1973	535779	134169	36719	0.2854
1974	590618	92893	36589	0.4478
1975	409499	87708	38764	0.4345
1976	690236	65552	32767	0.4947
1977	579644	72154	20567	0.3148
1978	1058525	72042	19715	0.26
1979	983083	99266	22608	0.2691
1980	535765	105261	30124	0.3878
1981	678151	99559	24922	0.3087
1982	703887	110070	19209	0.2229
1983	2318683	108475	32988	0.3576
1984	962740	189755	27450	0.2032
1985	1230044	191136	23343	0.1702
1986	945449	226460	28785	0.1803
1987	3223947	204913	48600	0.3427
1988	479105	300752	29100	0.2698
1989	713786	224205	29210	0.1818
1990	808482	193600	43969	0.26
1991	502387	167426	37700	0.2444
1992	415368	134121	31856	0.2754
1993	615893	113772	36763	0.3561
1994	802445	95424	33908	0.3634
1995	457522	79543	27792	0.4688
1996	831556	62643	32534	0.5836
1997	820276	63791	27225	0.5368
1998	526372	52202	38895	1.0349
1999	385536	44383	26109	0.7062
2000	436967	36885	19846	0.5318
2001	444824	34219	14756	0.6402
2002	544419	32709	17826	0.7118
2003	447516	37418	16502	0.6549
2004	464984	39284	13727	0.5995
2005	514471	39105	16231	0.6014
2006	289813	37076	19193	0.8573
2007	152205	29371	17791	0.6599
2008	217784	21083	13340	0.6731
2009	147868	20684	10468	0.6135
2010	255818	15113	10241	0.6909
2011	80069	15386	6919	0.648
Mean	514262*	93698	21830	0.3748

*** Geometric mean recruitment 1957-2010**

Table 6.6.1.4. 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	172128	29166	5070	0.227
1958	328849	28722	6825	0.3251
1959	476149	37812	5226	0.2058
1960	259700	50595	5401	0.0965
1961	205113	51549	6182	0.1207
1962	283718	55696	7399	0.1353
1963	308699	67159	5059	0.0854
1964	293395	68834	6169	0.0909
1965	2380194	74682	8016	0.1269
1966	165108	183919	12215	0.1983
1967	465267	110481	18881	0.2325
1968	542772	152805	20731	0.1707
1969	350139	140572	19607	0.1703
1970	405694	129930	20306	0.1931
1971	819521	114253	15044	0.1689
1972	737156	117492	23474	0.2041
1973	536555	134858	36719	0.2847
1974	591538	93246	36589	0.4466
1975	410365	88075	38764	0.433
1976	691701	65864	32767	0.4927
1977	581028	72495	20567	0.3133
1978	1061605	72396	19715	0.2589
1979	986365	99732	22608	0.2678
1980	537464	105813	30124	0.3857
1981	680070	100178	24922	0.3067
1982	706081	110726	19209	0.2214
1983	2325372	109232	32988	0.3554
1984	965463	190794	27450	0.2019
1985	1232862	192115	23343	0.1692
1986	947259	227530	28785	0.1793
1987	3229203	205984	48600	0.3409
1988	479737	301922	29100	0.2685
1989	714450	225085	29210	0.181
1990	808913	194375	43969	0.259
1991	502545	168011	37700	0.2436
1992	415441	134591	31856	0.2748
1993	615984	114159	36763	0.3555
1994	802574	95733	33908	0.3629
1995	457594	79662	27792	0.4683
1996	831660	62719	32534	0.5833
1997	820393	63848	27225	0.5364
1998	526439	52234	38895	1.0338
1999	385485	44410	26109	0.7053
2000	436915	36911	19846	0.5313
2001	444618	34233	14756	0.6396
2002	543947	32711	17826	0.7112
2003	446725	37398	16502	0.6549
2004	463416	39231	13727	0.6002
2005	511140	38991	16231	0.6026
2006	286017	36837	19193	0.8614
2007	148250	28997	17791	0.6663
2008	206033	20557	13340	0.6867
2009	133944	19622	10468	0.6379
2010	215500	13569	10241	0.7497
2011	64302	12561	6919	0.7737
Mean	511641*	94019	21830	0.3781

*** Geometric mean recruitment 1957-2010**

Table 6.6.1.5 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	-1.605	-0.647	0.571	1.25	2.862	0.171	0.068	0.363	0.138
2/3	0.751	0.031	-0.099	0.641	1.035	0.105	0.672	0.313	-0.194
3/4	0.864	-0.412	-0.632	-0.019	0.567	0.383	0.449	-0.264	0.387
4/5	-0.788	0.041	0.605	0.158	0.408	0.494	-0.071	0.608	0.533
5/6	0.273	0.106	0.589	-0.352	-0.221	-0.405	-0.312	0.079	-0.094
6/7	-0.417	0.167	-0.421	-0.115	-0.586	-0.447	-0.274	-0.589	-1.143
7/8	-0.521	0.134	-0.097	-0.435	-1.488	-0.145	-0.469	-0.182	0.498
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.002	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	-0.803	-3.37	0.808	0.851	-0.166	0.917	0.49	2.78	1.507
2/3	-0.401	-1.014	0.325	-0.049	1.767	-0.305	0.155	0.71	0.564
3/4	0.17	-0.594	0.077	-0.081	0.477	0.473	0.271	0.179	0.101
4/5	0.281	0.546	0.289	-0.027	-0.075	0.235	-0.207	-0.056	0.253
5/6	0.192	0.254	-0.108	0.042	-0.606	0.019	-0.253	-0.312	-0.017
6/7	-0.106	0.652	0.034	0.113	-0.725	-0.041	-0.177	-0.125	-0.247
7/8	-0.054	0.493	-0.697	-0.082	-0.82	-0.472	0.163	-0.674	-0.803
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	2.729	2.477	1.559	2.357	2.341	1.622	1.323	0.367	-0.693
2/3	0.564	0.63	0.703	1.159	0.436	0.077	0.483	-0.114	0.181
3/4	-0.255	-0.031	-0.392	0.132	-0.174	0.232	0.024	-0.091	0.182
4/5	-0.206	-0.18	-0.034	0.078	-0.114	0.067	0.077	0.087	0.316
5/6	-0.048	-0.181	0.181	-0.164	0.046	-0.193	-0.135	0.079	-0.168
6/7	0.088	-0.256	0.075	-0.539	-0.069	-0.066	0.423	0.158	-0.082
7/8	-0.415	-0.23	-0.688	-0.9	-0.357	-0.278	-1.004	-0.155	-0.358
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	2.186	2.996	0.738	2.609	-2.877	1.85	0.275	0.842	2.179
2/3	0.573	-0.067	-0.002	-0.094	-0.563	-0.293	0.308	0.238	0.323
3/4	0.642	0.01	0.116	0.032	0.445	-0.477	0.286	-0.094	0.125
4/5	0.216	-0.221	0.022	-0.167	0.436	0.16	0.151	-0.239	0.145
5/6	-0.419	0.148	0.267	-0.095	0.117	0.035	-0.08	-0.036	-0.196
6/7	-0.143	-0.018	-0.268	-0.212	0.161	-0.229	-0.203	0.27	-0.154
7/8	-1.086	-0.152	-0.208	0.275	-0.307	0.62	-0.489	-0.223	-0.461
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	1999/00	2000/01	2001/02
1/2	-1.715	2.858	-0.103	1.456	2.139	1.634	0.935	2.27	1.503
2/3	-0.015	0.832	0.047	0.221	0.335	-0.016	0.221	0.773	-0.06
3/4	0.083	0.273	0.24	0.178	-0.422	-0.163	-0.081	0.44	-0.049
4/5	0.328	-0.487	0.617	0.199	0.035	0.109	0.015	0.004	0.061
5/6	0.073	-0.197	0.058	-0.226	0.073	0.187	0.179	-0.371	0.076
6/7	-0.135	0.241	0.394	-0.25	-0.395	-0.02	0.124	-0.342	0.646
7/8	-0.162	-0.947	-1.346	-0.267	0.16	-0.26	-0.55	-0.729	-0.824
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	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/2011
½	1.673	1.58	0.996	-0.367	-0.095	-1.217	0.444	-0.353	1.134
2/3	0.228	0.116	-0.334	0.354	-0.749	0.453	0.111	-0.2	0.375
¾	-0.168	-0.181	-0.072	-0.06	-0.345	-0.019	-0.082	0.253	0.19
4/5	-0.09	0.279	0.186	-0.03	-0.178	0.137	0.108	-0.018	-0.054
5/6	-0.153	-0.222	-0.071	-0.228	0.222	0.057	-0.116	-0.011	-0.15
6/7	0.299	0.202	0.596	0.29	0.295	-0.212	0.077	-0.04	-0.115
7/8	-0.284	-0.351	-0.404	-0.289	0.764	-0.295	-0.142	0.052	-0.36
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	1	1	1	1	1

Table 6.6.1.6 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	-1.71	-0.754	0.469	1.152	2.763	0.073	-0.028	0.268	0.041
2/3	0.702	-0.023	-0.148	0.595	0.989	0.058	0.628	0.269	-0.239
3/4	0.853	-0.425	-0.645	-0.031	0.556	0.371	0.438	-0.274	0.376
4/5	-0.779	0.05	0.612	0.164	0.415	0.5	-0.066	0.613	0.539
5/6	0.297	0.132	0.613	-0.33	-0.199	-0.383	-0.291	0.1	-0.072
6/7	-0.385	0.203	-0.387	-0.083	-0.554	-0.414	-0.243	-0.558	-1.112
7/8	-0.516	0.14	-0.089	-0.428	-1.481	-0.138	-0.462	-0.175	0.505
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.002	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	-0.902	-3.47	0.709	0.752	-0.264	0.819	0.391	2.678	1.403
2/3	-0.448	-1.062	0.278	-0.097	1.72	-0.351	0.107	0.661	0.511
3/4	0.159	-0.605	0.066	-0.093	0.465	0.462	0.26	0.168	0.089
4/5	0.288	0.554	0.297	-0.02	-0.068	0.242	-0.199	-0.046	0.264
5/6	0.215	0.277	-0.085	0.065	-0.584	0.041	-0.23	-0.287	0.01
6/7	-0.074	0.685	0.065	0.145	-0.693	-0.01	-0.146	-0.094	-0.215
7/8	-0.048	0.499	-0.691	-0.075	-0.814	-0.465	0.168	-0.67	-0.8
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	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/2	2.621	2.37	1.457	2.256	2.237	1.518	1.222	0.264	-0.796
2/3	0.51	0.574	0.652	1.109	0.385	0.025	0.433	-0.164	0.129
3/4	-0.267	-0.044	-0.404	0.12	-0.185	0.219	0.012	-0.101	0.169
4/5	-0.193	-0.168	-0.025	0.087	-0.105	0.076	0.085	0.096	0.324
5/6	-0.019	-0.151	0.207	-0.139	0.071	-0.167	-0.11	0.104	-0.142
6/7	0.121	-0.221	0.109	-0.507	-0.037	-0.032	0.456	0.19	-0.048
7/8	-0.413	-0.226	-0.683	-0.895	-0.353	-0.272	-0.998	-0.15	-0.352
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	2.087	2.898	0.637	2.508	-2.975	1.751	0.175	0.743	2.079
2/3	0.526	-0.113	-0.049	-0.144	-0.61	-0.34	0.259	0.19	0.275
3/4	0.631	-0.001	0.106	0.02	0.434	-0.488	0.275	-0.106	0.114
4/5	0.222	-0.214	0.03	-0.159	0.443	0.168	0.159	-0.231	0.154
5/6	-0.397	0.17	0.29	-0.07	0.14	0.058	-0.056	-0.012	-0.172
6/7	-0.111	0.014	-0.237	-0.178	0.192	-0.198	-0.171	0.302	-0.123
7/8	-1.079	-0.145	-0.203	0.281	-0.301	0.626	-0.483	-0.218	-0.456
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	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	2000/01	2001/02
1/2	-1.815	2.758	-0.205	1.353	2.031	1.525	0.831	2.167	1.399
2/3	-0.065	0.782	-0.003	0.167	0.28	-0.077	0.165	0.72	-0.113
3/4	0.072	0.261	0.23	0.167	-0.432	-0.177	-0.094	0.428	-0.06
4/5	0.337	-0.478	0.628	0.211	0.05	0.125	0.028	0.016	0.074
5/6	0.098	-0.171	0.084	-0.198	0.103	0.223	0.209	-0.344	0.105
6/7	-0.103	0.272	0.424	-0.218	-0.365	0.016	0.158	-0.31	0.677
7/8	-0.157	-0.942	-1.342	-0.265	0.16	-0.262	-0.549	-0.727	-0.822
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	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
1/2	1.571	1.482	0.901	-0.456	-0.165	-1.264	0.434	-0.315	1.232
2/3	0.174	0.064	-0.383	0.308	-0.788	0.427	0.105	-0.182	0.428
3/4	-0.18	-0.193	-0.083	-0.069	-0.354	-0.024	-0.083	0.257	0.202
4/5	-0.077	0.291	0.197	-0.019	-0.168	0.143	0.109	-0.024	-0.065
5/6	-0.123	-0.195	-0.045	-0.204	0.244	0.071	-0.113	-0.023	-0.178
6/7	0.332	0.234	0.625	0.315	0.318	-0.197	0.081	-0.052	-0.146
7/8	-0.283	-0.349	-0.401	-0.287	0.764	-0.293	-0.142	0.055	-0.365
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	1	1	1	1	1

Table 6.6.1.7 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	-1.743	-0.788	0.436	1.121	2.732	0.043	-0.058	0.238	0.011
2/3	0.687	-0.039	-0.163	0.581	0.975	0.044	0.615	0.255	-0.252
3/4	0.85	-0.429	-0.648	-0.034	0.553	0.367	0.435	-0.278	0.373
4/5	-0.776	0.052	0.614	0.166	0.416	0.501	-0.065	0.614	0.54
5/6	0.305	0.14	0.62	-0.324	-0.192	-0.377	-0.285	0.106	-0.066
6/7	-0.375	0.214	-0.376	-0.073	-0.544	-0.404	-0.233	-0.548	-1.102
7/8	-0.514	0.142	-0.087	-0.426	-1.479	-0.135	-0.46	-0.172	0.507
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.002	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	-0.933	-3.501	0.678	0.721	-0.294	0.788	0.359	2.646	1.37
2/3	-0.462	-1.076	0.264	-0.111	1.706	-0.365	0.093	0.646	0.495
3/4	0.155	-0.609	0.063	-0.096	0.462	0.459	0.257	0.165	0.086
4/5	0.29	0.556	0.299	-0.018	-0.066	0.244	-0.197	-0.043	0.267
5/6	0.221	0.284	-0.079	0.072	-0.577	0.047	-0.223	-0.279	0.019
6/7	-0.064	0.695	0.076	0.155	-0.683	-0.001	-0.135	-0.084	-0.204
7/8	-0.046	0.501	-0.689	-0.074	-0.812	-0.464	0.17	-0.668	-0.799
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	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/2	2.588	2.337	1.424	2.224	2.205	1.485	1.19	0.231	-0.828
2/3	0.493	0.557	0.637	1.094	0.37	0.009	0.418	-0.179	0.114
3/4	-0.27	-0.048	-0.408	0.117	-0.188	0.216	0.009	-0.105	0.165
4/5	-0.19	-0.165	-0.023	0.089	-0.102	0.078	0.087	0.099	0.326
5/6	-0.011	-0.142	0.214	-0.132	0.079	-0.159	-0.103	0.111	-0.135
6/7	0.131	-0.209	0.119	-0.497	-0.026	-0.021	0.467	0.2	-0.037
7/8	-0.412	-0.225	-0.681	-0.893	-0.351	-0.271	-0.996	-0.149	-0.35
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	2.056	2.867	0.605	2.476	-3.006	1.719	0.144	0.712	2.047
2/3	0.512	-0.127	-0.063	-0.159	-0.624	-0.354	0.245	0.176	0.26
3/4	0.628	-0.004	0.103	0.016	0.431	-0.492	0.271	-0.109	0.111
4/5	0.224	-0.213	0.032	-0.157	0.445	0.17	0.161	-0.229	0.156
5/6	-0.39	0.177	0.297	-0.063	0.146	0.065	-0.049	-0.005	-0.165
6/7	-0.101	0.024	-0.227	-0.167	0.203	-0.188	-0.161	0.312	-0.113
7/8	-1.077	-0.143	-0.201	0.283	-0.299	0.628	-0.481	-0.216	-0.454
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	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	2000/01	2001/02
1/2	-1.847	2.726	-0.237	1.32	1.997	1.491	0.798	2.135	1.367
2/3	-0.08	0.767	-0.018	0.151	0.264	-0.096	0.148	0.704	-0.129
3/4	0.068	0.258	0.226	0.163	-0.435	-0.181	-0.098	0.425	-0.063
4/5	0.34	-0.475	0.631	0.214	0.054	0.13	0.032	0.019	0.077
5/6	0.106	-0.164	0.092	-0.189	0.112	0.234	0.219	-0.335	0.113
6/7	-0.093	0.282	0.434	-0.207	-0.355	0.027	0.169	-0.3	0.687
7/8	-0.156	-0.941	-1.341	-0.264	0.16	-0.263	-0.548	-0.726	-0.822
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	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
1/2	1.539	1.45	0.87	-0.486	-0.19	-1.284	0.425	-0.305	1.278
2/3	0.157	0.049	-0.398	0.294	-0.801	0.417	0.101	-0.177	0.452
3/4	-0.183	-0.197	-0.086	-0.072	-0.357	-0.027	-0.084	0.258	0.208
4/5	-0.073	0.294	0.2	-0.015	-0.165	0.145	0.11	-0.025	-0.07
5/6	-0.114	-0.187	-0.038	-0.196	0.252	0.076	-0.111	-0.026	-0.19
6/7	0.342	0.244	0.635	0.324	0.326	-0.191	0.084	-0.056	-0.161
7/8	-0.282	-0.348	-0.4	-0.286	0.764	-0.292	-0.142	0.056	-0.367
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	0.001	0.001	0.001	1	1	1	1	1

Table 6.6.1.8 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	-1.769	-0.815	0.411	1.096	2.707	0.018	-0.082	0.214	-0.014
2/3	0.675	-0.051	-0.175	0.57	0.964	0.033	0.605	0.245	-0.263
3/4	0.847	-0.432	-0.651	-0.037	0.55	0.365	0.432	-0.28	0.371
4/5	-0.774	0.054	0.615	0.167	0.417	0.502	-0.064	0.615	0.542
5/6	0.31	0.146	0.625	-0.319	-0.187	-0.372	-0.281	0.11	-0.061
6/7	-0.366	0.223	-0.368	-0.065	-0.536	-0.395	-0.225	-0.54	-1.094
7/8	-0.513	0.143	-0.085	-0.424	-1.478	-0.134	-0.458	-0.171	0.509
TOT	0.002	0.002	0.002	0.002	0.002	0.002	0.002	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	-0.958	-3.526	0.653	0.696	-0.319	0.764	0.334	2.62	1.344
2/3	-0.473	-1.087	0.253	-0.122	1.695	-0.375	0.082	0.634	0.483
3/4	0.153	-0.611	0.06	-0.099	0.459	0.456	0.254	0.163	0.083
4/5	0.291	0.557	0.3	-0.016	-0.065	0.246	-0.195	-0.041	0.269
5/6	0.226	0.289	-0.074	0.077	-0.572	0.052	-0.217	-0.273	0.025
6/7	-0.056	0.703	0.084	0.163	-0.675	0.007	-0.127	-0.076	-0.196
7/8	-0.045	0.503	-0.688	-0.072	-0.81	-0.462	0.171	-0.668	-0.798
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	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84
1/2	2.56	2.31	1.398	2.198	2.178	1.459	1.164	0.205	-0.854
2/3	0.481	0.544	0.625	1.083	0.358	-0.003	0.407	-0.19	0.102
3/4	-0.273	-0.051	-0.411	0.114	-0.191	0.213	0.006	-0.107	0.162
4/5	-0.187	-0.163	-0.021	0.091	-0.1	0.08	0.089	0.101	0.328
5/6	-0.004	-0.136	0.22	-0.126	0.084	-0.153	-0.098	0.117	-0.129
6/7	0.14	-0.2	0.128	-0.488	-0.018	-0.012	0.475	0.208	-0.028
7/8	-0.412	-0.224	-0.68	-0.892	-0.35	-0.27	-0.995	-0.148	-0.349
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	2.031	2.842	0.58	2.45	-3.031	1.694	0.118	0.687	2.022
2/3	0.501	-0.137	-0.075	-0.171	-0.635	-0.365	0.234	0.165	0.249
3/4	0.625	-0.007	0.1	0.013	0.428	-0.494	0.268	-0.112	0.108
4/5	0.225	-0.211	0.034	-0.155	0.446	0.171	0.163	-0.227	0.158
5/6	-0.385	0.182	0.302	-0.057	0.151	0.07	-0.044	0	-0.159
6/7	-0.093	0.032	-0.219	-0.159	0.211	-0.18	-0.153	0.32	-0.105
7/8	-1.076	-0.141	-0.2	0.284	-0.298	0.629	-0.48	-0.215	-0.453
TOT	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	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	2000/01	2001/02
1/2	-1.873	2.701	-0.263	1.294	1.97	1.464	0.772	2.109	1.34
2/3	-0.092	0.756	-0.03	0.139	0.251	-0.11	0.134	0.692	-0.141
3/4	0.066	0.255	0.224	0.161	-0.437	-0.184	-0.101	0.422	-0.066
4/5	0.342	-0.473	0.634	0.217	0.058	0.133	0.034	0.021	0.08
5/6	0.111	-0.158	0.098	-0.183	0.119	0.242	0.226	-0.329	0.12
6/7	-0.084	0.291	0.442	-0.199	-0.347	0.037	0.178	-0.292	0.695
7/8	-0.155	-0.94	-1.341	-0.264	0.16	-0.263	-0.548	-0.725	-0.822
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	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11
1/2	1.512	1.425	0.845	-0.51	-0.212	-1.301	0.416	-0.298	1.322
2/3	0.145	0.037	-0.409	0.282	-0.812	0.409	0.096	-0.174	0.473
3/4	-0.186	-0.199	-0.089	-0.074	-0.359	-0.028	-0.085	0.259	0.212
4/5	-0.071	0.296	0.202	-0.013	-0.162	0.147	0.111	-0.026	-0.074
5/6	-0.107	-0.18	-0.032	-0.19	0.258	0.081	-0.108	-0.028	-0.202
6/7	0.351	0.252	0.643	0.331	0.334	-0.185	0.087	-0.058	-0.175
7/8	-0.282	-0.347	-0.4	-0.286	0.763	-0.292	-0.142	0.057	-0.367
TOT	0	0	0	0	0	0	0	0	0
WTS	0.001	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.	497 274	500 247	501 313	502 197
F (1 ring)	0.002	0.003	0.003	0.004
M 1 ring	1	1	1	1
2 ring 2011	183 599	183 501	183 806	184 053
F-at-age				
1	0.002	0.003	0.003	0.004
2	0.168	0.224	0.245	0.264
3	0.372	0.475	0.512	0.543
4	0.486	0.602	0.643	0.678
5	0.584	0.715	0.762	0.802
6	0.636	0.791	0.846	0.894
7	0.655	0.815	0.873	0.924
8	0.397	0.509	0.549	0.584
9	0.397	0.509	0.549	0.584
Interim catch (t)	7 607	7 607	7 607	7 607
Biomass (t)	109 977	85 331	80 602	77 509
SSB (t)	55 456	32 977	28 630	25 778
F Multiplier	0.361	0.548	0.616	0.671
F Bar (3-6)	0.187	0.354	0.423	0.489

Table 6.7.2. Herring in Divisions VIa(S) and VIIb,c. Inputs to exploratory deterministic FLICA short term forecasts.

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	473854	1	0	0.67	0.67	0.082	0.001	0.092
2	174137	0.3	1	0.67	0.67	0.129	0.144	0.133
3	123000	0.2	1	0.67	0.67	0.152	0.317	0.160
4	38679	0.1	1	0.67	0.67	0.188	0.403	0.186
5	25187	0.1	1	0.67	0.67	0.207	0.445	0.198
6	8370	0.1	1	0.67	0.67	0.219	0.403	0.207

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	473854	1	0	0.67	0.67	0.082	0.001	0.092
2		0.3	1	0.67	0.67	0.129	0.144	0.133
3		0.2	1	0.67	0.67	0.152	0.317	0.160
4		0.1	1	0.67	0.67	0.188	0.403	0.186
5		0.1	1	0.67	0.67	0.207	0.445	0.198
6		0.1	1	0.67	0.67	0.219	0.403	0.207

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	473854	1	0	0.67	0.67	0.082	0.001	0.092
2		0.3	1	0.67	0.67	0.129	0.144	0.133
3		0.2	1	0.67	0.67	0.152	0.317	0.160
4		0.1	1	0.67	0.67	0.188	0.403	0.186
5		0.1	1	0.67	0.67	0.207	0.445	0.198
6		0.1	1	0.67	0.67	0.219	0.403	0.207

Population vector (N) in 2012 is taken from the final assessment with 1 ringers replaced by geometric mean recruitment from 1957 to 2009. Numbers of 2 ringers are derived from geometric mean reduced by natural and fishing mortality at age 1 from the assessment. Mean weights in the catch (CWt) and stock (SWt), natural mortality (M) and mortality proportions (PM, PF) are means over the last 3 years. The selection vector (Sel) is that from the assessment.

Table 6.7.3. Herring in Divisions VIa(S) and VIIb,c. Results of exploratory short term deterministic forecasts, based on four separable VPA runs.

	2013				2014	
Run	SSB	FMult	FBar	Landings	Biomass	SSB
0.2	72278	0	0	0	142175	90815
	70406	0.1	0.052	2844	139203	85570
	68591	0.2	0.1039	5567	136361	80709
	66830	0.3	0.1559	8174	133644	76202
	65121	0.4	0.2078	10670	131045	72021
	63463	0.5	0.2598	13061	128559	68139
	61854	0.6	0.3117	15353	126180	64533
	60293	0.7	0.3637	17548	123903	61181
	58778	0.8	0.4156	19653	121724	58064
	57307	0.9	0.4676	21671	119637	55163
	55879	1	0.5195	23606	117639	52461
	54493	1.1	0.5715	25462	115726	49943
	53147	1.2	0.6234	27243	113893	47595
	51841	1.3	0.6754	28951	112137	45403
	50572	1.4	0.7273	30592	110454	43357
	49340	1.5	0.7793	32166	108840	41444
	48143	1.6	0.8312	33679	107294	39656
	46981	1.7	0.8832	35131	105811	37981
	45851	1.8	0.9351	36527	104388	36413
	44754	1.9	0.9871	37868	103023	34943
	43689	2	1.039	39157	101714	33564

	2013				2014	
Run	SSB	FMult	FBar	Landings	Biomass	SSB
0.4	49472	0	0	0	118649	68563
	48084	0.1	0.0646	2161	116405	64392
	46742	0.2	0.1291	4222	114270	60557
	45445	0.3	0.1937	6187	112237	57026
	44189	0.4	0.2582	8062	110302	53773
	42975	0.5	0.3228	9851	108458	50773
	41800	0.6	0.3873	11560	106701	48003
	40663	0.7	0.4519	13191	105026	45443
	39562	0.8	0.5164	14750	103430	43076
	38497	0.9	0.581	16239	101907	40884
	37466	1	0.6455	17663	100454	38852
	36467	1.1	0.7101	19024	99068	36966
	35500	1.2	0.7747	20327	97745	35215
	34564	1.3	0.8392	21574	96481	33587
	33657	1.4	0.9038	22767	95275	32071
	32778	1.5	0.9683	23910	94122	30659
	31927	1.6	1.0329	25005	93020	29342
	31102	1.7	1.0974	26054	91966	28112
	30302	1.8	1.162	27059	90958	26962
	29527	1.9	1.2265	28024	89995	25885
	28776	2	1.2911	28949	89072	24877

		2013			2014	
Run	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	SSB
0.5	45117	0	0	0	114196	64308
	43818	0.1	0.069	2041	112083	60313
	42562	0.2	0.1381	3985	110074	56647
	41349	0.3	0.2071	5837	108164	53280
	40177	0.4	0.2762	7601	106348	50184
	39043	0.5	0.3452	9284	104619	47334
	37947	0.6	0.4143	10889	102974	44708
	36888	0.7	0.4833	12420	101409	42285
	35863	0.8	0.5524	13882	99917	40048
	34872	0.9	0.6214	15278	98496	37980
	33913	1	0.6904	16611	97142	36066
	32985	1.1	0.7595	17884	95852	34292
	32088	1.2	0.8285	19102	94621	32647
	31219	1.3	0.8976	20266	93447	31119
	30378	1.4	0.9666	21380	92326	29698
	29564	1.5	1.0357	22446	91257	28376
	28775	1.6	1.1047	23467	90236	27143
	28012	1.7	1.1738	24444	89260	25993
	27273	1.8	1.2428	25380	88328	24919
	26556	1.9	1.3118	26277	87437	23914
	25862	2	1.3809	27138	86586	22973

		2013			2014	
Run	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
0.6	42279	0	0	0	111306	61532
	41032	0.1	0.0729	1973	109268	57627
	39827	0.2	0.1459	3851	107332	54052
	38663	0.3	0.2188	5638	105494	50774
	37540	0.4	0.2917	7339	103747	47765
	36454	0.5	0.3647	8960	102087	45001
	35405	0.6	0.4376	10505	100508	42458
	34392	0.7	0.5105	11977	99007	40117
	33412	0.8	0.5835	13382	97579	37958
	32465	0.9	0.6564	14722	96220	35964
	31550	1	0.7293	16000	94926	34122
	30665	1.1	0.8023	17222	93693	32418
	29809	1.2	0.8752	18388	92519	30839
	28981	1.3	0.9481	19502	91400	29374
	28181	1.4	1.021	20568	90333	28013
	27406	1.5	1.094	21587	89316	26748
	26656	1.6	1.1669	22561	88345	25570
	25930	1.7	1.2398	23494	87418	24471
	25228	1.8	1.3128	24387	86534	23446
	24548	1.9	1.3857	25243	85689	22488
	23890	2	1.4586	26063	84882	21591

Table 6.7.4. Herring in Divisions VIa(S) and VIIb,c. Results of exploratory short term forecast in ICA.

Rationale	Fbar (2012)	Catch (2012)	SSB (2012)	Fbar (2013)	Catch (2013)	SSB (2013)	SSB (2014)
Catch(2013) = Zero	0.206	7607	47301	0.000	0	62825	80419
Catch(2013) = 2012 TAC -15% (3607 t)	0.206	7607	47301	0.073	3610	60455	73841
Catch(2013) = 2012 TAC sq (4247 t)	0.206	7607	47301	0.086	4247	60032	72712
Catch(2013) = 2012 TAC +15% (4884 t)	0.206	7607	47301	0.100	4884	59608	71591
Catch(2013) = 2012 TAC + 25% (5309 t)	0.206	7607	47301	0.109	5309	59324	70849
Catch(2013) = 2012 TAC + 30% (5521 t)	0.206	7607	47301	0.114	5521	59182	70479
Fbar(2013) = 0.20	0.206	7607	47301	0.200	9379	56569	63947
Fbar(2013) = 0.25	0.206	7607	47301	0.250	11484	55118	60527
Fbar(2013) = 0.110 (ICES HCR)	0.206	7607	47301	0.110	5357	59292	70766
Fbar(2013) = 0.119 (Pelagic RAC HCR)	0.206	7607	47301	0.119	5773	59013	70043

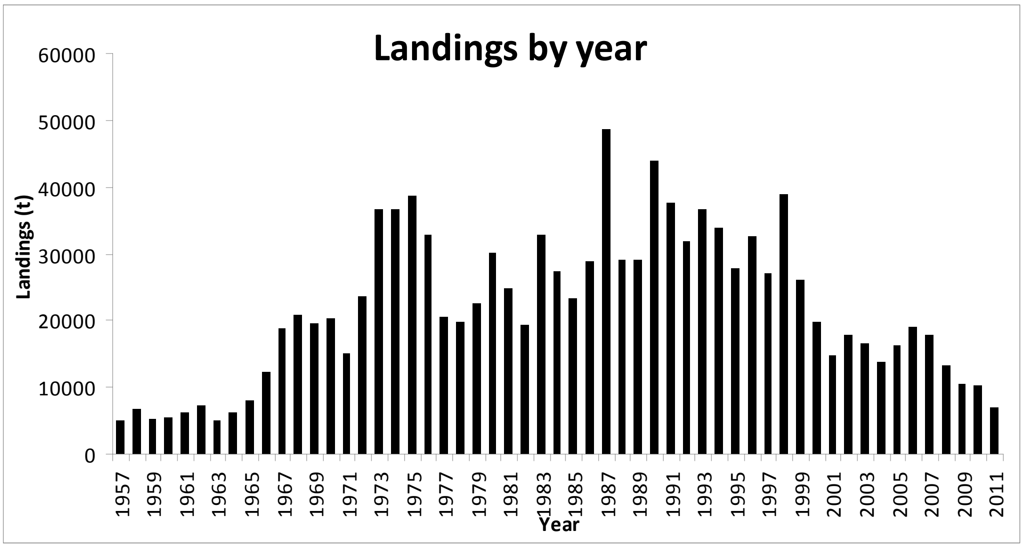


Figure 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Working group estimate of catches from 1957-2011.

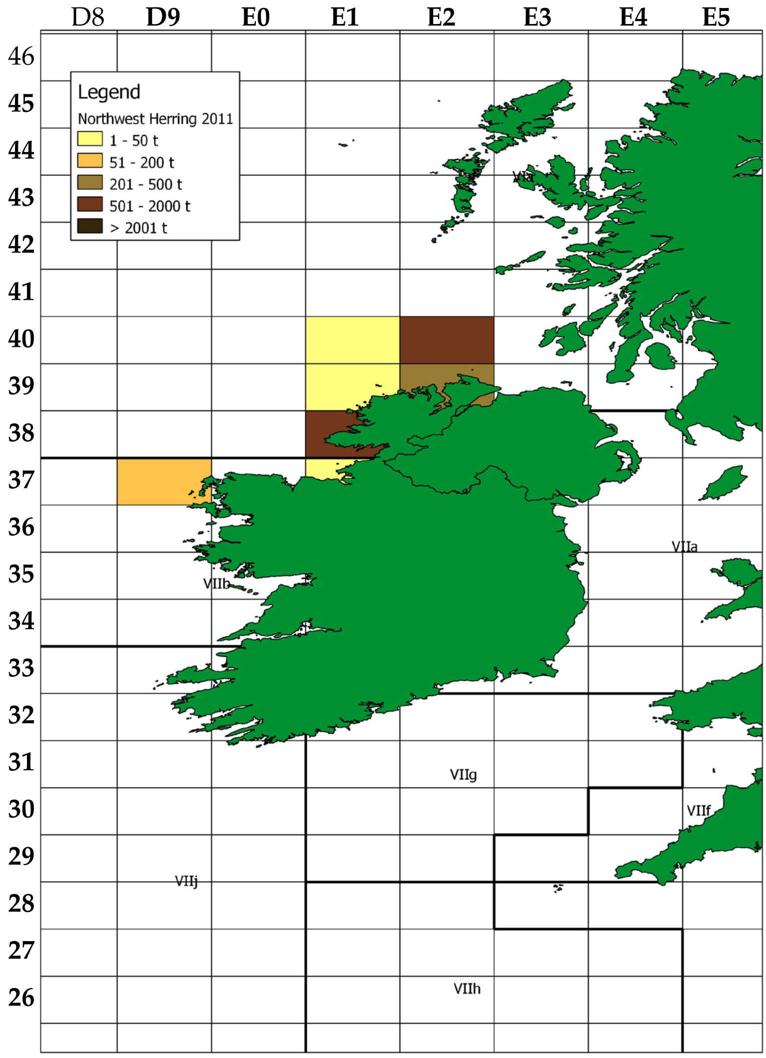


Figure 6.1.3.1. Herring in Divisions VIa(S) and VIIb,c. Herring landings by statistical rectangle in VIaS and VIIb,c in 2011.

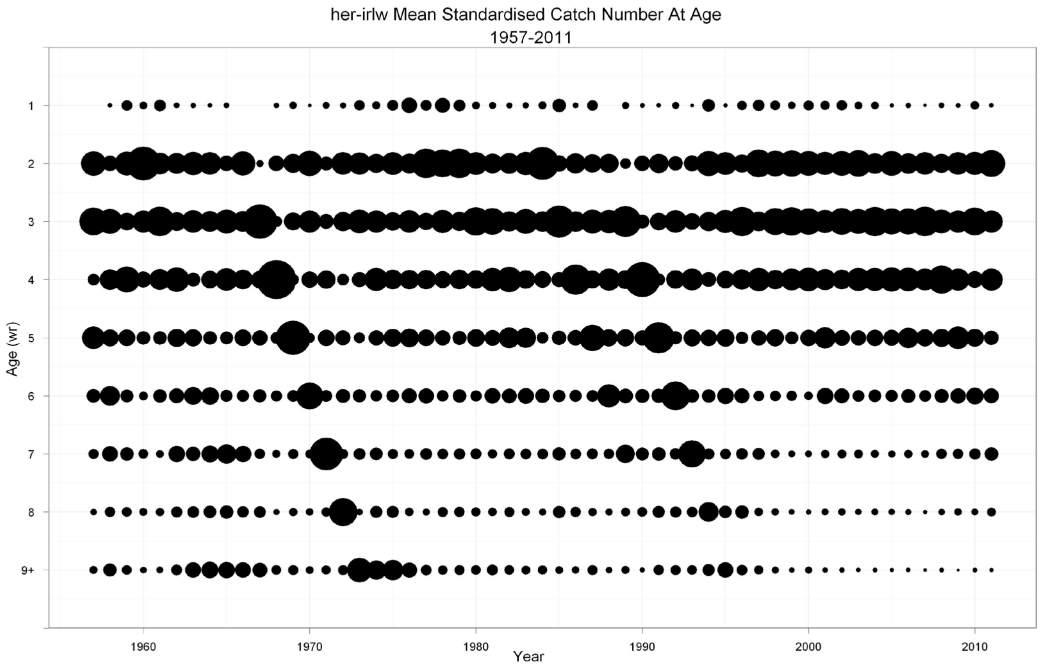


Figure 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean standardised catch numbers at age standardised by year for the fishery.

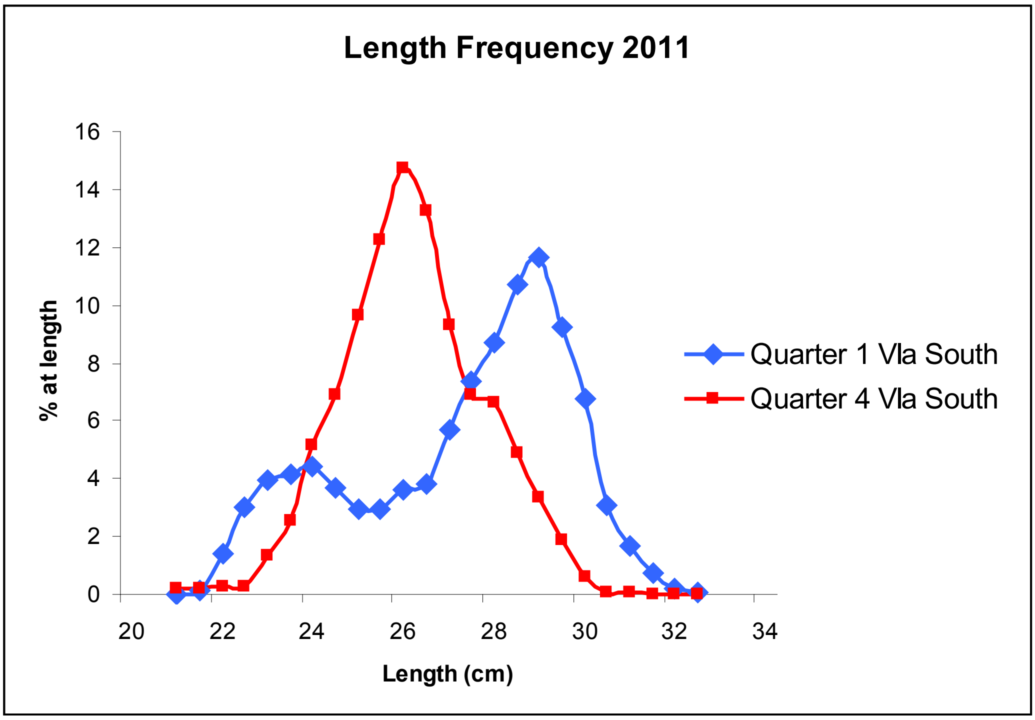


Figure 6.2.2.2. Herring in Divisions VIa(S) and VIIb,c. Length Frequency of herring samples.

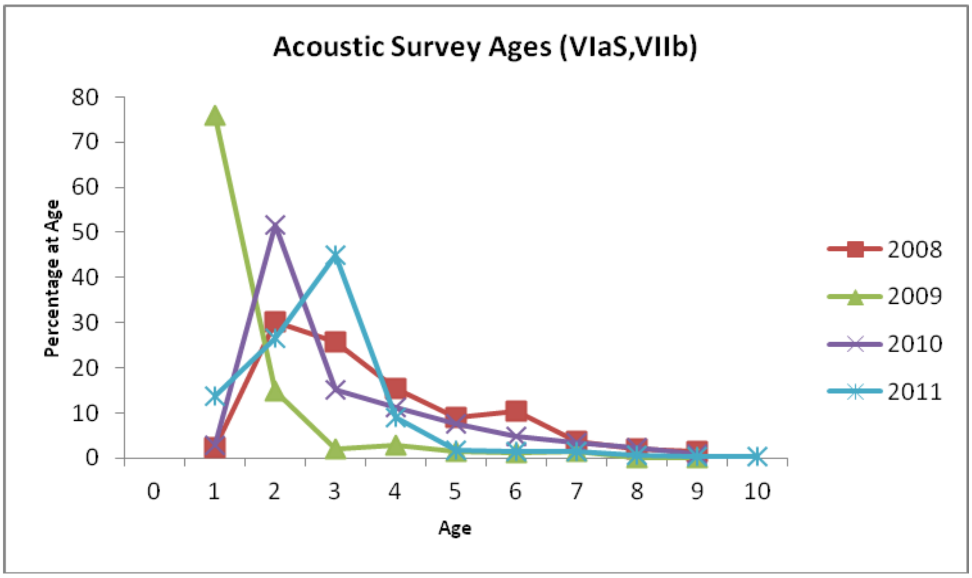


Figure 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Age profiles from the acoustic surveys that were carried out in VIaS and VIIb in 2008-2011.

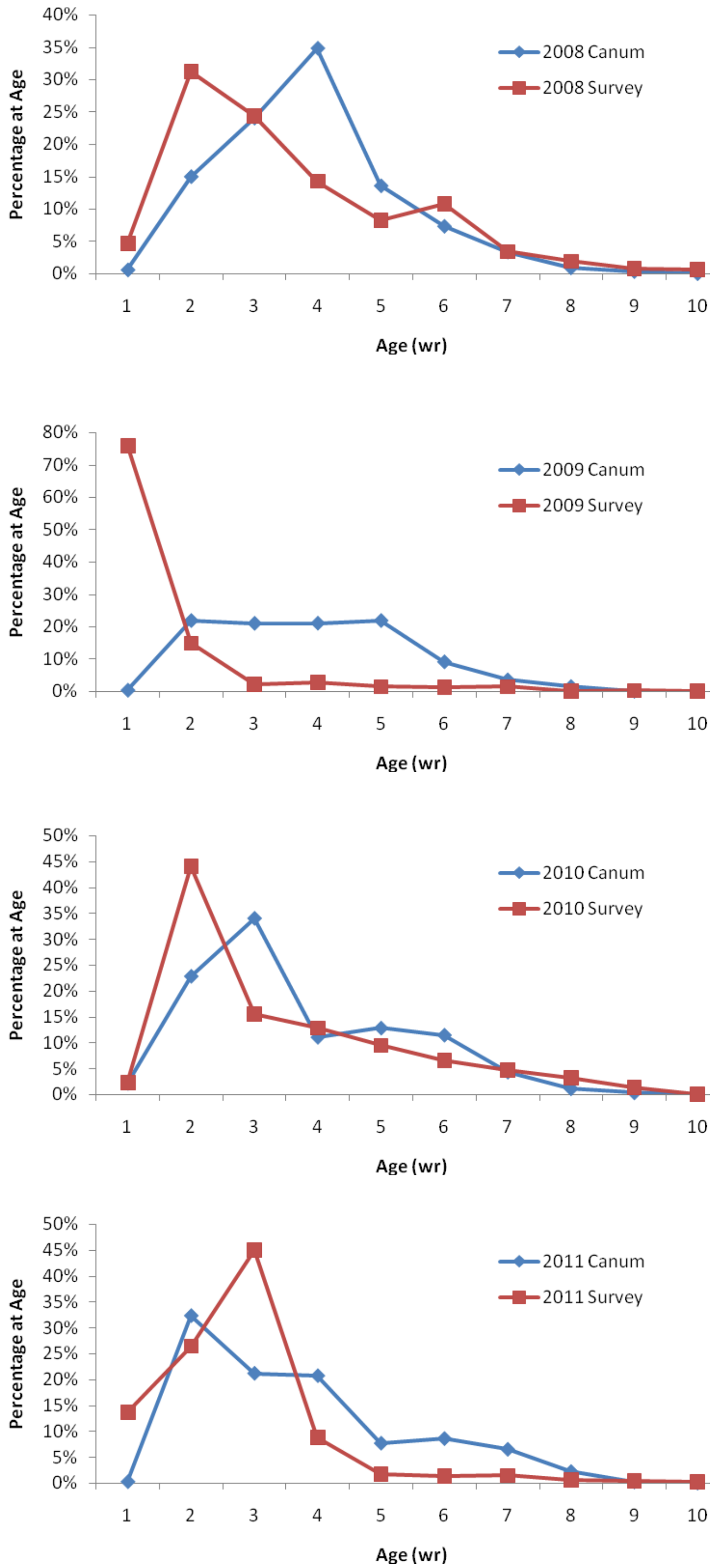


Figure 6.3.1.2. Herring in Divisions VIa(S) and VIIb,c. Proportions at age in the catch and survey data 2008-2010.

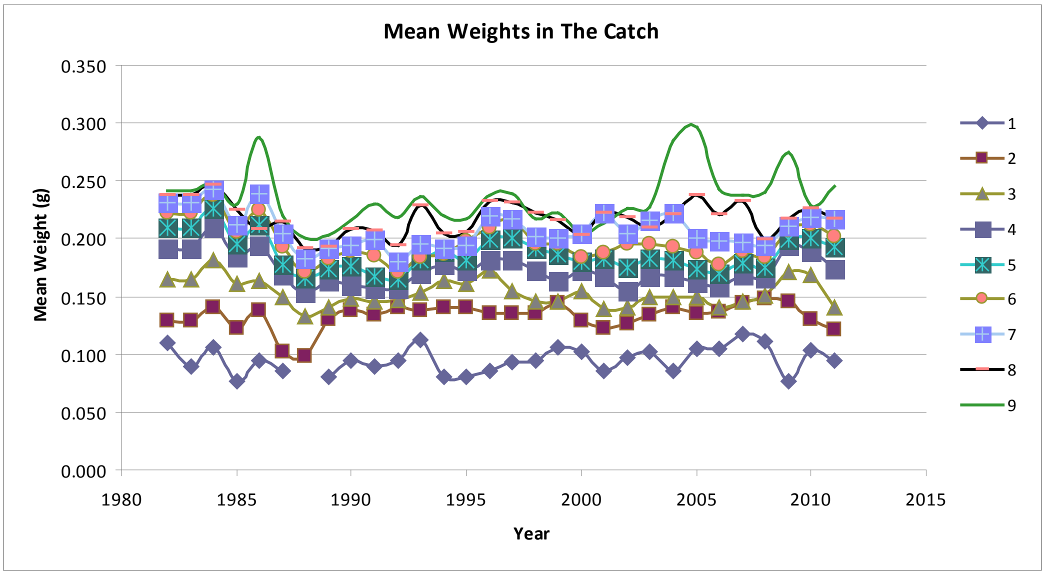


Figure 6.4.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean Weights in the Catch (kg) by age in winter rings.

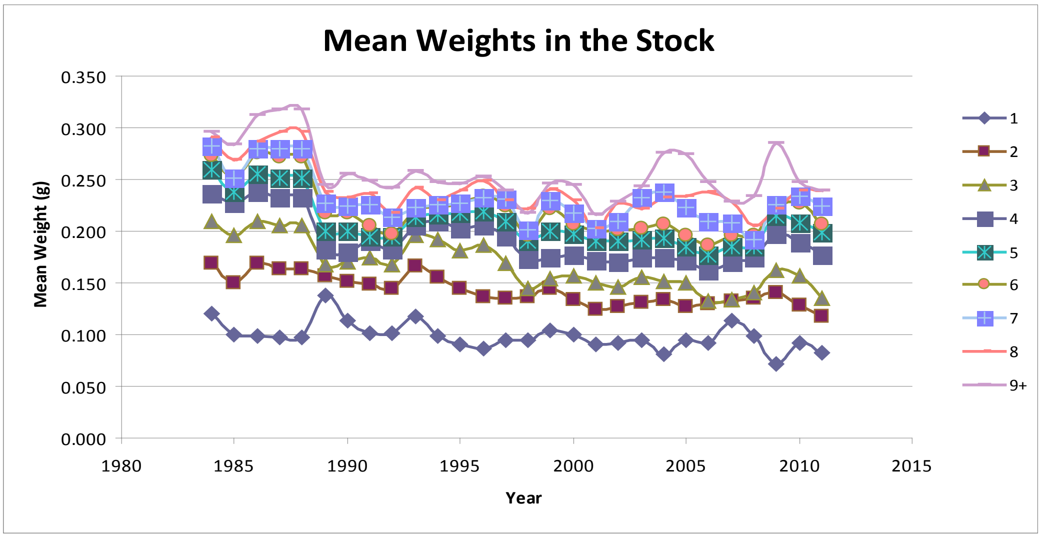
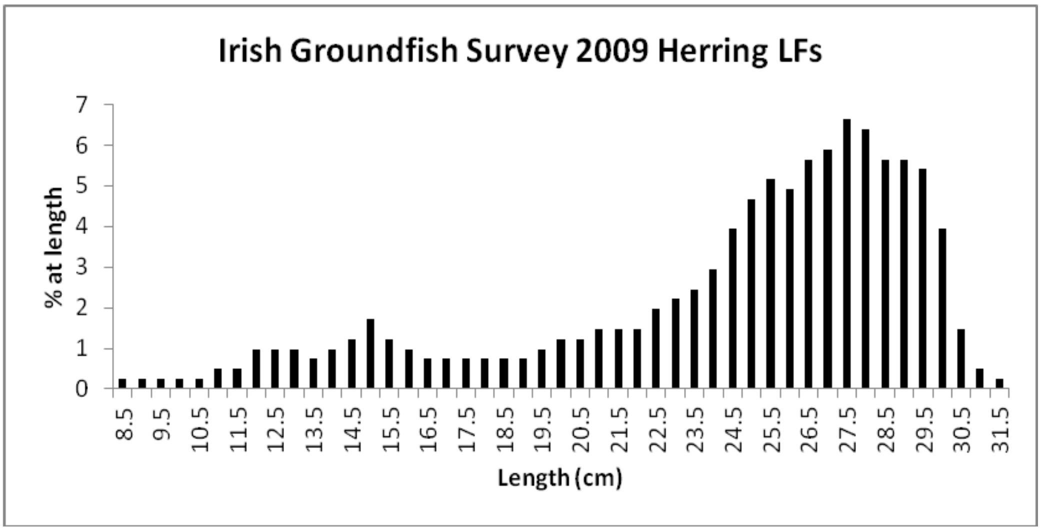
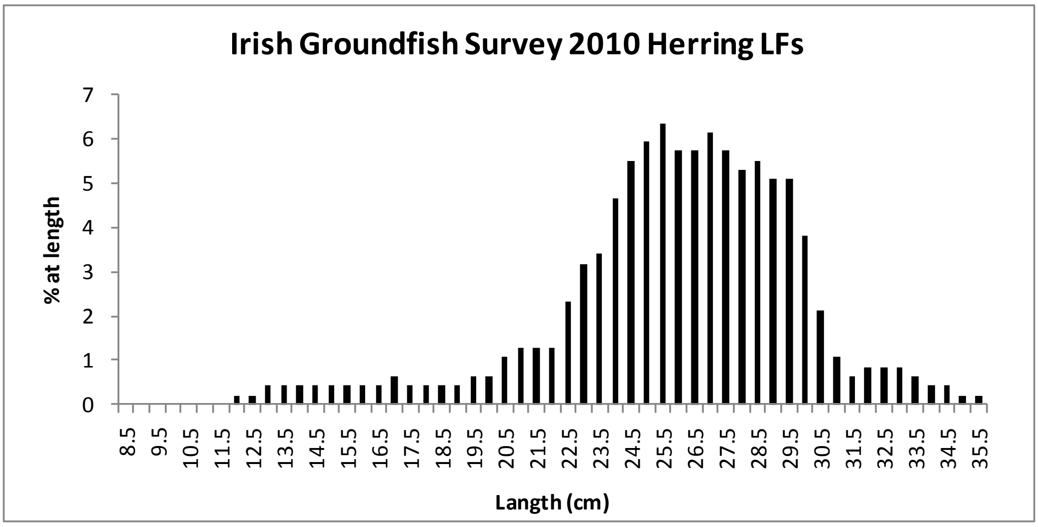


Figure 6.4.1.2. Herring in Divisions VIa(S) and VIIb,c. Mean weights in the stock (kg) by age in winter rings.





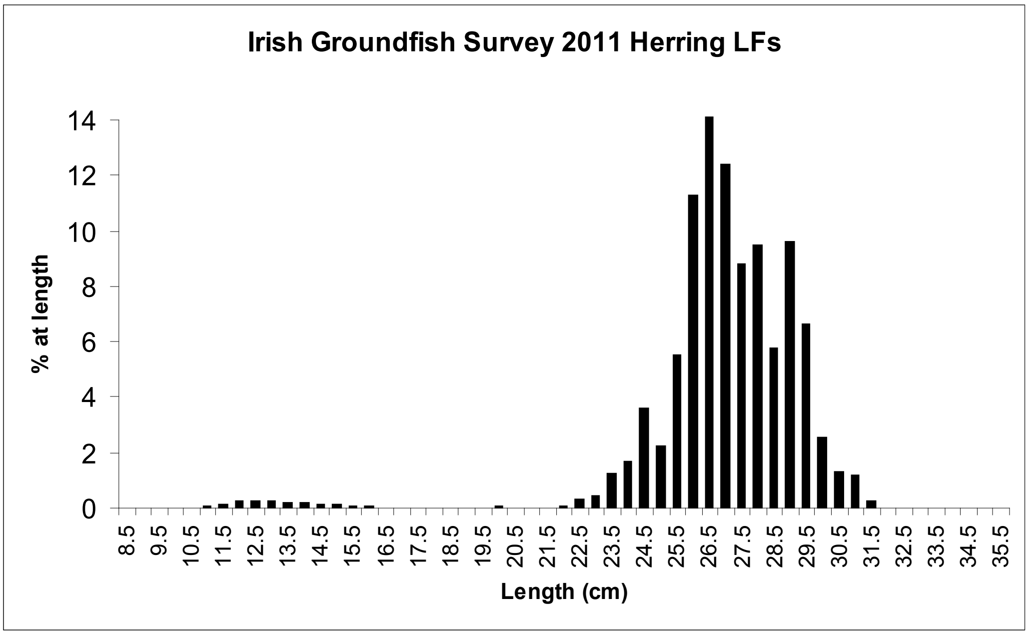


Figure 6.5.1.1. Herring in Divisions VIa(S) and VIIb,c. Irish Groundfish survey length frequency data 2009-2011.

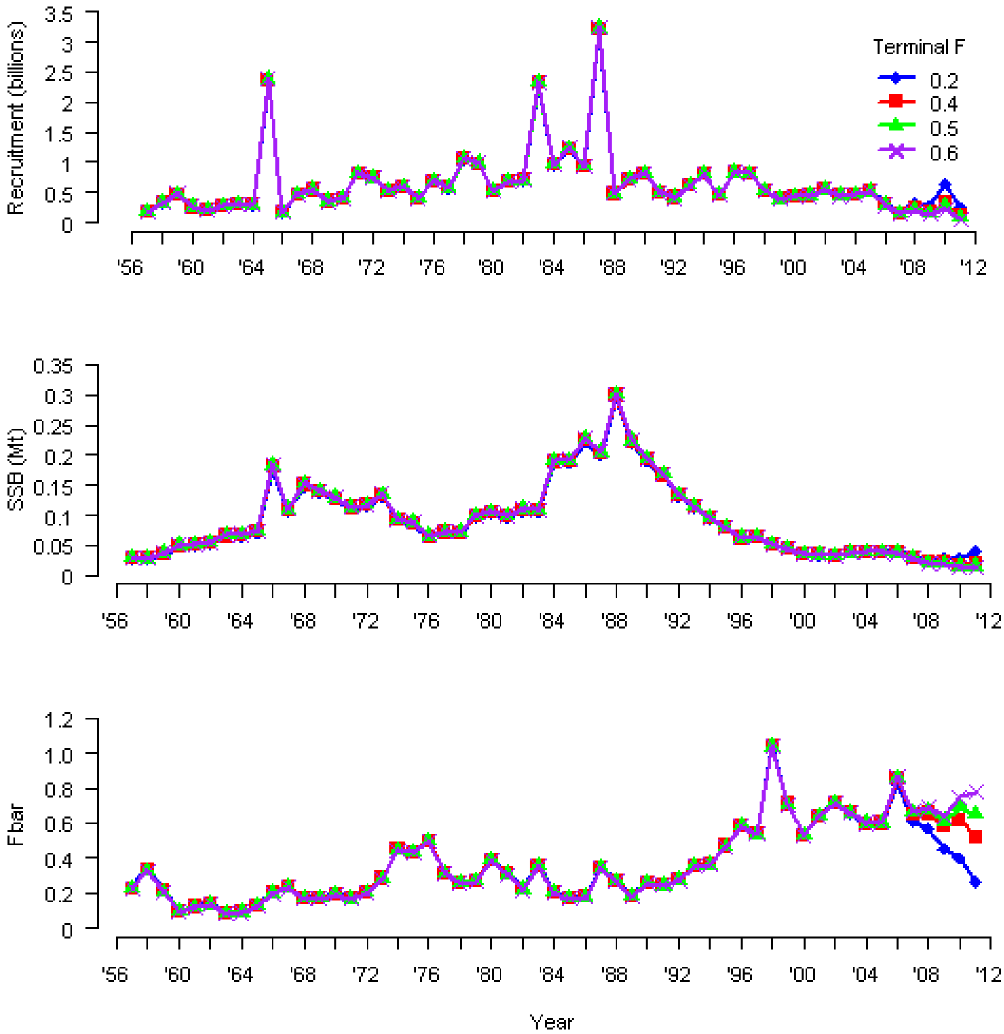


Figure 6.6.1.1. Herring in Divisions VIa(S) and VIIb,c. Results of the separable VPA assessment showing four separable VPAs, based on differing initial values of terminal F, over the period 1957-2011. Recruitment (top), SSB (middle) and mean F (bottom).

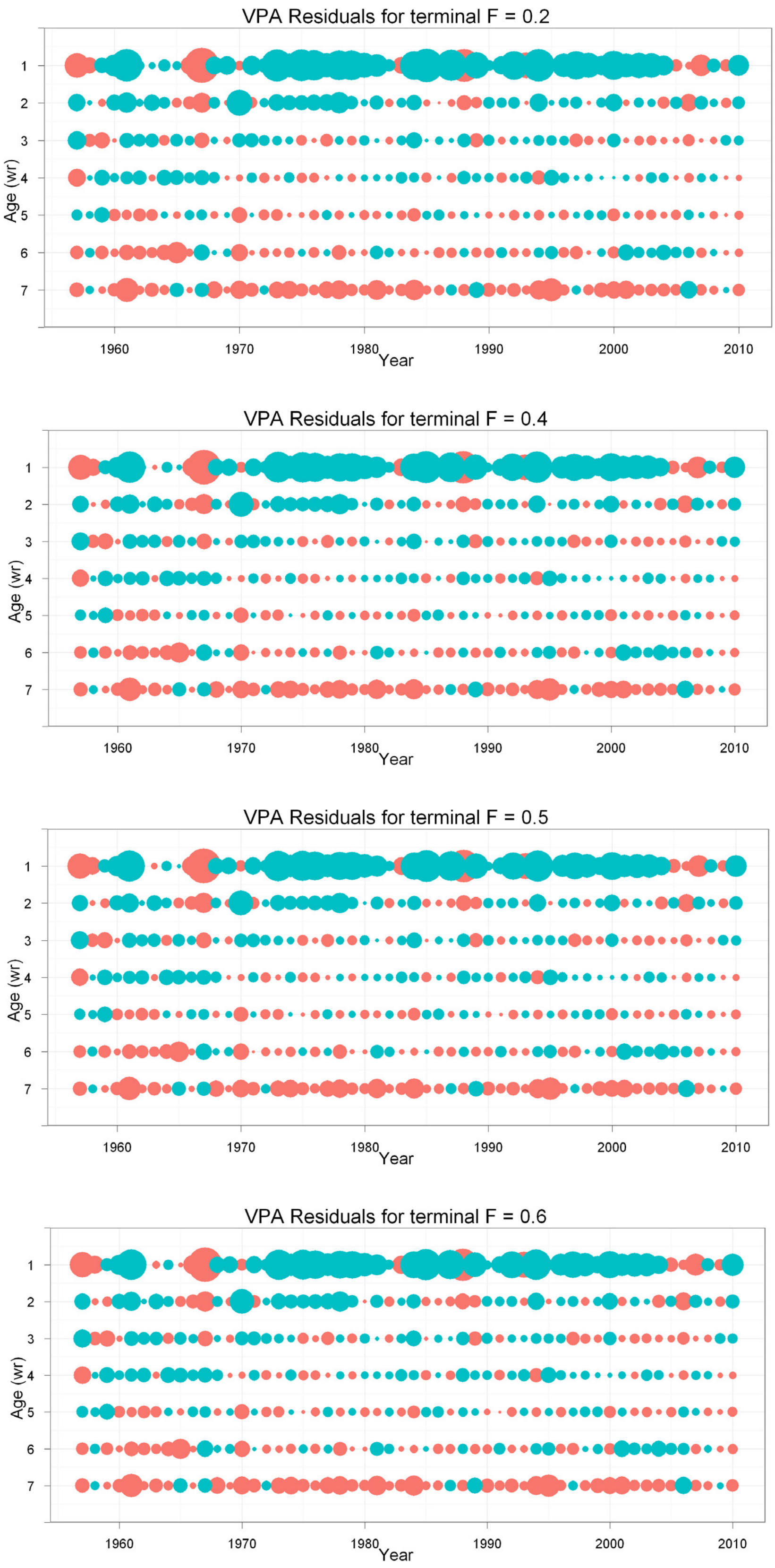


Figure 6.6.1.2. Herring in Divisions VIa(S) and VIIb,c. Residuals from the four separable VPA runs using terminal F values of 0.2 , 0.4, 0.5 and 0.6 . Blue indicates positive residuals and red indicates negative.

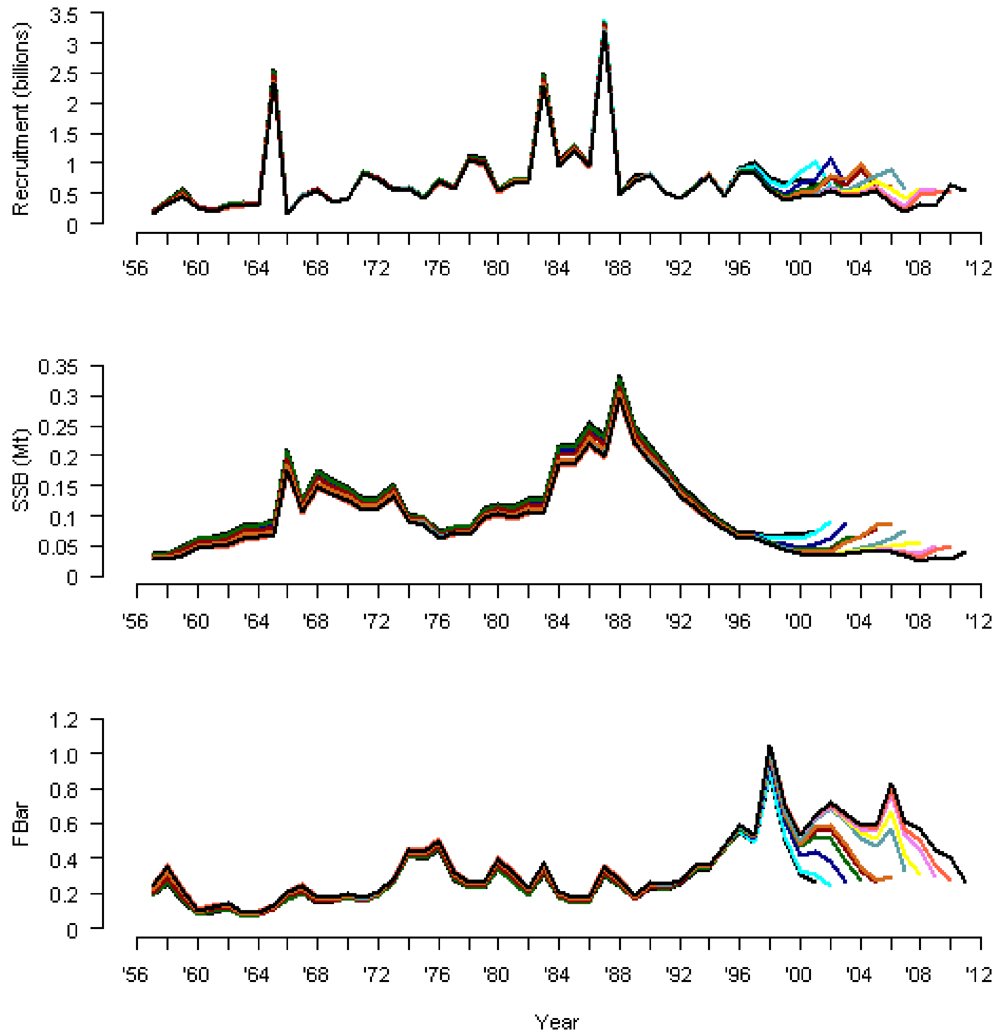


Figure 6.6.1.3. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F=0.2.

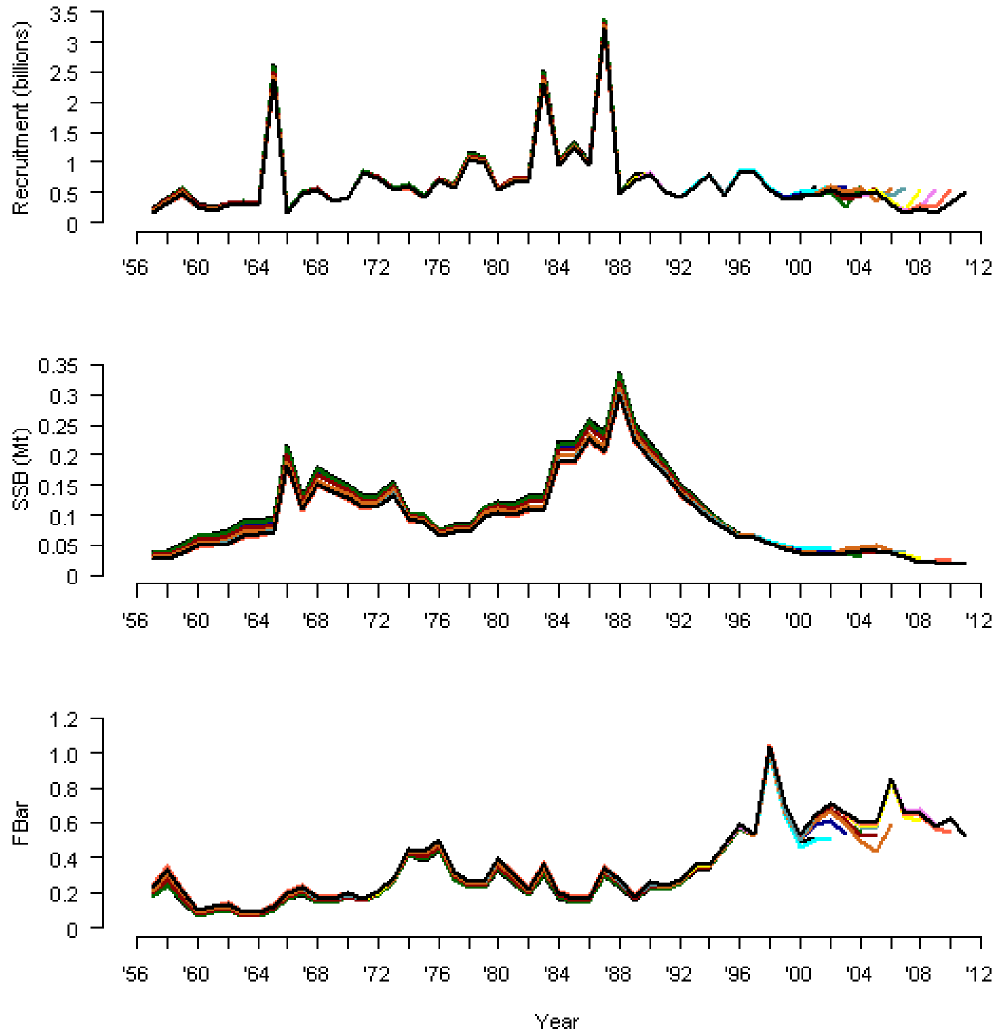


Figure 6.6.1.4. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.4.

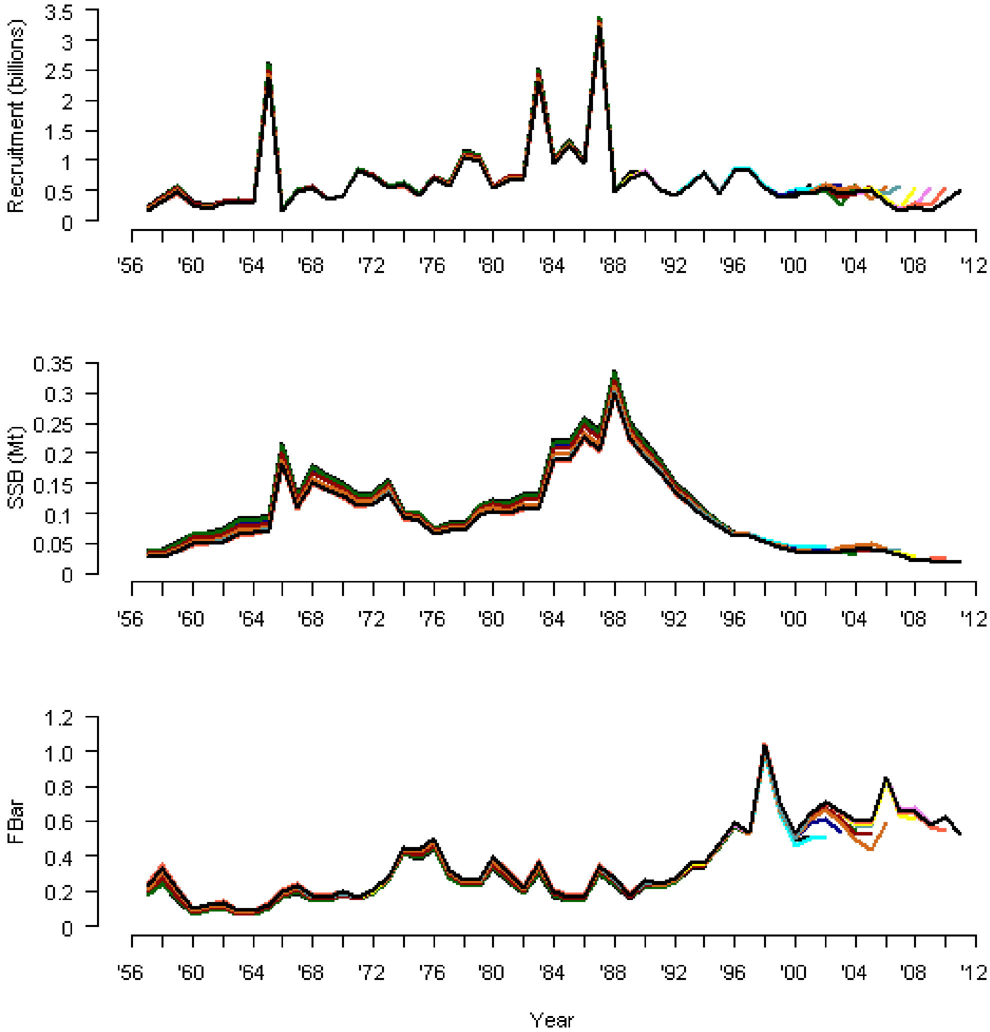


Figure 6.6.1.5. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.5.

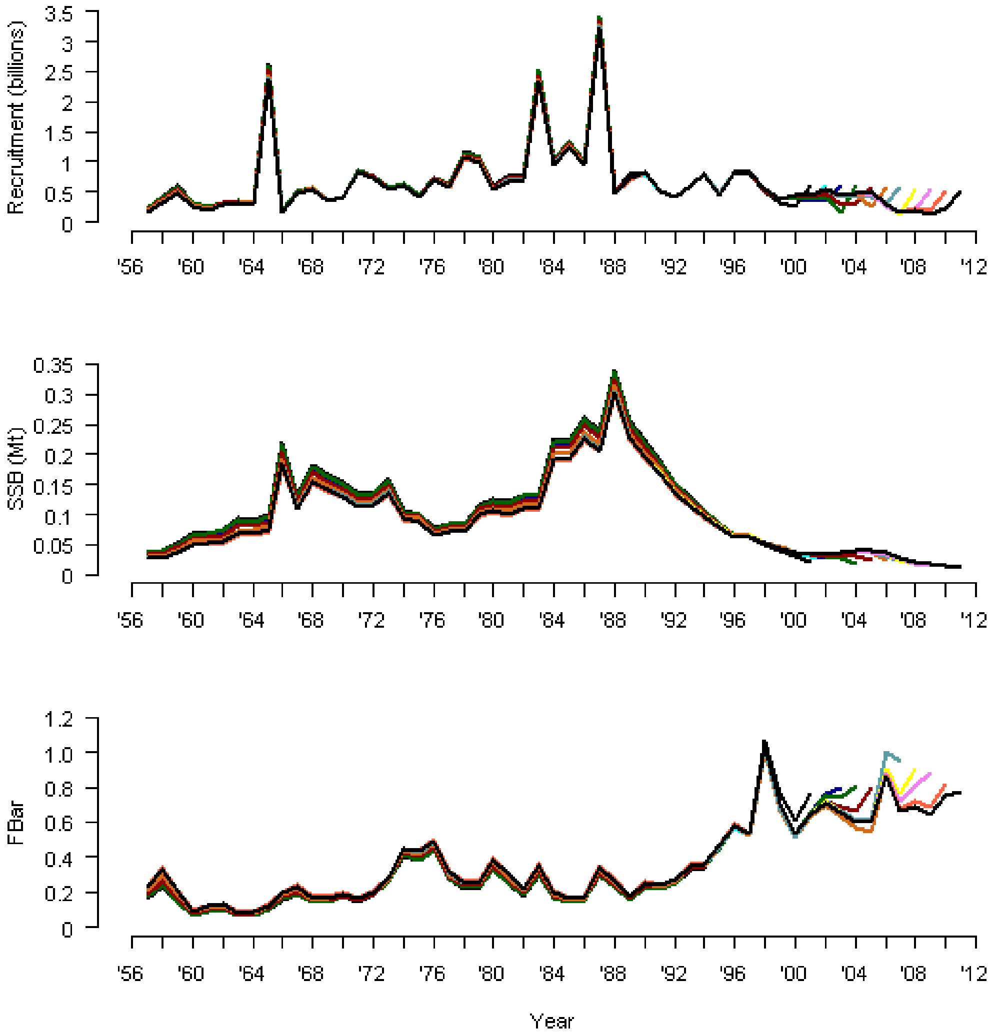


Figure 6.6.1.6. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.6.

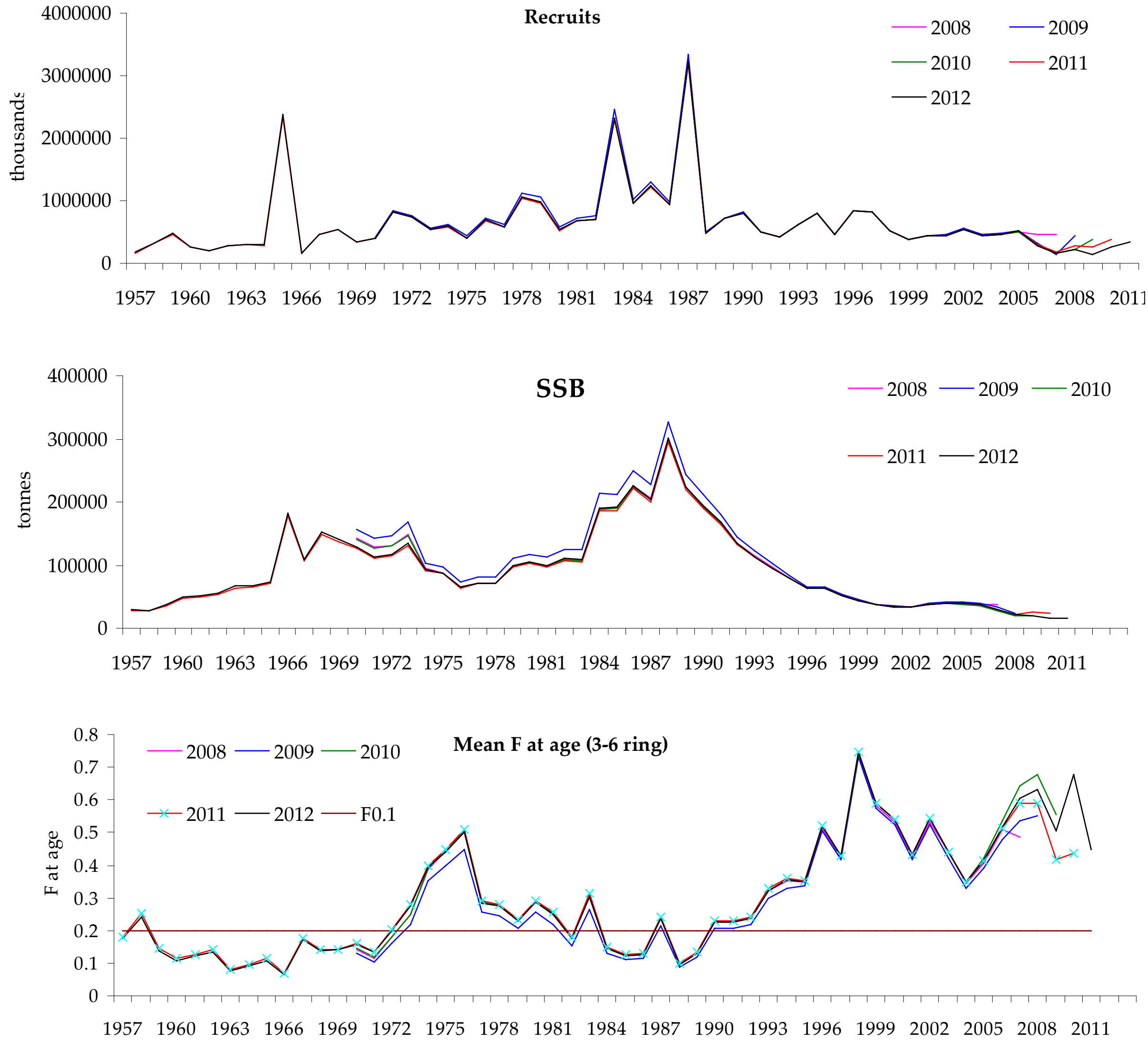


Figure 6.6.1.7. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective patterns from "best-estimate" separable VPA from working groups 2008-2012.

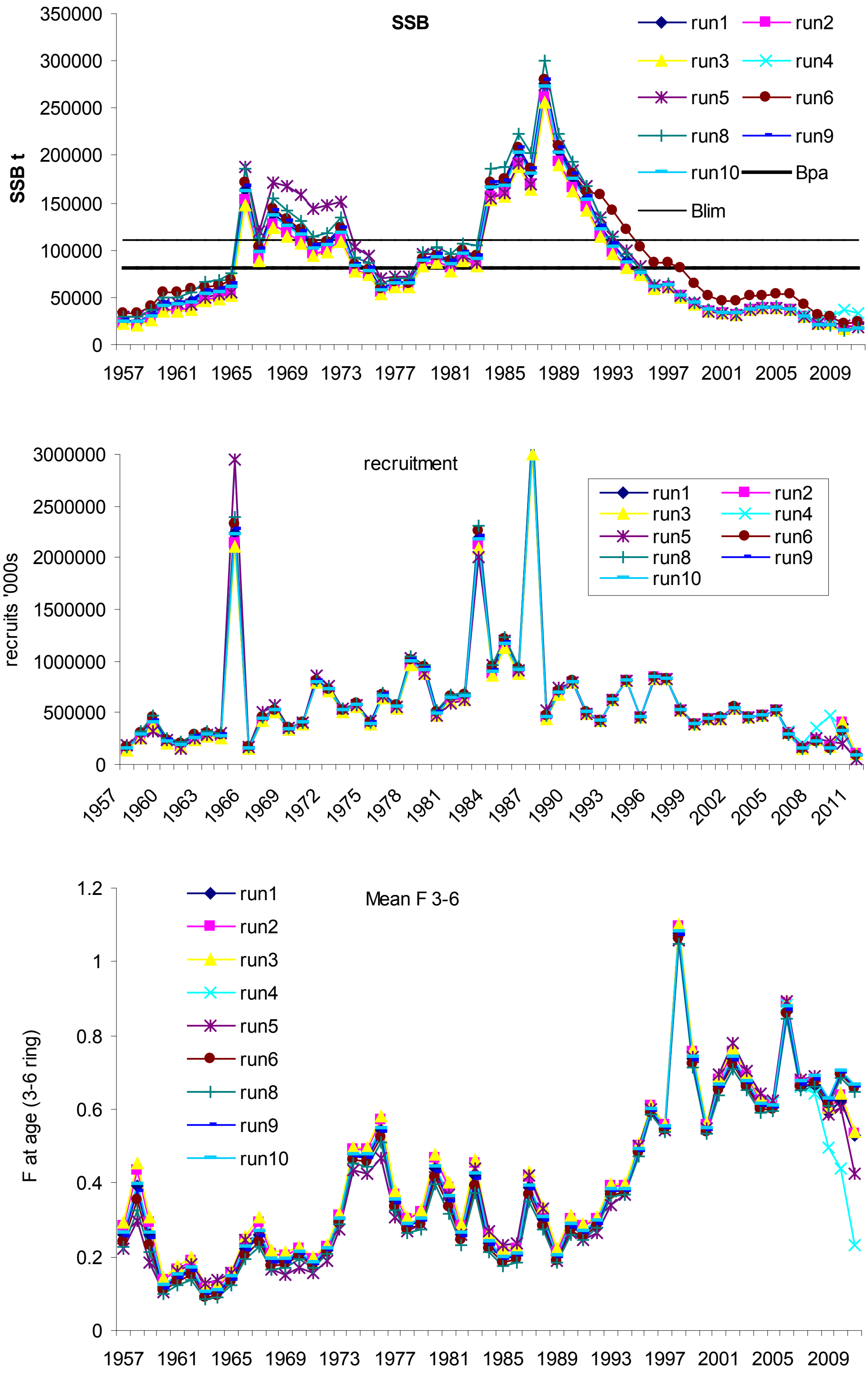


Figure 6.6.1.8. Herring in Divisions VIa(S) and VIIb,c. Sensitivity analyses for separable VPAs. Run identifiers cited in text.

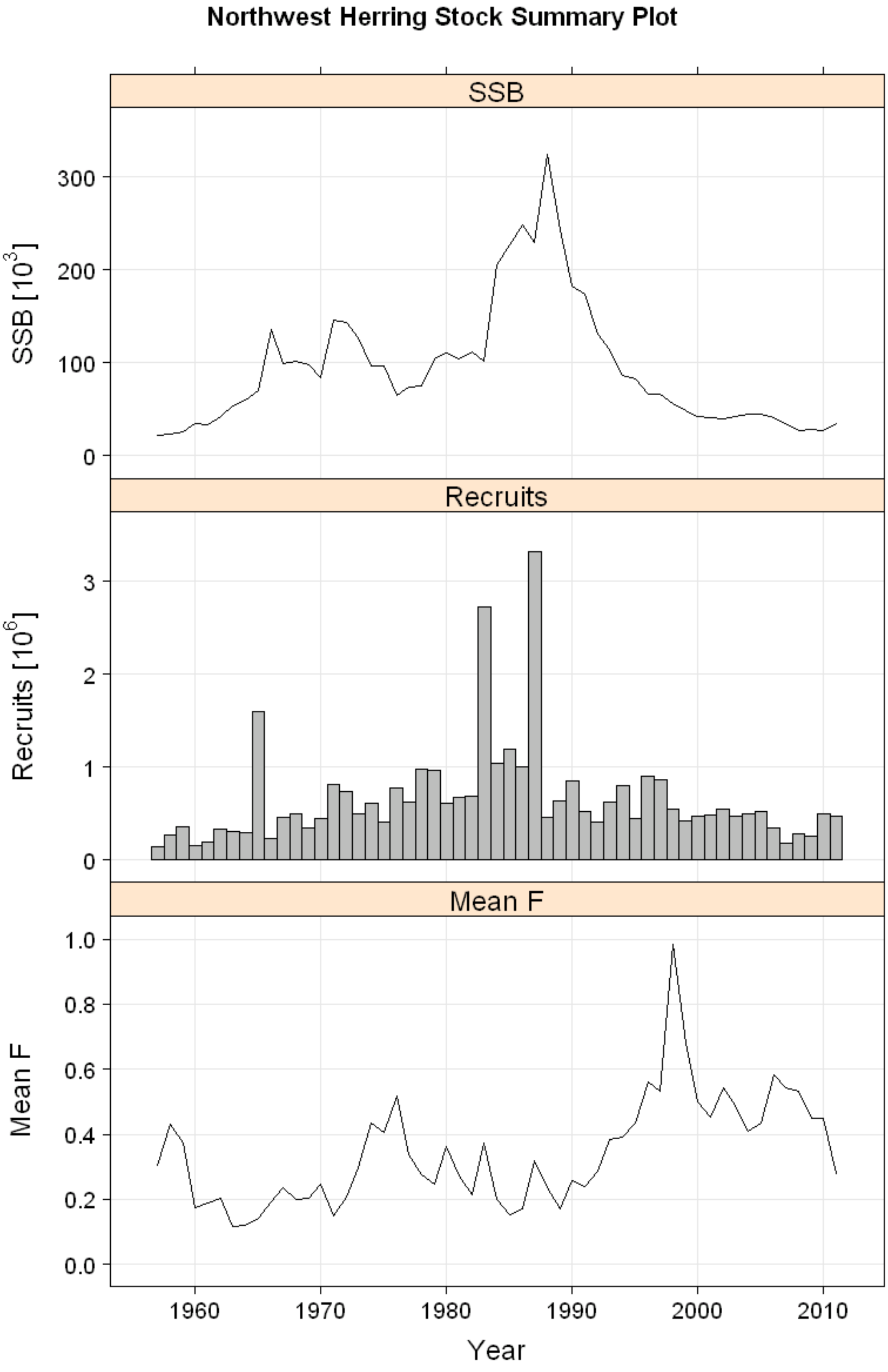


Figure 6.6.1.9 Herring in Divisions VIa(S) and VIIb,c. Stock summary plot for exploratory FLICA assessment, using the VIa and VIIbc (MSHAS) survey for tuning.

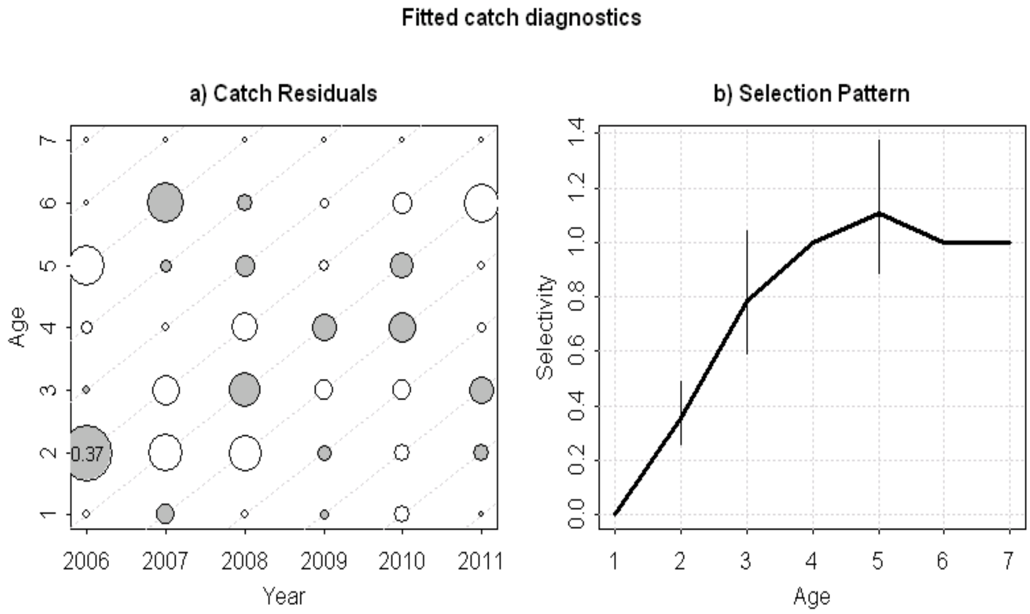


Figure 6.6.1.10 Herring in Divisions VIa(S) and VIIb,c. Catch diagnostics plot for exploratory FLICA assessment.

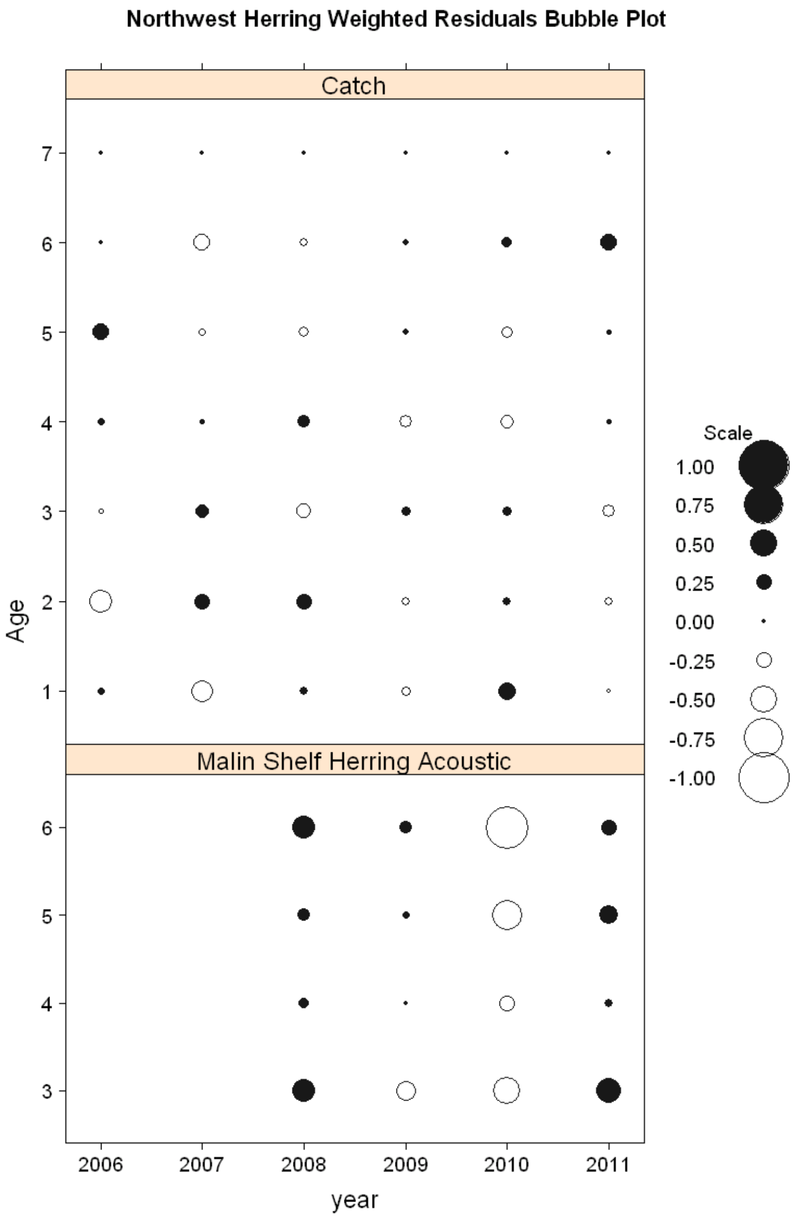


Figure 6.6.1.11 Herring in Divisions VIa(S) and VIIb,c. Catch and survey residuals for exploratory FLICA assessment.

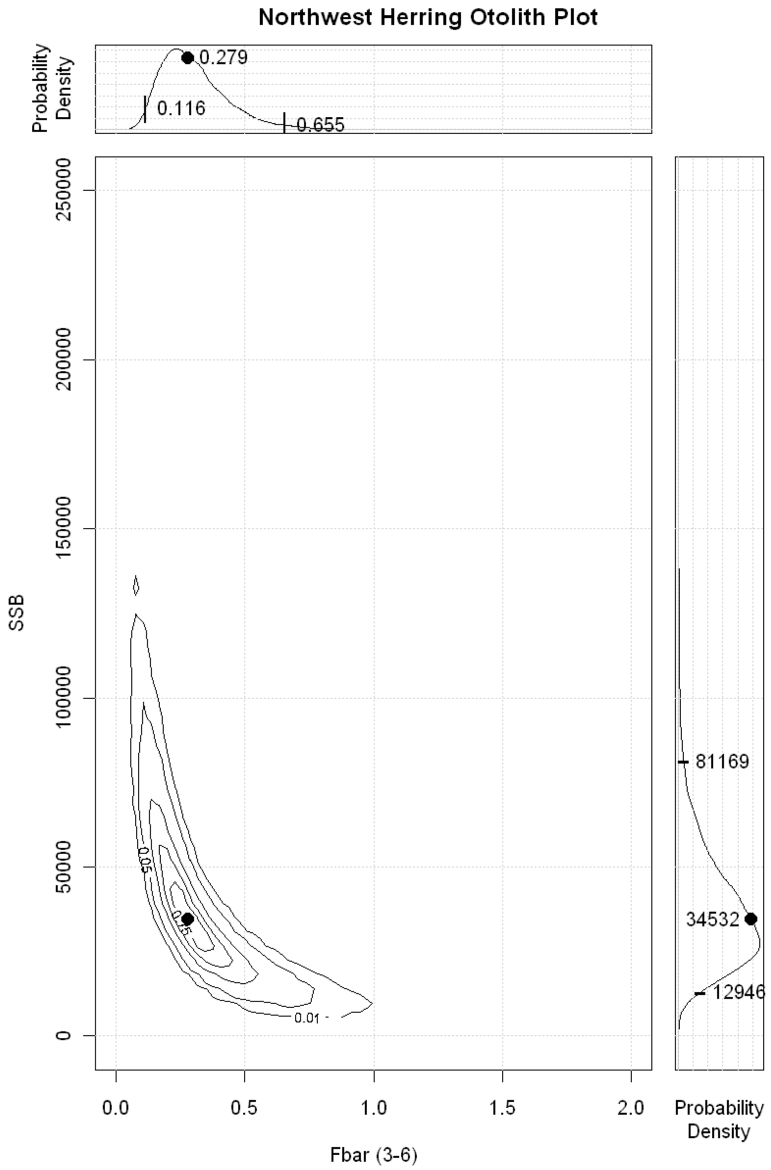


Figure 6.6.1.12 Herring in Divisions VIa(S) and VIIb,c. Uncertainty plot for exploratory FLICA assessment.

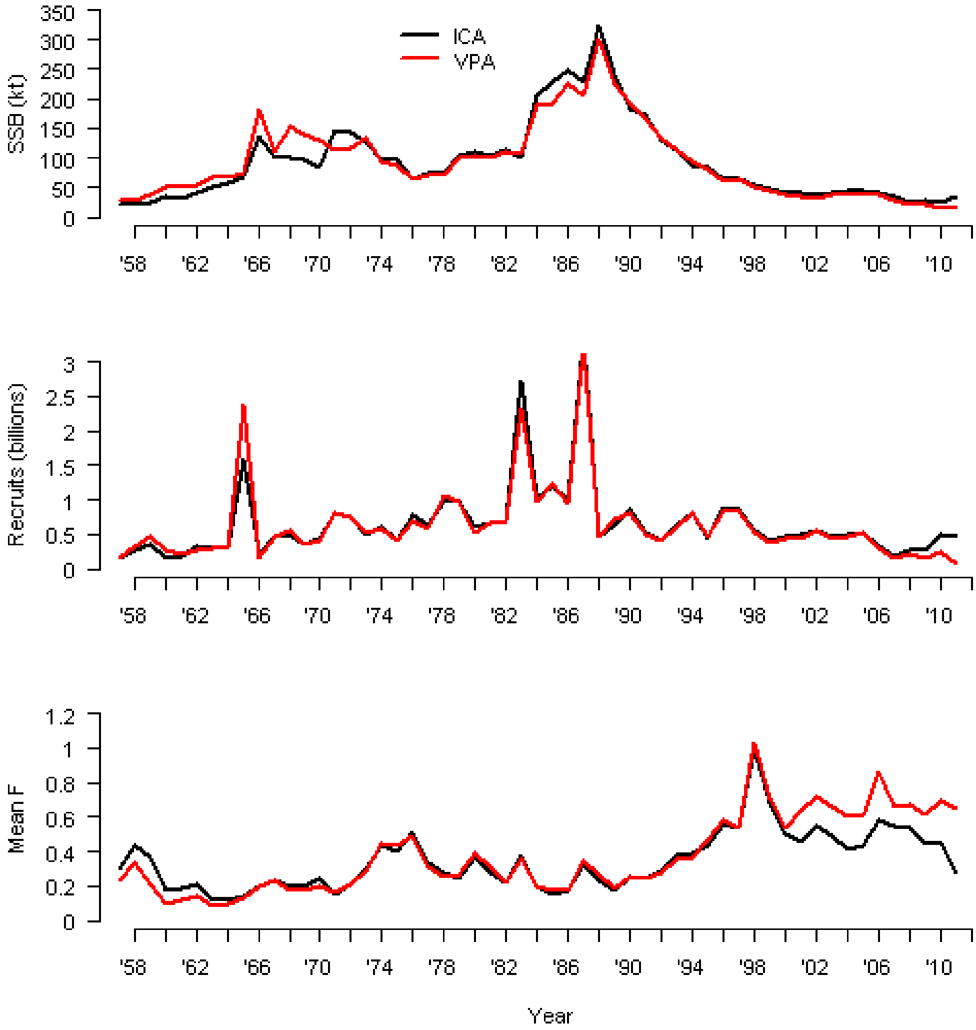


Figure 6.6.1.13 Herring in Divisions VIa(S) and VIIb,c. Comparison between exploratory FLICA assessment (black line) and separable VPA with terminal f = 0.5 (red line).

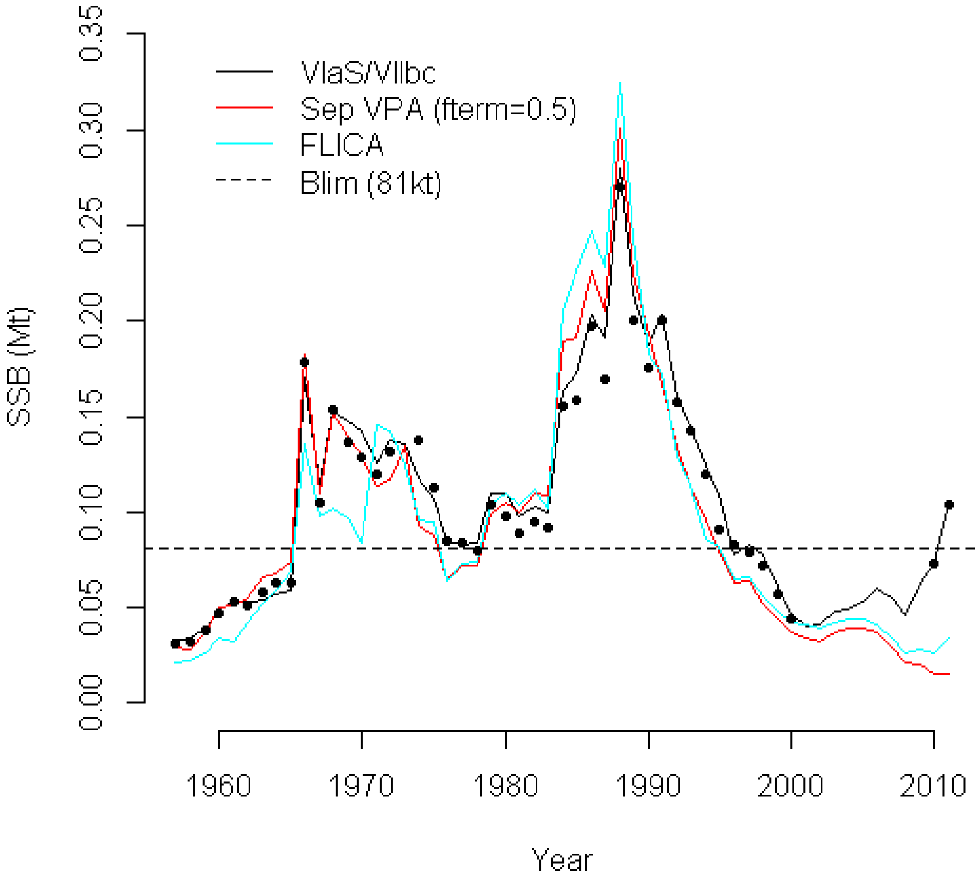


Figure 6.6.1.14 Herring in Divisions VIa(S) and VIIb,c. SSB derived from difference in abundance between VIaN assessment and Malin assessment (black line – using partial F, dots – using abundance ratios), exploratory FLICA assessment (cyan) and separable VPA with terminal F = 0.5 (red).

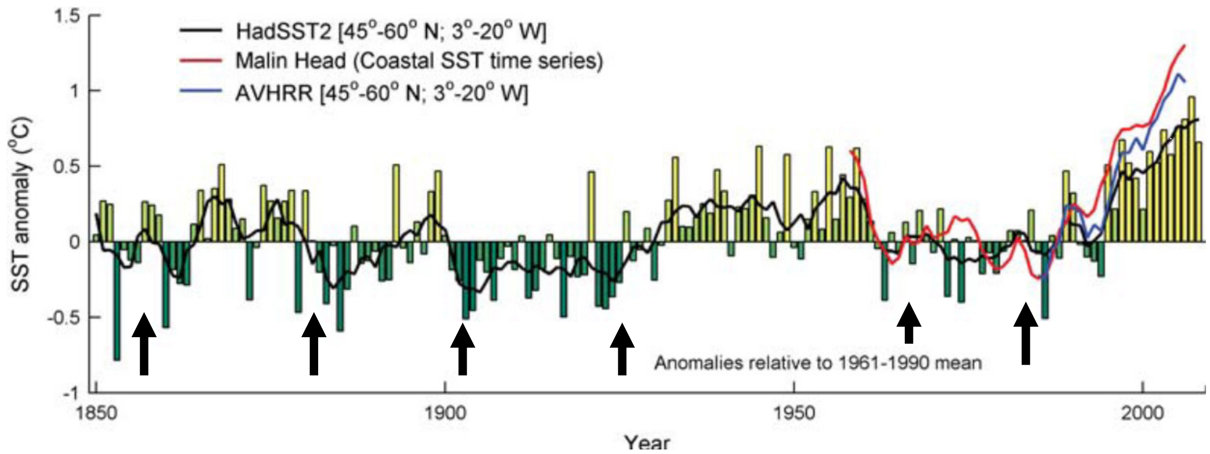


Figure 6.13.1. Herring in Divisions VIa(S) and VIIb,c. Long time series of sea surface temperature (SST) anomalies reproduced from Cannaby and Husrevoglu (2009). Historic instances of high recruitment and/or large fisheries are indicated by arrows.

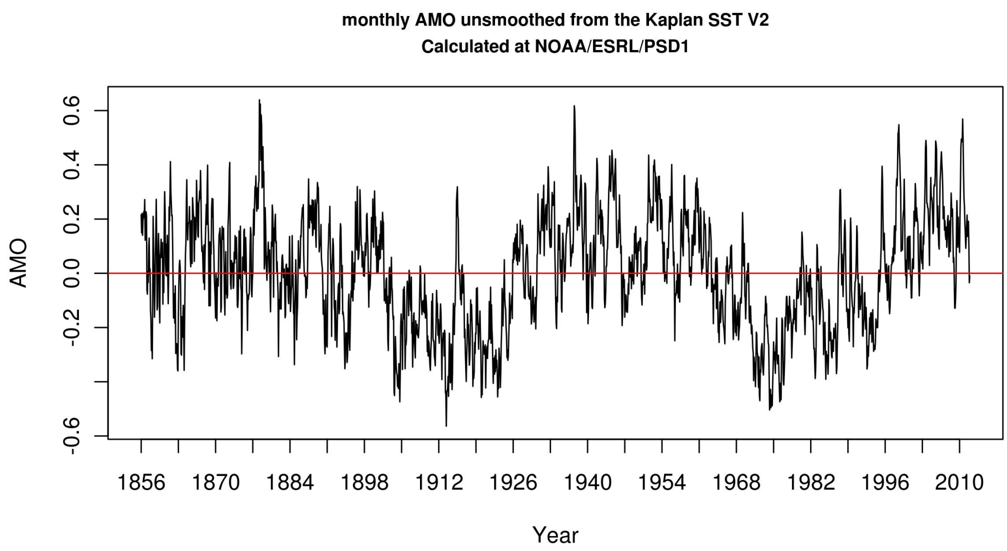


Figure 6.13.2. Herring in Divisions VIa(S) and VIIb,c. Monthly AMO from the Kaplan SST data set.

7 Herring in Division VIIa North (Irish Sea)

The stock was benchmarked in 2012 and a state-space assessment model, SAM, was proposed as the assessment model for the stock. The assessment presented here is an update assessment using the methodology and model configuration from the benchmark (ICES WKPELA 2012).

7.1 The Fishery

7.1.1 Advice and management applicable to 2011 and 2012

In 2011 a TAC of 5 280 t was adopted and partitioned as 3 906 t to the UK and 1 374 t to the Republic of Ireland. In 2011 ACOM advised no increase in catch, but did not predict the catch corresponding to the advice. A TAC of 4 752 t was subsequently adopted for 2012, partitioned as 3 515 t to the UK and 1 237 t to the Republic of Ireland.

7.1.2 The fishery in 2011

The catches reported from each country for the period 1987 to 2011 are given in Table 7.1.1, and total catches from 1961 to 2011 in Figure 7.1.1. Reported international landings in 2011 for the Irish Sea amounted to 5 202 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland. The majority of catches in 2011 were taken during the 3rd quarter.

The 2011 VIIa(N) herring fishery started off slowly in August, with catches taken in the North Channel and north west of the Isle of Man. A large proportion of the catches were taken on the Douglas Bank prior to the closure in September, with bigger shoals being avoided to ensure quality. Reported catch rates during this time were up to 300t/10min. A significant proportion of the landings was taken by a pelagic trawler in the 3rd quarter, but similar to recent years, the majority of catches were still taken by a pair of UK pair trawlers. September and October saw activity of the Mourne fishery, limited to boats under 40ft. This was the 7th year of recorded landings for this component of the fishery. In 2011 12 vessels recorded landings of ~148 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 2011. 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. This has contributed to a mismatch in the age structure of catches and the survey.

The arrangement of closed areas in Division VIIa(N) prior to 1999 is 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 should be considered carefully.

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, but 2011 saw the return of a single pelagic trawler taking some of the TAC. 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 2006-2009 landings increasing from ~20 t to ~171 t. After a reduction to ~129 t in 2010, the landings increased again to ~148 t in 2011.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

Routine sampling of the main catch component was conducted in 2011, with sampling coverage concentrated on the pair trawlers. There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. Catches in numbers-at-age are given in Table 7.6.3.1 for the years 1972 to 2011 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 2011, excluding 2009.

7.2.2 Quality of catch and biological data

30 samples from the main catch component were acquired in 2011, with a further 6 samples taken from the gillnet fishery operating on the Mourne ground. At sea observer data have been collected since 2010 (~11% of fishing trips sampled annually) with no discards observed. Discarding is not thought to be a feature of this fishery. 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. The SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The bulk of the acoustic survey in 2011 was carried out over the period 27 August - 10 September. The survey was severely affected by adverse weather conditions and transecting was discontinuous (transecting was interrupted for 3-4 days on three occasions and stitched together including data from the extended series). Transecting off the English coast (stratum 10 and 6) could only be completed 11-12 October, but this area historically has very low occurrence of adult herring. The area is characterised by mixed clupeoid abundance composed of 0-gp herring and sprat and abundance estimates will be less influenced by survey timing. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1.A). A significant increase in 0-gp herring and sprat biomass was observed in 2011, but particularly for sprat. Sprat and 0-group herring were distributed around the periphery of the Irish Sea (Figure 7.3.1B&7.3.2.B), with the abundance of 0-group herring noticeably higher in the eastern Irish Sea compared to last year. The bulk of 1+ herring targets in 2011 were observed off the Mull of Galloway (southwestern corner of stratum 5; Figure 7.3.1), with a fairly scattered lower abundance observed throughout the Irish Sea (Figure 7.3.2.A). The survey followed the methods described in the ICES WGIPS 2012 report. Sampling intensity was high during the 2011 survey with 38 successful trawls completed. The length frequencies generated from these trawls highlight the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.3.3).

The estimate of herring SSB of 49 128 t for 2011 is a significant reduction from the 2010 estimate (Table 7.3.1, Figure 7.3.5). This is expected considering that the timing of the survey did not coincide with the migration patterns of the spawning adult population (virtually no abundance of adult fish to the east and southwest of the Isle of Man compared to recent surveys estimates). The biomass estimate of 131 527 t for 1+ ringers is similar to the 2010 estimate, which was the highest in the time series. Similar to the 2007 survey, more than half of the 1+biomass estimate was to the north of the Isle of Man. This is an area of mixed size fish and the survey was mismatched with the migration of the main spawning biomass, as indicated by the high abundance of herring observed by the fishery on the Douglas Bank post survey. Preliminary results of a successive acoustic survey conducted later in September confirmed this. An obvious year effect is observed for the older ages (Figure 7.3.4). The year effect, evidence of higher abundance of spawning herring, coupled with the survey being severely affected by adverse weather conditions; suggest poor reflection of the current age structure and abundance of the herring population in the Irish Sea. The significant decrease in the SSB is in contrast to the increasing trend observed since 2007, considering the low landings levels and the expected associated low exploitation rate.

The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2. The high abundance of 1-ringers observed and relatively low numbers of older fish are clear from the numbers at age.

Results of a microstructure analysis of 1-ringer+ fish were updated for the 2010 data (Figure 7.3.6-7). The splitting information for 2011 was not yet available to the working group. Winter hatched fish, 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 hatched fish has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods. However, removal of the winter hatched fish, leaving only fish of autumn spawning origin, does not change the perception of a significant increase in biomass estimates (Figures 7.3.6-7). The benchmark working group (ICES WKPELA 2012) investigated the mixing issue and its impact on the assessment. The benchmark group concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment is conducted on the mixed stock. The recruitment data (age 1) have the highest proportion of "alien" stock. The benchmark suggested that this is considered in the assessment model configuration and dealt with objectively within the model.

7.3.2 Extended acoustic surveys

A series of additional acoustic surveys has been conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The enhanced survey programme was initiated to investigate the temporal and spatial variability in the population estimates from the routine acoustic survey and only concentrates 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 ~85% of the total Irish Sea SSB estimate since 2001 and ~81% of 1-ringer + biomass. The results of the first three years of the survey series were presented by Schön *et al*. (HAWG 2010, WD11).

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. The extended surveys were repeated in 2010 and 2011. A detailed analysis of these surveys is being conducted as part of the development of the management plan. The survey series highlighted the need for restratification of the main survey (for example including the high abundance area off the Mull of Galloway that is associated with peaks in a smaller stratum that will have less weight on the overall estimate). Preliminary results of the 2010-11 surveys support the high abundance of herring in the Irish Sea. WKPELA2012 also suggested that the survey series could be use to fine tune the main survey used as the tuning fleet in the assessment. This could solve the year effect observed in 2011.

7.3.3 Larvae surveys (NINEL)

Northern Ireland undertook a herring larvae survey (NINEL) over the period 6-9 November 2011. The survey followed the methods and designs of previous surveys in the time-series (see Stock Annex 8). The production estimate of (1.38 x 10^{12} larvae) for 2011 in the NE Irish Sea was lower than 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 southeast and northeast of the Isle of Man and less abundant in the western Irish Sea (Figure 7.3.8).

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 (NIGFS-WIBTS-Q1; NIGFS-WIBTS-Q4)

Groundfish surveys carried out by Northern Ireland since 1991 in the Irish Sea (NIGFS-WIBTS-Q1; NIGFS-WIBTS-Q4), 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 2011 (Figure 7.3.9). 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. The indices are very noisy and analysis at the benchmark suggested their exclusion (ICES WKPELA2012).

7.4 Mean weight, maturity and natural mortality-at-age

Biological sampling in 2011 was used to calculate mean weights-at-age in the catch (Table 7.6.3.2). The mean weights-at-age in the 3rd quarter catches (for the whole time-series 1961 to present) are used as estimates of stock weights at spawning time (Table 7.6.3.3). Mean weights-at-age have shown a general downward trend in the last 22 years (Figure 7.4.1). No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010. This is considered appropriate the trend in weight at age. The long-term average used by HAWG in 2010, when 2009 was the terminal year, will not reflect the decreasing trend observed in subsequent years. The 2012 benchmark considered the natural mortality estimates used historically in the model to be inappropriate. The final agreed model from the benchmark used the natural mortality estimates from the North Sea (Table 7.6.3.4), which is not ideal and these should be considered as preliminary estimates until specific values could be calculated for the Irish Sea. An variable maturity ogive are used based on the corresponding annual quarter 3 biological sampling from the catch (Table 7.6.3.5).

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). Further, the SAM assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated. The recruitment trends from the assessment are dealt with in section 7.6.

7.6 Assessment

7.6.1 Data exploration and preliminary modelling

2011 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. Extensive data analyses and benchmark assessment trials were performed during the 2012 benchmark meeting (ICES WKPELA 2012). Considerations to data input sources are discussed in the benchmark report and changes highlighted in the sections above. The tool for the assessment of Irish Sea herring is FLSAM, an implementation of the state-space assessment model (SAM, www.stockassessment.org), embedded inside the FLR (Kell et. al 2007) library.

Acoustic (AC(VIIaN)) ages 1-8+) and the NINEL larval indices are available for the assessment of Irish Sea herring. The 2011 acoustic survey estimate shows a year effect (as discussed in section 7.3.1) and was severely affected by poor weather conditions. The survey estimate is considered to be a poor estimate of the abundance of fish from older ages, not reflecting the high abundance of spawning stock biomass that was observed by the fishery and the preliminary results from the extended survey series. The acoustic and larval survey abundance estimates continues to show diverging trends (Figure 7.3.5).

The SAM model fits the catch well and residuals are relatively small (Figures 7.6.1-17). The residuals in the numbers-at-age in the catch and acoustic survey generally appear to be independent of time, but there are still some patterns in later years. These patterns are somewhat expected and could be explained by annual changes in migration patterns, magnitude and extent of the mixed component and converging trends in the surveys in recent years. The year effect in the last year's survey is also evident from these plots with consistent negative residuals at older (3+) ages. The acoustic survey fits reasonably well at all ages except for age 1. The model fit is poor for the larval survey, especially in recent years. Model fit is poor for age 1 in the catch and survey, which is the age with the highest occurrence of fish mixing from different hatching seasons. The modelled acoustic survey catchability parameter and the selectivity of the fishery by pentad are illustrated in Figures 7.6.18-19. The variable in fishery selection reflects both the historic changes in the fishery (e.g., industrial fishery in the 1970s towards a fishery on the spawning stock in recent years) and the interannual changes in the selectivity related to the variable migration patterns and the effect of the spawning closure.

A feature of the assessment model is the estimation of an observation variance parameter for each data set (Figure 7.6.20). Overall, the catch data (ages 2+) are associated with low observation variances, where age 1 (from catch and survey) and the NINEL data are perceived to be the noisiest data series. Figure 7.6.21 shows observation variance vs. uncertainty of the data sources used in the model. Although the majority of the data sources are associated with relatively high observation variances, none of the uncertainty estimates are particularly high. The CVs do not indicate a lack of convergence of the assessment model.

7.6.2 Exploratory assessment

Due to the problems highlighted with the 2011 acoustic survey data, a run excluding the 2011 survey data was performed. The model fit is still towards the catch data and the diagnostic plots are very similar to those presented for the run based on the benchmark settings (Figure 7.6.1-17) (model specific diagnostic plots are vailable on the data folder on the HAWG SharePoint). The magnitude of the observation variance parameter for each data source for this run (Figure 7.6.22) and observation variance vs uncertainty of the data sources used in the model (Figure 7.6.23) are also similar to that presented in Figures 7.6.20-21. The most noticeable difference is the decreased weight given to the larval survey in the model, when excluding the 2011 survey data.

The stock trends (Figure 7.6.24) from this exploratory assessment indicate a continuation of the increasing SSB and decreasing F trends observed from the benchmark assessment (ICES WKPELA 2012). The uncertainty estimates of the stock parameters from this model (Figure 7.6.25) shows relatively low uncertainty, indicating that the model estimates the stock parameters reasonably well.

These results suggest that the stock parameter estimates in the terminal year are sensitive to the noisy 2011 acoustic survey data. The mis-match between the survey timing and the distribution of the stock (particularly at older ages), has been a feature of the survey and an attempt are currently being made to address this. Additionally, the 2011 survey results have also been adversely affected by weather. The Working Group concluded that presenting an assessment without the 2011 survey data is not appropriate at this stage. The validity of the 2011 survey data needs further investigation and the group will be in a better position to conclude on this issue when an additional year's survey data are available.

7.6.3 Final assessment

The final assessment was carried out by fitting the state-space model (SAM, in the FLR environment) using the settings and data inputs in accordance to the stock annex (as decided at the 2012 benchmark). The input data and model settings are shown in Tables 7.6.3.1-11, the SAM output is presented in Tables 7.6.3.13-21, the stock summary in Table 7.6.3.12 and Figure 7.6.26, model fit and parameter estimates in Table 7.6.3.22, and negative log-likelihood for the model fit in Table 7.6.3.23.

Diagnostics and selectivity parameters for this run are presented in Figure 7.6.1-23. The stock parameters are estimated well by the model, as indicated by the relatively low uncertainty associated with the stock parameter (Figure 7.6.27).

The retrospective pattern shows a very similar perception in SSB, F and recruitment for the years 2011 and 2010 (Figure 7.6.28). The retrospective bias from the model is low, except for F. The retrospective pattern up to this year's assessment shows consistent underestimation of SSB and overestimation of F. This bias has been reversed in 2011 with SSB revised slightly downward and F slightly upwards compared to the

2010 assessment. Exploratory analysis indicated that this was primarily driven by the low SSB estimate from the 2011 acoustic data. No appropriate model fit was found for the 2008 retrospective run, which did not converge on a valid solution and was thus removed from the plots. Preliminary investigations into this indicate that this is mostly caused by the 2007 age 1 catch estimates. The exact effect this has on the model and the reasoning why this happens require more in-depth analysis.

7.6.4 State of the stock

Trends from the final assessment indicates an increase in SSB and recruitment in recent years, with an associated downward trend in F. Based on the most recent estimates the stock is being harvested sustainably and below F_{MSY}.

7.7 Short term projections

7.7.1 Deterministic short term projections

A deterministic short term forecast was conducted for Irish Sea herring using MFDP (Smith 2000). Population abundances, F at age and input data were taken from the final SAM accepted assessment, 1961-2011 (Table 7.7.1). Geometric mean recruitment of 1-ringers (1995-2009) replaced recruitment for 1-ringers in 2012. The forecast was based on a TAC constraint (2012 quota = 4,752 t) assuming full uptake of the UK quota, and full swapping to the UK, and subsequent uptake of the Irish quota. Fishing mortality, catch weights at age and stock weights were averaged over the past three years. Fishing mortality was not scaled to the last year, as the terminal estimate of F was not considered more informative.

The short term catch option table is given in Table 7.7.2. SSB is expected to be well above B_{pa} in 2012-2014 (and therefore also $B_{trigger}$, if taken as analogous, similar to other stocks), but is predicted to decrease.

7.7.2 Yield per recruit

The benchmark working group (ICES WKPELA 2012) performed a yield per recruit analysis and estimated yield per recruit reference points by means of the plotMSY software (Figure 7.7.1). Fmax and F0.1 have been poorly defined and no appropriate yield per recruit reference points could be defined for this stock.

7.8 Medium term projections

No medium term stock projections of stock size were conducted by the Working Group.

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 by the benchmark working group. There are no precautionary F reference points for this stock. MSY reference points were estimated by means of the plotMSY software (ICES WKPELA 2012). F_{msy} were calculated based on the three common stock recruit relationships; Ricker, Beverton-Holt and Hockeystick. The Beverton and Holt relationship was preferable as there is no evidence of reduced recruitment at high SSB, which is the underlying assumption for a Ricker curve. CVs and AICc suggest that Beverton and Holt is also slightly better model fit. F_{msy} appears to be well estimated and a F_{msy} of 0.26 is proposed as candidate reference point for management.

7.10 Quality of the assessment

The data used within the assessment, the assessment methods and settings were scrutinized during the 2012 benchmark (ICES WKPELA 2012). The benchmark group performed sensitivity tests to test model configurations and optimised the model fit to the data with the least amount of parameters estimated. The Working Group checked for convergence and judged that a good model fit was found. FLSAM will not run if convergence criteria are not achieved.

The stock is very well sampled and catch information is representative of the fishery (with the exception of 2009 when no samples were provided). The current assessment, being a time-series model, can estimate the missing catch numbers in 2009.

The main issues with the stock are stock mixing (at younger ages from fish of different spawning season origin) and the different trends in mortality observed in the survey and the commercial catches. 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, but is also affected by the effect the annual closure of the Douglas Bank spawning grounds has on the fishery patterns.

The benchmark working group concluded that the data should be treated as for a mixed stock. Both the fishery and survey operate on this mixture and by using the data without adjustment for winter hatched fish, the assessment will be conducted on the mixed stock. The noise in the data due to juvenile stock mixing resulted in increased estimates of F, catchability estimates >1 across the younger ages in the survey, or most likely a combination of these. Recruitment estimates from the SAM model appears unusually smooth. Examination of the model output suggests that the model does not fit the age 1 data and putting all the variability in the observation variance (rather than into the variability of the recruitment process). This result warrants further investigation. In the mean time, the recruitment estimates for the stock should be considered as smooth estimates. Currently, the model doesn't have the structure to deal with the emigration of small herring from other stocks.

The Fbar range has also been changed from 2-6 to 4-6 to be more representative of the mortality on the autumn spawning stock in the Irish Sea, excluding most the ages with significant mixed components.

An analysis of the output of the SAM assessment was made during the benchmark (ICES WKPELA 2012). No major validations of the assumption underpinning the assessment were found. The final assessment model is dominated by information from the catch, with the noise being added to the survey information as age and year effects. SAM down weights the age 1 and survey information in general. The model fit to the catch information needs further investigation, especially if the additional survey information adds more weight or accuracy to the abundance trends from the survey. The uncertainty estimates of the model parameters, however, suggest the model is both appropriate for the available data and that the model describes these data reasonably well. Very little retrospective bias was also present.

The weight given to catch data will make the model particularly sensitive to the structure within the catch data. This sensitivity is hinted at from the lack of an appropriate model for the 2008 retrospective run. Similar data issues could be introduced in future that could result in having no assessment model. To ensure robustness of the assessment model, the sensitivity to the model to certain data issues (such as observed in the 2008 run) require detailed further investigation.

The 2011 acoustic survey is thought to be a poor estimate of spawning stock stock abundance and structure (most likely being an underestimate at older ages). The affect the 2011 survey estimate has on the assessment, and the associated stock parameter estimates, is of major concern and should be given further consideration in future.

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).

The assessment for this stock has not been accepted by the WG for more than 20 years; ACFM did, however, produced a short-term forecast for advice in 1999. The current assessment and forecast indicate an increasing trend in SSB and fishing mortalities at or slightly below F_{msy}. There are uncertainties related to the estimate of the 2011 survey data being considered an underestimate, resulting in lower SSB and higher F estimates.

The Working Group supports the development of a long-term management plan for this stock. A significant amount of the issues highlighted by the benchmark process and the Working Group could be addressed as part of this process to improve the robustness of the assessment and advice. Such a plan should be developed with stakeholders 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, 1987-2011. 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	2011
Ireland	1 153	581	0	0	0	0	0
UK	3 234	3821	4 629	4895	4594	4894	5202
Unallocated	-	-				-	
Total	4 387	4 402	4 629	4895	4594	4894	5202

Table 7.2.2 Herring in Division VIIa North (Irish Sea). Catch at length data 1995-2011. 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	2011
14															-		
14.5															-		
15															-		
15.5					10								16		-	93	
16	21	21	17		19	12	9					2			-	107	30
16.5	55	51	94		53	49	27			13	1	44	33	1	-	487	165
17	139	127	281	26	97	67	53			25	39	140	69	3	-	764	356
17.5	148	200	525	30	82	97	105			84	117	211	286	11	-	1155	851
18	300	173	1022	123	145	115	229			102	291	586	852	34	-	1574	1406
18.5	280	415	1066	206	135	134	240	36		114	521	726	2088	64	-	1405	841
19	310	554	1720	317	234	164	385	18		203	758	895	2979	85	-	866	1029
19.5	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108	-	673	1026
20	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100	-	787	1062
20.5	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133	-	888	1502
21	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192	-	1470	1874
21.5	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217	-	1758	1396
22	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271	-	2363	2372
22.5	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229	-	3362	2778
23	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322	-	4530	4100
23.5	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264	-	5232	3394
24	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259	-	4559	4759
24.5	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204	-	3616	3729
25	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148	-	3083	3430
25.5	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114	-	2582	2662
26	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78	-	1777	2343
26.5	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42	-	950	1595
27	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23	-	460	1083
27.5	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10	-	216	472
28	834	906	638	1235	276	212	496	162	726	198	45	104	33	12	-	9	248
28.5	123	564	440	170	169	58	179	108	569	51	18	9	26	1	-		53
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 2011.

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)	4247	23	2930	1122
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	0	-	-	-
	UK (N. Ireland)	955	13	2063	623
	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 - 2011. 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
2011	Area VIIa(N)	27/08-10/09 11-12/10	131,527	0.36	49,128	0.22	280,000	0.11

[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
2011	1927.0	330.2	43.9	15.0	21.9	6.3	2.7	2.0

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
2011	-	-	8 Nov	13.8	0.05

Table 7.6.3.1 Herring in Division VIIa North (Irish Sea). CATCH IN NUMBER

Units : thousands

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	8692	5669	20290	8939	NA
2	21387	11879	16929	3743	11473	9021	4694	8833	13980	15253	18291	18974	NA
3	7562	3875	5936	5873	7151	1894	3345	5405	10555	8198	4980	7487	NA
4	7341	4450	1566	2065	13050	1866	2559	2161	3287	6318	1655	2696	NA
5	1641	6674	1477	558	3386	2395	882	623	1422	1325	1062	2082	NA
6	2281	1030	1989	347	936	953	2945	213	415	605	325	1761	NA
7	840	2049	444	251	650	474	872	673	292	262	122	328	NA
8	1432	451	622	147	803	337	605	127	368	246	111	216	NA

age	2010	2011
1	9588	7454
2	17627	17598
3	6679	8984
4	6201	3982
5	3200	3671
6	925	1751
7	370	690
8	185	425

Table 7.6.3.2 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	0.269	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	2011
1	0.0620	0.053	0.058
2	0.1080	0.106	0.106
3	0.1330	0.131	0.134
4	0.1490	0.145	0.152
5	0.1545	0.153	0.159
6	0.1730	0.164	0.175
7	0.1855	0.175	0.187
8	0.1890	0.172	0.196

Table 7.6.3.3 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	0.269	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	2011
1	0.0660	0.060	0.057
2	0.1140	0.118	0.109
3	0.1350	0.134	0.136
4	0.1500	0.147	0.155
5	0.1550	0.153	0.162
6	0.1740	0.165	0.177
7	0.1860	0.176	0.188
8	0.1895	0.173	0.197

Table 7.6.3.4 Herring in Division VIIa North (Irish Sea). NATURAL MORTALITY

Units : NA

age \ year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age \ year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age \ year	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
1	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787	0.787
2	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380	0.380
3	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353
4	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335	0.335
5	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315
6	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311	0.311
7	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304
8	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304	0.304

age \ year	2009	2010	2011
1	0.787	0.787	0.787
2	0.380	0.380	0.380
3	0.353	0.353	0.353
4	0.335	0.335	0.335
5	0.315	0.315	0.315
6	0.311	0.311	0.311
7	0.304	0.304	0.304
8	0.304	0.304	0.304

Table 7.6.3.5 Herring in Division VIIa North (Irish Sea). PROPORTION MATURE

Units : NA

year

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

year

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

year

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	0.114	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	1.000	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	0.970	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	1.000	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	1.000	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	1.000	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.000	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	1.000	1.00

year

age	2006	2007	2008	2009	2010	2011
1	0.19	0.16	0.16	0.13	0.11	0.08
2	0.89	0.94	0.84	0.82	0.92	0.90
3	1.00	0.98	1.00	0.97	1.00	1.00
4	1.00	1.00	1.00	0.98	0.98	1.00
5	1.00	1.00	1.00	1.00	0.97	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

Table 7.6.3.6 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	2011
1	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
3	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
5	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
7	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

Table 7.6.3.7 Herring in Division VIIa North (Irish Sea). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age \ year	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 \ year	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 \ year	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 \ year	2006	2007	2008	2009	2010	2011
1	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
3	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
5	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
7	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

Table 7.6.3.8 Herring in Division VIIa North (Irish Sea). SURVEY INDICES

AC(VIIaN) - 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	2011.0	0.7	0.8

Index type : number

AC(VIIaN) - 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	2011
1	94330	374731	1316673	475675	371230	580602	1927032
2	109938	96623	251276	452364	182643	561245	330180
3	97111	15625	46570	114210	177813	117699	43855
4	17023	9982	21101	39076	92741	120777	14978
5	8029	530	20818	26370	32490	34325	21896
6	810	369	1200	17063	15071	16759	6308
7	607	478	718	4254	13940	4336	2715
8	5804	469	556	599	6871	6453	1959

NINEL - Configuration

FLT04: Combined larvae (Catch: Unknown) (Effort: Unknown)

min	max	plusgroup	minyear	maxyear	startf	endf
NA	NA	NA	1993	2011	NA	NA

Index type : biomass

NINEL - Index Values

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
all	38.3	71.2	15.1	4.7	29.1	5.8	16.7	35.5	55.3	31.5	15.8	22.7	26.4	43.8

age \ year	2007	2008	2009	2010	2011
all	12.6	16.8	16.9	20.4	13.8

Table 7.6.3.9 Herring in Division VIIa North (Irish Sea). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	8	8	1961	2011	4	6

Table 7.6.3.10 Herring in Division VIIa North (Irish Sea). FLSAM CONFIGURATION SETTINGS

```
name           :
desc           :
range          :       min       max plusgroup   minyear   maxyear   minfbar
maxfbar
range          :         1         8         8      1961      2011         4
6
fleets         :     catch AC(VIIaN)     NINEL
fleets         :         0         2         3
plus.group     : TRUE
states         :            age
states         : fleet       1  2  3  4  5  6  7  8
states         :   catch     1  2  3  4  5  6  7  7
states         :   AC(VIIaN) NA NA NA NA NA NA NA NA
states         :   NINEL     NA NA NA NA NA NA NA NA
logN.vars      :             1  2  2  2  2  2  2  2
catchabilities :            age
catchabilities : fleet       1  2  3  4  5  6  7  8
catchabilities :   catch     NA NA NA NA NA NA NA NA
catchabilities :   AC(VIIaN)  1  2  3  4  4  4  4  4
catchabilities :   NINEL     NA NA NA NA NA NA NA NA
power.law.exps :            age
power.law.exps : fleet       1  2  3  4  5  6  7  8
power.law.exps :   catch     NA NA NA NA NA NA NA NA
power.law.exps :   AC(VIIaN) NA NA NA NA NA NA NA NA
power.law.exps :   NINEL     NA NA NA NA NA NA NA NA
f.vars         :            age
f.vars         : fleet       1  2  3  4  5  6  7  8
f.vars         :   catch     1  1  1  1  1  1  1  1
f.vars         :   AC(VIIaN) NA NA NA NA NA NA NA NA
f.vars         :   NINEL     NA NA NA NA NA NA NA NA
obs.vars       :            age
obs.vars       : fleet       1  2  3  4  5  6  7  8
obs.vars       :   catch     1  2  3  3  4  4  4  4
obs.vars       :   AC(VIIaN)  5  6  6  7  7  8  8  8
obs.vars       :   NINEL     NA NA NA NA NA NA NA NA
srr            : 0
cor.F          : FALSE
nohess         : FALSE
timeout        : 3600
```

Table 7.6.3.11 Herring in Division VIIa North (Irish Sea). FLR, R SOFTWARE VERSIONS

```
R version 2.13.1 (2011-07-08)

Package  : FLSAM
Version  : 0.99-1
Packaged :
Built    : R 2.13.2; ; 2012-03-19 10:49:36 UTC; windows

Package  : FLAssess
Version  : 2.4
Packaged :
Built    : R 2.14.0; i386-pc-mingw32; 2012-02-10 08:16:04 UTC; windows

Package  : FLCore
Version  : 2.4
Packaged :
Built    : R 2.14.0; i386-pc-mingw32; 2012-02-10 08:15:33 UTC; windows
```

Table 7.6.3.12 Herring in Division VIIa North (Irish Sea). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 4-6) f	Landings tonnes	Landings SOP
1961	81389	14220	7960	0.3121	5710	1.0002
1962	85734	10873	5947	0.3005	4343	0.9995
1963	127772	11450	5195	0.3140	3947	0.9992
1964	169566	14367	5191	0.2924	3593	1.0004
1965	183689	16850	7684	0.3067	5923	1.0021
1966	269682	25911	9104	0.2745	5666	1.0003
1967	330380	36169	10837	0.2801	8721	1.0023
1968	383847	46533	25162	0.2803	8660	0.9995
1969	385771	53413	31326	0.3173	14141	1.0004
1970	441088	66684	40629	0.3749	20622	0.9997
1971	447754	68618	43670	0.4074	26807	0.9994
1972	431490	56818	38690	0.4550	27350	0.8928
1973	468364	52358	32055	0.4860	22600	0.9927
1974	375120	47766	38126	0.5816	38640	1.0043
1975	332369	36271	28418	0.6325	24500	0.9747
1976	278730	29269	18967	0.6715	21250	1.0073
1977	261974	24380	13982	0.6469	15410	1.0484
1978	217728	22271	12220	0.6019	11080	1.0819
1979	173338	19780	10999	0.5639	12338	1.0757
1980	166875	17059	11054	0.5104	10613	1.0308
1981	178082	17428	10850	0.4120	4377	1.0999
1982	184425	20767	12221	0.3264	4855	1.0166
1983	174033	24272	14344	0.2754	3933	1.0165
1984	162918	26624	16257	0.2670	4066	1.0392
1985	176663	27432	16053	0.3100	9187	0.9802
1986	189662	26766	18027	0.3151	7440	1.0238
1987	194464	23683	15919	0.3234	5823	0.9632
1988	148301	24439	17762	0.3672	10172	0.9505
1989	143200	22332	14253	0.3436	4949	0.9966
1990	126374	21381	13889	0.3426	6312	0.9872
1991	110747	17773	9523	0.3236	4398	0.9994
1992	129573	14570	8987	0.3404	5270	0.9890
1993	99907	16479	8904	0.3355	4409	0.9869
1994	119134	14580	9937	0.3483	4828	0.9757
1995	113210	13815	9205	0.3552	5076	1.0007
1996	102130	12174	7250	0.3754	5301	0.9999
1997	104925	10957	7043	0.4293	6651	0.9996
1998	109645	10715	7214	0.4653	4905	0.9951
1999	84288	10833	7043	0.4241	4127	1.0001
2000	85477	10353	7367	0.3799	2002	0.9993
2001	92319	9783	5743	0.4473	5461	1.0004
2002	93807	10371	5850	0.4437	2393	0.9984
2003	119850	10904	5473	0.4710	2399	1.0010
2004	140646	12279	7727	0.4207	2531	0.9979
2005	165380	14091	9195	0.4210	4387	1.0062
2006	211082	15941	9627	0.3790	4402	1.0005
2007	254231	21879	13130	0.2879	4629	1.0012
2008	239426	24803	15928	0.2770	4895	1.0008
2009	254486	26134	16946	0.2640	4594	0.0000
2010	275130	27127	18542	0.2524	4894	0.9989
2011	296855	27951	18858	0.2509	5202	1.0014

Table 7.6.3.13 Herring in Division VIIa North (Irish Sea). ESTIMATED FISHING MORTALITY

Units : f

age \ year	1961	1962	1963	1964	1965	1966	1967
1	0.0217509	0.01926433	0.01870433	0.01649827	0.01493123	0.0144610	0.01544608
2	0.4435876	0.52286080	0.48414056	0.44556150	0.40033643	0.3498328	0.33685591
3	0.3141138	0.38805042	0.40310831	0.46436704	0.43759564	0.3916644	0.30537950
4	0.3357797	0.31120606	0.32788249	0.27817635	0.29416925	0.2813376	0.30255264
5	0.2406769	0.27332328	0.28633295	0.24031613	0.22317479	0.1799817	0.19405765
6	0.3598385	0.31685849	0.32781692	0.35883235	0.40264097	0.3623300	0.34359213
7	0.6899197	0.60110239	0.62708699	0.47799261	0.38530117	0.3275220	0.34763576
8	0.6899197	0.60110239	0.62708699	0.47799261	0.38530117	0.3275220	0.34763576

age \ year	1968	1969	1970	1971	1972	1973	1974
1	0.01616673	0.01931642	0.02603275	0.03630862	0.05030253	0.0630202	0.07516271
2	0.29194204	0.27954276	0.28785454	0.35274848	0.34455553	0.3730548	0.52857002
3	0.27587705	0.29238028	0.33658654	0.40362462	0.44499599	0.5258496	0.64670179
4	0.32752202	0.35643621	0.41184838	0.44620803	0.44382719	0.4695361	0.60731966
5	0.18499990	0.23195776	0.31714379	0.34770530	0.41981548	0.4722343	0.55442707
6	0.32840752	0.36363670	0.39579456	0.42842482	0.50135542	0.5163657	0.58314466
7	0.37541620	0.41655782	0.52732934	0.55288238	0.65236569	0.7674515	0.83445205
8	0.37541620	0.41655782	0.52732934	0.55288238	0.65236569	0.7674515	0.83445205

age \ year	1975	1976	1977	1978	1979	1980
1	0.08226578	0.08551188	0.08169193	0.07351249	0.06411993	0.05290275
2	0.56719620	0.60349351	0.60337282	0.54312271	0.58484408	0.55075787
3	0.68993354	0.71123670	0.71857873	0.69720904	0.64621695	0.60174591
4	0.64985891	0.70789465	0.67763262	0.64797705	0.61522329	0.55060919
5	0.63054548	0.64626865	0.63086714	0.54995985	0.52308568	0.48853703
6	0.61717047	0.66045915	0.63206060	0.60763555	0.55351856	0.49200323
7	0.83394319	0.84586966	0.79300163	0.63846399	0.51616438	0.43443454
8	0.83394319	0.84586966	0.79300163	0.63846399	0.51616438	0.43443454

age \ year	1981	1982	1983	1984	1985	1986
1	0.04348671	0.03592938	0.02946654	0.02645527	0.02573509	0.02561698
2	0.36960515	0.27329595	0.20248287	0.16950040	0.19390247	0.22044655
3	0.36403692	0.27060367	0.22139651	0.21807854	0.26402803	0.26305293
4	0.45459426	0.35197329	0.26689499	0.25135223	0.30897343	0.30107376
5	0.35643621	0.25147794	0.22935139	0.25009861	0.29162108	0.30167651
6	0.42493035	0.37580684	0.32998767	0.29948229	0.32936129	0.34263142
7	0.37664205	0.33769911	0.25438663	0.30977780	0.40414159	0.46237455
8	0.37664205	0.33769911	0.25438663	0.30977780	0.40414159	0.46237455

age \ year	1987	1988	1989	1990	1991	1992
1	0.02484248	0.02518013	0.02531394	0.02735106	0.02962312	0.03211924
2	0.21127388	0.21664396	0.19249213	0.22020420	0.23347039	0.25107590
3	0.25157855	0.27546354	0.25019867	0.24504829	0.24385049	0.26670823
4	0.28260645	0.32155072	0.28926849	0.27937509	0.26153164	0.28845967
5	0.32029911	0.35872471	0.33524288	0.33608203	0.32103665	0.33746280
6	0.36721785	0.42140538	0.40615923	0.41239238	0.38829497	0.39531593
7	0.52393377	0.62770812	0.59622927	0.58020140	0.51164718	0.44187422
8	0.52393377	0.62770812	0.59622927	0.58020140	0.51164718	0.44187422

age \ year	1993	1994	1995	1996	1997	1998
1	0.03093398	0.03271898	0.03588629	0.03890237	0.03947057	0.03577164
2	0.27687199	0.32507479	0.40971643	0.49755957	0.56558765	0.42806082
3	0.27335062	0.31329815	0.33715922	0.35409147	0.38813192	0.37658556
4	0.27389786	0.27748178	0.28874827	0.29906331	0.37829158	0.41563409
5	0.34410790	0.36513067	0.37595343	0.40356004	0.45571394	0.49216562
6	0.38839205	0.40215809	0.40098149	0.42350075	0.45395373	0.48809755
7	0.44524526	0.48517288	0.51303562	0.60086800	0.73699070	0.67472505
8	0.44524526	0.48517288	0.51303562	0.60086800	0.73699070	0.67472505

age \ year	1999	2000	2001	2002	2003	2004	2005
1	0.03241286	0.02915876	0.0270005	0.02399284	0.02578145	0.03073049	0.03633042
2	0.34041153	0.26085254	0.3251398	0.28354059	0.21427394	0.22246177	0.27209609
3	0.33857827	0.29402220	0.3508839	0.28192900	0.29243876	0.32280721	0.32654092
4	0.36869704	0.35722123	0.4661723	0.45275235	0.48147547	0.42884060	0.41714141
5	0.42944998	0.37129811	0.4183110	0.39964045	0.41761722	0.41011404	0.41813121
6	0.47423609	0.41126397	0.4573575	0.47873408	0.51390852	0.42311977	0.42777411
7	0.55444925	0.41848259	0.5586009	0.60354782	0.75425106	0.60415167	0.54485259
8	0.55444925	0.41848259	0.5586009	0.60354782	0.75425106	0.60415167	0.54485259

year

age	2006	2007	2008	2009	2010	2011
1	0.03998304	0.04416158	0.04505821	0.04485591	0.04462326	0.04381408
2	0.27971054	0.25405614	0.22791102	0.22514740	0.21478881	0.20589272
3	0.31370570	0.24622735	0.21727314	0.21047256	0.20597510	0.21207824
4	0.34753149	0.23883078	0.21753403	0.21677399	0.21636251	0.21729487
5	0.37337201	0.28573228	0.28283262	0.27376095	0.26726890	0.26074822
6	0.41607906	0.33901870	0.33054912	0.30134485	0.27351468	0.27472079
7	0.47507623	0.34794878	0.31790585	0.26450371	0.22002810	0.23265468
8	0.47507623	0.34794878	0.31790585	0.26450371	0.22002810	0.23265468

Table 7.6.3.14 Herring in Division VIIa North (Irish Sea). ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1961	1962	1963	1964	1965	1966
1	81389.374	85733.5920	127771.6544	169566.4221	183689.112	269682.3328
2	42616.637	32273.4439	31824.7638	58162.7271	89054.160	69563.8281
3	14974.440	20387.9639	10802.1450	11928.6697	25463.466	44801.6389
4	46212.241	8653.3344	9384.3623	4714.0373	4403.698	11230.6284
5	1756.187	22651.9224	5317.1887	4179.3040	2739.690	1939.5281
6	1367.583	1085.0702	11626.0087	2895.1726	2268.105	1557.5977
7	2474.268	652.0361	669.2783	5984.3320	1495.476	950.2261
8	4161.372	2301.6925	1211.3612	693.4645	2969.949	2277.1957

age \ year	1967	1968	1969	1970	1971	1972
1	330380.4010	383847.2631	385771.305	441088.141	447754.334	431490.166
2	146385.6710	151903.3891	207938.990	170075.885	217292.576	202804.958
3	31350.9547	77342.5859	83616.822	129314.151	95415.851	99309.846
4	21021.4789	16791.0284	47954.120	48630.199	75811.100	45433.273
5	6349.3010	11057.8958	8898.162	27611.842	23837.136	36680.480
6	1200.1478	3683.4312	7871.469	5536.401	14349.925	13275.825
7	802.6349	633.1453	2056.375	4440.845	2859.208	7036.738
8	1755.1331	1377.3271	1068.916	1747.952	2827.929	2704.845

age \ year	1973	1974	1975	1976	1977	1978
1	468363.508	375119.530	332368.642	278730.320	261973.858	217727.596
2	161296.570	237993.823	140224.502	140084.347	102436.667	114691.363
3	106404.165	79538.782	92410.880	50513.707	50919.437	33928.139
4	44891.332	47287.440	28001.126	31445.149	16642.251	16881.945
5	21752.849	22359.353	17434.390	10306.190	10257.865	5900.545
6	17556.859	10393.127	9817.286	6251.646	3820.360	3617.361
7	5784.863	8036.910	4230.604	4001.002	2151.671	1466.304
8	4025.080	3325.915	3562.793	2485.179	2006.606	1227.826

age \ year	1979	1980	1981	1982	1983	1984
1	173338.2211	166874.9486	178082.1073	184425.3401	174032.9625	162917.628
2	92874.0915	62818.1925	67104.0716	79459.2825	85991.1790	81961.098
3	51174.6719	33322.8958	18996.3095	31792.9549	42108.2937	54284.825
4	10920.5324	20066.3588	10038.6709	8630.8649	18055.3984	26849.433
5	6187.5841	3920.6001	8246.9606	3769.5089	4079.7868	11708.847
6	2559.3280	2619.1366	1476.1609	4126.9751	2141.1535	2501.636
7	1333.2835	1083.3355	1140.8171	639.0611	2038.7660	1149.635
8	977.5994	948.8019	945.5814	1036.0804	734.2136	1791.843

age \ year	1985	1986	1987	1988	1989	1990
1	176663.134	189662.224	194463.546	148301.108	143200.353	126373.868
2	68596.720	80097.506	85476.777	109425.584	55436.860	70969.111
3	60294.731	36901.224	40457.204	49861.279	67037.001	31571.181
4	38177.438	35066.446	18794.133	22404.117	24884.490	41647.641
5	19206.422	20677.470	19200.661	10818.360	10292.801	13196.409
6	7890.383	11806.435	11587.706	10743.971	5226.515	5119.950
7	1577.979	4559.645	6800.150	6266.041	4879.022	2531.077
8	1835.735	1905.501	3429.604	5288.024	4607.773	3807.012

age \ year	1991	1992	1993	1994	1995	1996	1997
1	110746.601	129573.038	99907.496	119133.501	113210.025	102129.817	104924.886
2	56387.343	40014.613	70685.801	34613.533	65907.004	49861.279	44489.122
3	40659.996	30976.992	18458.865	44178.786	14708.782	36026.138	22247.835
4	17636.043	24489.507	16219.995	9363.739	23741.978	6969.509	20451.265
5	24367.365	10810.790	12895.066	8901.722	4953.749	13307.725	4014.628
6	6652.181	14405.999	5976.557	6689.537	4514.276	2570.357	6741.246
7	2310.225	3370.108	7514.577	3172.896	3226.328	2357.601	1257.776
8	2464.145	1928.504	2603.208	5257.443	4029.913	3340.581	2343.967

age \ year	1998	1999	2000	2001	2002	2003	2004
1	109644.654	84288.4396	85476.777	92318.515	93807.492	119850.4507	140645.8067
2	42616.637	61512.7654	30242.394	37835.383	39497.790	38445.6179	58571.2945
3	14569.710	21547.1751	36753.914	16638.923	14565.340	18060.8158	20881.1058
4	11209.310	6733.1610	11314.043	23908.755	7374.623	6896.0220	8644.6853
5	10834.600	5103.5926	3540.418	6521.763	10626.435	3016.0400	2699.7110
6	2068.130	4837.2420	2272.419	2053.293	3136.303	5034.1501	1303.7500
7	3322.258	963.6229	1984.059	1163.398	1042.211	1332.6171	1928.1186
8	1194.162	1699.0083	1014.448	1593.200	1167.477	895.5159	622.2861

```
   year
age        2005        2006        2007        2008        2009        2010
  1 165379.8122 211081.5857 254231.3606 239426.0788 254485.719 275130.277
  2  61389.8628  68734.0508  95511.3149 118302.4784  93620.064 110194.250
  3  38063.0776  28940.5788  32630.4115  51225.8722  67710.734  47192.960
  4   9884.2712  19422.7434  13692.4518  18136.8308  29554.757  38063.078
  5   3859.5273   3983.8342   9465.4159   8526.2081  10822.689  16428.945
  6   1279.8524   1615.8235   1970.8102   5669.7483   4704.148   5867.008
  7    638.7416    614.4945    715.5847   1178.9742   2931.003   2431.588
  8   1076.5320    695.9654    565.7770    704.7196   1073.415   1999.795
   year
age       2011
  1 296855.272
  2 117477.253
  3  55105.235
  4  24514.008
  5  20642.349
  6   8694.970
  7   3271.814
  8   2487.168
```

Table 7.6.3.15 Herring in Division VIIa North (Irish Sea). PREDICTED CATCH NUMBERS AT AGE

Units : NA

year

age	1961	1962	1963	1964	1965	1966
1	1213.4708	1133.6412	1640.1287	1922.1892	24755.4266	17268.3392
2	12876.1237	11112.9903	10320.1131	17634.9851	7697.8011	12368.5223
3	3432.1426	5587.7389	3055.1684	3784.3143	961.4475	2358.6153
4	11303.0740	1983.5233	2249.4702	980.2229	472.8556	275.3216
5	324.2809	4679.7501	1144.1646	770.6852	652.8321	410.6988
6	358.5005	255.3078	2816.6683	757.1868	416.3432	230.7581
7	1081.7983	257.8686	273.0951	229.9657	826.9052	3510.5570
8	1819.4690	910.3326	494.3086	1887.1443	2681.8443	35214.0349

year

age	1967	1968	1969	1970	1971	1972	1973
1	7014.9580	893.6909	7858.7277	11074.717	14694.962	19876.432	18895.895
2	4703.1134	5115.8048	35724.7856	54355.441	49726.835	42281.292	82669.003
3	965.6583	42548.5051	31451.4385	27013.716	30454.834	37231.111	32509.902
4	4267.5706	18009.0556	14102.8192	23472.857	14010.888	14486.030	18596.339
5	32279.8992	12343.0694	6490.2738	6059.484	10900.566	7109.947	8282.416
6	15839.9419	1589.8262	1571.1922	4344.995	4556.864	6166.582	4006.326
7	4021.3784	2081.8454	1590.3032	1061.757	2955.313	2724.281	4004.003
8	1609.7594	610.4827	625.9434	1050.089	1136.070	1895.637	1656.894

year

age	1974	1975	1976	1977	1978	1979	1980
1	18274.648	15901.520	14294.4982	10731.0855	7481.8847	5975.7208	5259.7038
2	51415.759	53787.695	39355.8536	40680.3315	34856.6773	22509.6638	17449.0415
3	39608.539	22114.748	22455.7054	14639.6664	20901.5793	12913.0021	4936.1947
4	11576.472	13828.265	7090.9883	6964.0745	4336.6611	7329.9209	3155.3352
5	7109.591	4279.451	4184.8243	2171.9703	2191.5624	1316.4316	2140.9823
6	3947.509	2641.309	1563.3872	1437.8152	948.3276	885.8964	444.0113
7	2106.873	2011.086	1036.1011	606.2849	469.6135	332.7928	311.6809
8	1774.191	1249.277	966.1992	507.6539	344.3023	291.4679	258.3280

year

age	1981	1982	1983	1984	1985	1986	1987
1	4516.5784	3503.2977	2947.9639	3112.1528	3327.2120	3309.658	2556.310
2	15937.1796	13201.8203	10690.2779	10120.3143	13275.8251	13636.837	17860.378
3	6404.3325	7093.3996	9015.2242	11883.4268	7247.8489	7636.617	10201.398
4	2197.2239	3620.6542	5107.0642	8696.8833	7809.0610	3962.419	5283.003
5	723.6733	721.5849	2236.9978	4199.4549	4655.6648	4551.581	2823.747
6	1121.8787	521.6256	560.7135	1919.1161	2969.5331	3089.826	3209.948
7	159.2890	397.3947	266.1526	456.9756	1472.5782	2423.069	2558.842
8	258.2324	143.1195	414.8056	531.6206	615.3985	1221.958	2159.409

year

age	1988	1989	1990	1991	1992	1993	1994
1	2482.248	2365.7255	2241.6108	2840.6552	2111.8508	2660.821	2768.664
2	8124.667	11748.9599	9842.3521	7448.6643	14344.7600	8074.692	18664.339
3	12599.470	5820.1424	7469.9232	6155.5537	3749.4708	10105.650	3582.120
4	5353.255	8694.0138	3473.9932	5256.3913	3327.6779	1942.964	5098.797
5	2537.082	3259.4378	5787.6406	2679.6997	3249.6091	2358.332	1344.799
6	1515.166	1502.8822	1858.1934	4084.1953	1669.8515	1923.574	1294.889
7	1918.003	974.8465	808.1680	1049.4904	2354.5620	1064.649	1130.935
8	1811.318	1466.2597	861.9868	600.6125	815.7027	1764.090	1412.731

year

age	1995	1996	1997	1998	1999	2000	2001
1	2703.2229	2817.6543	2674.5596	1864.3542	1704.2834	1705.4427	1542.5004
2	16509.9746	16270.1920	12513.4582	14924.6577	5824.7421	8824.9657	8182.2299
3	9148.8183	6101.0734	3894.5756	5265.8613	7957.4192	4191.4416	3039.7483
4	1543.5959	5531.4762	3276.7259	1782.4783	2916.6763	7666.9948	2310.5711
5	3830.7658	1275.5338	3659.0543	1545.6503	951.1103	1933.4669	3034.4334
6	771.0090	2138.9065	695.0960	1589.1428	665.5342	655.3569	1038.1131
7	932.0906	576.0647	1429.6715	358.5901	591.2447	435.3934	413.4307
8	1320.8358	1073.5219	513.8698	632.2785	302.2910	596.2619	463.1218

year

age	2002	2003	2004	2005	2006	2007	2008
1	2114.0694	2951.0018	4095.8519	5744.1659	7621.5878	7320.0322	8335.0100
2	6209.8996	9786.4103	12269.4781	14082.1033	17968.5808	20199.0328	17844.8459
3	3891.7725	4899.6056	9021.4468	6624.6313	6046.2287	8479.8666	7442.7077
4	2269.1487	2592.2979	2898.0692	4892.4085	2488.5363	3031.2489	6329.7119
5	892.8691	787.5131	1143.8214	1075.2947	2033.2281	1815.2891	3328.5432
6	1761.7801	390.8016	387.0485	477.7750	491.3172	1383.2762	1215.1344
7	620.1367	765.4470	234.5432	202.7878	182.9202	279.0860	416.4015

```
  8  416.7431  247.0325   395.3138   229.6761   144.6201   166.8174   342.4720
   year
age       2010       2011
  1  8838.7434  1213.4708
  2 18312.6984 12876.1237
  3  8927.5743  3432.1426
  4  4092.9858 11303.0740
  5  4092.2491   324.2809
  6  1807.7893   358.5005
  7   589.0906  1081.7983
  8   447.8104  1819.4690
```

Table 7.6.3.16 Herring in Division VIIa North (Irish Sea). CATCH AT AGE RESIDUALS

Units : NA

year

age	1961	1962	1963	1964	1965	1966	1967
1	1.528290	-1.262770	1.252500	-0.281047	0.3690000	-0.566570	-0.7159840
2	-0.475693	0.416416	-0.366513	0.106007	0.1927860	0.743655	-0.0476464
3	-0.845897	0.865527	-0.844876	0.439131	0.0832174	-0.524931	0.7870770
4	0.300797	-0.288748	0.791786	-1.023390	0.9361840	-1.985900	-1.6575100
5	-0.715247	0.349816	1.598600	-0.868739	0.9688630	-0.354860	-0.2768020
6	0.674300	-0.680211	-0.513011	-0.150829	0.0371692	-1.572030	-0.5168550
7	0.233277	-0.703584	1.623880	-0.613595	-0.3738330	0.272015	0.0451502
8	0.392347	-0.729003	0.546114	-0.929131	-1.2141200	0.618507	-1.5925300

year

age	1968	1969	1970	1971	1972	1973	1974
1	-0.8874750	-0.391393	0.1090310	1.178070	0.8705370	0.9589630	0.6959420
2	-1.5679900	-0.560392	0.8562650	-0.261855	-1.0528900	1.1589000	-0.2623400
3	0.0240256	0.212367	0.5316460	-0.387960	0.0847366	0.6380520	-0.0157917
4	-0.2001930	0.491392	0.7151000	-0.193993	-0.7352470	0.8761710	-0.2085730
5	0.0857150	1.557000	-0.4178820	0.544326	-0.0634827	0.5893170	0.2381720
6	-0.4341750	0.255315	-0.4743130	0.924418	-0.4589540	0.5146370	0.1509000
7	0.5585170	0.653876	-0.1078770	-0.246757	-0.1184770	0.5899750	-0.0188451
8	-0.3402330	1.214700	-0.0819715	0.903007	0.7405710	-0.0383596	-0.1843550

year

age	1975	1976	1977	1978	1979	1980
1	0.9050260	0.8692770	0.428814	0.52469800	-0.0266102	-0.0471232
2	0.1777610	-0.0330444	-0.395902	0.38455100	0.5550320	-0.4112850
3	-0.1975120	0.0330905	-0.278406	0.37047500	1.3095400	-1.3754000
4	0.3042800	-0.1563670	-0.084988	-0.06403840	0.4774150	-0.3904660
5	0.1590950	0.1805930	-0.519763	0.00901541	0.9567330	0.1679350
6	0.1451150	-0.1603610	-0.165131	0.23872800	0.0629112	-0.6955800
7	0.4338390	-0.3041750	0.234233	-0.37606500	0.1842010	-0.1689930
8	0.0385727	0.3462320	-0.871637	-0.40231700	-0.5551600	-0.1724850

year

age	1981	1982	1983	1984	1985	1986	1987
1	0.1406880	-1.143620	-1.0721800	-0.2870100	0.3473540	-0.4598600	0.0227375
2	0.0239100	-0.337709	-0.9807720	-0.0286995	0.5750250	-0.2028940	0.7153590
3	-0.3864380	-0.751267	-0.6971650	1.1983300	0.0924043	-0.6890650	0.8518770
4	-0.0689459	-0.793030	-0.9039970	1.3448500	0.2876500	-0.8850120	0.9642580
5	-1.8405600	-1.133000	-0.0168174	1.2656400	-0.0651797	-0.1996270	1.1489100
6	-0.0249468	-0.175487	-0.9118730	0.7572510	0.1737340	-0.2501910	1.0778500
7	-0.3025390	-1.039930	-0.3524030	0.8863750	-0.0136951	-0.0938121	0.5474270
8	0.9054970	-2.077070	0.3372750	0.7239400	0.8303090	0.7335660	1.5665400

year

age	1988	1989	1990	1991	1992	1993	1994
1	-0.885007	-0.0260974	-0.1326620	1.6825700	-1.3717900	-0.348121	0.1691240
2	-0.991907	0.3639550	-0.0371336	-0.3239340	0.0827587	-0.586772	0.5495620
3	-0.144395	-0.0517395	-0.3248810	0.2896980	-0.6991620	0.588529	-0.1739800
4	-0.407576	0.3464620	-0.6472390	0.7652610	-0.3110040	-0.196997	0.1041890
5	-0.707578	0.2316270	-0.3112290	0.4565900	-0.2643820	0.197821	-0.2689720
6	-0.441568	0.2344760	-0.5128820	0.5307230	-0.0913826	0.210151	-0.2700010
7	-0.485749	0.1561580	-0.2740330	-0.0303211	-0.1794740	0.428130	-0.4686030
8	0.180116	0.2264680	-0.1313820	-1.0001300	0.0910072	0.283624	0.0642744

year

age	1995	1996	1997	1998	1999	2000	2001
1	0.7873240	1.413730	0.1593200	-0.0342649	-0.386191	0.537624	-2.494260
2	0.2465520	1.125670	-0.2142070	0.5187340	-1.820480	1.080250	0.401741
3	0.2055240	0.681203	-0.0159764	0.3801290	-0.963804	1.695130	-1.501170
4	-0.9065670	0.898080	0.9711840	-0.4108640	-1.095730	1.687690	-0.678114
5	-0.1436730	0.590528	1.4087400	-0.1064870	-1.249950	1.313390	-0.554660
6	0.0271870	0.150759	0.9217840	0.5260750	-1.526510	0.835467	-0.200511
7	0.0716031	0.884097	0.8435860	0.5007740	-2.008230	0.939265	0.320451
8	0.0753827	0.675343	-0.3058860	-0.0384130	-1.689870	0.697738	-0.745148

year

age	2002	2003	2004	2005	2006	2007	2008
1	-1.2900000	0.102827	0.871376	-0.0152498	1.1339400	0.231399	0.1621880
2	-1.1520500	-0.421937	0.537264	0.3288060	0.0732308	-0.257563	-0.0505522
3	-0.4804030	0.311524	0.498173	0.6761760	-0.6156180	-0.395136	-0.3435580
4	0.3814610	-0.577439	0.399594	0.8114280	-1.2943000	-0.371919	-0.0651912
5	-0.0287148	-0.549271	0.510260	0.4894630	-1.5223100	0.321321	-0.0923200
6	1.2042700	-1.422550	0.163449	0.5533750	-0.9686550	0.565890	-0.6394540
7	0.7989260	-0.301701	0.513578	0.6004870	-0.9493510	0.378537	-0.2769290
8	0.8737180	-1.559500	-0.167818	0.1609400	-0.6201550	0.605619	-1.4434700

year

age	2010	2011
1	-0.1973330	1.528290
2	-0.1638910	-0.475693
3	0.0200077	-0.845897
4	-0.0872298	0.300797
5	-0.2546150	-0.715247
6	-0.0748195	0.674300
7	0.3705910	0.233277
8	-0.1225440	0.392347

Table 7.6.3.18 Herring in Division VIIa North (Irish Sea). PREDICTED INDEX AT AGE NINEL

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
all	20.28781	21.93777	20.49047	16.41195	15.86714	15.38665	15.78263	16.35543

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
all	12.68627	13.15366	11.90442	16.86449	19.76356	20.63008	28.29231	34.70522

age \ year	2009	2010	2011
all	37.36035	41.06434	42.03321

Table 7.6.3.19 Herring in Division VIIa North (Irish Sea). INDEX AT AGE RESIDUALS NINEL

Units : NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000
all	0.773411	1.43293	-0.37156	-1.52198	0.738189	-1.1875	0.0687732	0.943262

age \ year	2001	2002	2003	2004	2005	2006	2007	2008
all	1.79196	1.06292	0.344574	0.361681	0.352391	0.916374	-0.984542	-0.88306

age \ year	2009	2010	2011
all	-0.965557	-0.85152	-1.35566

Table 7.6.3.20 Herring in Division VIIa North (Irish Sea). PREDICTED INDEX AT AGE AC(VIIaN)

Units : NA

age \ year	1994	1995	1996	1997	1998	1999
1	193087.745	182992.418	164670.206	169143.036	177353.465	136584.671
2	67144.346	119934.375	84948.460	72034.468	76519.432	117959.898
3	59545.738	19470.193	47103.378	28356.172	18722.663	28489.760
4	13065.494	32836.632	9568.770	26457.634	14100.986	8773.929
5	11806.671	6517.264	17148.226	4974.997	13063.534	6449.965
6	8655.325	5845.749	3272.665	8389.867	2508.700	5928.936
7	3877.787	3861.265	2641.705	1272.667	3522.196	1118.004
8	6425.373	4823.379	3743.476	2371.695	1265.978	1971.303

age \ year	2000	2001	2002	2003	2004	2005
1	138926.459	150256.633	153077.560	195125.8473	228136.6339	267373.0090
2	61555.839	73372.171	79007.653	81023.9444	122675.7531	123883.8857
3	50251.717	21799.450	20094.873	24720.7932	27936.7973	50792.2976
4	14870.728	28955.053	9022.529	8256.7803	10767.5257	12420.5793
5	4673.857	8311.954	13733.454	3845.5811	3461.9594	4919.5877
6	2920.091	2548.780	3831.302	5990.0198	1660.5099	1624.3289
7	2549.239	1345.579	1165.529	1330.9523	2155.3319	746.4286
8	1303.359	1842.742	1305.603	894.4241	695.5897	1258.0774

age \ year	2006	2007	2008	2009	2010	2011
1	340339.8649	408276.5327	384231.3023	408603.285	441794.447	477252.032
2	137998.7630	195360.1388	246767.0369	195731.676	232210.601	249272.013
3	38975.9473	46258.4764	74154.0526	98577.666	68892.321	80113.527
4	25714.2348	19667.6415	26468.2188	43152.688	55592.301	35781.991
5	5251.3476	13324.3704	12028.4505	15372.416	23447.051	29608.004
6	2068.9365	2673.5434	7740.1783	6564.161	8359.718	12378.174
7	756.7099	969.3444	1633.4343	4226.756	3625.400	4832.407
8	857.0446	766.3814	976.3489	1547.971	2981.733	3673.463

Table 7.6.3.21 Herring in Division VIIa North (Irish Sea). INDEX AT AGE RESIDUALS AC(VIIaN)

Units : NA

age	1994	1995	1996	1997	1998	1999	2000
1	-1.10605000	0.579671	-2.7892300	-0.241638	-0.493773	0.150263	-0.594789
2	0.02974580	-0.664110	-1.2249500	-0.643852	-1.814330	-0.734720	0.914058
3	0.37151200	-0.861908	0.6328820	-1.143650	-1.479300	0.312266	1.302640
4	-0.13384700	-0.160107	-0.0918199	-1.215420	-0.580558	-0.747988	0.852206
5	-0.33011900	-0.489547	0.6001760	-1.443810	-0.969595	0.641801	0.755510
6	-0.16289300	-0.611561	0.2891760	-0.728746	-0.410465	0.982888	0.740019
7	-0.00331587	0.280870	0.9602280	-0.955562	-0.532193	0.416888	0.778819
8	0.54135600	0.425839	0.5251010	-0.258120	-0.577417	1.383130	0.707345

age	2001	2002	2003	2004	2005	2006	2007
1	0.987783	0.977529	0.6067120	0.0571905	-1.086090	0.100385	1.2206500
2	0.425132	-0.165160	1.7592800	-0.1057950	-0.210287	-0.627697	0.4432680
3	-1.338610	0.802863	0.4535870	0.1013590	1.141320	-1.609800	0.0118294
4	-0.697058	1.398240	-0.7688270	0.4945730	0.435822	-1.308370	0.0972694
5	-0.105013	1.137990	0.0268479	-0.7130820	0.677276	-3.170920	0.6169770
6	-0.738416	1.613650	-0.4551900	0.3878900	-0.829579	-2.055430	-0.9550820
7	-0.912341	1.026060	-0.3686010	-2.6270300	-0.246524	-0.547682	-0.3578510
8	0.244936	1.464920	0.0153282	-1.2686900	1.822900	-0.718794	-0.3826070

age	2008	2009	2010	2011
1	0.222596	-0.100006	0.284776	1.454900
2	1.067390	-0.121890	1.554180	0.495029
3	0.760582	1.038820	0.943306	-1.061150
4	0.538599	1.057820	1.072810	-1.204100
5	1.085310	1.034710	0.526908	-0.417164
6	0.942453	0.990926	0.829222	-0.803707
7	1.141190	1.422740	0.213394	-0.687395
8	-0.582485	1.776880	0.920461	-0.749563

Table 7.6.3.22 Herring in Division VIIa North (Irish Sea). FIT PARAMETERS

	name	value	std.dev
1	logFpar	1.097500	0.245210
2	logFpar	1.191300	0.161800
3	logFpar	0.798020	0.163440
4	logFpar	0.792470	0.147670
5	logSdLogFsta	-1.351000	0.168100
6	logSdLogN	-1.394100	0.213650
7	logSdLogN	-1.559200	0.181120
8	logSdLogObs	-0.146770	0.142940
9	logSdLogObs	-1.415000	0.252620
10	logSdLogObs	-1.154700	0.150740
11	logSdLogObs	-0.851830	0.095907
12	logSdLogObs	-0.041583	0.175790
13	logSdLogObs	-0.565960	0.137740
14	logSdLogObs	-0.324000	0.130170
15	logSdLogObs	-0.175840	0.107790
16	logScaleSSB	-5.776700	0.207800
17	logSdSSB	-0.196310	0.169300

Table 7.6.3.23 Herring in Division VIIa North (Irish Sea). NEGATIVE LOG-LIKELIHOOD

589.903

Table 7.7.1. Herring in Division VIIa North (Irish Sea). Input data for short-term forecast.

MFDP version 1a
Run: ISHa
Time and date: 20:02 20/03/2012
Fbar age range: 4-6

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt			
1	133430	0.787	0.11	0.9	0.75	0.061	0.044	0.058	0.11	0.044	0.058
2	129338	0.38	0.88	0.9	0.75	0.114	0.215	0.107	0.114	0.215	0.107
3	65389	0.353	0.99	0.9	0.75	0.135	0.21	0.133	0.135	0.21	0.133
4	31317	0.335	0.99	0.9	0.75	0.151	0.217	0.149	0.151	0.217	0.149
5	14111	0.315	0.99	0.9	0.75	0.157	0.267	0.156	0.157	0.267	0.156
6	11607	0.311	1	0.9	0.75	0.172	0.283	0.171	0.172	0.283	0.171
7	4841	0.304	1	0.9	0.75	0.183	0.239	0.183	0.183	0.239	0.183
8	1913	0.304	1	0.9	0.75	0.187	0.239	0.186	0.187	0.239	0.186

2013

Age	N	M	Mat	PF	PM	SWt	Sel	CWt			
1	133430	0.787	0.11	0.9	0.75	0.061	0.044	0.058	0.061	0.044	0.058
2	.	0.38	0.88	0.9	0.75	0.114	0.215	0.107	0.114	0.215	0.107
3	.	0.353	0.99	0.9	0.75	0.135	0.21	0.133	0.135	0.21	0.133
4	.	0.335	0.99	0.9	0.75	0.151	0.217	0.149	0.151	0.217	0.149
5	.	0.315	0.99	0.9	0.75	0.157	0.267	0.156	0.157	0.267	0.156
6	.	0.311	1	0.9	0.75	0.172	0.283	0.171	0.172	0.283	0.171
7	.	0.304	1	0.9	0.75	0.183	0.239	0.183	0.183	0.239	0.183
8	.	0.304	1	0.9	0.75	0.187	0.239	0.186	0.187	0.239	0.186

2014

Age	N	M	Mat	PF	PM	SWt	Sel	CWt			
1	133430	0.787	0.11	0.9	0.75	0.061	0.044	0.058	0.061	0.044	0.058
2	.	0.38	0.88	0.9	0.75	0.114	0.215	0.107	0.114	0.215	0.107
3	.	0.353	0.99	0.9	0.75	0.135	0.21	0.133	0.135	0.21	0.133
4	.	0.335	0.99	0.9	0.75	0.151	0.217	0.149	0.151	0.217	0.149
5	.	0.315	0.99	0.9	0.75	0.157	0.267	0.156	0.157	0.267	0.156
6	.	0.311	1	0.9	0.75	0.172	0.283	0.171	0.172	0.283	0.171
7	.	0.304	1	0.9	0.75	0.183	0.239	0.183	0.183	0.239	0.183
8	.	0.304	1	0.9	0.75	0.187	0.239	0.186	0.187	0.239	0.186

Input units are thousands and kg - output in tonnes

Table 7.7.2. Herring in Division VIIa North (Irish Sea). Management options table.

Maturity 2009-2011
MFDP version 1a
Run: ISHa
Irish Sea Herring
Time and date: 20:02 20/03/2012
Fbar age range: 4-6

2012				
Biomass	SSB	FMult	FBar	Landings
41838	21155	0.8139	0.2081	4752

2013					2014	
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB
37027	22004	0	0	0	37616	22526
.	21572	0.1	0.0256	552	37086	21673
.	21149	0.2	0.0512	1094	36567	20853
.	20734	0.3	0.0767	1624	36059	20067
.	20327	0.4	0.1023	2143	35562	19312
.	19928	0.5	0.1279	2652	35075	18588
.	19538	0.6	0.1535	3150	34599	17893
.	19155	0.7	0.179	3639	34132	17226
.	18780	0.8	0.2046	4117	33676	16585
.	18413	0.9	0.2302	4586	33229	15970
.	18053	1	0.2558	5046	32792	15380
.	17700	1.1	0.2813	5496	32364	14813
.	17354	1.2	0.3069	5937	31945	14269
.	17015	1.3	0.3325	6370	31535	13746
.	16683	1.4	0.3581	6793	31133	13244
.	16358	1.5	0.3836	7209	30740	12762
.	16039	1.6	0.4092	7616	30355	12299
.	15726	1.7	0.4348	8015	29978	11854
.	15420	1.8	0.4604	8406	29609	11427
.	15120	1.9	0.4859	8789	29248	11016
.	14826	2	0.5115	9165	28894	10622

Input units are thousands and kg - output in tonnes

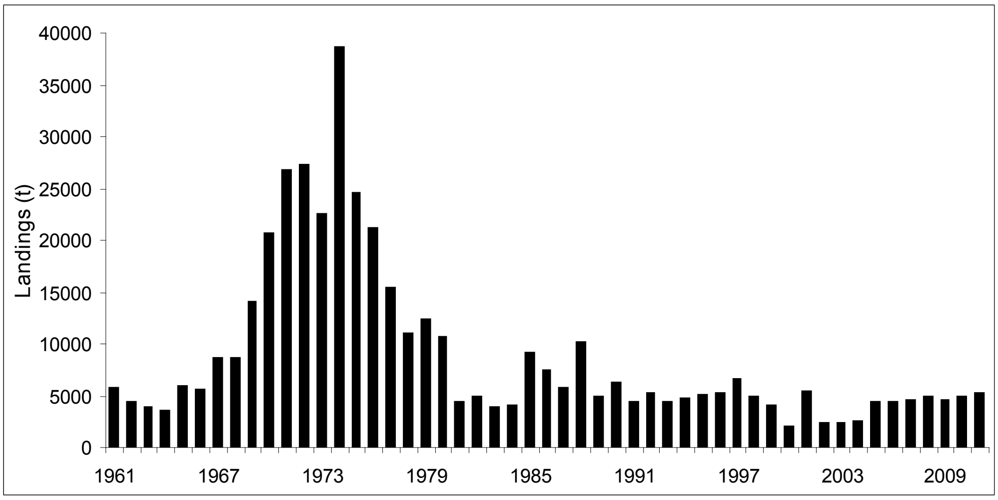


Figure 7.1.1 Herring in Division VIIa North (Irish Sea). Landings of herring from VIIa(N) from 1961 to 2011.

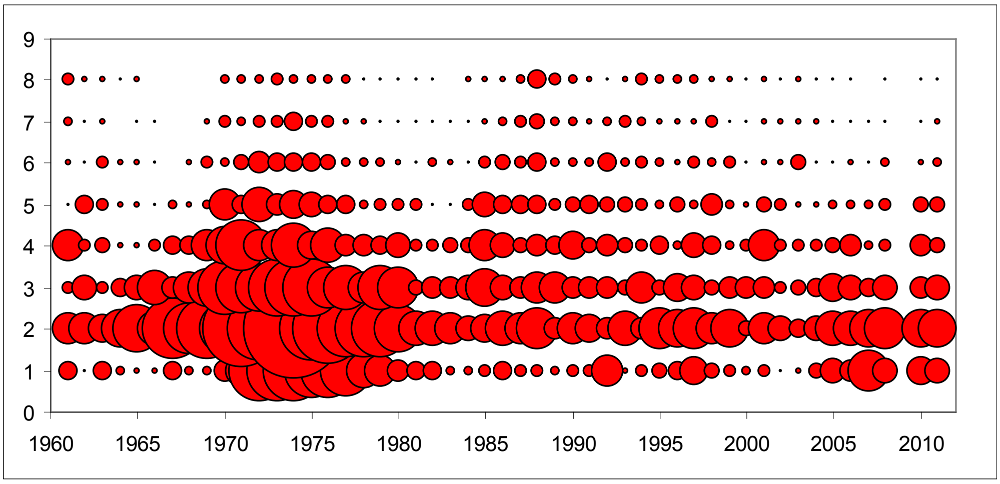


Figure 7.2.1 Herring in Division VIIa North (Irish Sea). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2011. No 2009 commercial samples.

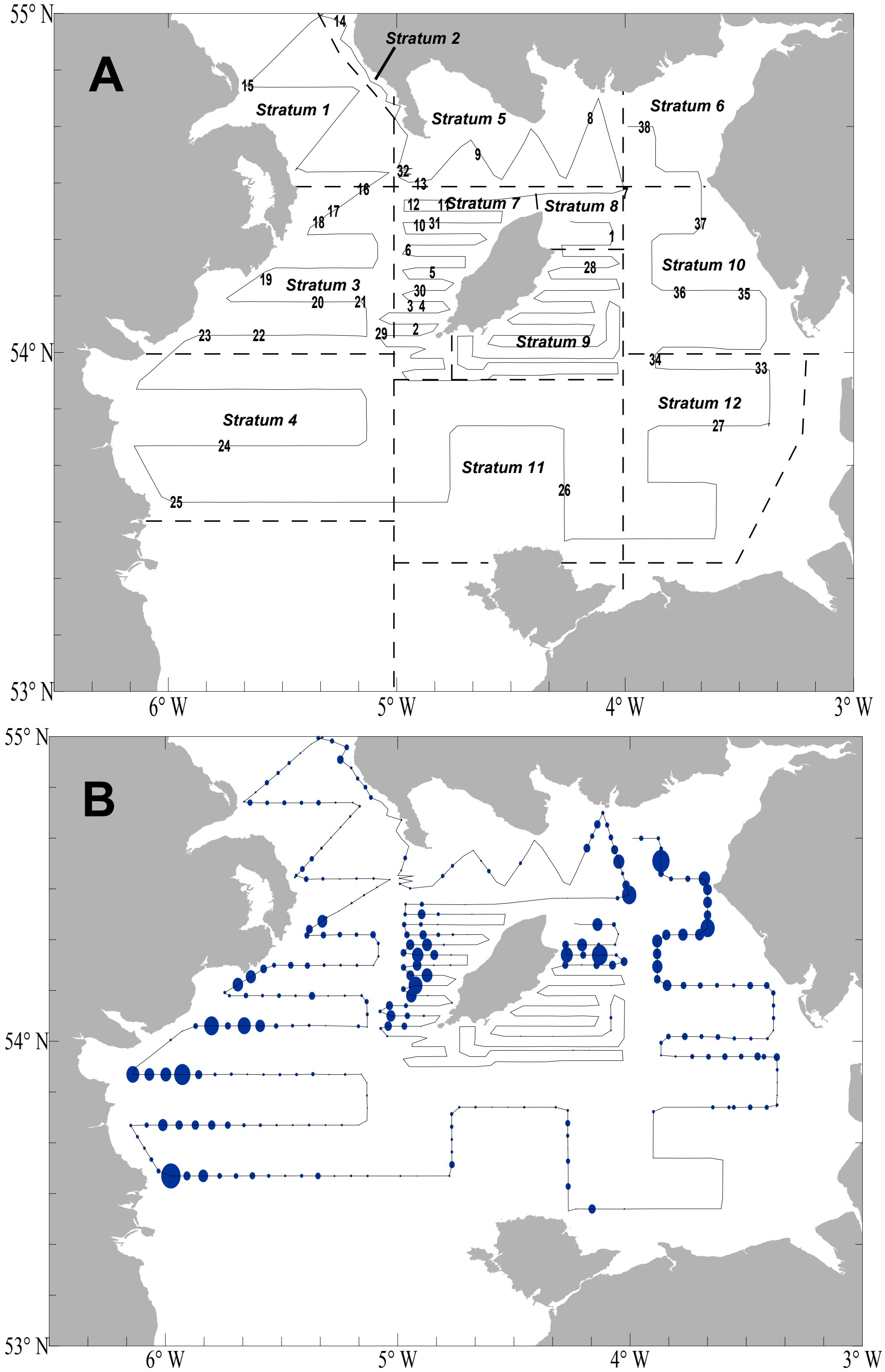
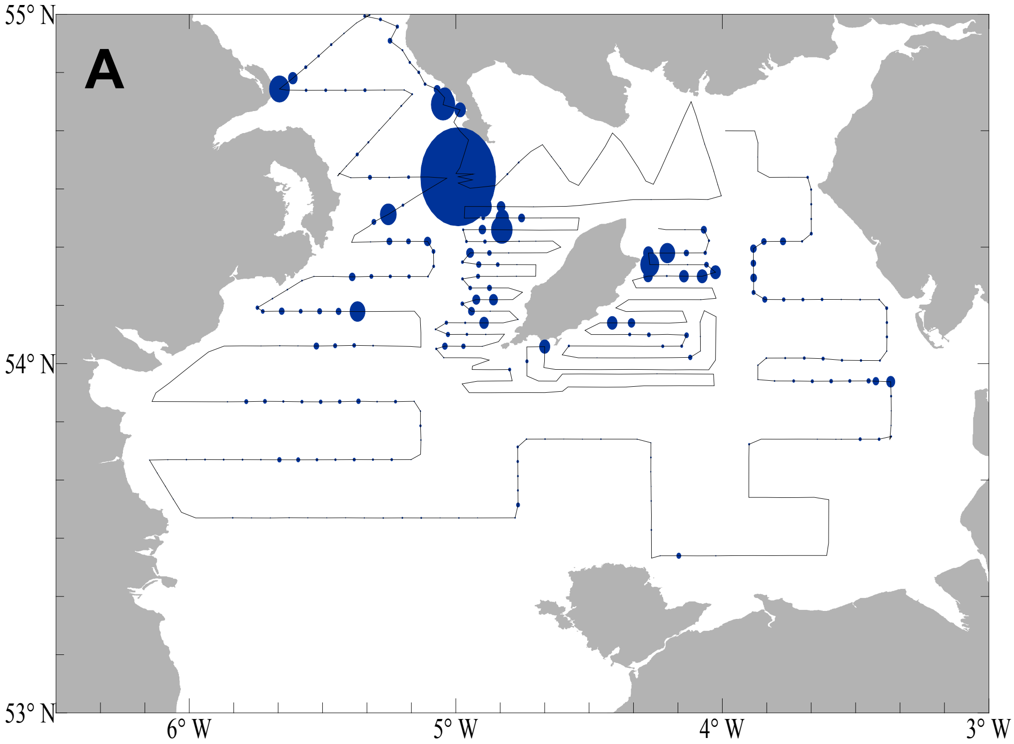


Figure 7.3.1 **Herring in Division VIIa North (Irish Sea). (A) Transects, stratum boundaries and trawl positions for the 2011 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t n.mile-2) per 15-minute interval). Maximum density was 730 t n.mile-2. Note: same scaling of ellipse sizes on above figures. The survey is a composite of the main survey and an earlier survey done as part of the extended survey series.**



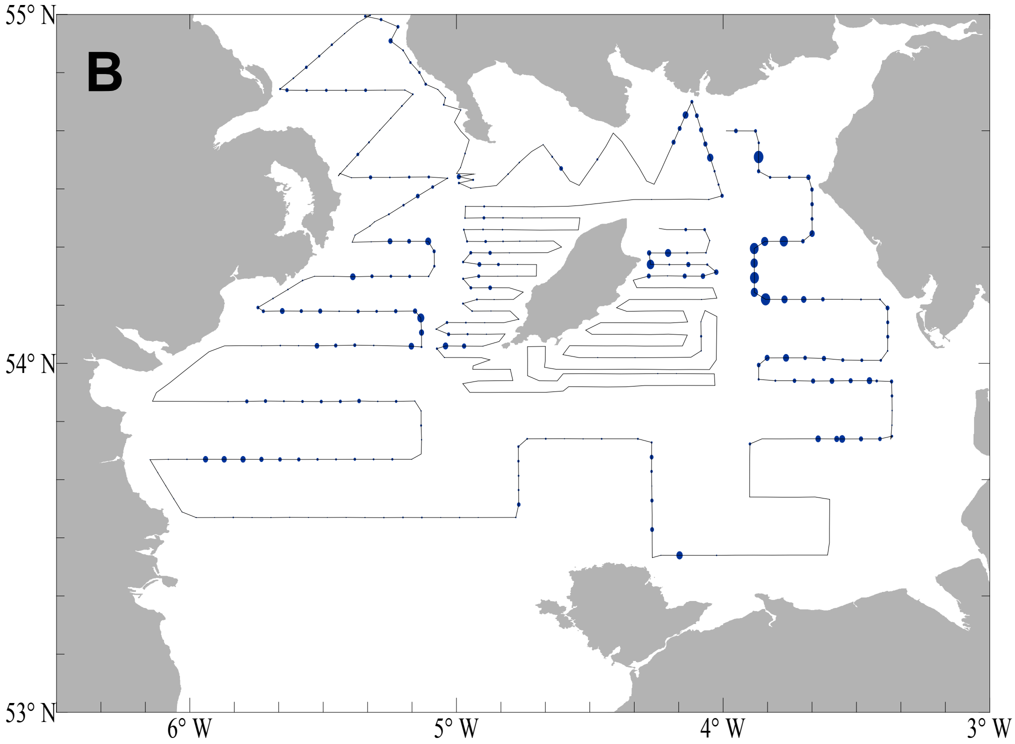


Figure 7.3.2 Herring in Division VIIa North (Irish Sea). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 6 590 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 100 t n.mile^{-2} . Note: same scaling of ellipse sizes on above figures. The survey is a composite of the main survey and an earlier survey done as part of the extended survey series.

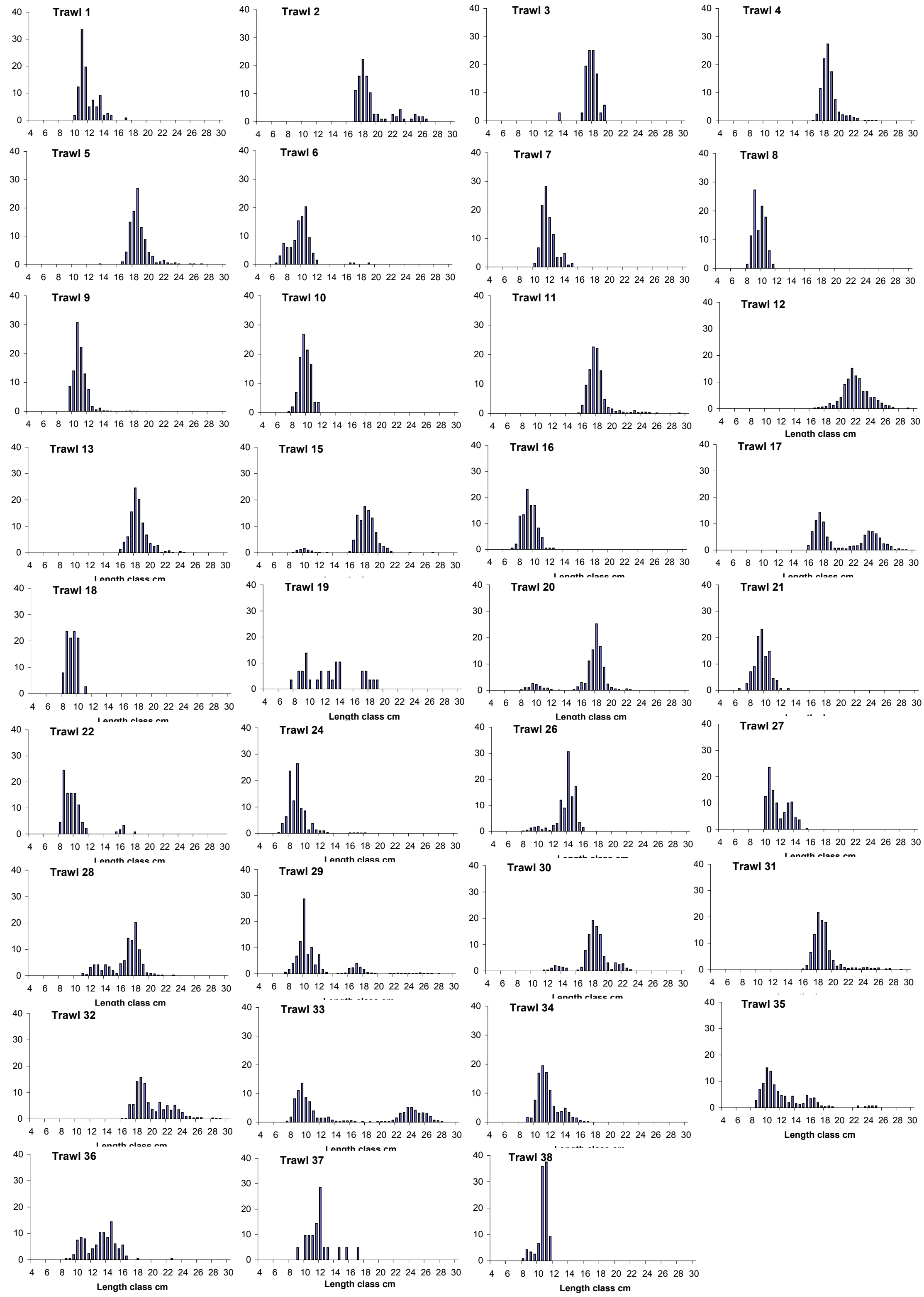


Figure 7.3.3 Herring in Division VIIa North (Irish Sea). Percentage length compositions of herring in each trawl sample in the September 2011 acoustic survey.

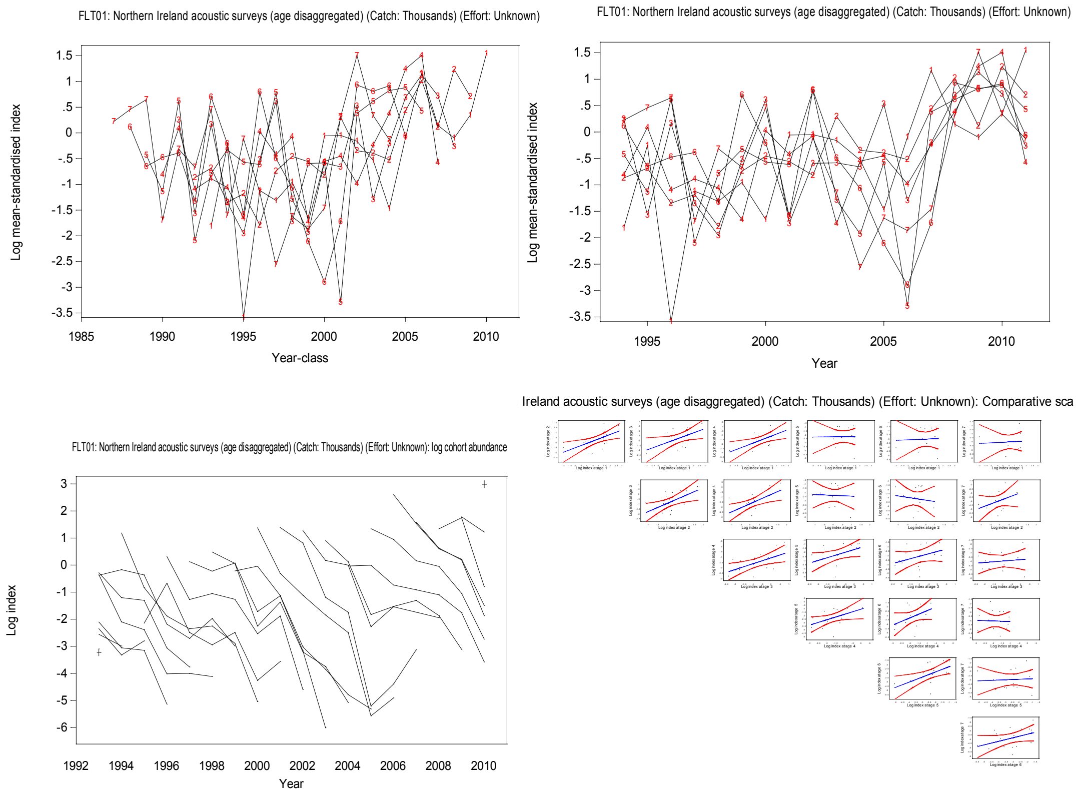


Figure 7.3.4 Herring in Division VIIa North (Irish Sea). Acoustic survey (AC(VIIaN)) log mean-standardised indices by year and age class, scatter plots and catch curves.

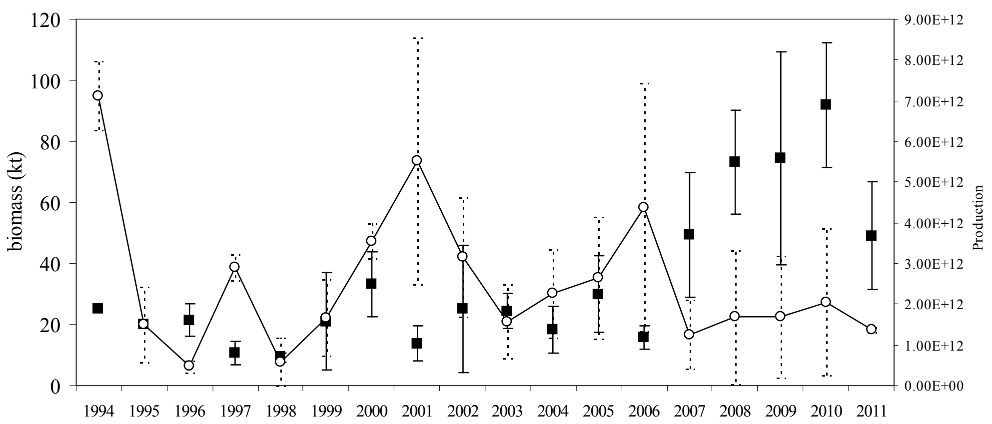


Figure 7.3.5 Herring in Division VIIa North (Irish Sea). Comparison of SSB indices from the acoustic survey estimates of SSB (sold squares) and the larval production estimates (open circles). Vertical bars are ±1 standard errors

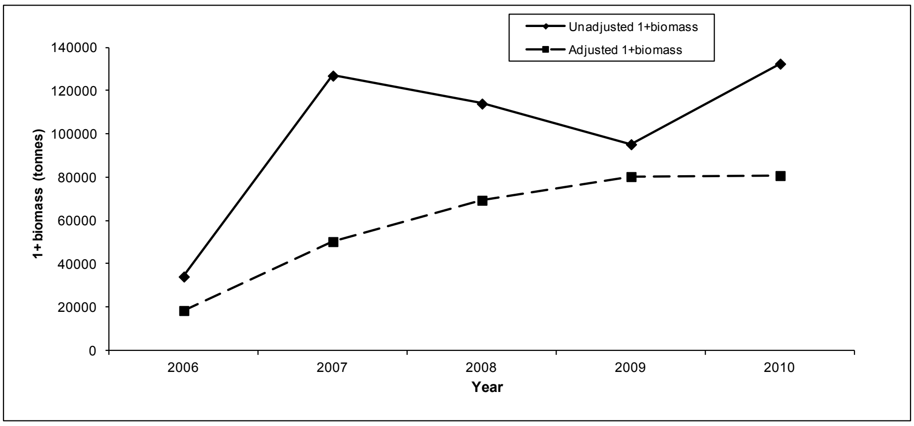


Figure 7.3.6 **Herring in Division VIIa North (Irish Sea). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.**

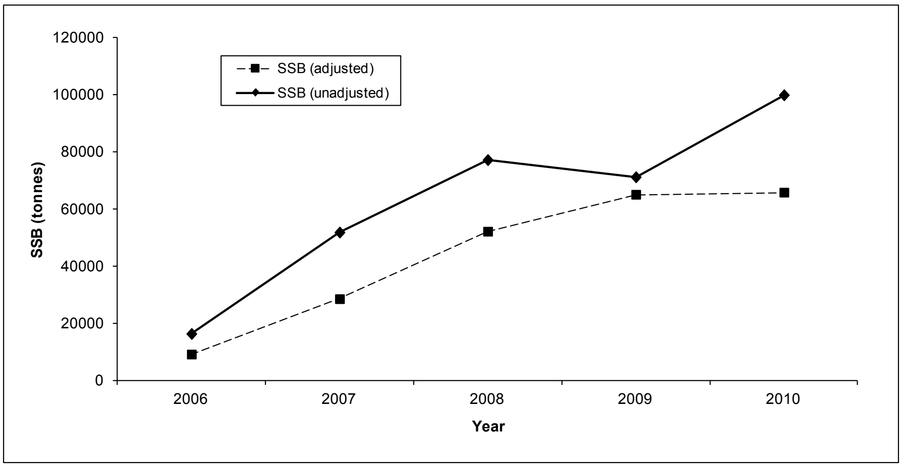


Figure 7.3.7 **Herring in Division VIIa North (Irish Sea). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawners removed") and unadjusted data sets.**

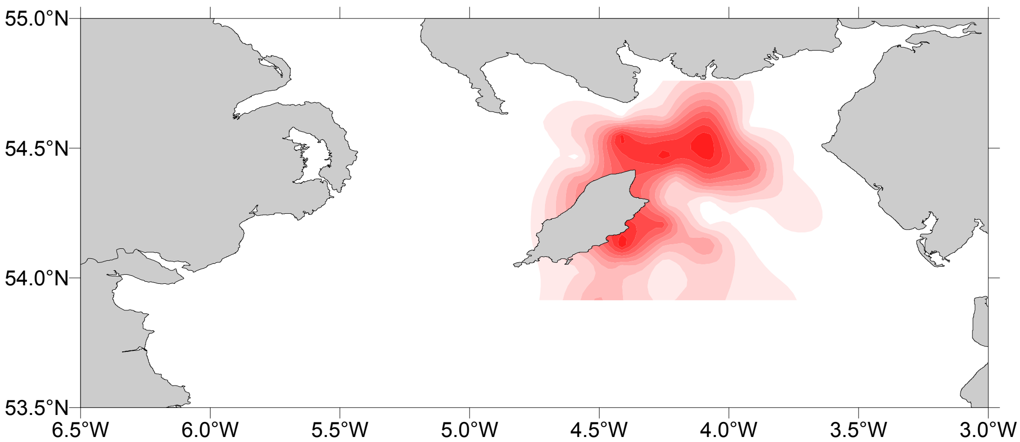


Figure 7.3.8 **Herring in Division VIIa North (Irish Sea). Estimates of larval herring abundance in the Northern Irish Sea in 2011. Areas of shading are proportional to larva abundance (maximum = 37.8 ind per m²).**

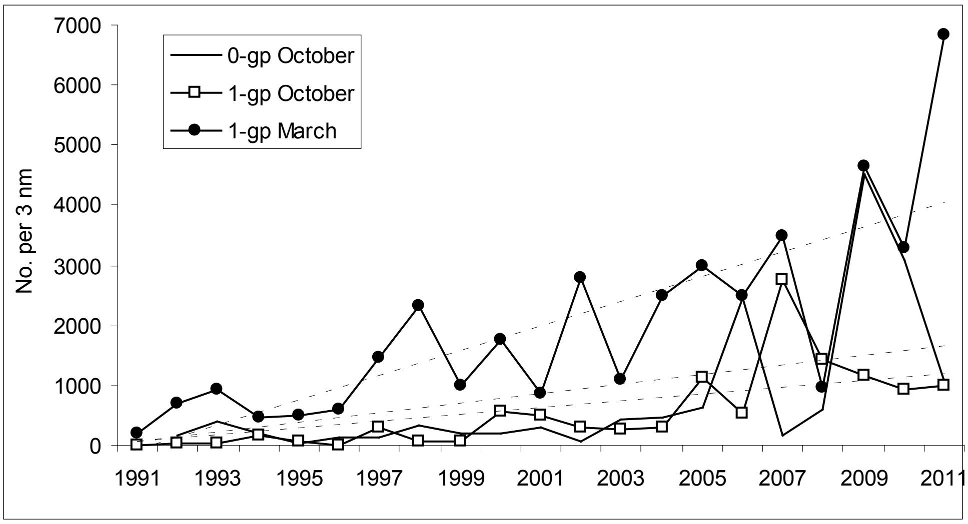


Figure 7.3.9 Herring in Division VIIa North (Irish Sea). Trends in 0-gp and 1-gp herring indices from the Northern Irish March and October groundfish surveys in the northern Irish Sea 1991 - 2011. [Ages are assigned from length frequency].

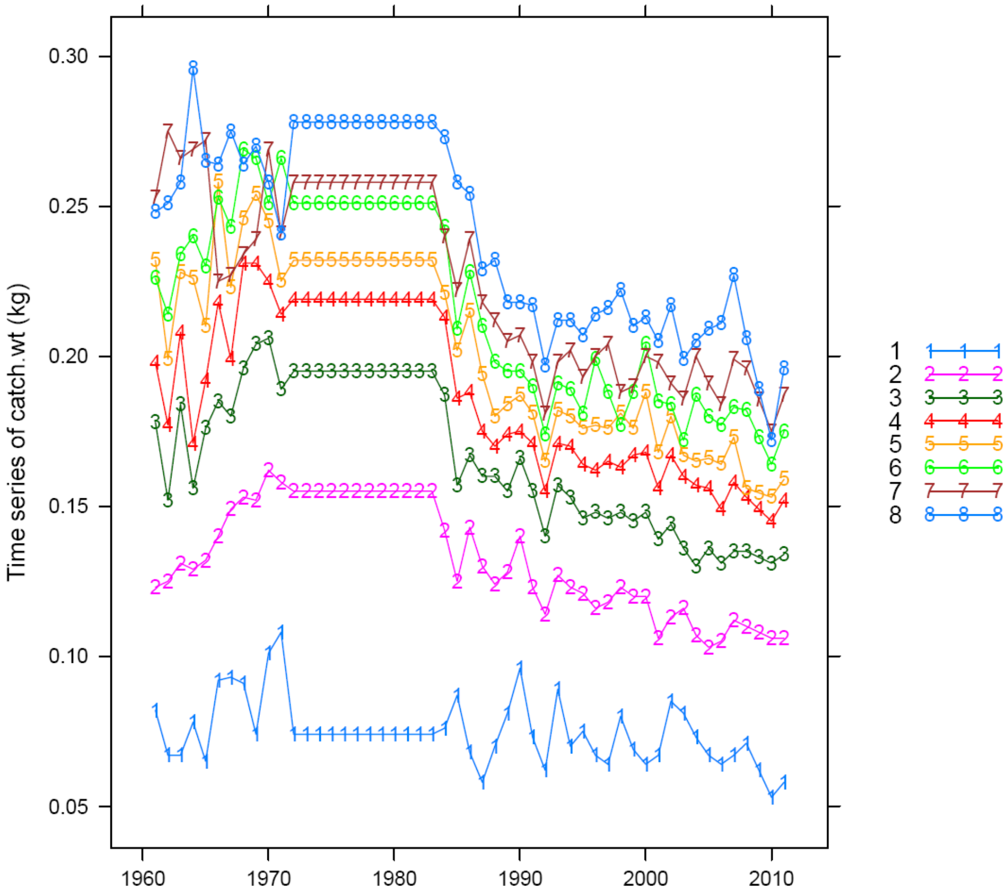


Figure 7.4.1 Herring in Division VIIa North (Irish Sea). Timeseries of catch weights at age.

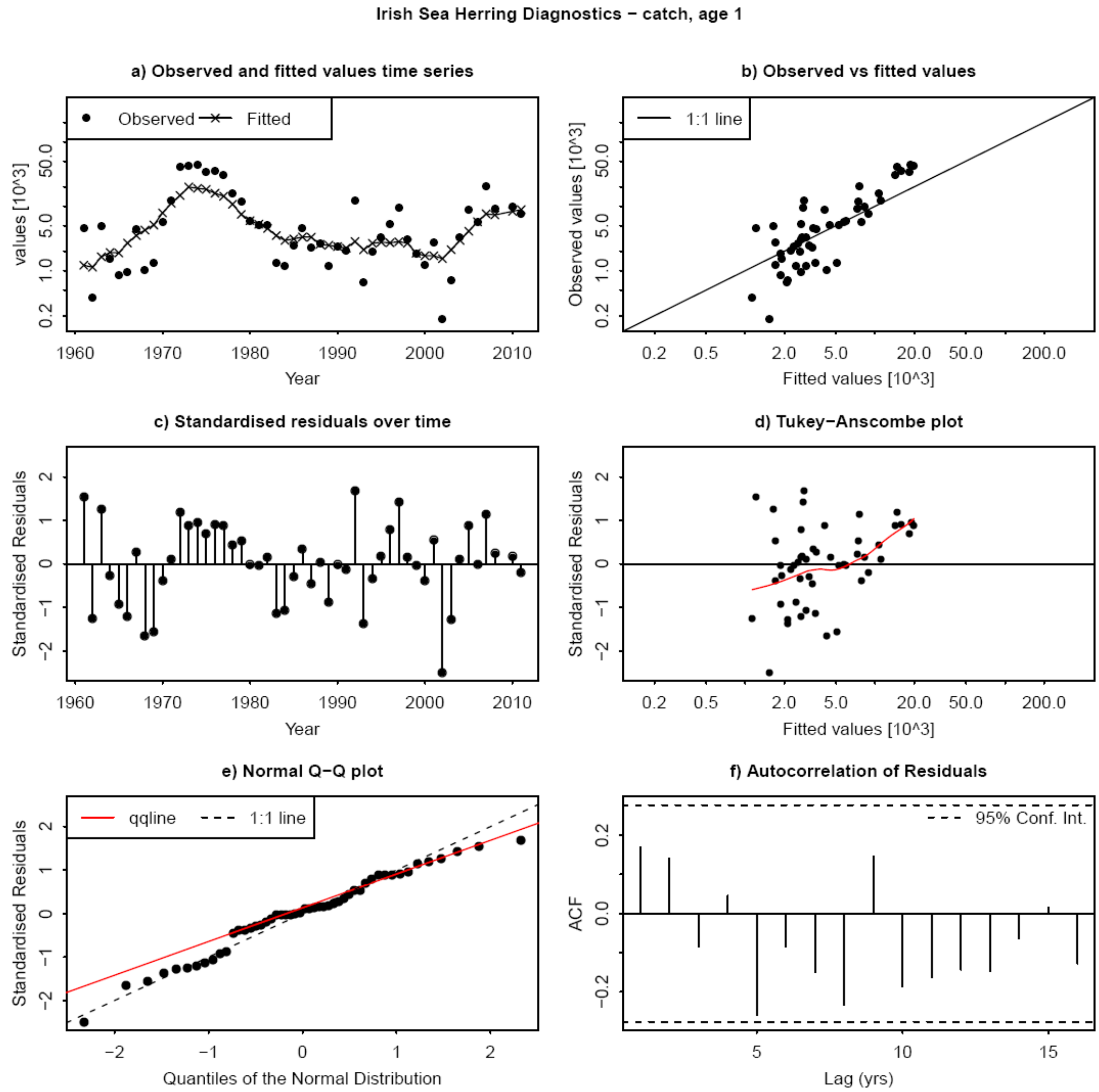


Figure 7.6.1 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age1.

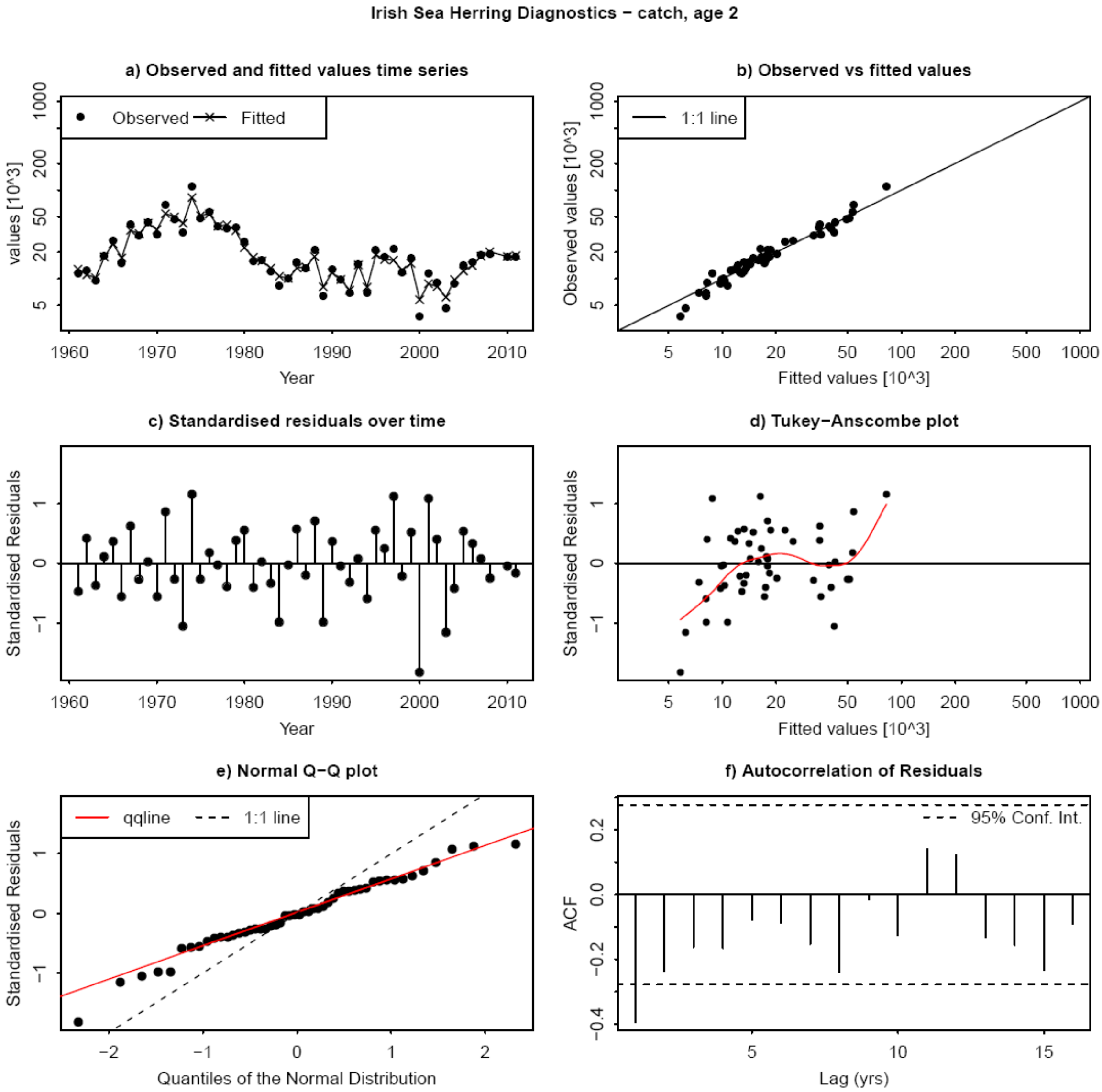


Figure 7.6.2 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age2.**

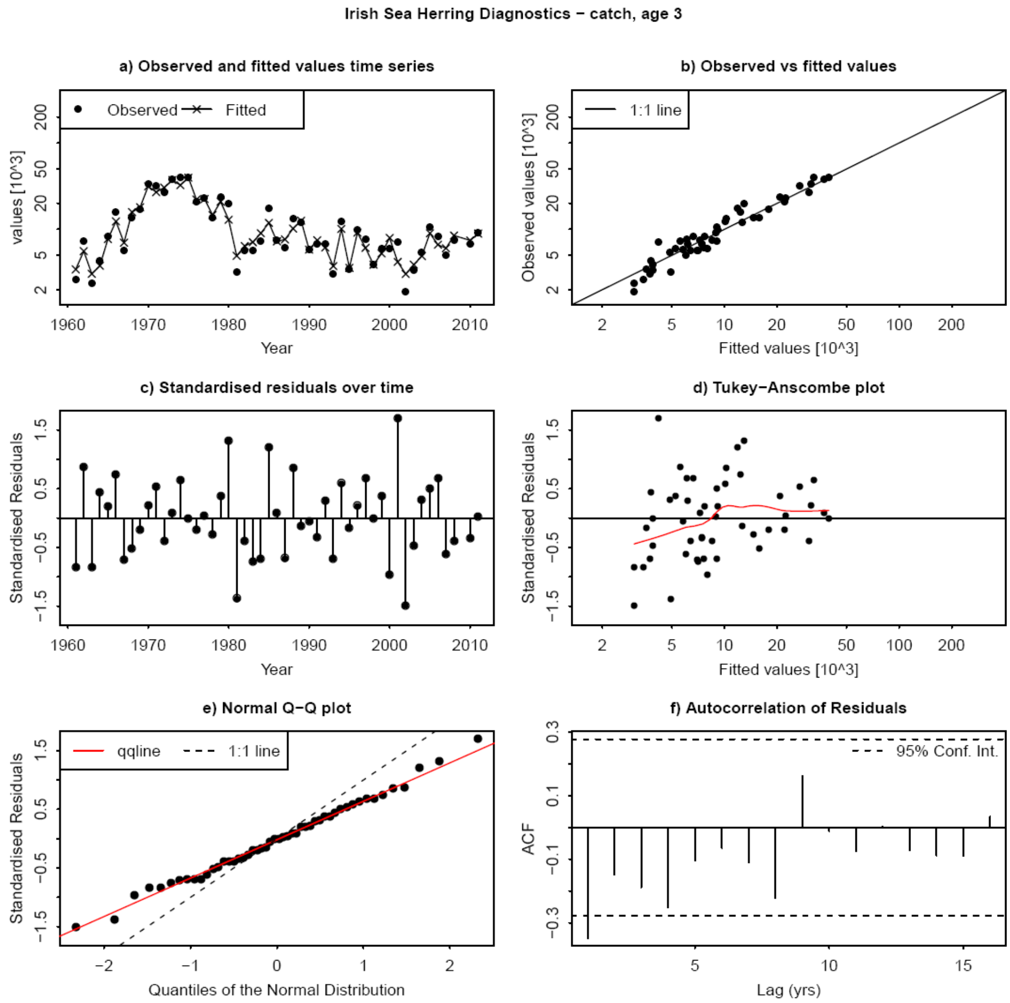


Figure 7.6.3 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age3.

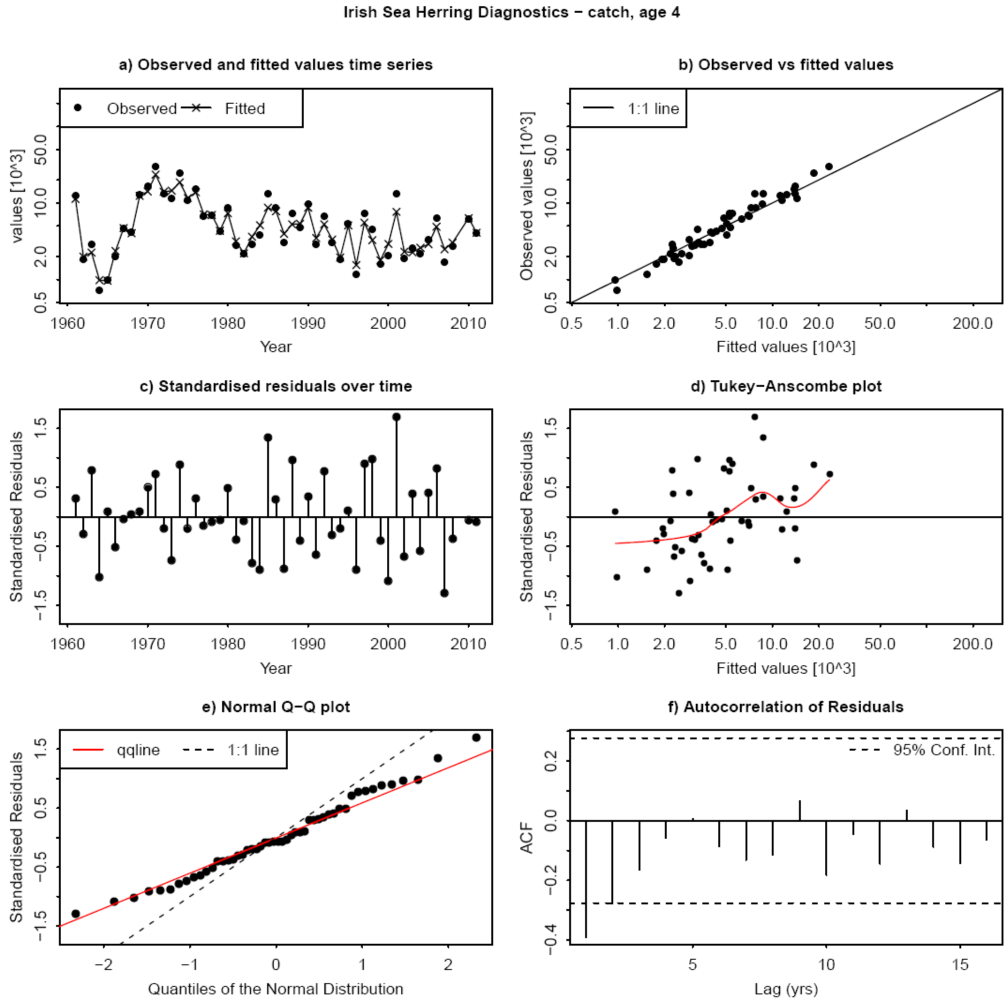


Figure 7.6.4 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age4.

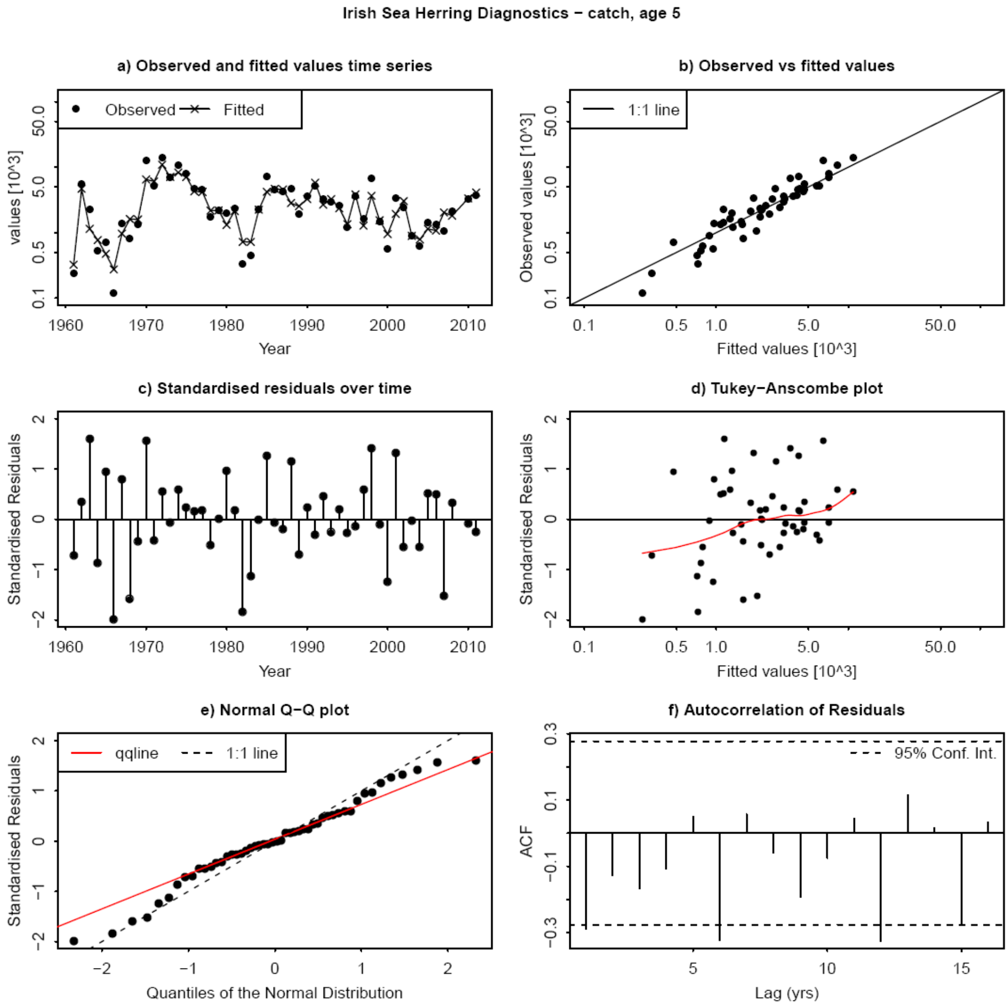


Figure 7.6.5 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age5.**

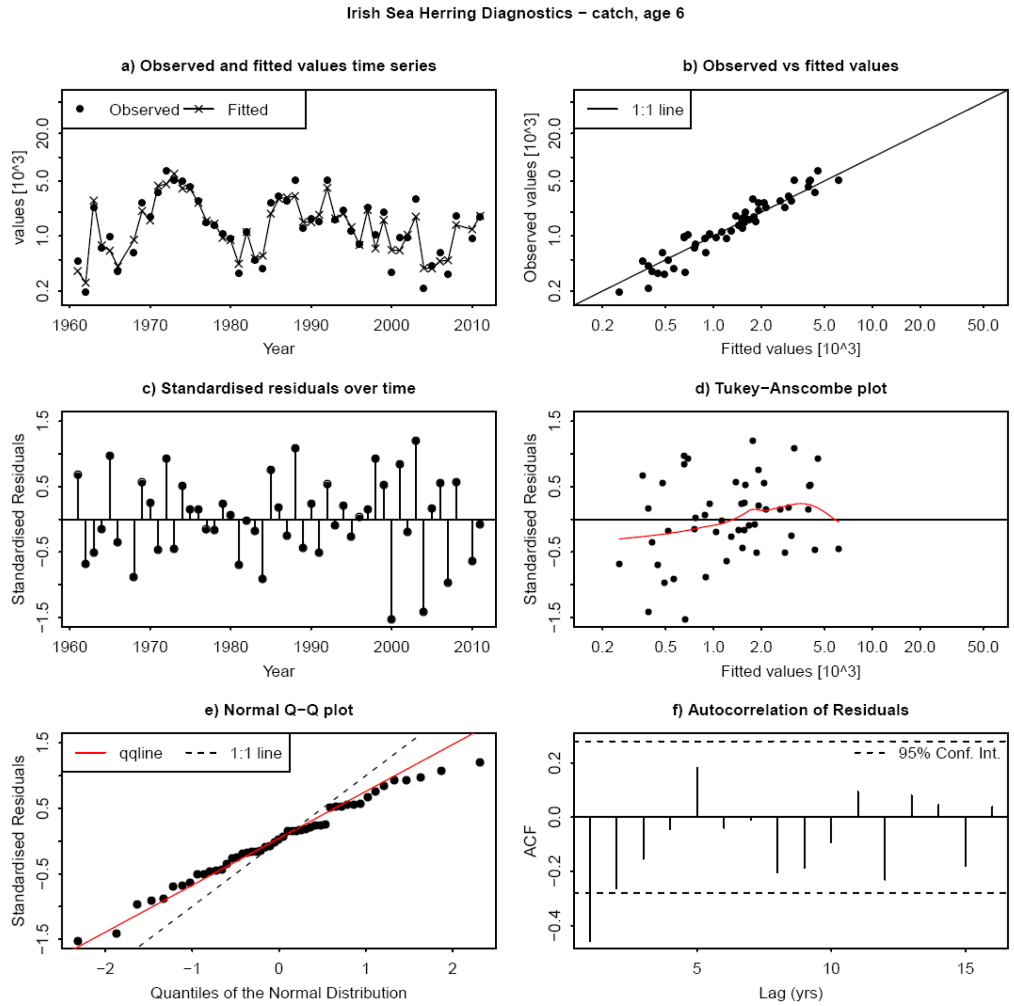


Figure 7.6.6 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age6.

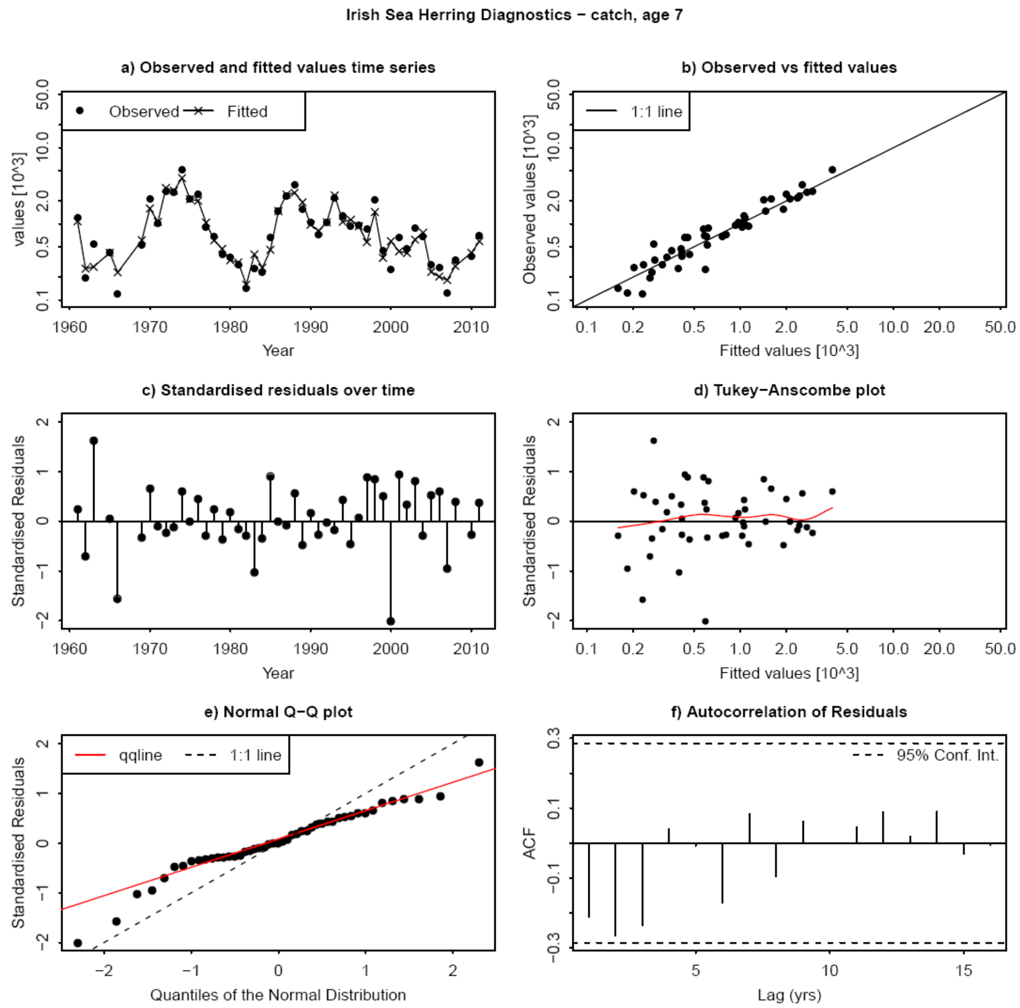


Figure 7.6.7 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age7.

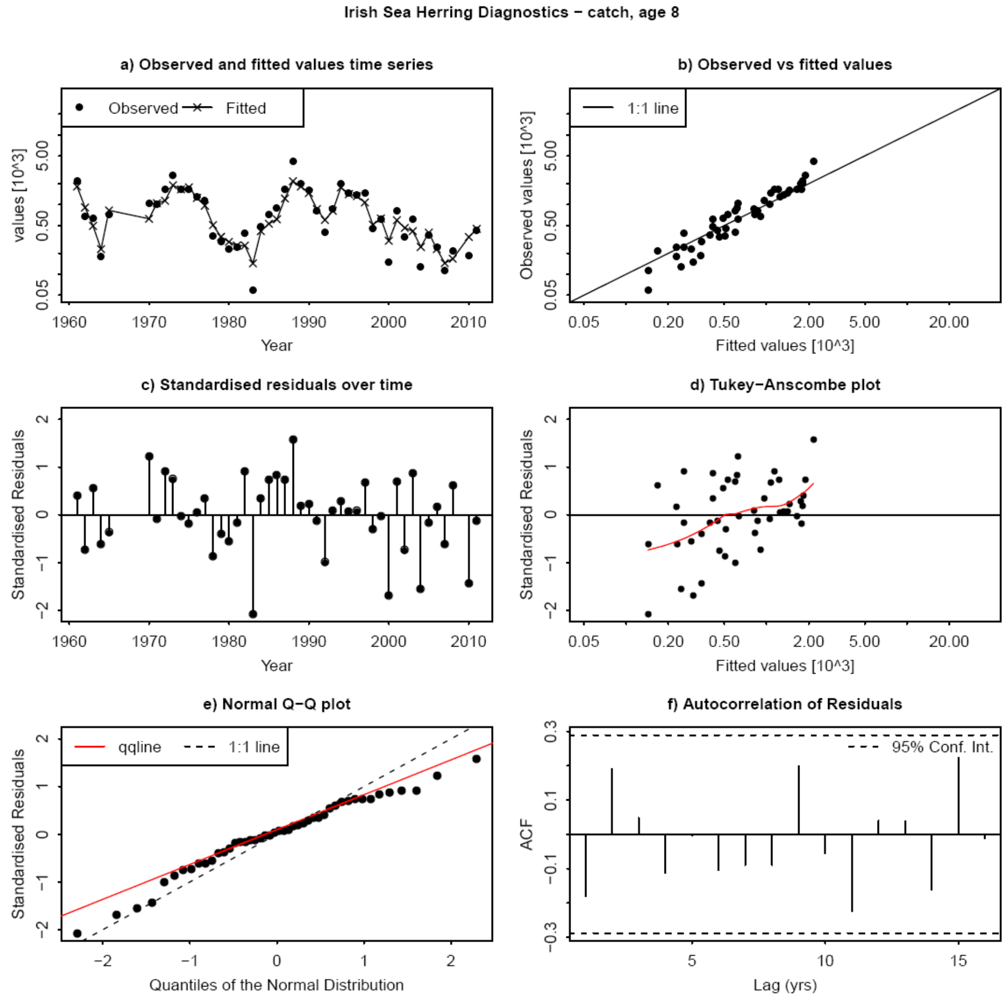


Figure 7.6.8 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to the catch data at age8.

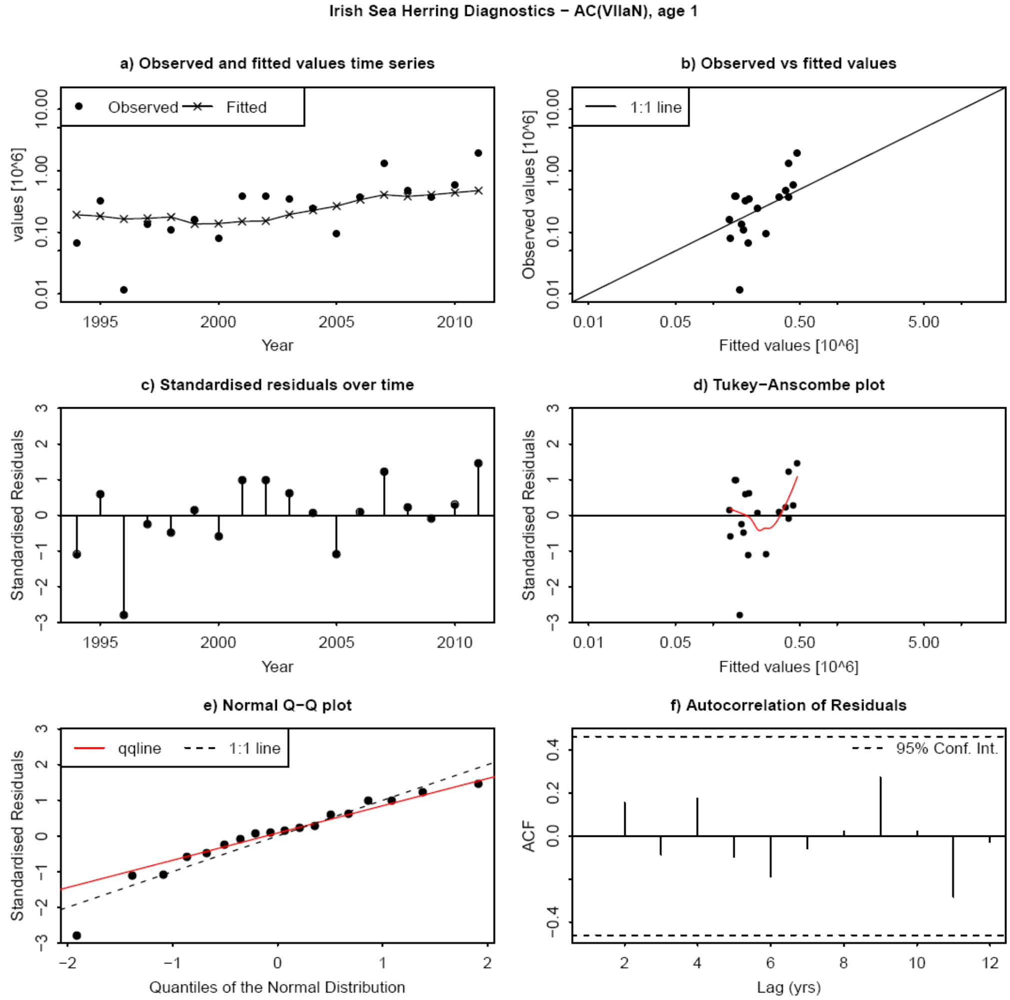


Figure 7.6.9 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age1.

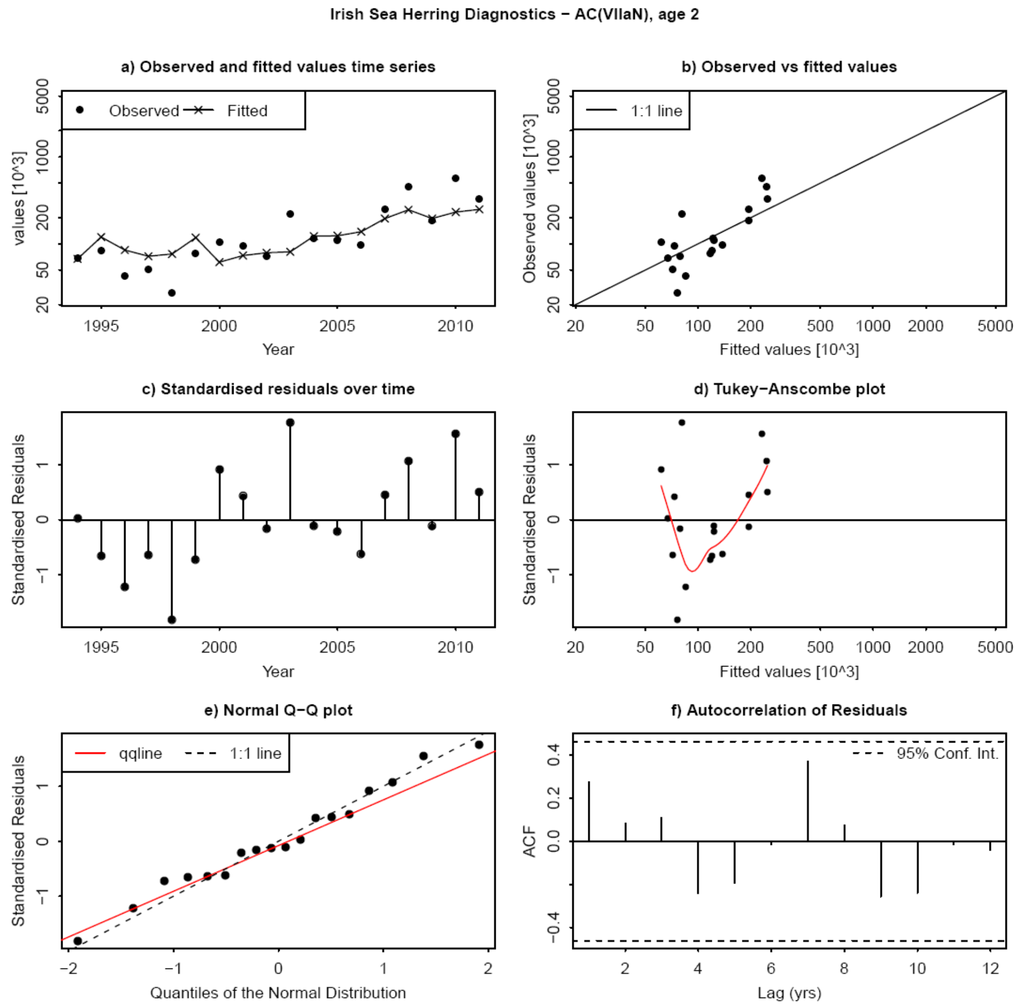


Figure 7.6.10 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age2.

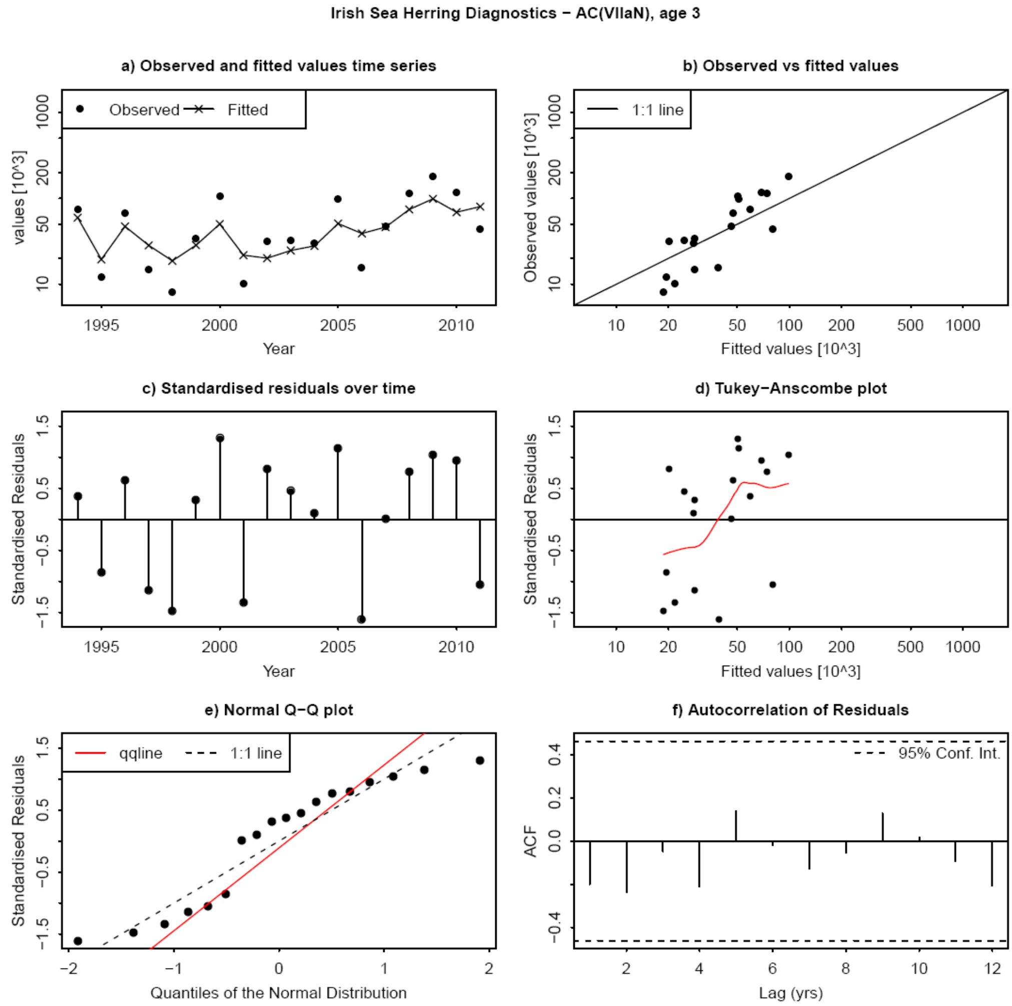


Figure 7.6.11 **Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age3.**

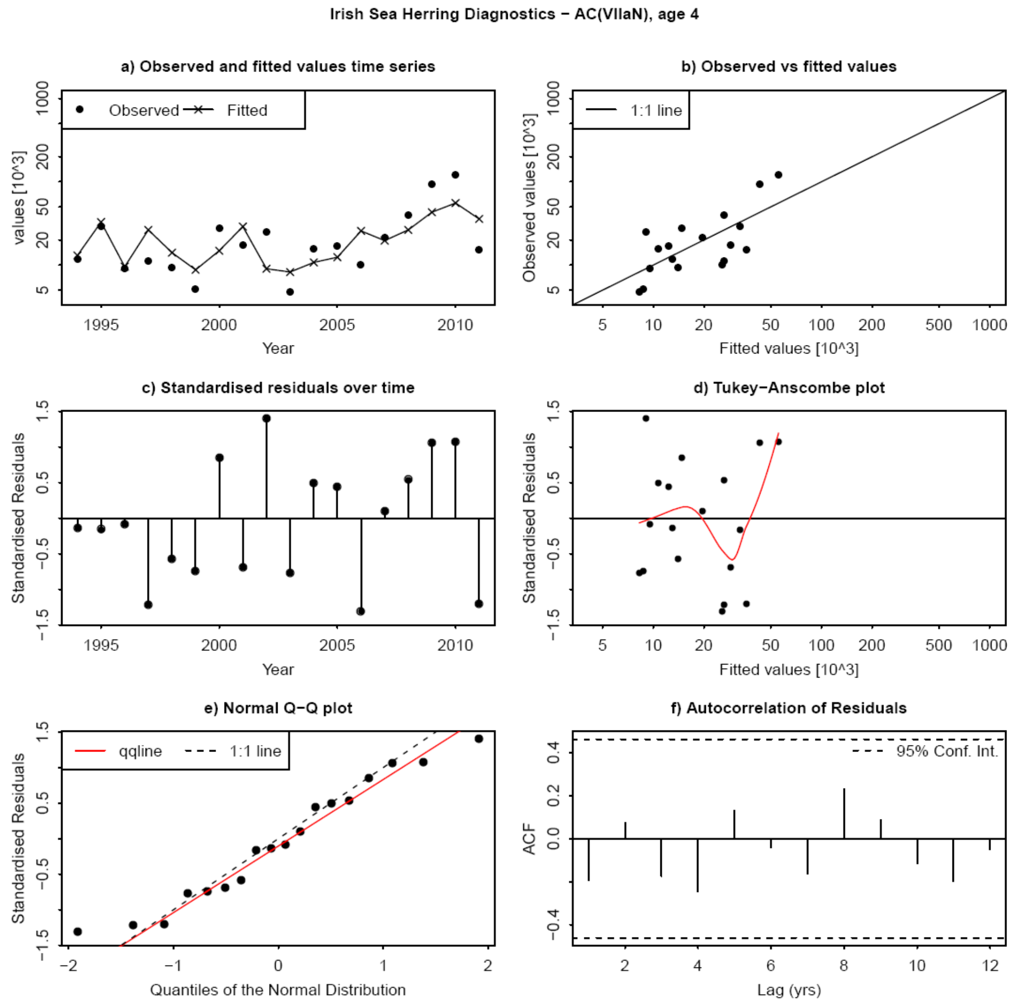


Figure 7.6.12 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age4.

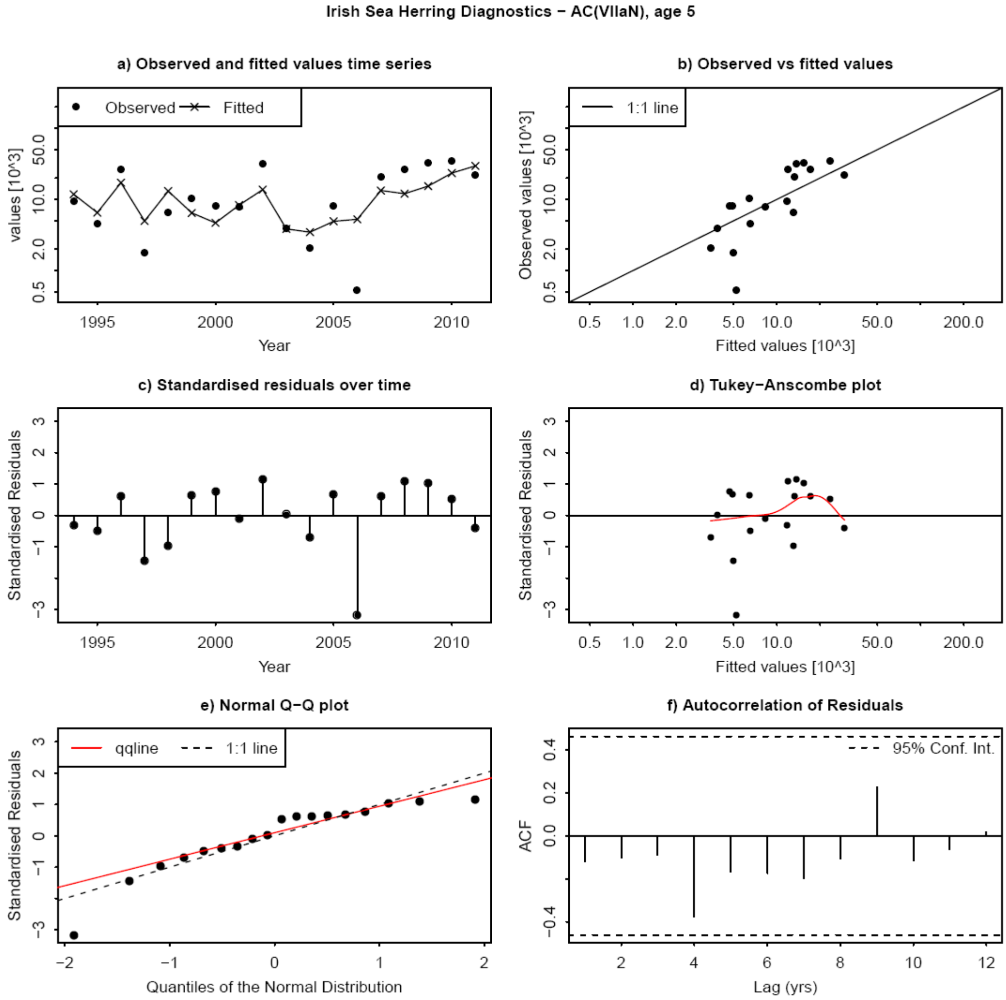


Figure 7.6.13 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age5.

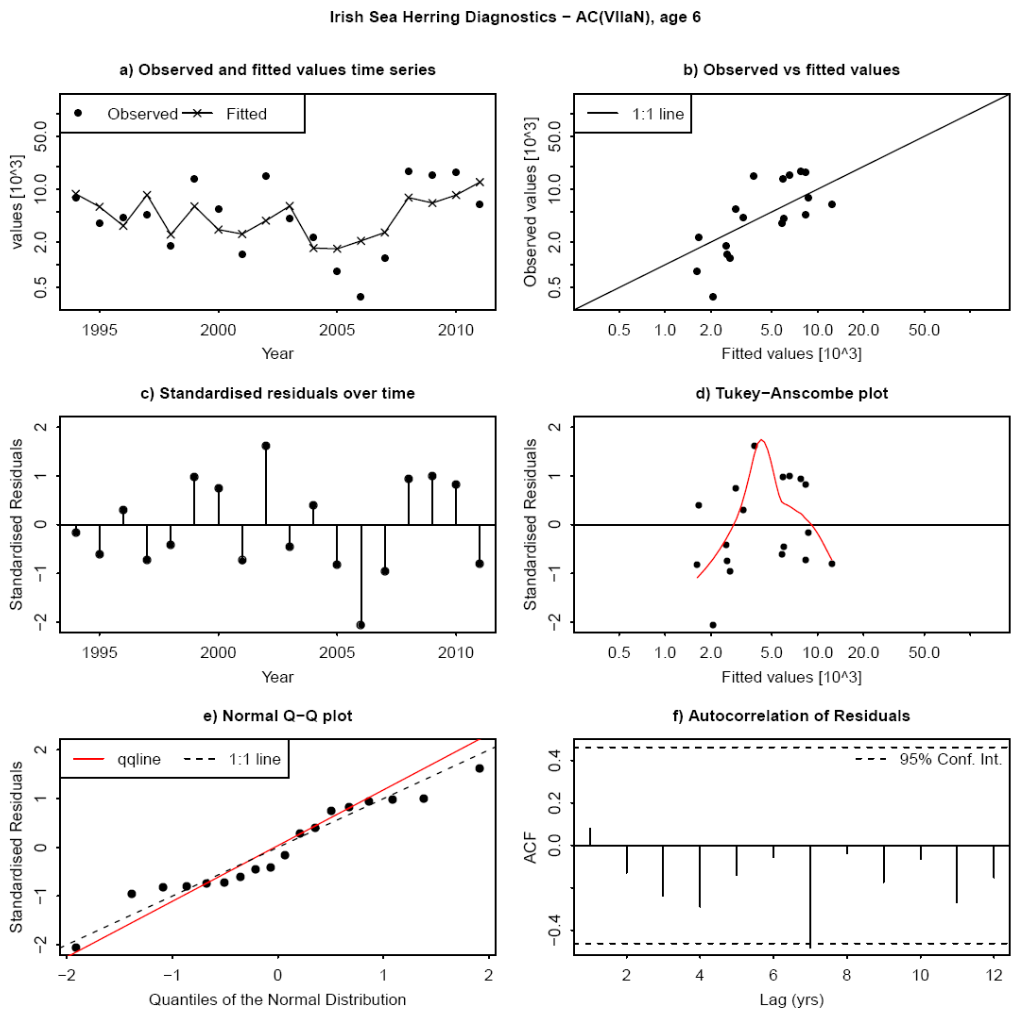


Figure 7.6.14 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age6.

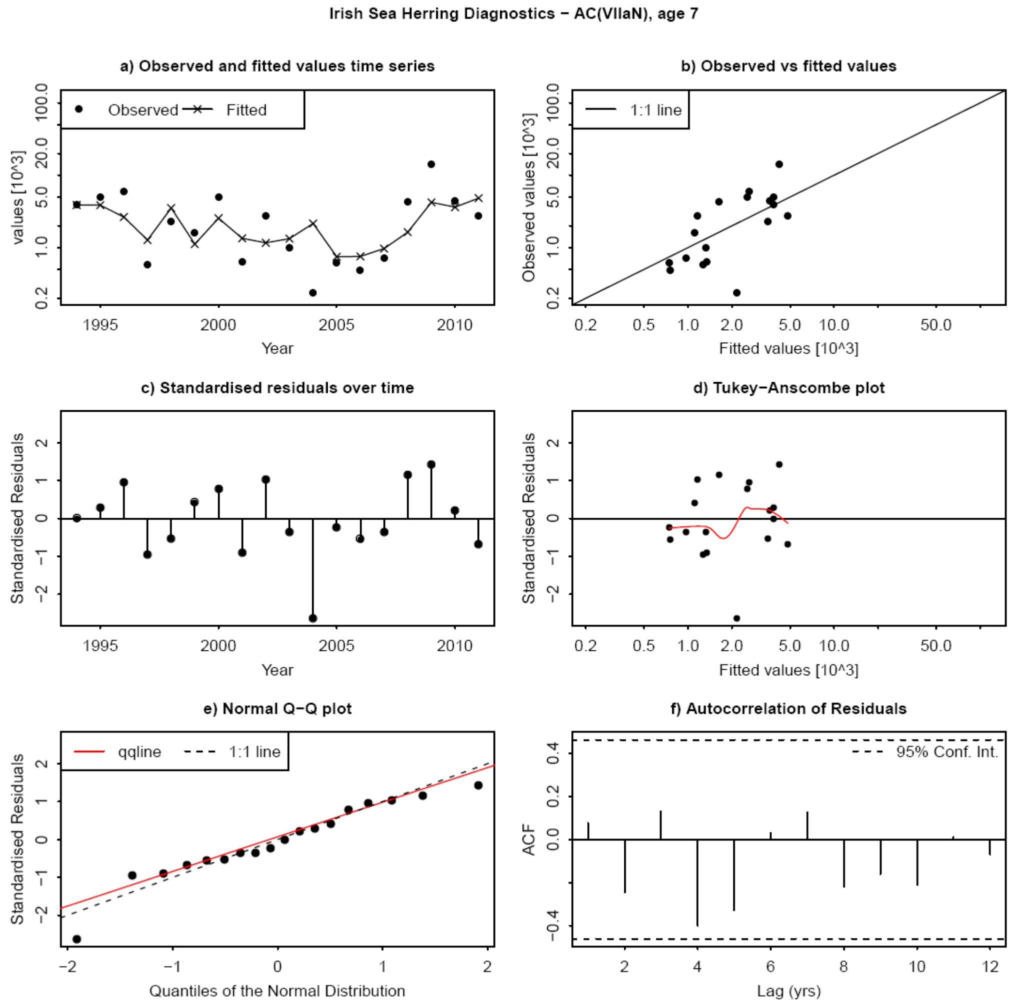


Figure 7.6.15 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age7.

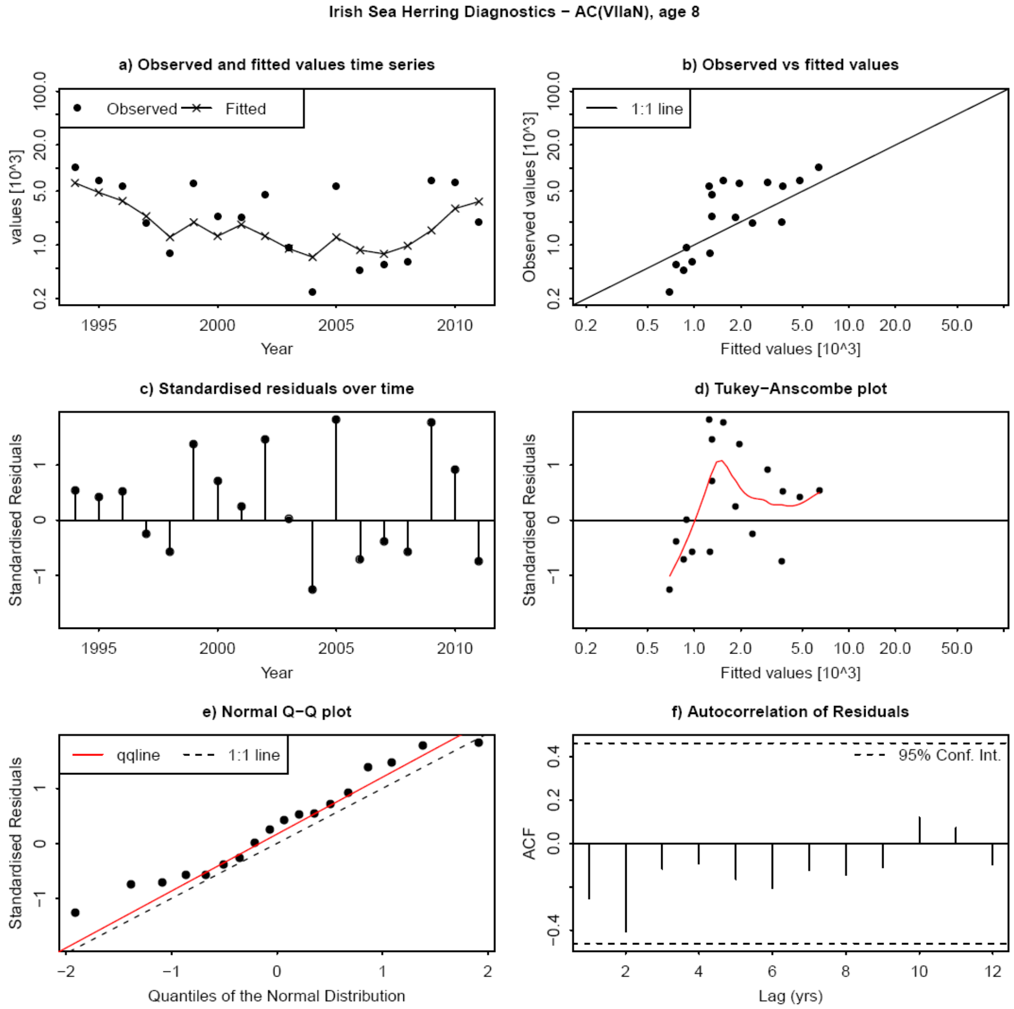


Figure 7.6.16 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to acoustic survey (AC(VIIaN)) data at age8.

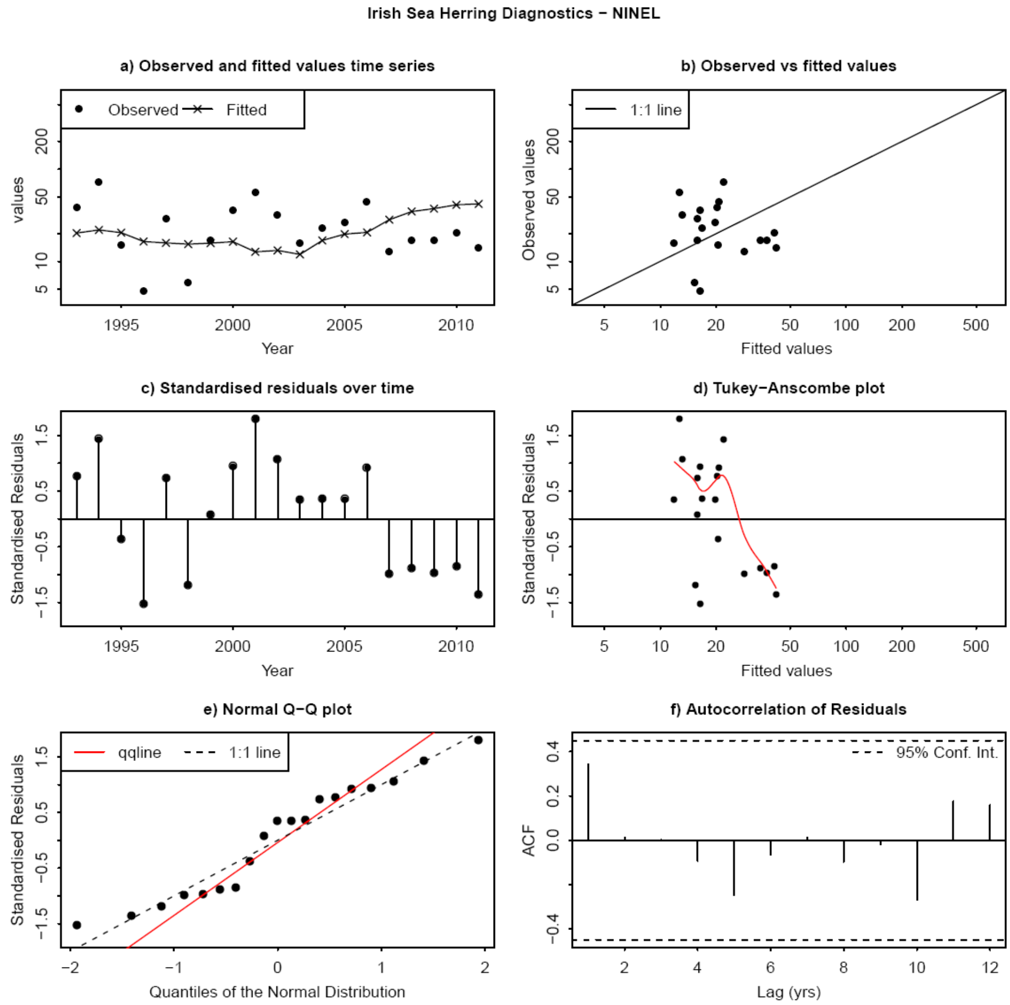


Figure 7.6.17 Herring in Division VIIa North (Irish Sea). FLSAM run output. Diagnostics of model fit to larval survey (NINEL).

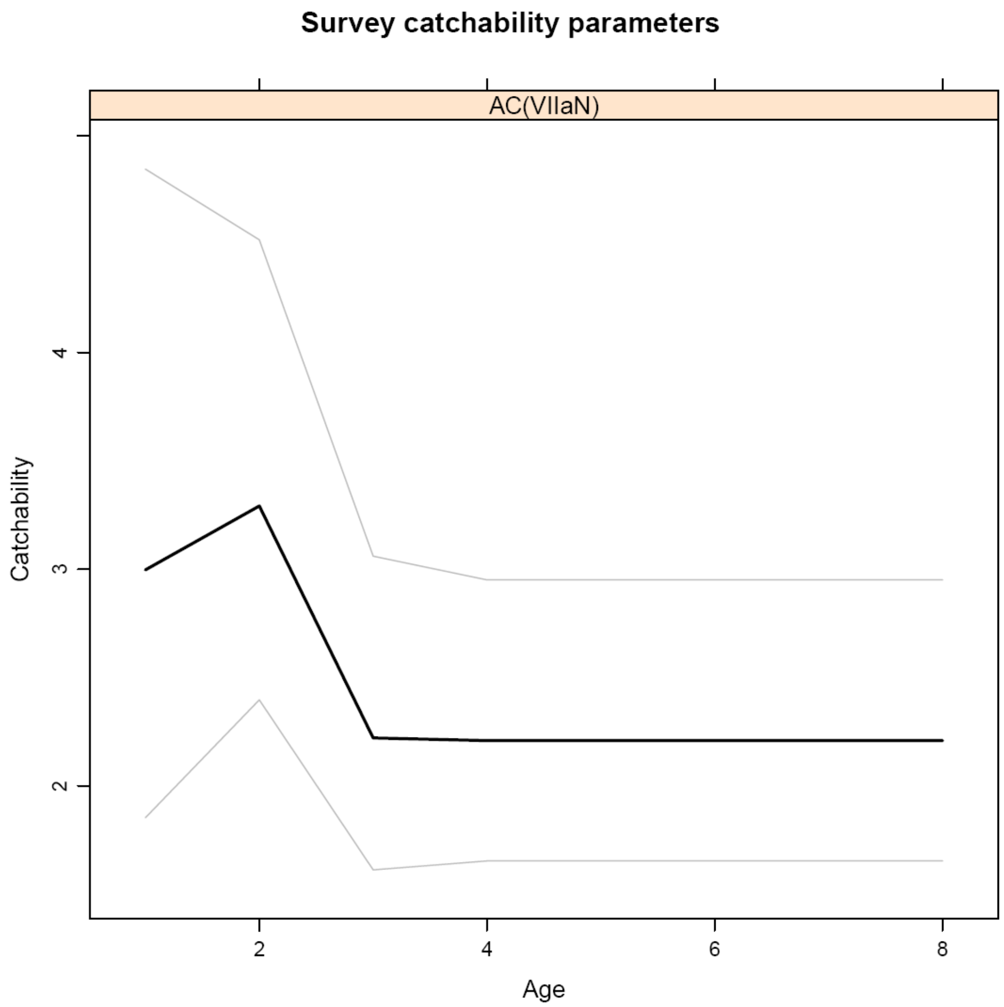


Figure 7.6.18 Herring in Division VIIa North (Irish Sea). FLSAM run output. Survey catchability parameter from the acoustic survey AC(VIIaN).

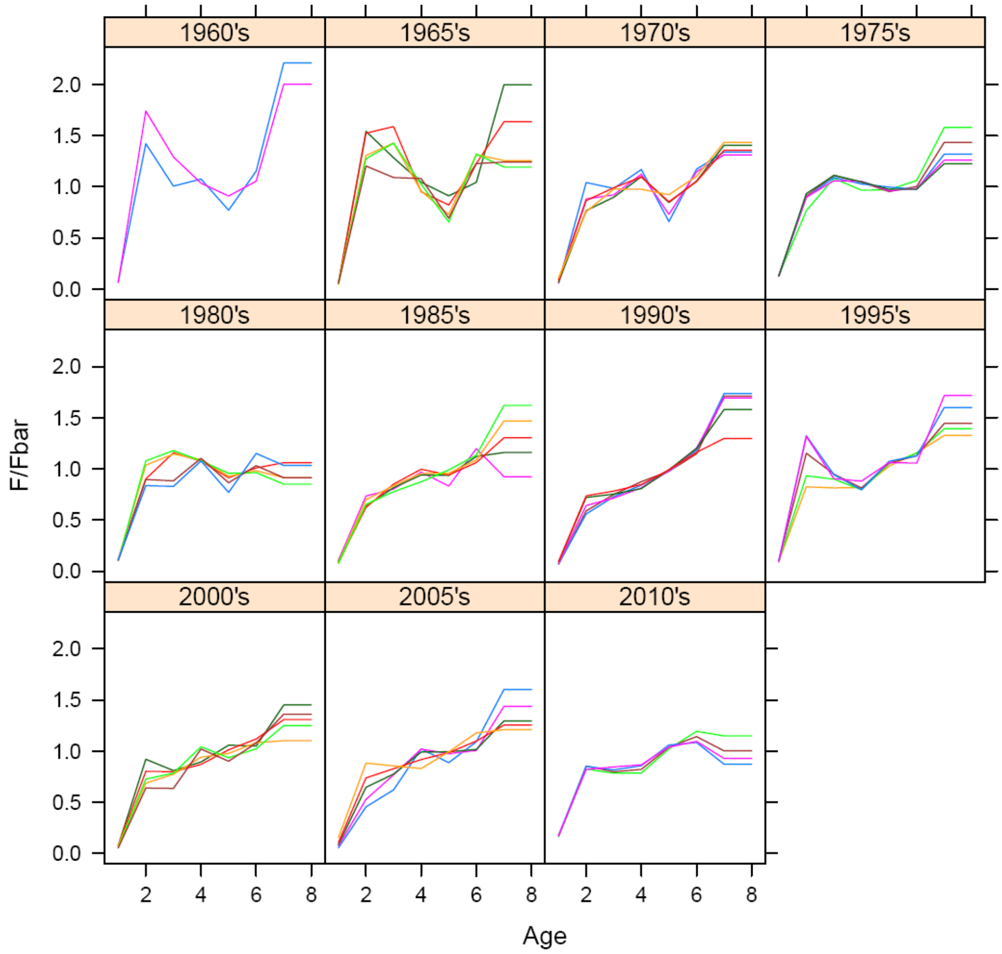


Figure 7.6.19 Herring in Division VIIa North (Irish Sea). FLSAM run output. Selectivity of the fishery by pentad.

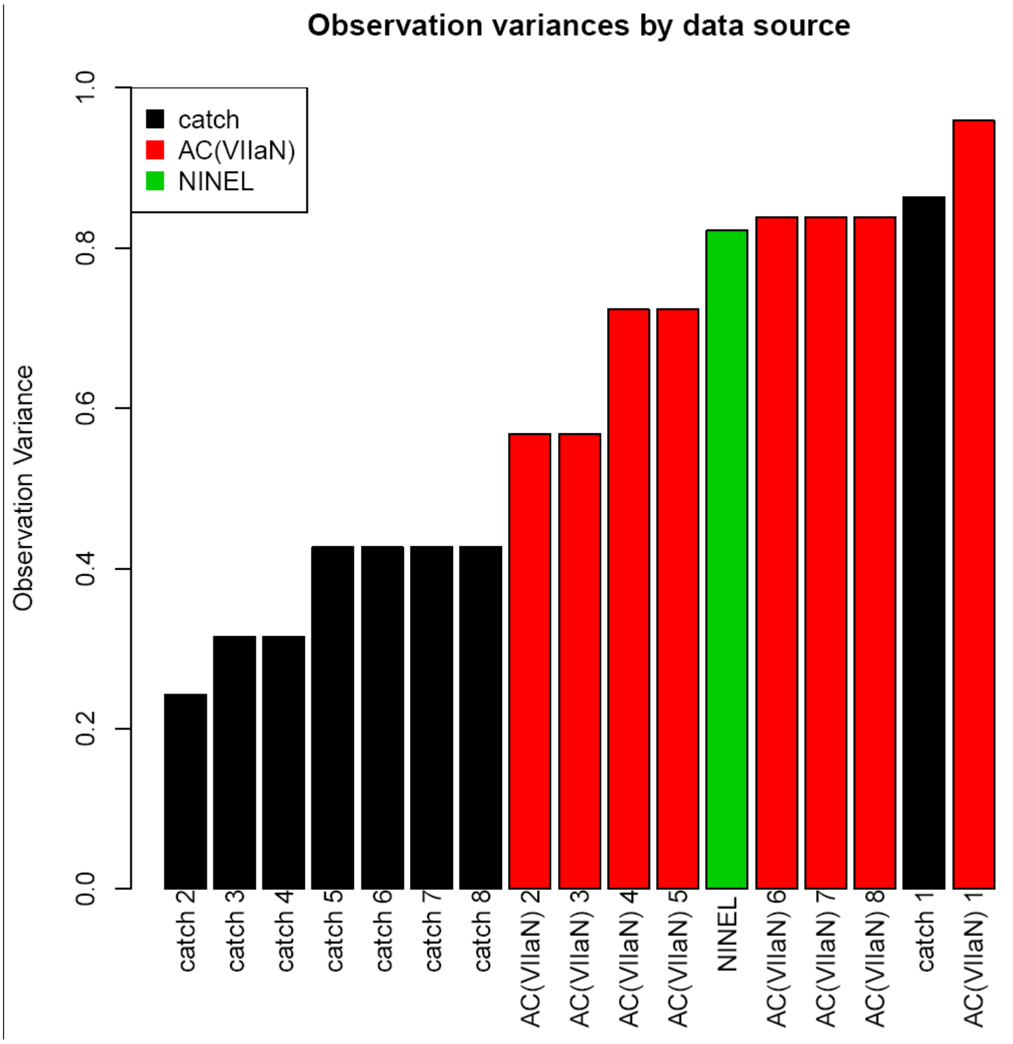


Figure 7.6.20 Herring in Division VIIa North (Irish Sea). Observation variances of all the data sources fitted in the FLSAM assessment model.

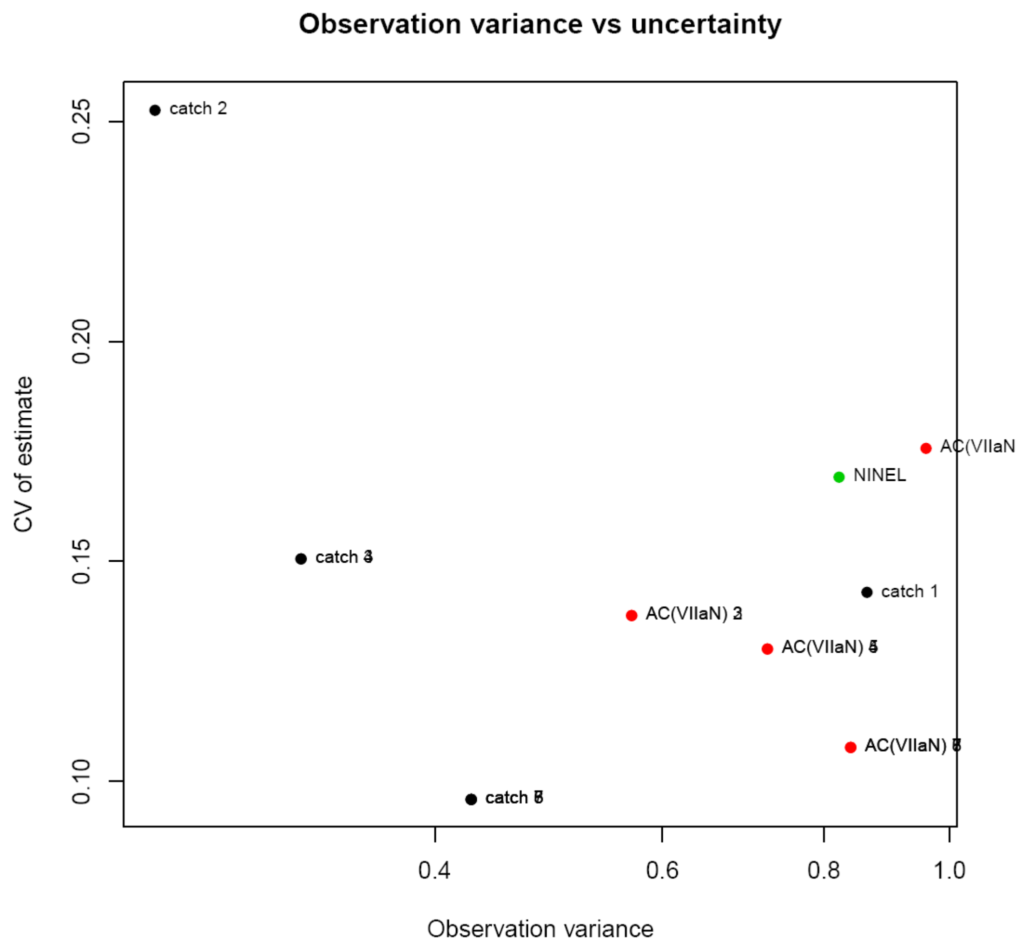


Figure 7.6.21 Herring in Division VIIa North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in the FLSAM assessment model.

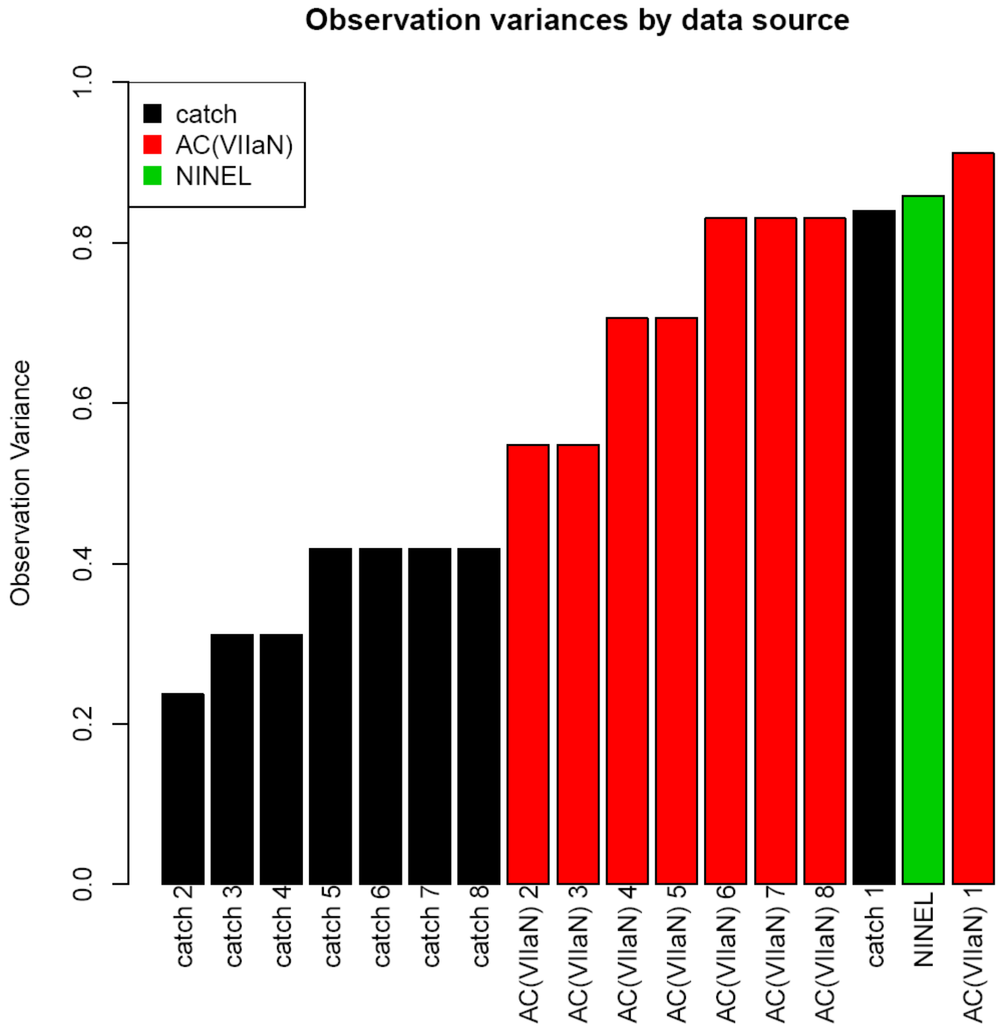


Figure 7.6.22 Herring in Division VIIa North (Irish Sea). Observation variances of all the data sources fitted in the exploratory FLSAM assessment model, excluding the 2011 acoustic survey data.

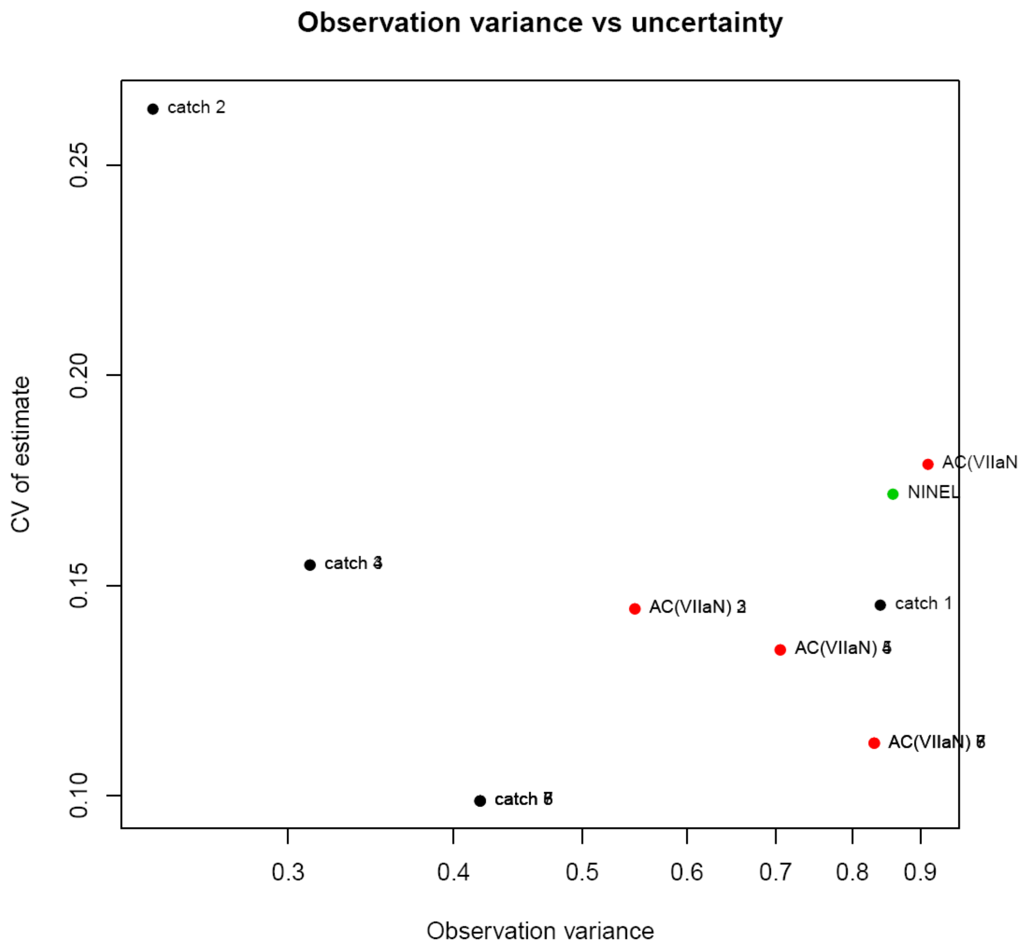


Figure 7.6.23 Herring in Division VIIa North (Irish Sea). Observation variances vs uncertainty of the data sources fitted in exploratory FLSAM assessment model, excluding the 2011 acoustic survey data.

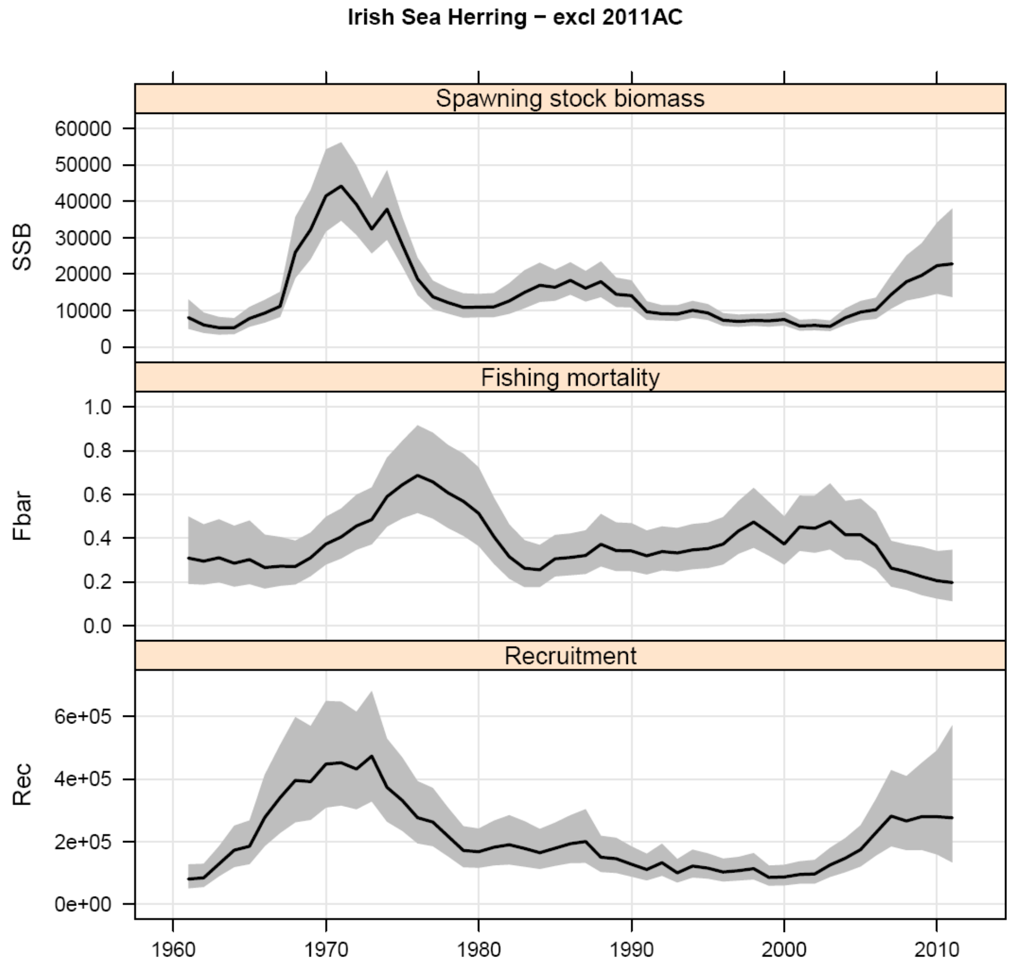


Figure 7.6.24 Herring in Division VIIa North (Irish Sea). Stock trends from the exploratory FLSAM run output (with 95% confidence intervals), excluding the 2011 acoustic survey data. Summary of estimates of spawning stock at spawning time, recruitment at 1-ring, mean $F_{4\text{-}6}$.

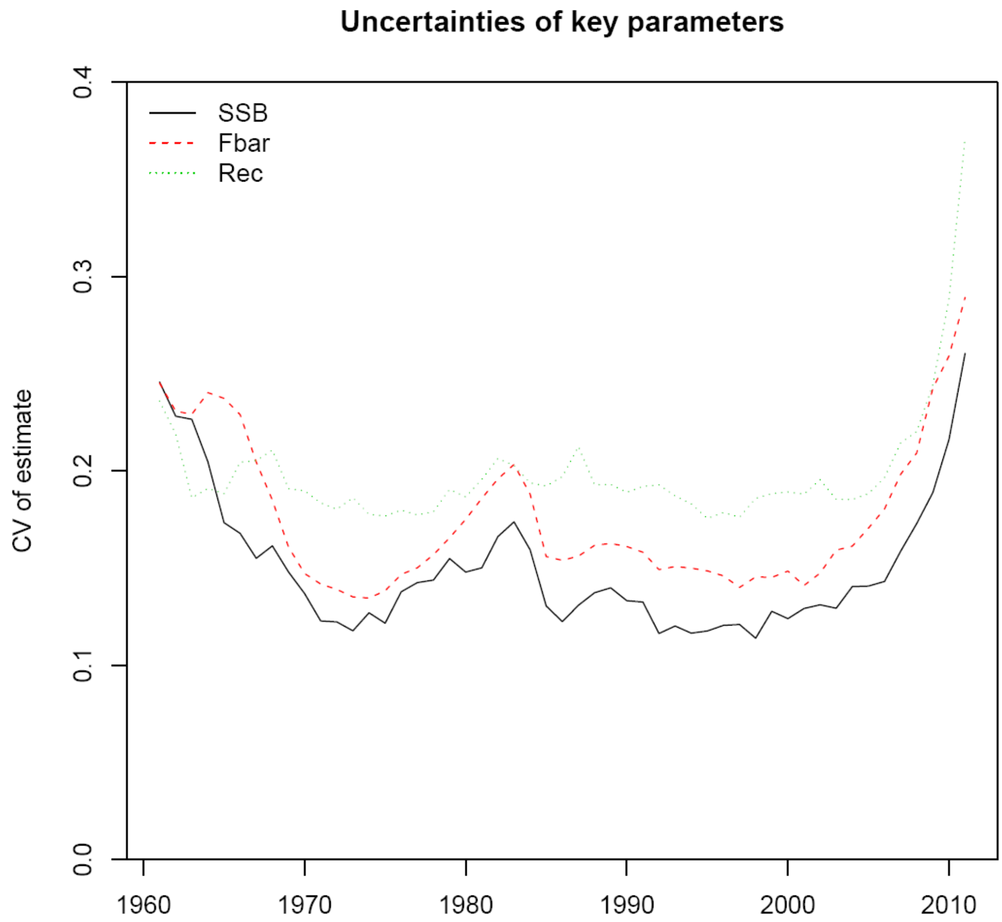


Figure 7.6.25 **Herring in Division VIIa North (Irish Sea). Uncertainty of stock parameter estimates from the exploratory FLSAM assessment model output, excluding the 2011 acoustic survey data. Rec = recruitment age 1.**

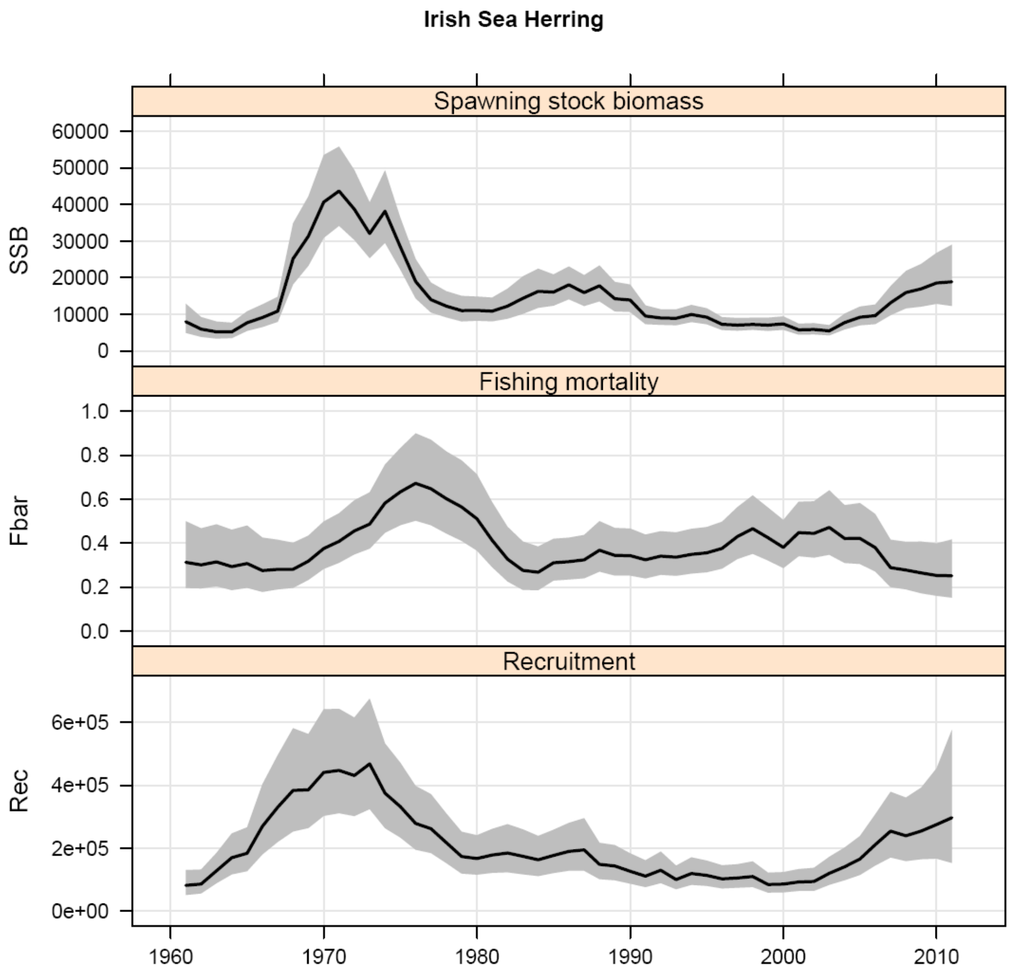


Figure 7.6.26 **Herring in Division VIIa North (Irish Sea). Stock trends from the final FLSAM run, with 95% confidence intervals. Summary of estimates of spawning stock at spawning time, recruitment at 1-ring, mean $F_{4\text{-}6}$.**

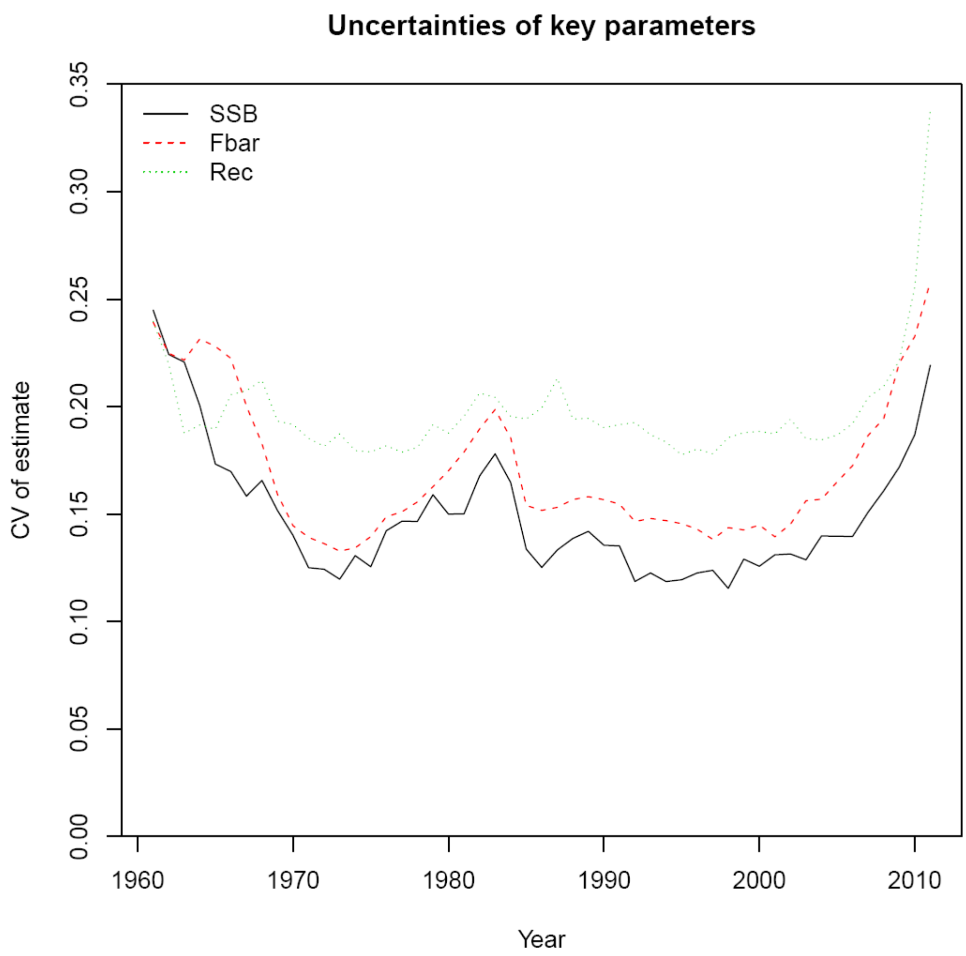


Figure 7.6.27 **Herring in Division VIIa North (Irish Sea). Uncertainty of stock parameter estimates from the final FLSAM assessment. Rec = recruitment age 1.**

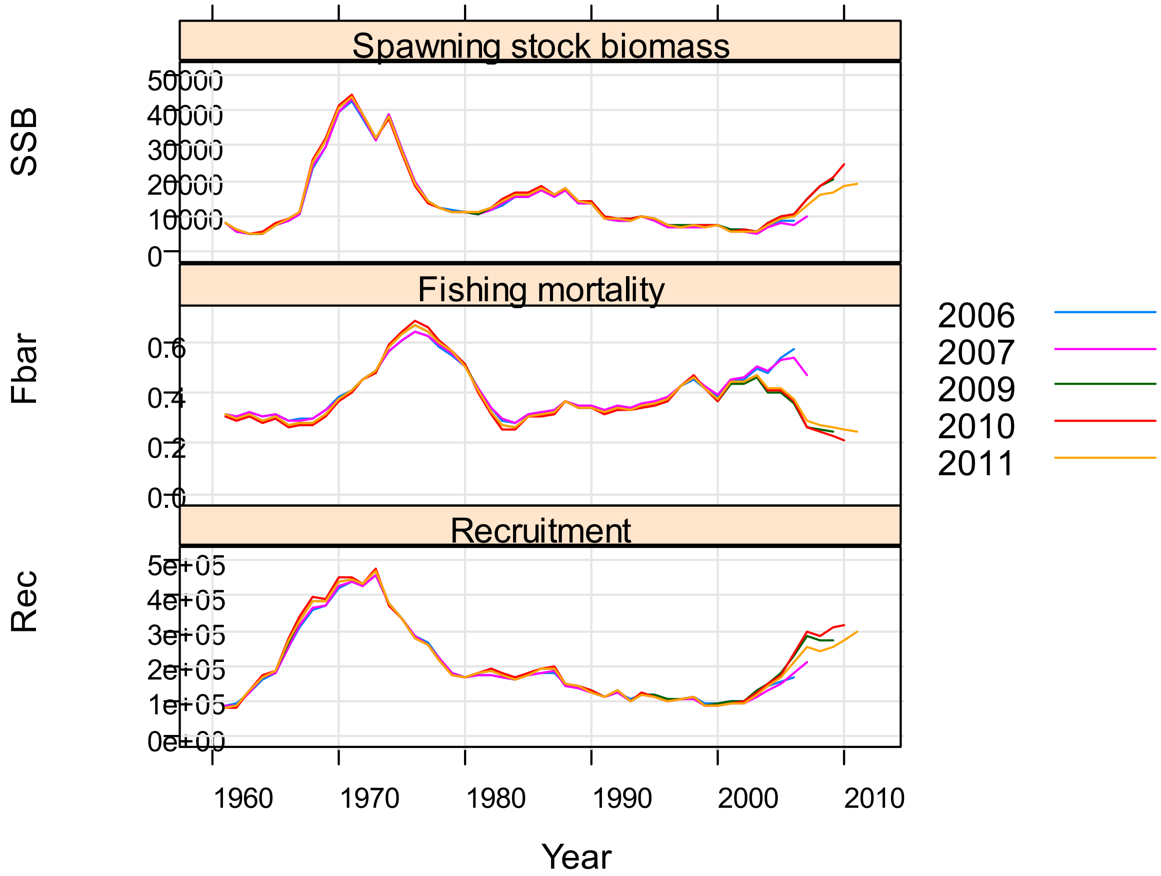


Figure 7.6.28 Herring in Division VIIa North (Irish Sea). Analytical retrospective patterns (2011 to 2005, excl 2008 where model did not converge) of SSB, recruitment and mean $F_{4\text{-}6}$ from the final FLSAM assessment.

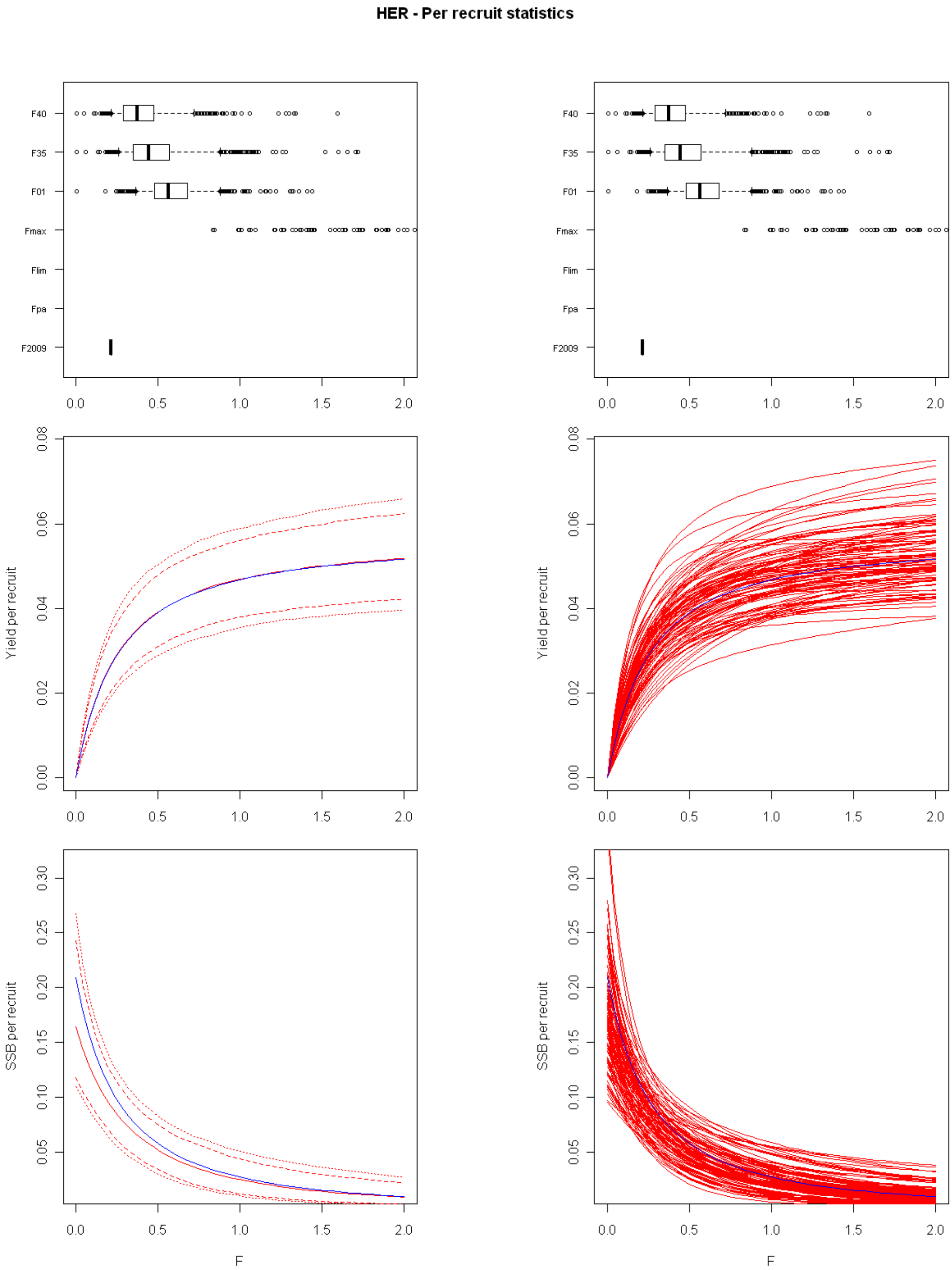


Figure 7.7.1 **Herring in Division VIIa North (Irish Sea). F reference points and yield-per-recruit and SSB-per-recruit against mortality.**

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACOM Advice Applicable to 2011 and 2012

There have never been any explicit management objectives for this stock. The TAC set for 2011 was 170 000 t. For 2011, the by-catch quota of herring (EU fleet) was set at 16 539 t. For 2012 a TAC was set at 170 000 t.

8.1.2 Catches in 2011

Catch statistics for 1996–2011 for sprat in the North Sea by area and country are presented in Table 8.1.1. Catch data prior to 1996 are considered unreliable (see Stock Annex). As in previous years, the small catches of sprat from the fjords of western Norway are not included in the catches for the North Sea, due to uncertainties in stock identity. Total catches for the North Sea in 2011 were 134 100 t (the WG estimate). This was slightly less than in 2010, but about average for the time series. The Danish catches represent over 80% of the total catches.

In 2011 the catches were taken in IVa, IVb and IVc. The spatial distribution of landings was similar to 2010: 74% was taken in IVb and 26% in IVc – landings in IVa were very small. Only small catches were landed in the second quarter in 2011, while majority of landings were taken in the 4th quarter (Table 8.1.2). Quarterly and annual distribution of catches per rectangle is seen in Figures 8.1.1a-d and Figure 8.1.2.

8.1.3 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the 2nd 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.

8.1.4 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported.

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%).

As there are very few 5+-year olds in the catches, the mean weight of this age group is frequently missing in the historic data. To eliminate the problem with missing data, ages 4 and 5+ were joined in a 4+ group and mean weight at age of this group re-estimated as the weighted average of mean weights of the two groups.

The estimated quarterly landings at age in numbers for the period are presented in Table 8.2.2. In 2011 the one-year old sprat contributed 45% of the total landings, which is below the average contribution (62% since 1996, range: 18-96%). 2-year olds contributed in 2011 with 38% of the total landings, leaving 17% of the contribution to 0- and 3+- year olds.

Mean-weight-at-age (g) in the landings in 2011 were on similar level as in the recent years (Table 8.2.3).

Denmark, Norway, and the Netherlands provided age data of commercial landings in 2011(Table 8.2.4). All the quarters were covered. The small fishery in quarter 2 was sampled by only two samples, and the landings data were raised by using samples from quarter 1. 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 2011 (0.6) was greatly improved compared to 2007-2010 (0.4 samples for 2007-2010), and is expected to increase further through the newly implemented sampling programme for collecting haulbased samples from the Danish sprat fishery. 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 2011 was again almost exclusively found in the eastern and southern parts of the North Sea, with highest abundances mainly in the south-eastern part (Figure 8.3.2). In 2011 some of the southern rectangles which held relatively high abundances of sprat in 2010 were not surveyed due to poor weather conditions (WGIPS). Total abundance in 2011 was estimated by WGIPS (see section 1.4.2) to be 42 600 million individuals and the biomass 444 000 tonnes (Table 8.3.2). This is an increase of about 18% in terms of biomass when compared to last year and the second highest biomass on record (ICES CM 2012/SSGESST:21). In terms of abundance, it is the fifth 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 90% of the biomass in 2011 (range observed 90%-99%).

8.3.3 Explorative analysis of survey consistency

The IBTS represents a long time series of data which can potentially be used to derive indices of sprat abundance. However, for the survey to be appropriate for this, the survey catches must show an acceptable level of internal and external consistency (large cohorts should be consistent in time and over surveys). This study presents a study of the internal and external consistency of the quarter 1 and 3 IBTS and the acoustic survey for sprat.

8.3.3.1 Estimation of average catch at age

Catch rates of fish are often highly skewed and one or a few large catches have a large influence on the average. This has led to suggestions on the inadequacy of the arithmetic mean as an estimator and to the suggestion of alternative estimators. Pennington (1983) examined the statistical properties of catches and suggested analyzing the probability of catching a species and the amount caught in non-empty catches separately, a method which is well suited for the typically highly skewed catch data from surveys. To investigate whether the method used to estimate the average catch rate by age of sprat can be improved, the internal and external consistency of three indices was examined:

1. Arithmetic mean catch at age per hour
2. Probability of catching sprat at age in a haul
3. Average catch at age estimated by the delta-method

Catch at age by haul was estimated using age length keys estimated separately for each roundfish area when possible using the method described in Rindorf and Lewy (2001). These catch rates are highly correlated with those estimated by ICES (correlation=0.98, P<0.0001). The area included in all analyses was the North Sea between 52°N and 57.5°N (the area covered by the acoustic survey).

The average catch predicted by the delta-method, *N*, can then be estimated as:

$$\hat{N} = \hat{p} * (\hat{N} \mid N \neq 0)$$

Where $\hat{p}$ is the probability of catching sprat of a given age and $(\hat{N} \mid N \neq 0)$ is the average number caught in non-empty catches. Following Stefánsson and Pálsson (1997), average predicted catch can be estimated using generalized linear models of *p* and $N|N \neq 0$ separately. A disadvantage of the method is that the assumptions are only met when trawl time is held constant. To assure this, only hauls with a duration between 25 and 35 minutes were included in the analyses.

The arithmetic mean was estimated as the average catch rate in a square averaged over all squares. No weighting was applied to the squares.

The probability of catching sprat of a given age in an area was estimated as the product of a year and area effect within a given quarter, corresponding to the assumption that the spatial distribution of catch probabilities remains constant over the years. To assure a reasonable number of observations in each cell, it was decided to estimate the average biomass caught within areas of 1°Latitude by 2° longitude. This area size assured a reasonable number of observations (8 trawl hauls per area at a given time) while preserving as much of the distributional aspects as possible.

The probability of a positive catch of a given age in an area was estimated as

$$\hat{p}_{area,y,q} = \frac{\log(\alpha_{area,q} + \beta_{y,q})}{1 + \log(\alpha_{area,q} + \beta_{y,q})} \qquad (1)$$

where α and β are age specific constants within indices estimated within the model and indices *a*, *y* and *q* refer to area, year and quarter, respectively (age indices omitted for clarity). The average probability of catching sprat of a given age in quarter *q* and year *y* was estimated as the average $\hat{p}_{area,y,q}$ over all areas.

The number at age caught in non-zero hauls was estimated by first fitting the model

$$(N_{area,y,q} \mid N \neq 0) = \log(\alpha_{area,q} + \beta_{y,q}) + \varepsilon_{area,y,q} \qquad (2)$$

where the error term ε was assumed to be gamma distributed (age indices omitted for clarity). The scale parameter (and hence the CV) was held fixed. The average catch estimated by the delta-method was estimated as

$$\overline{N}_{y,q} = \frac{1}{A}\sum_{area} \hat{p}_{area,y,q} * (\hat{N}_{area,y,q} \mid N \neq 0)$$

Where A is the number of areas.

Following estimation, all indices were logged and the internal consistency estimated as the correlation between catch at age in a given year and catch at age-1 the previous year. For comparison, the internal consistency of the acoustic survey was also estimated. External consistency was estimated both within the year (comparing quarter 1 catch rate at age to quarter 3 catch rate at age in the same year) and between years (comparing quarter 1 catch rate at age to quarter 3 catch rate at age-1 the previous year). External consistency with the acoustic survey was only investigated within the same year as the acoustic survey is midway between the quarter 1 and quarter 3 IBTS surveys.

8.3.3.2 Results

There was little difference between the consistency of the arithmetic mean and the delta average (Table 8.3.4.1). In total, the probability of catching the age group had the highest number of significant correlations (15 correlations significant at the 5% level) followed by the arithmetic mean (14 correlations significant at the 5% level) and the delta average (11 correlations significant at the 5% level). However, though the consistency of the probability of catching an age group was highest, this indicator was not significantly correlated to the HERAS index for any of the age groups. As a result of this, the arithmetic mean was considered the best estimator. The temporal development in the period sampled by HERAS and the internal and external consistency for the arithmetic mean of the area sampled in HERAS is seen in figs. 8.3.4.1 and 8.3.4.2. In general, the consistency was high age 1 and 2 and lower for age 3 and 4+. The consistency was markedly higher over a period of 6 months than for yearly comparisons. This is to be expected as variation caused by differences in mortality rates accumulates over time thereby decreasing consistency over time. The consistency from age 1 to age 2 was higher than that of HERAS and the 6-monthly consistency was highly significant for ages 1 and 2 with correlations exceeding that of the HERAS survey (0.25 for age 1 to 2 and 0.67 for age 2 to 3) in all cases (Table 8.3.4.1). The external consistency between the arithmetic mean and the HERAS survey was generally on the same level as the 6-monthly consistency, but the correlations missed the 5% significance level in half the cases, presumably due to the low number of observations.

8.4 Mean weights-at-age and maturity-at-age

Data on maturity by age, mean weight- and length-at-age during the 2011 summer acoustic survey are presented in the WGIPS report (ICES CM 2012/SSGESST:21). Maturity and mean weights-at-age from the catch data are given in Tables 8.6.4 and 8.6.7.

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 2012 (2011 year class) was estimated to be the 4^{th} highest in the time series. In 2011 the 1-group was below the average of the time series.

8.6 Stock Assessment

The last benchmark of this stock was in September 2009 (ICES CM 2009/ACOM:34). A new benchmark is planned for 2013.

8.6.1 Data Exploration

In preparation to next year's benchmark, a series of analyses were performed to identify the main issues which need to be addressed at the benchmark.

8.6.1.1 Sampling of commercial catches

There was some concern in the group that the spatial distribution of the biological samples taken from the fishery did not always follow the catch distribution. Correlations between landings and numbers of samples taken per statistical rectangle revealed that this concern was indeed well founded (Table 8.6.1). This presents a problem if there are spatial differences in growth and age composition and may decrease the consistency between years of the cohorts signal in the catches. To remedy the problem, it was decided to use the existing Danish and Norwegian biological samples to produce spatially explicit age compositions and weight at age whenever the sampling level allowed. Ideally, this should be coupled with total catches per quarter and statistical rectangle. However, only Danish spatial data were available for the present meeting and the total international catches were therefore allocated to quarter and statistical rectangle according to the Danish catches.

8.6.1.2 Quarterly distribution of catches

A second issue of importance to the temporal scale of as assessment model was the quarterly allocation of catches over the year (Figure 8.6.1). This has varied greatly over the years, suggesting that a yearly model or even a half-yearly model is inappropriate for this species, which also is subject to a high natural mortality. It was therefore decided to use a quarterly model for the explorative analyses and produce the age composition and mean weight at age data in accordance with this.

8.6.1.3 Estimation of catch at age and mean weight at age.

Biological samples taken by Norway (2005 to present) and Denmark (1991 to present) were re-analysed. Briefly, biological data from both countries were joined in a dataset and yearly and quarterly ALK's produced using the method of Rindorf and Lewy (2001). When sufficient data were available, separate ALK's were produced for each 4-rectangle area. If the data were insufficient, 16-rectangle areas were used. This level was followed by a quarterly, half-yearly and yearly all North Sea ALK. The ALK was applied to the length samples and the age composition investigated using the same hierarchical method. Age compositions were only used when a minimum of 5 length samples were recorded at a given level, otherwise the next hierarchical level was used. The spatio-temporal distribution of the total international catches (Table 8.6.2) were assumed to follow that of the Danish catches and the number caught by year, age group and quarter estimated along with the mean weight at age (Tables 8.6.3 and 8.6.4, Figure 8.6.2).

8.6.1.4 Following cohorts in the catches

As the total catch of sprat varies between years and quarters, it is not possible to follow cohorts over time by simply following the number caught per age group. Further, simply looking at the number of a given age group per kg is not appropriate as this figure may be low both due to a strong recruitment in one of the other cohorts present and the low abundance of a given cohort. This leaves the indicator *I* of the abundance of one cohort relative to the subsequent cohort:

$$I_{a+1,a,y,q} = \frac{C_{a+1,y,q}}{C_{a,y,q}}$$

Where *y*, *q* and *a* denotes year quarter and age and *C* is catch in numbers. This indicator reveals whether there were e.g. twice as many 2 year olds as 1-year olds in a given year and quarter. If this catch composition reflects the state of the stock, a high index in one year and quarter should be followed by a high index of the same cohorts the subsequent quarter or year. This would mean that the oldest cohort was still twice as large as the subsequent cohort when seen at other times. The indicator was investigated for consistency from quarter to quarter and from year to year. To avoid spurious correlations caused by lack of samples, only data from quarters where at least 5 samples were taken were included. In general, there was a reasonable consistency between quarterly age distributions (Figure 8.6.3, Table 8.6.5) and all correlations were significant at the 10% level (5% level for quarter 4). Hence it was possible to follow relative cohort size in the commercial catches, suggesting that it would be possible to estimate an age based model.

8.6.1.5 Estimating natural mortality and maturity at age

Natural mortality was estimated as the average by age and quarter for the period 1991 to 2011 as estimated by WGSAM (WGSAM 2011). Proportion mature was derived from the 1st quarter IBTS excluding data from Sweden, which had substantially lower proportions mature than the remaining countries. Maturity of age 4+ was set to 1. Natural mortalities and maturities are given in tables 8.6.6 and 8.6.7

8.6.1.6 Explorative assessment

The assessment was made using SMS (Lewy and Vinther 2004) with quarterly time steps (Table 8.6.8). Three surveys were included, IBTS Q1 ages 1-4+, IBTS Q3 ages 1-3 and HERAS (Q2) ages 1-3. Investigation of the initial runs showed that the IBTS Q3 had particularly high variance estimates for age 0, and this age group was excluded from further runs. Further, the age distribution of quarterly catches of less than 500 tons was very poorly estimated: with one exception, these were based on less than 4 samples. As these catches are too small to have any effect on the stock, they were removed from the data to avoid problems caused by the low sampling level. Catches of age group 0 were low in quarter 3, and fish were therefore assumed to recruit to the fishery in quarter 4.

The model converged and fitted the catches of the main ages caught in the main quarters (the periods with most samples) well (ages 1-2, quarters 3 and 4, Figure 8.6.4). The IBTS quarter 1 had a low CV as did the HERAS survey, whereas the CV of IBTS Q3 was somewhat higher (Figure 8.6.5). There were no obvious patterns in the residuals apart from a tendency for residuals to be higher for 0-groups and ages 3 and 4+.

The final outputs detailing trends in mean F, SSB and recruitment are given in Figures 8.6.6 and 8.6.7 and table 8.6.9. From these figures it is apparent that recent catch levels have occurred simultaneously with sustained high SSBs and recruitment.

The stock and recruitment relationship generated from these data indicates there is little relationship between the SSB and the subsequent recruitment (Figure 8.6.8).

8.6.2 State of the Stock

The sprat stock seems to be increasing judged both by surveys individually and by the explorative analyses performed.

8.7 Short-term projections

No projections are presented for this stock. However, given the increasing trend in the stock, maintaining the current TAC most likely is sustainable.

8.8 Reference points

Precautionary reference points have not been defined for this stock.

8.9 Quality of the assessment

The performed analysis is exploratory and does not include biological information from all countries.

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.

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 the magnitude or direction of such changes has not been quantified.

Table 8.1.1. North Sea sprat. Catches (' 000 t) 1996-2011. 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	2011
	Division IVa															
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*		
Norway														*		*
Sweden						0.1										
UK (Scotland)																0.5
Total	0.3			0.7		0.2	1.1		*		*	0.8	*	*		0.5
	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	90.9
Norway	52.8	3.1	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3	4.0	8.0	0.1
Sweden	0.5		1.7	2.1		1.4				*				0.3	0.6	1.1
UK(Scotland)				1.4								0.1		2.5	1.1	1.9
UK(Engl.&Wales)														*		
Germany																3.3
Netherlands																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	98.4
	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	20.0
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8	3.2	9.9
Sweden														0.6	0.6	0.2
UK(Scotland)													0.2			0.4
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6
Germany																*
Netherlands				0.2												4.2
Belgium																*
Total	6.5	7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4	10.6	53.0	35.2
	Total North Sea															
Denmark	80.7	98.8	131.1	164.3	191.1	157.1	142.0	175.2	192.7	206.0	103.4	76.8	59.6	123.8	129.3	111.0
Norway	52.8	3.2	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3	5.8	11.1	10.0
Sweden	0.5		1.7	2.1		1.5				*				0.9	1.2	1.2
UK(Scotland)				1.4								0.1	0.2	2.5	1.1	2.3
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*	0.8	0.6
Germany																3.3
Netherlands				0.2												5.3
Total	136.6	103.4	164.3	188.4	195.9	170.2	143.6	176.5	194.3	207.7	113.7	83.8	61.1	133.1	143.5	133.6

* < 50 t

Table 8.1.2. North Sea sprat. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996-1999 in ICES CM 2007/ACFM:11
The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02.

Year	Quarter	Area				Total
		IVaW	IVaE	IVb	IVc	
2000	1			18 126	28 063	46 189
	2			1 722	45	1 767
	3			131 306	1 216	132 522
	4			12 680	2 718	15 398
	Total			163 834	32 042	195 876
2001	1	115		40 903	9 716	50 734
	2			1 071		1 071
	3			44 174	481	44 655
	4	79		65 102	8 538	73 719
	Total	194		151 249	18 735	170 177
2002	1	1 136		2 182	2 790	6 108
	2			435	93	528
	3			70 504	647	71 151
	4			52 942	12 911	65 853
	Total	1 136		126 063	16 441	143 640
2003	1			11 458	7 727	19 185
	2			625	26	652
	3			56 207	165	56 372
	4			84 629	15 651	100 280
	Total			152 919	23 570	176 489
2004	1			827	1 831	2 657
	2	7		260	16	283
	3			54 161	496	54 657
	4			120 685	15 937	136 622
	Total	7		175 932	18 280	194 219
2005	1			11 538	2 457	13 995
	2			2 515	123	2 638
	3			107 530		107 530
	4			82 474	1 033	83 507
	Total			204 057	3 613	207 670

Year	Quarter	Area				Total
		IVaW	IVaE	IVb	IVc	
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
2011	1	0		3747	21039	24 786
	2	0		2067	3	2 070
	3	0		22309	451	22 761
	4	8		70256	13759	84 023
	Total	8	0	98 380	35 252	133 640

* < 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 1998-2011.

	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
Tonnes	2011	114130	10533	35	234	0	134	1	2021	385	127473
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
Percent	2011	89.5	8.3	0.0	0.2	0.0	0.1	0.0	1.6	0.3	100.0

Table 8.2.2 North Sea sprat. Catch in numbers (millions) by quarter and by age 1996-2011. Only samples from the Danish fishery w ere used in allocation.

Year	Quarter	Age 0	1	2	3	4	Total
1996	1		524.7	4 615.4	2 621.9	327.7	8 090
	2		1.9	241.5	32.7	15.8	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	349.4	11 511
1997	1		74.4	314.0	229.2	57.8	675
	2		11.3	47.8	34.9	8.8	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	124.7	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	95.8	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	98.4	19 139
2000	1		559.2	3 177.3	797.5	319.6	4 854
	2		6.8	107.4	60.1	13.3	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	332.9	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	58.4	8 858
	Total	540.4	12 528.7	3 152.3	226.6	70.2	16 518

Year	Quarter	Age 0	1	2	3	4	Total
2004	1		16.5	214.0	26.3	2.3	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	2.4	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	56.9	3 798
	2	5.6	211.9	177.0	8.4	2.4	405
	3	38.3	1 447.9	289.9	4.9	3.5	1 784
	4	1 056.4	3 824.3	2 956.0	773.7	920.4	9 531
	Total	1 100.4	5 551.0	6 758.2	1 126.1	983.2	15 519
2011	1	0.0	197.7	1217.4	433.1	56.0	1 904
	2	0.0	101.8	194.8	61.3	7.5	365
	3	3.0	1580.3	1075.6	231.7	32.2	2 923
	4	398.9	4463.3	2882.5	815.3	232.6	8 793
	Total	401.9	6 343.1	5 370.3	1 541.4	328.3	13 985

Table 8.2.3 North Sea sprat. Mean w eight (g) by quarter and by age for 1996 - 2011.
* Any inconsistencies in total catches and SOP are due to rounding errors.
** These w eights come from allocation of quarter 3 samples
*** These w eights come from allocation of quarter 1 and quarter 3 samples

Year	Quarter	Age 0	1	2	3	4+	SOP* Tonnes
1996	1		3.9	9.3	14.9	15.3	88 808
	2		6.9	8.4	11.6	19.9	2 736
	3		11.6	14.2	18.2	21.5	6 499
	4		12.1	15.9	17.2	20.5	37 360
Weighted mean			10.0	10.5	15.1	15.6	135 403
1997	1		8.0	10.0	15.0	17.1	8 161
	2		8.0	10.0	15.0	17.1	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	18.3	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	14.6	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	14.6	187 670
2000	1		4.2	10.1	10.7	10.3	46 192
	2		3.3	9.0	10.2	12.7	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	10.4	195 925
2001	1		3.3	9.7	12.9	16.5	50 794
	2		3.3	10.3	12.9		1 071
	3	4.0	12.0	15.3			44 656
	4	3.8	11.6	12.6	19.1		73 444
Weighted mean		3.8	11.0	10.8	13.9	16.5	169 967
2002	1		7.0	12.0	14.0	13.0	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	144 272
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	16.1	97 670
Weighted mean		4.6	10.3	12.9	13.8	15.9	176 085

Year	Quarter	Age 0	1	2	3	4+	SOP* Tonnes
2004	1		3.6	10.3	13.8	16.5	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	16.6	182 900
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	47 069
	2		3.7	8.1	11.2		197
	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	113 831
2007	1		4.0	9.0	12.0		772
	2		4.0	9.0	12.0		249
	3		12.0	17.0	13.0	17.0	16 269
	4	5.1	10.9	13.5	16.3		65 349
Weighted mean		5.1	11.1	13.8	15.5	17.0	82 705
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		132 952
2010	1		3.3	7.0	10.8	14.6	28 144
	2***	6.1	6.2	9.1	13.0	16.9	3 109
	3	6.1	7.6	9.9	13.9	18.0	14 249
	4	3.2	8.7	11.4	14.9	17.5	97 926
Weighted mean		3.3	8.3	9.1	13.7	17.4	143 150
2011	1		5.2	7.6	10.0	14.1	15 351
	2	5.1	4.5	7.1	9.3	10.7	2 492
	3	5.1	8.3	10.1	13.2	15.4	27 461
	4	5.3	8.7	11.2	13.9	16.7	88 696
Weighted mean		3.3	8.3	9.1	13.7	16.5	134 000

Table 8.2.4. **North Sea sprat.** Sampling for biological parameters in 2011.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	12.7	7	663	192
	2	2.1	2	142	50
	3	22.7	6	527	140
	4	73.5	22	2123	236
	Total	111.0	37	3455	618
Norway	1	10.0	2	200	76
	2				
	3				
	4				
	Total	10.0	2	200	76
The Netherlands	1				
	2				
	3				
	4	3.9	5	124	124
	Total	3.9	5	124	124
All countries	1	22.7	9	863	268
	2	2.1	2	142	50
	3	22.7	6	527	140
	4	73.5	22	2123	236
Total North Sea		121.0	39	3655	694

* < 1 t

Table 8.3.1. North Sea sprat. Abundance indices by age from IBTS (February) from 1984-2012. * 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	675.99	897.98	691.52	92.70	110.88	2 469.07
2012*	2 446.91	1 973.81	458.17	34.78	7.33	4 920.98

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
2000	0	11,569	6,407	180	18,156	0	100	92	3	196
2001	0	12,639	1,812	110	14,561	0	97	24	2	122
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2010	1,991	19,492	13,743	798	36,023	22	163	177	14	376
2011	0	26,536	13,660	2,430	42,625	0	212	188	44	444

***Re-calculated by the means of FishFrame (ICES 2009/LRC:02)**

Table 8.3.4.1. North Sea sprat. Internal and external consistency of arithmetic mean (mean), probability of catching the age group (P) and average estimated by the delta method (delta). Bold correlations are significant at the 5% level, italic at the 10% level.

Survey	Age	Consistency with cohort catch in previous survey			Consistency with cohort catch 6 months earlier			Consistency with HERAS		
Index		mean	P	Delta	Mean	P	delta	Mean	P	Delta
IBTSQ1	1				0.58 (0.0060)	0.48 (0.0283)	*0.42 (0.0561)*	0.53 (0.1422)	0.21 (0.5842)	0.32 (0.3982)
	2	0.49 (0.0069)	0.69 (<0.0001)	0.45 (0.0140)	0.55 (0.0096)	0.68 (0.0007)	0.45 (0.0404)	0.58 (0.1041)	-0.18 (0.6525)	0.41 (0.2730)
	3	0.54 (0.0025)	0.70 (<0.0001)	0.44 (0.0156)	0.51 (0.0176)	0.70 (0.0005)	0.55 (0.0100)	0.73 (0.0268)	0.28 (0.4639)	0.78 (0.0131)
	4+	0.45 (0.0152)	0.50 (0.0061)	0.38 (0.0423)	0.10 (0.1858)	0.55 (0.0091)	0.34 (0.1301)			
IBTSQ3	1	0.62 (0.0033)	0.55 (0.0113)	0.51 (0.00215)	0.54 (0.0121)	0.80 (<0.0001)	0.31 (0.1741)	0.44 (0.2353)	-0.03 (0.9390)	0.37 (0.3278)
	2	0.22 (0.3508)	0.73 (0.0003)	0.35 (0.1260)	0.70 (0.0004)	0.74 (0.0001)	0.69 (0.0005)	0.89 (0.0014)	0.14 (0.7251)	0.81 (0.0087)
	3	0.04 (0.8606)	0.67 (0.0012)	*0.40 (0.0845)*	0.50 (0.0220)	0.59 (0.0049)	0.51 (0.0183)	0.75 (0.0189)	0.32 (0.4051)	0.80 (0.0099)
	4+	0.18 (0.4535)	0.78 (<0.0001)	*0.43 (0.0604)*	0.55 (0.0128)	0.61 (0.0032)	0.35 (0.1247)			

Table 8.6.1. North Sea sprat. Correlations between catch in tonnes taken in ICES statistical rectangles and the number of biological samples (Danish and Norwegian) derived from the rectangle. Average over all years (mean), 10% and 90% quantiles and minimum and maximum observed over the time series. Main catches are in quarter 4.

Quarter	Min	10% quantile	mean	90 % quantile	Max
1	-0.04	0.04	0.58	0.87	0.95
2	-0.03	-0.03	0.20	0.62	0.99
3	-0.02	0.26	0.51	0.74	0.81
4	-0.16	0.33	0.54	0.77	0.78

Table 8.6.2. North Sea sprat. Total international catches and number of biological samples taken.

Year	Total catch	Number of samples
1991	69901	28
1992	103837	64
1993	180107	62
1994	323466	64
1995	357314	58
1996	135685	24
1997	100694	23
1998	162597	33
1999	188068	36
2000	195700	43
2001	170123	21
2002	146605	43
2003	176088	50
2004	194249	37
2005	208193	74
2006	113979	40
2007	82635	38
2008	61172	27
2009	133586	45
2010	143437	55
2011	145104	84

Table 8.6.3. North Sea sprat. Catch in numbers by age (1000's).

Year	Quarter	Age 0	Age 1	Age 2	Age 3	Age 4+
1991	Q1	.	33818	2235	190	36
	Q2	.	23723	1568	133	25
	Q3	.	987923	1228780	20884	527
	Q4	290515	1837840	380119	6017	188
1992	Q1	.	6844	3071	103	6
	Q2	.	347175	155778	5208	326
	Q3	.	7441340	952093	119635	11942
	Q4	148775	936098	115387	14939	1589
1993	Q1	.	891650	1428440	233688	5236
	Q2	.	498354	389788	53998	1053
	Q3	.	2551910	4433880	174115	22062
	Q4	1249080	4286220	1155860	28616	809
1994	Q1	.	571602	2005410	415517	52669
	Q2	.	720050	1083580	221373	20017
	Q3	.	30326900	556413	27502	380
	Q4	1881220	5150080	1440130	133480	5556
1995	Q1	.	496336	1840040	769910	10629
	Q2	.	169086	382353	135881	2520
	Q3	.	19750700	3121740	499913	3714
	Q4	731449	7332450	3291080	669926	13919
1996	Q1	.	4102290	1817820	411177	17804
	Q2	.	263445	114480	25250	1071
	Q3	.	171538	380781	132134	11876
	Q4	1584760	902760	2117260	782033	73840
1997	Q1	.	27124	349517	240956	21465
	Q2	.	4922	63423	43723	3895
	Q3	.	1597550	507661	72584	26683
	Q4	104712	3403110	1232120	195541	83303
1998	Q1	.	530199	233473	39220	120
	Q2	.	55001	24220	4069	12
	Q3	.	3558760	1344250	174346	799
	Q4	997505	3463710	1481990	412366	0
1999	Q1	.	1432860	992760	193243	38309
	Q2	.	150443	114474	17919	3484
	Q3	.	14657500	303972	65013	87
	Q4	80353	1828840	341269	20527	104
2000	Q1	.	2066390	2970560	652432	240303
	Q2	.	55826	110039	37710	21750
	Q3	.	9453680	1525210	83992	5221
	Q4	2445	730320	429210	39035	2200
2001	Q1	.	661987	2544430	1075380	141334
	Q2	.	11588	37984	13176	1297

	Q3	.	3222120	798081	66949	0
	Q4	810979	4806020	1669470	147414	0
2002	Q1	.	331648	71804	13635	811
	Q2	.	23852	5164	981	58
	Q3	.	6415520	404918	41258	3543
	Q4	493588	4308080	926892	198678	10447
2003	Q1	.	1599330	1153080	106703	3669
	Q2	.	67571	38477	3416	121
	Q3	.	3782700	537307	34742	11471
	Q4	412419	7649590	1051170	47966	30471
2004	Q1	.	133073	22943	1355	77
	Q2	.	28834	4971	294	17
	Q3	.	3637410	794236	47059	3617
	Q4	21480100	4871350	374538	33947	1859
2005	Q1	.	3233250	219973	9303	307
	Q2	.	694769	41375	1713	54
	Q3	.	12453800	224059	35011	1176
	Q4	914743	7696210	195381	15142	600
2006	Q1	.	602880	4490190	117835	5110
	Q2	.	12466	65085	1617	71
	Q3	.	2582670	1277730	216067	4066
	Q4	0	1744040	1013000	107728	2678
2007	Q1	.	5956	3535	675	33
	Q2	.	14427	8563	1634	81
	Q3	.	906231	423493	95349	3845
	Q4	608979	3589560	1648530	221072	17865
2008	Q1	.	168532	118707	5171	732
	Q2	.	4831	3459	223	37
	Q3	.	389352	1402720	284231	24085
	Q4	485633	1503530	1187920	250103	41909
2009	Q1	.	159913	18773	1146	75
	Q2	.	328266	38536	2352	155
	Q3	.	4866680	203772	20495	938
	Q4	224698	7627650	539694	90947	4109
2010	Q1	.	43401	3185570	466515	70407
	Q2	.	7269	380720	44396	9336
	Q3	.	1547520	468146	8517	1553
	Q4	327622	3345830	3007650	827943	965165
2011	Q1	.	214076	1318260	469027	60587
	Q2	.	110192	210934	66398	8167
	Q3	.	1711300	1164730	250852	34902
	Q4	431923	4833210	3121370	882850	251858

Table 8.6.4. North Sea sprat. Mean weight at age (kg)

Year	Quarter	Age 0	Age 1	Age 2	Age 3	Age 4+
1991	Q1	.	0.005	0.01	0.013	0.015
	Q2	.	0.005	0.008	0.01	0.011
	Q3	.	0.014	0.015	0.02	0.017
	Q4	0.005	0.015	0.019	0.02	0.017
1992	Q1	.	0.005	0.007	0.01	0.011
	Q2	.	0.005	0.007	0.009	0.011
	Q3	.	0.01	0.012	0.014	0.018
	Q4	0.007	0.011	0.015	0.017	0.017
1993	Q1	.	0.003	0.009	0.014	0.017
	Q2	.	0.004	0.007	0.009	0.01
	Q3	.	0.011	0.012	0.012	0.018
	Q4	0.008	0.011	0.013	0.017	0.017
1994	Q1	.	0.003	0.008	0.011	0.015
	Q2	.	0.004	0.007	0.009	0.011
	Q3	.	0.006	0.008	0.013	0.014
	Q4	0.009	0.01	0.012	0.015	0.014
1995	Q1	.	0.003	0.008	0.01	0.015
	Q2	.	0.005	0.008	0.01	0.012
	Q3	.	0.008	0.011	0.012	0.015
	Q4	0.005	0.01	0.013	0.016	0.016
1996	Q1	.	0.007	0.011	0.013	0.016
	Q2	.	0.007	0.011	0.015	0.017
	Q3	.	0.011	0.014	0.017	0.018
	Q4	0.006	0.01	0.015	0.016	0.019
1997	Q1	.	0.006	0.01	0.013	0.015
	Q2	.	0.006	0.01	0.013	0.015
	Q3	.	0.012	0.015	0.018	0.02
	Q4	0.003	0.011	0.016	0.019	0.022
1998	Q1	.	0.009	0.014	0.019	0.022
	Q2	.	0.009	0.014	0.019	0.022
	Q3	.	0.014	0.016	0.017	0.017
	Q4	0.007	0.012	0.015	0.018	0.017
1999	Q1	.	0.004	0.007	0.01	0.011
	Q2	.	0.005	0.007	0.01	0.011
	Q3	.	0.01	0.012	0.012	0.014
	Q4	0.004	0.01	0.013	0.013	0.014
2000	Q1	.	0.004	0.009	0.011	0.011
	Q2	.	0.005	0.008	0.01	0.012
	Q3	.	0.012	0.014	0.016	0.014
	Q4	0.006	0.012	0.014	0.016	0.014
2001	Q1	.	0.004	0.01	0.013	0.015
	Q2	.	0.006	0.009	0.012	0.014
	Q3	.	0.01	0.013	0.016	0.017

	Q4		0.005	0.011	0.013	0.016	0.017
2002	Q1	.		0.01	0.016	0.021	0.024
	Q2	.		0.01	0.016	0.021	0.024
	Q3	.		0.01	0.014	0.015	0.017
	Q4		0.006	0.011	0.013	0.014	0.017
2003	Q1	.		0.004	0.008	0.01	0.015
	Q2	.		0.005	0.008	0.01	0.011
	Q3	.		0.013	0.015	0.02	0.02
	Q4		0.007	0.011	0.014	0.014	0.015
2004	Q1	.		0.008	0.012	0.016	0.018
	Q2	.		0.008	0.012	0.016	0.018
	Q3	.		0.011	0.014	0.014	0.016
	Q4		0.004	0.009	0.012	0.015	0.018
2005	Q1	.		0.003	0.007	0.009	0.013
	Q2	.		0.003	0.005	0.007	0.008
	Q3	.		0.008	0.012	0.012	0.017
	Q4		0.006	0.01	0.011	0.012	0.017
2006	Q1	.		0.006	0.008	0.01	0.015
	Q2	.		0.005	0.008	0.01	0.011
	Q3	.		0.01	0.012	0.013	0.017
	Q4		0.005	0.009	0.012	0.014	0.015
2007	Q1	.		0.008	0.014	0.018	0.021
	Q2	.		0.009	0.013	0.018	0.02
	Q3	.		0.012	0.014	0.014	0.015
	Q4		0.006	0.01	0.013	0.015	0.015
2008	Q1	.		0.004	0.007	0.01	0.014
	Q2	.		0.005	0.008	0.01	0.011
	Q3	.		0.01	0.011	0.013	0.013
	Q4		0.005	0.009	0.013	0.014	0.016
2009	Q1	.		0.007	0.012	0.015	0.018
	Q2	.		0.007	0.011	0.015	0.017
	Q3	.		0.009	0.012	0.014	0.017
	Q4		0.005	0.01	0.013	0.016	0.017
2010	Q1	.		0.004	0.008	0.01	0.013
	Q2	.		0.005	0.008	0.01	0.012
	Q3	.		0.008	0.009	0.013	0.016
	Q4		0.004	0.009	0.011	0.013	0.017
2011	Q1	.		0.005	0.008	0.01	0.014
	Q2	.		0.005	0.007	0.009	0.011
	Q3	.		0.008	0.01	0.013	0.015
	Q4		0.005	0.009	0.011	0.014	0.017

Table 8.6.5. North Sea sprat. Correlation between $I_{a+1,a,y,q}$, an index of the ratio of one cohort to that a year younger in a given quarter and the ratio in the previous quarter. Only data points based one at least five samples included. N denotes number of observations

quarter	age	correlation	P(corr=0)	N
1	2 to 1	0.499	0.0582	15
1	3 to 2	0.489	0.0760	14
4	1 to 0	0.883	0.0003	11
4	2 to 1	0.543	0.0164	19
4	3 to 2	0.607	0.0059	19

Table 8.6.6. North Sea sprat. Natural mortality of sprat by age and quarter.

Age	Quarter 1	Quarter 2	Quarter 3	Quarter 4
0				0.640
1	0.235	0.670	0.523	0.345
2	0.228	0.344	0.418	0.251
3	0.204	0.140	0.112	0.110

Table 8.6.7. North Sea sprat. Maturity at age

age	Maturity
1	0.498
2	0.888
3	0.944
4	1.000

Table 8.6.8. North Sea sprat. Assessment summary.

```
objective function (negative log likelihood):  211.648
Number of parameters: 69
Maximum gradient: 5.50206e-005
Akaike information criterion (AIC):   561.296
Number of observations used in the likelihood:
                            Catch    CPUE     S/R Stomach     Sum
                             357     178      21       0     556

objective function weight:
                          Catch  CPUE   S/R
                          1.00  1.00  0.10

unweighted objective function contributions (total):
                Catch    CPUE    S/R    Stom.  Penalty     Sum
              230.6   -17.8   -12.0     0.0 0.00e+000   200.8

unweighted objective function contributions (per observation):
                Catch   CPUE     S/R   Stomachs
               0.65   -0.10   -0.57    0.00

contribution by fleet:
----------------------
IBTS Q1                     total: -19.885   mean:  -0.226
IBTS Q3                     total:  13.915   mean:   0.221
Acoustic                    total: -11.824   mean:  -0.438

F, Year effect:
---------------
1991:    1.000
1992:    0.894
1993:    1.852
1994:    1.253
1995:    1.461
1996:    1.086
1997:    1.251
1998:    1.287
1999:    0.690
2000:    1.032
2001:    1.905
2002:    1.846
2003:    1.550
2004:    2.389
2005:    1.122
2006:    1.213
2007:    1.687
2008:    1.298
2009:    0.435
2010:    0.563
2011:    0.881

F, season effect:
-----------------
age: 0
    1991-2011:   0.000 0.000 0.000 1.000
age: 1
    1991-2011:   0.006 0.002 0.137 0.250
age: 2 - 4
    1991-2011:   0.031 0.008 0.072 0.250

F, age effect:
--------------
                0      1      2      3      4
1991-2011:  0.003  0.959  3.524  3.524  3.524

sqrt(catch variance) ~ CV by :
--------------------------
              season
--------------------------------------
age        1       2       3       4

 0                                  1.427
 1       1.383   1.511   1.105   0.568
 2       1.462   0.991   0.721   0.699
```

```
 3       2.042   1.613   1.245   1.453
 4       2.042   1.613   1.245   1.453

Survey catchability:
--------------------                     age 1    age 2    age 3    age 4
 IBTS Q1                                0.173    0.856    1.371    1.371
 IBTS Q3                                1.350    2.796    2.796
 Acoustic                               0.605    1.642    2.810

sqrt(Survey variance) ~ CV:
---------------------------          age 1    age 2    age 3    age 4
 IBTS Q1                                 0.43     0.43     0.55     0.55
 IBTS Q3                                 0.62     0.62     1.11
 Acoustic                                0.35     0.35     0.49

Average F:
----------
         sp. 1
1991:    0.429
1992:    0.403
1993:    1.038
1994:    0.698
1995:    0.815
1996:    0.605
1997:    0.697
1998:    0.717
1999:    0.384
2000:    0.575
2001:    1.068
2002:    0.996
2003:    0.866
2004:    1.297
2005:    0.625
2006:    0.676
2007:    0.705
2008:    0.697
2009:    0.242
2010:    0.313
2011:    0.490

Recruit-SSB                                  alfa       beta        recruit s2
recruit s
Sprat        Geometric mean:             18.851                0.117
```

Table 8.6.9. Stock summary from explorative assessment model.

Year	Recruits 1000000's	SSB (tonnes)	TSB (tonnes)	Yield (tonnes)	mean-F age 1-2
1991	151453	91254	168501	69715	0.429
1992	1896412	206980	390815	103697	0.403
1993	267510	250960	428417	180103	1.038
1994	148143	255831	454346	323383	0.698
1995	69049	241949	384351	356825	0.815
1996	139436	218827	363599	134021	0.605
1997	131274	265464	492573	100388	0.697
1998	170734	416585	740721	162094	0.717
1999	139286	244187	442606	188142	0.384
2000	111689	229461	371143	195665	0.575
2001	115734	213594	351503	167737	1.068
2002	136069	375037	685150	146101	0.996
2003	118811	196696	358088	176114	0.866
2004	285053	312745	558766	191272	1.297
2005	107603	278911	534198	208118	0.625
2006	151332	274621	448333	113982	0.676
2007	112074	425724	771178	82647	0.705
2008	251702	174428	306180	61097	0.697
2009	194290	550727	1039963	133591	0.242
2010	204313	364336	604907	143346	0.313
2011	228043	403616	697487	145079	0.49

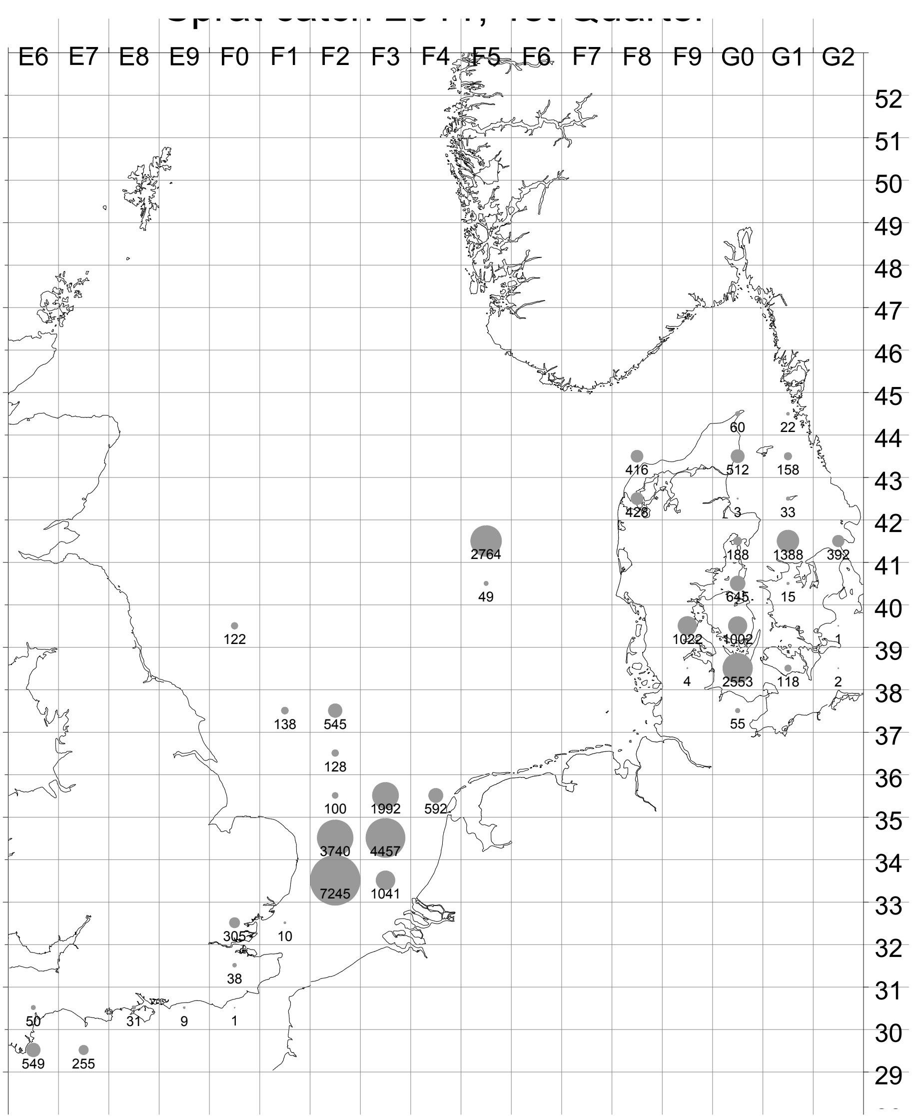


Figure 8.1.1a **North Sea sprat.** **Sprat catches in the North Sea and Div. IIIa (in tonnes) in the first quarter of 2011 by statistical rectangle.**

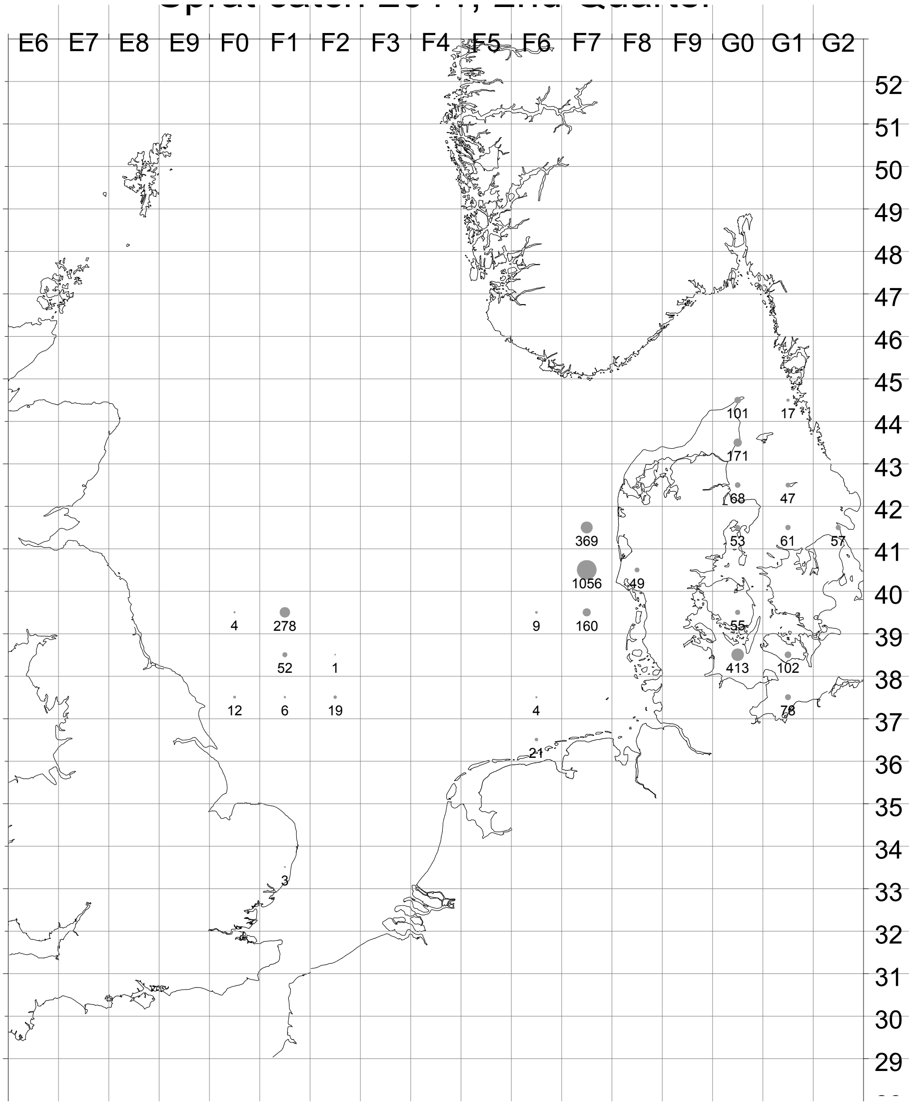


Figure 8.1.1b North Sea sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the second quarter of 2011 by statistical rectangle.

Figure 8.1.1c North Sea sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the third quarter of 2011 by statistical rectangle.

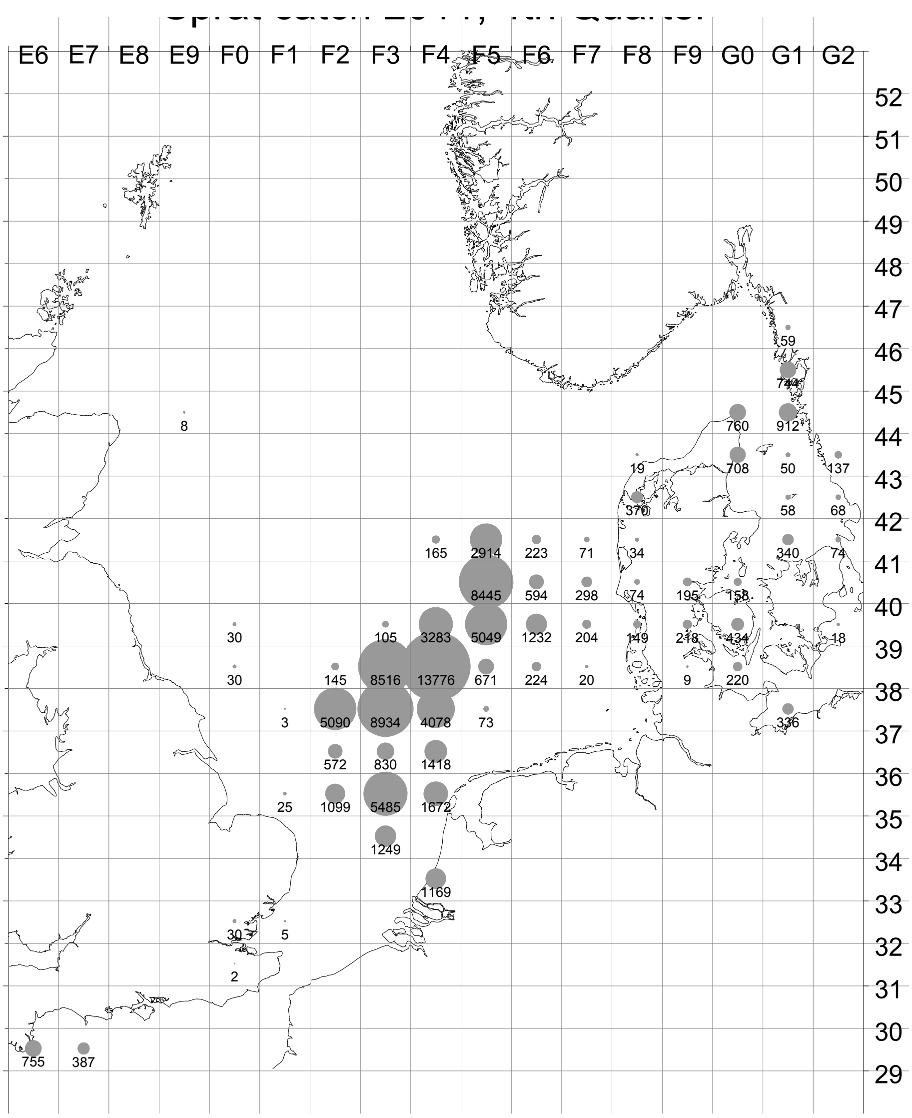


Figure 8.1.1d North Sea sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in the fourth quarter of 2011 by statistical rectangle.

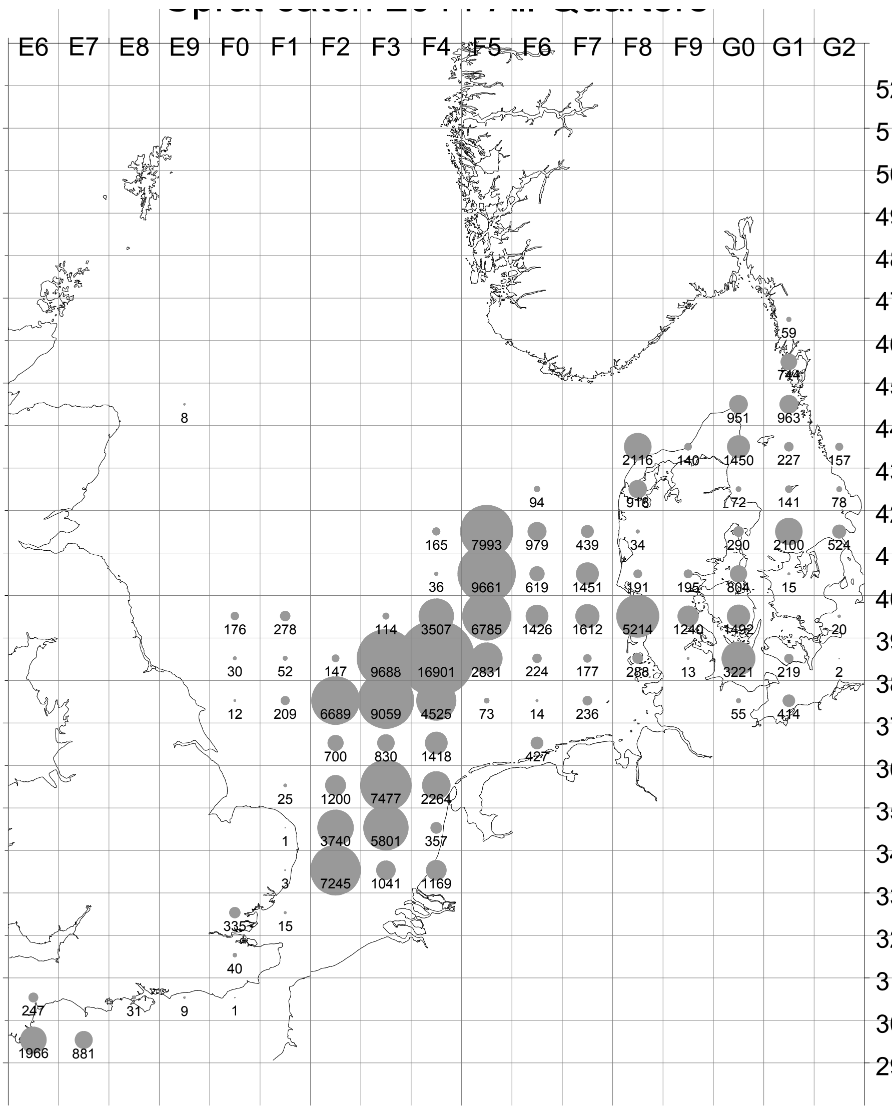


Figure 8.1.2 North Sea sprat. Sprat catches in the North Sea and Div. IIIa (in tonnes) in 2011 by statistical rectangle.

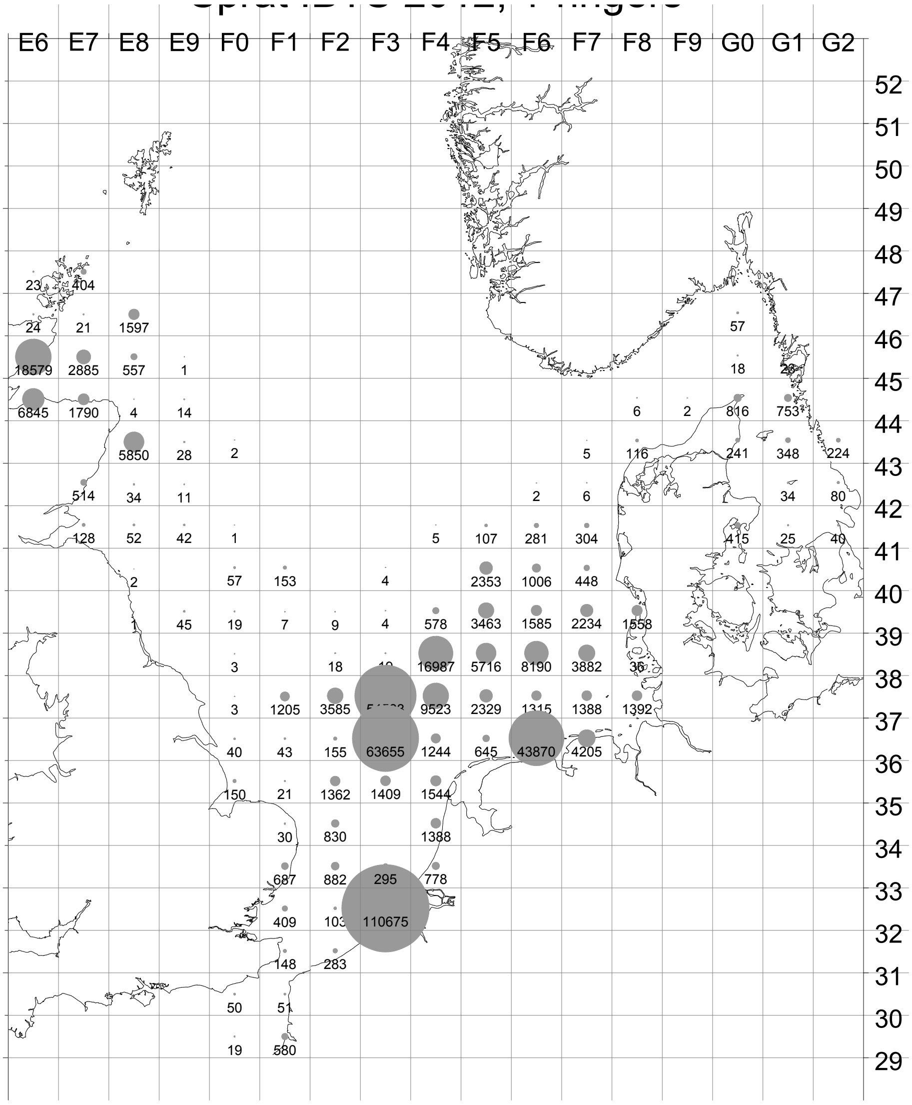


Figure 8.3.1a North Sea sprat. Distribution of 1-ringers in the IBTS (February) 2012 in the North Sea and Di-vision IIIa (Mean number per hour per rectangle).

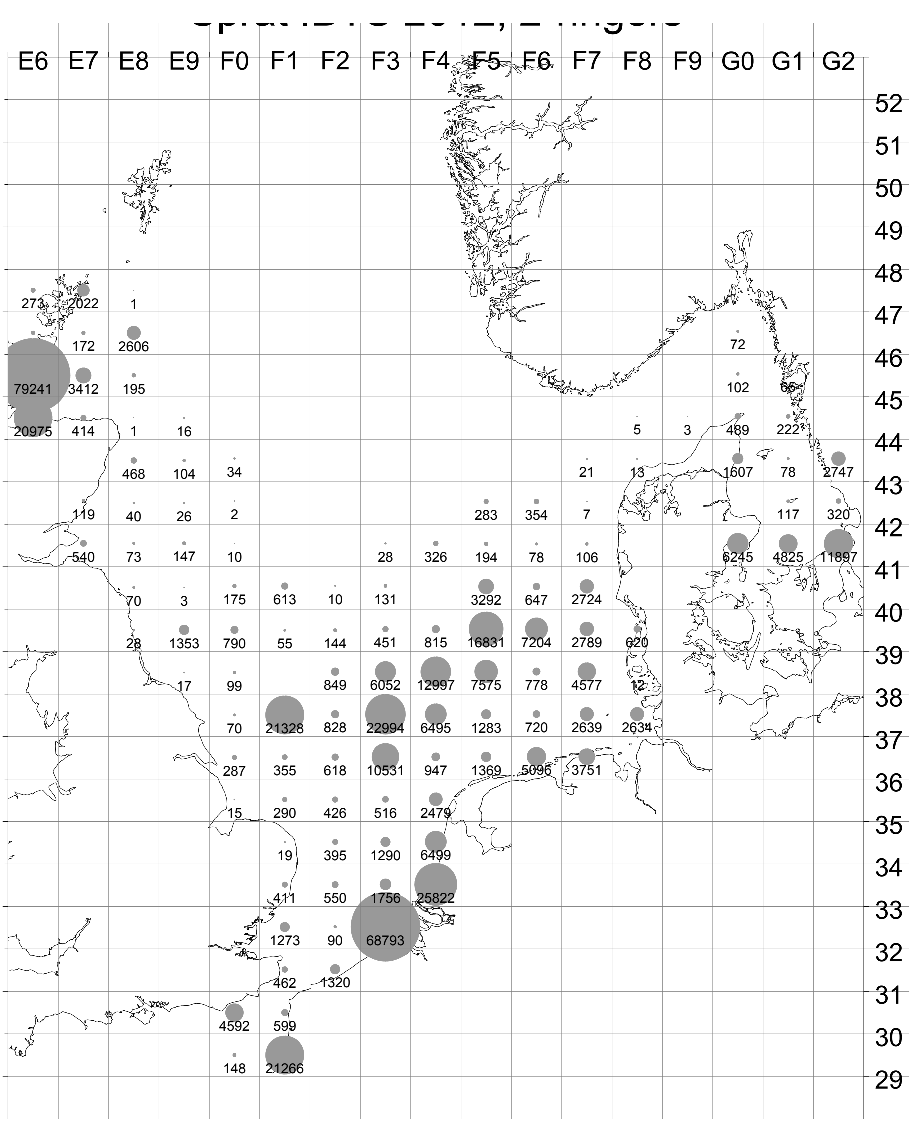


Figure 8.3.1b North Sea sprat. **Distribution of 2-ringers in the IBTS (February) 2012 in the North Sea and Di-vision IIIa (Mean number per hour per rectangle).**

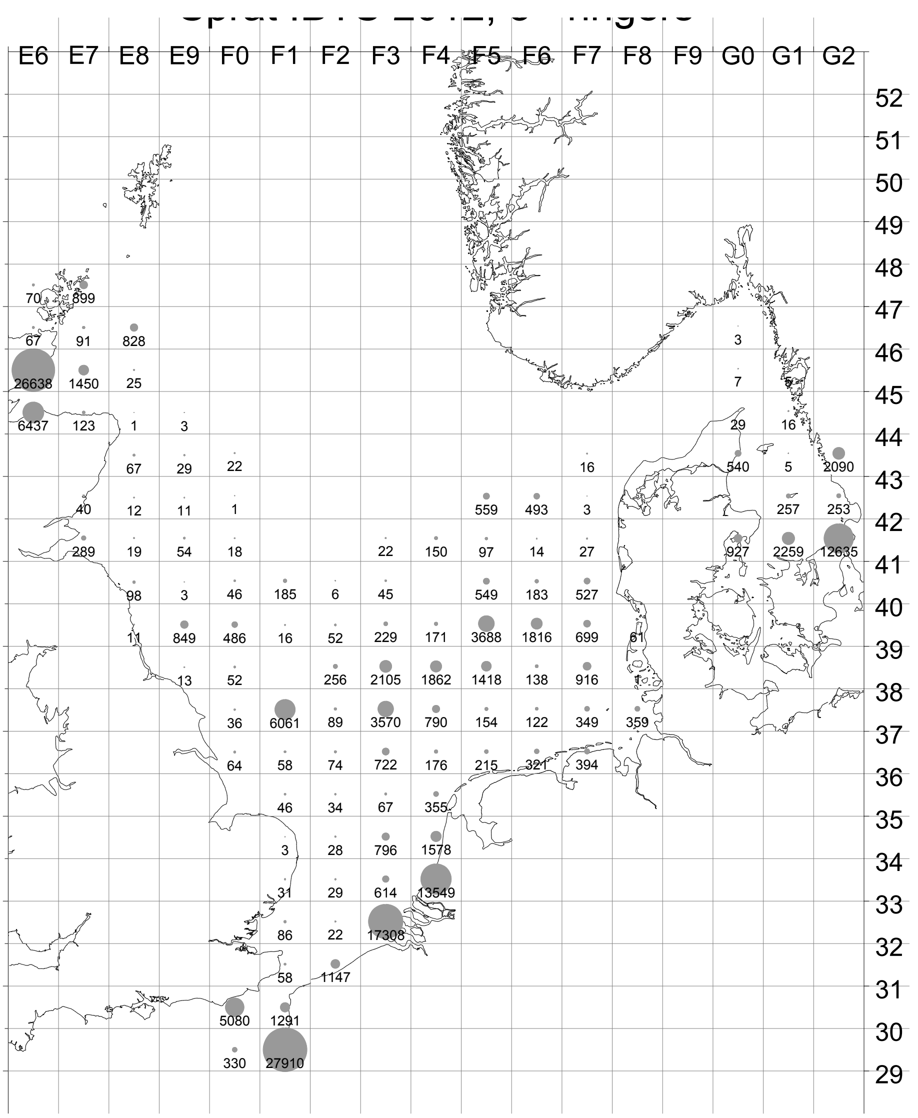


Figure 8.3.1c North Sea sprat. Distribution of 3-ringers in the IBTS (February) 2012 in the North Sea and Di-vision IIIa (Mean number per hour per rectangle).

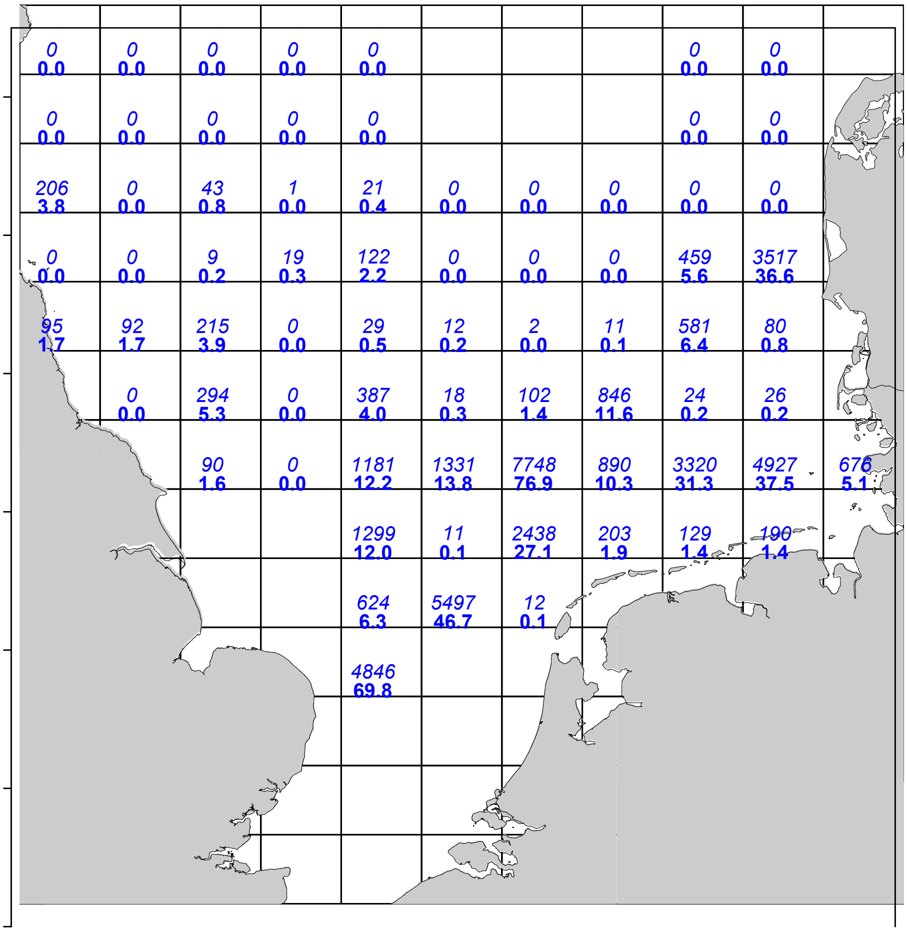


Figure 8.3.2 North Sea Sprat. Abundance (upper figure in each rectangle, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the herring acoustic sur-vey (HERAS) 2011. Blank rectangles were not covered.

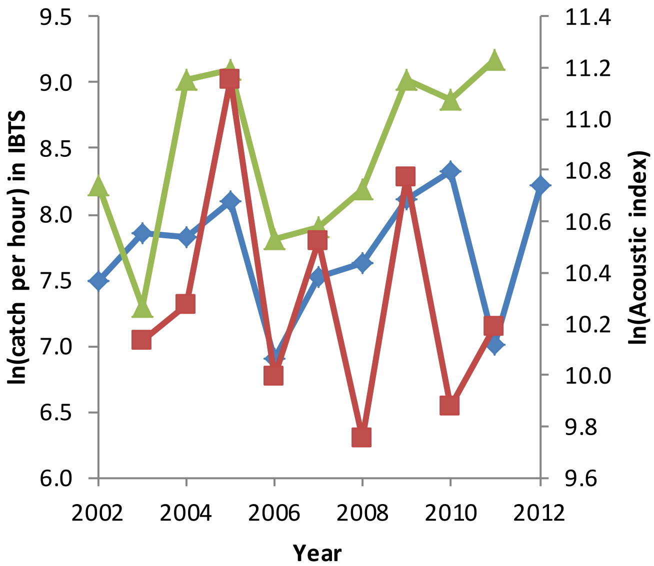


Figure 8.3.4.1. North Sea sprat. Mean catch rate of 1-year olds in quarters 1 (blue diamonds) and 3 (green triangles) and in HERAS (red squares).

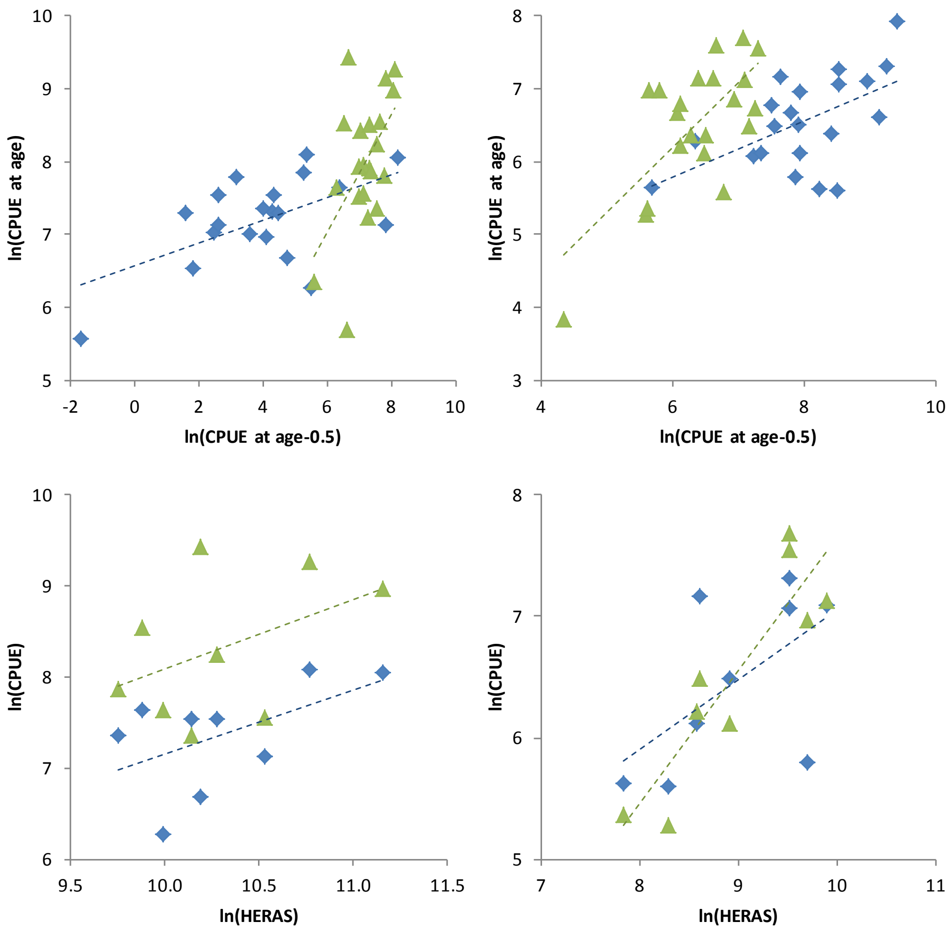


Figure 8.3.4.2. North Sea sprat. Internal (a and b) and external (c and d) consistency of IBTS quarter 1 (blue diamonds) and 3 (green triangles).

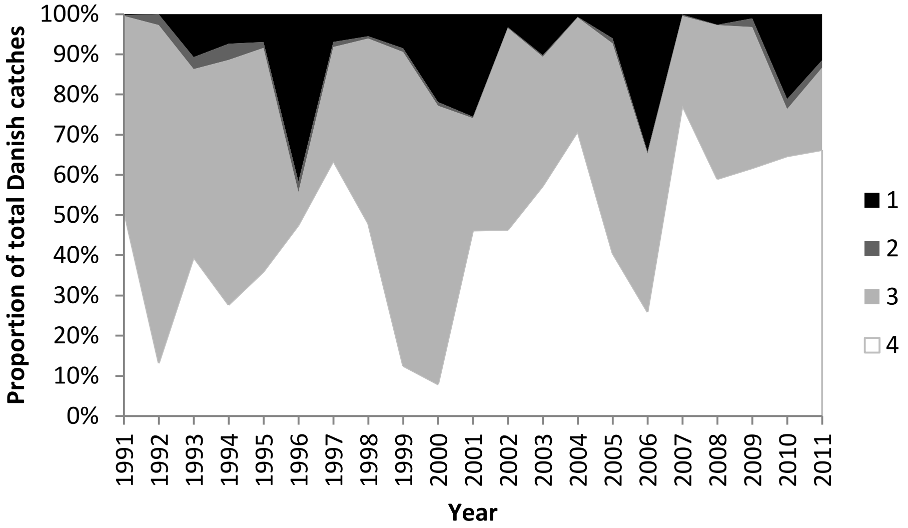


Figure 8.6.1. North Sea sprat. Quarterly distribution of Danish catches. Proportion in quarter 3 ranges from 10% to 85%, proportion in quarter 4 from 10% to 65%.

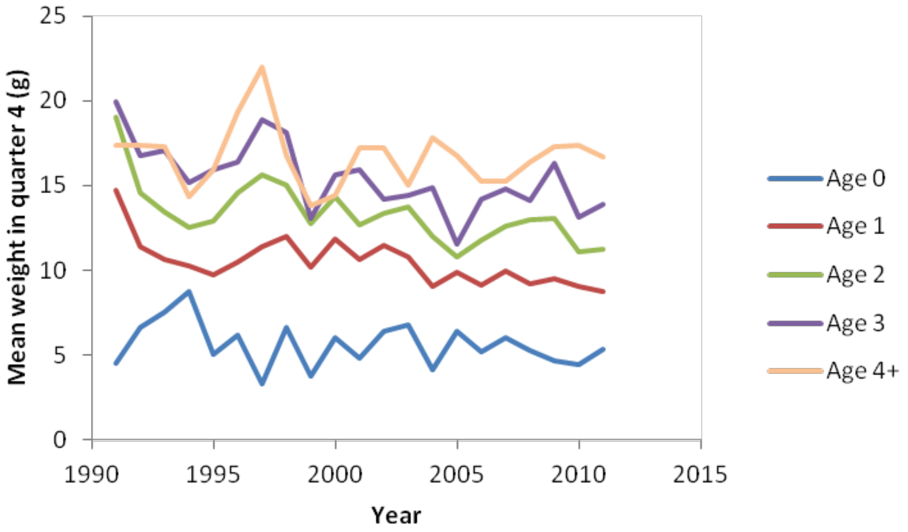


Figure 8.6.2. North Sea sprat. Mean weight at age in quarter 4.

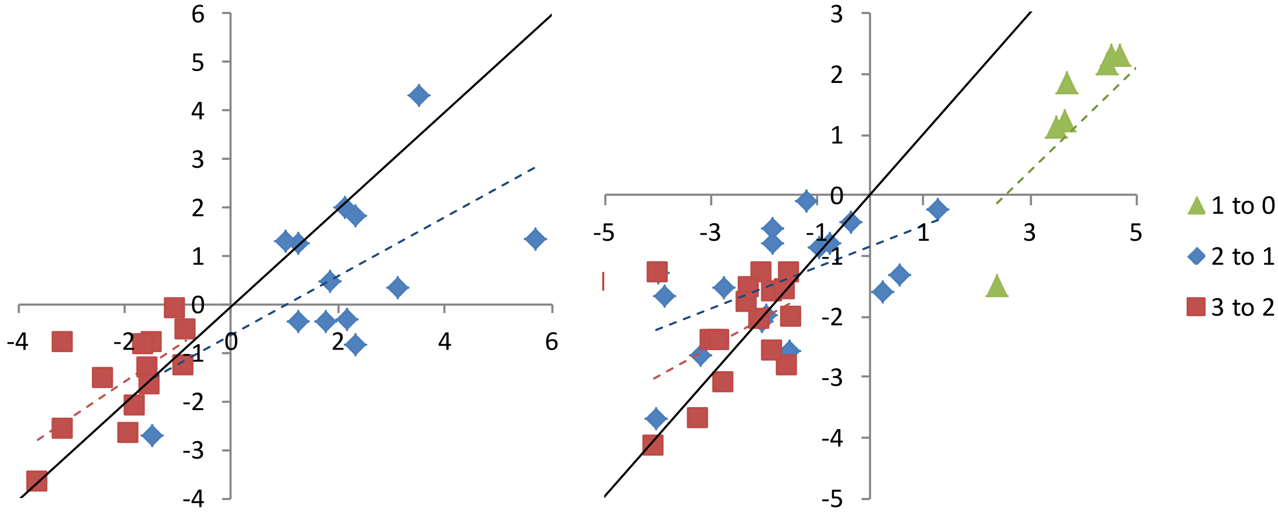


Figure 8.6.3. North Sea sprat. $I_{a+1,a,y,q}$, an index of the ratio of one cohort to that a year younger in quarter 1 (left) and quarter 4 (right) as a function of the ratio in the previous quarter. Only data points based one at least five samples included. Solid line is a 1:1 relationship, hatched lines are regression lines.

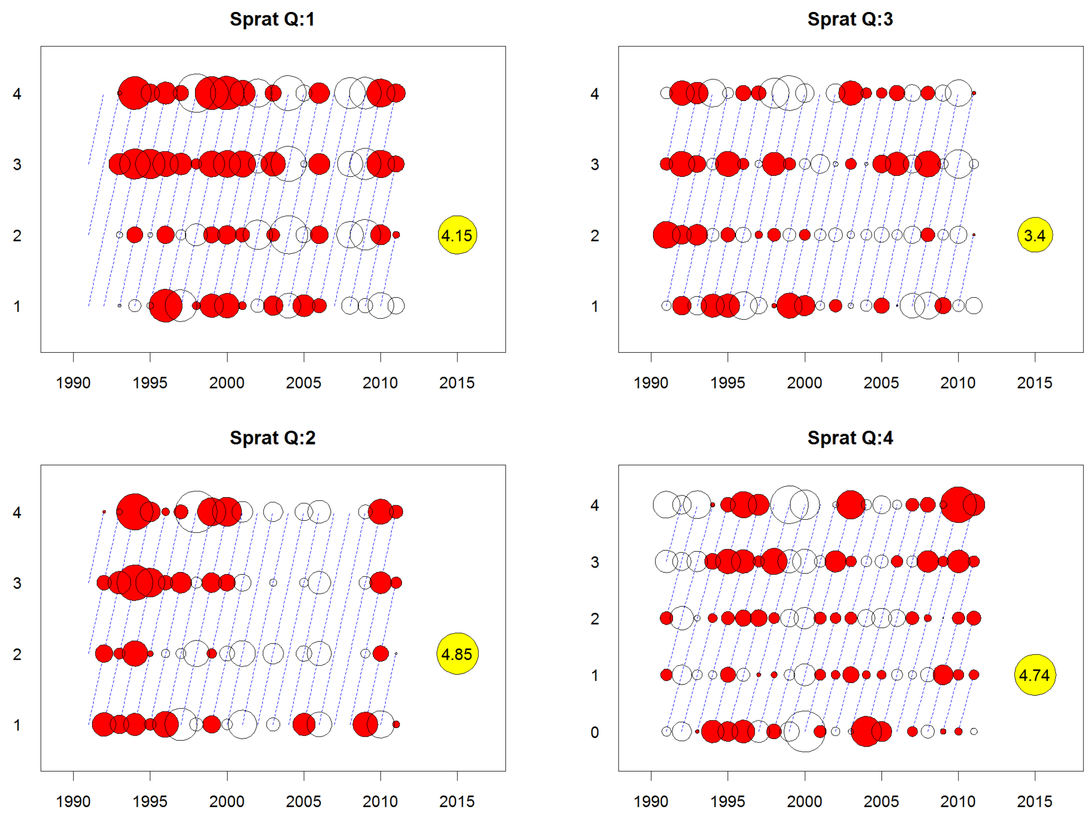


Figure 8.6.4. North Sea sprat. Catch residuals by age.

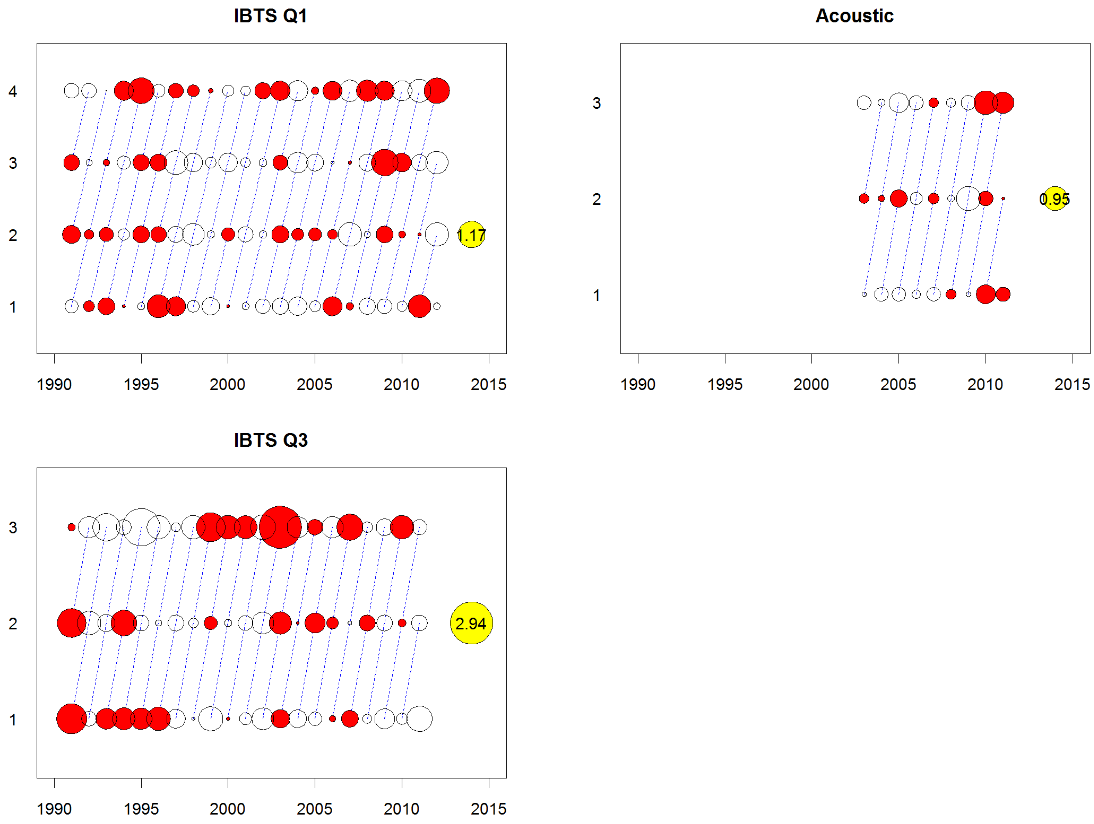


Figure 8.6.5. North Sea sprat. Survey residuals by age.

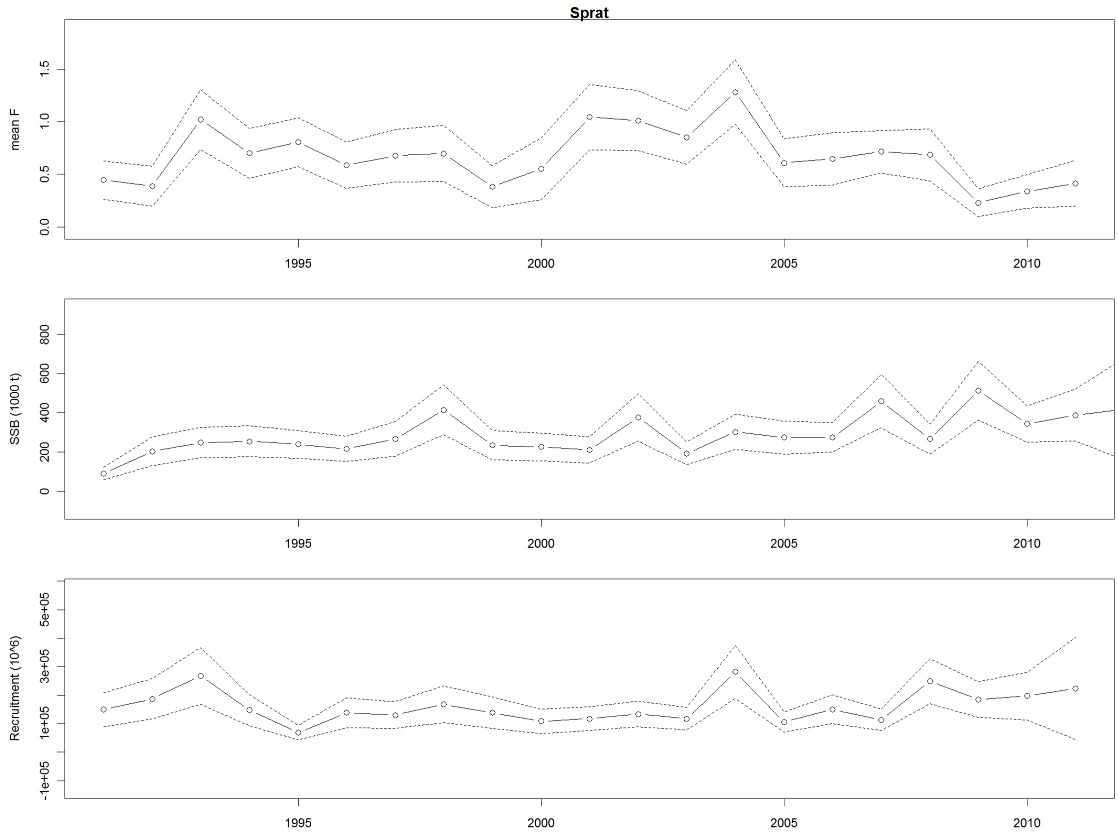


Figure 8.6.6. North Sea sprat. Temporal development in Mean F, SSb and recruitment. Hatched lines are 95% confidence intervals.

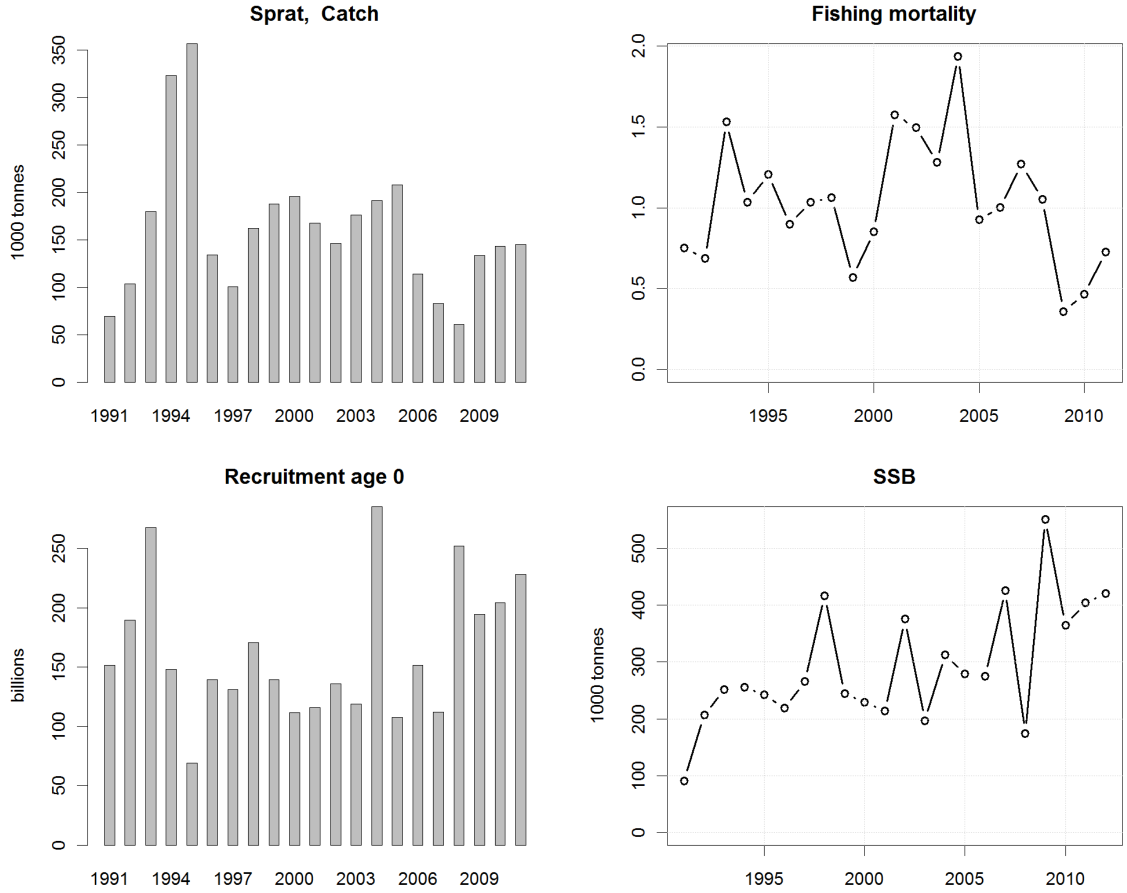


Figure 8.6.7. North Sea sprat. Assessment summary.

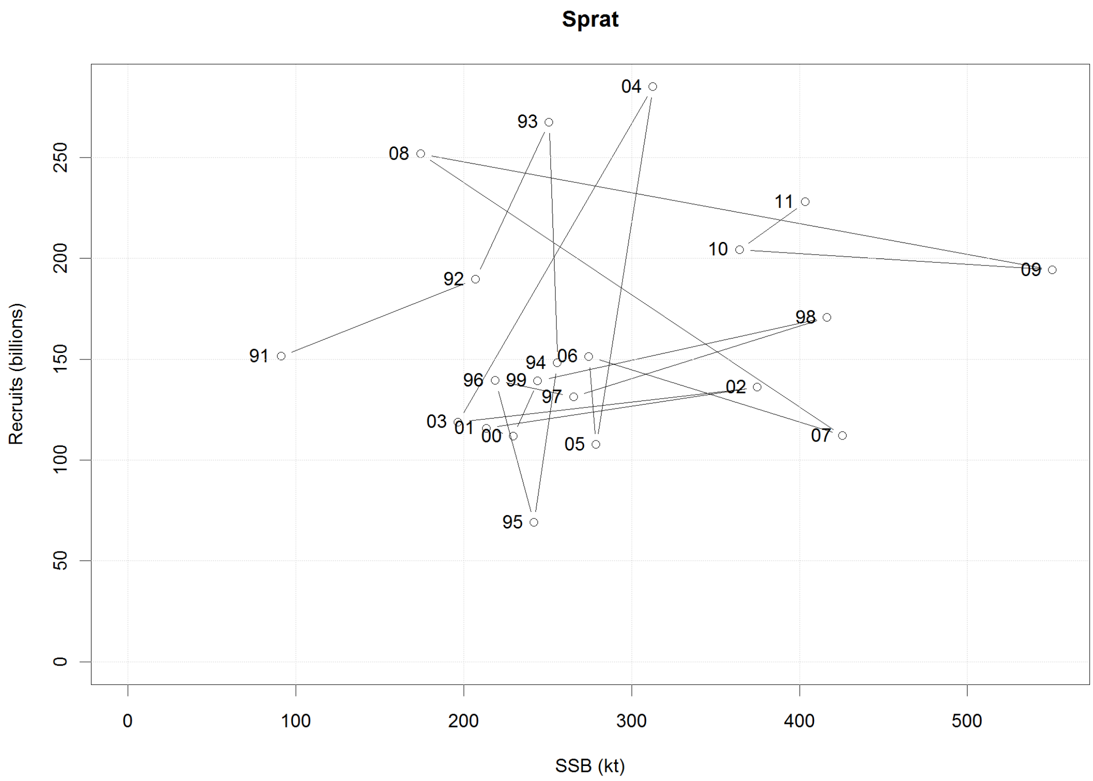


Figure 8.6.8. North Sea sprat. Stock-recruitment relationship.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ICES advice applicable for 2011 and 2012

The ACOM advice on sprat management in IIIa 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 TAC 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 2011, the TAC for sprat was set at 52 000 t and the by-catch TAC for herring for the EU fleet at 6 659 t. For 2012, the TAC for sprat is set at 52 000 t.

9.1.1 Landings

The total landings in 2011 (10 739 t) were similar to the landings 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 2011 the proportion of total landings from the 3rd and 4th quarters (63%) was lower than in 2010 (80%). In the Norwegian fishery sprat were, as before, taken in the 1st and 4th quarter, all as part of the fishery for canning production.

9.1.2 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.

9.1.3 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.

9.1.4 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 2011.

9.2 Biological Composition of the Catch

9.2.1 Catches in number and weight-at-age

In 2010 the majority of landings were spread across a number of age classes: 1-year-olds contributed about 40%, 2-year-olds about 35%, and 3-year-olds about 15%. In 2011 the 1- and 2-year-olds dominated the landings (in numbers) by contributing over 75% of the total landings in numbers.

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. 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 2nd and 4th quarter. Landings in 2011, for which no samples were collected, were raised using a combination of 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 (HERAS) in Division IIIa since 1996. In 2010 sprat were abundant in both the Kattegat and the Skagerrak area. At the time of the surveys in 2011, sprat was only found in Kattegat. The 2011 abundance was estimated to be 1 574 million individuals, a small increase compared to 1 556 million individuals in 2010. The biomass was estimated to be 27 464 tonnes, an increase of about 67%. Most sprat were 3+ group, and 90% of them were mature.

The IBTS (February) sprat indices for 1984-2012 are presented in Table 9.3.1. The preliminary total IBTS index for 2012 decreased by approximately 50% compared to the high 2011 index. The abundance index for the 1-group was low but not exceptionally low with the highest value occurring in the 3-year-olds.

9.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2011 summer acoustic survey are presented in Table 4.2.3 in the WGIPS report (ICES CM 2012/SSGESST:12). 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 2012 at 7% of the total index, as recorded in 2011 (2% of the total index), is in the lowest 25% recorded for the period 1984 to the present. However, In 2009 and 2010 age 1 indices contributed a much higher proportion of the total index (85 and 16% respectively). 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 is mainly fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. In recent years the sprat fisheries have 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 (ICES WGSAM 2011). 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). Overall, many of the plankton feeding fish species such as herring, sand eel and Norway pout have had poor recruitments within the last decade (ICES WGSAM 2011). 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 (Johannesen et al. 2011). In the North Sea a shift in species composition and biomass of zooplankton have been observed (Llope et al. 2012). 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) 1996-2011.
(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
2011	3.5	1.8	0.7	6.0	4.5	0.3	4.8	10.7

* < 50 t

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter by countries, 2000-2011. 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	6.5
	2			1.85	1.9
	3	4.80	0.10		4.9
	4	3.80	0.70	2.26	6.8
	Total	12.70	0.90	6.43	20.0
2001	1	2.53		2.63	5.2
	2	6.55		0.11	6.7
	3	10.16		0.06	10.2
	4	0.90	1.40	4.75	7.1
	Total	20.15	1.40	7.56	29.1
2002	1	3.80		1.42	5.2
	2	2.06		0.37	2.4
	3	5.90		0.07	6.0
	4	1.68		2.41	4.1
	Total	13.45		4.26	17.7
2003	1	3.54	0.10	1.67	5.3
	2	0.59		0.80	1.4
	3	1.00		0.72	1.7
	4	5.04	0.80	2.31	8.1
	Total	10.18	0.80	5.50	16.5
2004	1	3.11		1.35	4.5
	2	0.64		0.87	1.5
	3	3.70		0.44	4.1
	4	6.94	1.10	3.83	11.9
	Total	14.39	1.10	6.49	22.0
2005	1	6.47		1.68	8.1
	2	4.65		0.07	4.7
	3	18.61	0.71	0.81	20.1
	4	2.13		5.17	7.3
	Total	31.9	0.7	7.7	40.3

	Quarter	Denmark	Norway	Sweden	Total
2006	1	5.43	0.17	2.68	8.3
	2	0.17		0.16	0.3
	3	1.34		0.10	1.4
	4	0.88	0.13	1.46	2.5
	Total	7.82	0.30	4.39	12.5
2007	1	2.26	0.45	0.38	3.1
	2	0.70		0.59	1.3
	3	5.15	*	0.21	5.4
	4	1.79	1.16	2.98	5.9
	Total	9.90	1.60	4.16	15.7
2008	1	2.25	0.20	0.64	3.1
	2	0.67		0.35	1.0
	3	0.45		0.19	0.6
	4	2.46	0.70	1.21	4.4
	Total	5.83	0.90	2.39	9.1
2009	1	2.20	0.40	0.40	3.0
	2	0.30			0.3
	3	3.20		0.10	3.3
	4	1.20	0.24	1.20	2.6
	Total	6.90	0.64	1.70	9.2
2010	1	1.45	0.05	0.02	1.5
	2	0.64		0.01	0.6
	3	3.38		0.03	3.4
	4	2.93	0.86	1.35	5.1
	Total	8.39	0.91	1.40	10.7
2011	1	3.20	0.09	0.02	3.3
	2	0.60		0.02	0.6
	3	2.30	*	0.01	2.3
	4	1.90	0.61	1.99	4.5
	Total	8.0	0.7	2.0	10.7

* < 50 t

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 2004-2011 (based on Danish and Norwegian sampling). 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
2011	1	0.0	331.0	47.8	32.6	52.4	48.7	512.5
	2	0.0	58.4	8.2	5.8	9.3	8.7	90.5
	3	207.7	31.7	0.8	0.0	0.0	0.0	240.2
	4	136.5	88.1	50.3	6.1	2.7	0.2	283.9
	Total	344.2	509.3	107.1	44.5	64.4	57.5	1127.1

Table 9.2.2. **Division IIIa sprat.** Quarterly mean weight-at-age (g) in the landings for the years 2004-2011 (from Danish, Swedish, and Norwegian samples). The equivalent data for 1996-2003 can be found in ICES CM 2007 /ACFM: 11.

Year		Age					
	Quarter	0	1	2	3	4	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
2011	1	0.0	3.7	12.7	16.9	16.6	9.3
	2	0.0	2.9	10.1	12.4	13.6	13.5
	3	11.2	8.7	7.6	0.0	0.0	0.0
	4	11.2	15.4	20.2	24.0	23.5	35.5
Weighted mean		11.2	5.9	16.0	17.3	16.5	10.0

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2011.

Country	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged	Samples per 1000 t
Denmark	1	3 162	3	271	100	1
	2	559	1	87	0	2
	3	2 334	5	543	150	2
	4	1 940	5	474	57	3
	Total	7 994	14	1 375	307	2
Norway	1	94	5	196	188	53
	2					
	3					
	4	614	6	276	276	10
	Total	708	11	472	464	16
Sweden	1	16				
	2	17	1	223	223	59
	3	11				
	4	1 987	1	520	520	1
	Total	2 031	2	743	743	1
Denmark		7 994	14	1 375	307	2
Norway		708	11	472	464	16
Sweden		2 031	2	743	743	1
	Total	10 733	27	2 590	1 514	3

Table 9.3.1. **Division IIIa sprat**. IBTS (February) indices of sprat per age group 1984-2012.

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
2012*			209.49	1 555.55	627.29	346.96	128.08	2 867.37

* Preliminary

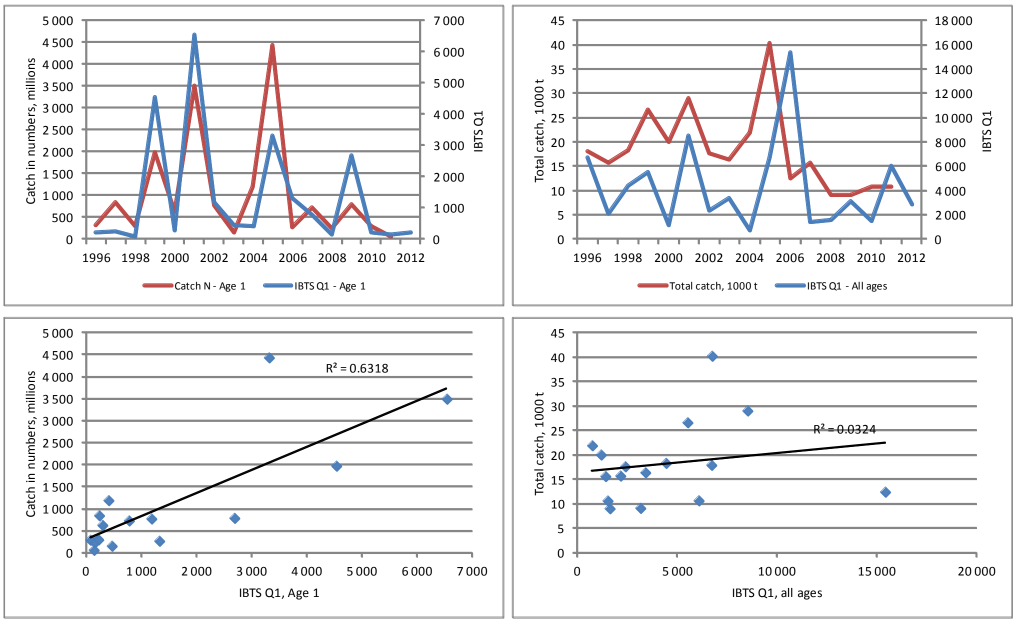


Figure 9.6.1 IIIa sprat. Data exploration of the IBTS and landings time series. Annual landings (in numbers) of 1-year-olds and the IBTS index of one-year-olds in 1st quarter and their regression (R^2 = 0.6318), left side plots. Total annual landings (in 1000 t) and the IBTS index of all age classes in 1st quarter and their regression (R^2 = 0.0324), right side plots.

10 Sprat in the Celtic Seas (Subareas VI and VII)

Most sprat fisheries in the Celtic Seas area are sporadic and occur in different places at different times. Separate fisheries have taken place in the Minch, and the Firth of Clyde (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. This year the ICES WG on New stocks (WGNEW) was asked to give guidance on the stock structure of sprat in the Celtic Seas (Subareas VI and VII) however, this was not carried out. In 2012, 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 and further work is required to solve the problem.

10.1 The Fishery

10.1.1 ICES advice applicable for 2010 and 2011

ICES analysed data for sprat in the Celtic Sea and West of Scotland for the first time in 2011. Currently there is no TAC for sprat in this area, and it is not clear whether there should be one or several management units. ICES stated that there is insufficient information to evaluate the status of sprat in this area. Therefore, based on precautionary consideration, ICES advised that catches should not be allowed to increase in 2012. 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 10.1.7 and in Figures 10.2.1-10.2.10).

Division VIa (West of Scotland and Northwest of Ireland)

Landings have been dominated by UK-Scotland and Ireland (Table 10.1.1). The Scottish fisheries have taken place in both the Minch and in the Firth of Clyde. The Irish fishery has always been in Donegal Bay. Despite the wide separation of these areas, the trends in landings between the two countries are similar, though the UK data have always been higher. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

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 substantially.

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. In the late 1990s and early 2000s , UK vessels landed up to 500 t per year. In recent years a trial fishery for sprat was carried out by the vessels that fish herring in the area. This was carried out to investigate the feasibility of a clean commercially viable sprat fishery. The results of the trials were inconclusive and plans to conduct further experiments are under discussion. Irish Landings from 1950-1994 may be from VIIaN or VIIaS. Recent Irish landings are mainly from VIIaS, mainly Waterford Harbour (Table 10.1.2b).

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. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

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). Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

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 VIIe, 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, English and Scottish vessels. In Ireland, many polyvalent vessels target sprat on an opportunistic basis. At other times these boats target demersals and tuna, as well as pelagics. Targeted fishing takes place when there are known sprat abundances. However the availability of herring quota is a confounding factor in the timing of a sprat-targeted fishery around Ireland.

Sprat may also be caught in mixed shoals with herring. The level of discarding is unknown.

In the English Channel the primary gear used for sprat is midwater trawl. Within that gear type three vessels under 15m 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 small-mesh fisheries for either human consumption or reduction to fish meal and oil. It is not clear whether by-catches of herring in sprat fisheries in Irish and Stottish waters are subtracted from quota.

10.1.5 Changes in fishing technology and fishing patterns

There is insufficient information available.

10.2 Biological Composition of the Catch

10.2.1 Catches in number and weight-at-age

There is no information on catches in number or weight in the catch for sprat in this ecoregion.

10.3 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.

Since 2004 the survey has taken place each October in the Celtic Sea. Due to the lack of reliable 36 kHz data in 2010, no sprat abundance is available for this year.

It can be seen that there are large inter-annual variations in sprat abundance. Large sprat schools were notably missing in 2006, and so no biomass could be calculated. The utility of this survey as an index of sprat abundance should be considered carefully (Fallon *et al*. 2012). Sprat is the second most abundant species observed from survey data. Sprat biomass over the time series (2004-2011) is highly variable, more so than could be accounted for by 'normal' inter survey variability (Table 2- Acoustic Time series**)**. This is in part due to the behaviour of sprats in the Celtic Sea which are often seen in the highest numbers after the survey has ended in November/December and again in spring during spawning. The survey is placed to coincide with peak herring abundance and is temporally mismatched with what would be considered sprat peak abundance.

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 in 2010. Estimates in 2011of 238 000 t suggest a substantial increase. Further work is required to investigate the utility of this survey for measuring sprat biomass in this area.

FSP Acoustic Survey off the western English Channel

An acoustic survey was carried out in October 2011 covering the Lyme bay area where the main sprat population was thought to be concentrated during the onset of the fishing season (September-October). A local sprat fishing vessel was chartered for the survey (the 11.98 m *FV Mary Anne*). Scientific quality acoustic data were collected using a calibrated portable EK60 Simrad echosounder operating at 120 kHz, attached to an over-the-side mount. Sprat schools were identified in the acoustic data based on a combination of expert knowledge and trawl catches. Trawling was conducted using the vessel's standard commercial mid-water sprat trawl and provided information on the species composition as well as biological material. The acoustic density attributed to sprat was converted into numbers of sprat according to standard Target Strength equations (Simmonds and MacLennan, 2005), using a b20 value of–76 dB at 120 kHz (Edwards et al., 1984) and a mean sprat length of 12.41 cm as derived from the trawls.

The total biomass of sprat in the four ICES rectangles surveyed was estimated to be 50 226 t (3.70×10^9 fish). The acoustic density distribution suggested that the survey covered a large part of the Western Channel sprat population, because densities decreased to very low values at the southern and eastern boundaries (Fig. 3). It was likely, however, that the population extended southwest beyond the westernmost transect, but there was insufficient time to extend the coverage to those areas. Given the effect of the TS value on the biomass estimate, we also calculated the biomass using a very conservative TS value of –71.2 dB (M. Doray, pers. comm. *sensu* Foote, 1987). The biomass estimate for the same surveyed areas was 16 631 t. Results from an acoustic survey conducted in the area during the preceding summer (PELTIC 2011), suggested however that the sprat biomass was more likely to be closer to the higher estimate .

Trawl catches suggested that most (73.1% by number) of the sprat were mature (spent), with 26.9% immature, and that the sex ratio slightly favoured females (59: 41). Four age classes were identified: 0, 1, 2 and 3, contributing 1.5%, 8.9%, 70.1% and 19.4 % to the population by number, respectively. Low numbers of the 0 and 1 age groups may be the result of gear selectivity. The observed low numbers of sprat age 4 and older could be the result of exploitation as the fishery targets the larger fish for human consumption. However, just three of the trawl hauls contained good samples of sprat, so it is equally possible that the age 4+ sprat were undersampled because of their different geographic distribution or behaviour.

IBTS Q1 in the Eastern English Channel

Starting in 2006, the French in quarter 1 started to carry out additional tows in the Eastern English Channel as part of the standard IBTS survey. This proved successful and starting in 2007 the RV 'Thalassa' carried out 8 GOV trawls and 20 MIK stations.

During the IBTSWG in 2009, Roundfish Area 10 (Fig. 10.6) was created to cover these new stations fished by France and the Netherlands.

Data are stored in DATRAS database and available for the period 2007 to 2012.

10.4 Mean weight-at-age and 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

A data exploration of sprat from English Channel sprat was carried out in 2012 (Roel & van der Kooij 2012). An LPUE time-series for English Channel sprat based on mid-water trawlers data was constructed (Figure 10.7). 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 because of sprat shoaling behaviour. Increase in fishing technology over time should also be factored out although LPUE was based on landings from small vessels that have been making use of standard sonar technology to locate the fish.

The LPUE time-series corresponding to the three vessels that target sprat in the Channel were fitted by means of a surplus production dynamic model of the Schaefer form. Observation error was assumed to be predominant, i.e. the error occurs in the relationship between the biomass and the index of abundance. For this form of estimator, the quantity minimized to estimate values for the parameters r, K and initial biomass (B_{1988}) is:

$$SS = \sum_{y=1}^{n} \left[lnI_y - ln(\hat{q}.\hat{B}_y) \right]^2$$

Where I_y corresponds to the LPUE index for year y and B_y is the stock biomass in year y. The catchability q was estimated analytically. The survey biomass estimate was incorporated into the sum of squares by adding a second term with weight = 1. The model was run on two modeling environments: Excel and AD Model Builder for verification.

The biomass dynamics was modelled as:

$$B_{y+1} = B_y + rB_y \left(1 - {B_y}/{K}\right) - C_y$$

Where *r* is the intrinsic growth rate, *K* is the average unexploited equilibrium biomass (carrying capacity) and C_y is the catch in year *y*.

Model fit to the LPUE data

The model was fitted to the LPUE data and to the 2011 survey estimate. The model fit to the three vessels LPUE data and to the lowest survey estimate (16600 t) is shown in Figure 10.6. This reveals a noisy series and a model fit suggesting an increasing trend in LPUE. The estimated biomass trend and the survey estimate are also shown in Figure 10.8.

Estimates of the parameters and the corresponding CVs are shown below for the two fits attempted: survey estimate 50 000 t and 16 600t.

Model Paramet	Survey=16600		Survey=50000	
	Estimate	CV	Estimate	CV
r	0.66312	0.71	0.35697	0.88
K	25540	0.56	62504.9	0.63
Initial B	7043.78	0.91	16100.4	0.97
q	0.044		0.01818	
MSY	4234.01		5578.11	

A lower sum of squares and more precise parameter estimates are obtained for the survey lower estimate = 16600.

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).

MSY estimates were computed for VIIde western English Channel sprat based on parameters *K* and *r* (Table, 10.6.1 above). Preliminary stimates of MSY were 4210 and 5625 tonnes for the 2011 survey estimates of 16600 and 50000 tonnes respectively.

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.

Sprat in VIIde

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.

Sprat annual landings from VIId-e over the past 20 years have been 2243 tonnes on average, with a maximum of just 4400 tonnes (in 2010). The 2010 landings of 4400 t constitute only 8.7% of the acoustic estimate of sprat biomass for the survey area, and 26% of the highly conservative estimation of 16 631 t. The model estimated biomass when the survey fitted values is 16600 tonnes results in an explotation fraction of 23%. This level of exploitation may be in line with similar low-trophic species such as sardine in ICES areas VIII and IX that support a catch of ~30% of spawning-stock biomass (ICES WGANSA 2011) and the Bay of Biscay anchovy for which a 30% constant proportion management strategy was tested by simulation (ICES WGANSA 2011).

The stable or increasing trend in commercial LPUE suggests that the fishery is not having a detrimental impact on the stock. However, this should be interpreted with caution because LPUE may not be a reliable indicator of abundance for a shoaling fish. The time series comprising the three vessels that target sprat, which includes searching time even in cases when no sprat was caught is probably the closest we could get at present to an index of abundance. Validation of the trend by a survey index would be useful so this year a second sprat acoustic survey will be carried out in the area.

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, 1985-2011 VIa. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	eroe Islands	Ireland	Norway	Wales+N.Irl.	K - Scotland	Total
1985	0	0	51	557	0	2946	3554
1986	0	0	348	0	2	520	870
1987	269	0	0	0	0	582	851
1988	364	0	150	0	0	3864	4378
1989	0	0	147	0	0	1146	1293
1990	0	0	800	0	0	813	1613
1991	0	0	151	0	0	1526	1677
1992	28	0	360	0	0	1555	1943
1993	22	0	2350	0	0	2230	4602
1994	0	0	39	0	0	1491	1530
1995	241	0	0	0	0	4124	4365
1996	0	0	269	0	0	2350	2619
1997	0	0	1596	0	0	5313	6909
1998	40	0	94	0	0	3467	3601
1999	0	0	2533	0	310	8161	11004
2000	0	0	3447	0	0	4238	7685
2001	0	0	4	0	98	1294	1396
2002	0	0	1333	0	0	2657	3990
2003	887	0	1060	0	0	2593	4540
2004	0	0	97	0	0	1416	1513
2005	0	252	1134	0	13	0	1399
2006	0	0	601	0	0	0	601
2007	0	0	333	0	0	14	347
2008	0	0	892	0	0	0	892
2009	0	0	104	0	0	70	174
2010	0	0	332	0	0	537	869
2011	0	0	464	0	248	507	1219

Table 10.1.2a Sprat in the Celtic Seas. Landings of sprat, 1985-2011 VIIa (not specified).

Country	Ireland	Isle of Man	UK - Eng+W	UK - Scotlar	Total
1985	668	0	20	0	688
1986	1152	1	6	0	1159
1987	41	0	0	0	41
1988	0	0	4	6	10
1989	0	0	1	0	1
1990	0	0	0	0	0
1991	0	0	3	0	3
1992	0	0	0	0	0
1993	0	0	0	0	0
1994	0	0	0	0	0
1995	0	0	30	0	30
1996	0	0	0	0	0
1997	0	0	2	0	2
1998	0	0	3	0	3
1999	0	0	146	0	146
2000	0	0	371	0	371
2001	0	0	269	3	272
2002	0	0	306	0	306
2003	0	0	592	0	592
2004	0	0	134	0	134
2005	0	0	591	0	591
2006	0	0	563	0	563
2007	0	0	0	0	0
2008	0	0	2	0	2
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	0	0	0	0	0

Table 10.1.2b Sprat in the Celtic Seas. Irish Landings of sprat, 1995-2011 from VIIaS . Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Ireland
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	7
1999	25
2000	123
2001	7
2002	0
2003	3103
2004	408
2005	361
2006	114
2007	0
2008	102
2009	0
2010	422
2011	1518
Total	6190

Table 10.1.3. Sprat in the Celtic Seas. Landings of sprat, 1985-2011 VIIbc. Irish data may be under-estimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Ireland	Total
1985	0	0
1986	0	0
1987	100	100
1988	0	0
1989	0	0
1990	400	400
1991	40	40
1992	50	50
1993	3	3
1994	145	145
1995	150	150
1996	21	21
1997	28	28
1998	331	331
1999	5	5
2000	698	698
2001	138	138
2002	11	11
2003	38	38
2004	68	68
2005	260	260
2006	40	40
2007	32	32
2008	1	1
2009	238	238
2010	0	0
2011	3.95	4

Table 10.1.4 Sprat in the Celtic Seas. Landings of sprat, 1995-2011 VIIde.

Country	Denmark	France	Netherlands	Wales+N.Irl.	K - Scotland	Total
1985	0	14	0	3771	0	3785
1986	15	0	0	1163	0	1178
1987	250	23	0	2441	0	2714
1988	2529	2	1	2944	0	5476
1989	2092	10	0	1520	0	3622
1990	608	79	0	1562	0	2249
1991	0	0	0	2567	0	2567
1992	5389	35	0	1791	0	7215
1993	0	3	0	1798	0	1801
1994	3572	1	0	3176	40	6789
1995	2084	0	0	1516	0	3600
1996	0	2	0	1789	0	1791
1997	1245	1	0	1621	0	2867
1998	3741	0	0	1973	0	5714
1999	3064	0	1	3558	0	6623
2000	0	1	1	1693	0	1695
2001	0	0	0	1349	0	1349
2002	0	0	0	1196	0	1196
2003	0	2	72	1368	0	1442
2004	0	6	0	836	0	842
2005	0	0	0	1635	0	1635
2006	0	7	0	1969	0	1976
2007	0	0	0	2706	0	2706
2008	0	0	0	3367	0	3367
2009	0	2	0	2773	0	2775
2010	0	0	0	4404	0	4404
2011	0	0	0	3136	0	3136

Table 10.1.5 Sprat in the Celtic Seas. Landings of sprat, 1985-2011 VIIf.

Country	Netherlands	UK - Eng+W	Total
1985	273	0	273
1986	0	0	0
1987	0	0	0
1988	0	0	0
1989	0	0	0
1990	0	0	0
1991	0	1	1
1992	0	0	0
1993	0	0	0
1994	0	2	2
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	51	51
1999	0	0	0
2000	0	0	0
2001	0	0	0
2002	0	0	0
2003	0	0	0
2004	0	0	0
2005	0	0	0
2006	0	0	0
2007	0	2	2
2008	0	0	0
2009	0	1	1
2010	0	7	7
2011	**0**	**0**	0

Table 10.1.6 Sprat in the Celtic Seas. Landings of sprat, 1985-2011 VIIg-k. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	France	Ireland	Netherlands	Spain	Wales+N.Irl.	Total
1985	0	0	3245	0	0	0	3245
1986	538	0	3032	0	0	2	3572
1987	0	1	2089	0	0	0	2090
1988	0	0	703	1	0	0	704
1989	0	0	1016	0	0	0	1016
1990	0	0	125	0	0	0	125
1991	0	0	14	0	0	0	14
1992	0	0	98	0	0	0	98
1993	0	0	0	0	0	0	0
1994	0	0	48	0	0	0	48
1995	250	0	649	0	0	0	899
1996	0	0	3924	0	0	0	3924
1997	0	0	461	0	0	6	467
1998	0	0	1146	0	0	0	1146
1999	0	0	3263	0	0	0	3263
2000	0	0	1764	0	0	0	1764
2001	0	0	306	0	0	0	306
2002	0	0	385	0	0	0	385
2003	0	0	747	0	0	0	747
2004	0	0	3523	0	0	0	3523
2005	0	0	4173	0	0	0	4173
2006	0	0	768	0	0	0	768
2007	0	0	3380	0	1	0	3381
2008	0	0	1358	0	0	0	1358
2009	0	0	3431	0	0	0	3431
2010	0	0	2435.532	0	0	0	2436
2011	0	0	1767.475	0	0	12	1779

Table 10.1.7 Sprat in the Celtic Seas. Landings of sprat, 1985-2011 Total Landings, Division VI, VII. Irish data may be underestimated, due to difficulties in quantifying the landings from vessels of less than 10 m length.

Country	Denmark	Faeroe Isla	France	Ireland	Isle of Man	Netherland	Norway	Spain	UK - Engla	UK - Scotla	Un.Sov.Soc.	Total
1985	0	0	14	3964	0	273	557	0	3791	2946	0	11545
1986	553	0	0	4532	1	0	0	0	1173	520	0	6779
1987	519	0	24	2230	0	0	0	0	2441	582	0	5796
1988	2893	0	2	853	0	2	0	0	2948	3870	0	10568
1989	2092	0	10	1163	0	0	0	0	1521	1146	0	5932
1990	608	0	79	1325	0	0	0	0	1562	813	0	4387
1991	0	0	0	205	0	0	0	0	2571	1526	0	4302
1992	5417	0	35	508	0	0	0	0	1791	1555	0	9306
1993	22	0	3	2353	0	0	0	0	1798	2230	0	6406
1994	3572	0	1	232	0	0	0	0	3178	1531	0	8514
1995	2575	0	0	799	0	0	0	0	1546	4124	0	9044
1996	0	0	2	4214	0	0	0	0	1789	2350	0	8355
1997	1245	0	1	2085	0	0	0	0	1629	5313	0	10273
1998	3781	0	0	1578	0	0	0	0	2027	3467	0	10853
1999	3064	0	0	5826	0	1	0	0	4014	8161	0	21066
2000	0	0	1	6032	0	1	0	0	2064	4238	0	12336
2001	0	0	0	455	0	0	0	0	1716	1297	0	3468
2002	0	0	0	1729	0	0	0	0	1502	2657	0	5888
2003	887	0	2	4948	0	72	0	0	1960	2593	0	10462
2004	0	0	6	4096	0	0	0	0	970	1416	0	6488
2005	0	252	0	5928	0	0	0	0	2239	0	0	8419
2006	0	0	7	1523	0	0	0	0	2532	0	0	4062
2007	0	0	0	3745	0	0	0	1	2708	14	0	6468
2008	0	0	0	2353	0	0	0	0	3369	0	0	5722
2009	0	0	2	3773	0	0	0	0	2774	70	0	6619
2010	0	0	0	3189	0	0	0	0	4411	537	0	8138
2011	0	0	0	3753	0	0	0	0	3396	507	0	7656

Table 10.3.1. Sprat in the Celtic Seas. Biomass estimates for Celtic Sea Sprat for the period November 1991 to October 2011, from Irish Celtic Sea Herring Acoustic Survey.

Date	Area	Biomass (t)	Method	Notes	Reference
1977	Irish Sea	22 653	$C_x = Z / F(1-e^{-Z})$	1-4 w. rings	Molloy *et al.* 1977
1977	Celtic Sea	24 041	$C_x = Z / F(1-e^{-Z})$	2-7 w. rings	Molloy *et al.* 1977
1978	Celtic Sea	14 720	DEPM	Minimum	Grainger 1978
1979	Celtic Sea	15 147	DEPM	Minimum	Grainger 1979
1980	Celtic Sea	22 326	DEPM		Grainger *et al.* 1981
Nov/Dec					
'91	VIIaS, b, g, j	36 880	Acoustic Survey		MI Unpublished data
Jan '92	VIIaS, g, j	15 420	Acoustic Survey		MI Unpublished data
Jan '92	VIIaS, g	5 150	Acoustic Survey		MI Unpublished data
Nov '92	VIIaS, b, g, j	27 320	Acoustic Survey		MI Unpublished data
Jan '93	VIIaS, g, j	18 420	Acoustic Survey		MI Unpublished data
Nov '93	VIIaS, b, g, j	95 870	Acoustic Survey		MI Unpublished data
Jan '94	VIIaS, g	8 035	Acoustic Survey		MI Unpublished data
Nov '95	Celtic Sea	75 440	Acoustic Survey		MI Unpublished data
2002	Celtic Sea	20 600	Acoustic Survey		MI Unpublished data
2003	Celtic Sea	1 395	Acoustic Survey		MI Unpublished data
2004	Celtic Sea	14 675	Acoustic Survey		O'Donnell *et al.* 2004
2005	Celtic Sea	29 019	Acoustic Survey		O'Donnell *et al.* 2005
2008	Celtic Sea	5 493	Acoustic Survey		O'Donnell *et al.* 2008
2009	Celtic Sea	16 229	Acoustic Survey		Saunders *et al.* 2009
2011	Celtic Sea	31 593	Acoustic Survey		O'Donnell *et al.* 2011

Table 10.3.2. Sprat in the Celtic Seas. Annual sprat biomass in ICES sub-division VIIa (Source: AFBINI annual herring acoustic survey).

	Sprat & 0-gp herring				Sprat
Year	Biomass (t)	CV	% sprat	% sprat	Biomass (t)
1994	68,600	0.1	95	95	65,200
1995	348,600	0.13	n/a	n/a	n/a
1996	n/a	n/a	n/a	n/a	n/a
1997	45,600	0.2	n/a	n/a	n/a
1998	228,000	0.11	97	97	221,300
1999	272,200	0.1	98	98	265,400
2000	234,700	0.11	94	94	221,400
2001	299,700	0.08	99	99	295,100
2002	413,900	0.09	98	98	405,100
2003	265,900	0.1	95	95	253,800
2004	281,000	0.07	96	96	270,200
2005	141,900	0.1	96	96	136,100
2006	143,200	0.09	87	87	125,000
2007	204,700	0.09	91	91	187,200
2008	252,300	0.12	83	83	209,800
2009	175,200	0.08	78	78	136,200
2010	107,400	0.1	87	87	93,700
2011	280,000	0.11	85	85	238,400

Note. 1997 Survey: North Channel not fully surveyed; IOM west and ea

n/s = not surveyed

1996 survey: faulty transducer in strata b, f and g

Figure 10.1. Sprat in the Celtic Seas. Map showing areas mentioned in the text.

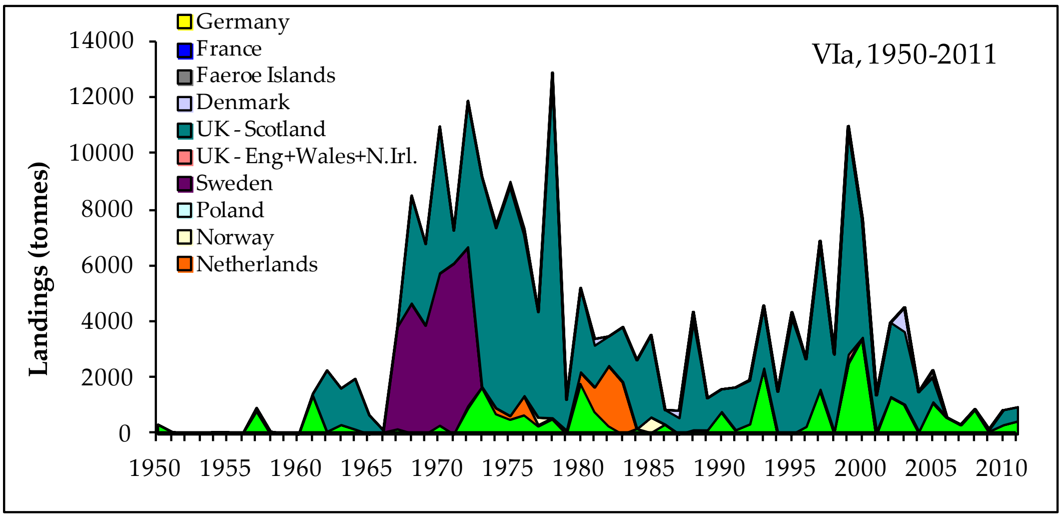


Figure 10.2.1. Sprat in the Celtic Seas. Landings of sprat 1950-2011 ICES Sub-division VIa.

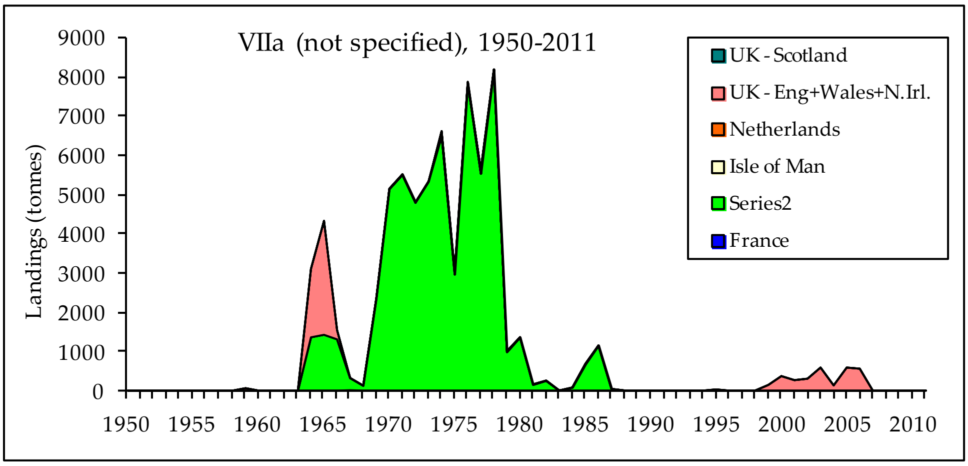


Figure 10.2.2. Sprat in the Celtic Seas. Landings of sprat 1950-2011 ICES Sub-division VIIaN. Note: Southern Irish landings from 1973-1995 may be from VIIaN or VIIaS.

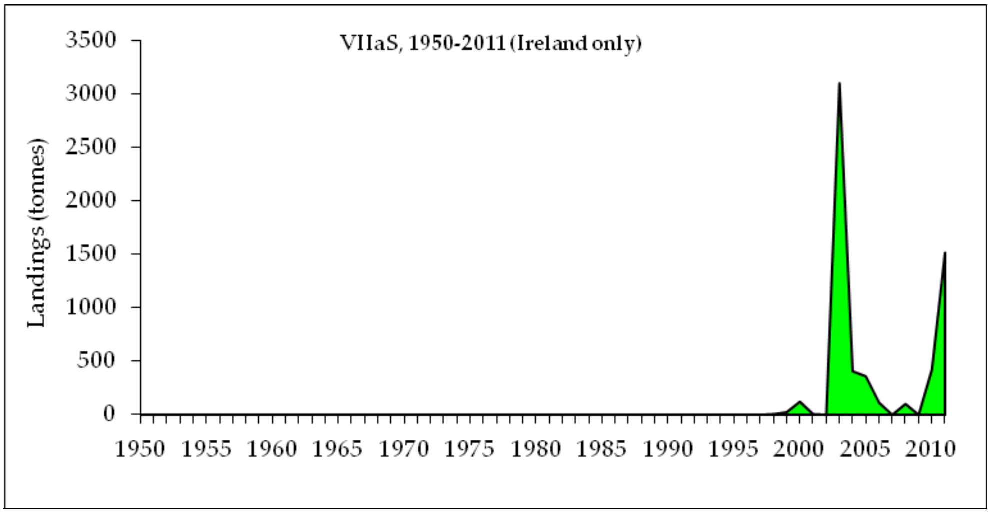


Figure 10.2.3. Sprat in the Celtic Seas. Landings of sprat 1950-2011 ICES Sub-division VIIaS.

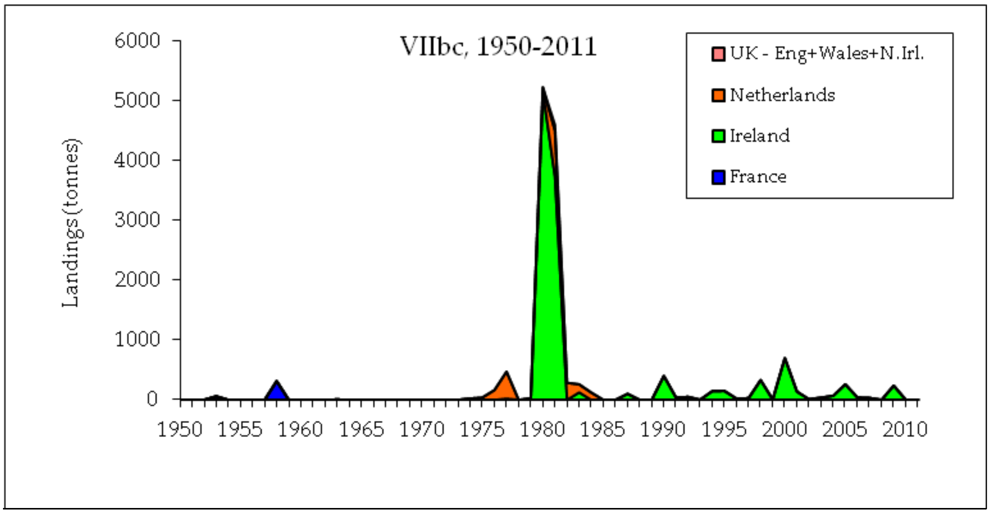


Figure 10.2.4. Sprat in the Celtic Seas Landings of sprat 1950-2011 ICES Sub-divisions VIIbc.

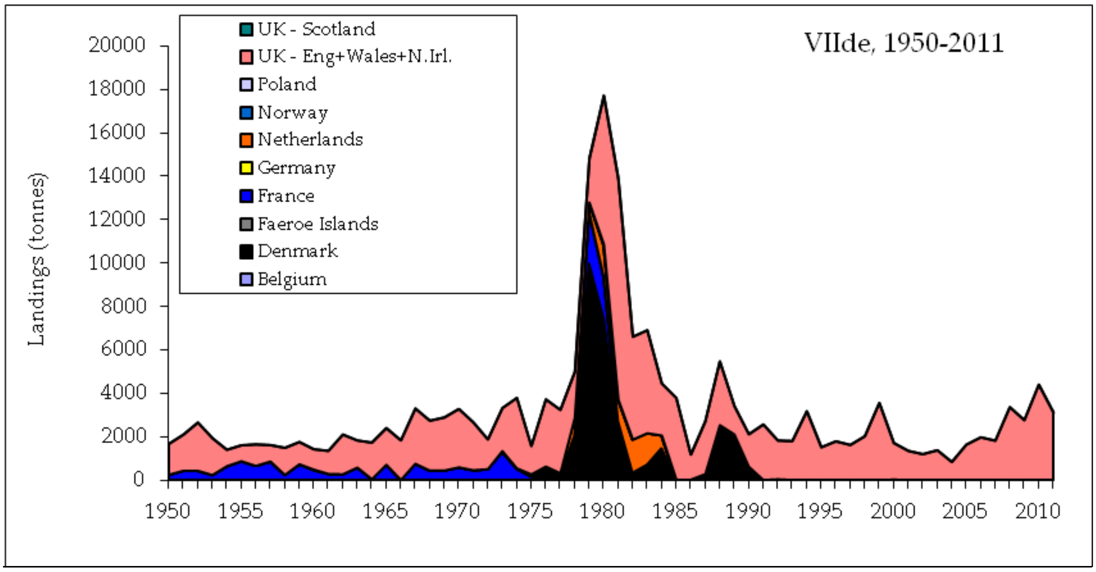


Figure 10.2.5. Sprat in the Celtic Seas. Landings of sprat 1950-2011 ICES Sub-divisions VIIde.

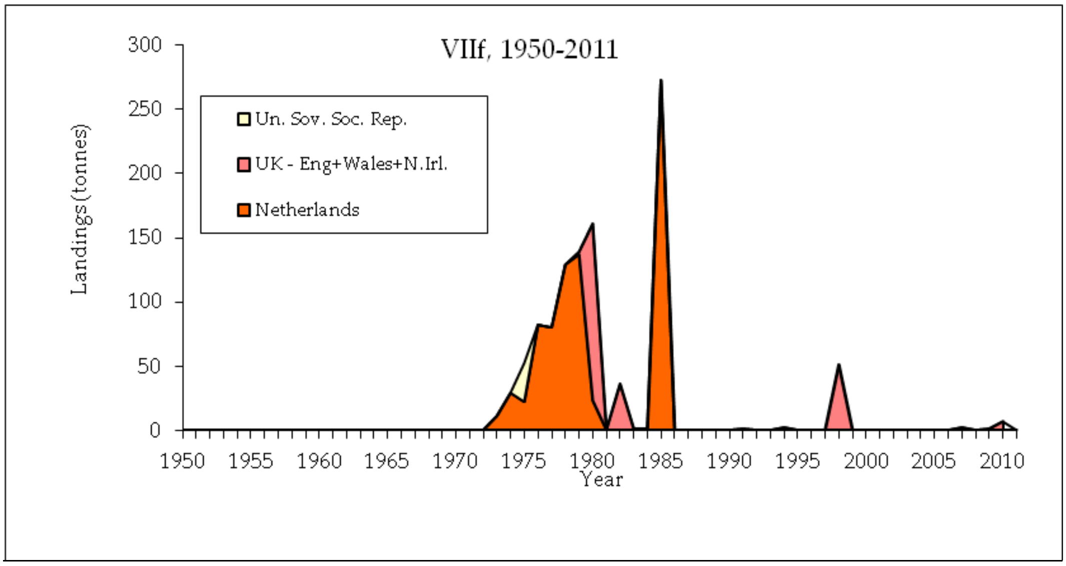


Figure 10.2.6. Sprat in the Celtic Seas. Landings of sprat 1950-2011 ICES Sub-division VIIf.

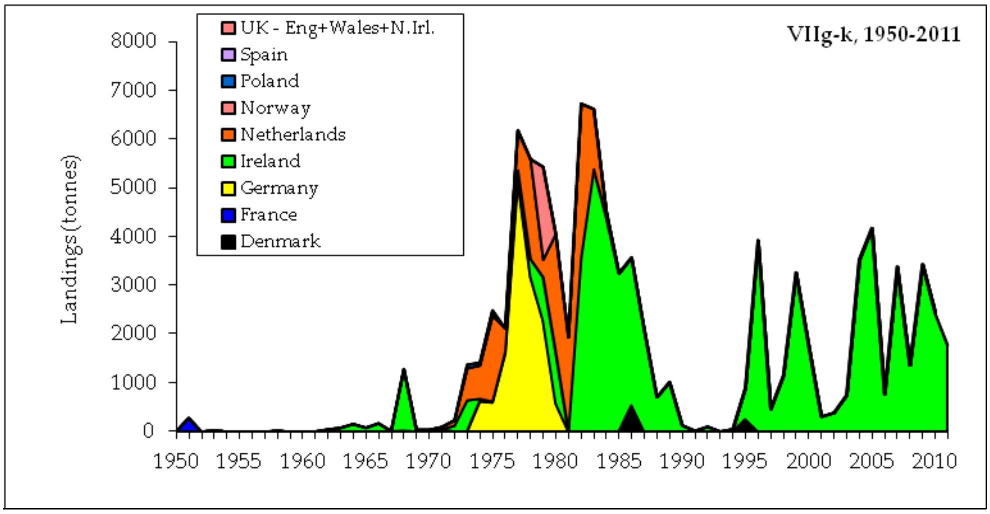


Figure 10.2.7. Sprat in the Celtic Seas Landings of sprat 1950-2011 ICES Sub-divisions VIIg-k.

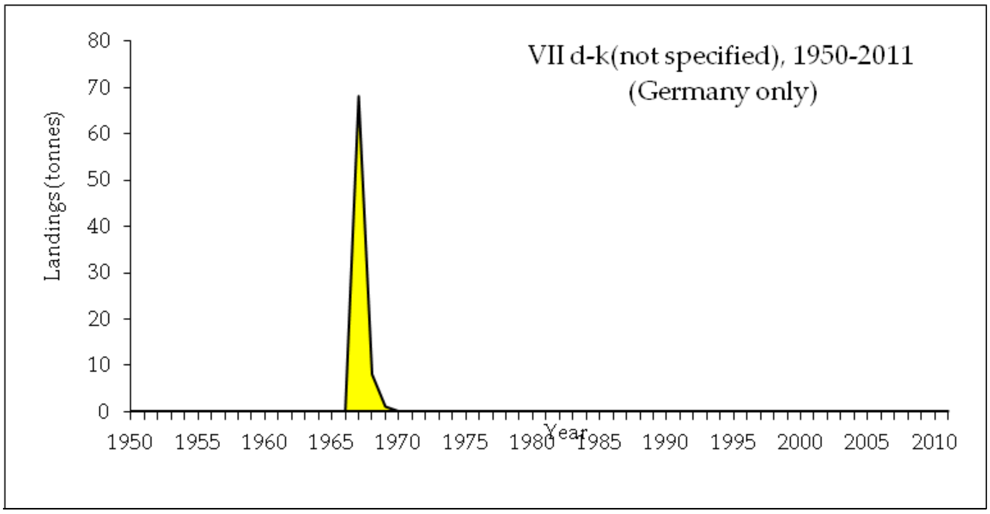


Figure 10.2.8. Sprat in the Celtic Seas Landings of sprat 1950-2011 ICES Sub-divisions VIId-k (not specified).

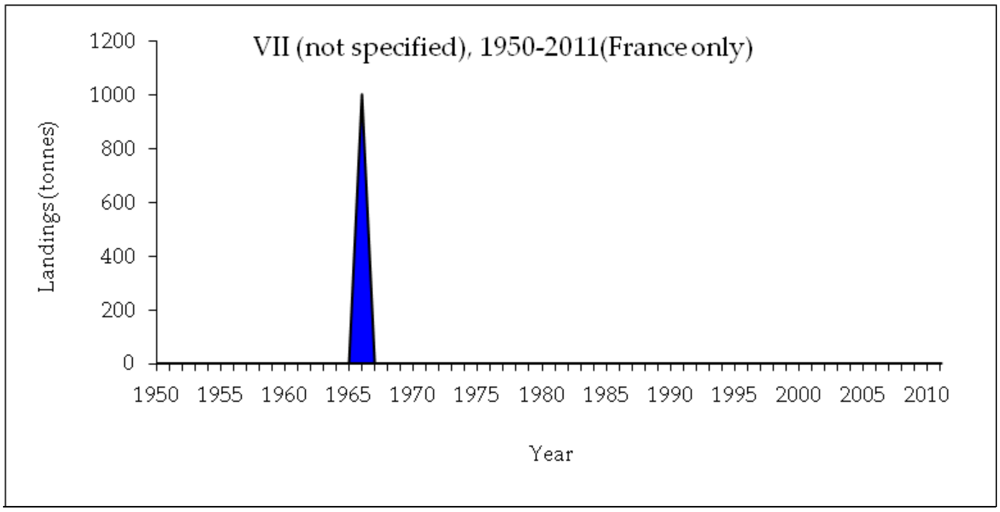


Figure 10.2.9. Sprat in the Celtic Seas Landings of sprat 1950-2011 ICES Sub-divisions VII (not specified).

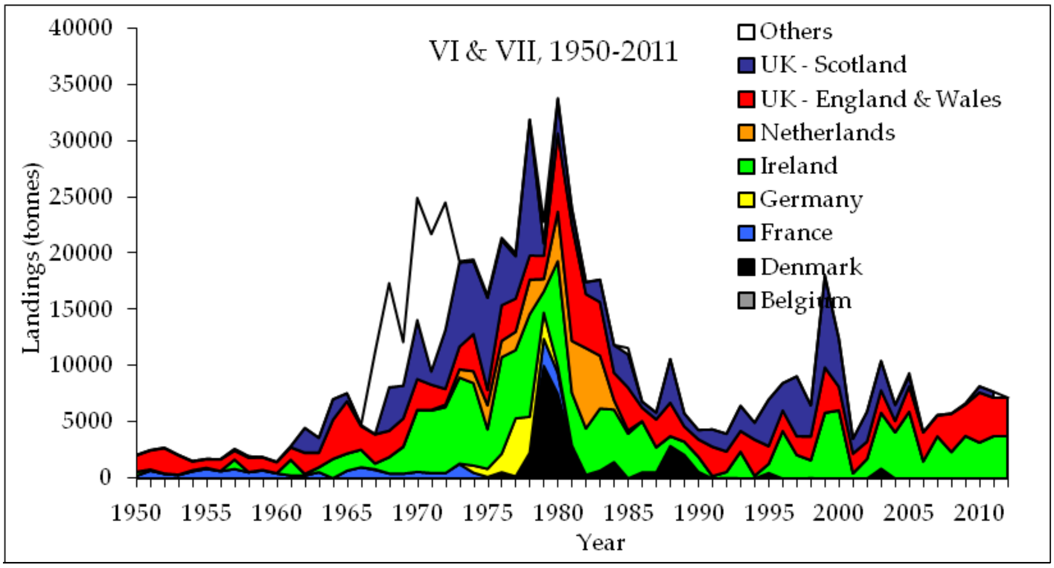


Figure 10.2.10. Sprat in the Celtic Seas Landings of sprat 1950-2011 ICES Divisions VI and VII (Celtic Seas Ecoregion).

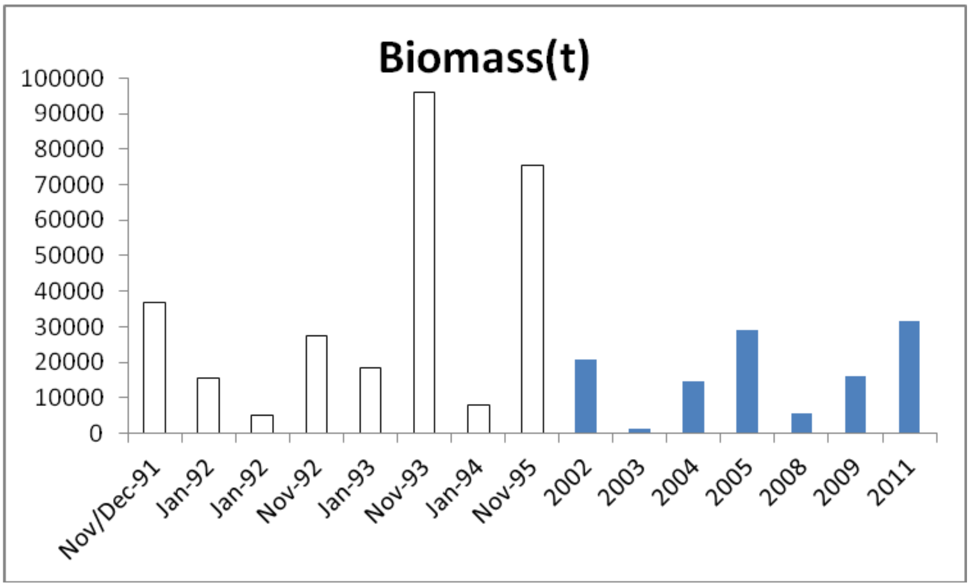


Figure 10.3. Sprat in the Celtic Seas. Annual sprat biomass in the Celtic Sea. (Source: MI Celtic Sea Herring Acoustic Survey).

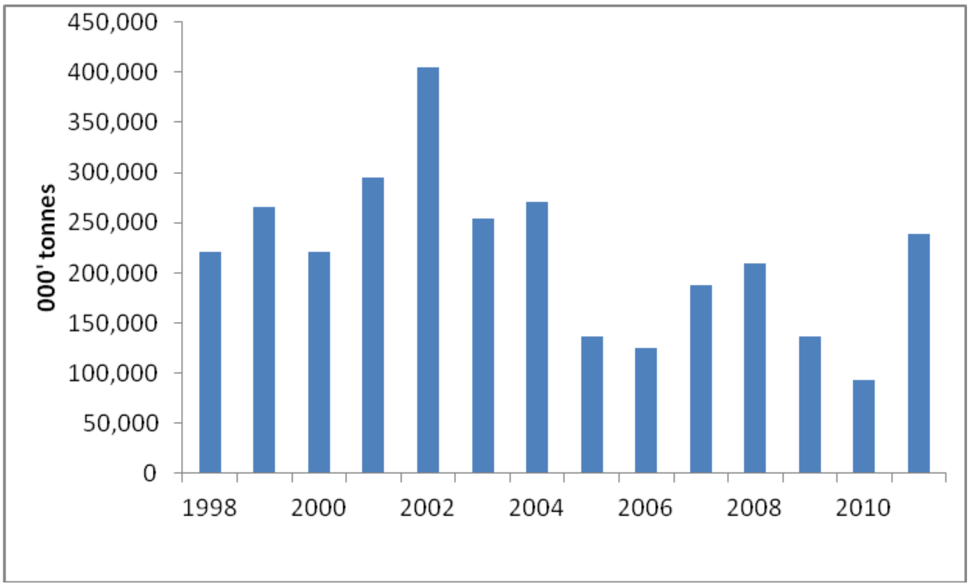


Figure 10.4. Sprat in the Celtic Seas. Annual sprat biomass in ICES sub-division VIIa (Source: AFBINI annual herring acoustic survey).

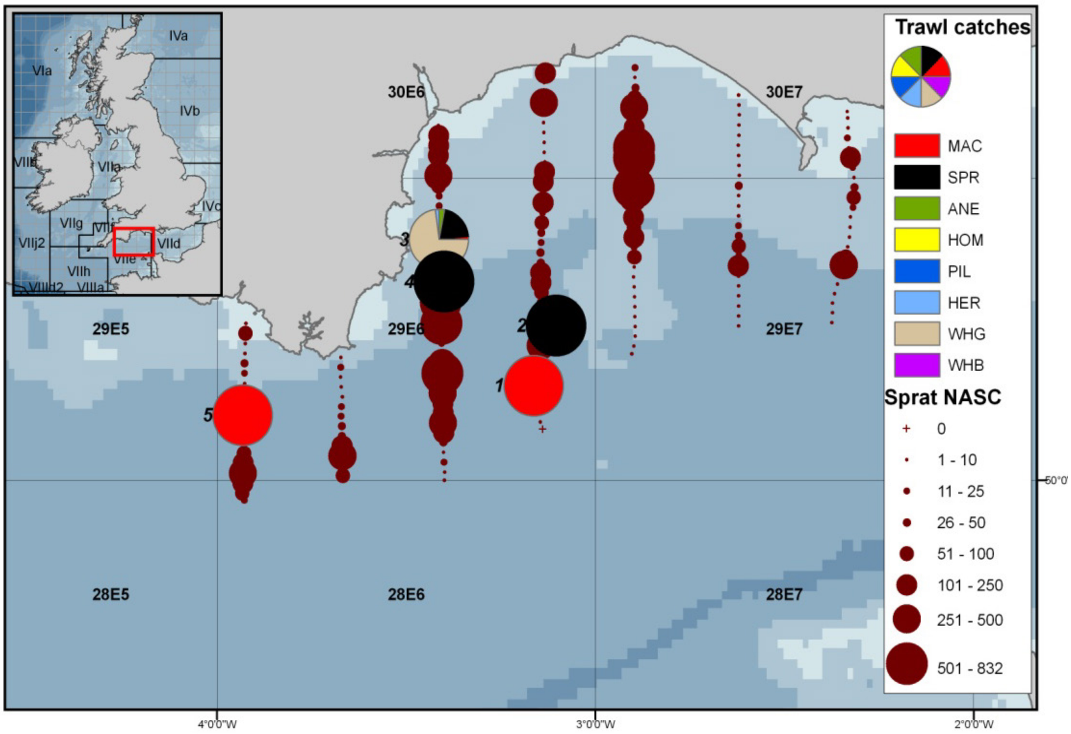


Figure 10.5. Overview map (inset) and detail of the survey area based on the FSP project, in ICES subdivision VIIE. Along-transect acoustic densities attributed to sprat (NASC) per nautical mile are shown in maroon. The position and the catch composition of the five trawls (*italics emboldened*) are also displayed. Boundaries of the ICES rectangles are indicated in grey (numbers emboldened within each rectangle). Three-letter species codes in legend: SPR sprat; MAC mackerel; WHG whiting; ANE anchovy; HER herring; HOM horse mackerel; PIL pilchard (sardine); WHB blue whiting.

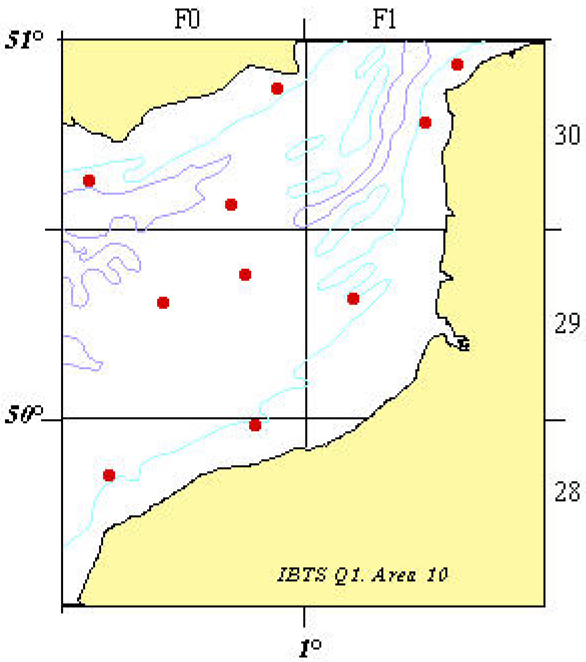


Figure 10.6: sampling area 10 in the Eastern Channel. (Hauls position for IBTS 11 sampled by France)

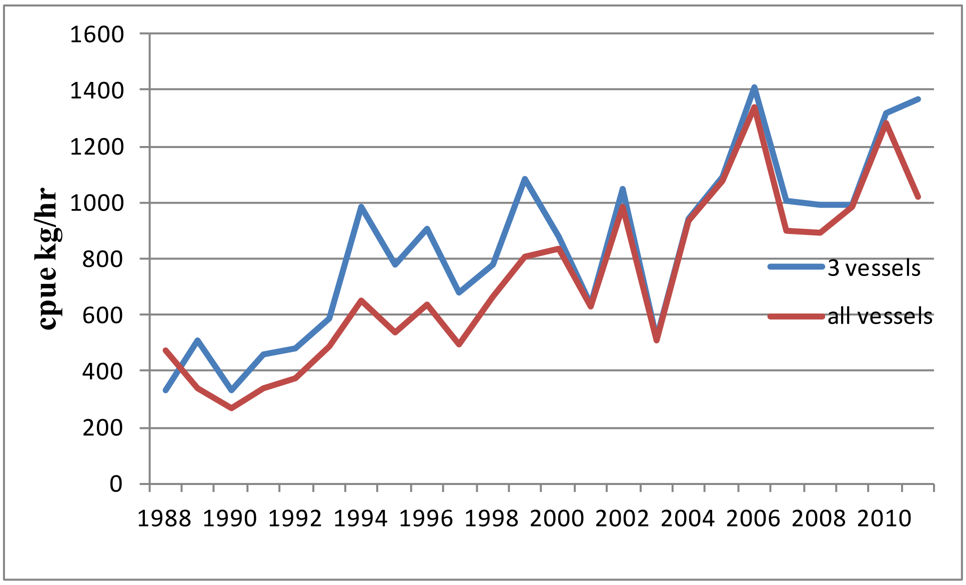


Figure 10.7. Sprat in the Celtic Seas. VIId e. Landing per unit of effort (LPUE) for main mid-water trawlers including effort linked to zero landings (in hours) and for all mid-water trawls (in hours).

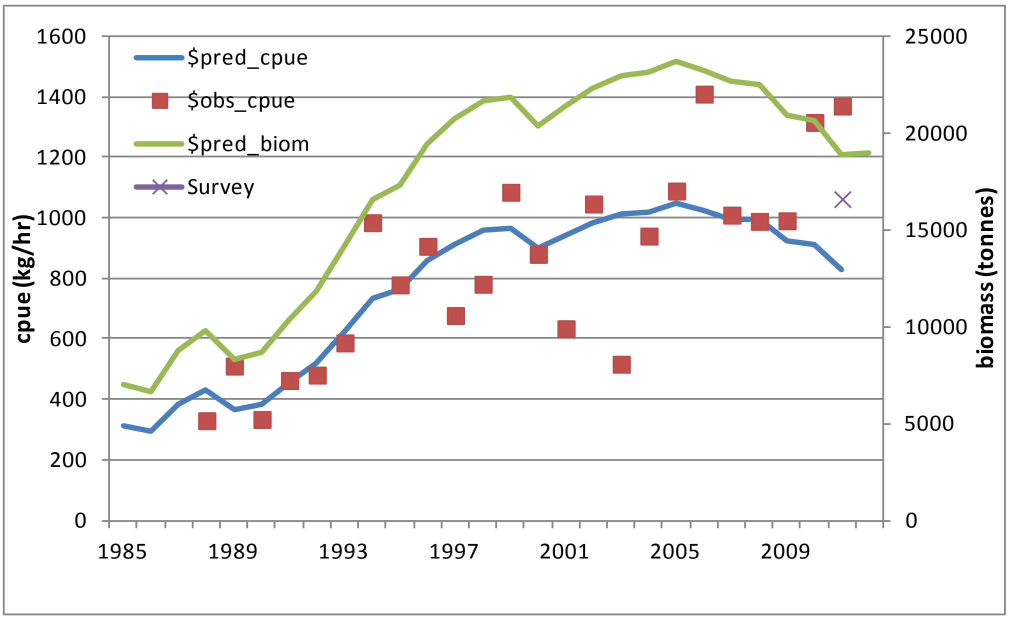


Figure 10.8. Surplus production model fit to the LPUE data and predicted biomass for the lowest possible estimate from the survey (16 600 t).

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 (Sub-area VIII). In this section only the times series of landings are maintained.

Since 1998, the agreed TAC for Clyde herring has never been reached. In 2011, the catch was 90 tonnes lower than the agreed TAC of 720 tonnes (Table 11.1) .There was no sampling of the catch in 2011 for Clyde herring. It is not clear to what extent catches in the Clyde relate to the resident stock or other stocks. Also the allocation of catches between Clyde and other stock areas (VIaN and VIIaN) needs further investigation.

Figure 11.1 shows time series of landings over the period 1951-2011 in VIIe and VIIf. Data for 2004 was 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. Since 1999, landings are more stable and have fluctuated between 5 and 800 t except in 2005 and 2008 where they reached more than 1000 t.

In VIIe, there was a pulse of landings 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 data from Spain updated. 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, 1956–2011. Spring and autumn-spawners combined.

Year	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
All Catches														
Total	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	10 594

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
All Catches														
Total	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	4 361

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Scotland	2 991	3 001	3 395	2 895	1 568	2 135	2 184	713	929	852	608	392	598	371
Other UK	247	22	-	-	-	-	-	-	-	1	-	194	127	475
Unallocated[1]	224	433	576	278	110	208	75	18	-	-	-	-	-	-
Discards	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	1 000
Total	5 770	4 800	4 650	3 612	1 923	2 343	2 259	731	929	853	608	586	725	846

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Scotland	779	16	1	78	46	88	-	-	+	163	54	266	-	90
Other UK	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	800	800	800	720	720
Total	1089	256	1	480	381	328	0	318	512	621	676	754	301	90

[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

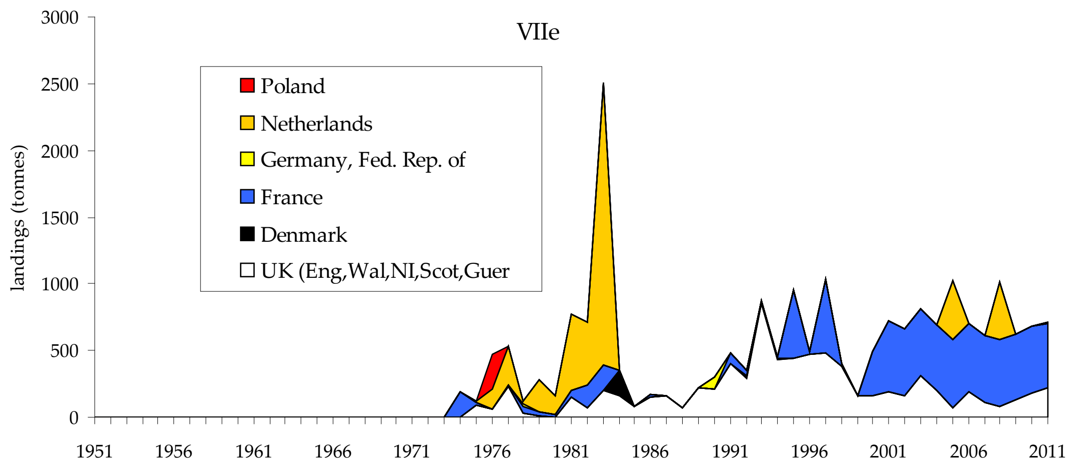
Table 11.2. Stocks with limited data. Landings of herring in Divisions VIIe and VIIf. Source: ICES FISHSTAT and National Database from 2005 to 2011.

Division	Country	2004	2005	2006	2007	2008	2009	2010	2011
VIIe	UK (Eng,Wal,NI,Scot,Guer	199	66	189	106	78	136	185	218
VIIe	Denmark	-	-	-	.	.	-	0	
VIIe	France	496	516	516	502	499	489	493	486
VIIe	Germany, Fed. Rep. of	.	.	.	.	.	-	0	
VIIe	Netherlands	-	440	-	-	433	-	2	6
	Total	695	1 022	705	608	1 010	625	678	710

Division	Country	2004	2005	2006	2007	2008	2009	2010	2011
VIIf	UK (Eng, Wal, Scot, NI)	47	198	76	115	29	8	23	78
VIIf	Belgium	-	-	-	-	-	-	0	
VIIf	France	-	-	-	.	.	-	0	
VIIf	Netherlands	-	-	-	-	-	-	0	
VIIf	Poland	-	-	.	.	.	-	0	
	Total	47	198	76	115	29	8	23	78

Table 11.3. Stocks with limited data. Landings of herring in Sub-area VIII.

Country	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
France	48	81	43	15	14	6	12	12	34	50	18
Netherlands	95	7733	1511	1426	28	12	24	24	68	502	29
Norway	-	-	-	-	-	.	.	.	-	-	-
Portugal	-	-	-	-	-	-	.	.	-	-	-
Spain	232	266	197	0	50	214	120	131	55	10	
UK	0	0	0	0	0	0	0	0	-	-	-
	280	7922	1665	1411	64	220	132	143	8	438	47



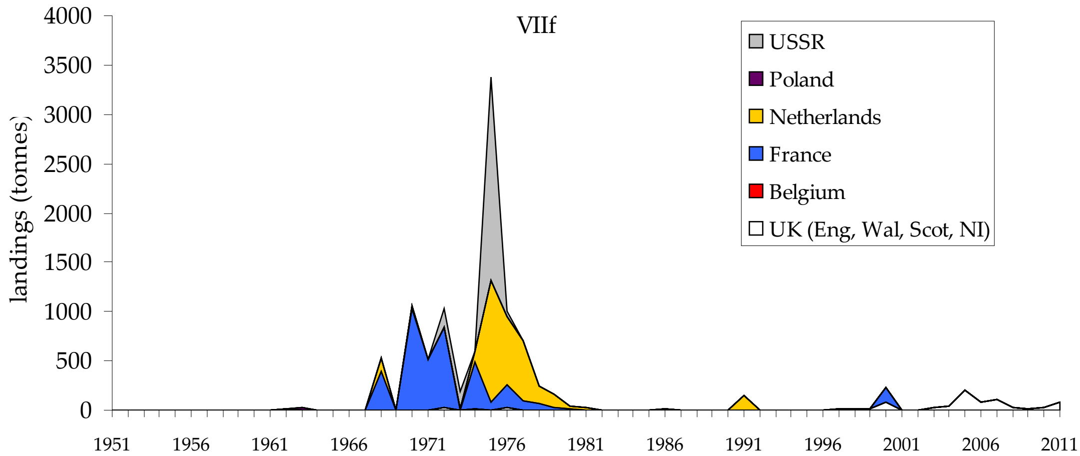


Figure 11.1. Stocks with limited data. Landings over time of herring in Divisions VIIe and VIIf.

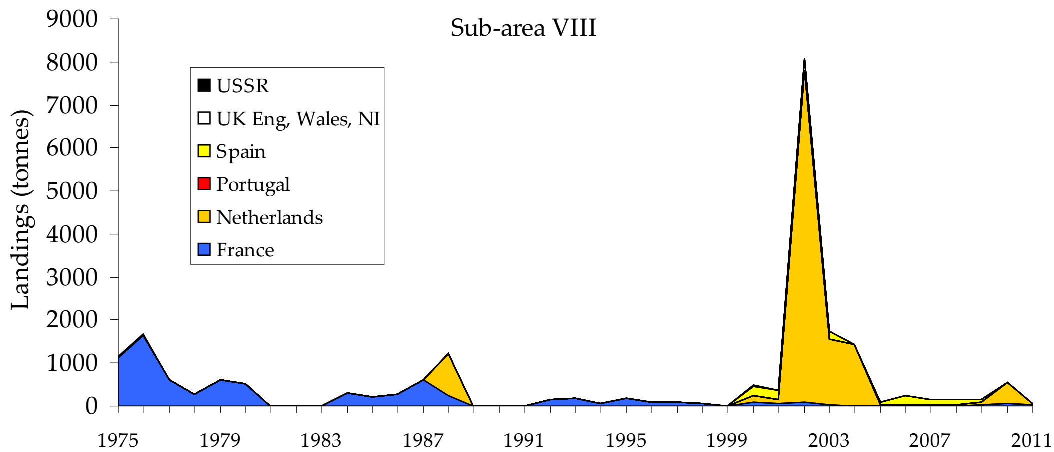


Figure 11.2. Stocks with limited data. Landings over time of herring in Sub-area VIII.

12 Working documents.

WD01. Ad Corten - Recruitment failures in North Sea herring

WD02. Maurice Clarke, Afra Egan, Stefano Mariani and Dana Miller Long term trends in population dynamics of NW Ireland herring revealed by data archaeology.

WD03. Aloysius T.M. van Helmond and Harriët M.J. van Overzee. Estimates of discarded herring by Dutch flagged vessels 2003-2011

WD04. B.A. Roel,. and J. Van der Kooij, 2012 - Sprat in the English Channel (VIId,e), data exploration.

WD05. T. Gröhsler. Fisheries & Stock assessment data in the Western Baltic in 2011.

WD06. T. Gröhsler, R. Oeberst, M. Schaber, M. Casini, V. Chervontsev, M. Wyszyński. Mixing of Western Baltic Spring Spawning and Central Baltic Herring (*Clupea harengus* L.) Stocks – Implications and Consequences for Stock Assessment

WD07. N. Fallon, C. O'Donnell and M. Clarke. Review of sprat in Irish waters

13 References

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Annex 1: List of Participants

Herring Assessment Working Group South of 62° N [HAWG]

13–22 March 2012

LIST OF PARTICIPANTS

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Annex 2 - Recommendations

RECOMMENDATION	ACTION
The North Sea Herring Short term forecast has the potential to perform stochastic forecasts. It is yet unclear however if the customers would benefit from estimates including 95% prediction interval. It is recommended to all HAWG members and the ICES secretariat to investigate the wish of stochastic forecasts with their customers, managers and fishers.	ICES secretariat; ACOM
Data from the herring acoustic surveys should be stored in a central data base in depth stratified Fish Frame stage 1 format. This will facilitate potential analyses of survey performance in terms of, e.g. coverage, changes in population structure or survey catchability, if the results of the assessment model suggest significant survey effects. Vessels participating in acoustic surveys should be equipped with and use multiple acoustic frequencies (minimum 4; between 18 – 333 kHz) additionally to the standard 38 kHz, in order to provide in situ abundance estimates of plankton and fish occurring in the survey area. This will provide information on the wider ecosystem and allows assessing changes in the environment.	WGIPS
HAWG recommends both appropriate documentation and training on the use of the state-space stock assessment model SAM. SAM is currently spreading within HAWG and among other WGs (i.e., WBFAS). Therefore, for the full application of SAM within the WG, a comprehensive user manual is needed, as well as specific training is recommended.	ICES Secretariat
The timing of benchmarks of stocks and the revision/creation of LTMP for those stocks must be coordinated to avoid situations where a benchmarked assessment with potentially new perceptions of the stock is used to give advice according to a LTMP which was preconditioned on the previous assessment and perception of the stock	ICES Secretariat, ACOM, and management bodies (EC, Norway, etc)
HAWG recommends ACOM to discuss moving the NSAS and WBSS back to the ADGNS as the link with the North Sea ecosystem has been strengthened after the benchmark in 2012 of NSAS implementing a natural mortality based on the multispecies outputs from the North Sea.	ACOM
The Malin Shelf Acoustic Survey (MSHAS) should be defined within the following boundaries: 1. MSHAS N = VIaN herring stock, acoustic tuning index. = VIaN not including rectangles 39E3 and 40E3, the North Channel or Clyde 2. MSHAS S =VIaS and VIIbc +Rectangles 39E3 and 40E3 in VIaN. This will require that the index for 2008 and 2009 be reassembled to exclude the Clyde and North Channel	ICES Secretariat, WGIPS and?

Varying vessel coverage by year means that the two survey components may be done by different vessels in different years.	
Collation of age-length keys of sprat in the Celtic Sea and West of Scotland should be done. A first step should be to validate the ageing of sprat from this area. HAWG recommends including available material on this part of the sprat stock complex in the upcoming large-scale exchange on Sprat in the North Sea. Provision of survey indices (total biomass, numbers at length, and/or numbers at age) for sprat in the Celtic seas eco-region	PGCCDBS; WGIBTS, WGIPS
HAWG requests the annual creation of a "briefing sheet" detailing the current state of the physical and biological environment in the ecoregions that it covers as an aid to generating advice. Suggestions as to the contents and structure of such a sheet are included in the HAWG report. HAWG has discussed this with members of the WGOOFE group, but would also welcome input and ideas from related working groups. E.g. WGOH, WGZE	WGOOFE, WGOH, WGZE
Stock ID work on herring caught in the Malin Shelf acoustic survey needs to be expedited to enable the eventual production of two separate tuning indices for herring from the VIa(North) and VIa (South) and VIIb,c stocks for the planned benchmarking of these two stocks in 2015. Expertise in analysis needs to be provided to enable the development of routine methods to identify and separate the two stocks in the first instance and then to use these outputs to split the acoustic data time-series to provide a series of age-disaggregated data.	ICES delegates and National Correspondents for UKS and Ireland
The Secretariat is asked to collate a definitive inventory of TACs and quotas that is updated regularly.	ICES Secretariat
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 2012	ICES Secretariat
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 2013 HAWG, until InterCatch provides the additional functionality.	ICES Secretariat

The **Herring Assessment Working Group for the Area South of 62ºN** (HAWG), chaired by Lotte Worsøe Clausen (Denmark) and Beatriz Roel (UK, England and Wales) and, will meet at ICES Headquarters, 12–21 March 2013, to:

a) compile the catch data of North Sea and Western Baltic herring on 12–13 March

b) address generic ToRs for Fish Stock Assessment Working Groups 14–21 March (see table below)

c) prepare for benchmark of Celtic Sea herring, planned for 2014.

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 8 April 2013 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Coord. 1	Assess. Coord. 2	Advice
her-3a22	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Update
her-47d3	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Update
her-irls	Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)	Ireland	Ireland	Ireland	Update
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland	Ireland	Update
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)	UK (E&W)	Update
her-vian	Herring in Division VIa (North)	UK (Scotland)	UK S	Ireland	Update
spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	Norway	Denmark	Norway	Update
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Update
spr-ech	Sprat in Division VIId,e	UK (E&W)	UK (E&W)	France	Update
spr-celt	Sprat in the Celtic Seas	UK (E&W)	UK (E&W)	Ireland	Update

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 February 2012

Authors: M. Dickey-Collas, M. Payne, N. Hintzen, H. Mosegaard, L.A.W. Clausen, N. Rohlf, E.M.C. Hatfield, S.M. Lusseau, K. Enberg, V. Bartolino, P. Munk, C. Zimmermann,

A. General

A.1. Stock definition:

Autumn spawning herring distributed in ICES area IV, Division IIIa and VIId. The stock consists of four major spawning components; contributions of these individual components to the total stock differ over time. Mixing with other stocks occurs, especially in Division IIIa (with western Baltic spring spawning herring). Recent studies have shown that the different spawning aggregations of this stock are genetically homogeneous (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 Orkney-Shetland area and northern North Sea in the 2nd and 3rd quarters, 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, four 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 gyre areas such as the Dogger Bank and at tidal fronts. Changes observed in trophic structure or diversity may be indicative changes in resilience of this ecosystem (Thrush *et al.*, 2009). This trend may partially be a response to inter-annual changes in the physical oceanography of the North Atlantic (Reid *et al.*, 2001).

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 by 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 (Nash *et al*., 2009; Payne *et al*., 2009).

Their spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences (Röckmann et al., 2011). 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 are 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 during 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) where 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; van Helmond & Overzee, 2011). 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. Since the mid 2000s the stronger recruitment of mackerel has probably led to an increase in discarding due to mixed hauls of herring and mackerel.

Ecosystem Considerations. A potential ecosystem impact of the North Sea herring fishery is the removal of fish that could provide other "ecosystem services". The North Sea ecosystem needs a trophic link to graze the plankton and act as prey for other organisms. If herring biomass is very low, other species, such as sandeel, may replace its role (it has been suggested that the shift from herring to sandeel as prey for seals along the English coast in the 1970s, resulted from the collapse of the herring stock), or the system may shift in a more dramatic way. The interaction of herring with cod and Norway pout population dynamics has been alluded to (Cushing, 1980; Huse *et* al., 2008; Fauchald, 2010), and Speirs *et al*. (2010) suggest that the current biomass of herring will prevent the recovery of the cod population even if fishing mortality on cod is reduced. Large populations of predator fish like saithe, cod and whiting, but also to some degree large cetacean or seal populations, will also impact the herring biomass (ICES WGSAM REPORT –ICES, 2011). However, many of the current ecosystem models are very sensitive to the assumptions about herring, or do not include herring as a predator and prey species, thus it is difficult to test the impact of increasing or reducing the herring biomass on the ecosystem functioning as a whole. It is highly likely that, for Good Environmental Status (GES), the North Sea requires a certain threshold of herring biomass.

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 *et al.* (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 a UK observer programme that ended in 2003 (Northridge, pers. Comm.) and Dutch observers (1 catch from 2007-2009 over 210 days observed; Couperus, 2009; ICES 2011b).

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. Off 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 data are 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. This spreadsheet which was developed originally to ease the handling of Mackerel data supplied to its (then parent) Working Group (WGMHSA) and it was then further adapted to the special needs of the Herring Assessment Working Group (HAWG). The current version used for reporting the catch data is v1.6.4. Traditionally, the SALLOCL-application (Patterson, 1998) is then used to allocate samples to catches that do not contain direct biological samples. This programme gives the needed 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.

Since 2007, the commercial catch and sampling data have also been stored and processed using the InterCatch database. In the first year, larger discrepancies (up to 5 %) between the two applications occurred, but since 2008 the estimates of CANON, CATON and WECA have been highly comparable. However, InterCatch operates on the basis of Subdivisions and lacks the capacity to store catch information by rectangle and catch-length frequency distribution. This level of data division is a prerequisite of the HAWG. Both data collation methods are, therefore, still used in parallel.

The "wonderful table" lists all of the information on area TACs and estimated catches of herring in both the North Sea and Division IIIa, to show the derivation of the total catch of North Sea autumn spawning herring (NSAS) each year. The following figure explains where the estimates in the wonderful table are derived from;

Year		2007	2008	
Sub-Area IV and Division VIId: TAC (IV and VIId)				
Recommended Divisions IVa, b 1	22			
Recommended Divisions IVc, VIId	14			
Expected catch of spring spawners				
Agreed Divisions IVa,b 2	TAC human consumption in IVa and b	303.5	174.6	Total TAC for human consumption in North Sea
Agreed Div. IVc, VIId	TAC human consumption in IVc and VIId	37.5	26.7	
Bycatch ceiling in the small mesh fishery	TAC industrial fishery	31.9	18.8	
CATCH (IV and VIId)				
National landings Divisions IVa,b 3		326.8		
Unallocated landings Divisions IVa,b		21.9		
Discard/slipping Divisions IVa,b 4		0.1		
Total catch Divisions IVa,b 5		348.8		
National landings Divisions IVc, VIId 3		34.3		
Unallocated landings Divisions IVc,VIId		4.7		
Discard/slipping Divisions IVc, VIId 4		-		
Total catch Divisions IVc, VIId		39.0		
Total catch IV and VIId as used by ACFM 5		**387.8**		Herring caught in the North Sea
CATCH BY FLEET/STOCK (IV and VIId) 10				
North Sea autumn spawners directed fisheries (Fleet A)		379.6		NS catch human consumption
North Sea autumn spawners industrial (Fleet B)		7.1		NS catch industrial fishery
North Sea autumn spawners in IV and VIId total		**386.7**		
Baltic-IIIa-type spring spawners in IV		1.1		Catch of WBSS in IV, estimated by splitting
Coastal-type spring spawners		0.0		e.g. spring spawner in river estuaries (Thames, Wash)
Norw. Spring Spawners caught under a separate quota in IV 20		0.7		direct information from Norway
Division IIIa: TAC (IIIa)				
Predicted catch of autumn spawners	22			
Recommended spring spawners	22			
Recommended mixed clupeoids				
Agreed herring TAC		69.4	51.7	
Agreed mixed clupeoid TAC				
Bycatch ceiling in the small mesh fishery		15.4	11.5	
CATCH (IIIa)				
National landings		47.3		
Catch as used by ACFM		47.4		
CATCH BY FLEET/STOCK (IIIa) 10				
Autumn spawners human consumption (Fleet C)		16.4		
Autumn spawners mixed clupeoid (Fleet D) 19		3.4		
Autumn spawners other industrial landings (Fleet E)				
Autumn spawners in IIIa total		**19.8**		Catch of NSAS in IIIa, estimated by splitting
Spring spawners human consumption (Fleet C)		25.3		
Spring spawners mixed clupeoid (Fleet D) 19		2.3		
Spring spawners other industrial landings (Fleet E)				
Spring spawners in IIIa total		**27.6**		
North Sea autumn spawners Total as used by ACFM		**406.5**		

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators are available in a folder called "archive" (found on the ICES W-drive; refer to the ICES data centre for the correct link). These high-resolution data are not reproduced in the report. The archived data contain the disaggregated dataset (disfad), the allocations of samples to un-sampled 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 data, 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 stock 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.

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 between obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group.

Uncertainty in the catch data. A thorough examination of the precision of the international market sampling for North Sea herring and its influence on the assessment was carried out in 2001 for the period 1991 to 1998 (ICES, 2001db). The conclusion was that the fishery is well sampled. Estimates of catch-at-age delivered by the combined international sampling programme for North Sea herring were rather precise and the contribution of this variability to the overall precision of the assessment at the time was relatively small and acceptable.

Several institutes already routinely calculate the uncertainty associated with the numbers -at -age through the COST raising procedure. With the move to an assessment model that can readily incorporate a-priori information regarding uncertainty in the input data it is essential to formalise the provision of such catch precision estimates and for the Working Group to develop methods for aggregating these to reflect the uncertainty in the aggregated catch data.

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 forless 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 the implementation of the sampling scheme described above for their overall landings, 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.

B.2. Biological

Weight-at-age

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 above. Information on recent sampling levels and nations providing samples should be provided as part of the working group report (typically sec. 2.2.).

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 winter-ring fish are assumed to be immature, and all fish over five winter-rings are assumed to be mature.

For North Sea herring, increasing fish size has been observed from 1940 to 1980, possibly resulting from a decreasing competition for food while the stock collapsed (Burd 1984; Saville, Bailey et al. 1984). Particularly large year-classes may also suffer from intra-cohort competition and have a slower growth than average ones (ICES 2008). Superimposed to these density-dependent effects, environmental factors such as plankton production (Shin and Rochet 1998) and temperature (Brunel and Dickey-Collas 2010) also influence growth. There is no study dealing specifically with variations in North Sea herring maturation, but it has been shown for other stocks having also collapsed and recovered in the recent history, that maturation was closely related to growth (i.e. faster growth resulting in earlier maturation) (Engelhard and Heino 2004; Melvin and Stephenson 2007).

Maturity

Growth and maturation variations are the expression of phenotypic plasticity in response to variability in environmental factors such as food level (Berrigan and Charnov 1994), temperature (Atkinson 1994), and density-dependent processes (Engelhard and Heino 2004).

Maturation seems to be closely related to growth. Poor growth between age 1 and 2 often leads to a low proportion of mature individuals at age 2. If growth is also poor between age 2 and 3, maturation is further delayed. As the assessment of North Sea herring and the projections are based on smoothed stock weight data, most of the inter-annual variability in growth is filtered out. Therefore the weights at age used for the prediction (assumed same as last year of data) are not too different from the weight observed in the data in the assessment of the following year. Brunel 2012 showed, however, that the assumption made for the maturity ogive used in the projections (an average of the last three years of data) generates large errors, particularly for slow maturing cohorts. However, given the absence of a predictive model for growth, and hence maturation, it seems difficult to propose an alternative to improve this situation.

The precision of the maturity-, sex-, and age estimates are analysed every 3-4th year according to a pre-set schedule defined by ICES and PGCCDBS. Through exchanges and workshops, the individual estimates of maturity stage, sex, and age are subject to a quality check by calibrating the laboratories involved in supplying data on those biological parameters. From these workshops, estimates of the uncertainty around the estimates of maturity, sex and age are available for consideration by the HAWG.

Natural Mortality

Natural mortality at age was previously fixed by age for the entire time series of the assessment, as calculated by the equivalent of the current ICES multispecies working group in 1987 and was used up to 2011 (ICES 1987; Table B2.1). From 2012 onwards, the assumed fixed natural mortality at age is replaced with a variable (over time) natural mortality at age in the assessment. The multi-species stock assessment model for the North Sea (SMS key-run 2010) has been used to inform the variable natural mortality pattern. Annual total predation and background mortality estimates from the SMS model, spanning 1963 to 2010, were obtained and scrutinized for patterns.

Table B2.1. Previous metrics for natural mortality (M) used for the assessment of North Sea autumn spawning herring. Taken from ICES 1987.

Age	Herring Assessment WG meetings in years				Multispecies WG meetings		
	1964-1970	1970-1983	1984-1986	1987	1984[1]	1985[2]	1986[3]
0	0.20	0.10	1.00	1.00[4]	1.07	0.82	1.067[4]
1	0.20	0.10	0.80	1.00	0.46	0.84	1.023
2	0.20	0.10	0.10	0.30	0.13	0.16	0.253
3	0.20	0.10	0.10	0.20	0.44	0.30	0.274
4	0.20	0.10	0.10	0.10	0.13	0.12	0.131
5	0.20	0.10	0.10	0.10	0.19	0.13	0.131
6	0.20	0.10	0.10	0.10	0.10	0.12	0.117
7	0.20	0.10	0.10	0.10	0.10	0.10	0.100
8+	0.20	0.10	0.10	0.10	0.10	0.10	0.100

[1] Anon. (1984b) key-run, mean 1974-1983.
[2] Anon. (1986b) key-run, mean 1974-1984.
[3] Anon. (1987a) key-run, mean 1978-1982.
[4] Mortality rate per half year.

The Multispecies VPA carried out in 1986 was, according to Anon. (1987a), an improvement on the 1985 MSVPA mainly because:

Many different predators have herring in their diet. However, young herring age groups are primarily eaten by cod, saithe and whiting, where whiting mainly predates on age 2-4herring. The contribution of saithe and cod alone makes up for nearly 90% of the predation mortality from age 4 onwards. Predation mortality by cod has gone down in the period 1995-2010 while predation mortality has gone up for saithe. In the years 2008 – 2010 however total predation mortality has gone down rapidly. This trend or shift in predation mortality might imply a change in predator biomass or a diet shift.

Cod shows a nearly continuous decline in biomass while saithe has increased considerably over the years up to 2005 but has crashed in the most recent years. These trends in cod and saithe biomass are in agreement with the trends observed in the single species assessments. Herring mortality (ages 2 and older) has, according to the SMS key-runs, increased over the period 1991-2007 but seems to have reduced again in the more recent years. This trend is in close agreement with the development of the saithe stock, while the decline in the cod stock seems to have been compensated by the saithe increase over the years.

To capture these highly variable dynamics, and allow for extrapolation of the time series both backwards (1947 to 1962) and forwards in time (2011 onwards) a loess smoother (span 0.5) is fit through the variable natural mortality estimates at ages 0-7. M on age 8+ is assumed to be the same as that at age 7.

B.3. Surveys

B.3.1 Acoustic: ICES Co-ordinated Acoustic Surveys for herring in North Sea, Skagerrak and Kattegat (HERAS)

The ICES Coordinated acoustic surveys started in 1979 around Orkney and Shetland with the 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 Donegal, 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 and in the Skagerrak where short additional transects are 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 a standardised data exchange format and uploaded into the FishFrame database, currently held at DTU Aqua, Charlottenlund, Denmark. National estimates are aggregated through FishFrame during WGIPS to calculate global estimates for the North Sea, VIa (North) 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+ mature. 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.

Precision estimates on the biological samples obtained during the acoustic surveys are available since 2012 (WGIPS 2012). Average weight and length values with corresponding standard deviations have been computed for North Sea herring (based on the combined biological information collected during the Dutch, German, Danish and Scottish acoustic survey) and the Malin Shelf area (based on Irish survey data in 2012). Bootstrapping is used to characterise uncertainty in maturity-at-age. Details on the results are given in the Working Group report of WGIPS (ICES, 2012).

Precision estimates of the spawning stock biomass estimates obtained from the acoustic surveys are available for the period 2004-2011. In the precision estimation exercise done during WGIPS 2012, uncertainty in global mean acoustic density estimates is characterised. Because mean size of adult herring does not vary a lot (most adult age classes have mean lengths of 25-30 cm), uncertainty in mean acoustic density should give a good, albeit conservative, estimate of uncertainty in total stock biomass. Areas containing the vast majority of adult herring (90-95%) in the North Sea have traditionally been covered by the Netherlands and Scotland. In the areas covered by the other nations participating in the international survey, a great proportion of immature herring is encountered. Schools and aggregations of immature herring will exhibit different morphological and acoustic characteristics that are not representative of the adult portion of the stock. Therefore, only data from the Netherlands and Scotland were used to estimate uncertainty in the mean acoustic density and stock size of the North Sea herring SSB.

Bootstrapping was used to estimate uncertainty in the mean acoustic density. Bootstrapping was done by stratum, treating observations from vessels equally and using lengths of survey track as weights when calculating mean density. Estimates of mean acoustic density were calculated for 1000 bootstrap replicates per stratum. The overall mean acoustic density is the mean of these 1000 bootstrap estimates, and confidence limits were obtained as quantiles of the distribution.

The results of this exercise for the period 2004 -2011 are shown below. The level of acoustic uncertainty is the same order of magnitude, with the exception of the survey in 2006, when the distribution of the acoustic density values was much wider than usual.

Table B.3.1: Confidence intervals obtained from 1000 bootstrap replicates of acoustic survey data based on the Dutch and Scottish North Sea herring surveys.

Year	95% C.I. lower [%]	95% C.I. upper [%]	50% C.I. lower [%]	50% C.I. lower [%]
2004	-20.4	+21.0	-7.5	+7.2
2005	-23.0	+24.6	-8.8	+8.5
2006	-34.8	+43.9	-15.3	+13.3
2007	-17.2	+17.4	-5.6	+5.8
2008	-25.2	+28.3	-9.7	+8.8
2009	-22.7	+26.1	-8.9	+8.3
2010	-19.7	+23.7	-7.4	+7.0
2011	-17.2	+20.3	-6.6	+6.3

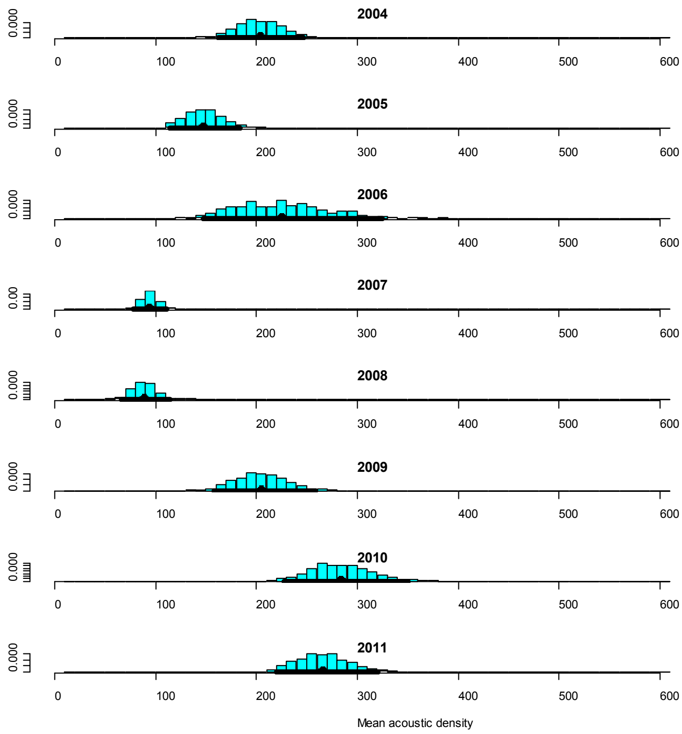

Figure B.3.1.1: Distribution of mean acoustic density (in m²/nmi²), by year, based on 1000 bootstrap replicates of acoustic data from the Dutch and Scottish North Sea herring surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

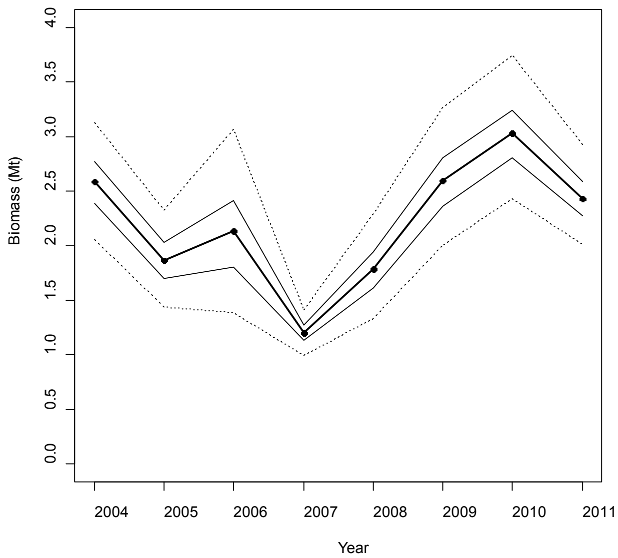

Figure B.3.1.2: Approximate 50% and 95% confidence limits for North Sea herring SSB (x1 000t) estimates from the acoustic survey. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability of acoustic observations.

B.3.2 International Bottom Trawl Survey (IBTS-1Q):

The International Bottom Trawl Survey (IBTS) started out as the International Young

Herring Survey (IYHS) in 1966 with the objective of obtaining annual recruitment indices for the combined North Sea herring populations (Heesen 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. The survey was standardised gradually from 1977, and is considered fully standardised from 1983 onwards, where it became known as the International Bottom Trawl Survey (IBTS). 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 1977 sampling for late stage herring larvae was introduced at the IBTS 1st quarter, using Isaacs-Kidd Midwater trawl (IKMT). These catches appeared as a good indicator of herring recruitment. However, examination of IKMT performance showed deficiencies in its catchability of 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 1990s, 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 (to a maximum depth of either 100m or 5m from the bottom) per ICES statistical rectangle are made at night.

Indices of 2-5+ ringer herring abundances in the North Sea (1st quarter). Fishing gear and survey practices were standardised from 1983 onwards and herring abundance estimates of 2-5+ ringers are available since. 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. The time-series was used in North Sea herring assessment until 2011. During the Benchmark in 2012, it was decided not to include the 2-5+ index in the assessment due to a general inability of the index to track cohorts and poor precision.

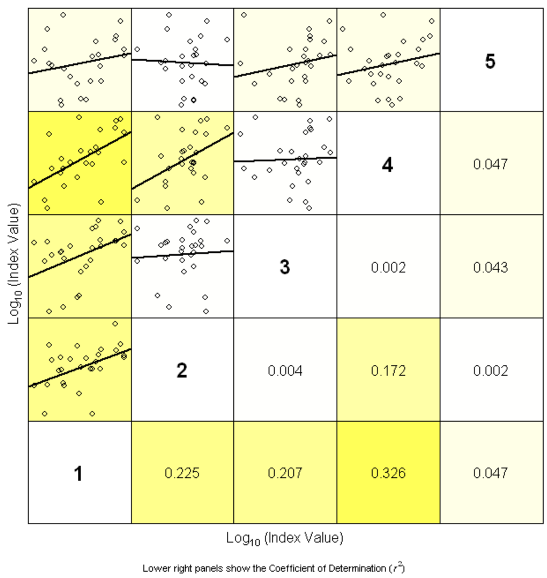

Figure B.3.2.1: Fitted linear relationships of cohort trends within the IBTS surveys. Internal consistency of cohorts in the IBTS-1Q survey.

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).

IBTS0 index of 0-ringer recruitment in the North Sea (1st quarter). The catches of late stage herring larvae (using the MIK gear) are used to calculate an 0-ringer index of autumn spawned herring in the North Sea and used as a proxy for 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 for each haul.

Data storage: The data are initially tabulated in an excel sheet where the data are scrutinised for consistency and quality and the different correction factors that standardise the data amongst nations is applied. The data are then uploaded to the ICES "eggsandlarvae" database where the historic data are also held. This database is used for a range of larval species and different sets of data can be selected and downloaded and can be accessed by contacting the ICES secretariat.

Index Calculation: The mean herring density (in no. per m^2) in statistical rectangles is raised to mean within sub-areas, and based on areas of these sub-areas an index of total abundance is estimated. The series provides estimates for sub-areas as well as the total index.

In order to consider "skewness" in sampling intensity due to less intense or no sampling in some areas, the averaging of densities is first done for statistical rectangles and subsequently for defined, larger sections. Finally, abundances are found for the sections and these are summed for the total area.

In order to exclude the Downs larvae, which are too patchily distributed and too young (might reach extreme abundances), the abundances of larvae south of 54°N for which the mean size at station is below 20 mm are excluded before calculating the standard IBTS0 index.

The procedure is the following:

1. Averages of no-per-m^2 is calculated for each rectangle

2. Averages of no-per-m^2 for rectangles are averaged for sections defined by:

If stat1 is the first two digits of "statistical rectangle" and stat4 is the two last then:

if stat4<F2 and stat1>39 and stat1<46 then section='cw';

if stat4>F1 and stat1>39 and stat1<46 then section='ce';

if stat4<F2 and stat1<40 and stat1>34 then section='sw';

if stat4>F1 and stat1<40 and stat1>34 then section='se';

if stat4<F2 and stat1>45 then section='nw';

if stat4>F1 and stat1>45 then section='ne';

if stat4>F8 then section='ka';

if stat1<35 then section='ch';

3. Averages of no-per-m^2 for subareas are multiplied by section-area factors defined by:

if section='cw' then af=28;

if section='ce' then af=33;

if section='sw' then af=12;

if section='se' then af=30;

if section='nw' then af=27;

if section='ne' then af=11;

if section='ka' then af=10;

if section='ch' then af=10;

miksec=section average in no-per-m^2 *af*3086913600;

4 The index is then the sum of all abundances in sections (which amount to an estimate of the total number of larvae)

IBTS0 = sum of miksec.

Summary of data missing and data excluded due to data inconsistencies: The following section contains information about the completeness of the survey data used to calculate the IBTS0 index over the years. The information has been gathered from the annual Herring Assessment Working Group reports where such issues are normally reported and are listed by year. Further details are available in the respective Working Group reports.

1977 Scottish data have no larvae length measurements and therefore no mean length.

1978 Swedish data have no larvae length measurements and therefore no mean length.

1983 North-western part not surveyed

2002 No French data available. Dutch data excluded from data base and index calculation

2010 Dutch data excluded from database and index calculation

2011 Swedish part of survey in IIIa not carried out

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 (Heath 1993; Schmidt *et al*., 2009). Larval abundance estimates derived from these surveys are used 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). The abundance of newly hatched larvae (less than 10 mm total lengt; 11 mm for the Southern North Sea) are used as the basis for 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 for a given time interval.

Multiplicative Larval Abundance Index (MLAI): The use of both LAI and LPE (Larval Production Estimates) estimates as indices of spawning stock biomass 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 1980s, these indices could not be calculated in their traditional form since 1994. Instead, a multiplicative model was developed 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 is done using the equation:

$$\ln(LAI_{year,LAI\ unit}) = MLAI_{year} + MLAI_{LAI\ unit} + u_{year,\ LAI\ unit}$$

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 $u_{year,\ LAI\ unit}$ are the corresponding residuals (Gröger *et al.*, 1999, 2000). The unit effects are setup so 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 the Larval Abundance Indices dervived above ($LAI_{year,\ LAI\ unit}$). The MLAI is updated annually and represents all larval data since 1972. The time series has previously been used as an spawning stock index of the spawning stock biomass in the herring assessment.

The MLAI, however, assumes that the sampling unit effects ($MLAI_{LAI\ unit}$) are constant throughout the time series: in response to this limitation, another larval abundance index (**SCAI- Spawning Component Abundance Index**) was developed (Payne 2010). The SCAI index, like MLAI, also models the LAIs as the basic data unit. However, rather than considering the sampling units as providing information about the entire stock, as in the MLAI, the SCAI considers them to be representative of the individual spawning components. Furthermore, the SCAI can be considered as analogous to a simple biomass model applied at the component level, and therefore autocorrelation is explicitly incorporated i.e. the abundance estimated in one year also provides information about the expected level in neighbouring years. Breaks in the time-series are therefore not a problem for the SCAI, as it can effectively "bridge" these the gaps in a sensible manner based upon the modelled auto-correlation structure. SCAI can therefore provide information about the dynamics of the individual components: summing these component-wise indices together therefore also provides an estimate of the abundance of the combined stock. 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.

When comparing the model fit of the SCAI and the MLAI, no significant differences occur. Both indices provide comparable survey trends on the SSB estimation. However, preference is given to the SCAI, as it give insight into the dynamics of the individual spawning components, in addition to the total spawning stock.

Details regarding the development and calculation of the SCAI index can be found in (Payne 2010). The code for generating the SCAI index is available on the herring stock assessment code repository, http://hawg.googlecode.com in the directory /trunk/NSAS/data/SCAI.

B.4. Commercial CPUE

Not used in this stock.

B.5. Other relevant data

B.5.1 Separation of North Sea Autumn Spawners and IIIa-type Spring Spawners

North Sea autumn spawners (NSAS) 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 (WBSS) and 0-2-ringers from the NSAS, including winter spawning Downs herring. In addition, several local spawning stocks have been identified with a minor importance for the herring fisheries (ICES, 2001a).

Priori to 1996, the method for separation of these components was based on the use of vertebral counts as described in former reports of this Working Group (ICES 1990). The method 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.

The method for separation of the herring stock components has developed the past decade. Prior to 1996, the splitting key used by ICES was calculated from a sample-based mean vertebral count using a cut-off algorithm for calculating the proportion of WBSS in a sample as MIN(1,MAX(0,(VSsample-55.8)/(56.5-55.8))), where VSsample is the sample mean vertebrae count and assuming a population mean VS of 55.8 for WBSS and 56.5 for NSAS. This method is still being used to split samples of Norwegian catches from the transfer area in IVa East. In the period from 1996 to 2001 splitting keys were constructed using information from a combination of vertebrae count and otolith microstructure (OM) methods (ICES, 2001a). From 2001 and onwards, the splitting keys have been constructed solely using the otolith microstructure method which uses visual inspection of season-specific daily increment pattern from the larval origin of the otolith, with the exception of the splitting key made for the mixture area in Sub Division IVaE, where vertebrae counts currently is the only method used to split the mixed stock (Mosegaard and Madsen, 1996; ICES, 2004; Clausen et al., 2007).

Otolith shape analysis has been used to discriminate between populations for a variety of species and for herring this approach has had increasing success with development of imaging techniques and statistical methods. Both temporal and geographical separation of populations give rise to variation in the shape of otoliths (Messieh, 1972; Lombarte, 1992; Arellano et al., 1995). These variations may suggest differences in the environmental conditions of the dominant habitats of populations within a species. However, both genetic and environmental influences have been reported as relevant in determining otolith shape (Cardinale et al., 2004). Using Fourier Series Shape Analysis on otoliths from Alaskan and northwest Atlantic herring, Bird et al. (1986) showed that otolith shape reflects population differences as well as differences between year classes of the same population. Sagittal otoliths have certain morphological features that are laid down early in the ontogeny of the fish (Gago, 1993), and measurements of internal otolith shape in adult herring has proven a powerful tool for stock discrimination (Burke et al., 2008).

Image analysis software (MATLAB) has been developed to automatically extract otolith contour curves and calculate 60x4 Elliptic Fourier Coefficients from one or two herring sagittal otoliths per image in batches with more than 1000 images.

From 2009 otolith shape analysis has been used as a supplementary method to increase sample size for estimating stock proportions of NSAS and WBSS in mixing areas of Division IIIa. For each assessment year individual population identity has been established by OM visual inspection and used as a baseline for assignment of shape characteristics to the involved stock components. A baseline of about 800-1200 otoliths with known hatch type has then been used as calibration in an age structured discriminant analysis where additionally 3000-4000 otolith shapes have been assigned to one of the two hatch types using a combination of shape Elliptic Fourier Coefficients, otolith metrics, fish metrics, length, weight and maturity as well as longitude, latitude, and seasonal parameters.

B.5.1.1. Validation

The purpose of classifying individual spawning type is to estimate proportions of the two major stock components, by age, in both catches and surveys from the different areas and seasons. Combining OM with otolith shape and fish meristic characters in a discriminant analysis approach is expected to increase precision of the estimated stock proportions. Validation of the shape and meristic based methodology was performed using samples of known spawning type from OM analysis.

OM and otolith shape data from the 2010 HAWG was used as a typical example of the procedure for estimating proportions of hatch type representing North Sea autumn and winter spawners and western Baltic spring spawners in the samples. The data was disaggregated into age groups 0, 1, 2 and 3+ and individuals of known autumn/winter or spring hatched types were used to assign the corresponding shape parameters and fish metrics from the same individuals by cross validated nonparametric nearest neighbour discriminant analysis.

The individual assignment of 1279 otoliths into known hatch type varied somewhat among hatch types and ages (2%-100%) but exhibited an overall error rate of 15.7% (see text table), however, more importantly, the average absolute error of the proportions of WBSS was only 2%, indicating the robustness of the method for up-scaling the baseline to the larger production sample.

Stock assignment data from 2009 commercial samples of herring in Division IIIa

		assigned to type		known type	estimated	deviasion		% error in	
Age group	known type	WBSS	NSAS	number	number	Individ. assignm.	prop.	Individ. assignm.	prop.
0	WBSS	34	13	47	44	13	3	27.7%	-6.4%
	NSAS	10	145	155	158	10	3	8.2%	1.9%
1	WBSS	188	72	260	254	72	6	27.7%	-2.3%
	NSAS	66	204	270	276	66	6	26.1%	2.2%
2	WBSS	288	14	302	305	14	3	4.6%	1.0%
	NSAS	17	3	20	17	17	3	82.4%	-15.0%
3+	WBSS	216	4	220	221	4	1	1.8%	0.5%
	NSAS	5	0	5	4	5	1	100.0%	-20.0%
		824	**455**	**1279**	**1279**	**201**	**26**	**15.7%**	**2.0%**

B.5.1.2. Conclusions

The two management stocks mixing in Division IIIa represent a complex underlying sub-population structuring, where local adaptation, especially in the WBSS component (Bekkevold et al., 2005) may drive an evolutionary divergence of otolith shape and create within-stock variation patterns. Nearest neighbour discriminant analysis has been chosen to avoid biased proportions in this situation; however the results still exhibit a small trend in the proportion error with changing proportions. The overall proportion error of 2% is in the order of, or less than, reported assignment errors using OM visual inspection (Clausen et al., 2007) and would probably increase precision of the total production sample in relation to the baseline. However the subject needs a more thorough analysis including all years in the emerging time series.

In the present case where distinction between two stocks may be based on genotypic as well as phenotypic expressions of contrasting life history characteristics, the chances of successful discrimination are substantial and appear to mainly depend on sampling effort.

The current vertebral count based estimation of WBSS in catches of herring in the transfer area of IVa East should be combined with an OM calibrated method exploiting differences in meristic characters among stocks such as maturity index, length-weight- age relationships etc. This appears to be a way forward to a more reliable estimate of the catches of WBSS in the North Sea.

The separation of Downs and other components of the NSAS are yet to be implemented and prior to such an increase in variables (and sources of uncertainty) comparative analysis of assessments with and without such splitting is needed. Such analyses are not yet a possibility and assessment models capable of running assessments on several stocks simultaneously are highly warranted. Analysis of the stock proportions and their sources of variation at different sampling levels is an important tool when planning the optimal sampling strategy for precise estimates of stock proportions at age.

B.5.2 Mixing of North Sea spawning components

The biomass of herring in the North Sea is dominated by autumn spawning fish (NSAS). The known spawning grounds, located along the east coast of Great Britain, show fine spatial structure (Dickey-Collas et al., 2010; Figure B.5.2.1) and significant events have occurred at the individual bank level (e.g. recolonisation of the Aberdeen bank ground (Corten, 1999), loss of the Dogger Bank population). However, the individual local spawning groups are typically grouped into four "spawning components" that spawn at four main locations: Orkney/Shetland; Buchan; Banks; and Downs. These spawning components exhibit different growth rates, meristic characteristics and recruitment patterns (Bjerkan, 1917; Cushing and Bridger, 1966). The different components mix during part of the year and most likely experience different fishing pressures but are assessed and managed as one unit (Simmonds, 2007). Genetic studies have not shown a clear distinction between the components of herring in the North Sea (Ruzzante et al., 2006; Gaggiotti et al., 2009). Despite a decline in abundance of several orders of magnitude during the stock collapse in the late 1970s (Cushing, 1992; Dickey-Collas et al., 2010), there has been no loss of genetic diversity (Mariani et al., 2005). The current definition of the North Sea herring stock of autumn and winter spawners as a single management unit appears to have operated well in the past (Reiss et al., 2009; Simmonds, 2009), despite changes in the relative strengths of the different spawning components and in their relative importance during collapse and recovery.

This complex sub-stock structure of North Sea herring, with its different spawning components, results in the production of offspring with different morphometric and physiological characteristics, different growth patterns and differing migration routes (see Figure B.5.2.1). A healthy North Sea herring stock is not just one where the fishing mortality on the stock is sustainable and the biomass of herring high enough to maintain successful recruitment and other ecosystem services (such as prey for top predators), but also where the phenotypic complexity and sub-stock structure is maintained, thus increasing the resilience of the population (see Schmidt et al., 2009).

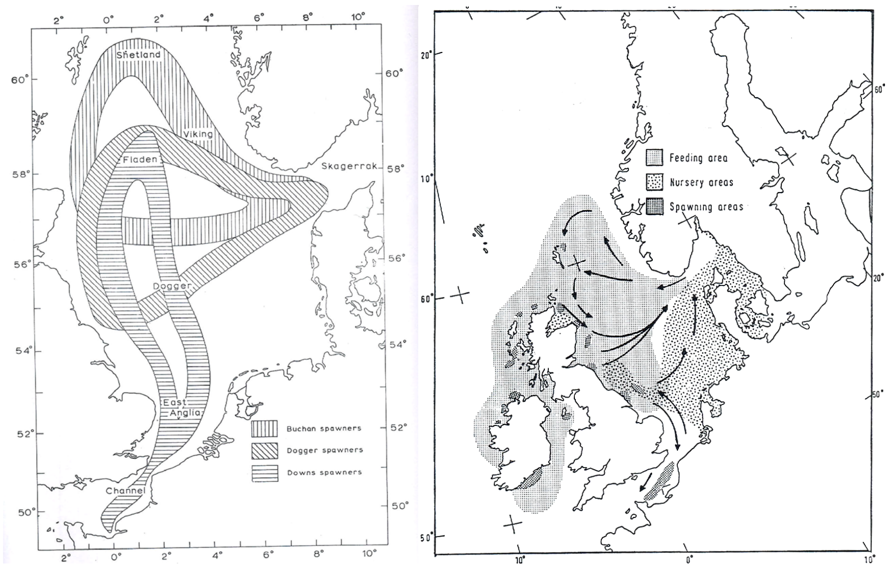

Figure B.5.2.1. Schematic of assumed generalised migration patterns of North Sea herring, taken from Cushing and Bridger (1966) and Burd (1978).

The productivity of the spawning components also varies. The three northern components show similar population trends and differ from the Downs component (Payne 2010); this appears to be influenced by different environmental drivers (Fässler et al., 2011). Although the different components mix outside their 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.

The individual spawning components have been surveyed on a regular basis by the annual international herring larval survey (IHLS) since the early 1970s (Heath, 1993). These surveys enable investigation of the dynamics of each component (Payne, 2010; Figure B5.2.2).

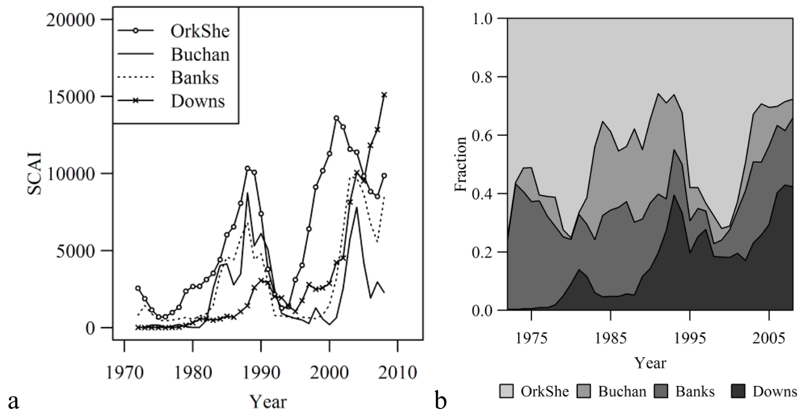

Figure B.5.2.2 a) Time series of spawning component abundance index (SCAI) for each individual component in the North Sea autumn spawning herring stock b) Time series of the fraction contribution of each spawning component to the total North-Sea autumn spawning herring stock, as estimated from the spawning component abundance indices (SCAIs). Shaded areas are arranged from top to bottom according to the north-to-south arrangement of the components.

The individual components each follow a broad trend reflecting that of the total stock (i.e. collapse in the late 1970s, peaks in around 1990 and 2000. Appreciable differences also exist, especially between the winter spawning Downs and the other autumn spawning components, leading to the contribution to the stock by each component varying over time (Figure B.5.2.2). The Orkney/Shetland component is generally the largest but its contribution has varied between 25% and 80%, whereas, the Downs component has varied from almost negligible in the 1970s to 40% of the stock in recent times (Payne, 2010). In some years there may be a gradient in the spatial distribution by component but this is not true for all years (Bierman *et al.*, 2010).

The variation in the component abundances has important implications for the input of NSAS juveniles into sub-division IIIa. Each component represents a spatially and temporally different starting point for the larvae that are ultimately observed in the Skagerrak as juveniles. In making the transition from spawning ground to nursery ground, the different components will experience different conditions (food availability, temperature, and predation) along the way. Accounting for these differences in both starting points and the number of larvae seeded is therefore critical to predicting the number of individuals that make it to the nursery grounds.

In addition there are still historic spawning grounds that have not been recolonised since the collapse of the herring stock in the 1970s (Figure B.5.2.3; taken from Corten 2002).

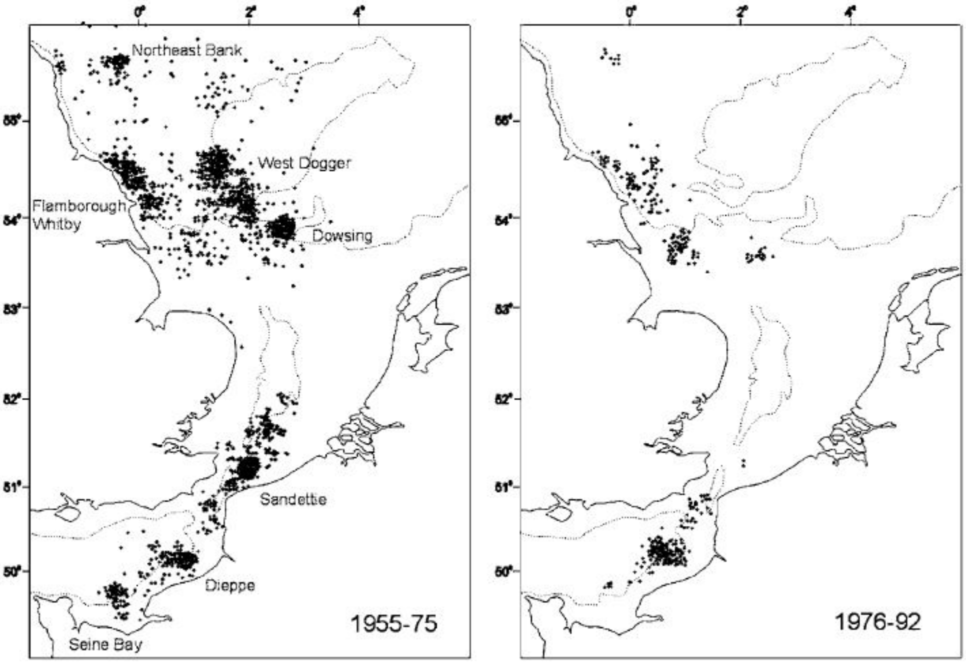

Figure B.5.2.3. The number of spawning grounds in the central and southern North Sea. Each dot represents a catch of spawning herring. Data combined from Dutch fisheries from before the stock collapse (1955–1975) and for the period of the recovery (1976–1992). From Corten 2002.

C. Historical Stock Development

C.1. Choice of Stock assessment model

The North Sea autumn spawning (NSAS) herring stock was assessed using the assessment model ICA (Statistical Catch at Age with a separable period and VPA part) from the mid 1990s until 2011. Despite the computational limitations when the model was first created, it was generally regarded as performing well and was considered 'ahead of its time'. However, in later years, a number of technical problems with this assessment became apparent, including non-convergence of the model, its ability to only take a maximum of fifty-nine years of data, the inability to fix technical issues (the core minimisation library is no longer maintained resulting in the inability to compile the ICA Fortran code). Advances in computational power and the development of new assessment methods ultimately led to this model being superseded.

The WKPELA benchmark meeting in February 2012 developed and evaluated the "state-space" modelling approach for NSAS herring. This modelling framework has a number of highly desirable characteristics, such as the stochastic treatment of all observations, a full statistical framework for evaluating model results, open source and cross platform source code, and an extremely high degree of flexibility allowing ready customisation to the peculiarities of the stock. The state-state approach was first pioneered by Gudmundsson (1987; 1994) and Fryer (2002): however, the computationally intensive nature of the method has meant that state-space models have hereto not yet become widespread. Recent advances in both software and hardware in recent years have, however, opened the door to these approaches.

C.2. Model used as basis for advice:

The NSAS herring assessment model is based on the state-space assessment model (SAM) (Nielsen et al., 2012). Version details and model configuration are listed below.

Technical details of the SAM framework can be found in the peer-reviewed literature (Nielsen *et al*., 2012)

SAM Model details:

The SAM source code is available from the "Stock assessment" version control repository, http://code.google.com/p/stockassessment/ : the code used corresponds to revision 7.

Scripts, packages and running environment

The SAM environment detailed above is encapsulated into the Fisheries Library in R (FLR) (Kell *et al*., 2007) in the form of the package "FLSAM". All assessments are performed with version 0.50 (2012-02-29) of FLSAM, together with version 2.4 of the FLR library (FLCore). The FLCore and FLSAM packages are hosted under version control at the "R-forge" repository, https://r-forge.r-project.org/projects/flr/ Built packages of FLSAM are available from the HAWG stock assessment repository, http://hawg.googlecode.com. All scripts to perform the assessment are available from the same location in the folder "/trunk/NSAS".

C.3. Assessment model configuration

Input data types and characteristics

(Y=data year)

Name	*Type*	*Year range*	*Age range*	*Data Modifications*	*Variable from year to year?*
Caton	*Catch in tonnes*	*1947 to Y*	-	-	*Yes*
Canum	*Catch-at-age in numbers*	*1947 to Y*	*0-8+*	*See note 1*	*Yes*
Weca	*Weight-at-age in the commercial catch*	*1947 to Y*	*0-8+*	-	*Yes*
West	*Weight-at-age of the spawning stock at spawning time.*	*1947 to Y*	*0-8+*	*See note 2*	*Yes*
Mprop	*Proportion of natural mortality before spawning*	*1947 to Y*	*0-8+*	-	*No*
Fprop	*Proportion of fishing mortality before spawning*	*1947 to Y*	*0-8+*	-	*No*
Matprop	*Proportion mature-at-age*	*1947 to Y*	*0-8+*	-	*Yes (from 1983 onwards: constant prior to this)*
Natmor	*Natural mortality*	*1963 to 2010*	*0-8+*	*See note 3*	*Yes*

[1] Catch-at-age data for the years 1978-1979 are exclude from the assessment model fit. All other data, including the fishery-independent surveys, are included.

[2] The procedure to calculate the weight-at-age in the stock (*west*), given a set of weight-at-age values as calculated from the acoustic survey, has been standardised and applied uniformly to the raw data. *West* values used in the assessment are calculated as the running mean of data in the assessment year together with the preceding two years (*i.e.*, $s_i=(w_{i-2}+w_{i-1}+w)/3$, where s_i is the smoothed weight and w_i is the raw weight in year *i*)

[3] Natural mortality estimates are derived from the SMS model used in WGSAM (ICES, 2011). The input data to the assessment are then smoothed values (loess smoother, span=0.5, order=2) of the raw SMS model annual *M* values, which are vari-

able both at-age and over the time period 1963 – 2010. Natural morality in years outside this time-period are filled and estimated for each age as a five year running mean in the forward direction for 2011+ (*i.e.* $m_i = (M_{i-1}+M_{i-2}+M_{i-3}+M_{i-4}+M_{i-5})/5$ where m_i is the smoothed natural mortality and M_i is the raw natural mortality in year *i*) and in the reverse direction for years prior to 1963 i.e. $m_i = (M_{i+1}+M_{i+2}+M_{i+3}+M_{i+4}+M_{i+5})/5$. There is currently no agreed approach about how to handle revisions to the natural mortality time series: this issue will need to be reviewed when new estimates become available.

Type	*Name*	*Year range*	*Age range (wr)*
Tuning fleet	***IBTS Q1***	***1984 to Y+1***	***1***
Tuning fleet	***IBTS-0***	***1992 to Y+1***	***0***
Tuning fleet	***HERAS***	***1989 to Y*** ***(1997 to Y for age 1)***	***1-8+***
Tuning fleet	***SCAI***	***1972 to Y***	***SSB***

Many of the data time series are made available with a 9+ age group. In such situations, an age 8+ plus group value is produced by arithmetic sum of age 8 and 9 for numbers-at-age variables and an arithmetic mean for other variables.

Model configuration

An example of the SAM model configurations used in the FLSAM package, for the 2011 assessment, is given below. Note that the "maxyear" argument in the range slot should be set to value of the intermediate year in other situations

```
An object of class "FLSAM.control"

Slot "name":

[1] "NSAS Herring"

Slot "desc":

[1] "North Sea Autumn Spawning Herring Assessment"

Slot "range":

     min      max plusgroup   minyear   maxyear   minfbar   maxfbar

       0        8         8      1947      2011         2         6

Slot "fleets":

  catch    SCAI   HERAS IBTS-Q1   IBTS0

      0       3       2       2       2

Slot "plus.group":

plusgroup

     TRUE

Slot "states":

        age

  fleet   0 1 2 3 4 5 6 7 8

  catch   1 2 3 4 5 6 7 8 8

  SCAI    NA NA NA NA NA NA NA NA NA
```

```
 HERAS   NA NA NA NA NA NA NA NA NA
 IBTS-Q1 NA NA NA NA NA NA NA NA NA
 IBTS0   NA NA NA NA NA NA NA NA NA
Slot "logN.vars":
0 1 2 3 4 5 6 7 8
1 2 2 2 2 2 2 2 2
Slot "catchabilities":
       age
 fleet    0  1  2  3  4  5  6  7  8
 catch   NA NA NA NA NA NA NA NA NA
 SCAI    NA NA NA NA NA NA NA NA NA
 HERAS   NA  3  3  4  4  5  5  5  5
 IBTS-Q1 NA  1 NA NA NA NA NA NA NA
 IBTS0    2 NA NA NA NA NA NA NA NA
Slot "power.law.exps":
       age
 fleet    0  1  2  3  4  5  6  7  8
 catch   NA NA NA NA NA NA NA NA NA
 SCAI    NA NA NA NA NA NA NA NA NA
 HERAS   NA NA NA NA NA NA NA NA NA
 IBTS-Q1 NA NA NA NA NA NA NA NA NA
 IBTS0   NA NA NA NA NA NA NA NA NA
Slot "f.vars":
       age
 fleet    0  1  2  3  4  5  6  7  8
 catch    1  1  2  2  3  3  4  4  4
 SCAI    NA NA NA NA NA NA NA NA NA
 HERAS   NA NA NA NA NA NA NA NA NA
 IBTS-Q1 NA NA NA NA NA NA NA NA NA
 IBTS0   NA NA NA NA NA NA NA NA NA
Slot "obs.vars":
       age
 fleet    0  1  2  3  4  5  6  7  8
 catch    3  4  4  4  4  4  6  6  6
 SCAI    NA NA NA NA NA NA NA NA NA
 HERAS   NA  4  5  5  5  5  6  6  6
```

```
 IBTS-Q1 NA  1 NA NA NA NA NA NA NA
 IBTS0    2 NA NA NA NA NA NA NA NA
Slot "srr":
[1] 0
Slot "timeout":
[1] 3600
```

This example configuration encapsulates the following configuration options and bindings:

Minimum age 0, maximum age 8

The model is configured to cover the full time series of catch data plus the intermediate year i.e. from 1947 to the intermediate year. In the above example, the intermediate year is 2011.

Mean fishing mortality is defined as ages 2-6

The four data sources are included in the following manner

"Catch at age" observations are treated as a fishing fleet (fleet =0)

The SCAI index is treated as an SSB index (fleet=3)

The HERAS, IBTS-Q1 and IBTS0 indices are treated as numbers-at-age indices (fleet=2)

The oldest age (8) is treated as a plus group. This is specified in the range slot, and again in the "plus.group" slot

The fishing mortalities at each age are estimated by independent random walks (one for each age), with the exception of ages 7 and 8+, which are represented by a single common random walk. This is expressed in the model configuration above by binding the "state" parameters for ages 7 and 8.

The variances in the estimated numbers at age (logN.vars) are represented by two parameters – one variance for the age 0 numbers and a second for the other ages.

Catchabilities of the individual surveys are bound as follows:

The IBTS 1Q and IBTS0 surveys, each of which contain only a single age group, are represented each with a single catchability parameter (catchabilities slot)

The HERAS survey is represented by three catchability parameters: one for ages 1-2, one for ages 3-4 and one for ages 5-8 (catchabilities slot)

All observations are represented with a linear relationship (i.e. no parameters activated in the "power-law" slot)

The variances of the fishing mortality random walks (f.vars) are bound together in sequential-age pairs i.e. four parameters are used, one for age 0-1, one for age 2-3, one for age 4-5, and one for age 6-8

The observation variances of the surveys (obs.vars slot) are bound as follows:

Both the IBTS-1Q and IBTS0 indices are fitted with their own observation variances

The HERAS observation variances are bound into three groups: one covering age 1 on its own, one for ages 2-5 and one for ages 6-8+.

The catch observation variances are also bound into three groups: one covering age 0 on its own, one for ages 1-5, and one for ages 6-8+.

No stock-recruitment relationship is imposed upon the model i.e the "srr" slot is set equal to 0.

The model is not allowed to use more than one hour to converge ie the "timeout" slot is set of 3600

Other notes

Survey data in the intermediate year should be included wherever possible. In particular, the IBTS-1Q and IBTS0 surveys performed in January and February should be ready in time for the assessment meeting (typically in March).

There is no method in the current version of SAM to explicitly bind or alter the representation of the SCAI SSB index in the model, i.e. the catchabilities, observation variances and use of a power-law model

It is not possible with the current configuration of the SAM framework to reliably estimate the fishing mortality around the time of the closure of the fishery (late 1970s) as the associated rapid changes in F are a clear violation of the model assumptions. Catch data from 1978-1979 are excluded from the assessment for this reason. Furthermore, the fishing mortalities estimated by the model during this time are not considered reliable and therefore F values from 1977-1980 should not be reported. SSB and recruitment, however, can still be estimated during this period (albeit with increased uncertainties). Stock summary plots and tables should be adjusted manually to reflect these limitations.

D. Short-Term Projection

A multi-fleet, multi-option, deterministic short-term prediction tool (MFSP) has been used for many years and an FLR implementation of the tool has replaced the MFSP from 2009 onwards. 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 works well. The FLR implementation has been extended to allow Monte-Carlo simulations, enabling a stochastic approach by varying population parameters. The stochastic approach is used for illustration purposes only while the deterministic approach is used to provide advice.

Method

Both the Short Term Forecast Module North Sea (STFMNS, Hintzen) and the MFSP program were extensively tested in 2009 to ensure that they both gave identical results. For the North Sea herring stock, managers have agreed to constrain the total out-take 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. In total four fleets are considered; a dedicated human consumption fishery in the North Sea, an industrial fishery in the North Sea, a dedicated human consumption fishery in IIIa also taking NSAS, and an industrial fishery in IIIa also taking NSAS. In the short term predictions, recruitment in the TAC year (intermediate year) is taken directly as predicted from the assessment model, and recruitment in the advice year is assumed similar to the recruitment regime of lower productivity since 2002.

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 those defined in Section A.2 above.

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 the table below:

Type	*Name*	*Basis*
Weca	***Weight-at-age in the commercial catch***	***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***
West	***Weight-at-age of the spawning stock at spawning time.***	***The weights at age applied in the last assessment year are used for all prediction years. These are running averages of the raw data calculated as the running mean of data in the assessment year (Y) together with the preceding two years (i.e., Y-2,Y-1,Y)***
F	***Fishing mortality-at-age in the stock***	***Selection by fleet-at-age is calculated by splitting the total fishing mortality in the assessment year at each age proportionally to the catch numbers by fleets at that age. These selections-at-age are used for all years in the prediction. For illustration purposes only: Variability in the total fishing mortality is generated from a multi-variate random distribution informed by the variance-co-variance matrix as obtained from the assessment output***
N	***Stock numbers***	***For the start of the intermediate year the stock numbers at age by 1. Jan that year are taken from the calculateions made by SAM. For illustration purposes only:Variability in the numbers-at-age is generated from a multi-variate random distribution informed by the variance-co-variance matrix as obtained from the assessment output***
Mprop	***Proportion of natural mortality before spawning***	***Standard value of 0.67***
Fprop	***Proportion of fishing mortality before spawning***	***Standard value of 0.67***
Matprop	***Proportion mature-at-age***	***Average of maturity-at-age of the most recent three years. For illustration purposes only:Varies over time by sampling from historic observations on maturity-at-age values***
Natmor	***Natural mortality***	***Average of mortality-at-age of the most recent five years from the smoothed SMS output***
R	Recruitment in Intermediate (Y+1), Advice(Y+2) and Continuation (Y+3) years	***Recruitment in the intermediate year is estimated inside the SAM assessment model. Recruitment in the advice and continuation year[1] is calculated as the weighted geometric mean of the years 2002 to year Y. The inverse variance estimate, obtained from SAM, is used as weighting criteria. For illustration purposes only:Variability in the stock numbers propagates through in the recruitment estimates.***

[1] For the prediction years, the recruitment has, in recent years, been set to the geometric mean of the recruitments of the year classes from 2002 onwards, as estimated in the assessment of the data year. The low recruitment was assumed because all the year classes from 2002 onwards have been poor except for 2008 year class. Analysis of the time series of SSB and recruitment data by the SGRECVAP (ICES, 2006) clearly indicates a shift in the recruitment success after 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.

Prediction

Assumptions for the intermediate year.

A-fleet: The TAC for the A fleet has been over-fished every year since 2003 until 2008. Since 2009 however, there is no indication of over-fishing anymore. Hence, catches equal the TAC in the intermediate year.

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 fraction of the TAC in the intermediate year is assumed to be equal to the fraction used in the assessment year. Also the C and D fleets have NSAS catches well below the total Division IIIa 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.

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 (ICES, 2008). The revised rule specifies fishing mortalities for juveniles (F0-1) and for adults (F2-6) 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

F2-6 = 0.25-(0.15*(1500-SSB)/700),

with allowance for a stronger reduction in TAC if necessary. Below 0.8 million tonnes F2-6 = 0.1 and F0-1 = 0.04.

Furthermore, there is a constraint at 15% change in the TAC from one year to the next. The F0-1 and F2-6 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. For example, 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 the average of the last 3 years, 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 the average of the last 3 years. 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 by a numerical minimisation.

E. Medium-Term Projections

Medium-term projections are not carried out for this stock

F. Long-Term Projections

Long-term projections are not carried out for this stock

G. Biological Reference Points

The North Sea herring is nominally being managed by a precautionary management plan. It has been considered that the critical issue is identifying the risk of SSB falling below Blim. The following sections on limit reference points 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.

	Type	Value	Technical basis
Management plan	F_{MP}	$F_{0-1} = 0.05$ $F_{2-6} = 0.25$	If SSB greater than SSB_{MP} upper trigger of 1.5 million t (based on simulations).
		$F_{0-1} = 0.05$ $F_{2-6} = 0.25 - (0.15*(1500000-SSB)/700000)$	If SSB between SSB_{MP} triggers 0.8 and 1.5 million t (based on simulations).
		$F_{0-1} = 0.04$ $F_{2-6} = 0.10$	If SSB less than SSB_{MP} lower trigger of 0.8 million t (based on simulations).
MSY Approach	MSY $B_{trigger}$	not defined	
	F_{MSY}	0.25	Simulations under different productivity regimes, research between 1996 and 2010.
Precautionary approach	B_{lim}	800 000 t	< 0.8 million t; poor recruitment has been experienced. Defined in 1997/2008.
	B_{pa}	1.3 million t	B trigger in the previous harvest control rule.
	F_{lim}	not defined	
	F_{pa}	$F_{2-6} = 0.25$	Target Fs in the harvest control rule.

The benchmark assessment performed in WKPELA 2012 revised the perception of the stock and the current management plan is preconditioned on the former perception of the stock from the then applied assessment methodology. HAWG question the validity of the current management plan. The analysis carried out by WKPELA 2012 implies that the reference points for NSAS may have shifted under the perception of the stock assessment and thus a full revision of the existing management plan for NSAS is highly warranted.

Currently the reference points listed in the above table are considered appropriate for the NSAS stock until revised in the upcoming MSE.

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, 2002). 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 an evaluation of a harvest rule, one will use simulations with a 'virtual stock' which as far as possible resembles the stock in question to evaluate the risk 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.

The current management plan for NSAS is due revision in 2012.

MSY framework for North Sea herring

There is no ICES MSY framework biomass trigger point for this stock as the MP is thought to have primacy over the ICES MSY framework when providing advice.

In 2010 ACOM agreed with HAWG that Fmsy for NSAS was 0.25. This was supported by WKFRAME2. The analyses carried out by WKPELA 2012 suggested that MSY reference points may vary over time. Further, WKPELA suggested that a minor increase in Fmsy might be appropriate given the increase in SSB resulting from the FLSAM benchmark assessment. An Fmsy around 0.3 was considered. However, associated uncertainty with the WKPELA Fmsy has not yet been estimated. Such estimate is required to determine whether the WKPELA proposed estimate is significantly different from the ACOM agreed Fmsy. Therefore, and until a full evaluation of Fmsy under the current perception of the stock is carried out, Fmsy for NSAS remains = 0.25.

Concept of precautionary reference points

Conceptually, precautionary reference points 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, 2002). 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 have been 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. 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 has considered that the parameters of the management plan should take primacy over the management against precautionary reference points F_{pa} or B_{pa}.

The precautionary reference points for this stock were adopted in 1998. The analysis carried out by WKPELA 2012 implies that the reference points have shifted under the perception of the stock assessment, thus a thorough scientific process is necessary to revise the existing reference points.

Concept of precautionary reference points

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H. Other Issues

H.1 Biology of the species in the North Sea

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 (Geffen, 2009). Herring evolved from fish that spawned in rivers and at some later date re-adapted to the marine environment (Geffen, 2009). The herring's unique habit is that it produces benthic eggs which are attached to a gravely substrate on the seabed (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 Islands 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 a teleost. 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. In other regions there is evidence of large interannual variability of egg mortality (Richardson et al., 2011). The larvae on hatching are 6 mm to 9 mm long and rise, due to buoyancy changes, in the water column 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). The environmental impact during this phase is crucial to life cycle closure and probably controls the spawning season of the components (Hufnagl & Peck 2011).

Herring continue to be mainly planktonic feeders throughout their life 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 euphausiids, 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, 1989).

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 1950s. The International Council for the Exploration of the Sea (ICES) encouraged tagging and other studies for separating the spawning components and a review of all the historic evidence to resolve this problem and innovative approaches to assessing mixed and connective stocks (Kell et al., 2009; Secor 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 spawns 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 spawns 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 derives its name from its 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 four 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 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.

In recent decades, recruitment strength is determined during the larval phase (Nash and Dickey-Collas, 2005; Oeberst et al., 2009) and larval mortality in the first few weeks of life, although differing between components, co-varies with recruitment strength (Fassler et al., 2011).

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 accessibility and responses to markets, particularly the demand from urban populations in the nineteenth century and for fish meal and oil in the twentieth century. 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 1950s when the spawning stock biomass of North Sea autumn spawning herring fell from above 4 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 1960s 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.

Figure H.2.1 illustrates the dynamics in modelled selectivity (F/Fbar) over the past 60 years, shown by age and year in pentads (five year groupings). It is evident that the fishing mortality imposed on the NSAS is quite variable even on a yearly scale, though general patterns can be discerned for the specific age-groups.

Fishing mortality on the herring in the central and northern North Sea began to increase rapidly in the late 1960s 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 300 000 t (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).

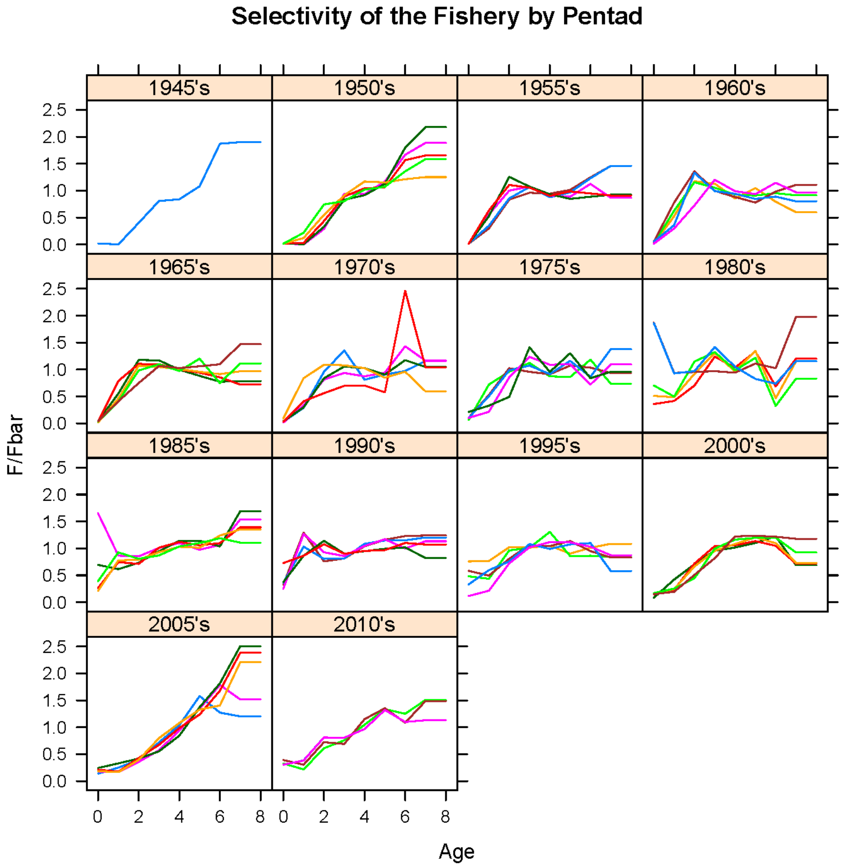

Figure H.2.: Selectivity (F/Fbar) over the past 60 years, shown by age and year (each year in individual colours) in pentads

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 re-opened 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 re-opening 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 Fages 2-6 = 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 Fages 2-6=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 averaging 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 increase in natural mortality induced by the disease was insignificant.

The increased fishing pressure during the first half of the 1990s 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 1970s. 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 overly optimistic perception of the size of the spawning stock. It was, for example, 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.

The herring stock apparently recovered during the late 2000s and in 2011 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, and the minimal amount of target species in the EU industrial fisheries in IIIa was reduced to 50% (for sprat, blue whiting and Norway pout).

H.3 Current Fisheries

There are at least four techniques used to fish for herring in the North Sea:

i. Human consumption fishery using mid-water trawl by single or pair RSW (refrigerated seawater) trawlers (mesh size 40-44 mm). These are not allowed to carry sorting equipment on board and thus cannot process the catch whilst at sea (other than emptying tanks or slipping catch from the net). They either land their catch as caught or pass it on to a processing vessel. Their catching potential is limited by the size of their tanks. This fishery is operated by vessels from the UK- Scotland, Denmark and Norway.

ii. Human consumption fishery using mid-water trawl by single or paired pelagic freezer trawlers (mesh size 40 mm). These catch and then process on-board, off-loading frozen blocks of sorted and categorised fish. Their catching potential is limited by their processing capacity, usually 200-250 tonnes per day. This fishery is operated by vessels from Germany, The Netherlands, France and UK-England.

iii. Human consumption fishery using purse seine by RSW trawlers. Purse seine nets are used to encircle the shoals of herring rather than chase them with trawls. These vessels do not carry sorting equipment. Their catching potential is limited by the size of their tanks. This fishery is operated by vessels from Norway, Sweden and Denmark.

iv. Industrial fishery as bycatch. The herring is caught when targeting sprat or Norway pout using mid-water trawls with fine mesh nets (<32mm). Their catching potential is limited by the size of their tanks and a maximum bycatch percentage of herring. This fishery is operated by Denmark.

All of these fishing methods use fishers experience and acoustic techniques to find the shoals of fish. The mid-water trawls (single and paired) and purse seines are damaged if contact is made with the seabed. The fleets are characterised by a few vessels (all >40m), with even fewer owners. For example the German, Dutch, English and biggest French vessels are all owned by three companies operating out of the Netherlands.

H.4 Management and ICES advice

Management plan

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 t was set above which the TACs would be based on an F= 0.25 for adult herring and F= 0.12 for juveniles. If the SSB fell below 1.3 million tonnes, other measures would be agreed and implemented taking account of scientific advice. A management plan was agreed by EU and Norway in 2008. ICES evaluated this management plan and concluded that the plan was consistent with the precautionary approach and the MSY approach. The stock is managed according to this EU-Norway Management agreement, the relevant parts of the text are included here for reference:

Annex 3: 1. Every effort shall be made to maintain a minimum level of Spawning Stock Biomass (SSB) greater than 800 000 tonnes (B_{lim}).

Annex 4: 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.

Annex 5: 3. Where the SSB is estimated to be below 1.5 million tonnes but above 800 000 tonnes, the Parties agree to set quotas for the direct fishery and for bycatches in other fisheries, reflecting a fishing mortality rate on 2 ringers and older equal to:

Annex 6: 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

Annex 7: 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.

Annex 8: 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.

Annex 9: 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.

Annex 10: 7. By-catches of herring may only be landed in ports where adequate sampling schemes to effectively monitor the landings have been set up. All catches landed shall be deducted from the respective quotas set, and the fisheries shall be stopped immediately in the event that the quotas are exhausted.

Annex 11: 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.

Annex 12: 9. A review of this arrangement shall take place no later than 31 December 2011.

Annex 13: 10. This arrangement enters into force on 1 January 2009.

The EU–Norway agreement calls for a review of the current plan no later than December 2011. This has however not been performed and the demand for a full scale Management Strategy Evaluation and thus a revision of the North Sea Herring Management Plan has now increased considerably in the light of the changes made in the benchmark assessment performed in WKPELA 2012. The benchmark assessment has led to considerable revisions the perception of the stock and suggests that Fmsy as well as a target-F should be reconsidered, and thus the harvest control rules for the stock need evaluation against exceptional variations in biology, testing for robustness under varying starting conditions in population size and changes in the North Sea Ecosystem. This should be done as a collaborative iterative process between scientists, managers and stakeholders. To facilitate the process, it would be useful if the trade-off between the objectives of stability and long term yield could be expressed clearly.

Spawning component diversity

As noted above, the North Sea herring stock can effectively be viewed as a meta-population consisting of at least four unique sub-populations (and potentially more). Maintaining the diversity of spawning components is widely recognized as being crucial to the successful and sustainable exploitation of herring stocks. Large differences in exploitation pressures between the components in the past has lead to wide changes in the composition of the total stock e.g. prior to 1980, the Downs component comprised less than a few percent of the total stock, whereas in 2010 it was nearly 50% (Cushing 1992; Payne 2010).

Traditionally the EU sets a separate sub-TAC, from within its own North Sea herring TAC, for the southern North Sea and eastern English Channel. This is designed to protect the Downs spawning component as it aggregates to spawn. Downs herring is assumed to be more susceptible to the impacts of exploitation (Cushing, 1992). This sub-TAC is re-negotiated every year and is generally fixed at approximately 11-14% of the total TAC (EU and Norway; see Council regulation (EU) No 57/2011).

The working group responsible therefore needs to provide advice regarding the current component diversity of the stock. The SCAI indices are currently the main source of information in this regard, and therefore should be presented as part of the advice for this stock. Other indicators, where available, should also be presented alongside the SCAI.

Other Management measures

There are other management tools currently used for the North Sea herring fishery:

i. Minimum landing size for herring for human consumption fisheries of 20cm in the North Sea (Council regulation (EC) No 850/98).

ii. Closed areas for both herring and/or sprat fisheries to protect either spawning or juveniles (Council regulation (EC) No 850/98). These closed areas are relatively small and localised, and usually seasonal (Figure H.3.1).

iii. The industrial fishery is not only limited by the bycatch ceiling which is set every year based on the EU/Norway management plan (Council regulation (EU) No 57/2011) but also by a by-catch percentage for each haul. This was initially set such that 10% of the catch of the sprat can be herring (Council regulation (EC) No 850/98) but in recent years this by-catch proportion has been increased to 20% of the catch as the total mixed catch has declined.

iv. In 2009, the EU and Norway agreed a ban on high grading in the North Sea and eastern English Channel (Council Regulation (EC) No 43/2009). This prevented the discarding of fish of a size that could be landed for which there was still quota available.

Within and between the countries in the fishery, the TAC is greatly swapped, with ITQs (or de facto ITQs) in most countries and some countries selling much of their annual quota (e.g. Belgium). As the fishery catches against an area TAC and the advice is for a stock TAC, the landings against the TAC do not completely reflect the exploitation on the stock, or the true catches from the stock. Fisheries scientists reallocate catch from areas IV and IIIa, based on sampling, to determine the catches from the stock. In addition, there are two boundary areas where misreporting has been a problem: ICES areas IV/IIIa and IVa/VIa. There are different regulatory solutions to each. Area-misreporting from catches taken in ICES area IV to IIIa is allowed through EU/Norway agreements, i.e. herring caught in IV can be written off against IIIa quota. In contrast, in the northern North Sea there are specific licensing regulations to prevent area misreporting, that control the landing of herring catches from and at the border of ICES areas IVa and Via.

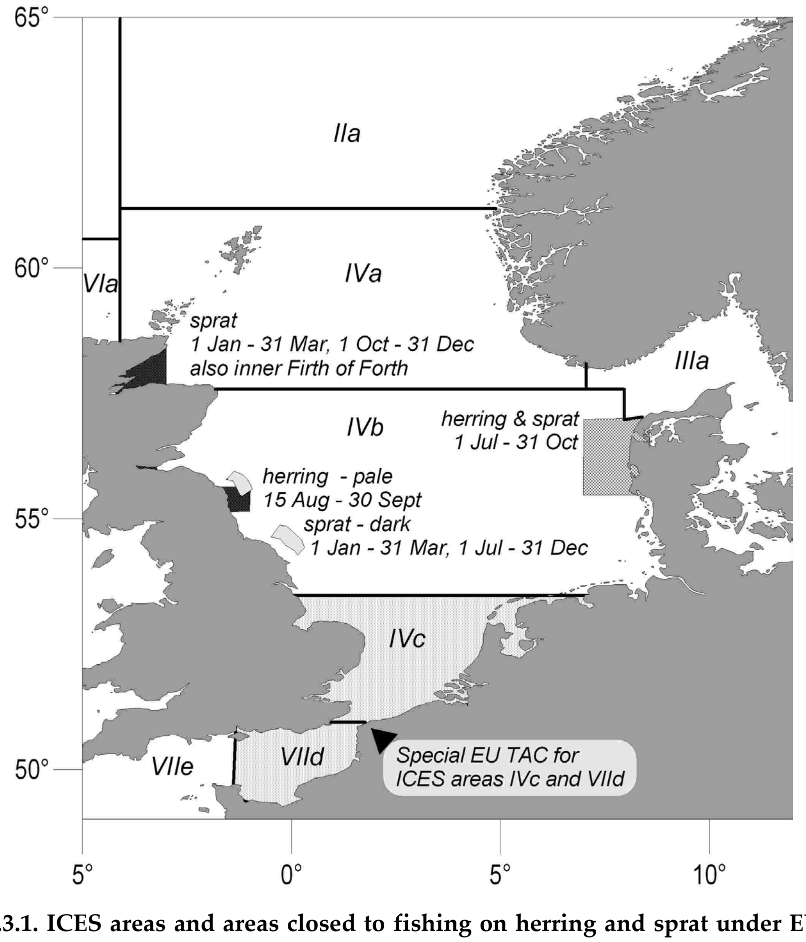

Figure H.3.1. ICES areas and areas closed to fishing on herring and sprat under EU legislation. Black areas denote three small sprat closures to protect juvenile herring. Pale areas denote two closures on the herring fisheries to protect spawning herring around the Banks spawning ground. The shaded area to the west of Denmark is closed to the juvenile herring and the sprat fishery (although there is no targeted juvenile herring fishery).

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) 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 Groups reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating west-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES Working Groups, there might be a case for a uniform system of age definition throughout all ICES Working Groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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Annex 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: Area	Herring Assessment Working Group for the 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 (Sub-division 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, sub-division 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 gill-nets 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.

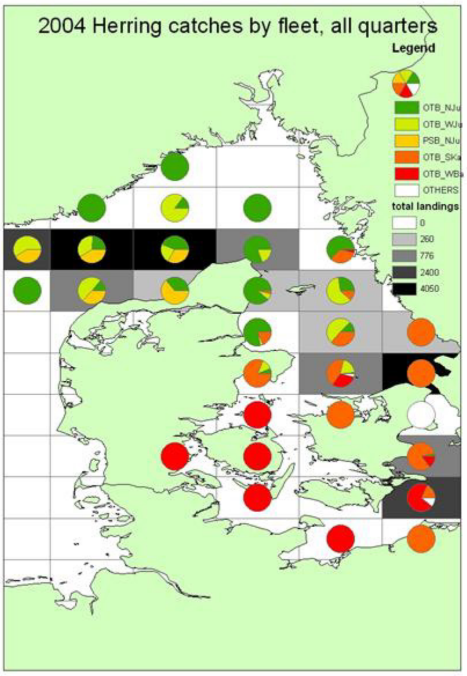

Figure A.2.1 Danish landings in IIIa by vessel and homeport.

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 Div. IIIa is part of the North Sea and Div. IIIa bottom trawl survey carried out in the 1st and 3rd quarter. The IBTS has been conducted annually in the 1st quarter since 1977 and 3rd quarters from 1991. From 1983 and onwards the survey was standardised according to the IBTS manual (ICES 2002/D:03). During the HAWG 2002 the IBTS survey data (both quarter) were revised from 1991 to 2002. Historical catch rates are heavily skewed and therefore the survey indices by winter rings 1-5 were calculated as geometric means from observed abundances ($n \cdot h^{-1}$) at age at trawl stations. However, inspections of the distributions of CPUE ($n \cdot h^{-1}$) reveals that they are characterized by a relatively large number of low values, including true zeroes, but also occasional catches comprising large number of individuals. Statistical inference based on such data is likely to be inefficient or wrong unless an appropriate distribution is carefully chosen. Generally, a quasi-Poisson distribution (with a log-link function in order to constraint the estimates of CPUE to be positive) and a so called zero inflated models (Minami et al. 2006; Martin et al., 2005) are used. While quasi-Poisson can treat zeroes and non-zeroes in the same models, zero-inflated models are expressed in two parts: the probability of being in a 'perfect-state' (e.g., no catch), and the probability of being in an 'imperfect-state' where positive events (e.g., catch) may occur (Minami et al. 2006). The perfect-state is usually modeled with a logistic, and a quasi-Poisson or a negative binomial distribution is assumed for the imperfect state. Those models are usually referred to as zero-inflated (ZIP and ZINB) models. Zero-inflated models are also attractive because they make a distinction between covariates associated with the perfect state (no catch) and covariates associated with the imperfect state in which catch can occur, but is not certain. Analysis is ongoing to test the use of ZIP and ZINB for estimating catch at age from

IBTS dataset to be included in the next benchmark assessment. Thus, the IBTS 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 Div.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 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:

$$\begin{aligned}\text{Risk} &= P(\text{harmful event}) \times \text{severity of harmful event} \\ &= P(\text{lower SSB limit undercut}) \times \text{EL}\end{aligned} \quad (1)$$

with expected loss (EL) being defined as

$$\text{EL} = E[\text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}} \mid \text{SSB}_{\text{estimated}} < \text{SSB}_{\text{lower limit}}] \ . \quad (2)$$

While this definition of risk is not only implemented as part of many national constitutions (for instance, of the German constitution; Schuldt 1997, Schulte 1999, Schulz *et al.* 2001) but is also commonly used in engineering, in natural or environmental sciences or in medicine (see, for instance, Burgmann 2004), in mathematical sciences however P (harmful event) is often solely used as a definition for risk. As we aim at specifying costs or loss from a political and economic perspective, Eq. (1) turns out to be the appropriate risk measure, as it contains a probability term specifying the chance or likelihood of a harmful event and a severity term quantifying the magnitude of the loss. Further information on the theory underlying risk assessment and risk management can be found in Burgmann (2004), Francis and Shotton (1997) and Lane and Stephenson (1997). For a formal treatment of quantitative risk assessment and management see McNeil (2005).

H. Other Issues

None

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Annex 5 – Stock Annex Herring in the Celtic Sea and VIIj

Quality Handbook Herring in Celtic Sea and VIIj

Stock specific documentation of standard assessment procedures used by ICES

Stock: Herring in the Celtic Sea and VIIj

Working Group: Herring Assessment Working Group for the area south of 62^0

Date: March 2012

Authors: Afra Egan, Maurice Clarke, Andrew Campbell and Deirdre Lynch

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This annex was updated in 2012 to reflect the change to the period used to calculate GM recruitment for the short term forecast.

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. From 2009-2011, recruitment was set at geometric mean, from 1995 - minus the most recent two years. In 2012 HAWG changed the period for calculation of geometric mean to 1981-2009 (excluding the two most recent years). The current recruitment regime has been observed to be similar to that in the 1980s and early 1990s, with several strong year classes recruiting in recent years. 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[1]. The size of the egg determines the size of the larvae. Larger eggs have a greater chance of survival but this must be balanced against environmental conditions and the inverse relationship between fecundity and egg size (Blaxter and Hunter, 1982).

A study on fecundity of Celtic Sea herring, conducted in the 1920s found that the eggs produced by spring spawners were 25% bigger than those autumn spawners but were less numerous (Farran, 1938). Later studies of Celtic Sea herring fecundity by Molloy (1979), found that there were two spawning populations with the autumn one being most important.

The relationship between fecundity and length has been calculated for both spawning components of Celtic Sea herring. The regression equations are as shown in 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

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[1] http://www.gma.org/herring/biology/life_cycle/default.asp

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 morality, 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, Sub-Division 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 Sub-Division 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

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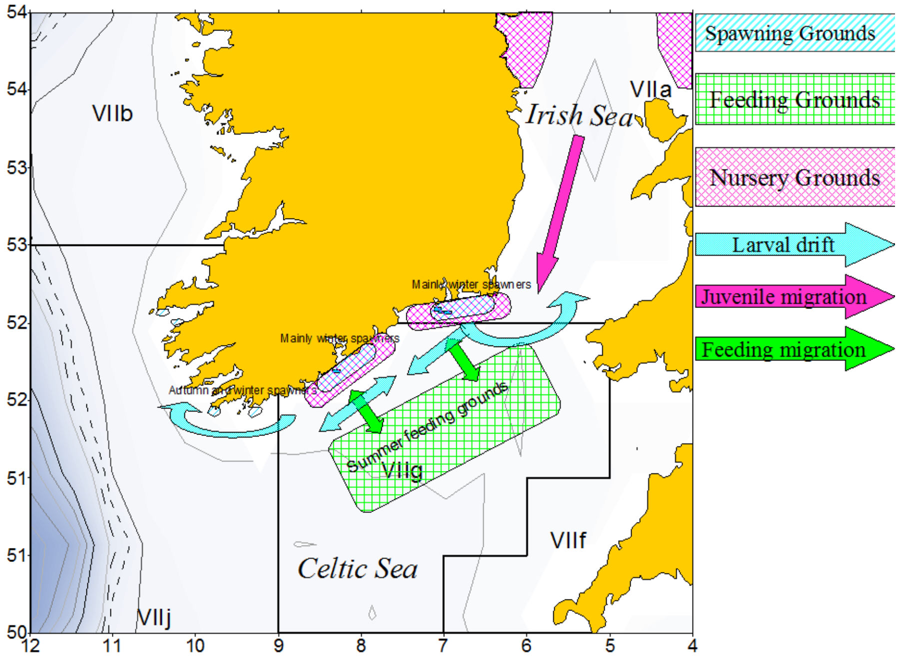


Figure 1. Herring in the Celtic Sea. Schematic presentation of the life cycle of Celtic Sea and VIIj Herring (ICES, 2005c, SGRESP).

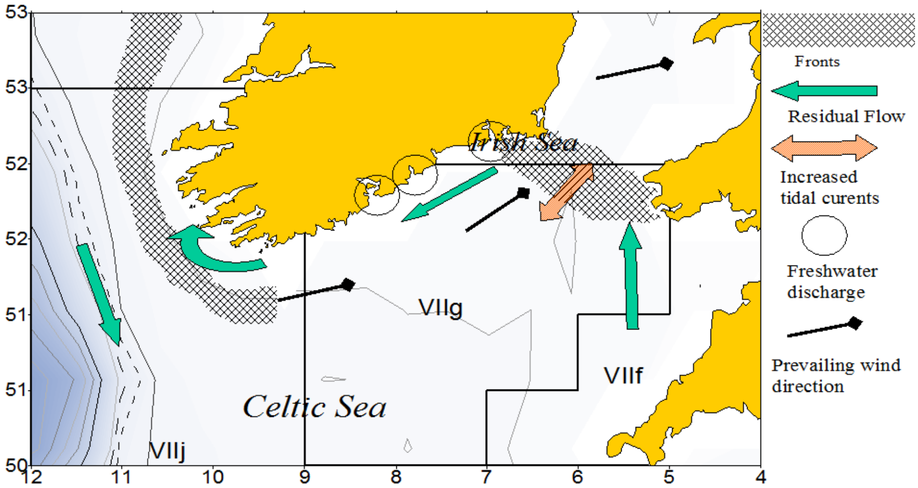


Figure 2. Herring in the Celtic Sea. Schematic presentation of prevailing oceanographic conditions in the Celtic Sea and VIIj (ICES, 2005c, SGRESP).

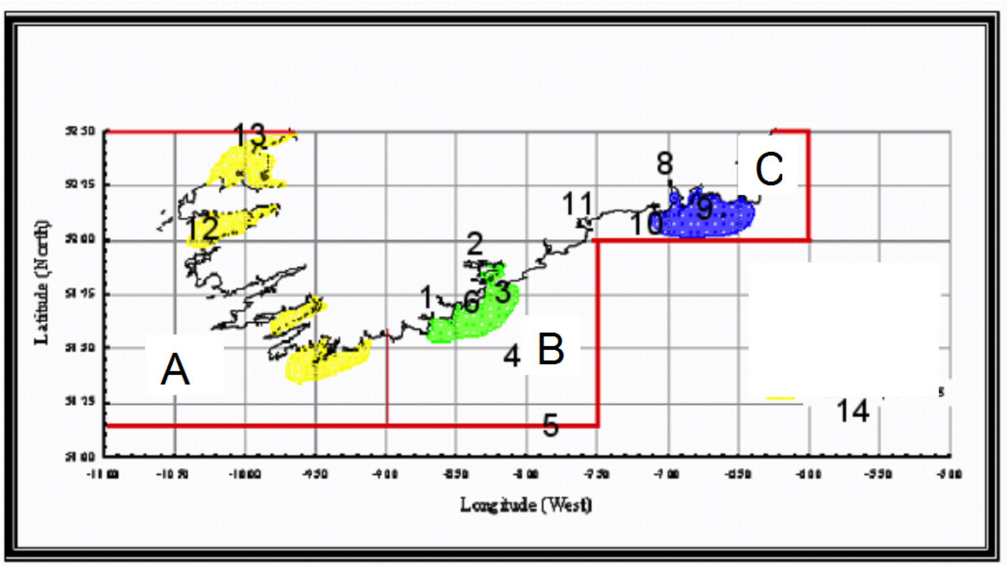


Figure 3. Herring in the Celtic Sea. Areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford Harbour, 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.

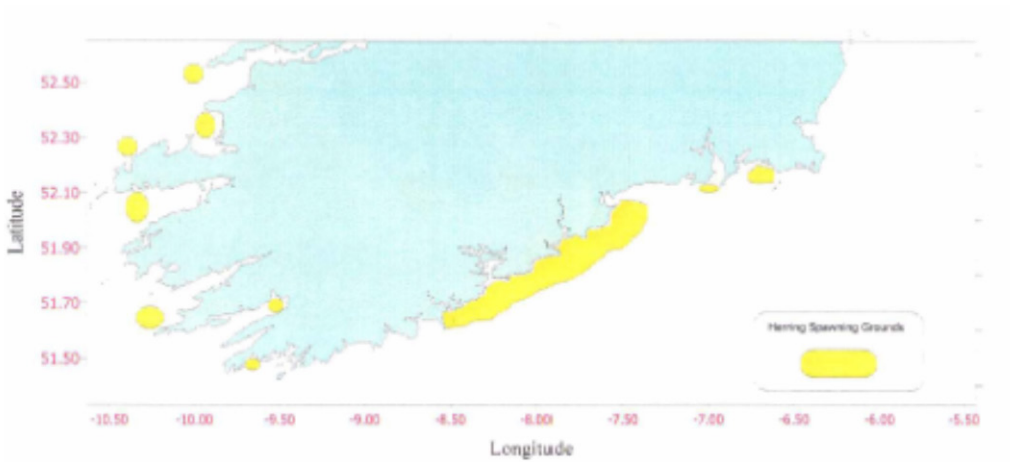


Figure 4. Herring in the Celtic Sea. Spawning ground of herring along the south coast of Ireland, inferred from information on the Irish herring fishery (Breslin, 1998).

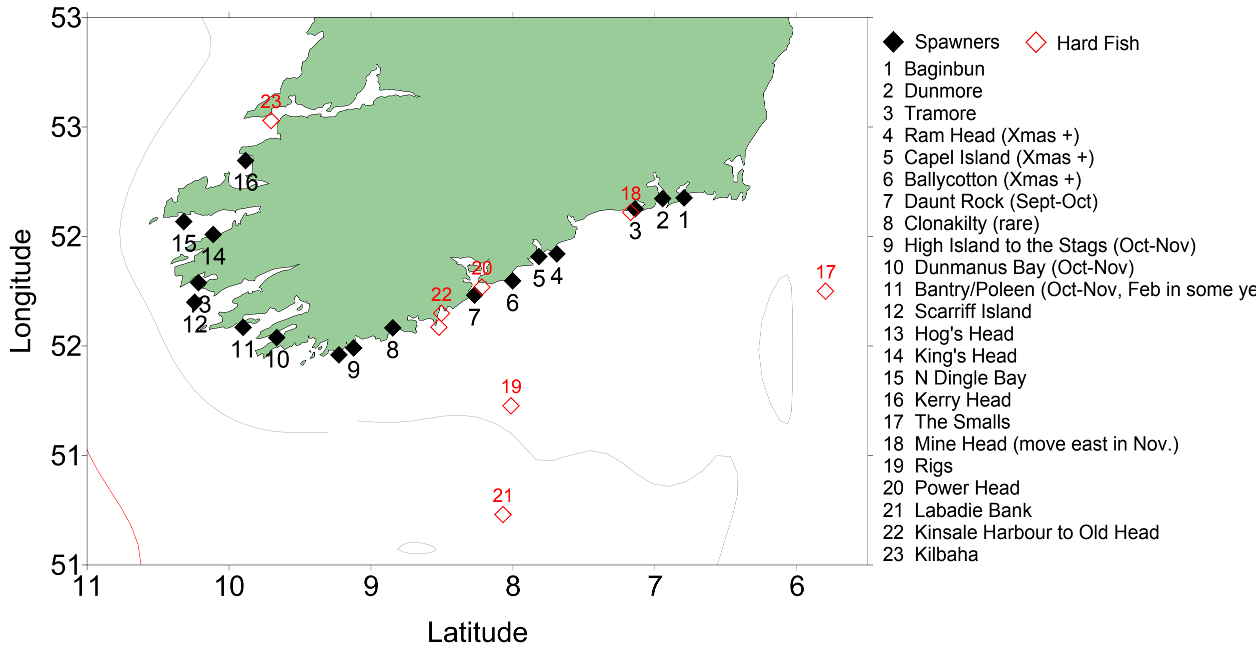


Figure 5. Herring in the Celtic Sea. Location of spawning (closed symbol) and non spawning (open symbol) herring in the Celtic Sea and SW of Ireland, based on expert fishemens' knowledge.

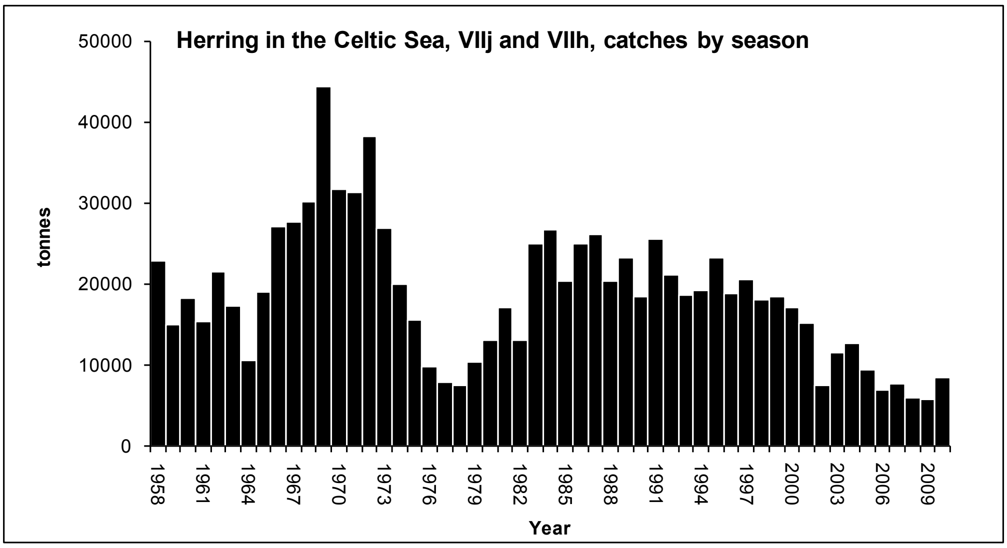


Figure .6. Herring in the Celtic Sea. ICES estimates of herring catches (tonnes) per season 1958/1959 to 2010/2011.

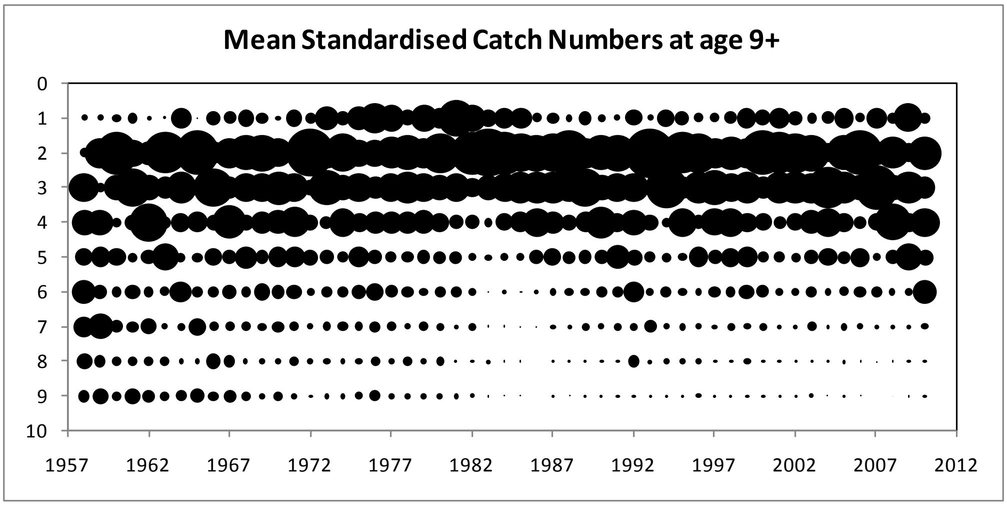


Figure 7. Herring in the Celtic Sea. Catch numbers at age standardised by yearly mean. 9+

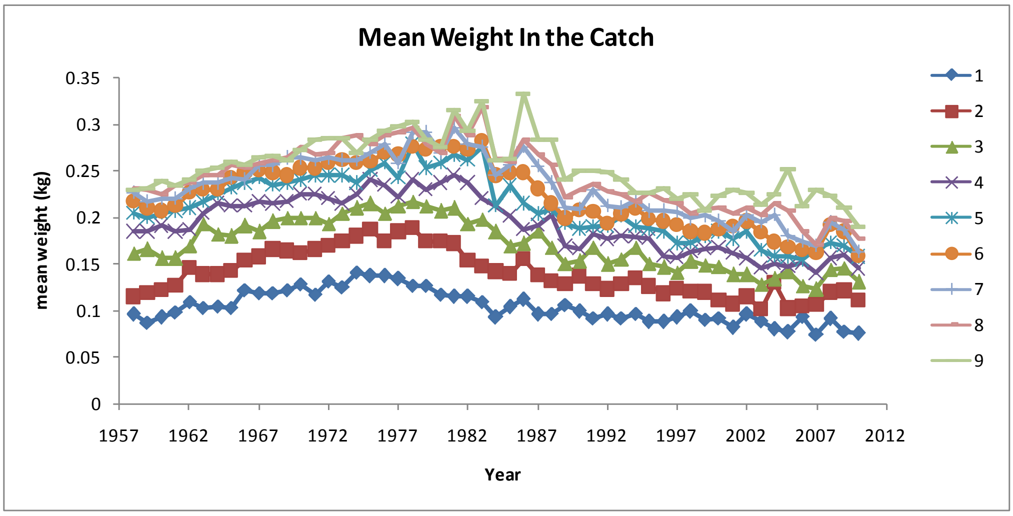


Figure 8. Herring in the Celtic Sea. Trends over time in mean weights in the catch.

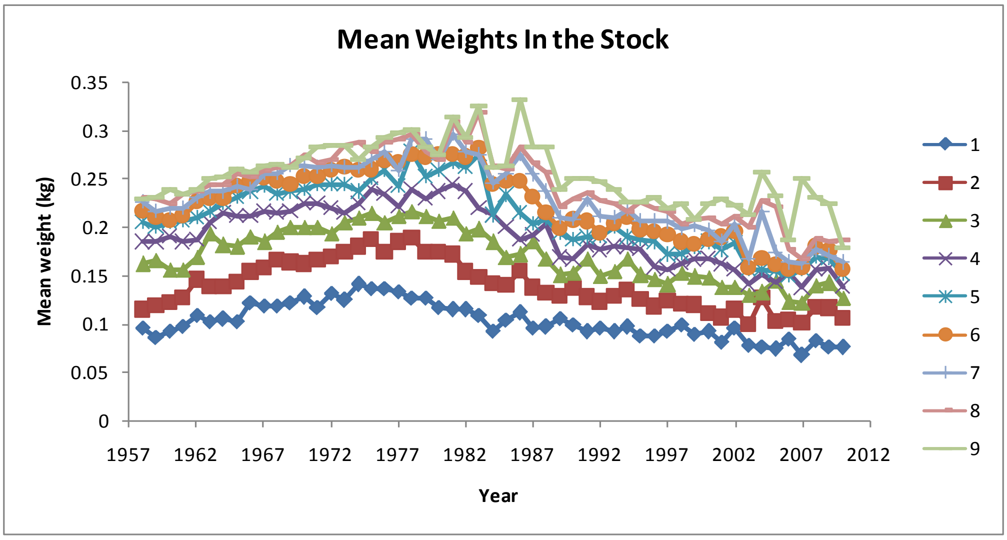


Figure 9. Herring in the Celtic Sea. Trends over time in mean weights in the stock at spawning time.

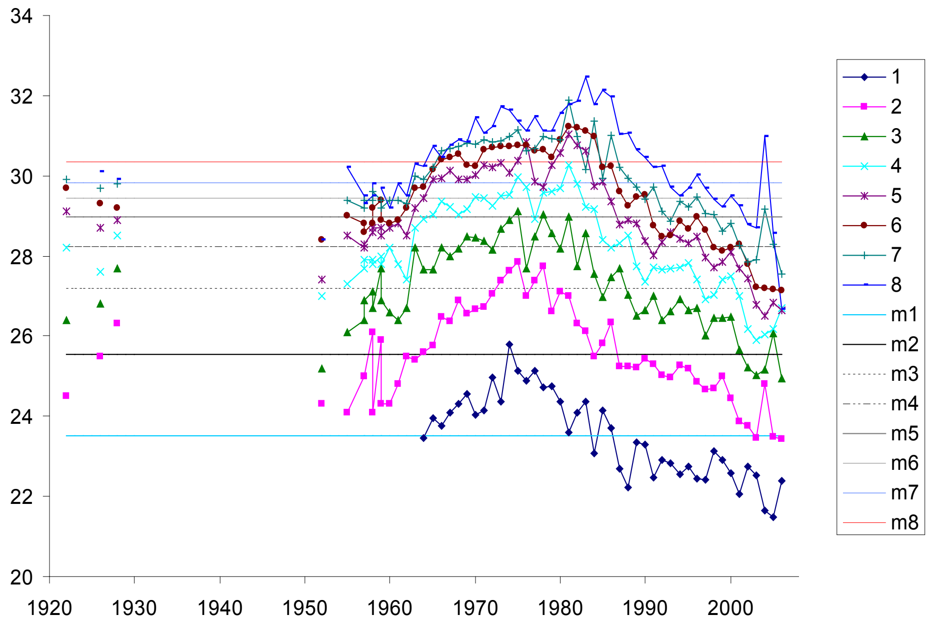


Figure 10. Herring in the Celtic Sea. Mean length at age from historic sources (Burd et al, 1965) and references therein. Data from 1964 onwards are Irish data. Long term means are shown for each age and are labelled m1-m8. The data from the 1920s are depicted as single years though they represent a group of years (Lynch, 2011).

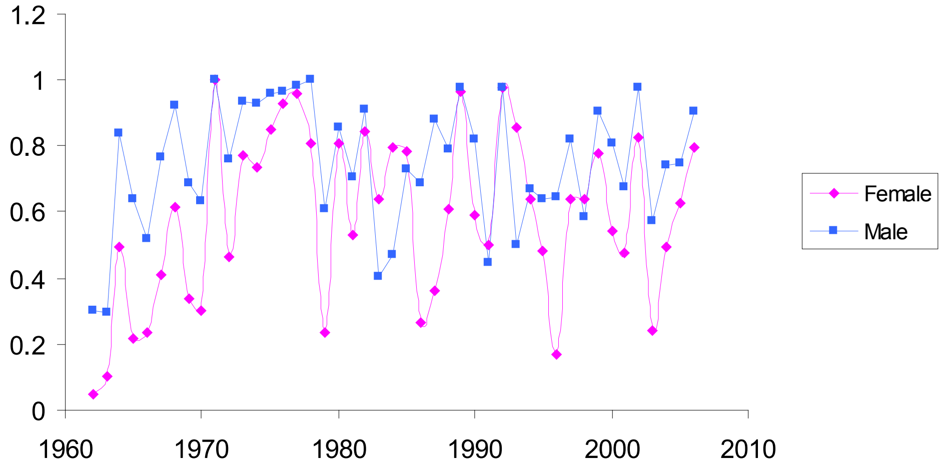
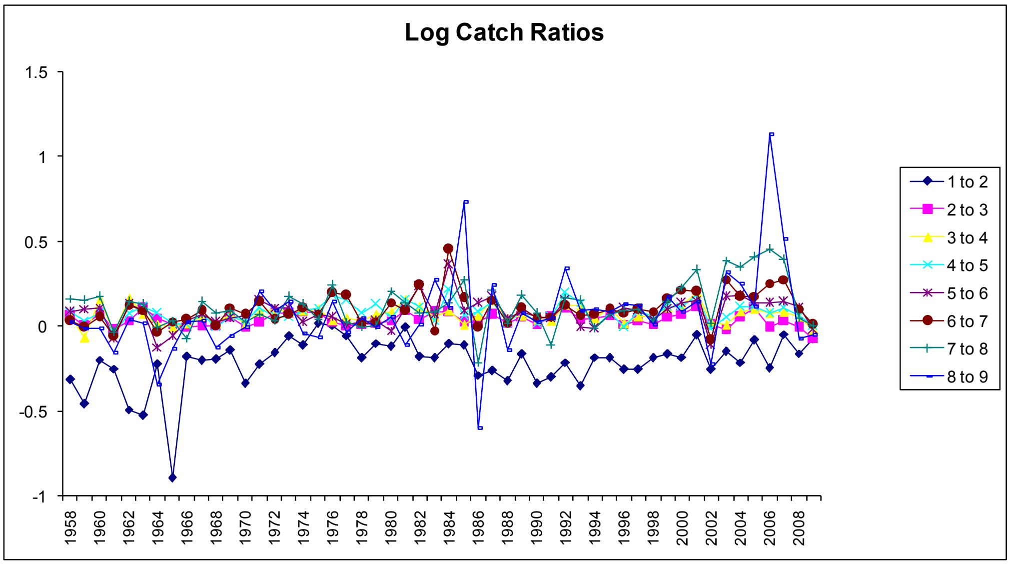


Figure 11: Herring in the Celtic Sea. Percentage maturity in males and females at 1 winter ring (Lynch, 2011).



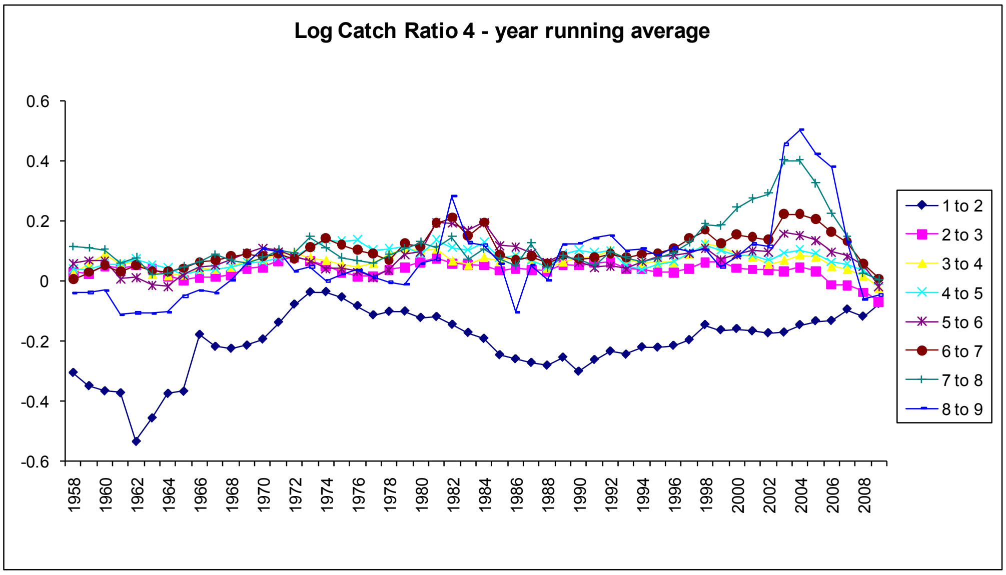


Figure 12. Herring in the Celtic Sea. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2010.

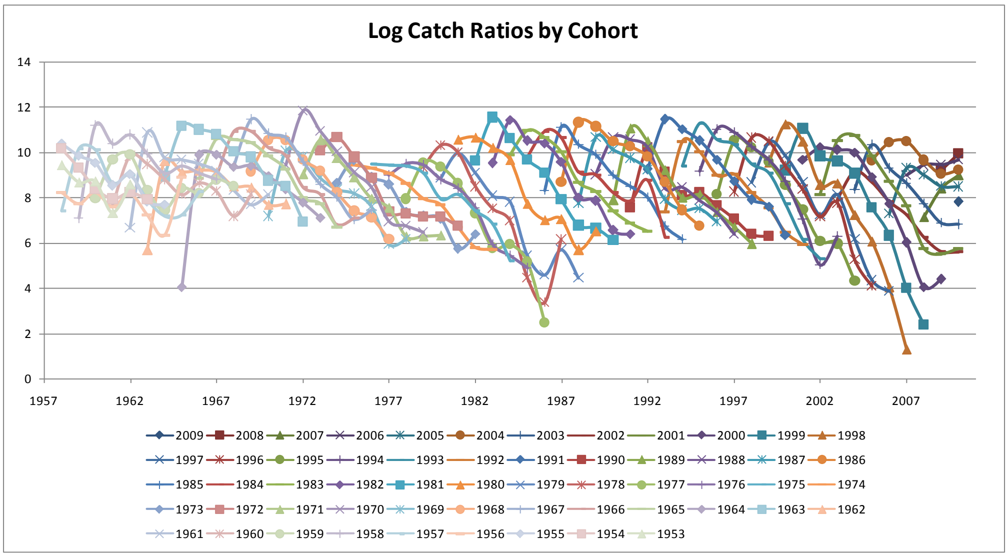


Figure 13. Herring in the Celtic Sea. Log Catch Ratios by cohort

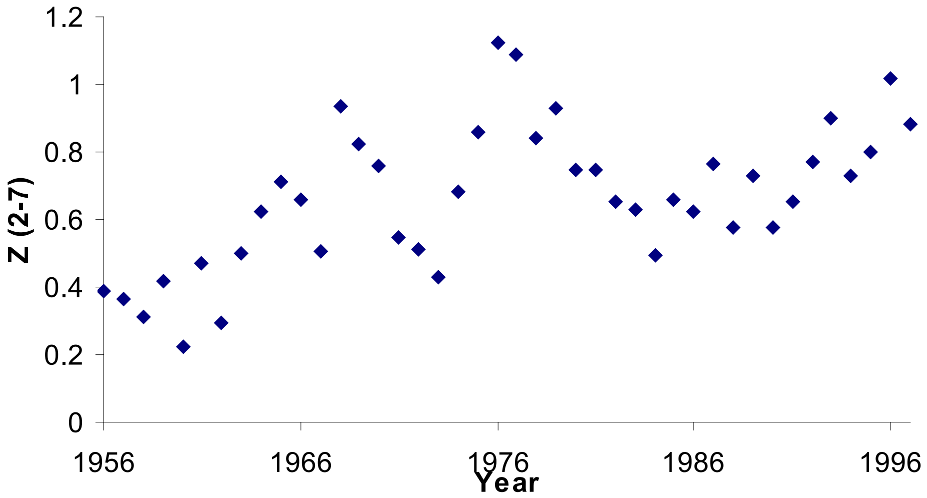


Figure 14: Herring in the Celtic Sea. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

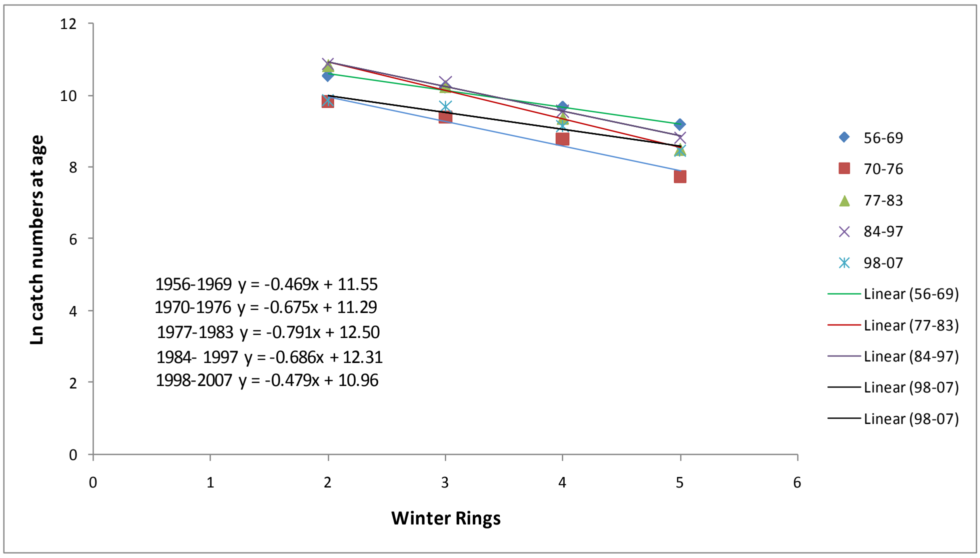


Figure 15. Herring in the Celtic Sea. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

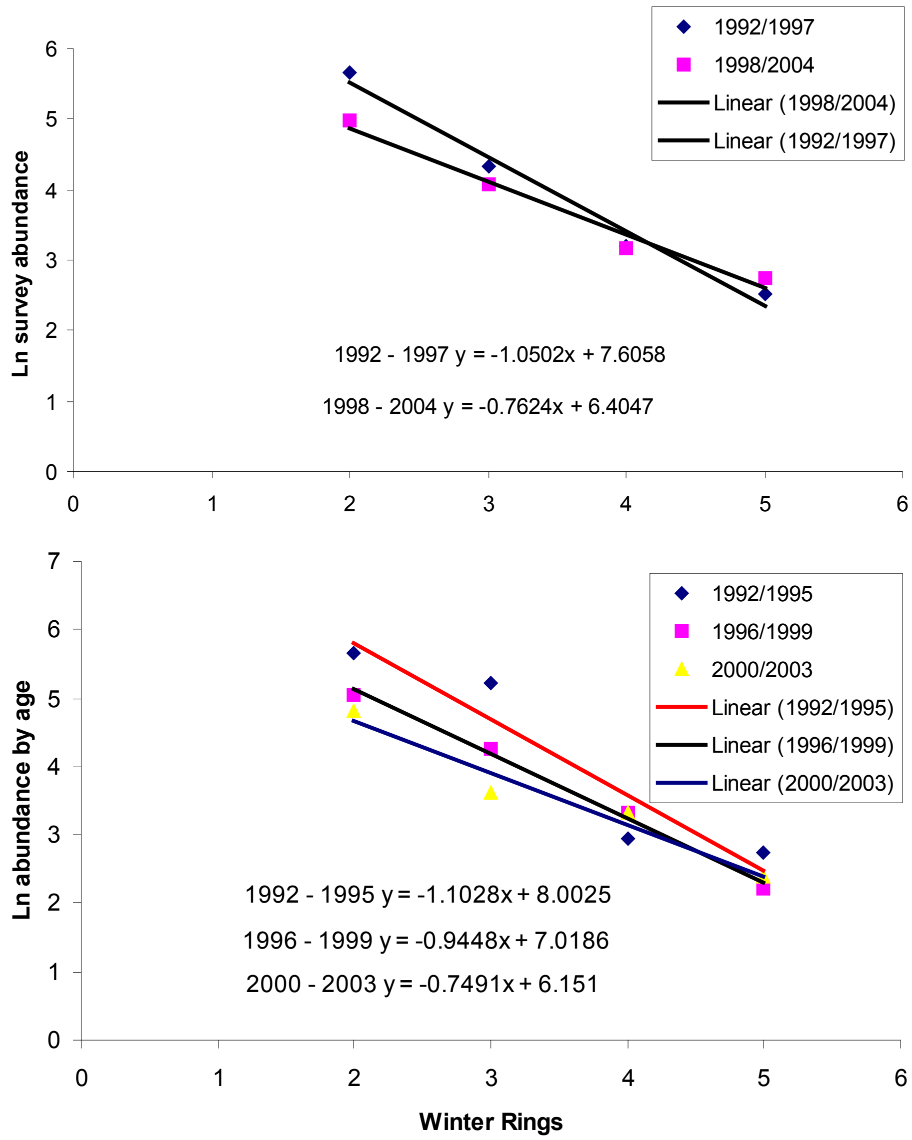


Figure 16. Herring in the Celtic Sea. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys

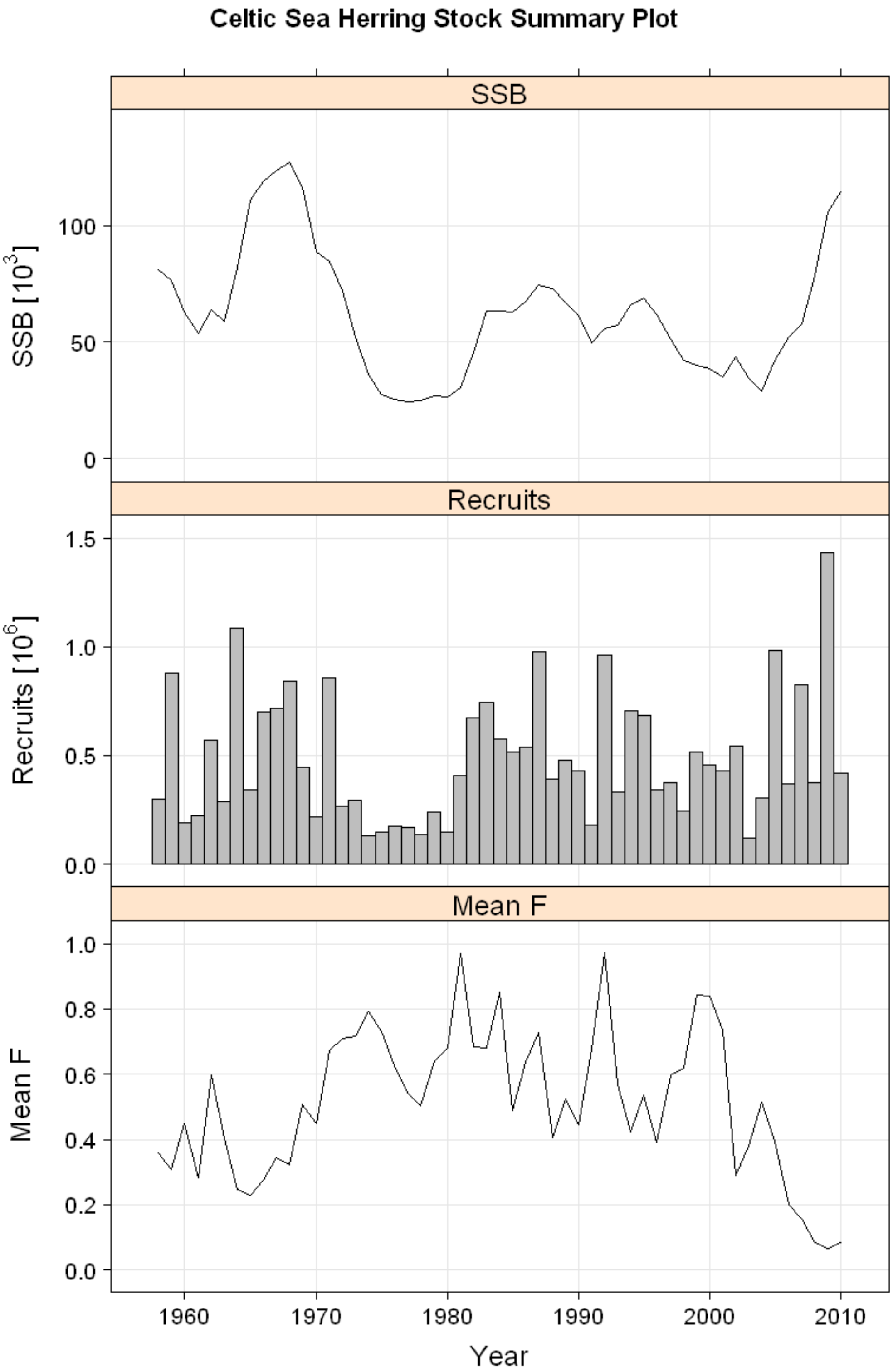


Figure 17. Herring in the Celtic Sea. SSB, F and recruitment (1-ringer) from the final assessment in 2011.

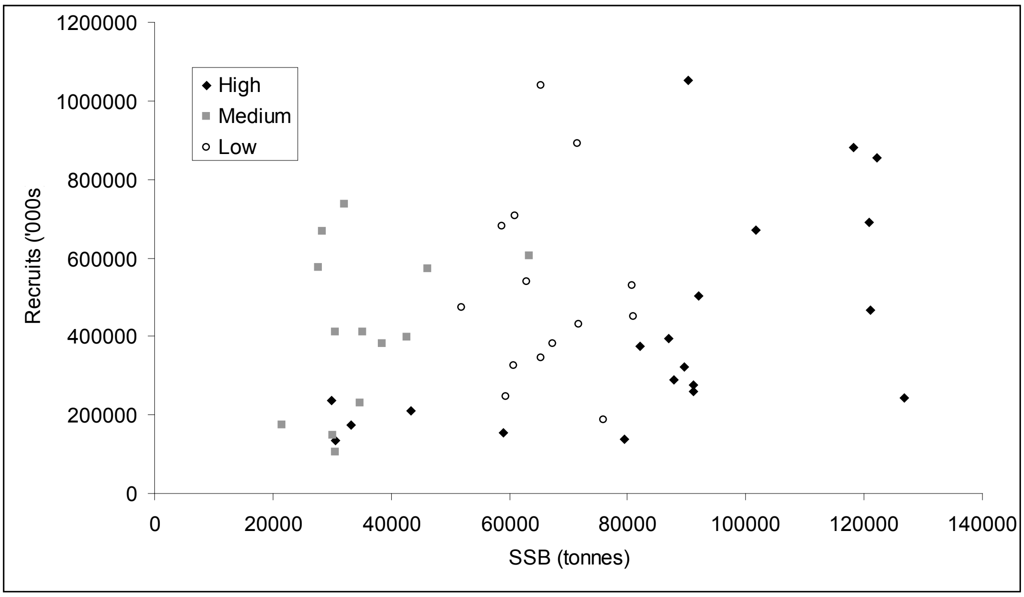


Figure 18. Herring in the Celtic Sea. Stock recruit relationship from ICA base case runs. Data classified according to quality of input data, see Table 4.

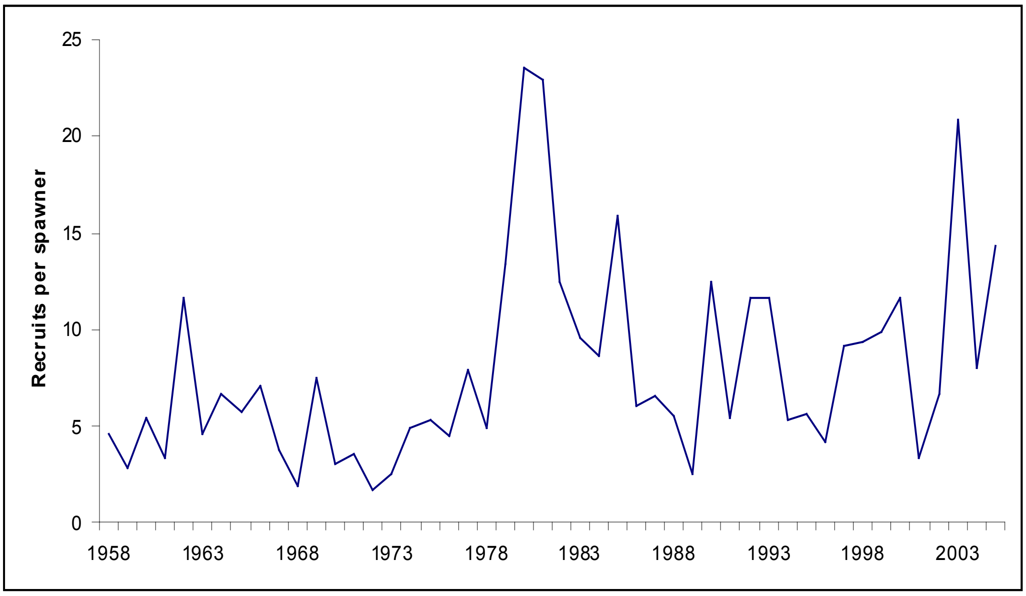


Figure 19. Herring in the Celtic Sea. Recruits per spawner, in '000s/tonnes

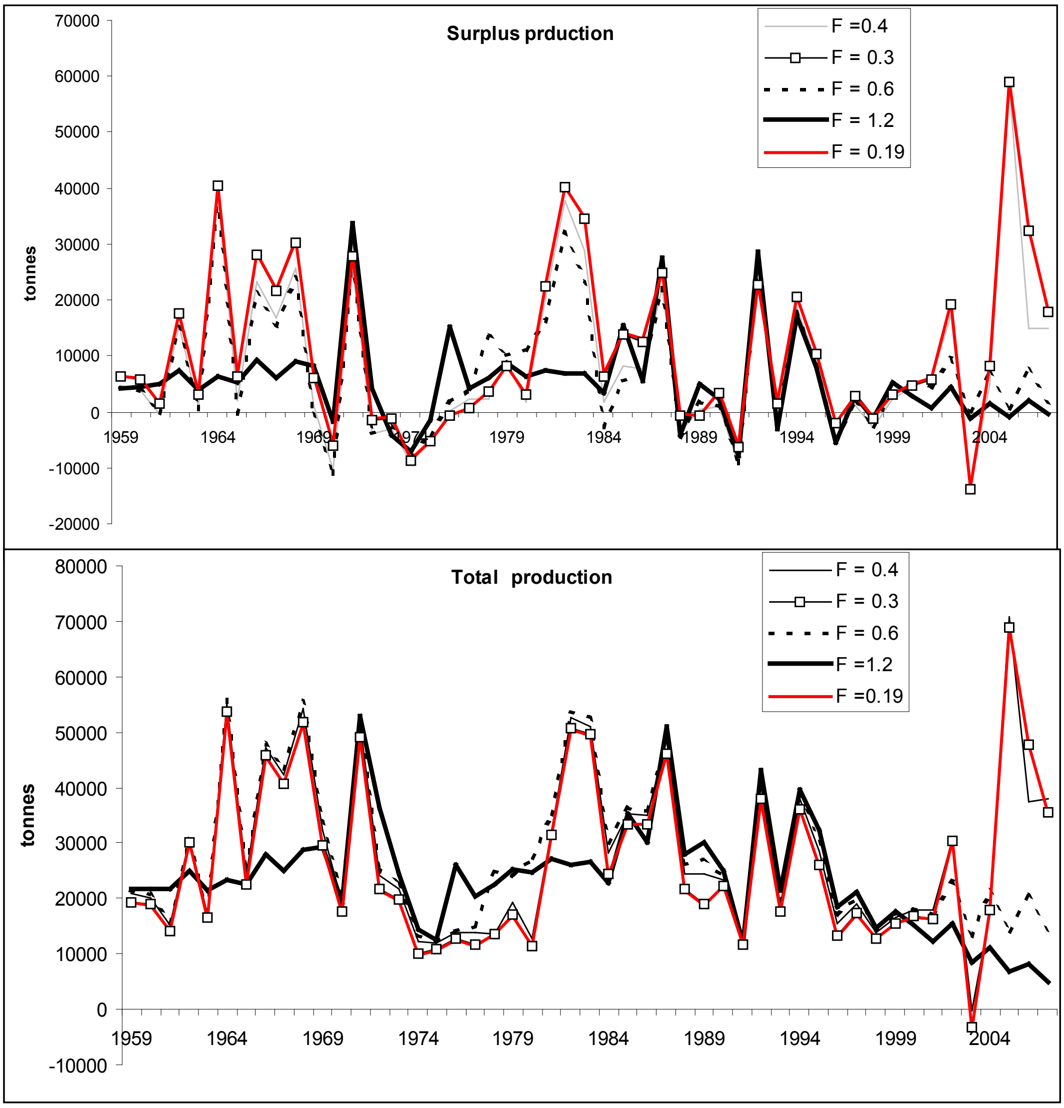


Figure 20. Herring in the Celtic Sea. Total and surplus production in the time series over a range of fishing mortalities.

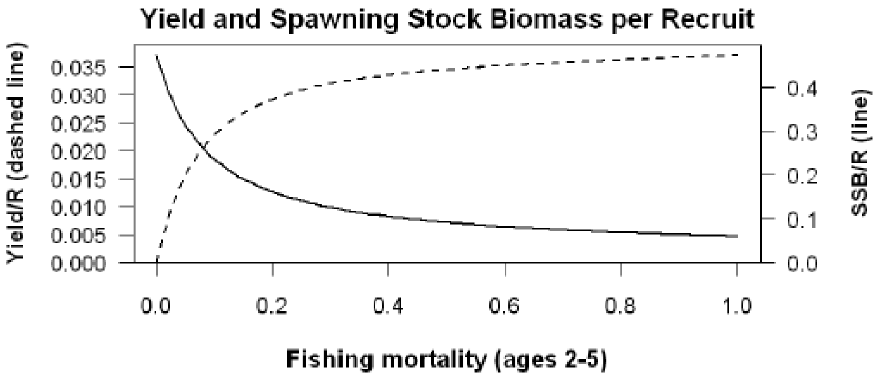


Figure 21. Herring in the Celtic Sea. Yield per recruit carried out in 2011.

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	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

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.**

	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 5. Herring in the Celtic Sea. Biological history of the stock.

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:	20 March 2012
Authors:	E.M.C. Hatfield, E.J. Simmonds and A. Edridge

The section on short term forecast has been updated in 2012 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 south-western Hebrides. The Scottish and Norwegian purse seine fleets targeted herring mostly in the northern North Sea, but also operated in the northern part of VIa (N). An international freezer-trawler fishery operated in deeper water near the shelf edge where older fish are distributed. These vessels are mostly registered in the Netherlands, Germany, France and England. In recent years the catch of these fleets has become more similar.

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^{o}W and 5^{o}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, 1991-2011.

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 full SSB time series, incorporating these revisions, is given in Table Annex 6-1 below.

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 to the year prior to the last data year) replaces recruitment for 1-ringers in both the intermediate year and TAC year. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period. Population numbers of 2-ringers in the intermediate year are calculated by the degradation of geometric mean recruitment (1989-2010) using the equation below:

$N_{t+1} = N_t * e^{-Ft+Mt}$

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 (eight because this is the assessment model assumption of 8 years separable period).

Intermediate year assumptions: **F** constraint, based on an average of F_{3-6} 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.

F. 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

G. Other Issues

G.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

H. 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

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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. Time series of spawning stock biomass (SSB) from the VIa (North) acoustic survey, incorporating the revised values calculated in 2009.

Year	1991	1992	1993	1994	1995
SSB (t)	410 000	351 460	845 452	533 740	452 300
Year	1996	1997	1998	1999	2000
SSB (t)	370 300	175 000	375 890	460 200	444 900
Year	2001	2002	2003	2004	2005
SSB (t)	359 200	548 800	739 200	395 900	222 960
Year	2006	2007	2008	2009	2010
SSB (t)	471 700	298 860	788 200	578 757	308 055
Year	2011				
SSB (t)	457 900				

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 2012
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 1st January. The first winter ring that is counted is that which corresponds to the second “birth date” of the fish. Therefore a fish of 2 winter rings is a 3 year old. This convention applies to all ICES herring stocks with autumn spawning (Lynch, 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 synoptic coverage of a stock that spawns over a period from October to February in an area spanning all of Divisions VIaS and VIIb cannot be achieved with a winter survey. Thus the series was discontinued in 2007. The review group of the 2007 assessment highlighted that although there is an acoustic abundance estimate, the historical series is too short to consider it as a tuning survey in an analytical assessment.

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 2008-2011. This series is not directly comparable with the surveys conducted from 1999-2007, but is consistent in design with those surveys conducted from 1994-1996.

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, FLICA 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

FLICA

In 2012, FLICA was used to conduct an assessment of the stock, using as tuning, the Malin Shelf Acoustic Survey. No information was available with which to separate this stock from VIaN in the tuning index, therefore the survey can be considered an overestimate of abundance of this stock. The final exploratory assessment used the same data as the separavle VPAs above, and these settings:

- Catch data with a 7+ plus group. Age 1 down-weighted to 0.1
- Ages 3-6 from the VIa,VIIbc survey data (2008-2011)
- Reference age 4
- Terminal selection on plus group and oldest true age = 1.0

In an attempt to deal with the stock mixing, an approach was taken to conduct a combined assessment for both stocks, and then subtract the population numbers for VIaN (SPALY assessment, Section 5). The remaining population numbers could be considered to be an estimate of stock abundance of VIaS. This approach was not entirely successful, because negative abundances were generated in some of the recent years. This indicates the need to better understand the mixing of this stock and the VIaN stock, and in particular, to understand the contribution of VIaS fish to the VIaN tuning index.

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. In 2011 and 2012, short term predictions were conducted, based on the various sVPA runs, and also on the 2012 FLICA assessment. A recent GM was used as an estimate of recruitment, assuming that the stock is still in a low productivity phase. Interim year catch was taken to be the TAC in VIaS/VIIbc and the Irish quota in VIaN.

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

Work was conducted on simulating the long term dynamics of this stock for HAWG 2011. This work focused on using the converged part of the separable VPA exploratory assessments and projecting forward. The analysis aimed to define a range of target F, $B_{trigger}$ and percentage TAC constraints that would be appropriate for this stock. 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).

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 = F_{loss}

Applying the segmented regression method to the extended time series 1957-2010 (Clarke et al. 2011 found the the breakpoint to be 79,000 t, or 76,000 t if the three large year classes

(1963, 1981 and 1985) were removed. Thus, 76,000 t could be considered as the B_{lim} reference points.

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

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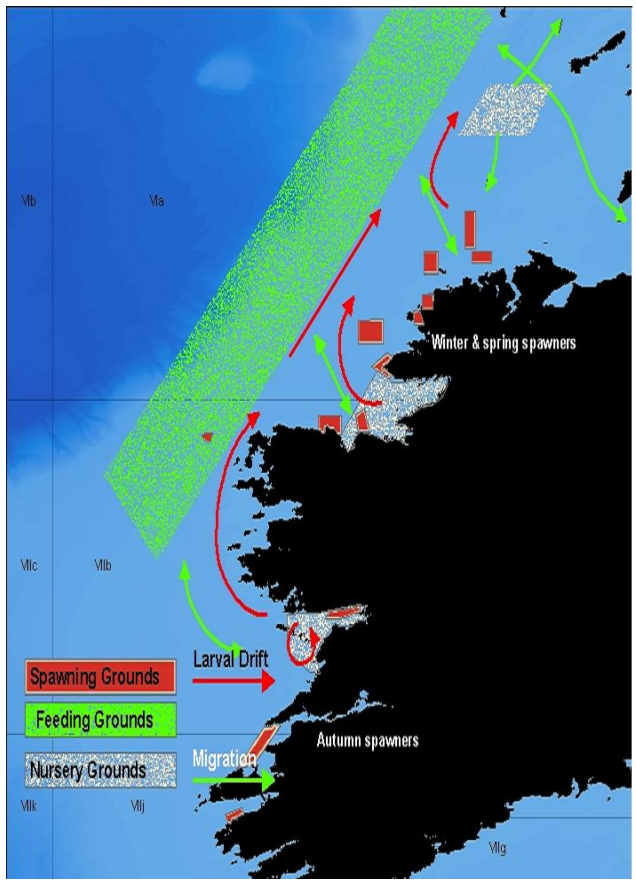


Figure 1: Schematic presentation of the life cycle of Herring west and northwest of Ireland.

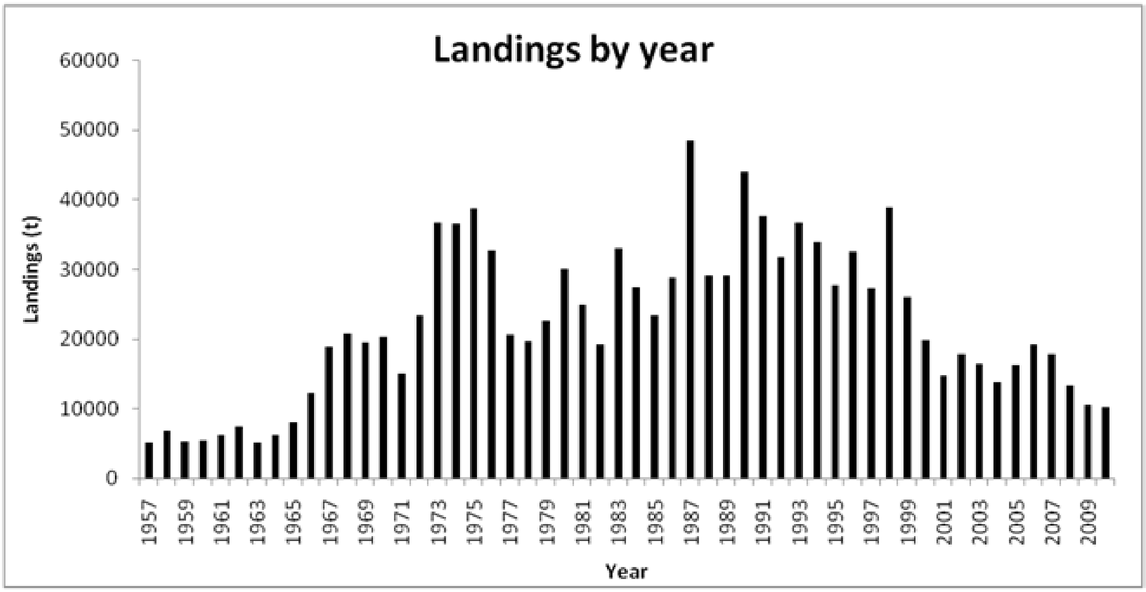


Figure 2: Total landings from VIaS, VIIb,c

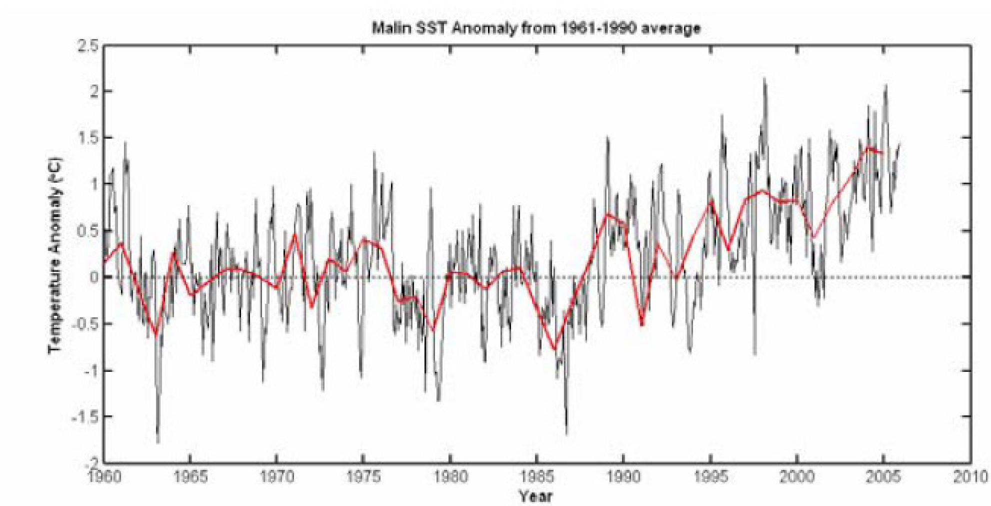
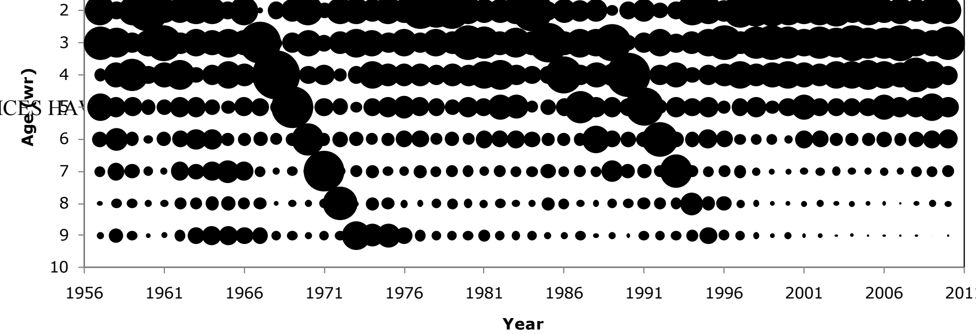


Figure 3: Sea surface temperature anomaly at Malin Head (1960-2005) (Nolan and Lyons, 2006)



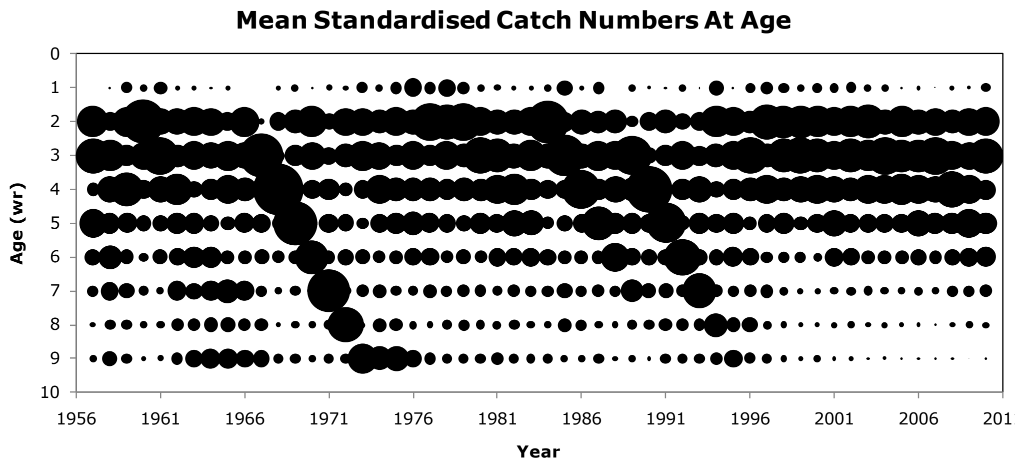
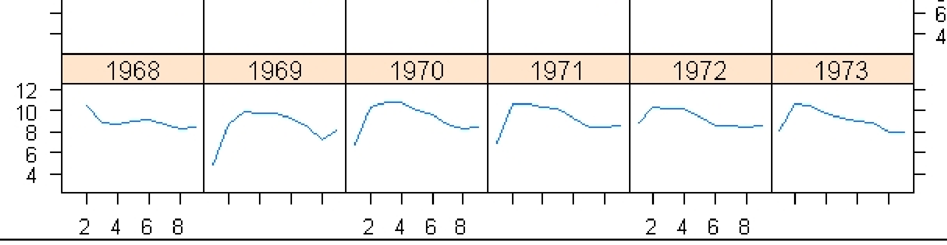


Figure 4: Mean Standardised Catch Numbers at Age



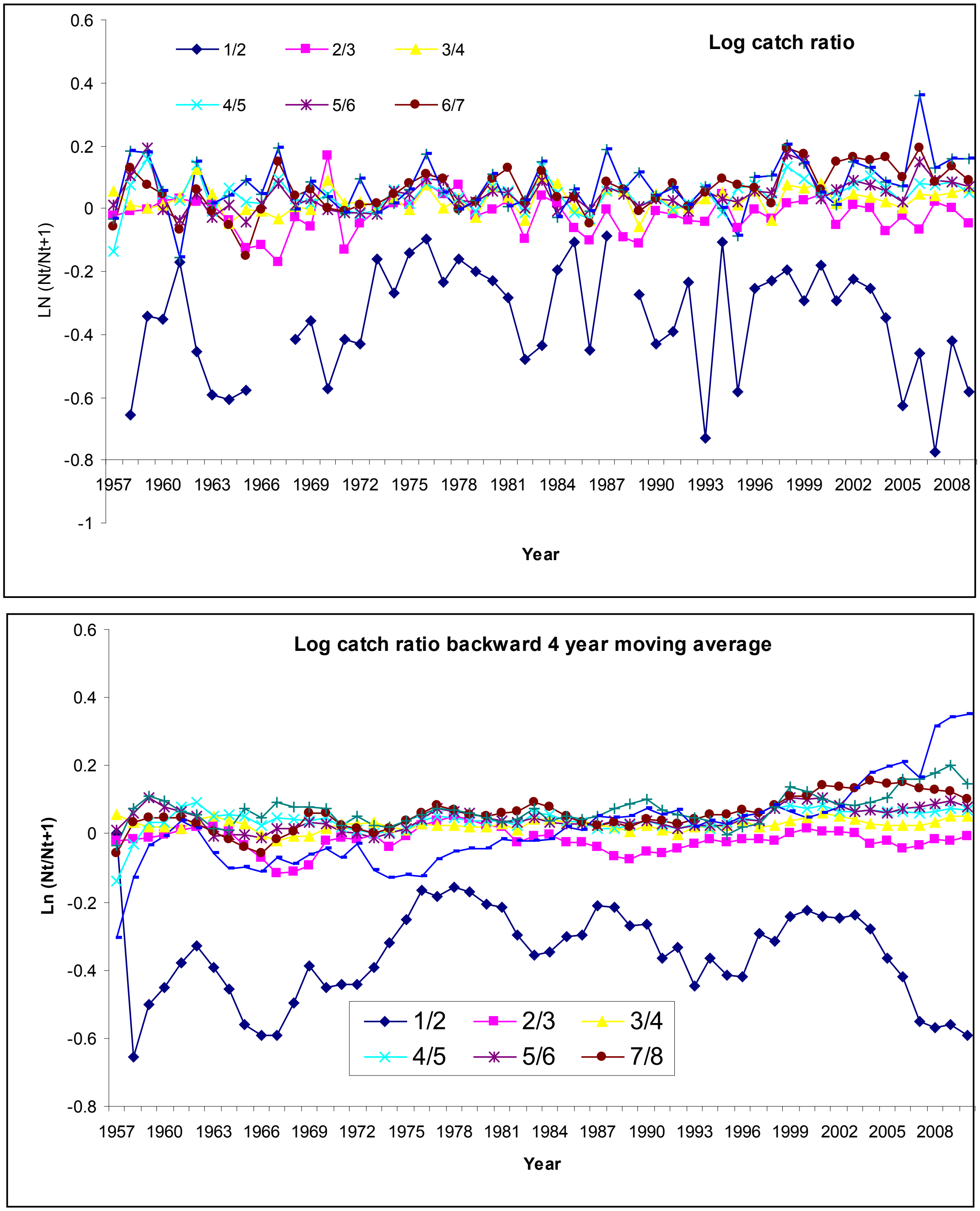
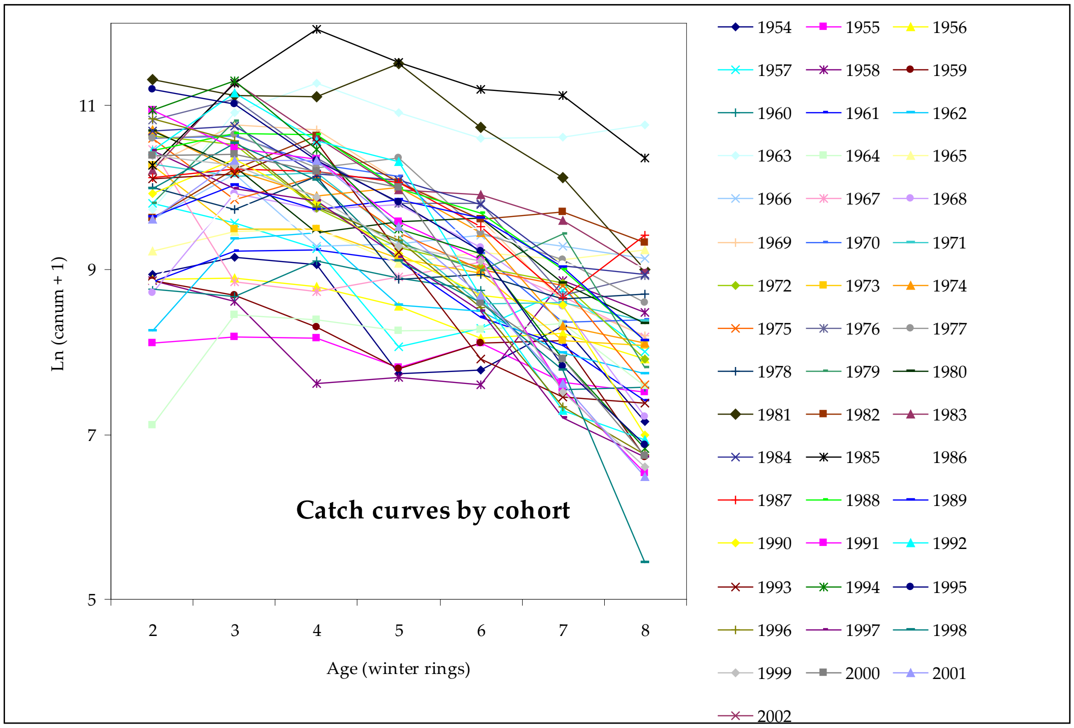


Figure 5. Log catch ratios 1957-2010. Top panel individual years, lower panel applying a backward 4 year moving average smoother.



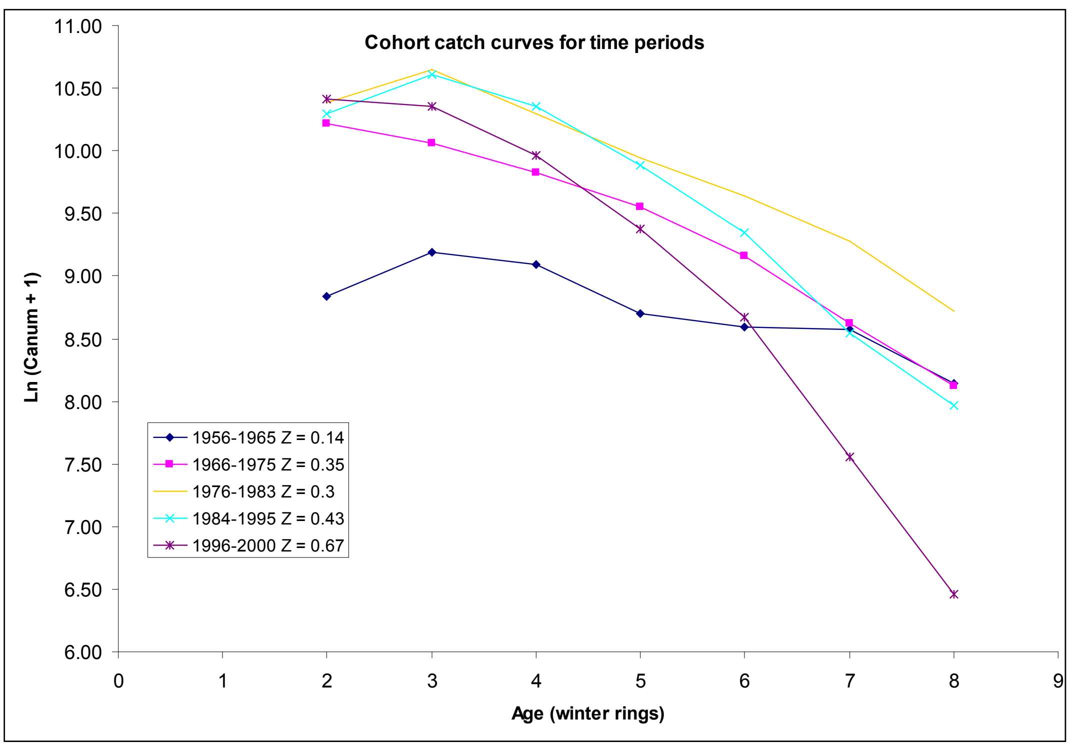


Figure 6: Cohort catch curves by birth year, 1954-2002 (top panel) and for various time periods 1956-2000 (bottom panel).

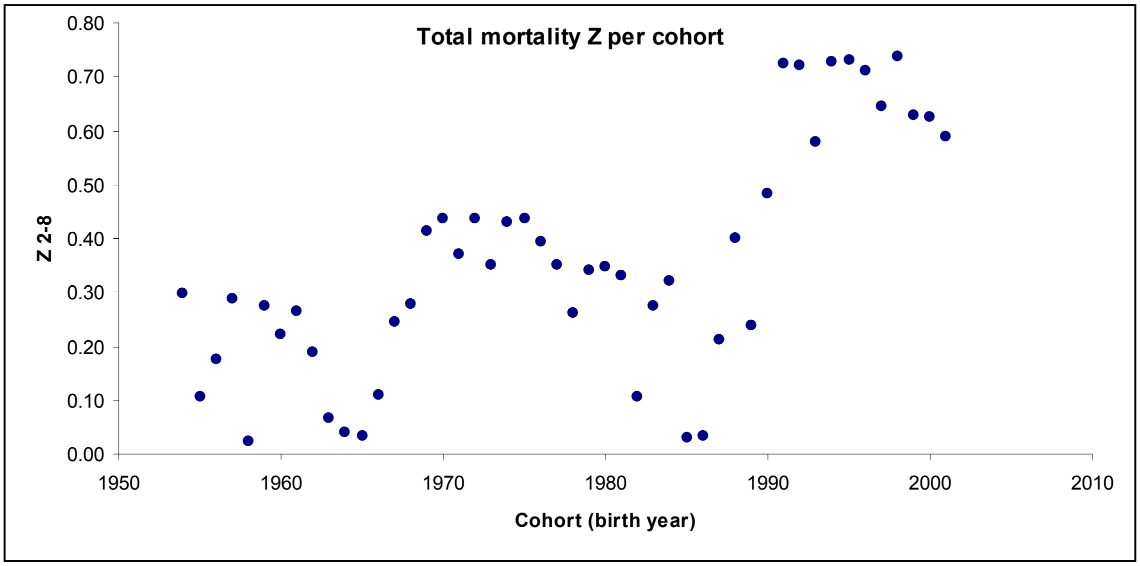


Figure 7: Total mortality (2-8 winter rings) by cohorts born from 1954-2001.

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.

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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

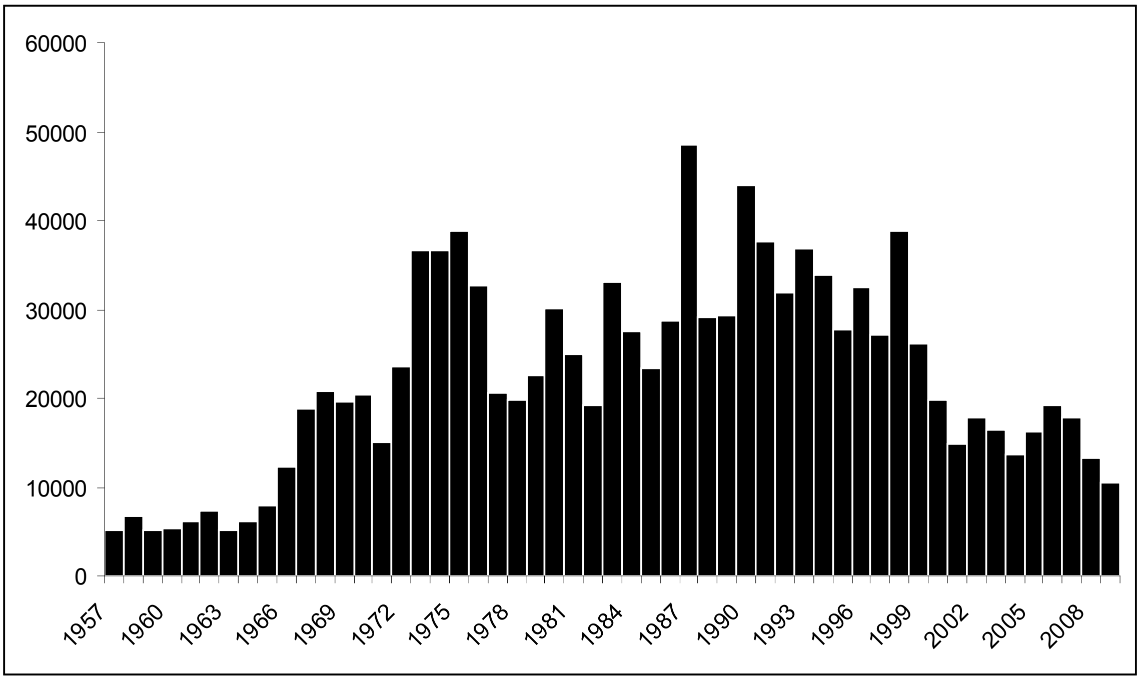

Figure 1. Best estimate of landings in VIaS VIIbc from 1957 to 2009. Data for 1957-1969 reconstructed in the current study.

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

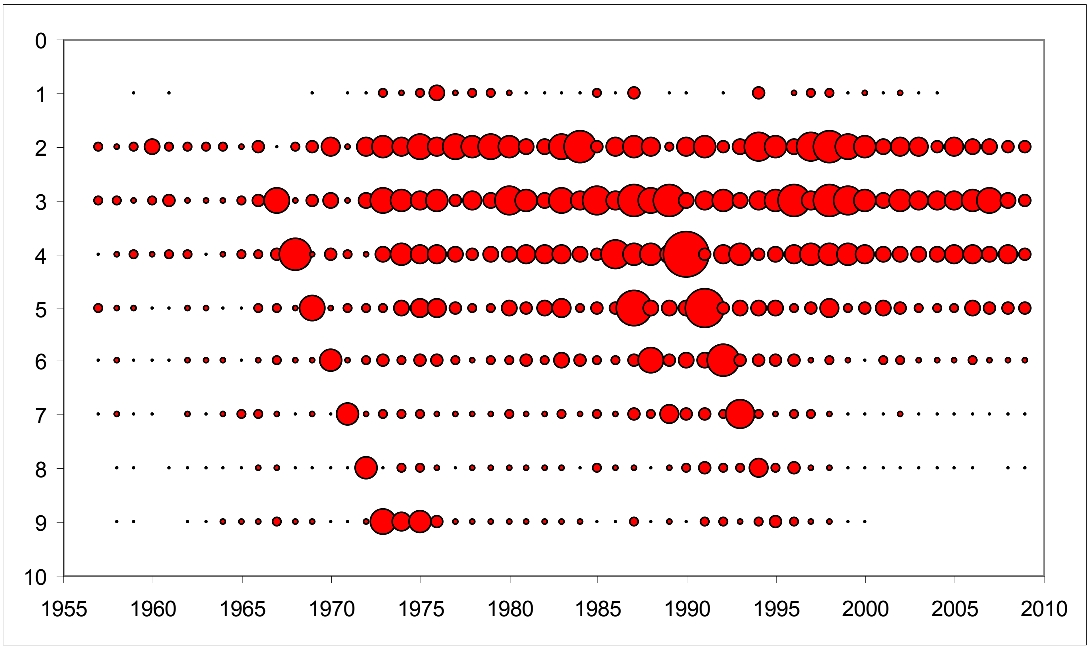

Figure 2. Bubble plot of catch numbers at age for extended series in VIaS and VIIbc.

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:	**8** March 2012
Revised by	Pieter-Jan Schön

A. General

A.1. Stock definition

Herring spawning grounds in the Irish Sea are found in coastal waters to the west and north of the Isle of Man and on the Irish Coast at around 54°N (ICES, 1994; Dickey-Collas *et al.*, 2001). Spawning takes place from September to November in both areas, occurring slightly later on average on the Irish Coast than off the Isle of Man. ICES Herring Assessment Working Groups from 19XX to 1983 used vertebral counts to separate catches into Manx and Mourne stocks associated with these spawning grounds. However, taking account of inaccuracies in this method and the results of biochemical analyses, the 1984 WG combined the data from the two components to provide a "more meaningful and accurate estimate of the total stock biomass in the N. Irish Sea." All subsequent assessments have treated the VIIa(N) data as coming from a single stock. During the 1970s, catches from the Manx component were about three times larger than those from the Mourne component. By the early 1980s, following the collapse of the stock, the catches were of similar magnitude. The fishery off the Mourne coast declined substantially in the 1990s then ceased, whilst acoustic and larva surveys in this period indicate that the spawning population in this area has been very small compared to the biomass off the Isle of Man.

The occurrence in the Irish Sea of juvenile herring from a winter-spring spawning stock has been recognized since the 1960s based on vertebral counts (ICES, 1994). More recently, Brophy and Danilowicz (2002) used otolith microstructure to show that nursery grounds in the western Irish Sea were generally dominated by winter-spawned fish. Samples from the eastern Irish Sea were mainly autumn-spawned fish. Recaptures from 10,000 herring tagged off the SW of the Isle of Man in July 1991 occurred both on the Manx spawning grounds and along the Irish Coast with increasing proportions from the Celtic Sea in subsequent years (Molloy *et al.*, 1993). The pattern of recaptures indicated a movement towards spawning grounds in the Celtic Sea as the fish matured.

A proportion of the Irish Sea herring stocks may occur to the north of the Irish Sea outside of the spawning period. This was indicated by the recapture on the Manx spawning grounds of 3-6 ring herring tagged during summer in the Firth of Clyde (Morrison and Bruce, 1981). Aggregations of post-spawning adult herring were detected along the west coast of England during an acoustic survey in December 1996 (Department of Agriculture and Rural Development for Northern Ireland, unpublished data), showing that a component of the stock may remain within the Irish Sea.

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

A.2. Fishery

There have been three types of fishery on herring in the Irish Sea in the last 40 years:

i) Isle of Man- aimed at adult fish that spawn around the Isle of Man.

ii) Mourne- aimed at adult fish that spawn off the Northern Irish eastern coast.

iii) Mornington- a mixed industrial fishery that caught juveniles in the western Irish Sea.

The Mornington fishery started in 1969 and at its peak it caught 10,000 tonnes per year. It took place throughout the year. The fishery was closed due to management concerns in 1978 (ICES, 1994). In the 1970s the catch of fish from the Mourne fishery made up over a third of the total Irish Sea catch. The fishery was carried out by UK and Republic of Ireland vessels using trawls, seines and drift nets in the autumn. However the fishery declined and ceased in the early 1990s (ICES, 1994). The biomass of Mourne herring, determined from larval production estimates is now 2-4% of the total Irish Sea stock (Dickey-Collas *et al*., 2001).

The main herring fishery in the Irish Sea has been on the fish that spawn in the vicinity of the Isle of Man. The fish are caught as they enter the North Channel, down the Scottish coast, and around the Isle of Man. Traditionally this fishery supplied the Manx Kipper Industry, which requires fish in June and July. However the fish appeared to spawn slightly later in the year in the 1990s and this lead to problems of supply for the Manx Kipper Industry. In 1998 the Kipper companies decided to buy in fish from other areas. Generally the fishery has occurred from June to November, but is highly dependent on the migratory behaviour of the herring.

The fishery has been prosecuted mainly by UK and Irish vessels. TACs were first introduced in 1972, and vessels from France, Netherlands and the USSR also reported catches from the Irish Sea during the 1970s before the closure of the fisheries from 1978 to 1981. By the 1990s only the fishery on the Manx fish remained, and by the late 1990s this was dominated by Northern Irish boats. The number of Northern Irish vessels landing herring declined from 24 in 1995-96 to 6-10 in 1997-99 and to 4 in 2000. Only two vessels operated in 2002 and 2003. However, total landings have remained relatively stable since the 1980s whilst the mean amount of fish landed per fishing trip has increased, reflecting the increase in average vessel size

A.3. Ecosystem aspects

The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*). The size composition of herring in the stomach contents indicates that predation by whiting is mainly on 0-ring and 1-ring herring whilst adult hake and spurdogfish also eat older herring (Armstrong, 1979; Newton, 2000; Patterson, 1983). Sampling since the 1980s has shown cod (*Gadus morhua*), taken by both pelagic and demersal trawls in the Irish Sea, to be minor predators on herring. Small clupeids are an important source of food for piscivorous seabirds including gannets, guillemots and razorbills (ref…) which nest at several locations in and around the Irish Sea. Marine mammal predators include grey and harbour seals (ref.) and possibly pilot whales, which occur seasonally in areas where herring aggregate.

Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). The biomass of small herring has typically been less than 5% of the combined biomass of small clupeids estimated by acoustics (ICES, 2008 ACOM:02). However in recent years the proportions have increased in favour of small herring (ICES, 2009 ACOM:??).

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

Changes in Environment

There has been an increase in water temperatures in this area (ICES, 2006) which is likely to affect the distribution area of some fish species, and some changes of distribution have already been noted. Temperature increase is likely to affect stock recruitment of some species. In addition, the combined effects of over exploitation and environmental variability might lead to a higher risk of recruitment failure and decrease in productivity (ICES, 2007).

B. Data

B.1. Commercial catch

National landings estimates

The current ICES assessment of Irish Sea herring extends back to 1961, and is based on landings only. ICES WG reports (ICES 1981, 1986 and 1991) highlight the occurrence of discarding and slippage of catches, which can occur in areas where adult and juvenile herring co-occur. Discarding has been practised on an increasing scale since 1980 (ICES, 1986). This increase is primarily related to the onset of slippage of catches that coincided with the cessation of the industrial fishery in early 1979 (ICES, 1980). As a result of sorting practices, slippage has led to marked changes in the age composition of the catch since 1979 and considerable change in the mean weights at age in the catch of the three youngest age groups (ICES 1981). Estimates of discarding were sporadically performed in the 1980s (ICES, 1981, 1982, 1985 and 1986), but there are no estimates of discarding or slippage of herring in the Irish Sea fisheries since 1986. Highly variable annual discard rates are evident from the 1980s surveys. For example, discards estimates of juvenile herring (0-group) for the Mourne stock taken in the 1981 *Nephrops* fishery was estimated at $1.9x10^6$ of vessels landing in Northern Ireland, which amounts to approximately 20% of the Mourne fishery (ICES 1982). In 1982, at least 50% of 1-group herring caught were discarded at sea by vessels participating in the Isle of Man fishery (ICES, 1983). A more comprehensive survey programme to determine the rate of discarding in 1985 revealed discard estimates of 82% by numbers of 1-ring fish, 30% of 2-ring and 6% of 3-ring fish, with the dominant age group in the landed catch being 3 ring (ICES, 1986). A similar survey in 1986, however, found the discarding of young fish fell to a very low level (ICES, 1987). The 1991 WG discussed the discard problem in herring fisheries in general and suggested possible measures to reduce discarding. No quantitative estimates were given, but reports of fishermen suggesting discards of up to 50% of catch as a result of sorting practices by using sorting machines (ICES, 1991). The variation in discard rates since 1980, as a result of changes in discard practices, can probably be attributed to several changes in the management of the fishery. These include the availability of different fishing areas, the change to fortnightly catch quotas per boat (ICES, 1987) and level of TAC, where lower discard rates are observed with a higher TAC (ICES, 1989). The level of slippage is also related to the fishing season, since slippage is often at a high level in the early months (ICES, 1987). Due to the variable nature of discard estimates and the lack of a continuous data series, it has not been included in the annual catch at age estimates (with the exception of the 1983 assessment when the catch in numbers of 1-ringers was doubled based on a 50% discard estimate of this age group).

Landings data for herring in Division VIIa(N) are generally collated from all participating countries providing official statistics to ICES, namely UK (England & Wales, Northern Ireland, Scotland and the Isle of Man), Ireland, France, the Netherlands and what was formally the USSR. The data for the period 1971 to 2002 are reported in the various Herring Assessment Working Group Reports and are reproduced in Table 1. The official Statistics for Irish landings from VIIa have been processed to remove data from the Dunmore East fishery in area VIIa(S), and represent landings from VIIa(N) only.

Over the past three decades, the WG highlighted the under- or misreporting of catches as the major problem with regards to the accuracy of the landing data. Related to this are the problems of illegal landings during closed periods and paper landings. Area misreporting was also recognised (ICES, 1999), although a less prominent problem that is mostly corrected for.

The 1980 WG first identified the problem of misreporting of landings based on the results of a 3-year sampling programme, which was initiated after 1975 when herring were being landed in metric units at ports bordering the Irish Sea (1 unit = 100 kg nominal weight). The study showed the weight of a unit to be very variable, but was usually well in excess of 100 kg. An initial attempt to allow for misreporting using adjusted catches made very little difference to any of the values of fishing mortality (ICES, 1980). Subsequently, despite serious concerns about considerable under-reporting being raised (ICES 1990, 1994, 2000 and 2001), the WG made no attempts to examination the extent of the problem. This uncertainty signifies no estimates of under-reporting and consequently no allowance for under-reporting of landings has been made. Considerable doubt was raised as to the accuracy of landing data over the period 1981-87 (ICES, 1994). However, after apparent re-examination all WG landing statistics are assumed to be accurate up to 1997 (ICES, 2000), but with no reliable estimates of landings from 1998-2000 (ICES, 2001). The WG acknowledged that poor quality landing data bring the catch in numbers at age data into question and hence the accuracy of any assessment using data from such periods (ICES, 1994).

In 2002 the ICES assessment was extended back to include data for 1961-1970 with the intention of showing the stock development prior to the large expansion in fishing effort and stock size in the early 1970s. This has now been extended further back to 1955. Landings data for this period were extracted from the UK fisheries data bases (England & Wales, Scotland and Northern Ireland: Table 1, columns 8-10) and publications by Bowers and Brand (1973) for Isle of Man landings (column 11). Landings data for Ireland and France were not available.

To estimate the VIIa(N) herring landings for Ireland and France during 1955-1970, the NE Atlantic herring catches for each country were obtained from the FAO database (column 16). Using the ICES landings data for each country (column 17) the mean proportion of the VIIa(N) catch to the NE Atlantic catch during 1971 to 1981 was estimated (column 18). This was applied to the NE Atlantic catches from each country, for the period 1955 to 1970, to give an estimated landing for both France and Ireland (column 19). These landings were added to the known catches from the CEFAS database to give the total landings. The landings data (tonnes) used in the assessment are given in Table 1, column 14. It is anticipated that landings data for VIIa(N) for years prior to 1971 can be extracted from the Irish databases. However, the French landings will remain as estimates. As yet there has been no analysis of magnitude of errors in the old data. Need discussion on errors due to misreporting

Catch at age data

Age classes in the ICES Canum file refer to numbers of winter rings in otoliths. As the Irish Sea stock comprises autumn spawners, *i*-ring fish taken in year *y* will comprise fish in their i_{th} year of life if caught prior to the spawning season and $(i+1)_{th}$ year if caught after the spawning period. An *i*-ring fish will belong to year-class *y*-2. As spawning stock is estimated at spawning time (autumn), spawning stock and recruitment relationships require estimates of recruitment of *i*-ring fish in year *y* and estimates of SSB in year *i*-2. The current assessment estimates recruitment as numbers of 1-ring fish.

The most recent description of sampling and raising methods for estimating catch at age of herring stocks is in ICES (1996). This includes sampling by UK(E&W) and Ireland, but not UK(NI) and Isle of Man

UK(NI):A random sample of 10-20kg of herring is taken from each landing into the main landing port (Ardglass) by the NI Department of Agriculture and Rural Development. Samples are also collected from any catches landed into Londonderry. Prior to the 1990s, the samples were mostly processed fresh. During the 1990s, there was an increasing tendency for samples to be frozen for a period of weeks before processing. No corrections have been applied to weight measurements to allow for changes due to freezing and defrosting. The length frequency (total length) of each sample is recorded to the nearest 0.5cm below. A sample of herring is then taken for biological analysis as follows: one fish per 0.5 cm length class, followed by a random sample to make the sample up to 50 fish.

Otoliths are removed from each fish, mounted in resin on a black slide and read by reflected light. Ages are assigned according to number of winter rings.

Length frequencies (LFDs) for VIIa(N) catches are aggregated by quarter. The weight of the aggregate LFD is calculated using a length-weight relationship derived from the biological samples. The LFD is then raised to the total quarterly landings of herring by the NI fleets. A quarterly age-length key, derived from commercial catch samples only, is applied to the raised LFD to give numbers at age and mean weight at age.

IOM: IOM sampling covers the period 1923 – 1997. Samples are collected from any landings into Peel, by staff of the Port Erin Marine Laboratory (Liverpool University). The sampling and raising procedures are the same as described for UK(NI) with the following exceptions: i) the weight of the aggregate quarterly LFD is obtained from the original sample weights rather than using a length-weight relationship, and ii) the biological samples are random rather than stratified by length. The 1993 ICES herring assessment WGs noted a potential under-estimation by one ring, of herring sampled in the IOM. This was caused by a change in materials used for mounting otoliths and appears to have been a problem for ageing older herring in 1990-92. This was since rectified. However, the bias for the 1990-92 period has not yet been quantified and will be examined in the near future.

Ireland: Irish sampling of VIIa(N) herring covers the period 19xx – 2001. Some samples are from landings into NI but transported to factories in southern Ireland. Irish sampling schemes for herring in Div. VIa(S), VIIb, Celtic Sea and VIIj are described in ICES (1996). Methods for sampling catches in VIIa(N) are similar. The procedure is the same as described above for UK(NI) except that the biological samples are random rather than length stratified. ICES (1996) notes that a length-stratified scheme should be adopted to ensure proper coverage at the extremes of the LFDs.

Quality control of herring ageing has fallen under the remit of EU funded programmes EFAN and TACADAR, to which the laboratories sampling VIIa(N) herring contribute. An otolith exchange exercise was initiated in 2002 and is currently being completed.

B.2. Biological

Natural Mortality

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following (since 2012):

Rings	M
1	0.787
2	0.380
3	0.353
4	0.335
5	0.315
6	0.311
7+	0.304

These values have been held constant from 1972 to date. These correspond to estimates for North Sea since 2012. A multi-species stock assessment model for the North Sea (SMS key-run 2010) has been used to inform the variable natural mortality pattern. The use of these values are considered preliminary until stock specific estimates can be obtained.

The values used up to the 2011 assessment 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).

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

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. No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010.

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). No biological sampling information was available for 2009 and the weights at age for 2009 were replaced by averaging the weight at age observed in 2008 and 2010.

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 foot-rope. 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 as basis for advice:

The assessment model is based on the State-space Assessment Model (SAM) (Nielsen et al., 2012). Technical details of the SAM framework can be found in the peer-reviewed literature (Nielsen et al., 2012)

At the Benchmark (WKPELA, 2012) the state-space models SAM model was chosen as the assessment model for Irish Sea herring. . This modelling framework has a number of highly desirable characteristics, such as the stochastic treatment of all observations, a full statistical framework for evaluating model results, open source and cross platform source code, and an extremely high degree of flexibility allowing ready customisation to the peculiarities of the stock.

Assessment model configuration

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	NA	Yes

		year		
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	AC_VIIa(N)	1994-last data year	1-8+
Tuning fleet 2	NINEL	1993-last data year	SSB

The table below present the SAM configuration options (file model.cfg). In the file text following a hash-mark ("#") is a comment:

```
# Min, max age represented internally in model
 1 8
# Max age considered a plus group? (0 = No, 1= Yes)
 1

# Coupling of fishing mortality STATES (ctrl@states)
 # 1 2 3 4 5 6 7 8 #
 1 2 3 4 5 6 7 7 # catch
 0 0 0 0 0 0 0 0 # FLT01(AC)
 0 0 0 0 0 0 0 0 # NINEL

# Use correlated random walks for the fishing mortalities
# ( 0 = independent, 1 = correlation estimated)
0

# Coupling of catchability PARAMETERS (ctrl@catchabilities)
 # 1 2 3 4 5 6 7 8 #
 0 0 0 0 0 0 0 0 # catch
 1 2 3 4 4 4 4 4 # FLT01(AC)
 0 0 0 0 0 0 0 0 # NINEL

# Coupling of power law model EXPONENTS (ctrl@power.law.exps)
 # 1 2 3 4 5 6 7 8 #
 0 0 0 0 0 0 0 0 # catch
 0 0 0 0 0 0 0 0 # FLT01(AC)
```

```
0 0 0 0 0 0 0 0 # NINEL

# Coupling of fishing mortality RW VARIANCES (ctrl@f.vars)
# 1 2 3 4 5 6 7 8 #
1 1 1 1 1 1 1 1 # catch
0 0 0 0 0 0 0 0 # FLT01(AC)
0 0 0 0 0 0 0 0 # NINEL

# Coupling of log N RW VARIANCES (ctrl@logN.vars)
1 2 2 2 2 2 2 2

# Coupling of OBSERVATION VARIANCES (ctrl@obs.vars)
# 1 2 3 4 5 6 7 8 #
1 2 3 3 4 4 4 4 # catch
5 6 6 7 7 8 8 8 # FLT01(AC)
0 0 0 0 0 0 0 0 # NINEL

# Stock recruitment model code (0=RW, 1=Ricker, 2=BH, ... more in time
0
# Years in which catch data are to be scaled by an estimated parameter (mainly cod related)
0
# Fbar range
4 6

# so called checksum
123 123
```

The options for "`Coupling of fishing mortality STATES`" show that random walk for F is independent by age for the ages 1-6, and combined for age 7 and 8.

It is assumed that F at age is correlated to some degree estimated by the models. Therefore the option for "`Use correlated random walks for the fishing mortalities`" is set to 1.

The "`Coupling of catchability PARAMETERS`" specifies the grouping of ages with respect to survey catchability. For the ACVIIa(N) survey there is assumed an age dependent catchability for age 1-3, and a combined (the same) catchability ages 4-8.

In the ACVIIa(N) survey a linear relation between CPUE and stock size is assumed, such that the options for "`Coupling of power law model EXPONENTS`" are all set to 0.

The variance for the random walk for F ("`Coupling of fishing mortality RW VARIANCES "`) is assumed the same for all ages.

The "`Coupling of OBSERVATION VARIANCES`" specifies the options for observation noise for both catches and survey indices. For catches the observation variance is age dependent for age 1 and 2. For ages 3-4 the variance is assumed the same, and different from the variance for ages 5-8. For the ACVIIa(N) survey the variance is set the same within the groups of age 1, 2-3, 4-5 and 6-8.

There is no obvious relation between SSB and recruitment, but recruitment seems to be correlated between years. To reflect this, the "`Stock recruitment model code`" is set to 0=Random Walk.

D. Short-Term Projection

Model used: Age structured

Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1-ring recruits taken from a geometric mean for the years 1995 to two years prior to the terminal year.

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 (not scaled to the last year, as the terminal estimate of F is not considered more informative)

Intermediate year assumptions: TAC constraint.

Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

Not done

G. Biological Reference Points

Until there is confidence in the assessment the Working Group decided not to revisit the estimation of $\mathbf{B}_{pa}$ (9,500 t) and $\mathbf{B}_{lim}$ (6,000 t). There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:10).

H. Other Issues

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Table 1. Biological sampling of Irish Sea (VIIa(N)) landings. Country denotes sampling nation.

	Coverage	% of landings sampled	No of samples	Total landings	landings by Q?	IRELAND				NORTHERN IRELAND				ISLE OF MAN				OTHERr UK/UK OFFSHORE				TOTAL			
Year						Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages
1988	(4)					**2579																	0	0	0
1989	(3) temp spread good		88	4962	NO	1430	21	1843	555		45	11464	2249		21	5173	1057		1	96	0	4962	88	18576	3861
1990	p(1,2)	68%	100	6312	YES	1699	44	5176	1022	2322	38	9310	1900	542	18	5276	897	179/1570	0	0	0	6312	100	19762	3819
1991	g	90%	138	4398	YES	80	5	1255	247	3298	105	16724	2484	629	28	8280	1392	0/391	0	0	0	4398	138	26259	4123
1992	g	98%	32	5270	YES	406	3	593	99	4120	16	1588	770	741	13	3488	680	3	0	0	0	5270	32	5669	1549
1993	p (1)	65%	48	4408	YES	0	5	1378	245	3632	34	3744	832	776	9	1560	448	0	0	0	0	4408	48	6682	1525
1994	v.g	95%	59	4828	YES	0	21	569	100	3956	43	3691	1175	716	14	3724	614	156	0	0	0	4828	59	7984	1889
1995	g (1)	87%	85	5076	YES	0	21	569	100	3860	75	8282	2545	615	8	2182	400	601	0	0	0	5076	85	11033	3045
1996	g (1,5)	70%	51	5301	YES	100	1	537	55	4335	45	4813	1050	537	5	997	228	329	0	0	0	5301	51	6347	1333
1997	g (1,2)	91%	34	6649	YES	0	2	473	50	5679	25	2900	1199	765	7	2246	340	205	0	234	76	6649	34	5853	1665
1998	g (2)	84%	31	4904	YES	0	2	150	50	4131	29	2979	1450	0	0	0	0	7732	0	0	0	4904	31	3129	1500
1999	g (2)	72%	32	4127	YES	0	4	0	200	2967	28	2518	1400	0	0	0	0	11602	0	0	0	4127	32	2518	1600
2000	v.g	97%	28	2002	YES	0	5	932	0	2002	23	1915	1150	0	0	0	0	0	0	0	0	2002	28	2847	1150
2001	p (2)	70%	31	5461	YES	862	8	1031	222	3786	23	2915	1149	86	0	0	0	7272	0	0	0	5461	31	3946	1371
2002	p (1)	62%	9	2392	YES	286	0	0	0	2051	9	949	450	4	0	0	0	51	0	0	0	2392	9	949	450
2003			9	2399	YES	0				2399	9	1132	445												
2004			9	2531	YES	749	2	190	133	1782	7	991	350												
2005			26	4387	YES	1153	5	1312	372	3234	21	4135	1018												
2006			22	4402	YES	581	8	2248	549	3821	14	1982	686												
2007			29	4629	YES	0				4629	29														
2008			19	4895	YES	0				4895	19														
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 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
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**									

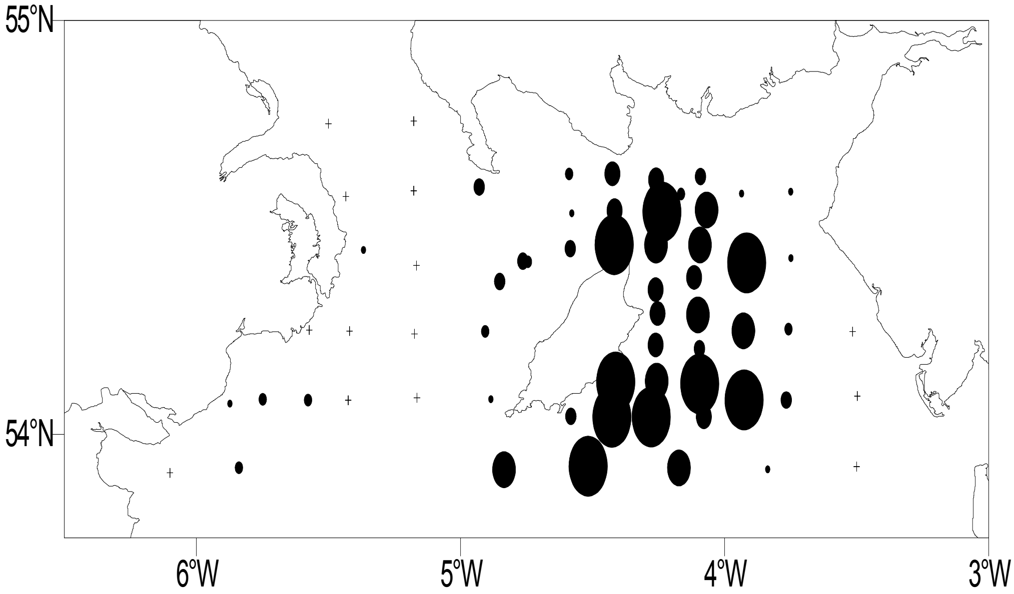
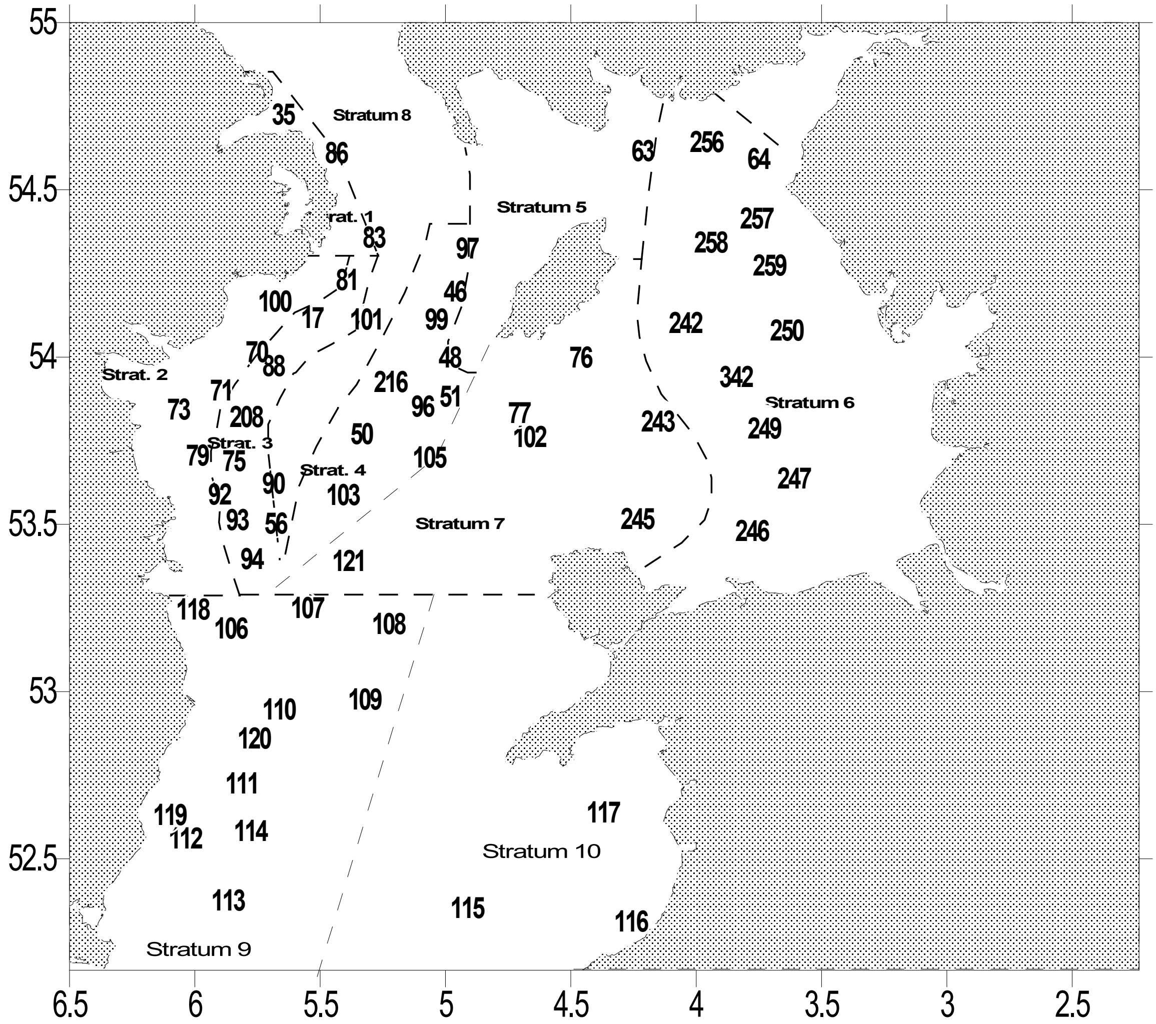


Figure 1. Sampling stations for larvae in the North Irish Sea (NINEL). Sampling is undertaken in November each year.



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 Date	Isle of Man Production	SE
1989	26 Oct	3.39	1.54
1990	19 Oct	1.92	0.78
1991	15 Oct	1.56	0.73
1992	16 Oct	15.64	2.32
1993	19 Oct	4.81	0.77
1994	13 Oct	7.26	2.26
1995	19 Oct	1.58	1.68
1996			
1997	15 Oct	5.59	1.25
1998	6 Nov	2.27	1.43
1999	25 Oct	3.87	0.88

Annex 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 inter-annual 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.

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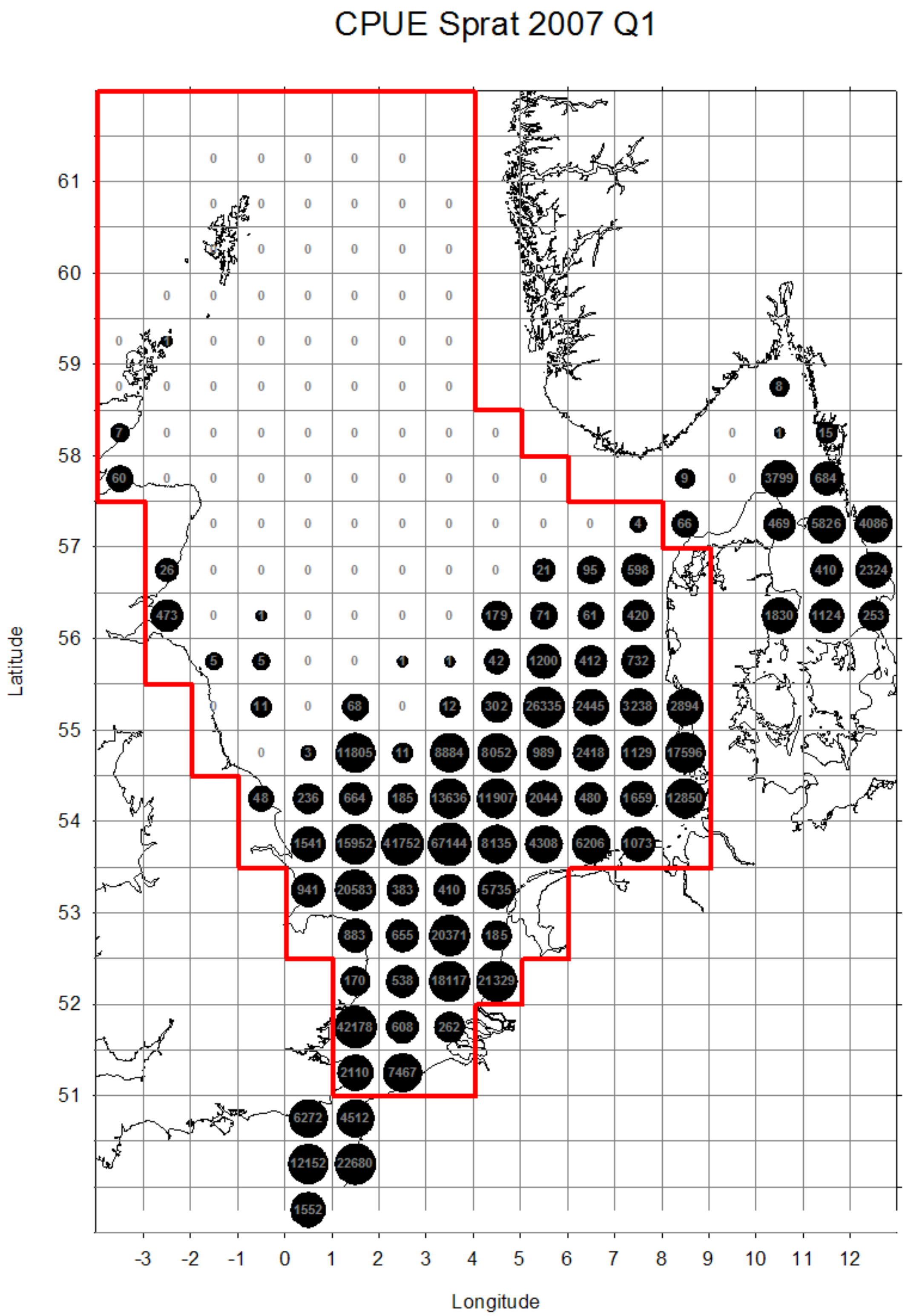

Figure 1. North Sea sprat. IBTS logCPUE from subareas; IV, IIIa, VII. The red area encircles the management area used for North Sea sprat. After ICES HAWG 2009.

Figure 2. North Sea sprat. Sampling stations (Limborg et al. 2009).

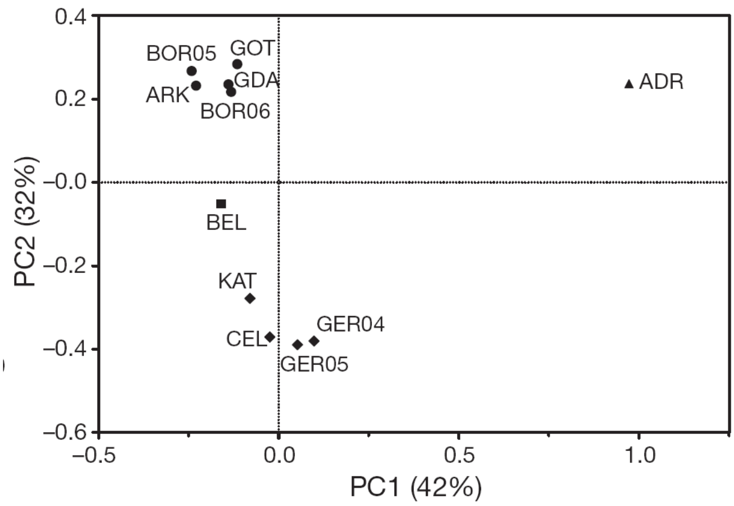

Figure 3. North Sea sprat. Plot of the generic variance in the samples. ADR = Adriatic Sea, ARK = Arkona Basin, BEL = Danish Belt, BOR = Bornholm Basin, CEL = Celtic Sea, GDA = Gdansk Deep, GER = German Bight (North Sea), GOT = Gotland Basin (Limborg et al. 2009).

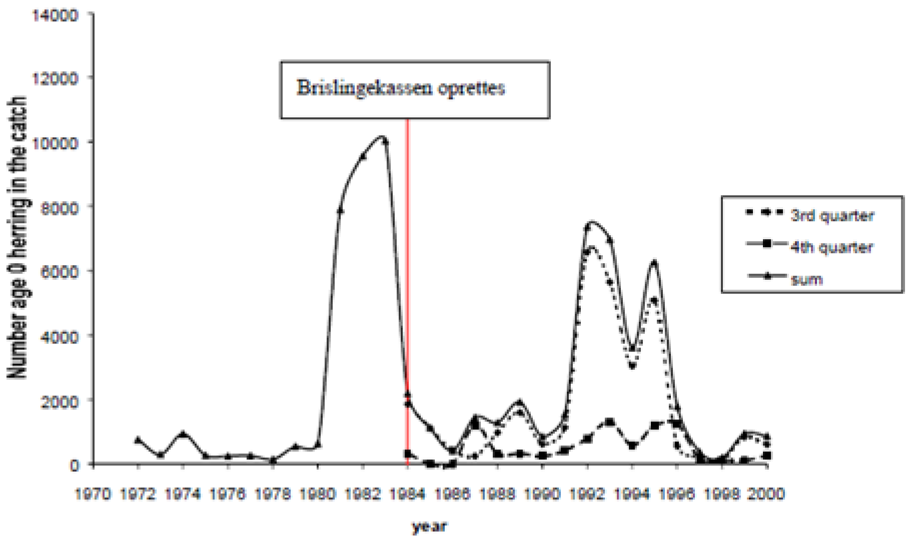

Figure 4: Catches of 0-group herring in the industrial fisheries in the central North Sea (IVb) in the 3rd and 4th quarter 1972-2000. The red line shows the time for establishing the sprat box. From Hoffman et al 2004.

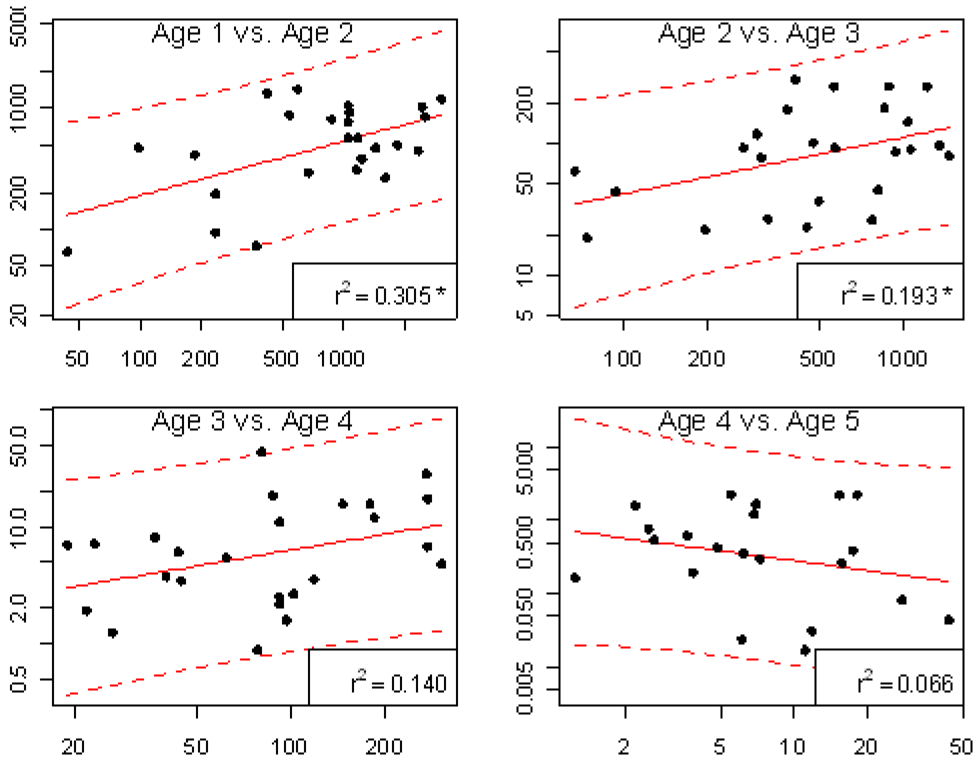

Figure 5 North Sea sprat. Internal consistency analysis from the IBTS Q1 survey. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (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.

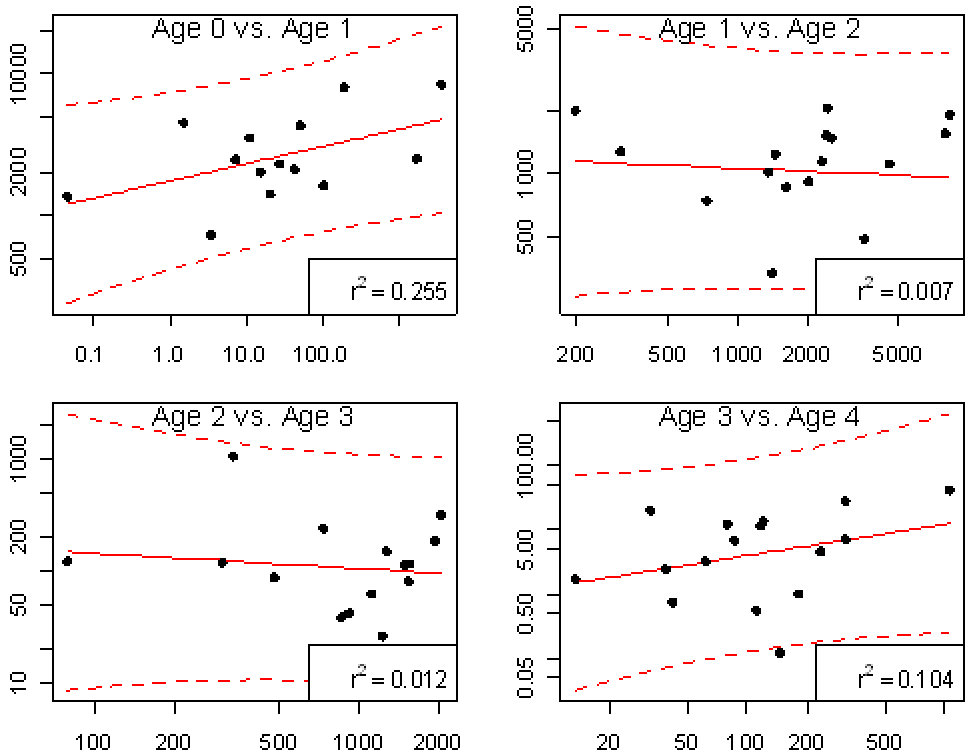

Figure 6. North Sea sprat. Internal consistency analysis from the IBTS Q3 survey. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (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.

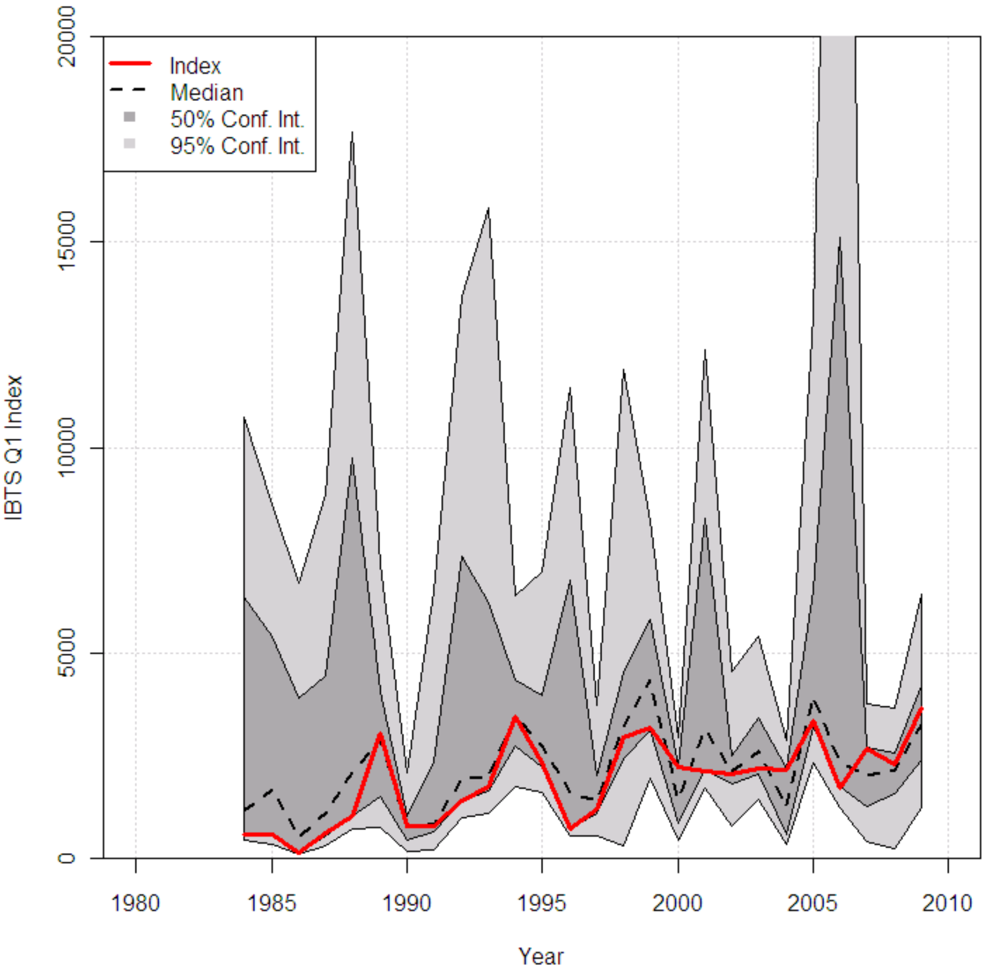

Figure 7. North Sea sprat. Distribution of index values for the IBTS Q1 index, as estimated by the DATRAS database. Values of both the mean index and median value are plotted, in addition to the 50% and 95% confidence bands.

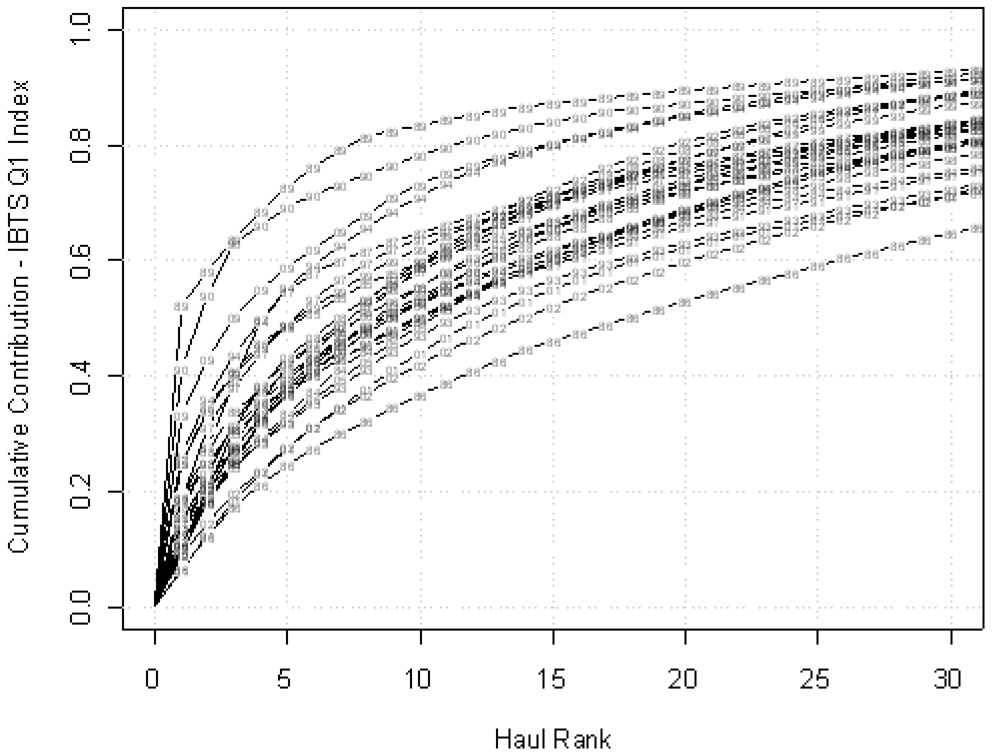

Figure 8. North Sea sprat. Cumulative distribution of the per-haul contribution to the total IBTS Q1 index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 30 largest hauls. Numbers on each line indicate the year for the survey.

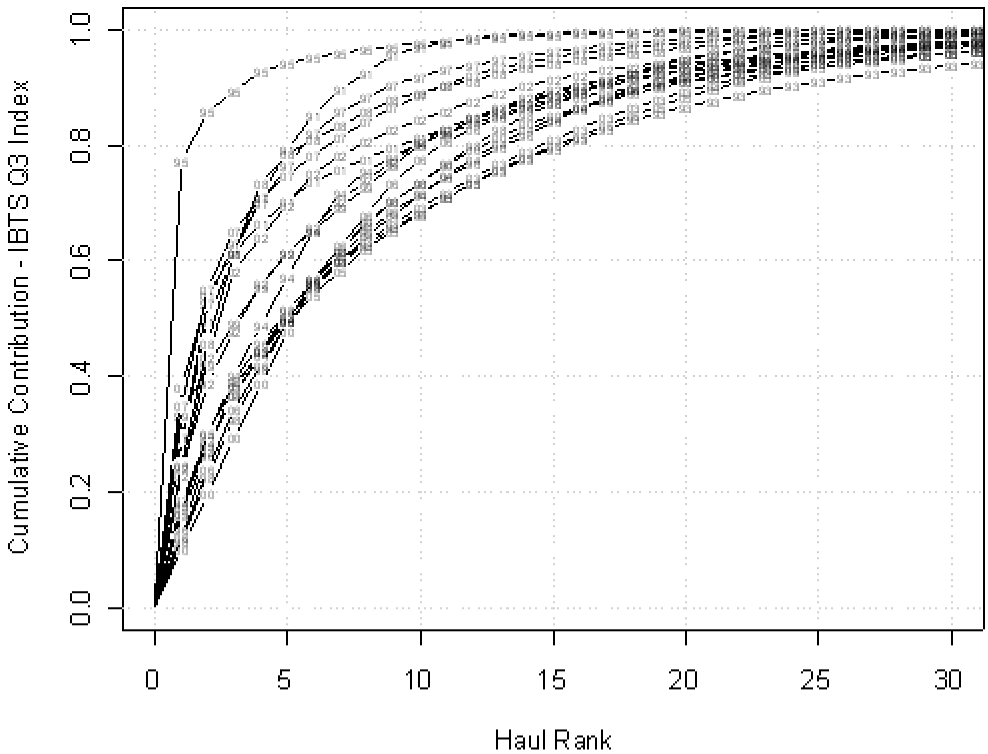

Figure 9. North Sea sprat. Cumulative distribution of the per-haul contribution to the total IBTS Q3 index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 30 largest hauls. Numbers on each line indicate the year for the survey.

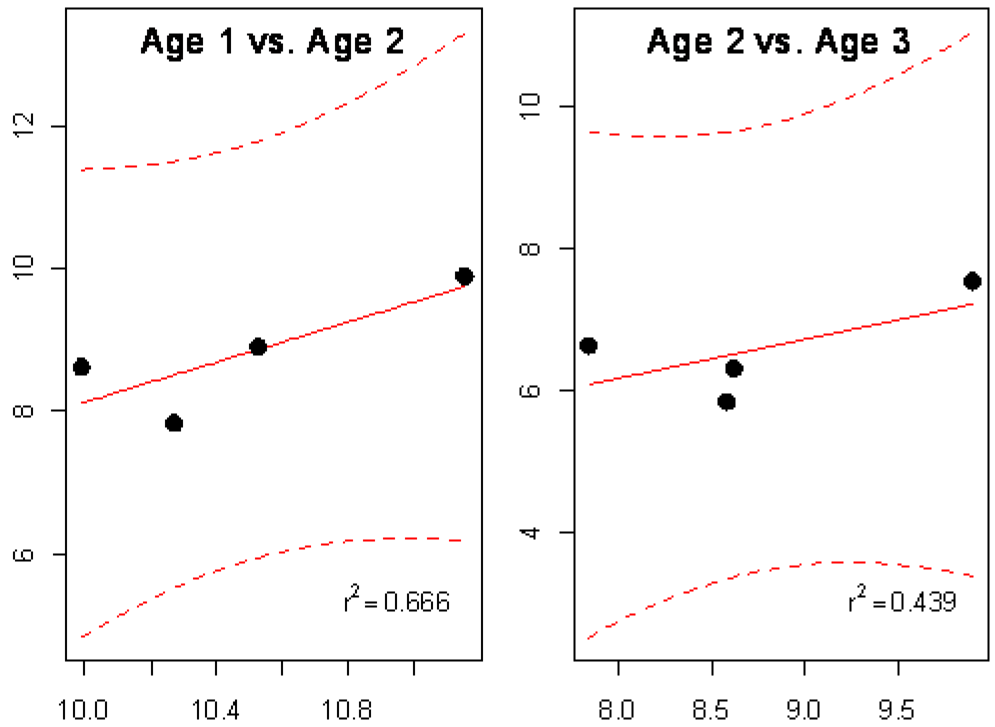

Figure 10. North Sea sprat. Internal consistency analysis from the herring acoustic survey, HERAS. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient 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

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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 Benchmark information per stock

To be filled in by the stock coordinator (send to Barbara@ices.dk)

Stock	**Western Baltic Spring Spawning Herring**			
Stock coordinator	Name: Lotte Worsøe Clausen	Email:		
Stock assessor	Name: Tomas Gröhsler/Valerio Bartolino	Email:		
Data contact	Name:	Email:		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**

Stock	**Western Baltic Spring Spawning Herring**			
Stock coordinator	Name: Lotte Worsøe Clausen	Email:		
Stock assessor	Name: Tomas Gröhsler/Valerio Bartolino	Email:		
Data contact	Name:	Email:		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Tuning series	1a. Larval survey coverage of the stock(s) available to fishery 1b. Larval components in the area 1c. Spawning components in the area (for the SSB estimation) 2. Do the available surveys really reflect the abundance of the respective year classes? 2b. The Sound survey 3. Survey indices back in time (acoustic (HERAS) and IBTS) are not split into stock components 4. Central Baltic herring; how much do the potential migration into the area affect the indices?	1a. Recent evaluation of the N20; can we expand our knowledge of larvae in the area (recent research; larval drift models) 1b. Availability of other larval components (e.g. Moksness); components in the area (local stocks), drift modelling, recruiting to the fished population. 1c. Ripe and running herring encountered in the area at any one time 2. Detailed analysis of survey data; examination of precision of indices; Survey fit will be investigated in assessment. 2b. Look into application of data; possibility of re-starting this survey 3. Split of survey dataseries based on a modelled split 4. Split back in time of GerAS survey (2005-2011) based on the SF. Include Swedish, Polish and German data	Data are easily available and supplied by survey groups (IBTSWG and WGIPS). Check MuPED surveys too. Historic working group reports. Drift models of herring larvae. *1) Polte P., Mosegaard H. Payne M, Swedish wingman to be found by Henrik M* *2) Berg C, Bartolino V* *2b) Mosegaard H* *3) Mosegaard H, Worsøe Clausen L, Berg C* *4) Gröhsler T. et al*	Richard Nash (Nor) They are not really external (even if more than welcome). What about having expertises outside HAWG?

Stock	**Western Baltic Spring Spawning Herring**			
Stock coordinator	Name: Lotte Worsøe Clausen	Email:		
Stock assessor	Name: Tomas Gröhsler/Valerio Bartolino	Email:		
Data contact	Name:	Email:		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Data	1. Misreporting from NS to Div IIIa (1991-2008) are going to be estimated and corresponding catches corrected; 2. Historical information is poorly utilised but can provide value information about stock 3. Central Baltic herring; how big an impact does this potential migration into the area have on the catch-at-age data 4. Standardization of the procedure for compiling the assessment input data from different country sources 5. Database on input data	1. Collaboration between DK and SWE industry and national institutes scrutinizing existing data bases. 2a. retrieve historical data from archives 2b. Incorporate historical catch data from archived information into assessment model. These data obviously need to be split, using a modelled split on the historical data 3. Split back in time catch data (2005-2011) in SD 24 based on the SF (including Polish, German, Danish and Swedish data) 4. development of a standard protocol for data compilation 5. Input files, keeping track of historic data	Log book and sales slip data and for later years VMS (vessel level). Archives (specifically SWE), biological sampling data should all be available at the national institutes. *1) Worsøe Clausen L, Bartolino V* *2a) Mosegaard H, Worsøe Clausen L, Bartolino V?* *2b) Mosegaard H, Worsøe Clausen L, Berg C* *3) Gröhsler T et al, Bartolino V, NN Poland* *4) Worsøe Clausen L??* *5) Berg, C, Gröhsler T*	National stakeholders (possibly through BSRAC)
Discards	Not an issue			

Stock	**Western Baltic Spring Spawning Herring**			
Stock coordinator	Name: Lotte Worsøe Clausen	Email:		
Stock assessor	Name: Tomas Gröhsler/Valerio Bartolino	Email:		
Data contact	Name:	Email:		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Biological Parameters	1. Stock components in the Western Baltic 2. Age and size at age 3. Constant natural mortalities are currently used 4. Constant maturity ogives are currently used/Fecundity	1. Investigative model of growth and maturity 1b. Precision of stock separation methodologies (including also the CBH issue) 1c. Migration and mixing (modelling spatio-temporal resolution) 2. Revision of the precision of ageing and the sampling for age structures 3. Revision of natural mortalities 4. Revision of maturity ogives	Need unified data set from Surveys and also data from stock coordinator Data also from published studies and literature *1) Mosegaard, H., Worsøe Clausen, L., Bekkevold, D.,* *1b) Was A?, Mosegaard H, Bekkevold D, Oeberst R?, Gröhsler T et al* *1c) Kasper Kristensen and Mosegaard H.* *2) Worsøe Clausen, L. And others* *4) Neunfeldt S* *5) Worsøe Clausen L, Bartolino V, Vitale F*	Ana Was (Poland) Dorte Bekkevold (Denmark) Stefano Mariani (IR) Audrey Geffen (IMR)

Stock	**Western Baltic Spring Spawning Herring**			
Stock coordinator	Name: Lotte Worsøe Clausen	Email:		
Stock assessor	Name: Tomas Gröhsler/Valerio Bartolino	Email:		
Data contact	Name:	Email:		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Assessment method	1. Current assessment model is not optimal and cannot be maintained 2. Investigate the impact on the assessment results given the outcomes of the input data analyses as proposed under Tuning Series and Biological data 3. Incorporate a multi-stock approach into the assessment procedure 4. Incorporate estimation of mixing of Central Baltic Herring and NSAS in the stock assessment 5. Forecast methodology	1. Develop new model 2a. Investigation of input data. 2b. Comparison of available stock assessment models and assumptions. 2c. Perform sensitivity runs with different model input data configurations 3. Modification to assessment methodology 4. Modification to the assessment methodology 5. Migration and mixing shall be dealt with in forecasting on the stock(s). Include the M and fecundity…	Data from HAWG, IBTSWG and WGIPS. Models from DTU-AQUA, IMR, IMARES,CEFAS and MSS *1-4) Berg C, Bartolino V, Grohsler T, Mosegaard H* *5) Ulrich, C., Mosegaard H*	Elizabeth Brooks (USA) Chris Francis (NIWA)

Stock	**Western Baltic Spring Spawning Herring**			
Stock coordinator	Name: Lotte Worsøe Clausen	Email:		
Stock assessor	Name: Tomas Gröhsler/Valerio Bartolino	Email:		
Data contact	Name:	Email:		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
Biological Reference Points	1. Investigate reference points under benchmarked assessment outcomes and in relation to the management plan 2.Need to protect component diversity. Consequences of different abundances, productivity and exploitation patterns across components are not understood 3. Investigate alternative reference points 4. Management considerations	1. Calculate new reference points based on assessment results, with main focus on Fmsy and Blim/Btrigger. Need clear guidance from ICES on how to provide advice to ACOM if reference points are deemed inappropriate given the new assessment results. 2a. Develop component-wise reference points 2b. Development of multi-component long term management plan 3. Literature / other assessment work review 4. Handling the advice structure to keep managers satisfied with the information given to provide management…	HAWG, multispecies WG and literature. *1-2) Mosegaard H, Grohsler T, Berg C, Ulrich Rescan C, Rindorf A?* *3) Berg C, Ulrich C., Worsøe Clausen, L.* *4) Worsøe Clausen, L., and the old gang from URSIN, GAP and others.*	Laurie Kell (ICCAT) Geir Huse (Nor) Mike Heath (UK)

Benchmark information per stock

To be filled in by the stock coordinator (send to Barbara@ices.dk)

Stock	**Sprat (Division IIIa; North Sea; VIId,e; Celtic Seas Ecoregion)**			
Stock coordinator	Cecilie Kvamme Katja Enberg Beatriz Roel	cecilie.kvamme@imr.no katja.enberg@imr.no beatriz.roel@cefas.co.uk		
Stock assessor	Name: To be decided	Email:		
Data contact	Lotte Worsøe Clausen Else Torstensen	law@aqua.dtu.dk Else.Torstensen@imr.no		
Issue	**Problem/Aim**	**Work needed / possible direction of solution**	**Data needed to be able to do this: are these available / where should these come from?**	**External expertise needed at benchmark type of expertise / proposed names**
(New) data to be Considered and/or quantified[1]	Additional M - predator relations/ quantify M through input to multispecies models	Bird predation and the levels of sprat needed to sustain bird populations Mammal predation and the levels of sprat needed to sustain bird populations Identification and quantification of other predators	Availability of data – unsure Availability of data – unsure Data should exist/be available	Bird consumption rates, abundances and ecology in the relevant areas / CAU, Kiel / UStA, Scotland Mammal consumption rates, abundances and ecology in the relevant areas / IMARES Various / A. Riindorf
	Prey relations	Quantify potential prey i.e. zooplankton (spatial and temporal aspects)	Spatial distributions and temporal dynamics – data should be available from a range of sources	Access to relevant databases and analytical skils for these data / UH, Hamburg, PEML, SAHFOS, WGOOFE
	Ecosystem drivers	Quantify the spatial and temporal variability in physical dynamics of the region	Physical oceanographic data and models of the physical system	Analyses of data and access to model outputs. / WGOOFI, WGZE

[1] Include all issues that you think may be relevant, even if you do not have the specific expertise at hand.If need be, the Secretariat will facilitate finding the necessary expertise to fill in the topic. There may be items in this list that result in 'action points for future work' rather than being implemented in the assessment in one benchmark.

	Stock identity and boundaries	1. Drift modelling to look at connectivity re egg and larval drift - include a review of egg and larvae development rates 2. Definition of stocks or components Review the logical divisions between populations. 3. Genetic differences in 'stocks' 4. Review the boundaries i.e. coastal areas and the potential for inclusion of fjordic/coastal fish in to the catches or the influence of biological samples in to the catch data. 5. Review shifts in adults distribution over time	1. Physical oceanographic data and models of the physical system, egg and larvae development rates 2. Requires data request to be similar for all areas. ALK comparisons: 3. What ever is available 4. Current information and literature. 5. Available data and new models	1. Modelling skills /M. Payne (DTU Aqua) 2. Access to data and Analyses / A.Rindorf 3. Access to data / LAW/M.Limborg 4. Access to information / RDMN 5. Access to data e.e. IBTS etc and modelling / RDMN, GH (Norway), Cefas
	Stock indices	1. Review IBTS data and the presentation of indices 2. Review HERAS and the presentation of indices, also review the area coverage and the influence of incomplete coverage. 3. Larval indices	1. IBTS data by haul and rectangle 2. HERAS data, coverage etc 3. CPR, MIK, old time series (Scotland, MBA, RoI)	1. Access to data and analyses / A. Rindorf 2. Access to data and analyses / WGIPS, S. Fässler 3. Access to data and analyses / M. Payne, RDMN, M.Clarke, SGSIPS, Cefas, S.Beggs (NI). MSS
	Biological sampling	1. Obtain sample level biological information on length distribution, weight and age at length from all countries back in time. 2. Review the biological sampling and input to the catch data - catch-at-age matrix etc. 3. Review the ageing of sprat 4. Check all mean weights.at-age, especially the 0 groups versus 1s	1. Request to all countries for relevant data 2. National representatives and databases. 3. In hand, information due probably after Benchmark 4. Nationally held information	1. Access to data and analyses / A. R, LAW 2. Access to data and analyses / A.R., LAW, ET (Norway) 3. Access to expertise / PGCCDBS, LAW

	Catch data	6. Review the by-catch and target species calculations, including whether there has been significant historic misreporting. 1. Total catch per country, square, year and quarter as far back in time as possible to allow the estimation of catch by age and quarter and mean weight in catch and stock	6. Information held at national institutes 1. All countries	6. Access to data and analyses / A.R, IMARES, RDMN 1. Access to data / A.R., LAW
Tuning series	Methods, indices, output – re-examination of surveys and output	HERAS, IBTS, IRGFS, NI Acoustic survey, Malin Shelf acoustic survey and any others – All to be examined	All data from each survey	Access to data from the various surveys
Discards	Availability of data			
Biological Parameters	Maturity and ageing			
Assessment method	**To be determined**			
Biological Reference Points	None exist at present for any of the components			

Annex 13: Technical Minutes of the Celtic Sea Review Group

Review of the Herring Assessment Working Group (HAWG) Report

HER-IRLS [HAWG Section 4: Herring in Divisions VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland)]

1) **Assessment Type**: Update assessment with catch and survey data through 2011 (benchmarked in 2007).

2) **Assessment**: Analytical.

3) **Forecast**: Short- and long-term projections were presented.

4) **Assessment method**: FLICA (split year: 1st April-31st March) tuned to the CSHAS acoustic survey from 2002 to 2011. Additional exploratory FLICA runs were conducted in 2012.

5) **Consistency**:

- A few minor changes were made to the benchmark assessment in 2009 and have been continued in the current assessment.
- A slight retrospective trend of overestimating SSB has developed in the last few years of the retrospective analysis.
- The 2010 SSB has been adjusted downwards by 26% from the 2011 assessment.

6) **Stock Status**:

- The stock has been relatively stable with SSB and F both remaining at levels comparable to 2010.
- SSB in 2011 (85,366t) is well above B_{PA} of 44,000t and B_{LIM} of 26,000t.
- The F in 2011 (0.152) is below $F_{0.1}$ (0.17) and F_{MSY} (0.25).

7) **Management Plan**:

- A rebuilding plan is in place for this stock based on $F_{0.1}$ as a proxy for F_{MSY}. The rebuilding plan is deemed in accordance with the PA if $F_{0.1}$ is adhered to.
- A long-term management plan is currently being discussed. This plan sets target F equal to 0.23 and the trigger biomass point at 61,000t.
- The TAC (calendar year) for 2011 was set to 13,200t and for 2012 is 21,100t. This represents a 60% increase from 2011, which corresponds to the harvest control rule contained in the rebuilding plan.
- Assuming the full 2012 TAC of 18,236t is caught indicates a SSB of 84,241t for 2012.
- Following the proposed management plan target F (0.23) 2013 landings are 17,152t leading to a 2013 SSB of 78,643 and a 2014 SSB of 74,586t.

General Comments

The methodology is well explained and data inputs and assessment methods are consistent with the stock annex.

The WG included a new survey stratum (stratum 20) based on previously unsurveyed fishing grounds. The RG agrees that the inclusion of stratum 20 in the tuning series is reasonable.

The effect of extending the plus group from 6+ to 7+ was tested since the 6+ is quite large, but this did not improve the diagnostics. The RG agrees with the WG decision to maintain the 6+ configuration.

In the assessment, age-3 is chosen as the first fully recruited age (reference age for separable constraint). Judging by the catch-at-age distributions (Figures 4.2.1.1 and 4.2.1.3) it appears that full recruitment at age-2 should be considered.

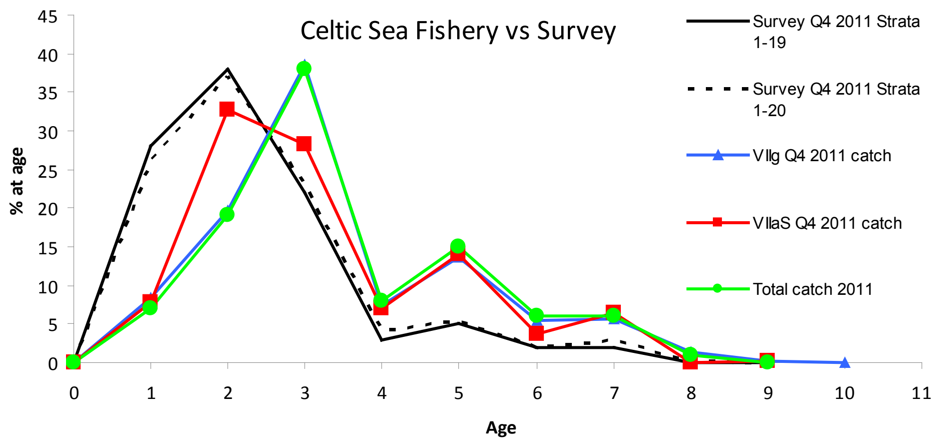

Figure 4.2.1.3. Herring in the Celtic Sea. The percentage age composition in the survey and the commercial fishery 2011/2012.

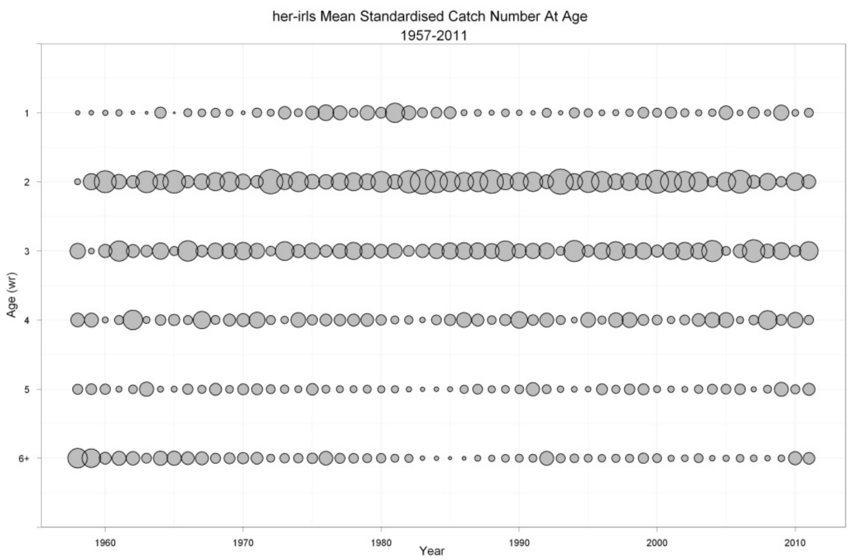

Figure 4.2.1.1. Herring in the Celtic Sea. Catch numbers-at-age standardised by yearly mean. 6-ringer is the plus group.

The RG suggests that discards should be taken into account for the next assessment.

Technical Comments

It would be informative to know the proportions at age for the exploratory runs when the plus group is changed from age-6+ to age-7+.

Conclusions

The RG suggests that this model is acceptable for use as the basis of management advice. The assessment results are consistent with previous updates and suggest that the stock SSB is above the time-series average. The SSB is well above the yield-based reference points and F has been maintained at historically low levels. However, the increase in discards in the last two years must be monitored, and possibly considered in the next stock assessment. Further analysis of stock mixing with herring in the Irish Sea is recommended.

HER-VIAN [HAWG Section 5: Herring in Division VIa (North)]

1) **Assessment type**: Update from 2011 including one additional year of catch and acoustic survey data (through 2011).

2) **Assessment**: Analytical.

3) **Forecast**: A deterministic short-term projection using average Fbar (ages 3-6) over the last three years and geometric mean recruitment since 1989 (corresponding to period of low productivity) was presented.

4) **Assessment Model**: FLICA tuned to the MSHAS_N acoustic survey from 1991-2011.

5) **Consistency**:

- The assessment follows the procedures set out in the stock annex, the settings of which were last explored in 2009.
- The model performs reasonably well with limited, but balanced, retrospective patterns.
- The results are consistent with previous models despite revisions to the acoustic survey's observations of abundance, weight, and maturity.

6) **Stock Status**:

- SSB in 2011 (82,158t) is approximately 1.7*B_{LIM} (50,000t) and above B_{PA} (75,000t), while Fbar in 2011 (.178) is below F_{MSY} (.25).
- However, YPR and SPR analysis were carried out indicating that F in 2011 was greater than both $F_{0.1}$ (.16) and $F_{35\%}$ (.134).
- Little information is given regarding the origins of the estimate of F_{MSY}. It is presumed to be taken from North Sea herring.

7) **Man. Plan**:

- The 2012 TAC is 22,900t, which is a slight increase from the 2011 TAC of 22,481t (17,759t of which is believed to have been removed).
- This follows the agreed upon management plan (Council Regulation 1300/2008; provided below).
- Misreporting of catches from other areas in VIaN continues to be an issue resulting in uncertainty in landings estimates.
- Status quo F (0.2159) should result in a 2012 SSB of 101,313t and a 2013 SSB of 104,000t.
- Following the management plan, the proposed 2013 TAC increases by 20% to 27,500t (F~0.22) and should result in a 2014 SSB of ~103,000t (well above B_{PA}).

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.

General Comments

This assessment was extremely well done and contained a thorough annex that documented the reasoning behind a majority of modelling decisions. The report file also contained extensive diagnostic documentation that made it easy for the reviewer to assess model performance.

As the WG states this assessment is fairly noisy due to the reliance on a variable acoustic survey. The RG agrees that the point estimates provided by this approach must be applied carefully. However, the lack of any strong retrospective or residual patterns indicates that this model is performing remarkably well considering the data limitations.

The WG states that misreporting has been minimal in recent years, but, due to past instances of high misreporting of catches from other stock areas in VIaN, the RG warns that past misreporting may still be impacting the reliability of model results.

The continual temporal and spatial contraction of effort into northern areas in quarter three should be monitored. The RG is concerned that this contraction could indicate a decrease in stock abundance. If this is the case, the damage caused will be multiplied if the fish being harvested from this area represent a single spawning population, which is being progressively fished down.

As mentioned by the WG, the decreased productivity over the last decade is likely a mixture of decreased spawning potential due to extremely low SSB since the mid-1970s and adverse environmental changes. Although the stock appears to be in good shape compared to current reference points, recruitment should be continually monitored and F should be maintained well below F_{MSY}. It appears to the RG that the stock has settled into a low productivity regime and may not be able to recover with any speed from large or even medium size perturbations.

Although the RG agrees that age-varying natural mortality is appropriate for this stock, it would be helpful to provide information regarding what the mortality schedule is based on. Additionally, considering the ecosystem changes described in the report and the importance of herring as a forage fish, time-invariant natural mortality may not be appropriate for this species. The RG suggests that this should be investigated in the near future, especially since the increasing seal populations in this stock area may have large impacts on mortality rates.

There is no documentation for the basis of F_{MSY}=.25. It is assumed that this value comes from work with North Sea herring, but this connection is not made within the documentation provided. The RG suggests that this value needs to be re-evaluated specifically for herring in division VIaN as it is considerably higher than estimates of $F_{0.1}$ (.16) or $F_{35\%}$ (.134). Considering the discrepancy between F_{MSY} and $F_{35\%}$ it is possible that current fishing mortality is impairing productivity and impeding stocks from rebuilding to previous time-series SSB highs of 300-500,000t. A more formal estimate of SSB associated with F_{MSY} may also help to determine whether the current biomass is low or biomass prior to 1975 was simply well above B_{MSY}.

Technical Comments

The reference to the annex on page 1 does not match the annex report. It should likely read H.1.

The retrospective plots (figure 5.6.13) should be enlarged and colour coded. They are currently difficult to read and assess which year each line represents.

No source for maturity and weight-at-age is given prior to 1992 and 1993, respectively (see annex p. 713).

The annex (p. 711) states that the SGHERWAY would take place in 2008 to investigate the WESTHER recommendations regarding stock structure and stock identity, but no results of this study are presented in any of the documentation. Until this information is available, the RG agrees with the WG that the current management units should be maintained. However, future WG's should be weary of continued effort contraction or any other sign that individual spawning components within any of the herring stocks might be exhibiting contraction.

Conclusions

The RG concludes that this assessment is appropriate for the basis of management advice. The RG agrees with the WG that the division VIaN herring stocks appears to be in 'acceptable' condition and that the current management plan and proposed TACs are appropriate and consistent with the MSY and precautionary approaches. It appears that the current management plan is adequately flexible to deal with the variability inherent in this assessment due to its constraints on yearly deviations in the TAC. Although the assessment is extremely well done a number of data limitations and uncertainties exist. These include: unknown stock structure, past misreporting of catch, and ecosystem changes that may have impacted natural mortality and productivity. Additionally, it is unknown if effort contraction represents spatial population contraction, and F_{MSY} may not be appropriately measured for this stock. Continued low recruitment may indicate that F_{MSY} is too high and/or environmental changes necessitate a lower fishing mortality to maintain stock sizes above B_{PA}.

HER-IRLW [HAWG Section 6: Herring in Divisions VIa (South) and VIIb,c]

1) **Assessment type**: Update from 2011 including one additional year of catch and survey data.
2) **Assessment**: Trends based on exploratory separable VPAs.
3) **Forecast**: Uncertain short-term forecast presented based on low recruitment regime, but no medium- or long-term forecasts were presented.
4) **Assessment Model**: Exploratory separable VPA and FLICA models were run using various combinations of available tuning indices.
5) **Consistency**:
    - There is no accepted assessment for this stock, but a separable VPA has been used in recent years as an exploratory assessment, while FLICA was also explored for 2012.
    - All the exploratory models generally suggest continued low SSB, poor recruitment, and high F. ICA runs indicate that F may be declining in recent years.
    - Retrospective patterns of F and SSB resulting from the separable VPA suggest a trend of overestimating SSB and underestimating F, providing inconsistent management advice annually.
6) **Stock Status**:
    - The exploratory assessments suggests that $B < B_{LIM}$ (81,000t) and $F > F_{MSY}$ (.25) and $F_{0.1}$ (0.2).
    - R is stable and at low levels since 2000 with a possible strong 2008 cohort.
    - The terminal year estimates of B, F and R are uncertain.
7) **Man. Plan**:
    - The Pelagic Regional Advisory Council (RAC) proposed a rebuilding plan with a status quo TAC in 2012 and a TAC set at $F_{0.1}$ in subsequent years that was reviewed by STECF but not applied.
    - The generic ICES rule of a linear decrease in F towards the origin when $B < B_{LIM}$ suggests an F=0.11 in 2013, which indicates landings of 5,500t and a SSB of 59,000t. This would lead to a 2014 SSB of 70,043t.

General Comments

The methodology is well explained and data inputs and assessment methods are consistent with the stock annex.

Inclusion of catch in numbers-at-age back to 1957 and improved reporting from the Irish fishing fleet, have improved the overall data quality of the assessment. However, lack of understanding of movement patterns and stock mixing between VIa South and VIa North confound assessment results for the most recent years. The WG report describes alternative analysis with aggregated stocks that was considered too uncertain.

The retrospective patterns in F resulting from all VPA configurations (terminal F=0.2, 0.4, 0.5 and 0.6) suggest that quota reductions have not reduced F to levels near F_{MSY} in recent years. Although SSB seems to be stable in recent years, it is well below B_{PA} and B_{LIM}. The 2012 exploratory FLICA assessment suggests similar trends as the separable VPA; however both assessment methods have considerable uncertainty in estimates of F and SSB in the most recent years.

The assessment includes a value for F_{MSY} at F=0.25. The HAWG did not consider candidate values for $B_{TRIGGER}$ in detail and suggested a range that may be appropriate, recommending that a final value be determined during management plan development. The basis of F_{MSY} is not reported in the annex, but appears to be an analogy to North Sea herring.

Technical Comments

The assessment does not mention natural mortality, despite recent studies reported in the Advice suggesting that seals are an important predator of herring and have increased in abundance in Division VIa in recent years. A sensitivity analysis of a range of natural mortality levels could be incorporated in the separable VPA assessment.

Statement on page 377: "All of the runs with starting F values greater than 0.2, show that SSB is at the lowest level in the series" is not accurate. Tables 6.6.1.2 and 6.6.1.3 show 2010 SSB as lowest in the series.

Paragraph on page 377 contains inaccuracies in Table references and statements with respect to the direction of retrospective patterns (original text):

"Historical retrospective analyses were performed for each of the terminal F initial values. Using a terminal F = 0.2 as a starting value (Figure 6.6.1.4) shows a bias towards underestimation of SSB and overestimation of F. Using a terminal F = 0.4 (Figure 6.6.1.5) displays a more stable estimation of F with a slight overestimation of SSB. The retrospective assessment using F=0.5 (Figures 6.6.1.6) shows stability in SSB estimation, with a slight underestimation in F. The scenario for F=0.6 (Figure 6.6.1.7) shows a bias towards a slight overestimation of SSB and an underestimation of F."

The paragraph should read (see Figures below):

"Historical retrospective analyses were performed for each of the terminal F initial values. Using a terminal F = 0.2 as a starting value (Figure 6.6.1.3) shows a bias towards overestimation of SSB and underestimation of F. Using a terminal F = 0.4 (Figure 6.6.1.4) displays a more stable estimation of SSB with a slight underestimation of F. The retrospective assessment using F=0.5 (Figures 6.6.1.5) shows stability in SSB estimation, with a slight underestimation in F. The scenario for F=0.6 (Figure 6.6.1.6) shows a bias towards a slight overestimation of SSB and an underestimation of F."

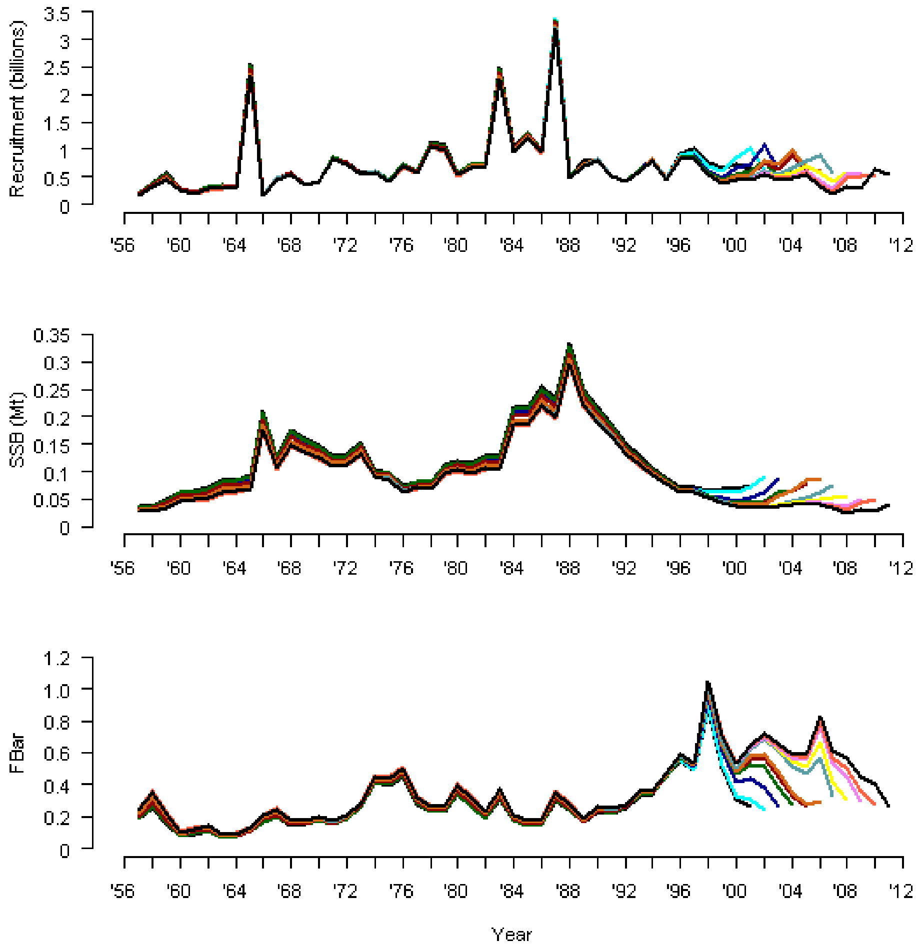

Figure 6.6.1.3. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F=0.2.

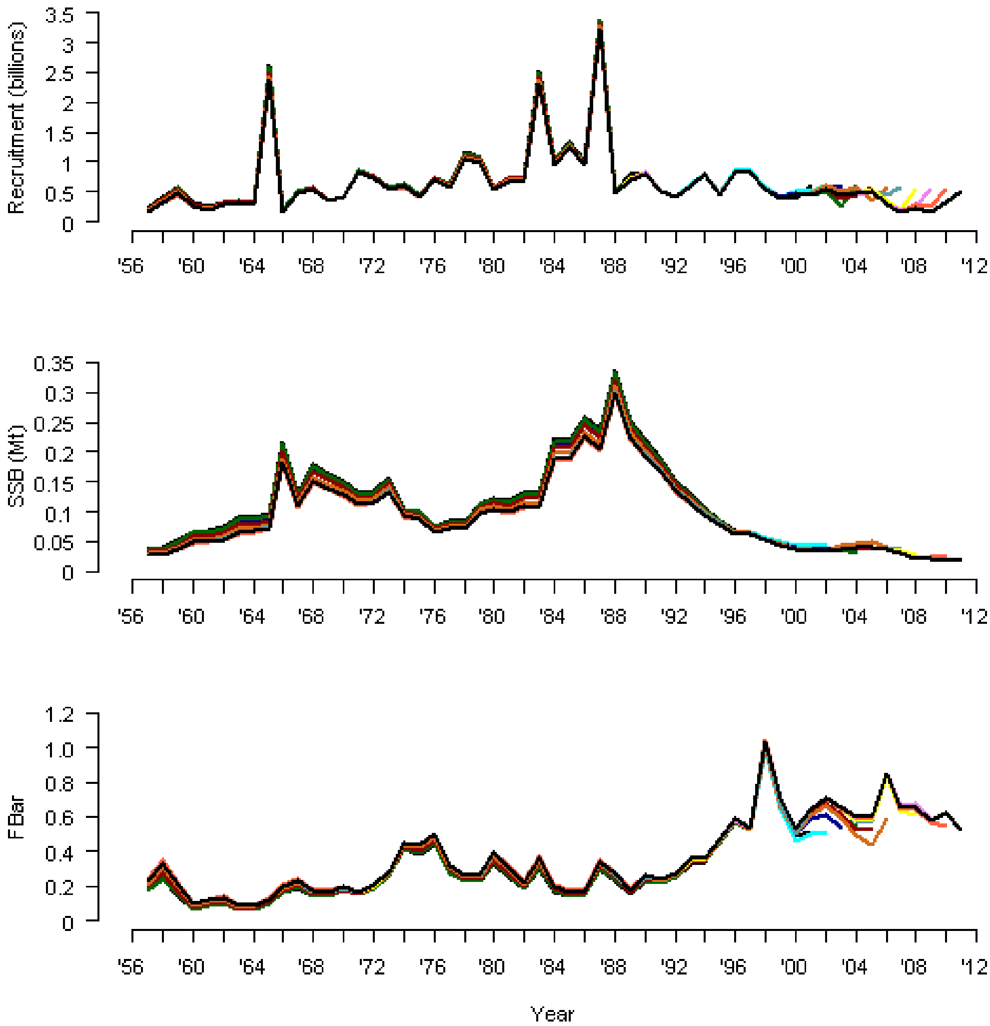

Figure 6.6.1.4. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.4.

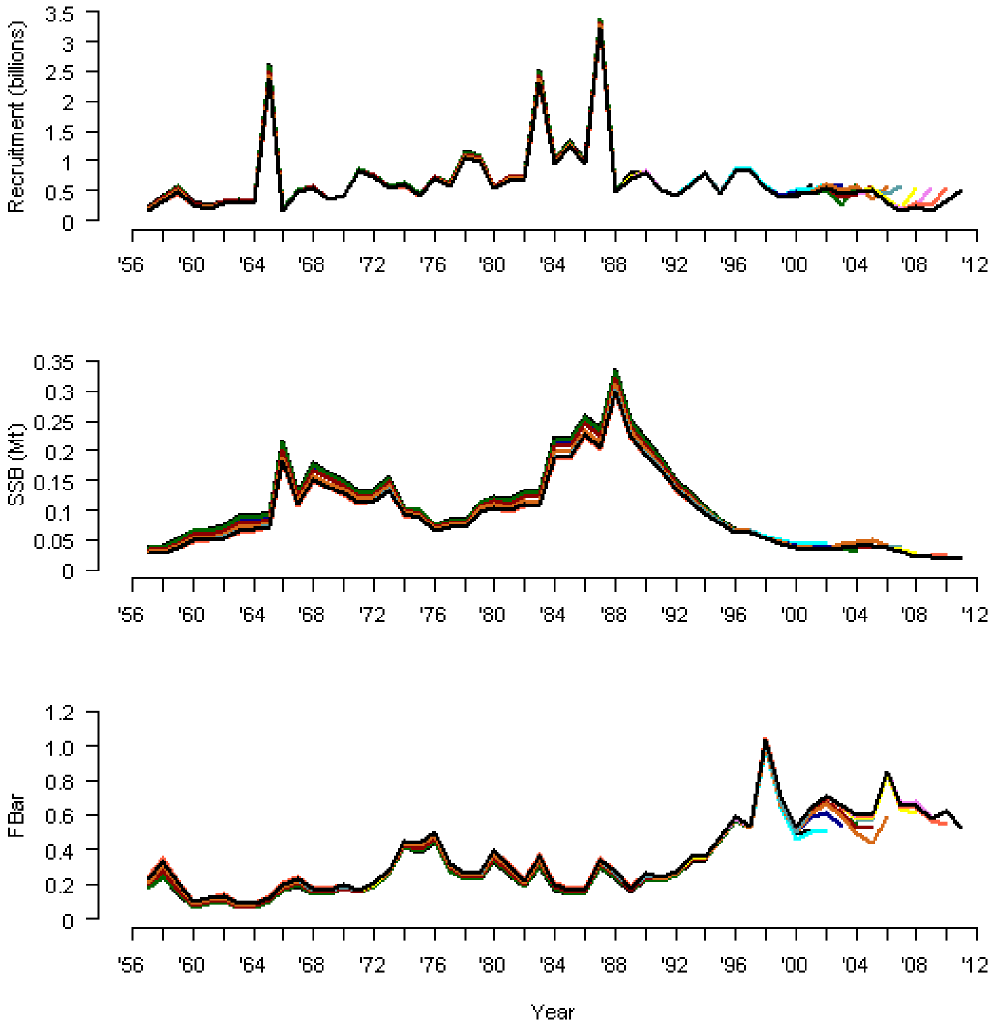

Figure 6.6.1.5. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.5.

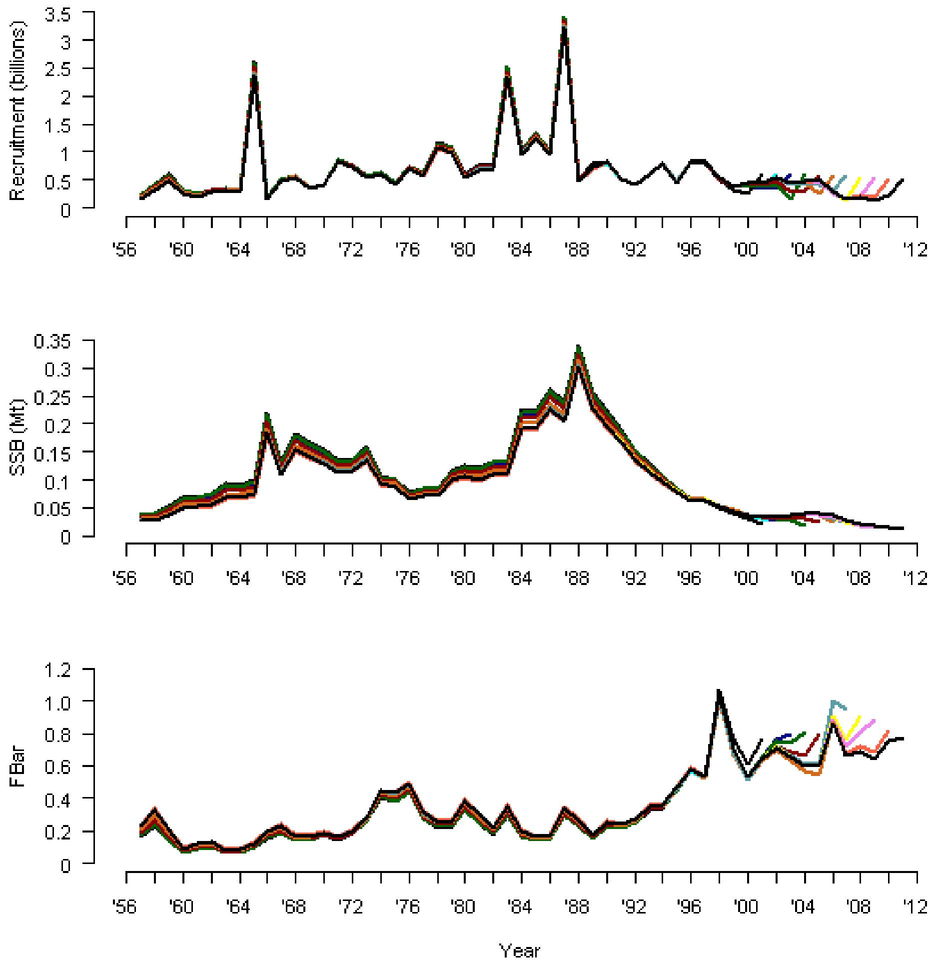

Figure 6.6.1.6. Herring in Divisions VIa(S) and VIIb,c. Historical retrospective separable VPA assessment using an initial terminal F =0.6.

Page 378: The bullet for VIa/VIIb,c survey time series should be corrected to 2008-2011, rather than 2008-2022.

Page 379: The sentence "Optimal FLICA performance was achieved with the VIa/VIIbc tuning series, compromising the lowing:…" should be corrected to "compromising the following…"

Conclusions

The RG concludes that trends from the exploratory separable VPA are appropriate for the basis of management advice. The assessment results are consistent with previous updates and suggest that the stock is overexploited and outside of biological limits. Although both the separable VPA and FLICA methods have high levels of uncertainty for terminal year estimates, both show a downward trend in SSB and recruitment and indicate increasing F. The RG agrees with the WG that, as suggested by the generic ICES MSY framework, catches should be decreased in order to reduce mortality and rebuild SSB. However, the WG notes that the pelagic RAC disagrees with the stock status presented by the HAWG, and instead argues that herring abundance is high. Further exploration of the aggregated ICA approach is warranted with a longer time series of acoustic survey data. Additionally, continued analysis of stock mixing in the VIa area is needed to determine the appropriate use of acoustic survey information as recommended by SGHERWAY.

HER-NIRS [HAWG Section 7: Herring in Division VIIa North of 52° 30′ N (Irish Sea)]

1) Assessment Type: Update including 2011 survey indices and commercial catch data (benchmarked in 2012).

2) **Assessment**: Analytical (previously based on trends from FLICA model runs).

3) **Forecast**: Short-term only, no medium or long term projections were presented.

4) **Assessment method**: A state-space assessment model (SAM) was used, which was tuned to the AC-VIIaN (acoustic) and NINEL (larval) survey indices.

5) **Consistency**:

- The model was applied as per the stock Annex.
- No retrospective trends in SSB, F or R were present.
- An exploratory analysis was run excluding the 2011 acoustic survey. The trends remained the same, but the magnitude of the SSB trend was inflated and the F and R trends were deflated.

6) Stock Status:

- There is an increasing trend in SSB and R with a decreasing trend in F.
- SSB in 2011(18,858t) is twice the estimate of B_{PA} (9500t).
- Fbar (ages 4-6) in 2011 (0.2509) is below F_{MSY} (0.26).

7) **Management Plan**:

- No management plan has been agreed upon for this stock, but the WG supports the development of a long-term management plan.
- The 2011 TAC was 5,280t, which was decreased to 4,752t in 2012.
- The 2011 advice was to not increase catch.
- Assuming the 2012 TAC is fully harvested indicates a 2012 F of 0.208 indicating SSB of 41,838t in 2012.
- Status quo F suggests landings of 4-5,000t in 2013 and an SSB of 18,000t in 2013 and 15,500t in 2014.

General Comments

The WG report is well written, concise, and follows the stock annex.

The WG states that the retrospective analysis indicates underestimation of SSB, and overestimation of F, but retrospective plots do not indicate any distinct patterns (Figure 7.6.28).

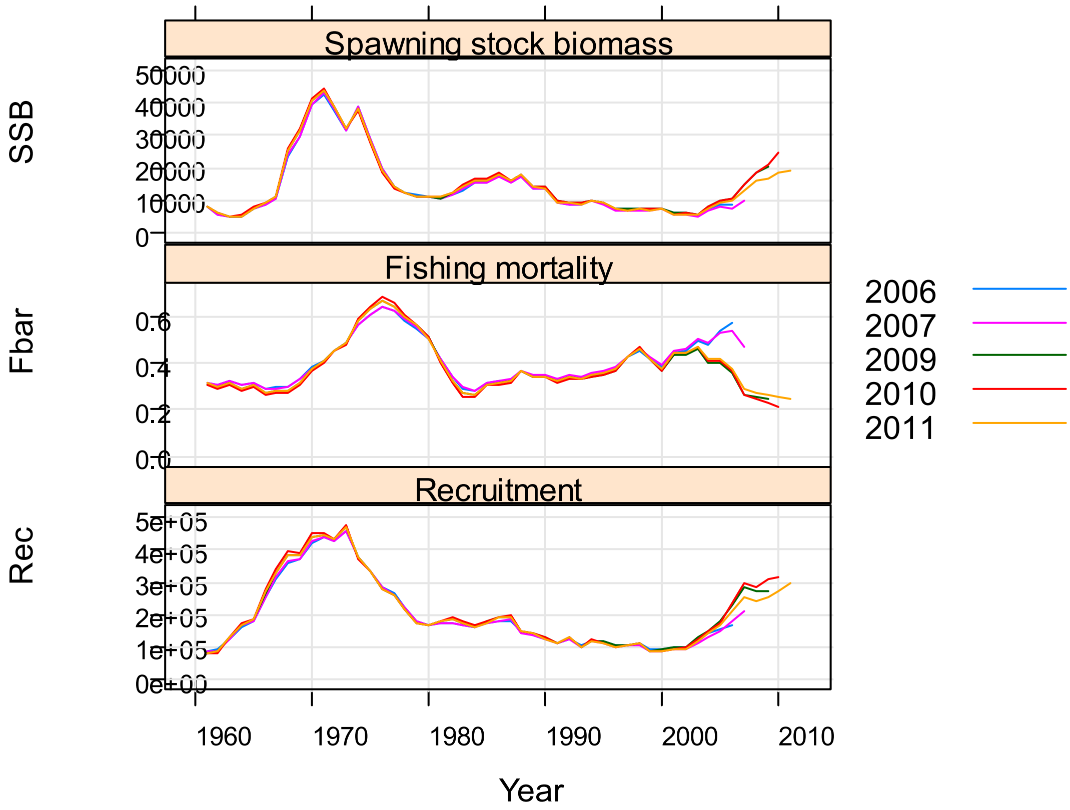

Figure 7.6.28 Herring in Division VIIa North (Irish Sea). Analytical retrospective patterns (2011 to 2005, excl 2008 where model did not converge) of SSB, recruitment and mean $F_{4\text{-}6}$ from the final FLSAM assessment.

The 2008 retrospective analysis run was removed because the model would not converge on a solution. Preliminary investigations indicated that the 2007 age-1 catch estimates were the main culprit, but the effect on the model is unknown. The RG agrees that further exploration is needed to identify the issue.

Technical Comments

An extended acoustic survey has been performed since 2007 on a small portion of the stock area. The survey area accounts for over 80% of the Irish Sea SSB since 2001, but this survey is not included in the assessment. It is only used to verify the results of the standard acoustic survey. The RG agrees with the findings of WKPELA2012, that it would be beneficial to use this survey in the future.

Figure 7.6.25 and 7.6.27 are hard to read. The colours should be changed or image resolution increased.

Conclusions

This assessment appears well done and indicates no retrospective patterns or major diagnostic issues. The RG recommends that this assessment should be used as a basis for management advice. According to the ICES MSY framework this stock appears in 'acceptable' condition. Status quo catch rates appear to be sustainable and adhere to the MSY approach.

SPR-CELT [HAWG Section 10: Sprat in Divisions VI and VII (the Celtic Sea eco-region)]

1) **Assessment type:** Update from 2011 report including additional year of catch, LPUE, and acoustic survey data (benchmark scheduled for 2013).
2) **Assessment**: Catch only (no Assessment, but LPUE and acoustic biomass trends are presented).
3) **Forecast**: None.
4) **Assessment model**: No assessment has been accepted for this stock. An exploratory LPUE time-series fitted with a biomass dynamics model was performed, but was not accepted for advice.
5) **Consistency**:
    - This is the second year ICES analyzed data for sprat in the Celtic Sea and West of Scotland.
    - This year the ICES WG on New stocks (WGNEW) was asked to give guidance on the stock structure of sprat in the Celtic Seas (Subareas VI and VII). This was not done so the HAWG presented all available data on these sprat populations in a single chapter.
    - There is no previous model to compare consistency to.

6) **Stock status**:
    - There is insufficient information to evaluate the status of sprat in this area.
    - LPUE indices appear to be increasing, but reliability of this data is unknown.
    - Landings appear to be stable over the last half decade, but only about 1/5th the levels of the early 1980s.
    - Acoustic surveys indicate a slight increasing trend in the last year, but are relatively noisy.
7) **Management Plan**:
    - There is a TAC for sprat in division VIId,e, (English Channel), but no other TACs exist for sprat in the Celtic Sea eco-region.
    - ICES advised that catches should not be allowed to increase in 2012.
    - The landings in 2012 for the entire eco-region were 7,656t, which appears to be around the time-series average.

General Comments

The WG provided a very detailed description of all available data on sprat landings and surveys in a clear and concise manner.

The stock structure of sprat in the eco-region is unclear. The development of analytic assessments to inform management will require additional information on stock structure and movement.

The HAWG suggests that areas VI and VII should not be considered as a single management unit for sprat.

A trial fishery for sprat was carried out by herring vessels in the Irish Sea (Division VIIa). The results of the trial fishery were inconclusive, but plans to conduct further experiments are under discussion. The RG suggests that this may provide an opportunity to collect information on catch composition. It should also be noted that without quantitative estimates of stock abundance and sustainable catch levels, the effect of a new directed fishery is unknown.

There are a number of acoustic surveys that are used to estimate sprat abundance. However, many of these surveys are designed to measure herring biomass and may not be appropriate as indices of sprat abundance.

Molloy and Bhatnagar (1977) estimated $F_{0.1}$ for Irish Sea and Celtic Sea sprat populations independently. They concluded that the Celtic Sea population could withstand a higher F. The estimates of $F_{0.1}$ were 0.5 for the Irish Sea and 0.8 for the Celtic Sea. The RG recommends continued work developing reference points for sprat to support the advisory guidance from WKLIFE and RGLIFE, but cautions against the utilization of these reference points for management purposes due to the uncertainties about stock structure and catch.

Technical Comments

The WG points out that LPUE may not be a reliable indicator of abundance for a shoaling fish and its utilization should be considered carefully in future assessments. The RG agrees and notes that the LPUE index presented in the report does not appear to factor in changes in fishing effort over time.

Herring by-catch in the sprat fishery may be counted as 'sprat landings', which indicates that sprat landings in some areas may be overestimated. The RG recommends further investigation of this issue to: (1) determine if this is a significant problem, and, if so, can it be isolated to particular fisheries, areas, seasons, or gear types; (2) attempt to quantify the amount of mis-reporting.

Conclusions

Estimates from surveys in the Celtic Sea indicate an increase in biomass of sprat in 2011 relative to recent years. LPUE data from the Celtic sea also indicates an increasing trend. However, several surveys were not completed or the data was not available in time to be incorporated as part of this assessment. Considering the uncertainties about stock structure and catch, the RG supports the WG in its assertion that "*there is insufficient information to evaluate the status of sprat in this area*". Future assessments should carefully consider the utility of each survey and should consider the continuation or expansion of dedicated sprat surveys.

Annex 14: Technical Minutes from the North Sea Review Group

Review of ICES	**HAWG Report 2012**
Reviewers:	Gary Melvin (Canada, chair)
	Anthony Wood (USA)
	Höskuldur Bjornsson (Iceland)
Chair WG:	Lotte Worsoe Clausen, Denmark and Maurice Clarke, Ireland
Secretariat:	Barbara Schoute

General

The North Sea Technical group reviewed several stocks examined by the 2012 Herring Assessment Working Group for the Area South of 62° N (HAWG). This was one of 4 working group reports used by the NSRG to conduct their review of North Sea Stocks. The RG would like to acknowledge the effort by the working group to produce a coherent report and for mostly completing their documentation in a timely manner. The NSTG would also like to thank the ICES Secretariat for their support throughout the review process.

The Review Group considered the following stocks:

spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)
spr-nsea	Sprat in Subarea IV (North Sea)

Stocks with a scheduled benchmark assessment are:

The North Sea Sprat in Sub-area IV is scheduled for a benchmark assessment in 2013. The last was in September 2009.

Sprat in Subarea IV (North Sea) spr-nsea

1) **Assessment type: Update**
2) **Assessment**: An exploratory analytical assessment was undertaken in 2012
3) **Forecast**: No short/long term forecast presented
4) **Assessment model**: Last framework in 2009 concluded that previous assessment methods were inappropriate.
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**: Appears to be increasing based on surveys and exploratory analysis. . SSB and F up slightly, with recruitment relatively high over the past 4 years.
7) **Man. Plan.**: No. Management by TAC, ITQ and herring by-catch quota. By-catch up slightly for 2012. Maintaining current TAC likely sustainable given observed trends. No defined reference points.

General comments

Stock structure continues to be uncertain with potentially strong overlap with English Channel sprat, but weak and variable with Kattegat sprat, based on genetic studies.

There were no major changes in fishing technology or patterns. Catches were about average for the time series and well below the advised and agreed TAC. By-catch of herring restrictions implemented in 1996 to restrict catches were not exceeded.

Biological sampling improved in 2011 and now meets the recommended 1 sample per 2000t landed. However, did not follow the catch distribution. Prior to this year sampling was poor. Average mean weight at age was similar to 2010 for ages 1 and 2, but slightly smaller for ages 3 and 4. There seems to be a problem in the table (8.2.3) as the 2010 and 2011 weighted means are identical for ages 1-4.

The IBTS Q1 (1-group) is used as an indication of recruitment. The 2012 index, although preliminary, was the 4th highest in the 28 year time series. Last year's incoming 1-group (2010year class) was well below average for the whole time series, both in absolute and relative terms.

Technical comments

In preparation for the 2013 benchmark assessment a number of analyzes were undertaken to identify issues that need to be addressed. These include; sampling of commercial catches, quarterly catch distribution, estimation of catch at age, tracking cohorts, estimating natural mortality, and an exploratory SMS assessment.

The IBTS results are considered to be the best available to characterize the abundance of sprat in the North Sea. How reliable these indices are is unknown as day/night, yearly, and seasonal affects have been observed. A much better relationship was observed for acoustic data but the time series is very short and the survey does not provide complete coverage of sprat distribution, especially in the southern portion, potentially leading to an underestimate in biomass.

The three abundance indices appear to track one another to some extent for over lapping periods. IBTS Q1 and Q3 are considered the best available time series, but they are plagued with a few extremely large catches making up a very high portion of the index in some years. Internal consistency analyses of successive cohorts for both the IBTS Q1 and Q3 are extremely poor. The relationships are statistically significant for ages 1vs 2 and 2 vs 3, but not for the older age groups.

The successful implementation and acceptance of an analytical assessment in upcoming benchmark will hopefully improve the evaluation of stock status.

Conclusions

Based on the trends in the surveys and the exploratory assessment the RGNS agrees with the WG conclusions and that the stock may be showing a slight increase.

Sprat in Subarea IIIa (Skagerrak-Kattegat) spr-kask

1) **Assessment type:** Category 3/4
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 2011 the TAC was 52,000t with a herring by catch of 6659. The TAC for 2012 remains unchanged. Sprat landings have typically been far less than the TAC due to the restriction on by-catch. Total landings for 2011 were similar to 2010 at 10,739t.

The acoustic abundance index showed a slight increase in number from 2010 to 2011 but did not detect the 300% increase observed in the IBTS for the same period. The 2012 preliminary IBTS results showed an approximate 50% decrease in abundance from 2011 to 2012. Recruitment as indicated by the group1 index is in the lowest 25% of the time series. Unfortunately the index does not fully reflect the strong and weak year-classes observed in the catch.

Technical comments

No changes in fishing technology or fishing patterns.

Mean weight at age for Age 1 for 2011 was low compared to 2010 which was the highest in the time series. The IBTS Q1 age 1 index show a significant relationship with the age 1 landings (number), however the index for all ages does not depict a significant relationship with total catches.

Conclusions

The RG agrees with the WG conclusions.

Annex 15: Technical Minutes of the Baltic Stocks Review Group

Her-3a22 (HAWG Section3: Herring in Division IIIa and Subdivisions 22-24)

1) **Assessment type:** update, in line with Stock Annex
2) **Assessment**: analytical
3) **Forecast**: presented
4) **Assessment model**: ICA – tuning by 3 surveys (2 acoustic and 1 larval).
5) **Consistency**: Last year assessment accepted – this years' assessment is consistent with last year's and accepted.
6) **Stock status**: SSB at historic minimum, F declined in the last two years, F2011 is below F_{msy}, 2010 year-class estimated to be well above the 2006-2009 low year-classes, 2011 year-class also estimated to be above those year-classes but is still uncertain .

Man. Plan.: None. Management options have been explored in recent meetings of HAWG. A management plan is being developed within the EU FP7-project "JAKFISH". A value of FMSY=0.25 and a Btrigger of 110 000 t have been outlined by WKHMP (ICES 2008); these reference points are currently used in the advice.

General comments

The splitting of catches on stocks, and the management procedure for mixed stocks are complex. Although the procedures are well described in several tables and an overview diagram, a full understanding is difficult within the time available to the RG. In particular, the procedure to calculate the catch constraint for the intermediate year is not clearly explained in the stock annex. Therefore it is difficult to check if the predictions have been carried out according to the agreed methodology.

Does the HERAS survey sample a mixture of NSAS and WBSS herring ? If yes, how are the two stocks split? The 2011 GERAS survey indicates a less pronounced immigration of CBH herring into the assessment area. An updated method for the quantification of mixing between CBH and WGBSS has been presented. This is well documented in a working document.

The assessment has been done according to the stock annex

Short term predictions appear to be done according to the stock annex (but see comment above). In addition, the result of a catch constraint assuming that the total IIIa TAC is taken in IIIa (i.e., no transfer to IV) in the intermediate year was explored. This option gives a slightly more pessimistic perception of the current status and short term development of the stock.

This year assessment has slightly revised upward the most recent estimates of SSB and downward F and recruitment. Fishing mortality continued to decline in 2011 and is below FMSY. This is a result of the low TAC and continued enforcement in 2011. SSB in 2011 was at a historic minimum due to a series of low recruitments in 2006-2009. The 2010 recruitment is well above the level of the low period and contributed to the increase of SSB in 2012 (which is above Btrigger). The 2011 recruitment is estimated to be lower than that in 2010 but still above the low level of 2006-2009. Thus, SSB is expected to recover from the historic low in the short term. The Fmsy option for 2013 implies a 12% reduction of the TAC (51942 t). SSB is predicted to increase 8% from 2013 to 2014.

As in previous assessments, the limited level of sampling for the splitting of NSAS and WBSS and the extent of mixing of CBH and WBSS herring are the main uncertainties in the assessment.

Technical comments

The transfers of catches of this stock taken in Division IV and the transfers of North Sea Autumn Spawners taken in IIIa are done in the same manner as in preceding years. The total number of fish examined for stock separation is rather high. Broken down on quarters and areas (Tables 3.2.6 and 2.2.12) there seem to be poor sampling in quarter 2 in Skagerrak and Kattegat and in quarter 3 in IVaE.

Conclusions

Assessment and forecast accepted by RG.