ICES HAWG REPORT 2010

ICES ADVISORY COMMITTEE

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

15 – 23 March 2010

ICES Headquarters, 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 7 days in March 2010 to assess the state of 7 herring stocks and 3 sprat stocks. The working group conducted update assessments for four of the herring stocks. No analytical assessments were carried out for the remaining four herring stocks although available survey and/or fishery data were examined. No update assessments were possible for any of the sprat stocks.

The SSB of **North Sea autumn spawning herring** in autumn 2009 was estimated as 1.29 million t. $F_{2\text{-}6}$ in 2009 was estimated at 0.11, below the target $F_{2\text{-}6}$ of 0.2. The year classes from 2002 are estimated to be among the weakest since the late 1970s. In particular, the most recent year class, 2009, was estimated to be about 80% higher than 2008, but still lower than long term average. Best estimates of catches in 2009 were 168 000 t, a decrease from 258 000 t in 2008. The **Western Baltic spring spawning** stock's SSB is now estimated around 105 000 t and has declined substantially in the last three years. Fishing mortality in 2009 was 0.52, more than double the proxy for F_{MSY} (0.25). Recruitment has declined consistently from 2003 to 2008. When maturing, these poor year classes are expected to have a reducing effect on the spawning stock biomass. The **Celtic Sea autumn and winter spawning** stock has continued to increase, and remains in a state of recovery. SSB in 2009 was estimated as 75 000 t, and mean $F_{2\text{-}5}$ has declined to the lowest estimate observed (0.07). Catch in 2008/2009 decreased to the lowest in the time series (5 700 t). Two strong and two weak year classes have recruited recently. **West of Scotland autumn spawning** stock's SSB (in 2009) was estimated as 79 000 t. The stock is currently fluctuating at a low level and is being exploited below estimated F_{MSY}. Recruitment has been low since 1998. Catch in 2009 was 18 500 t, a slight increase from 2008. **West of Ireland (Division VIaS and VIIb,c) autumn- and winter/spring-spawning** stock cannot be assessed analytically because no tuning data are yet available. However, there are indications that the stock is at a low level, with a series of low recruitments. Current levels of SSB and F are unknown. Catch in 2009 was 10 400 t, a decrease from 13 300 t in 2008. **Irish Sea autumn spawning** herring was not assessed analytically. Survey indicators and exploratory assessments suggest increasing SSB, whilst stable fishing effort suggests a stable or declining F. Catches (4 600 t in 2009) have been close to TAC level in recent years. Catches of the **Clyde spring spawning** stock were 1 000 t in 2010, an increase of almost 50% from 2008, but no sampling or other information was available.

Given the poor datasets, no reliable estimates of stock status of **North Sea sprat** were possible. Catches in 2009 were 133 000 t, an increase from 61 100 t, in 2008. The data available for **sprat in Division IIIa** were too sparse to perform an assessment. The total landings were 9 200 t in 2009, compared to 9 100 t in 2008. **Sprat in VIId,e** catch was somewhat lower than that in 2008 (2 700 t in 2009). No assessment of this stock was possible.

A generic term of reference was to consider the new F_{MSY} framework in the preliminary drafting of advice, a task being considered by WKFRAME. The working group met before WKFRAME had its meeting. However, HAWG produced a methodology that was used to develop such a framework, for the herring stocks considered by the group. This framework was presented at WKFRAME and met with approval of the latter group.

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

Steven Beggs	UK/Northern Ireland
Massimiliano Cardinale	Sweden
Maurice Clarke (Co-Chair)	Ireland
Lotte Worsøe Clausen	Denmark
Mark Dickey-Collas	The Netherlands
Afra Egan	Ireland
Tomas Gröhsler (Co-Chair)	Germany
Joachim Gröger	Germany
Emma Hatfield	UK/Scotland
Niels Hintzen	The Netherlands
Teunis Jansen	Denmark
Cecilie Kvamme	Norway
Susan Mærsk Lusseau	UK/Scotland
Henrik Mosegaard	Denmark
Peter Munk	Denmark
Lisa Readdy	UK/England & Wales
Norbert Rohlf	Germany
Barbara Schoute	ICES Secretariat
Pieter-Jan Schön	UK/Northern Ireland
Dankert Skagen	Norway
Else Torstensen	Norway
Yves Verin	France

Contact details for each participant are given in Annex 1.

1.2 Terms of Reference

2009/2/ACOM06 The **Herring Assessment Working Group for the Area South of 62ºN** [HAWG] Chaired by: Tomas Gröhsler, Germany and Maurice Clarke, Ireland will meet at ICES Headquarters, 15–23 March 2010 to:

a) compile the catch data of North Sea and Western Baltic herring on 15–16 March

b) address generic ToRs for Fish Stock Assessment Working Groups 17–23 March (see table below).

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

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

HAWG will report by 31 March 2010 for the attention of ACOM.

Fish Stock	Stock Name	Stock Coord.	Assesss. Cord. 1	Assess. Coord. 2	Perform assessment	Advice
her-3a22	Herring in Division IIIa and Subdivisions 22–24 (Western Baltic Spring spawners)	Denmark	Germany	Denmark	Y	Update
her-47d3	Herring in Subarea IV and Division IIIa and VIId (North Sea Autumn spawners)	Germany	NL	UK (Scotland)	Y	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		Y	Update
her-irlw	Herring in Divisions VIa (South) and VIIb,c	Ireland	Ireland		Y	Same advice as last year
her-nirs	Herring in Division VIIa North of 52° 30′ N (Irish Sea)	UK (Northern Ireland)	UK (Northern Ireland)		Y	Same advice as last year
her-vian	Herring in Division VIa (North)	UK (Scotland)	UK S		Y	Update
spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	Norway	Denmark	-	Y	Same advice as last year
spr-nsea	Sprat in Subarea IV (North Sea)	Denmark	Denmark	Norway	Y	Update
spr-eche	Sprat in Division VIId,e	Norway	-	-	N	Catch statitics only

1.3 Working Group's response to ad hoc requests

1.3.1 Towards implementation of the F_{MSY} framework

A generic term of reference was to consider the new F_{MSY} framework in the preliminary drafting of advice: *Set MSY reference points (F_{MSY} and MSY $B_{trigger}$) according to the ICES MSY framework and following the guidelines developed by WKFRAME.* In general terms, ICES is aiming at changing the basis for its advice from F_{pa} - B_{pa} to F_{MSY}, combined with a trigger spawning biomass ($B_{trigger}$). The significance of $B_{trigger}$ is that, if a stock is assessed to be below this level, the F for the advice is reduced linearly with SSB.

ICES is still in the process of establishing guidelines for how WGs will implement this new framework. The HAWG met before WKFRAME had produced any guidelines. This section, 1.3.1, reflects the HAWG's views on how this new approach can be implemented in management advice. This section is based on theoretical and simulation work conducted within the group for several years, including work on management plans, both existing and in preparation.

HAWG interprets F_{MSY} as a value of F that is expected to lead to a near maximum yield in the long term. For most stocks, there will be a lower bound where long term yield is lost because of low exploitation and an upper bound where there is an increasing risk of recruitment impairment. Within that range, there may sometimes be a distinct maximum, depending on selection at age, growth rate and natural mortality. The pattern may be modified if growth and maturity are density dependent, or if the natural mortality is sensitive to multispecies effects.

For most herring stocks, which typically are lightly exploited at small size and young age, there is no distinct maximum. Hence, the highest long term yield may be expected at a fishing mortality which is close to that leading to recruitment failure. The lower bound may be represented by $F_{0.1}$, but in some cases $F_{0.1}$ may be higher than the mortality leading to impaired recruitment. Hence, the most rational target fishing mortality may be one where the loss is small, and which is safely away from the region where the recruitment may be impaired.

HAWG regards the development of management plans as the way forward to a rational utilisation of the resources, and is concerned that too strong an emphasis on specific values for an F_{MSY} may hamper the development of good management plans.

There are management plans in place or under development for most of the stocks considered by the HAWG. Such management plans typically have the objective to ensure 'a high yield' or a 'maximum sustainable yield' within the framework of the precautionary approach. In the development of such plans, extensive studies have often been made that also considered maximum yield under various productivity regimes, the VIa (North) herring being one example. Hence, they do not seem to be in conflict with the MSY objective. Management plans may sacrifice some long term yield to achieve other objectives, like stability. A possible criterion with respect to MSY may be that the management plan can be expected to lead to an effective fishing mortality within the range that should lead to a near maximum long term yield, taking into account likely errors in assessment and implementation.

HAWG has attempted to outline the region of fishing mortalities associated with a near maximum long term yield by calculating yield per recruit combined with a stock-recruit relationship. In addition HAWG estimated the effect of random variation in the recruitment in a stochastic equilibrium. HAWG has used this to suggest a range for candidate target Fs compatible with the MSY objective. The stochastic equilibrium, however, only reflects the variability of the recruitment, and not the uncertainties in assessment and implementation, nor variation in weights, maturity and selection.

Yield per recruit is sensitive to natural mortality, growth rate and selection-at-age, and assumes that all these are independent of F-level and stock size. This may not be true, and change in these factors may lead to a quite different perception of the shape and level of the yield per recruit curve, as well as the risk to stock collapse.

The risk is calculated as the probability that the stock will be below B_{lim} at the end of the projected period (50 years). The only source of uncertainty that has been taken into account is variation in recruitment. Other factors like variations in weights- and maturity-at-age, may increase the risk and move the point where the risk starts to increase, at low values of F. However, they have not been taken into account in this exercise. Therefore, the upper bound of a feasible range for the F_{MSY} is well below the limit indicated here. A more precise estimate of the F levels where the risk starts to increase will require more in-depth simulations taking all sources of uncertainty into account. This was outside the scope of this meeting. Such work has been done already, in simulations of existing management plans, and in those under development.

The calculations were done with the HCS10 software (Skagen 2010) which is an update of the software used for evaluating the mackerel, blue whiting and Celtic Sea herring rules. It runs a stochastic medium term simulation (here 1000 iterations and for 50 years), starting with either input numbers taken from an assessment or by priming the population with a fixed fishing mortality. The 10^{th}, 50^{th} and 90^{th} percentiles are presented for the catch in year 50 of the projection period with constant fishing mortality. The risk presented is the fraction of the iteration trajectories where the SSB is below B_{lim} in year 50. Yield and biomass per recruit and $F_{0.1}$ are produced as a by-product.

In general, these calculations were conditioned with respect to natural mortality, weights, maturities and selection, as in the short term predictions made in 2009, taking into account assumptions made in recent management plan evaluations. Recruitment was modelled assuming a hockey stick function with lognormal variation, with a breakpoint typically taken from previous medium term predictions. Details are outlined below.

All these stocks have a yield per recruit curve that continues to rise at high fishing mortalities, until it reaches the fishing mortality that leads to stock collapse. The stochastic yields start to decline somewhat before the breakpoint. The range of the stochastic variation, which is only reflecting the variation in recruitment, gives some indication of the range of catches to be expected at constant F. It does not reflect the effect of assessment and implementation uncertainty, variations in selection, and other factors that generally will broaden the range.

Candidate values for a $B_{trigger}$ have not been considered in detail. HAWG notes that the role of the $B_{trigger}$ has several aspects. As one obvious criterion for F_{MSY} should be that it should not lead to reduced recruitment, the impact on productivity of reducing F below the $B_{trigger}$ would generally be minor unless it is set at a very high level, where it may even lead to under exploitation of the stock. The $B_{trigger}$ may be a dynamic element in a management plan, to allow a higher F when the stock is in a good shape, and a lower F if the productivity is reduced, as is the case with the current management plan for North Sea herring. However, it is also necessary to have a safeguard to enable efficient action if things get out of control, either because nature behaves in an unexpected way or the fishery gets out of control. Hence, a candidate $B_{trigger}$ should not be below the lower range of SSBs expected at F_{MSY} with the currently assumed productivity. Another obvious candidate would be the trigger point in existing management plans, where the effect of the $B_{trigger}$ has been explored, provided the trigger point is mainly used for protecting the stock and not as a dynamic element in the plan.

North Sea herring (Figure 1.3.1.)

Weights, maturities, natural mortality and selection at age from input to short term prediction by 2009 WG. Recruitment: segmented regression based on recruitments for year classes 2001 – 2007, with breakpoint at 800 000 t and CV taken from the same recruitments. B_{lim} is 800 000 t. The current, lower productivity, regime has been assumed to continue in these projections.

Western Baltic spring spawning herring (Figure 1.3.2)

Weights, maturities, natural mortality and selection at age from input to short term prediction by 2009 WG. Recruitment: segmented regression based on recruitments for year classes 2003 – 2007, with breakpoint at 110 000 t as suggested by HAWG and

CV taken from the same recruitments. The breakpoint (110 000 t) is used as a proxy for B_{lim}. The current, lower productivity, regime has been assumed to continue in these projections.

Herring in Division VIaN (Figure 1.3.3)

Weights, maturities, natural mortality and selection at age from input to short term prediction by 2009 WG. Recruitment: segmented regression with parameters as in Table 5.8.1.2 (input to medium term predictions) in last years report. This was one of several options evaluated at that time. The breakpoint (50 000 t) coincides with B_{lim}. The current, lower productivity, regime has been assumed to continue in these projections.

Herring in VIaS &VIIb,c (Figure 1.3.4)

Weights, maturities and natural mortality were taken from the input to last year's assessment, averaged over 3 years. Selection at age was taken from the SVPA run with terminal F = 0.5. Recruitment: segmented regression with breakpoint 76 500 tonnes and plateau level at 651, with a CV of 0.3 as used in recent management plan explorations. A provisional B_{lim} at 81 000 t was used as reference when calculating risk to B_{lim}. The current, lower productivity, regime has been assumed to continue in these projections.

Herring in the Celtic Sea (Figure 1.3.5)

Weights, maturities, natural mortality and selection at age and stock-recruit function were taken from ongoing studies of possible harvest control rules for this stock. The recruitment was modelled with a segmented regression function with breakpoint 40 943 tonnes and plateau level of recruitment, with a CV of 0.6, as used in recent management plan explorations. B_{lim} at 26 000 t was used.

Herring in the Irish Sea

Some work was done on this stock during the meeting. However, further work is required.

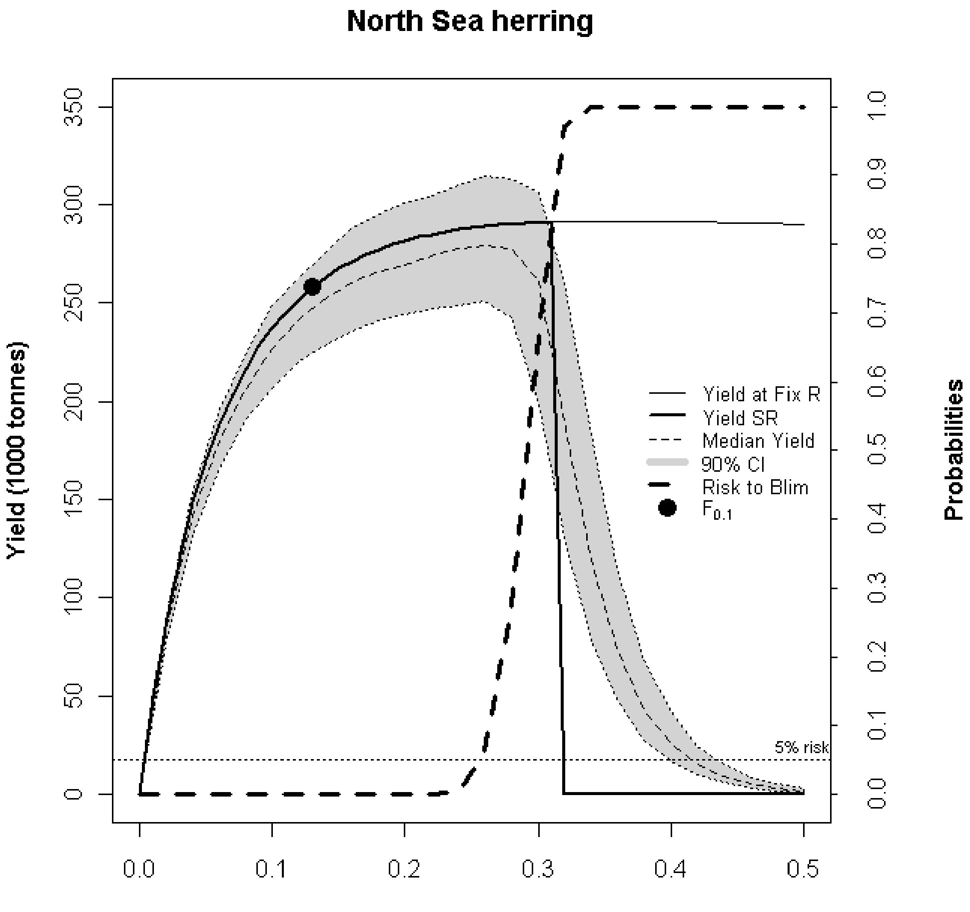

Figure 1.3.1 North Sea herring. Yield per recruit and equilibrium distribution of catches.

Yield at fixed R: Conventional yield per recruit raised to the plateau level of recruitment.
Yield SR: Yield per recruit at equilibrium level of recruitment according to the stock-recruit function.
Percentiles of catch in year 50 of projections (10th, 50th and 90th) are indicated.
Risk to B_{lim}: B_{lim}: Probability of SSB < B_{lim} in year 50 of the projections.
Low productivity regime assumed.

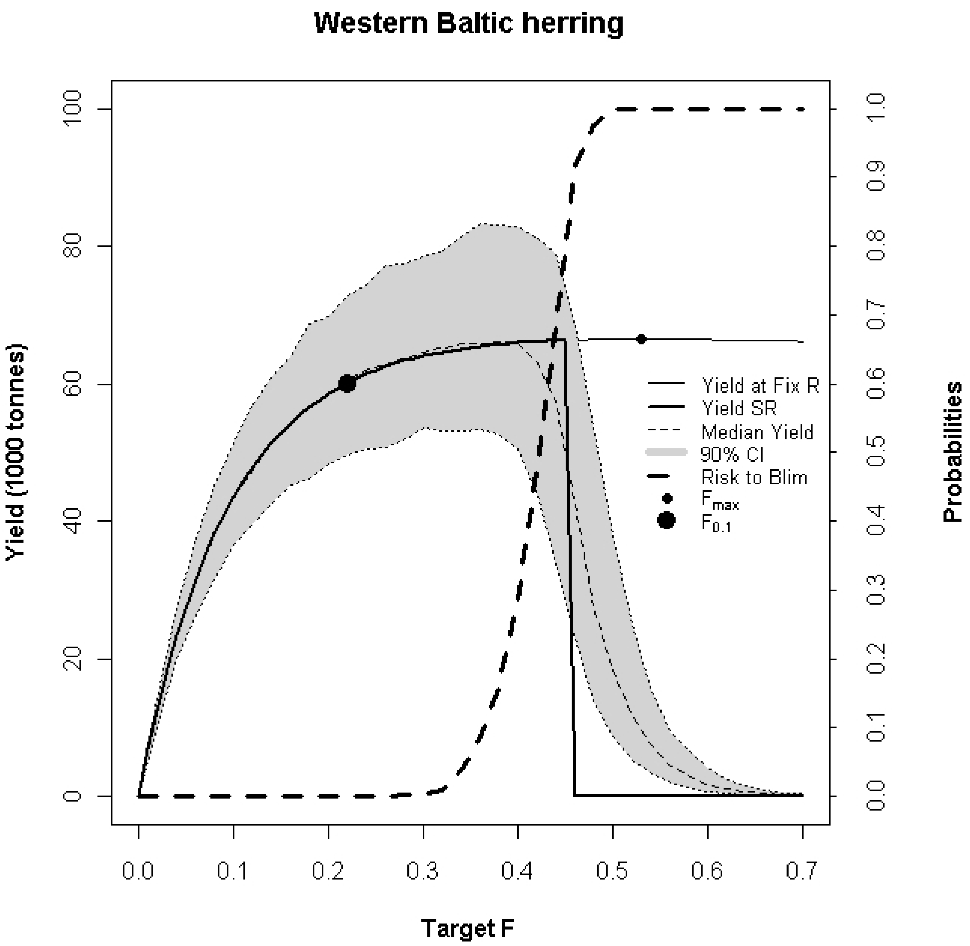

Figure 1.3.2 Western Baltic spring spawning herring. Yield per recruit and equilibrium distribution of catches.

Yield at fixed R: Conventional yield per recruit raised to the plateau level of recruitment.
Yield SR: Yield per recruit at equilibrium level of recruitment according to the stock-recruit function.
Percentiles of catch in year 50 of projections (10th, 50th and 90th) are indicated.
Risk to B_{lim}: B_{lim}: Probability of SSB < B_{lim} in year 50 of the projections.
Low productivity regime assumed.

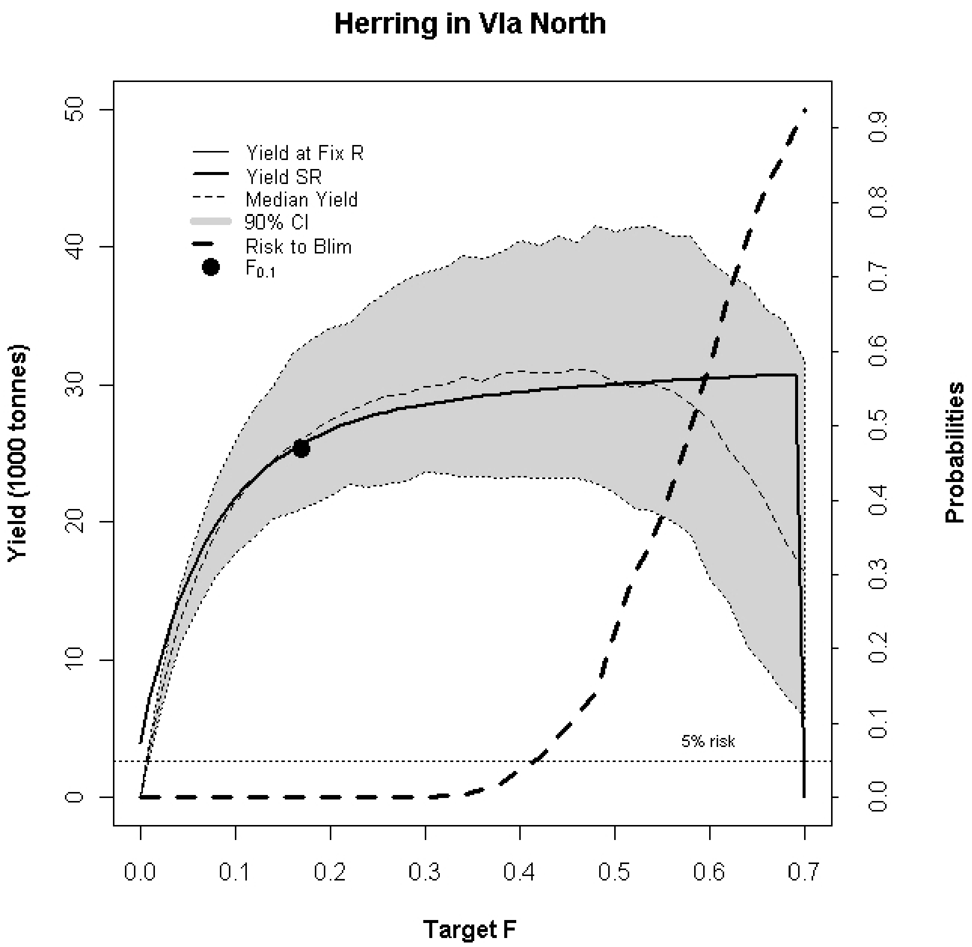

Figure 1.3.3 Herring in VIa (North). Yield per recruit and equilibrium distribution of catches.

Yield at fixed R: Conventional yield per recruit raised to the plateau level of recruitment.
Yield SR: Yield per recruit at equilibrium level of recruitment according to the stock-recruit function.
Percentiles of catch in year 50 of projections (10th, 50th and 90th) are indicated.
Risk to B_{lim}: B_{lim}: Probability of SSB < B_{lim} in year 50 of the projections.
Low productivity regime assumed.

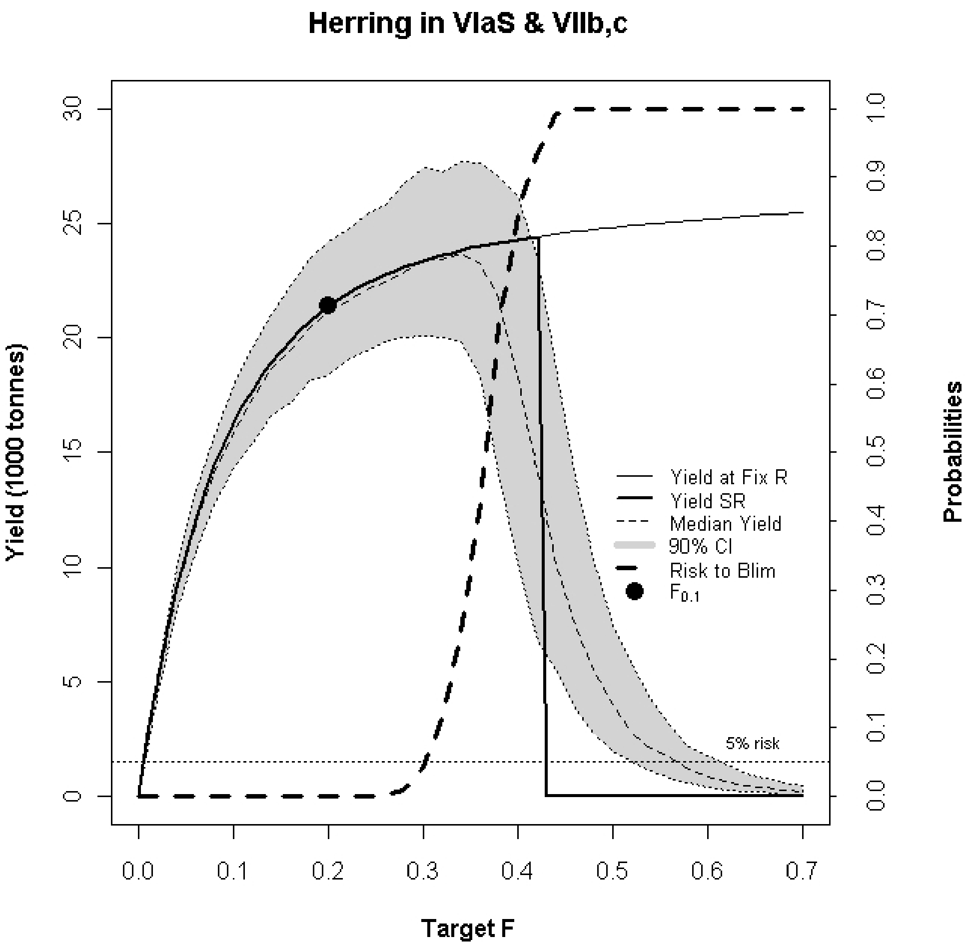

Figure 1.3.4 Herring in VIaS &VIIb,c. Yield per recruit and equilibrium distribution of catches.

Yield at fixed R: Conventional yield per recruit raised to the plateau level of recruitment.
Yield SR: Yield per recruit at equilibrium level of recruitment according to the stock-recruit function.
Percentiles of catch in year 50 of projections (10th, 50th and 90th) are indicated.
Risk to B_{lim}: B_{lim}: Probability of SSB < B_{lim} in year 50 of the projections.
Low productivity regime assumed.

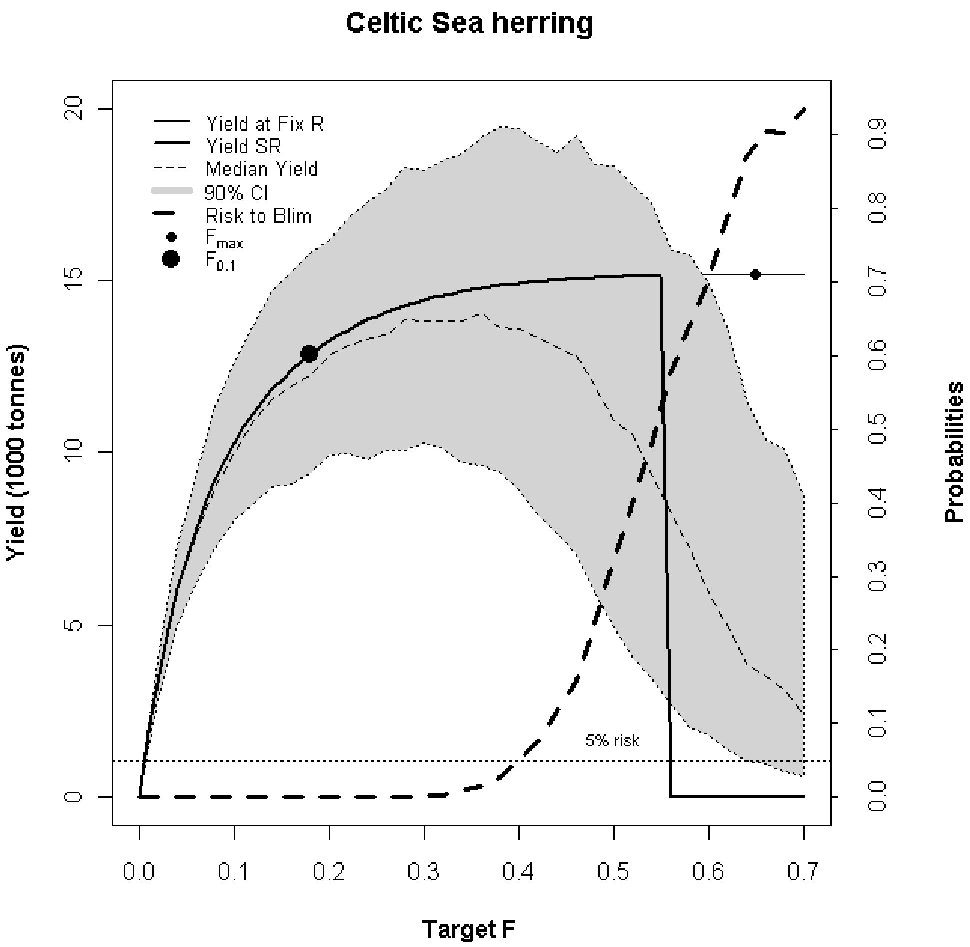

Figure 1.3.5 Celtic Sea herring. Yield per recruit and equilibrium distribution of catches.

Yield at fixed R: Conventional yield per recruit raised to the plateau level of recruitment.
Yield SR: Yield per recruit at equilibrium level of recruitment according to the stock-recruit function.
Percentiles of catch in year 50 of projections (10th, 50th and 90th) are indicated.
Risk to B_{lim}: B_{lim}: Probability of SSB < B_{lim} in year 50 of the projections.
Low productivity regime assumed.

Conclusions

The table outlines some values of F and SSB that may be a guide to setting F_{MSY} and $B_{trigger}$. The suggested values are suggestions only. Biomasses are in thousands of tonnes.

Stock	F range		F_{MSY}	$B_{trigger}$		Management plan	
	L	U	Suggested	10th %ile SSB at suggested F_{MSY}	Suggested	$B_{trigger}$	F
North Sea herring	0.15	0.25	0.25 (MP)		MP	800 to 1,500	0.25 (@ high SSB)
Western Baltic	0.22	0.3	0.25	170	UD*		UD*
VIa (North)	0.17	0.35	0.25 (MP)	85	MP	62.5 and 75	0.25 (@ high SSB)
VIa (South) & VIIb,c**	0.2	0.28	0.25?	95	UD**		UD**
Celtic Sea	0.18	0.3	0.25?	50	UD***		UD***
Irish Sea	NA	NA	NA	NA	NA	NA	NA

* As per simulation work in support of management plan development, underway in Jakfish Project.

** No analytical assessment available to estimate a TAC for a given F. Stock recruit information taken from converged VPA, as per simulation work conducted by Irish Marine Institute in 2010, in support of management plan development. Other inputs from sVPA using a terminal F of 0.5, considered the most informative exploratory assessment (Chapter 6).

*** As per simulation work conducted by Irish Marine Institute in 2010, in support of management plan development in conjunction with stakeholders' committee in Ireland.

MP: As per existing management plan

UD: Management plan under development

1.4 Reviews of groups or work important for the WG

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

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

HAWG was informed about the WGCHAIRS meeting in January 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:

F_{MSY} Framework: ICES is moving towards implementation of F_{MSY} into its fisheries advice. A presentation was given to the group on this progress. A new group, WKFRAME, will consider this process. Unfortunately, WKFRAME did not meet till after HAWG.

Inter-benchmark process: The term benchmark refers to methodology for assessing a fish stock that is the result of an intense process to decide on the most appropriate scientifically defensible way of interpreting or using biological knowledge, available data, and models to address management needs. ACOM agreed that benchmark methodologies should be decided in workshops conducted separately from sessions of expert groups that conduct assessments. Benchmark workshops can also be used to evaluate options for integrating new scientific results and ecosystem considerations into methodologies used to give advice. The workshops include experts from outside of the ICES community to broaden the idea pool available as the basis of for a benchmark and to enhance credibility. The results of a benchmark are recorded in a stock annex. Expert groups then update assessments according to the agreed methodology in the stock annex.

While benchmark workshops are the preferred approach for benchmarking methodologies, there are circumstances where methodology needs to be improved and it is impractical to conduct a benchmark workshop. Neither benchmark workshops nor application of this protocol are intended to inhibit expert groups from thinking creatively and showing initiative when it comes to improving methods. However, benchmark workshops and this protocol are intended to formalize the process by which changes in methodology are agreed in order to assure quality, consistency and documentation.

The protocol is available as in the background documents.

Benchmarks in 2011 and 2012: None of the stocks considered by HAWG are scheduled for benchmark in these years. However, in light of the results of ICES SGHERWAY it may be necessary to consider a benchmark for the Malin Shelf Stock Complex, or of component stocks, in 2012.

Templates for advice: A new template has been agreed for ICES advice. In December 2009, ACOM agreed a set of new templates for advice. There is a template for full fish stock advice and also one for other (non-fish stock) advice. For the first time the traffic light approach is incorporated. The new template incorporates the F_{MSY} approach.

New stock assessment tools: The ACOM leadership has become concerned that ICES stock assessment methodologies have not kept pace with international standards. Consequently a new program of work has been proposed. A series of workshops will be convened and in the coming years, an ICES symposium will take place.

DCF surveys: ICES is helping the European Commission and STECF to review use of DCF surveys. This information is important as it may influence future priorities for the surveys after 2013 (next DCF). This activity is part of an exercise relevant to design of a survey system.

WKACCU: These workshops provide guidance to scientists on estimating accuracy of input data. WKACCU identified procedures and other factors that could cause bias in fisheries data used in stock assessments, and provided recommendations for improved procedures that could reduce such bias. Whereas precision in fisheries statistics can be improved by increasing the sample sizes in data collection programs, this is not the case with bias. Bias is a systematic departure from the true values, and can generally not be quantified because the true values seldom are known. Minimising bias is best achieved by developing and following sound field data collection procedures and analytical methods. A practical framework for detecting potential sources of bias in fisheries data collection programs was provided by WKACCU. The workshop identified several indicators to detect bias in each of these parameters. A simple score-card was then developed where each indicator was rated as green (minimal or no risk of bias), yellow (some risk of bias), and red (established sources of bias). Benchmark groups should apply WKACCU Score Card on data quality.

1.4.2 Working Group for International Pelagic Surveys [WGIPS]

WGIPS met in January 2010 (ICES, 2010/SGESST:03) to co-ordinate acoustic and larvae surveys in the North Sea, the Malin Shelf and the Western Baltic; to combine recent survey results for assessment purposes and to elucidate parameters influencing these calculations.

Review of larvae surveys in 2009: Six survey metiers were covered in the North Sea. Larvae abundance has increased in all observed areas, with the exception of the Central North Sea. The Multiplicative Larval Abundance Index is the highest on record.

North Sea, West of Scotland and Malin Shelf summer acoustic surveys in 2009: Seven acoustic surveys were carried out during late June and July 2009 covering the North Sea, West of Scotland and Malin Shelf area. The estimate of the North Sea, autumn spawning herring, spawning stock is at 2.6 million tonnes. This is a third higher than the previous year (1.8 million tonnes).

The point estimate of West of Scotland SSB is 579 000 tonnes. The SSB is smaller compared to last year's 788 000 t, (the second highest estimate in the time-series). Immature fish were not abundant; however, the present upcoming year class is the highest since the last four years.

This is the second year of the synoptic survey, covering what is currently considered the Malin Shelf meta-population of herring. The estimate provided comprises four herring stocks to the west of the British Isles: the West of Scotland in Division VIaN; the Clyde; Division VIaS and VIIb and c; and the Irish Sea. The Malin Shelf estimate of SSB, excluding the Clyde stock and the Irish Sea (from where surveys results were not available at the meeting), was 593 000 tonnes. This is largely dominated by the West of Scotland estimate.

Sprat: In most recent years, there has been a downward trend in North Sea sprat. However, in 2009 the total biomass was estimated at 556 000 tonnes, which is an increase of 105% compared to 2008. The majority of the stock consists of mature fish. The sprat stock is dominated by 1- and 2-year old fish representing more than 98% of the biomass.

In Division IIIa, sprat was abundant in the Kattegat only. No sprat was observed in the Skagerrak area. The biomass is estimated at 36 500 tonnes.

Western Baltic acoustic surveys in 2009: A joint German-Danish acoustic survey was carried out in the Western Baltic in October 2009. The estimate of Western Baltic spring spawning herring is about 81 200 tonnes in Subdivisions 22–24 and is dominated by young herring as in previous years. The present overall estimates are low, both in terms of abundance and biomass, when compared to the long-term mean. The estimated total sprat stock is around 43 000 tonnes and there are indications of a weak upcoming year class.

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

The ICES Study Group on the evaluation of assessment and management strategies of the western herring stocks [SGHERWAY] met in Aberdeen, UK, from 7th-11th December 2009. The chair was Emma Hatfield (UK) and 8 people in total attended, from five nations.

The report addresses the ToRs, in turn, and discusses the work required to enable us to produce a set of full results for the deliberation of ACOM in July 2010.

During the meeting, progress was made towards determining the best settings for the combined assessment of the three herring stocks (VIaN, VIaS/VIIb,c and VIIaN). The dataset was updated fully and a number of different assessment runs were carried out to explore the combined dataset. The selection on the oldest age, the reference age and a number of data combinations using different surveys and ages were explored. It was found that the only way to improve the retrospective pattern is to remove survey years prior to 1998. The VIaN assessment uses all ages and all years in the VIaN survey time series. Further work is still required here and there is no basis, as yet, from which to offer advice from the combined assessment

A second synoptic survey of the Malin and Hebrides shelf areas was carried out in 2009. The area was surveyed in June/July by vessels from Scotland, Northern Ireland and the Republic of Ireland. The data from Northern Ireland were not available in time to be included herein. The Malin Shelf estimate, without the Northern Irish survey results, of SSB was 593 000 tonnes and 2 647 million fish compared to the 2008 estimates of 826 000 tonnes and 4 007 million fish. The results are, again, largely dominated by the VIaN estimate. The development of this synoptic acoustic survey will allow survey coverage of all areas in which mixing of the various western herring stocks is thought to occur, and create a more apposite tuning index which may be used in a combined assessment.

The modelling approach developed for the 2009 SGHERWAY meeting is different from the approach taken in 2008, with the main focus on sustainable management targets to maintain each spawning component in a healthy state. The distinction between mixing populations and non-mixing fisheries are consecutively evaluated. This approach is complex and has taken a lot of time to develop; no clear results can be presented as yet as time was limited. However, during development of the model, many new insights have led to the confidence that the modelling approach will represent, in clear detail, the processes occurring in the area. Additionally, the model gives new insights in the processes that might play an important role in driving the populations such as the level of mixing and the accuracy of correctly identifying the spawning origin. This study intends to calculate the risk of depletion for each of the stocks under a number of management scenarios. By varying the levels of fishing mortality, we will be able to comment on safe management targets for the combination of these stocks.

1.4.4 Final report linking Herring 2009 [ICES/PICES/GLOBEC sponsored symposium]

The Linking Herring symposium was organized to link our understanding of herring biology, population dynamics and exploitation in the context of ecosystem complexity. It is beyond argument that herring play a pivotal role in shaping the structure and dynamics of many boreal continental-shelf ecosystems. Since the last ICES symposia on herring in the 1960s (ICES Herring Symposium, 1961; Biology of Early Stages and Recruitment Mechanisms of Herring, 1968), many of the former paradigms have been rejected and substantial progress has been made by striking out along new avenues. The main message from the symposium is that herring stocks are diverse and that one cannot necessarily apply the rules from one stock to another. Though there is still much work to be done to develop the ecosystem approach, this symposium has provided a basis for progress. Recognition for herrings' role in the "wasp's waist" ecosystem was a key feature of the conference. The six thematic areas covered were:

- Advances in herring biology
- Assessment methods
- Variations in production
- Population integrity
- Trophic relationships
- Management

The symposium took place from the 26th to the 29th August 2008, at the National University of Ireland, Galway, Ireland. In total there were 80 presentations, 64 oral and 16 posters. These studied the Atlantic (NE and NW), Pacific (NE and NW), Baltic and Arctic herrings. Delegates, numbering 100 in total, attended from Ireland, UK, Norway, Denmark, Italy, France, the Netherlands, Germany, Canada, USA, Russia, Latvia, Iceland and Poland. The proceedings have been recently published. In total 24 papers were published, covering all six thematic areas and NE, NW Atlantic, NE Pacific and Baltic stocks.

Several presentations at the conference and in the proceedings dealt with issues relating to the HAWG. Among these issues covered were:

- VIaN: Fish in western sea lochs not all of VIaN origin. Also VIaS and maybe Clyde.
- Baltic: Failure to identify clear boundaries between Central and Western Baltic, with either genetic or morphological studies. Several papers on larval development and year class strength
- British Isles: Spawning and mixed aggregations contained fish from different management areas: Adopted migrant hypothesis?
- Irish/Celtic: Possibility to split Northern Ireland survey data to provide recruit indices for each stock
- North Sea: Larval survival higher close to fronts. Changes in fronts have had detrimental effect on survival. Parasitism and food availability could be a factor in larval survival

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

Contact persons as link between HAWG and PGCCDBS

PGCCDBS considered that the system of contact persons providing a link between ICES stock assessment Working Groups and PGCCDBS worked better in 2009 at the defined protocol for contacts officers to provide feedback from AWGs (assessment working groups) was followed by most contact persons. 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 2010.

Quality Assurance Framework (QAF)

The development of a Quality Assurance Framework (QAF) and associated data catalogue to strengthen links between AWGs and PGCCDBS by automating the reporting of data usage by the AWGs, reducing demands on already reduced WG time was continued.

The outcomes of the methodological workshops (WKACCU, WKPRECISE, WKMERGE) previously initiated by PGCCDBS were reported to the 2010 meeting. The workshops WKACCU, WKPRECISE and WKMERGE were dealing with sampling design in relation to the métier based approach. The métier based approach in the EU data collection framework as well as the aim to move towards regional task sharing have high-lightened the need for a more appropriate, robust and transparent sampling design for countries involved in catch sampling. The workshops have provided valuable general knowledge in how such catch sampling programs can be designed and the reports are beneficial for countries aiming to improve the current situation.

It is recognized that sampling of fisheries is difficult primarily due to cluster effects at different levels as well as logistical constrains. This means that the "devil is in the details" and methodological aspects, assumptions etc. would benefit from a transparent international discussion. This is particularly true for countries aiming towards regional data collection programs to achieve international precision targets within the DCF. The PGCCDBS realize that several working groups are established to coordinate international trawl surveys but that no equivalent system exists to support and improve catch sampling programs. As most stock –assessment models used at present in ICES (such as standard VPA) work with the assumption that the Catch-At-Age data are unbiased it seems very important to actually be able to measure this parameter. Some of the recommendations passed on to the PG from different assessment working groups are further related to assessment of the quality of different estimates such as catch-at–age data. To be able to give validation on the data quality it is crucial that the sampling program is set up in a transparent, statistical sound way. Such assessments need suitable sampling designs and estimation processes that are well documented.

This further stresses the need to establish a methodological support system for catch sampling.

1.4.6 Report of the Benchmark Workshop on short-lived Species [WHSHORT]

The WKSHORT 2009 Benchmark Workshop was held at the Institute of Marine Research in Bergen, Norway from 31 August–4 September 2009. The Workshop was chaired by Jim Berkson (USA), with support from ICES Coordinator Harald Gjøsaeter (Norway), and involved 29 participants from 12 nations. The primary objectives of the Workshop were to evaluate the appropriateness of the data and methods used in the assessments of four stocks – Barents Sea capelin, Icelandic capelin, Bay of Biscay anchovy, and North Sea sprat – and also to discuss possible improvements to these assessments.

For the North Sea sprat the main sources of data (i.e., the IBTS surveys) may not be appropriate for an assessment and suffer from extremely wide confidence intervals. The acoustic survey time-series is currently not of sufficient length (five-years) to enable its application in an assessment context. Additionally, there are disagreements in age-reading, mainly due to the prolonged spawning season. The mean weight-at-age is variable over time as a consequence of the extended spawning season and ageing problems.

It is the opinion of the WKSHORT participants that previously used assessment methods are inappropriate.

A length-based assessment has been attempted (Skagen 2009, WD #6.2), hoping to avoid the problem of age-reading and prolonged recruitment season. So far, the model has only been fitted to the 1st quarter IBTS survey indices at length. Due to inconsistencies in the input data, model parameters could only be established based on strong assumptions. The assessment results then essentially reflected the assumptions only. The information on length distribution proved too little to be used as the basis of an assessment at present.

The WKSHORT concluded that there is no basis for performing an analytical assessment of this stock.

1.4.7 Simulations on a rebuilding plan for Celtic Sea herring

The ICES advice for Celtic Sea herring in 2007, 2008 and 2009 has been that there should be no targeted fishing without a rebuilding plan. In 2008, the local Irish management committee presented a rebuilding plan to the European Commission and Council. The plan was not formally adopted, but the TAC for 2009 was consistent with the plan. Subsequently, in early 2009, the plan was endorsed by the Commission. The text of the plan is cited below.

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.

The evaluation of this plan dealt with points 2 and 3. The evaluation found that setting a TAC, consistent with a fishing mortality rate of $F_{0.1} = 0.19$, for 2010 and subsequent years is not associated with an unacceptable risk of SSB < B_{lim}, in the simulation period 2009-2029. If TACs consistent with F in the range 0.17 to 0.19 are set, then there is minimal risk that SSB < B_{lim} in the simulation period 2009-2029. However, if fishing takes place at F > 0.4 the 25% TAC reduction in the proposed plan may not be precautionary.

The proposed rebuilding plan for Celtic Sea and Division VIIj herring is estimated to be in accordance with the precautionary approach, if the target fishing mortality of $F_{0.1}$ is adhered to.

1.4.8 Report of the Working Group on Methods of Fish Stock Assessment [WGMG]

The Working Group on Methods of Fish Stock Assessments [WGMG] (Chair: Coby L. Needle, UK) met in Nantes, France, from 20–29 October 2009 to:

1. Work according to specific ToRs developed intersessionally by the end of June 2009 in consultation with ACOM, relevant benchmark and assessment WG chairs, and relevant stock assessors. These ToRs are to be considered and finalized by SCICOM at the ASC meeting in September 2009.

2. Review the major problems and possible solutions to fish stocks assessments. The review should include an analysis of strengths and weaknesses, conditions for applicability of alternative solutions and process issues such as quality assurance protocols, sequential peer reviews and benchmarking.
3. Prioritize (in combination with ACOM) common methodological problems identified in benchmark reviews and recommendations by external reviewers.

Given the 2009 ToRs, WGMG addressed the following issues

- XSA shrinkage
- XSA iteration convergence
- State-space assessment models
- Survey-based assessment methods
- Length-based assessment methods
- Uncertainty in age–length keys (ALKs)
- Future directions for WGMG

XSA shrinkage: Shrinkage (either by year or by age) is a relatively ad hoc device that was implemented in the XSA model to try to reduce unwanted assessment fluctuations driven by noise rather than signal. WGMG summarized the history of shrinkage in XSA and considered how shrinkage is being used in current ICES assessment working groups. WGMG concluded that a) shrinkage should where possible be "light", and b) what "light" means needs to be determined by reference to estimation weights (rather than potentially dubious metrics such as retrospective bias). More generally, WGMG points out that it is more appropriate turning to models that use data (rather than ad hoc assumptions) to generate inferences.

XSA iteration convergence: XSA does not include a statistical estimation process in the usual sense, but rather uses an iterative estimation procedure that can be stopped before full convergence. The approach taken by ICES assessment working groups to the question of whether or not to converge varies widely. WGMG showed that the point at which the iteration is stopped can have a very significant affect on abundance estimates for a number of important ICES stocks. A comparison between an XSA run and an alternative exploratory state-space model for North Sea haddock showed that increased iterations also increases the discrepancy between the model estimates. WGMG showed further through simulation that there is a tendency for further iterations to move the assessment away from the underlying true population state. There are also indications that both the q-plateau age and the plus-group age appear to affect convergence, although this list of causal effects is by no means exhaustive. WGMG concluded that a) it is essential to determine the convergence characteristics of any XSA assessments, and b) alternative methods need to be explored in cases where convergence is slow and leads to large changes in perceived stock dynamics.

State-space assessment models: WGMG further stated that although there is (as yet) relatively limited experience and acceptance of state-space models in most ICES assessment working groups, these methods provide advantages over more traditional methods in a number of respects: a) they provide uncertainty estimates for stock metrics, b) they can accommodate observation error in catches, and c) they remove the need for ad hoc assumptions. Given this they should be considered as valid alternatives in cases where these issues arise.

Survey-based assessment methods: During the meeting of WGMG work on two developments in the SURBA model was presented. SURBA+ is an ADModelBuilder implementation that addresses several shortcomings in the original SURBA model: a) it models fishing mortality rather than total mortality, which is more useful for fishery managers but assumes a knowledge of natural mortality; b) it uses random effects approaches to smooth variations in mortality components, rather than ad hoc smoothing; c) it allows the age-effect in mortality to vary through the time-series, rather than being fixed as before; and d) it incorporates a recruitment model. WGMG22 show the improvement in inference and management advice that these modifications can make for a sample case stock (3Ps cod). WGMG also discussed briefly a parallel development in the original SURBA code, which is an implementation in the R package (SURBA-R). This may smooth the transition between the outdated current SURBA code and the new SURBA+ code. WGMG hopes that a single joint implementation can be developed in time.

Length-based assessment methods: WGMG reviewed recent work in length-based assessment methods, and collated conclusions on the utility of different approaches. WGMG considered it a potentially valuable but also very difficult field that does not appear to have a natural home at the moment in ICES. WGMG considered further an analysis of the sensitivity of a spurdog assessment to assumptions about early fishery selectivity for which there is few data, and found that the assessment is relatively robust to these assumptions.

Uncertainty in age–length keys (ALKs): Through a simulation study, WGMG demonstrated the effect of uncertainty in age–length keys on the assessment of roundnose grenadier in several Atlantic areas. WGMG concluded that age-based assessments are unreliable for this stock because of ALK uncertainty, and suggested development of life-stage-structured approaches.

Future directions for WGMG: For the future WGMG finally suggested that the most useful way forward in the short term could be a series of themed workshops for which WGMG would act as a steering group. The first of these could be a collation and comparison of assessment models from around the world, including many which are not currently used in ICES but which might bring benefits.

1.5 Commercial catch data collation, sampling, and terminology

1.5.1 Commercial catch and sampling: data collation and handling

Input spreadsheet and initial data processing

Since 1999 (catch data 1998), the working group members have used a spreadsheet to provide all necessary landing and sampling data. The current version used for reporting the 2009 catch data was v1.6.4. These data were then further processed with the SALLOC-application (Patterson, 1998). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set. This allows recalculation of data in the future, or storage and analyses in other tools like InterCatch (see section 1.5.4), choosing the same (subjective) decisions currently made by the WG. Ideally, all data for the various areas should be provided on the standard spreadsheet and processed similarly, resulting in a single output file for all stocks covered by this working group. National catch data submission was due by 22nd February 2010. Some nations failed to deliver their data in time. 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 the stock annex 3. To facilitate a long-term data storage, the group stores all relevant catch and sampling data in a separate "archive" folder on the ICES network, which is updated annually. This collection is supposed to be kept confidential as it will contain data on misreporting and unallocated catches, and will be available for WG members on request. Table 1.5.1 gives an overview of data available at present, and the source of the data. Members are encouraged to use the latest-version input spreadsheets if the re-entering of catch data is required. Figure 1.5.1 shows the separation of areas applied to data in the archive.

1.5.2 Sampling

Quality of sampling for the whole area

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

Area	Official Catch	Sampled Catch	Age Readings	Age Readings per 1000t
IVa(E)	9915	1621	204	21
IVa(W)	73199	51174	2838	39
IVb	61945	48702	1963	32
IVc	2603	1838	50	19
VIId	18903	13265	389	21
VIIa(N)	4594	171	200	44
VIa(N)	16977	11470	993	58
IIIa	69900	59700	13548	194
Celtic, VIIj	5745	5745	3130	545
VIa(S), VIIb,c	8532	8532	2262	265

The EU sampling regime

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

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

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

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

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

1.5.3 Terminology

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

1.5.4 Intercatch

InterCatch is a web-based system for handling fish stock assessment data. National fish stock catches are imported to InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models." Stock coordinators used InterCatch for the first time at the 2007 Herring Assessment Working Group. Comparisons between InterCatch and conventional used systems (e.g., Salloc and spreadsheets) were carried out annually since 2007. During HAWG 2010, InterCatch was not always operational. The system prompted out the users when trying to aggregate stock estimates. Consequently, for the most recent year, this comparison is available for the North Sea stock (her_47d3), Celtic Sea herring (Her-IRLS) and Northwest of Ireland herring (Her-IRLW). The maximum discrepancies between the systems are presented in Table 1.5.2. These are in general small. During HAWG, there was no time for a more detailed comparison at the area level. This may be done by correspondence between stock-coordinators and ICES InterCatch team.

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

1.6 Methods Used

1.6.1 ICA

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

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

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

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

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

1.6.3 FLR and MFDP

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

1.6.4 Medium term projections

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

1.6.5 F_{MSY} management simulations

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

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

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

1.6.6 Separable VPA

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

1.6.7 Software used to split IIIa and North Sea herring catches

To determine the difference between IIIa herring and North Sea herring, a routine has been used to determine the differences in their otolith shape. Therefore, pictures have been taken with a Leica 350F digital camera attached to a dissection microscope (Leica MZ6). Otolith shape was hereafter found with ImagePro 5.0 software, whereafter the AOI tool was used to transfer the contour into x.y coordinates. Based on an Elliptic Fourier Transformation and condition of the model, a distinction between the two different shaped otoliths could be made.

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, two nations reported discards from fleets in 2009. Scotland incorporated discards in the catch data by stock. The discard figures were raised to national landings (based on the spatial and temporal distribution of the fleet by metier), and used in the assessment of North Sea autumn spawning (see Section 2.2) and VIaN (see Section 5.2) herring. The Netherlands estimated herring discards from sorting of approximately 2 500 tonnes (CV=51%) in 2009 but sampling was not at a high enough resolution to allocate the catch in individual stocks (Helmond & van Overzee WD02; Borges *et al*. 2008). This estimate is for all Dutch flagged vessels across the entire ICES area. The fleet has total landings is over 300 000 tonnes of fish per year in the ICES area. The estimates were based on observer trips and in 2009 included observations from Pelagic Freezer Trawler vessels from the Netherlands, Germany and England which were raised to the Dutch catch. These discards are the processing (sorted) discards and have been routinely monitored since 2003. This year, an additional form of discarding was assessed; discarding unsorted catch directly from tanks (a form of slippage). This is more difficult to assess (Helmond & van Overzee WD01). In 2009 tank discarding was approximately 4 000 tonnes but this is an extremely imprecise estimate. From 2006 to 2009 less than 5% of hauls observed were discarded directly from the tanks. There appears to be no size selection for landed herring compared to discarded herring in the Dutch fleet (Figure 1.7.1).

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

There were no other studies on unaccounted fishing mortality in herring presented to HAWG.

The inclusion of discarded catch is considered to reduce bias of the assessment and thus give more realistic values of fishing mortality and biomass. However, they might also increase the uncertainty in the assessment because the sampling level for discards is usually lower than that for landings (Dickey-Collas et al. 2007). This low sampling rate is caused by the large number of different metiers in the pelagic fishery and the difficulty of predicting behaviour of the fisheries (in terms of target species and spatial and temporal distribution). Raising discard estimates to the national landings might result in a higher bias than an area based estimate of discards from the total international fleet, if sampling is insufficient. HAWG therefore recommends that the development of methods for estimating discards should be fleet based, rather than on a national basis. Recent regulations have been introduced to constrain discarding and slippage of catch in EU waters. Discarding has been illegal in Norwegian waters for many years and the requirements for the reporting of slippage are currently under review. Slippage events are counted against quota in Norway.

Conclusion

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

Request from WGQAF

A request to HAWG was received by WGQAF to provide details of any sources of unaccounted fishing mortality relevant to the fisheries assessed. In particular, what issues are HAWG aware of that may be better addressed with the support of other ICES expert groups (e.g., WGFTFB, WGECO) or by consultation with the industry and other organisations outwith ICES. WGQAF would also be very interested to hear about examples of previously unaccounted sources of fishing mortality that have now been addressed by HAWG, either by including estimates in the relevant stock assessment or by using mitigating management measures.

The only non-conventional fishing mortalities that are estimated by HAWG are discarding and death through disease. The estimation of discard estimates (including slippage) is described above. Some nations account for the practice in their catch figures, some monitor the practice and don't allocate them to the catch data due to poor precision and resolution (temporal, spatial, stock and age) of the estimates and some do not monitor the practice. *Ichthyophonus* outbreaks occur sporadically in herring populations and herring are routinely monitored by some countries for *Ichthyophonus* during surveys (Norway, Scotland and The Netherlands). During the 1990s the natural mortality of the Norwegian spring spawners was adjusted using Bayesian methods to account for the impact of *Ichthyophonus*. Should an outbreak occur in the North Sea, the stock assessment is likely to be adjusted to account for the impact of the disease.

By-catch of herring in industrial fisheries is accounted for in the compilation of the catch data for the North Sea and IIIa but not in others areas (although few industrial fishes exist in the other regions). One potential source of mortality that is likely to occur but is not assessed by the working group (as it is thought to be very small) is incidental fishing on herring by demersal fisheries. Occasional investigations usually show very small amounts of by-catch of herring in demersal fisheries. Thus HAWG feels justified in not accounting for this source of mortality. Changes in natural mortality are occasionally reviewed by HAWG but the working group has no systematic approach to dealing with, for example, changes in gadoid, sea mammal or bird populations.

1.8 Ecosystem considerations, sprat and herring

The role of herring in the marine ecosystem is difficult to evaluate quantitatively (Dickey-Collas *et al.*, 2010). Fisheries science cannot at present provide management advice and predictions of herring that account for this role, especially when extrapolating beyond the range of recent observations. At the ecosystem level, the behaviour and interactions of species are adaptive and complex. However, management should always endeavour to maintain recruitment, a certain biomass of spawning adults and spatial diversity, to sustain the ecosystem services of herring. At present, we cannot predict the effects of collapse or recovery of a single stock on the ecosystem as a whole, nor can we predict the direct and indirect effects of large environmental change, such as global warming, on a single stock (Dickey-Collas *et al.*, 2010). Moreover, as managers try to reconcile commitments to single-species MSY targets with the ecosystem-based approach, they must consider the appropriate management objectives for the North Sea ecosystem as a whole.

Recruitment is intrinsically variable and, in combination with variability in predation mortality on adults, can yield large natural variation in stock abundance. Recent work has improved our understanding of when year class strength of North Sea herring is determined. Nash and Dickey-Collas (2005) demonstrated that events during the overwintering phase of the larvae (between the early and late stages: 10–30 mm) determine year class strength. In extending this analysis, Payne *et al.* (2009) found support for this conclusion based on data collected during the recent recruitment failure (2002–2008). Cardinale *et a*l. (2009) did not find any conclusive evidence for an effect of climate on recruitment of Western Baltic herring.

The different spawning grounds experience different environmental variability (Petitgas *et al.*, 2009). Therefore, searching for one environmental driver of herring productivity without accounting for spatial and temporal differences, and discounting the influence of parental factors, might be naïve. Although many hypotheses on environmental drivers have been proposed, there is as yet no explanation for the events that resulted in the recruitment failures in either the mid-1970s or the 2000s.

An analysis was performed during 2009 HAWG in order to identify groups of different stocks that showed similar trends in growth, measured as weight-at-age, over time. The analyses were unconvincing and HAWG concluded that the possible link between trends in weight-at-age and climate conditions should be investigated at a finer spatial scale, using stock specific time series of monthly SST in assumed key-periods for growth and condition of herring stocks. A recent meta-analysis showed that there were between-stock differences in growth associated with temperature but only the North Sea herring showed a within-stock cohort effect of temperature (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.

Because herring occupy both prey and predator positions in boreal marine ecosystems, a decrease in stock size will release predation on its prey species and constrain the food resource of its predators, whereas an increase has the opposite effects. Given its potential numerical dominance, the effect of these trajectories of decline and increase on many other organisms in the system could undoubtedly be large. However, it is questionable whether the outcomes of all of these interactions could be predicted (Kempf *et al.*, 2006; ICES 2008b). Projecting the effect on the ecosystem of a large increase in biomass would rely on extrapolations of information gained largely during periods of relatively low abundance.

The working group did not consider in detail the role of sprat in the marine ecosystem.

1.9 Pelagic Regional Advisory Council [Pelagic RAC]

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

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

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

Assessment Working Group (AWG) recommendations

During HAWG 2009, Lotte Worsøe Clausen (DTU Aqua) compiled all issues relevant to PGCCDBS in the table "Stock Data Problems Relevant to Data Collection" (and included it in the HAWG 2009 report). The PGCCDBS reviewed AWG reports with respect to recommendations addressed to PGCCDBS and processed these for either further action/other groups (like RCM, LM). The relevant recommendations for HAWG and the PGCCDBS response are listed in the below table.

EG	Stock	Data Problem	How to be addressed?	PGCCDBS	RCM-NS&EA	RCM-NA
HAWG	All stocks	Sampling coverage	HAWG encourages the development of guidance on the sampling of landings of flagged vessels landing into different states under the DCF.	PGCCDBS feels that no further guidance is required and this matter has been addressed at RCM level. See comments from RCM NS&EA section 3.2.3 (Regional agreements on collection of data)		
HAWG	All stocks	HAWG recommends that all metiers with substantial catch should be sampled (including by-catches in the small meshed fishery). (see Section 2.2.2).		See comments from RCM NS&EA and RCM NA.	HAWG refers to the old DCR. Since 2009, sampling of biological variables is based on the métier ranking system as established in Decision 2008/949/EC (III.B1.3.1). In principle, this ranking system should cover all relevant métiers that have substantial catches. If not, HAWG is requested to specify exact data needs which are not covered within the current system.	See RCM NS&EA comments
HAWG	All stocks	Spatial data and information on sampling coverage and precision needs to be provided and if possible used in the assessment.	PGCCDBS should formulate data requirements	Documentation of the sampling strategies and documentation of the raising has to be established in the bilateral agreement. If COST is the basis for analysis then the national countries have to en sure that estimators in COST are appropriate for the actually sampling program in place. For COST to handle the range of sampling it need a further development.		

EG	Stock	Data Problem	How to be addressed?	PGCCDBS	RCM-NS&EA	RCM-NA
HAWG	North Sea herring	Guidance on the sampling of landings of flagged vessels landing into different states under the DCF.	PGCCDBS and North Sea RCM	PGCCDBS feels that no further guidance is required and this matter has been addressed at RCM level. See comments from RCM NS&EA section 3.2.3 (Regional agreements on collection of data)	This issue was discussed at RCM NS&EA 2009 and reported in section 3.2 of the report. Sampling of flag vessels ensured trough bilateral agreements between MS.	
HAWG	Celtic sea herring	recruitment index	It has long been recognized by HAWG that a recruit index is required for Celtic Sea herring. To achieve this HAWG makes a three-fold recommendation: 1) Update the NI GFS survey data for 0- and 1- ring herring. In order to segregate these by season of spawning otolith techniques should be used. This could provide an index of recruitment for Irish Sea herring and of the abundance of Celtic Sea emigrants in the Irish Sea. 2) The 1-quarter trawl survey, using GOV trawl , conducted in 2009, should continue in subsequent years. 3) The time allocated to VIIj in the q-4 Celtic Sea acoustic survey has rarely encountered substantial herring abundance. Sacrificing this VIIj acoustic ship	Survey related request should be dealt with by the respective survey planning groups. Therefore PGCCDBS forwards this request to PGIPS.		

EG	Stock	Data Problem	How to be addressed?	PGCCDBS	RCM-NS&EA	RCM-NA
			time would not jeopardize the existing acoustic index. However the ship time saved could be re-allocated to the q-1 trawl survey mentioned in point 2 above.			
PGCCDBS	Maturity staging of herring and sprat	Workshop on Sexual Maturity Staging of Herring and Sprat [WKMSHS]	WKMSHS is included in the ICES Resolutions for 2011,	The need for this WK will be checked by HAWG 2010 and reported back to the PGCCDBS		
WKSHORT-2009	North sea sprat	Age reading	WKSHORT is unclear as to whether the age reading of sprat otoliths can be achieved with sufficient accuracy and precision for generation of age structured data. Given that there has not been an age reading comparison for this stock since 2004, the Working Group therefore recommends the formation of a workshop with the aims of reviewing past work, investigating new techniques for age reading and answering this important and unresolved question.	The PGCCDBS recommends to set up a large scale otolith exchange in 2011 following the PGCCDBS guidelines.		

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 DCF or other data collection programmes	By who
WBSS	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.*
Clyde herring	Catches have increased in 2009; no sampling performed on this stock?	Sampling of age-weight-length information needed	*Should be a part of the DCF for relevant countries*
NSAS HERAS indices	High negative residuals over the recent years for NSAS: Is this an year-effect or a 'sampler effect' (by country)?	Scrutinize acoustic estimates by country – comparative analysis, etc.	*WGIPS+ recommendation by PGCCDBS*
HERAS survey Combined acoustic; all countries	Stock ID on mixed catches	Incorporate splitting methodology and sampling of individuals for this in the survey design. Get all participating countries to split their herring into stock ID's.	*WGIPS+ recommendation by PGCCDBS*

1.11 Stock overview

Analytical assessment could be carried out for four of these eleven stocks. Results of the assessments are presented in the subsequent sections of the report and are summarized below and in Figures 1.11.1 - 1.11.3.

North Sea autumn spawning herring (her-47d3) is the largest stock assessed by this WG. It experienced very low spawning stock biomass levels in the late 1970s when the fishery was closed for a number of years. This stock began to recover until the mid-1990s, when it appeared to decrease again rapidly. A management scheme was adopted to halt this decline. Given this, ICES advises on the basis of the agreed EU-Norway management plan. Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and harvested sustainably. The SSB in autumn 2009 was estimated at 1.29 million t, and is expected to remain at approximately B_{pa} (1.3 million t) in 2011. $F_{2\text{-}6}$ in 2009 was estimated at 0.11, below the target $F_{2\text{-}6}$ of 0.20. The year classes from 2002 are estimated to be among the weakest since the late 1970s. Following the agreed management plan implies catches of 189 000 t for fleet A and 16 000 t for fleet B in 2011 in the North Sea which is expected to lead to SSB of 1.63 million tonnes in 2012.

Western Baltic Spring Spawners (her-3a22) is the only spring spawning stock assessed within this WG. It is distributed in the eastern part of the North Sea, the Skagerrak, the Kattegat and the Sub-Divisions 22, 23 and 24. Within the northern area, the stock mixes with North Sea autumn spawners. An analytical assessment demonstrates that SSB is now estimated around 105 000 tonnes which is the lowest observed for the whole time series and lower than the breakpoint (110 000 tonnes). Fishing mortality in 2009 is 0.52, higher than the same estimate for 2008 (0.37). F is still higher than both $F_{0.1}$ (0.22) and estimates of F_{MSY} (0.25). Recruitment in 2009, however, has increased to a level higher than the last 5 years.

Herring in the Celtic Sea and VIIj (her-irls): The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj have been considered to exploit the same stock. For the purpose of stock assessment and management, these areas have been combined since 1982. The update assessment, conducted in 2010, showed that the stock continues to be in a state of recovery. SSB continues to be above B_{pa} and mean $F_{2\text{-}5}$ at an historic low level. However, it is still very dependent on the strength of the incoming year class, which is poorly estimated. A projection, based on the $F_{0.1}$ prescribed in the rebuilding plan, is provided.

Herring in VIa North (her-vian): The stock was larger in the 1960s when the productivity of the stock was higher. The stock experienced a heavy fishery in the mid-70s following closure of the North Sea fishery. The fishery was closed before the stock collapsed. It was opened again along with the North Sea. In the mid 1990s there was substantial area misreporting of catch into this area and sampling of catch deteriorated. Area misreporting was reduced to a very low level and information on catch has improved, and in recent years misreporting has remained relatively low. In the absence of precautionary reference points other than B_{lim} the state of the stock cannot be evaluated. An analytical assessment shows that SSB (in 2009) is 1.7 times B_{lim}. ICES considers that the stock is currently fluctuating at a low level and is being exploited close to F_{MSY}. Recruitment has been low since 1998.

Herring in VIa South and VIIbc (her-irlw) are considered to consist of a mixture of autumn- and winter/spring-spawning fish. The winter/spring-spawning component is distributed in the northern part of the area. The main decline in the overall stock since 1998 appears to have taken place on the autumn-spawning component, and this is particularly evident on the traditional spawning grounds in VIIb. However, there are indications that the stock is at a historically low level. The current levels of SSB and F are not precisely known, as there is no tuned assessment available for this stock. Recent F is estimated around 0.5, though current F is unknown. There are no signs of stock recovery in VIaS herring, and no evidence of improved recruitment.

Herring in the Irish Sea (her-nirs) comprises two spawning groups (Manx and Mourne). This stock complex experienced a very low biomass level in the late 1970s with an increase in the mid-1980s after the introduction of quotas. The stock then declined from the late 1980s onwards. During this time period the contribution of the Mourne spawning component declined. An increase in activity on the Mourne spawning area has been observed since 2006. In the past decade there have been problems in assessing the stock, partly as a consequence of the variability in spawning migrations and mixing with the Celtic Sea stock. Trends from acoustic surveys indicate a significant increase in 1+ herring biomass in the Irish Sea since 2007. The catches have been close to TAC levels in recent years and the main fishing activity has not varied considerably, therefore fishing mortality is not thought to have risen above the recent average. There is some evidence of increased recruitment in the stock in most recent years.

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

1.12 Structure of the report

The report 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 2010 HAWG carried out four assessments:

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

These were update assessments in 2010. Irish Sea herring and North Sea sprat were exploratory assessments. One stock with poor data (IIIa sprat) is described in Section 9. Two stocks, with very poor data (no catch at age sampling) and no current ongoing research are described in Section 10. These are Clyde herring and sprat in the English Channel.

Medium term predictions have not been performed in 2010. This is because work is now focussing on developing the F_{MSY} framework for the stocks. For this reason, the medium term section of each chapter has been removed.

1.13 Recommendations

Please see Annex 2

Table 1.5.1 Available disaggregated data for the HAWG per March 2010. X: Multiple spreadsheets (usually .xls); W: WG-data national input spreadsheets (xls); D: Disfad inputs and Alloc-outputs (ascii/txt); I: Intercatch input

Stock	Catchyear	Format				Comments
		X	W	D	I	
Western Baltic Sea:						
IIIa and SD 22-24	1991-2000	X				raw data, provided by Jørgen Dalskov, Mar. 2001, splitting revised
(her_3a22)	1998	X				provided by Jørgen Dalskov, Mar. 2001, splitting revised
	1999	X				provided by Jørgen Dalskov, Mar. 2001, splitting revised, catch data revised
	2000	X				provided by Jørgen Dalskov, Mar. 2001
	2001	X				provided by Jørgen Dalskov, Mar. 2002
	2002	X				provided by Jørgen Dalskov, Mar. 2003
	2003	X				provided by Jørgen Dalskov, Mar. 2004
	2004	X	W	D		provided by Lotte Worsøe Clausen, Mar. 2005
	2005	X	W	D		provided by Lotte Worsøe Clausen, Mar. 2006
	2006	X	W	D	(I)	provided by Mikael van Deurs, Mar. 2007
	2007	X	W	D	I	provided by Lotte Worsøe Clausen, Mar. 2008
	2008	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2009
	2009	X	W		I	provided by Lotte Worsøe Clausen, Mar. 2010
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
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
North Sea						
(her_47d3, her_nsea)	1991	X				provided by Yves Verin, Feb. 2001
	1992	X				provided by Yves Verin, Feb. 2001
	1993	X				provided by Yves Verin, Feb. 2001
	1994	X				provided by Yves Verin, Feb. 2001
	1995	X	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1996	(X)	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1997	(X)	W	D		provided by Yves Verin, Feb. 2001, updated Oct 2003
	1998	(X)	W	D		provided by Yves Verin, Mar. 2000, updated Oct 2003
	1999		W	D		provided by Christopher Zimmermann, Mar. 2000, updated Oct 2003
	2000		W	D		provided by Christopher Zimmermann, Mar. 2001, updated Oct 2003
	2001		W	D		provided by Christopher Zimmermann, Mar. 2002
	2002		W	D		provided by Christopher Zimmermann, Mar. 2003
	2003		W	D		provided by Christopher Zimmermann, Mar. 2004
	2004		W	D		provided by Christopher Zimmermann, Mar. 2005
	2005		W	D		provided by Christopher Zimmermann, Mar. 2006
	2006		W	D	I	provided by Norbert Rohlf, Mar. 2007
	2007		W	D	I	provided by Norbert Rohlf, Mar. 2008
	2008		W	D	I	provided by Norbert Rohlf, Mar. 2009
	2009		W	D	I	provided by Norbert Rohlf, Mar. 2010
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

Table 1.5.1: Available disaggregated data for the HAWG per March 2010. continued

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
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
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
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
National Data						
Germany: Western Balti	1991-2000	X				provided by Tomas Gröhsler, Mar. 2001 (with sampling)
Germany: North Sea	1995-1998		W			provided by Christopher Zimmermann, Mar 2001 (without sampling)
Norway: Sprat	1995-1998		W			provided by Else Torstensen, Mar 2001 (without sampling)
Sweden	1990-2000		W			provided by Johan Modin, Mar 2001 (without sampling)
UK/England & Wales	1985-2000	X				database output provided by Marinelle Basson, Mar. 2001 (without sampling)
UK/Scotland	1990-1998		W			provided by Sandy Robb/Emma Hatfield, Mar. 2002

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

North Sea (47d3)							
2009	CANUM	CANUM	Proportion	2009	WECA	WECA	Proportion
wr	Salloc	IC	Match (%)	wr	Salloc	IC	Match (%)
0	650043	650043	100.00%	0	0.009	0.009	100.00%
1	175923	176286	100.21%	1	0.051	0.051	100.01%
2	259434	259454	100.01%	2	0.144	0.143	99.94%
3	106738	106754	100.02%	3	0.181	0.180	99.90%
4	93321	94850	101.64%	4	0.216	0.215	99.93%
5	86137	86525	100.45%	5	0.216	0.215	99.93%
6	37951	37037	97.59%	6	0.239	0.239	100.04%
7	53130	53401	100.51%	7	0.243	0.242	99.92%
8	110394	111317	100.84%	8	0.248	0.247	99.98%
9+	32737	31992	97.73%	9+	0.272	0.273	100.10%
Sum	1605808	1607658	100.12%				

HerIRLS	Canum InterCatch	Canum Spreadsheet	Proportion Match %	Weca InterCatch	Weca Spreadsheet	Proportion Match %
1	10171	10171	100	0.078	0.078	100
2	4465	4465	100	0.122	0.122	100
3	12859	12859	100	0.146	0.146	100
4	4887	4887	100	0.160	0.16	100
5	8458	8458	100	0.169	0.169	100
6	1578	1578	100	0.188	0.188	100

Her-IRLW	Canum InterCatch	Canum Spreadsheet	Proportion Match %	Weca InterCatch	Weca Spreadsheet	Proportion Match %
1	202	202	100	0.077	0.077	100
2	12574	12574	100	0.146	0.146	100
3	12077	12077	100	0.171	0.171	100
4	12096	12096	100	0.194	0.194	100
5	12574	12574	100	0.200	0.2	100
6	5239	5239	100	0.207	0.207	100
7	2040	2040	100	0.211	0.211	100
8	853	853	100	0.218	0.218	100
9	17	17	100	0.275	0.275	100

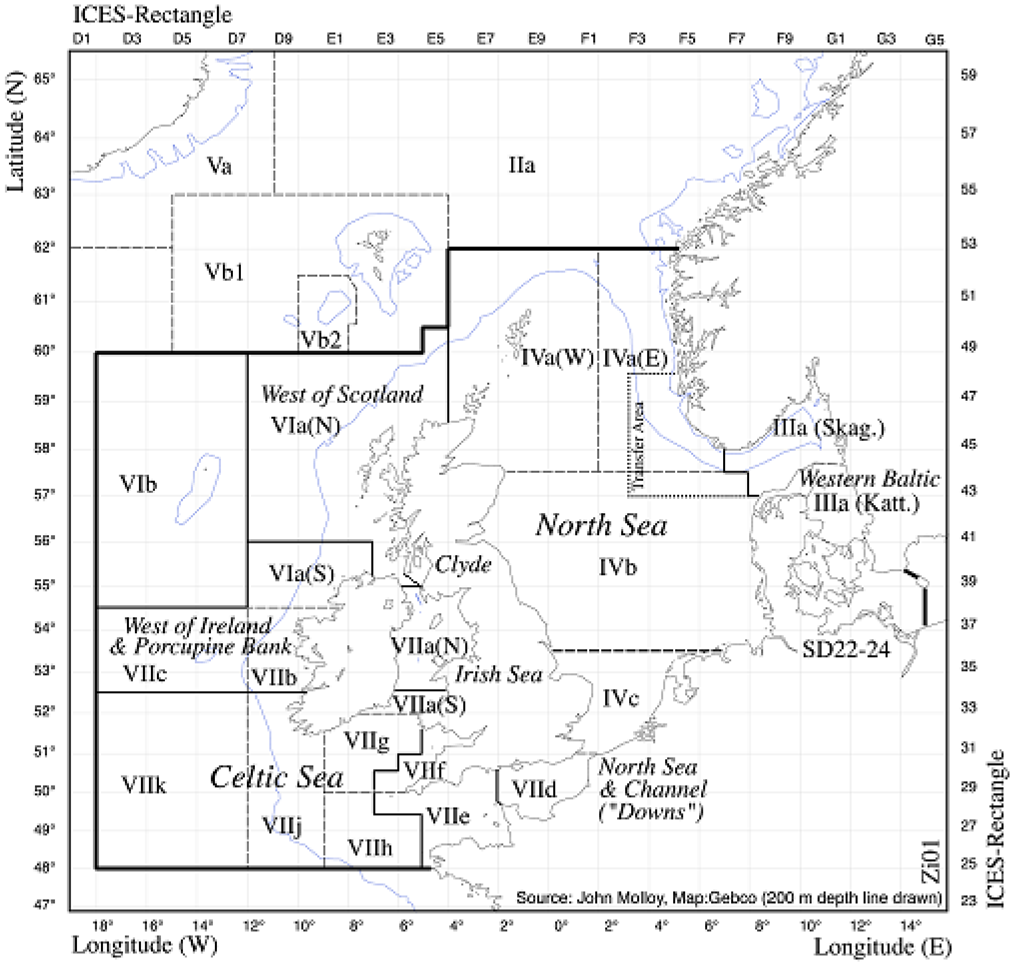

Figure 1.5.1 ICES areas as used for the assessment of herring stocks south of 62°N. Area names in italics indicate the area separation applied to the commercial catch and sampling data kept in long term storage. "Transfer area" refers to the transfer of Western Baltic Spring Spawners caught in the North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

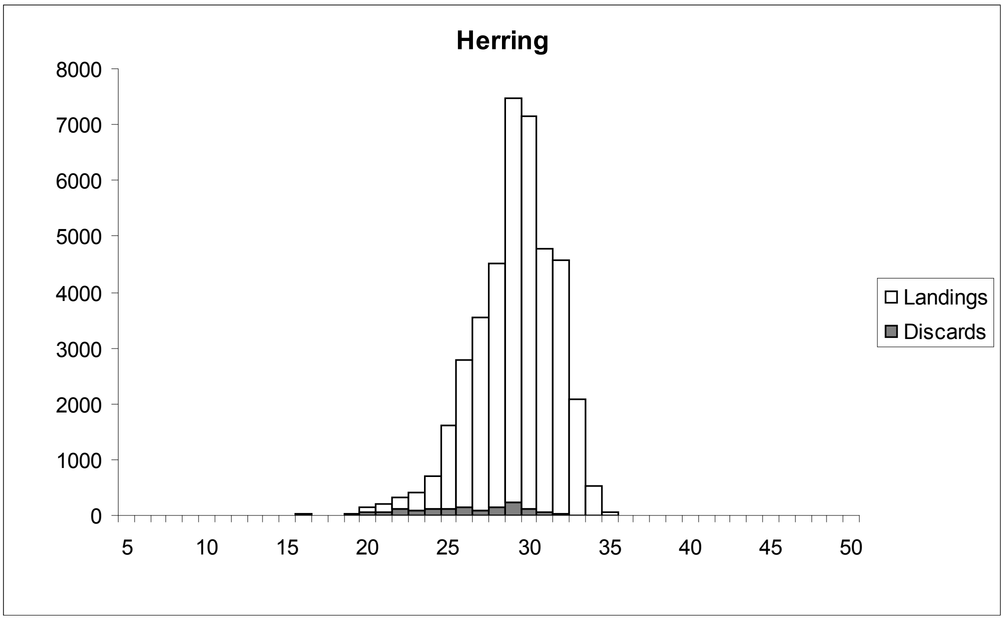

Figure 1.7.1 Numbers of herring landed and discarded (in thousands) against length (cm) by the sampled Dutch pelagic freezer trawlers in 2009.

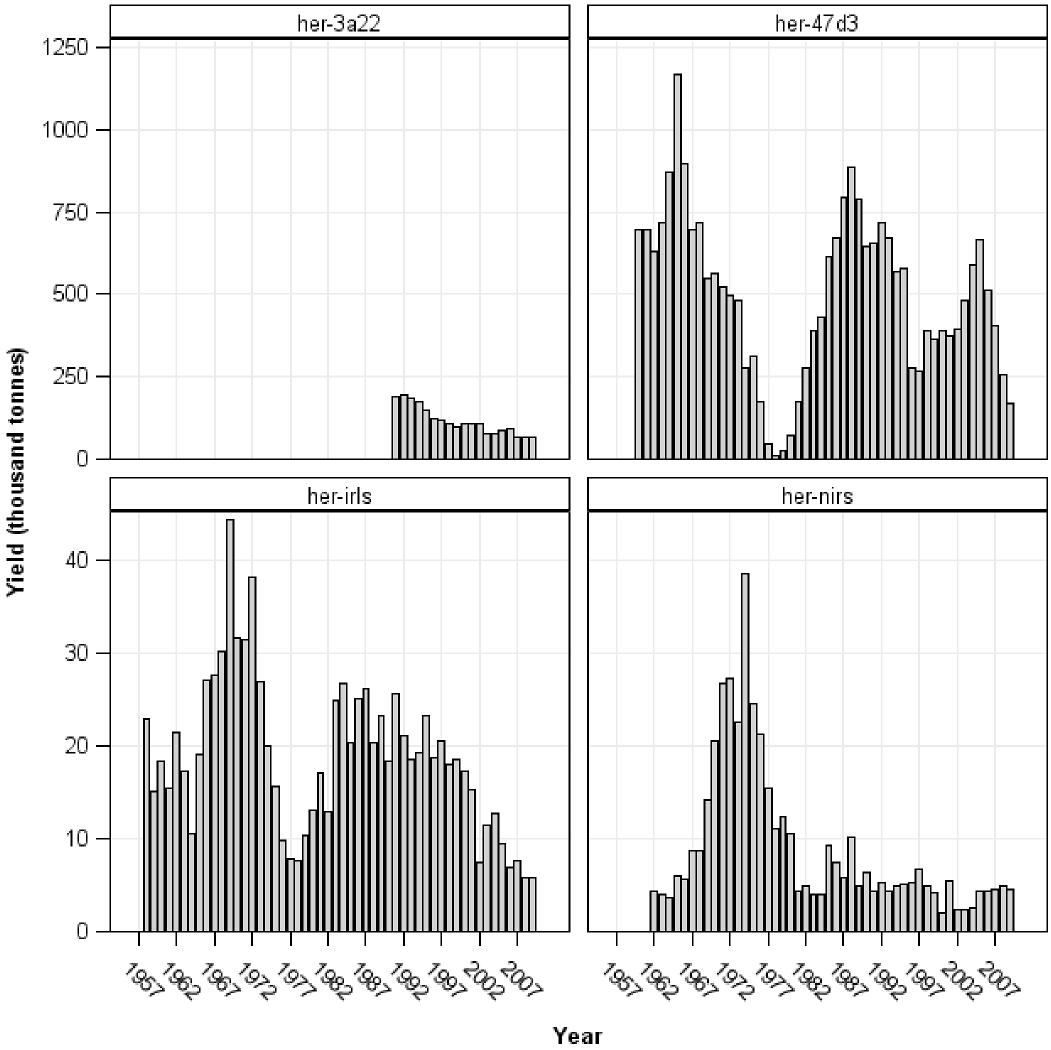

Figure 1.11.1 WG estimates of catch (yield) of the stocks presented in HAWG 2010.

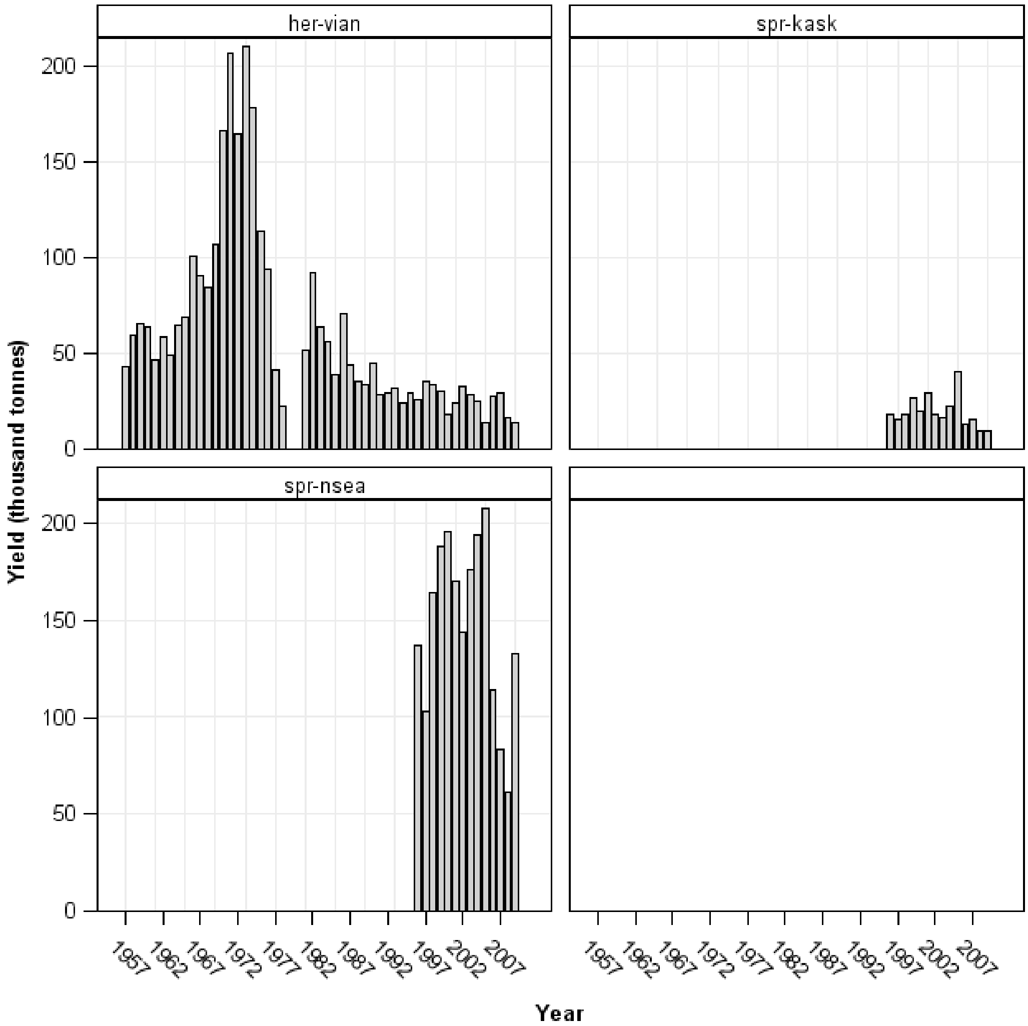

Figure 1.11.1 (cont). WG estimates of catch (yield) of the stocks presented in HAWG 2010.

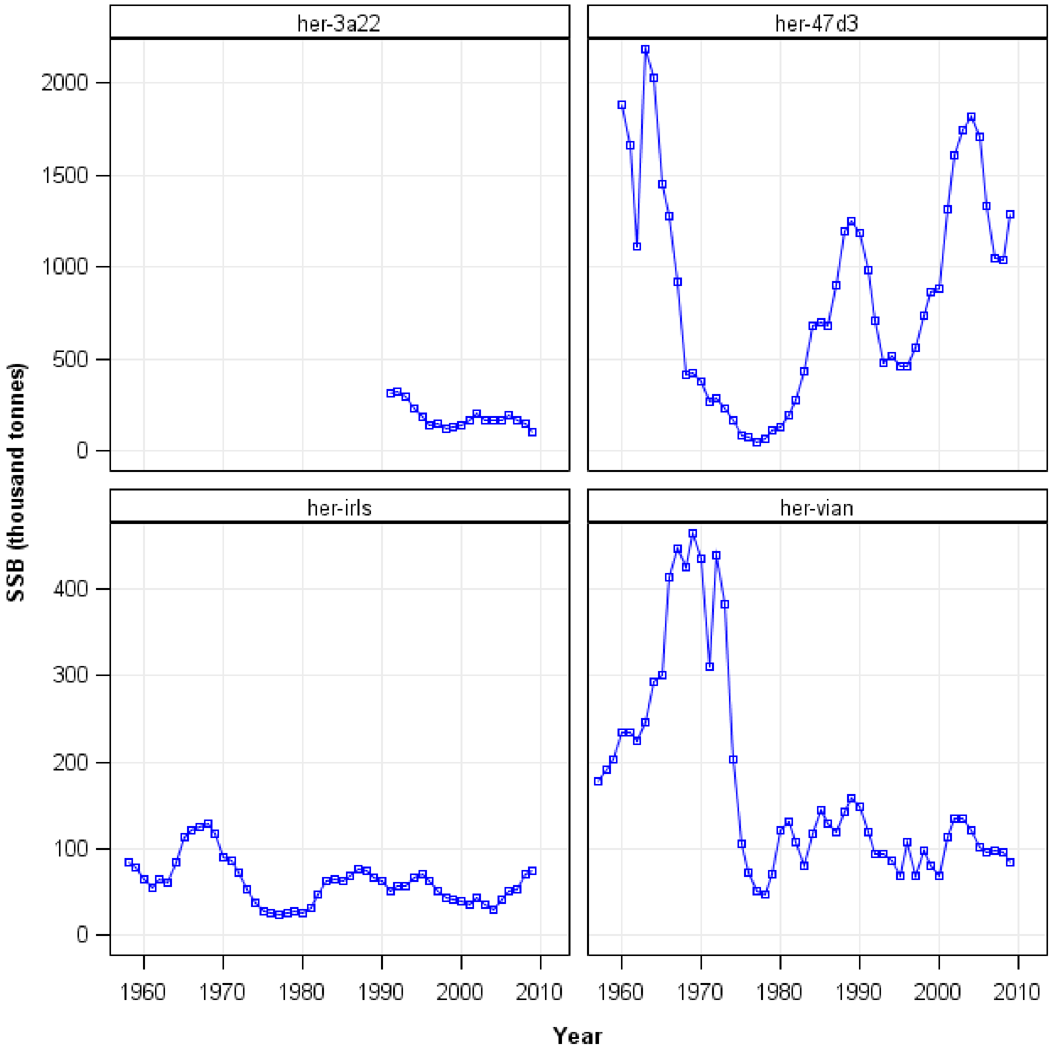

Figure 1.11.2 Spawning stock biomass estimates of the 4 herring stocks for which analytical assessments were presented in HAWG 2010.

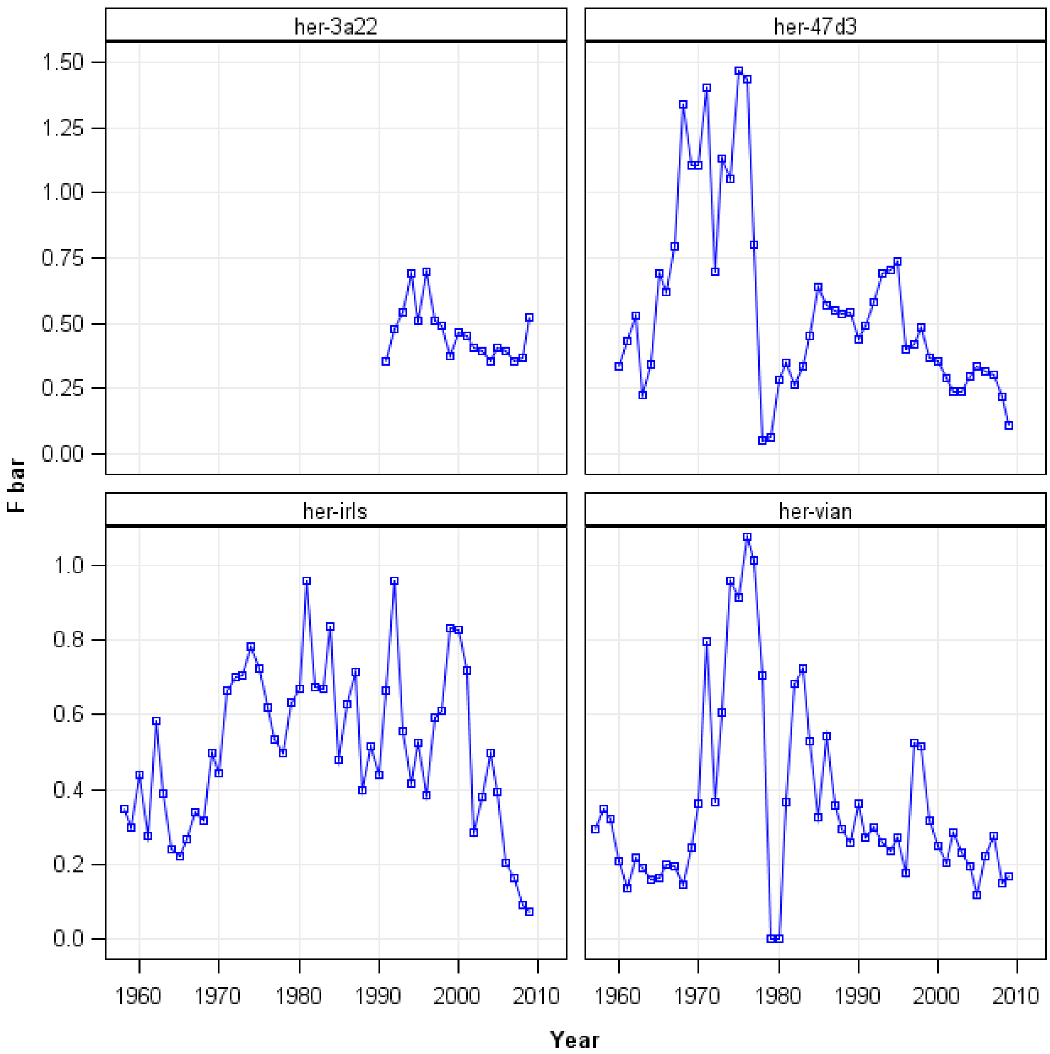

Figure 1.11.3 Estimates of mean F of the 4 herring stocks for which analytical assessments were presented in HAWG 2010.

2 North Sea Herring

This is an update assessment.

2.1 The Fishery

2.1.1 ICES advice and management applicable to 2009 and 2010

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 ($F_{0\text{-}1}$) and for adults ($F_{2\text{-}6}$) 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.

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

The final TAC adopted by the management bodies for 2009 was 171 000 t for Area IV and Division VIId, whereof not more than 23 567 t should be caught in Division IVc and VIId. For 2010, the total TAC was reduced by 5% to 177 887 t (164 300 t for the A-Fleet), including a TAC of 15 567 t for Division IVc and VIId.

The by-catch ceiling set for fleet B in the North Sea was 15 985 t for 2009 and was decreased by 15% to 13 587 t for 2010. As North Sea autumn spawners are also caught in Division IIIa, regulations for the fleets operating in this area have to be taken into account for the management of the WBSS stock (see Section 3). Catches of herring in the Thames estuary are not included in the TAC. For a definition of the different fleets harvesting North Sea herring see the stock annex and Section 2.7.2.

2.1.2 Catches in 2009

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

The catch figures in Tables 2.1.1 - 2.1.5 are mostly provided by WG members and may or may not reflect national catch statistics. These figures can therefore **not** be used for legal purposes. Denmark and Norway provided information on by-catches of herring in the industrial fishery. These are taken in the small-meshed fishery (B-fleet) under an EU quota by Denmark and are included in the A-fleet figures for Norway. Catch estimates of herring taken as by-catch by other small-mesh fisheries in the North Sea may be an underestimate. The total Working Group catch of all herring caught in the North Sea in 2009 amounted to 165 800 t.

Landings of herring taken as by-catch in the Danish small-meshed fishery in the North Sea have increased by 14 % to 9 769 t as compared to last year (Table 2.1.6). These industrial herring catches were much lower than the by-catch ceiling set by the EU (15 985 t).

In the Norwegian industrial fishery, herring by-catch has increased substantially in 2009 to 3 576 t (compared to 293 t last year).

Official catches by the human consumption fishery were 156 700 t in 2009. This is an undershot of 8 % of the TAC. Working group catches in the human consumption fishery were in the same order of magnitude in 2009 (156 100 t, decreased by 35 % from last year).

At HAWG, only preliminary data were reported for catches taken by French flagged vessels. The catch figure of French landing and thus of the North Sea may increase when more data become available.

In the southern North Sea and the Eastern Channel, the total catch of 21 923 t in 2009 is in good accordance with the TAC of 23 567 t.

The total North Sea TAC and catch estimates for the years 2001 to 2009 are shown in the table below (adapted from Table 2.1.6). Since the introduction of yearly by-catch ceilings in 1996, these ceilings have never been exceeded.

YEAR	2001	2002	2003	2004	2005	2006	2007	2008	2009
TAC HC ('000 t)	265	265	400	460	535	455	341	201	171
"Official" landings HC ('000 t)[1]	275	282	414	484	547	478	354	219	157
Working Group catch HC ('000 t)	303	331	438	537	617	498	381	236	156
Excess of landings over TAC HC ('000 t)	38	66	38	77	83	43	40	35	0
By-catch ceiling ('000 t) [2]	36	36	52	38	50	42	32	19	16
Reported by-catches ('000 t) [3]	20	22	12	14	22	12	7	9	10
Working Group catch North Sea ('000 t)	323	353	450	550	639	511	388	245	166

HC = human consumption fishery

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

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

3 provided by Denmark only.

2.1.3 Regulations and their effects

Landings taken in the North Sea but reported from other areas such as Divisions IIa and IIIa and from Division VIaN have decreased in 2009 and are less than 2 000 t (compared to 17 000 t in 2008). Unexpectedly, for the first time, the estimates of the total amount of catch does not exceed the TAC, neither in the human consumption fishery (excluding within-area misreporting) nor in the sum of all fleets.

Following the apparent recovery of the autumn spawning North Sea herring, some regulatory measures were amended: In 2004, the total Norwegian quota and half of the EU quota for Division IIIa could be taken in the North Sea. A licence scheme introduced in 1997 by UK/Scotland to reduce misreporting between the North Sea and VIaN was relaxed. The minimal amount of target species in the EU industrial fisheries in IIIa has been reduced to 50 % (for sprat, blue whiting and Norway pout). In 2010, Norway can take up to 20 % of it's quota for Division IIIa in the North Sea.

2.1.4 Changes in fishing technology and fishing patterns.

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

2.2 Biological composition of the catch

Biological information (numbers, weight, catch (SOP) at age and relative age composition) on the catch as obtained by sampling of commercial catches is given in Tables 2.2.1 to 2.2.5. Data are given for the whole year and by quarter. Except in cases where the necessary data are missing, data are displayed separately y area for herring caught in the North Sea, Western Baltic spring spawners (only in IVaE), and the total NSAS stock, including catches in Division IIIa.

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

The Tables are laid out as follows:

- Table 2.2.6: Total catches of NSAS (SOP figures), mean weights and numbers-at-age by fleet
- Table 2.2.7: Data on catch numbers-at-age and SOP catches for the period 1994-2009 (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 1999 – 2009.

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

2.2.1 Catch in numbers-at-age

The total number of herring taken in the North Sea (1.4 billion fish) and the total number of NSAS (1.6 billion fish) have decreased in both cases by 22 %, as compared to last year. 0- and 1-ringers contributed 44 % of the total catch in numbers of NSAS in 2009 (Table 2.2.7). 0- and 1-ringer catch has decreased by 25 % and 35 %, respectively, as compared to 2008. Most of these herring are still taken in the B-Fleet. Catch of 0- and 1-ringers is around 50 % for all Divisions in the North Sea, with the exception of IVc and VIId, were almost only older herring were caught. Roughly 30 % of the total catch by number in the North Sea consist of the age group 4+ winter ringers.

Western Baltic and local Division IIIa Spring-spawners (WBSS) are taken in the eastern North Sea during the summer feeding migration (see stock annex 3 and section 3.2.2). These catches are included in Table 2.1.1 and listed as IIIa type. Table 2.2.8 specifies the estimated catch numbers of WBSS caught in the North Sea, which are transferred from the North Sea assessment to the assessment of Division IIIa/Western Baltic in 1994-2009. After splitting the herring caught in the North Sea and IIIa between stocks, the total catch of North Sea Autumn spawners was 168 400 tonnes.

Area	Allocated	Unallocated	Discards	Total
IVa West	72 224	-977	91	72 224
IVa East	9 915	-	-	9 915
IVb	61 780	-166	-	61 780
IVc/VIId	21 923	417	-	21 923
	Total catch in the North Sea			165 842
	Autumn Spawners caught in Division IIIa (SOP)			6 543
	Baltic Spring Spawners caught in the North Sea (SOP)			-3 941
	Blackwater Spring Spawning herring			-48
	Other Spring Spawners			0
	Total Catch NSAS used for the assessment			**168 400**

2.2.2 Other Spring-spawning herring in the North Sea

Norwegian Spring-spawners and local fjord-type spring spawning herring are taken in Division IVa (East) close to the Norwegian coast under a separate TAC. These catches are not included in the Norwegian North Sea catch figures given in Tables 2.1.1 to 2.1.6, but are listed separately in the respective catch tables. Along with the increasing biomass of these spring spawning herring, the catches have increased to 44 560 t in 2009 (2 721 t in 2008).

Blackwater herring are caught in the Thames estuary under a separate quota and included in the catch figure for England & Wales. Catches were only 48 t in 2009.

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

2.2.3 Data revisions

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

2.2.4 Quality of catch and biological data, discards

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

Information on discards is low in 2009. The final figure for discards as used in the assessment was only 91 t, based on the raised discards for one fleet. As discards are likely to occur in all national fisheries, this figure may be an underestimate. Discard data has not been consistently available for the whole time series and was only included in the assessment when reported.

In 2009, the sampling of commercial landings covers 70 % of the total catch (2008: 76 %). However, the number of herring length and weight measured has decreased by far in 2009 (-40 %) (Table 2.2.12). It should be observed that "sampled catch" in Table 2.2.12 refers to the proportion of the reported catch to which sampling was applied. This figure is limited to 100 % but might in fact exceed the official landings due to sampling of discards, unallocated and misreported catches.

More important than a sufficient overall sampling level is an appropriate spread of sampling effort over the different metiers (here defined as each combination of fleet/nation/area and quarter). Of 76 different *reported* metiers, only 29 were sampled in 2009. The recommended sampling level of more than 1 sample per 1 000 t catch has been met only for 12 metiers, (13 in 2008). For age readings (recommended level >25 fish aged per 1 000 t catch) 13 metiers appear to be sampled sufficiently (2008: 12).

On the other hand, some of the metiers yielded very little catch. In 44 metiers the catch is below 1000 t. The total catch in these metiers sums to 11 800 t, so the remaining 32 metiers represents 154 800 t of the official catch (93 %). Of these 32 metiers, 18 were sampled and 10 of them fulfil the recommended level of more than 1 sample per 1 000 t catch and than 25 age readings per 1 000 t catch.

However, the catch of France, Sweden and the Faroe Islands from the North Sea has not been sampled. Some catches of UK England and landed to Ijmuiden was sampled by the Netherlands.

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, West of Scotland VIa(N) and the Malin Shelf area in June–July 2009 (HERAS)

Seven surveys were carried out during late June and July covering most of the continental shelf north of 52°N in the North Sea and to the west of Scotland and Ireland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian, Danish, Swedish and German coastline and to the west by the shelf edge between 200 and 400 m depth. The individual surveys and the survey methods are given in the report of the Working Group for International Pelagic Surveys (WGIPS; ICES CM 2010/SSGESST:03). The vessels, areas and dates of cruises are given in Table 2.3.1.1 and in Figure 2.3.1.1.

The surveys are reported individually in the report of the WGIPS. The global estimate of the North Sea herring from all of these surveys is reported here. 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 2.6 million tonnes and 12 900 million herring. This is about a third higher compared to the previous year. The survey continues to show the particularly strong 2000 year class. Growth of this 2000 year class still seems to be slower than average; individuals from this year class were smaller in both mean length and weight than the younger 2001 year class (Table 2.3.1.2).

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

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

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

Herring larvae surveys were conducted in September 2009 and January 2010. 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 2009 and January 2010 (Figures 2.3.2.1 – 2.3.2.4). The survey effort in vessel days and numbers of samples taken is comparable to previous years.

The total number of newly hatched larvae increased in all observed areas, with the only exception of the central North Sea (where abundance decreased from the very high level found in 2008 to still high estimates in 2009). The central North Sea area is well known for large annual variability in larvae abundance. As anticipated, spatial distribution varied between areas and time periods. Some abundance estimates are influenced by larvae patchiness in a higher degree compared to former years, which has influenced the estimates especially in the southern North Sea (Table 2.3.2.1, Figure 2.3.2.5).

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

In an additional approach, the impact of larvae patchiness on the MLAI calculation was tracked by artificially deleting samples yielding more than 10 000 larvae per square metre in the input file (3 stations). The resulting MLAI is reduced by 35 % (320 compared to 478), but still on a historic high level. Thus the driving force is not only the patchiness, but the overall occurrence of herring larvae in the surveys. None of these manipulated input data were used in the final MLAI as used in the assessment.

Detailed information on survey results are given in the Report of the herring larvae surveys in the North Sea (Rohlf & Gröger, WD 09).

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

2.3.3.1 The 0-ringer abundance (IBTS0 survey)

The total abundance of 0-ringers in the survey area is used as recruitment index for the stock. This year's IBTS-0 index is based on 550 depth-integrated hauls with the ring-net. The Dutch 2010 sampling is not included in the series, due to outstanding low catches and uncertainties about gear catchability and calibration. Index values are calculated as described in the WG report of 1996 (ICES 1996/ACFM:10). The series of estimates is shown in Table 2.3.3.1, the new index value of 0-ringer abundance of the 2009 year class is estimated at 77.1

The index is about 70% of the long term mean, and indicates a continuation of the series of relatively poor recruitments starting from the 2002 year class. The 0-ringers which are included in the index were predominantly distributed in the central-southern areas of the North Sea (Figure 2.3.3.1). Compared to the preceding two year classes, the 0-ringers from the 2009 year class are distributed much further to the south. A large concentration was found south of the Dogger Bank, while no herring larvae were seen in the Skagerrak/Kattegat. Concentrations of Downs herring larvae were apparent from ring net catches in the area of the English Channel, however, due to their small size (many below 12 mm mean length) most of these will not contribute to the recruitment index at a scale comparable to estimates based on larger larvae (> 20 mm). Hence, these small larvae are not included in the standard procedure of index estimation and not illustrated in the Figure 2.3.3.1. At last years meeting the WG investigated the changes in IBTS0 indices when including the catches of small Downs and accounting for a daily mortality rate of 0.1 until these reached the 20 mm length. This investigation indicated only marginal influence from such inclusion of Downs larvae in the IBTS0 index (ICES 2009/ACOM 03, section 2.10.2).

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 56%.

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

1-ringer abundance

The 1-ringer recruitment estimate (IBTS-1 index) is based on trawl catches in the entire survey area. The time series for year classes 1977 to 2008 are shown in Table 2.3.3.2. This year’s estimate of the 2008 year class strength indicates a very poor recruitment, 63% of the long term mean. Figure 2.3.3.3 illustrates the spatial distribution of 1-ringers as estimated by trawling in February 2008, 2009 and 2010. Across years, the main areas of 1-ringer distribution is in the German Bight and south of Dogger Bank, the 2008 year class appears more widespread and extends to the Fisher Banks area off the northern coast of Denmark.

The Downs herring hatch later than the autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:12, and ICES CM 2001/ ACFM:12). Table 2.3.3.2 includes abundance estimates of 1-ringer herring smaller than 13 cm, calculated as the standard index but is in this case for herring <13 cm only. Indices for these small 1-ringers are given either for the total area or the area excluding division IIIa, and their relative proportions are also shown. In the time-series, the proportion of 1-ringers smaller than 13 cm (of total catches) is in the order of 20%, and the contribution from division IIIa to the overall abundance of <13 cm herring varies markedly during the period (Table 2.3.3.2). About 24% of this year's group of 1-ringers is smaller than 13 cm.

2-5+ ringer abundances

Table 2.3.3.3 shows the time-series of abundance estimates of 2-5+ ringers from the 1st quarter IBTS for the period 1983-2010. The present 2010 indices for 2 -4 ringers are low (7-45 % of long term means), only the index of 5+ ringers – which includes the large 2000 year class - is of significant magnitude (136% of long term mean).

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

2.4.1 Mean weights-at-age

Table 2.4.1.1 shows the historic mean weights-at-age (winter ringers, wr) in the North Sea stock during the 3rd quarter in Divisions IV and IIIa from the North Sea acoustic survey (HERAS) as well as the mean weights-at-age in the catch from 1996 to 2009 for comparison. The data for 2009 were sourced from Tables 2.3.1.2. and 2.2.2. In the third quarter most fish are approaching their peak weights just prior to spawning. The mean weights in 2009 for 2- to 7-ringers were much higher than 2008 but lower for the 8-ringers and 9+ group.

Generally, mean weight of the older fish (4+wr) in the acoustic survey has been declining since 1996. In more recent years however, sizeable increases in weight for the 4- to 7-ringers have been observed (Figure 2.4.1.1). This pattern was observed in both the acoustic survey and catch data indicating that these increased weights are not merely survey noise.

Variations in size-at-age in North Sea herring can to a large extent be explained by density dependent mechanisms but also seem to be affected by environmental effects to some degree (reviewed in Dickey-Collas et al. 2010). In particular, it has been noted that the very strong 2000 year class, which was competing with an already large herring stock biomass, has been growing slower than other year classes throughout. This was still evident in 2009 where this cohort is represented by the 8-ringers.

The large 4- to 7-ringers seen in 2009 represents the 2002, 2003 and 2004 year classes. These year classes have been growing at a much increased rate in agreement with density dependant mechanisms affecting North Sea herring growth. These year classes are the first of the very small year classes to fully recruit into the fishery from 2007 and onwards (at age 4) and have been coming through at a time of relative low cohort abundance.

2.4.2 Maturity ogive

The percentages at age of North Sea autumn spawning herring that were considered mature in 2009 were estimated from the North Sea acoustic survey (Table 2.4.2.1). The method and justification for the use of values derived from a single year's data was described fully in ICES (1996/ACFM:10). For 2-ringers the proportions mature in 2009 was 89% which is high but similar to 2008 (Table 2.4.2.1). The 3 and 4-ringers were all considered fully mature in the 2009 survey, a slight change from 2008, but in line with the increased weights (Table 2.4.1.1.). The 2000 year class, which matured more slowly, became fully mature in 2006.

2.5 Recruitment

Information on the development in North Sea herring recruitment comes from the International Bottom Trawl Surveys, from which IBTS-0 and the IBTS-1 indices are available. Further, the ICA assessment provides estimates of the recruitment of herring in which information from the catch and from all fishery independent indices is incorporated.

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

The estimation of 0-ringer abundance (IBTS-0 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 years prediction of the 2008 year class is well in accordance with this year's IBTS-1wr index of the year class (circled in the figure). Generally, there is a good agreement between the indices in their description of temporal trends in recruitment (Figure 2.5.2), but for the recent two year classes 2006 and 2007 the predicted levels of recruitment deviate. Possible explanations for this discrepancy were discussed in last year's report (ICES 2009/ACOM 03, sections 2.3.3.1-2).

2.5.2 Trends in recruitment from the assessment

Abundances of recruiting North Sea herring are estimated from the assessment (see the temporal trend of recruitment in Figure 2.6.3.1). The recruitment declined during the sixties and the seventies, followed by a marked increase in the early eighties. After the strong 1985 year class recruitment declined again until the appearance of the strong year classes 1998-2000. During the following years the recruitment has generally been low. The trends in recruitment are described in detail by Payne *et al*. (2009). The IBTS-0 recruitment index for the year class 2009 indicates a continuation of the recent series of relatively poor recruitments (section 2.3.3.1).

2.6 Assessment of North Sea herring

2.6.1 Data exploration and preliminary results

North Sea herring was classed as an update assessment in 2010 by ACOM, as a benchmark assessment took place in 2006. The choice of assessment model, catch and survey weightings and the length of separable period were not explored in 2010, and for justification of the approach refer to the benchmark assessment (ICES CM 2006/ACFM:20) and Simmonds (2003; 2009). Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is FLICA.

Acoustic (HERAS ages 1-9+), bottom trawl (IBTS-1Q ages 1-5), IBTS0 (formerly named MIK, age 0) and MLAI larvae (IHLS) surveys are available for the assessment of North Sea autumn spawning herring. The surveys and the years for which they are available are given in Table 2.6.1. In recent years it has been observed that the indices for IBTS-Q1 are noisy when used in the assessment. The WG still shares the opinion however that the assessment is best executed including all surveys (Simmonds 2009).

This year's assessment is an update assessment, therefore the input data and the performance of the assessment have been carefully scrutinised to check for potential problems, but no changes to the methods or development of the model took place in 2010. The diagnostics do not indicate any significant pattern or unreliable data points (Figure 2.6.1.1 to Figure 2.6.1.16). The assessment fit to the acoustic survey (ages 6-9+) over the past 5 years have resulted in larger residuals. However, this year's indices have a markedly better fit to the assessment. The IBTS survey continues to result in noisy signals, while this year's IBTS0 index fits well in the assessment (Figure 2.6.1.17). The estimates of the 2009 IBTS 1wr and the 2008 IBTS0 appear to conform again to the expected relationship. This years MLAI index is the highest value observed in its entire time-series, and is approximately 2.5 times higher than the value in 2008. As expected, the stock assessment did not fit this value well (Figures 2.6.1.17 and 2.6.1.19). The WG decided to keep this value in the final stock assessment. In the 2006 benchmark assessment it was concluded that one of the reasons for the relatively stable assessment was the balance of the major sources of information, with each potentially delivering short periods with bias but in combination providing a balance of errors.

Overall the catch residuals are small.

Figures 2.6.1.20 to 2.6.1.21 show retrospective estimates of SSB, recruitment, mean $F_{2\text{-}6}$, selectivity pattern and year class cohorts, by removing one year of data at a time, up to 10 years in total. The estimation of F had shown considerable consistency over the last 10 years but has minor revisions downwards in the more recent years. SSB is reasonably consistent over the last 10 years. The retrospective estimates of recruitment in the year 2007 deviate more than the estimates of SSB and $F_{2\text{-}6}$ retrospectives. This is most likely due to the noisy IBTS-Q1 survey. However, overall the retrospective patterns are small. Figure 2.6.1.22 shows the retrospective pattern of the number per cohort. This pattern is consistent over the years as well, where only a small revision can be observed in the 2007 year class, which is most likely due to the noisy IBTS-Q1 survey. The selectivity pattern has not changed greatly over recent years (Figure 2.6.1.20). Figure 2.6.1.23 shows the 'otolith' plot, representing the uncertainty of the fit of the assessment model. The 99% confidence interval of SSB indicates that the stock is above B_{lim} and the mean indicates a biomass slightly below B_{pa}.

Further data screening of the input data on mature – immature biomass ratios, survey CPUEs, proportion of catch numbers and weights at age and proportion of IBTS and acoustic survey ages have been executed, as well as correlation coefficient analyses for the acoustic and IBTS survey (see Figures 2.6.1.24 to 2.6.1.31). It was observed that both the estimates of both weight at age in the catch and in the stock for ages 3-6, have increased considerably over the past three years. Also the 2006 year class (2 wr in 2009) is now estimated to be stronger than previously thought. No further issues were raised by this exercise.

2.6.2 Exploratory Assessment for NS herring

As an exploratory assessment run, this year the WG has performed an assessment including a Spawning Component Abundance Index (SCAI, Payne *et al*. 2010 in press) instead of the MLAI index. This index, which is designed to smooth trends in the abundance index, analyses the individual parts of the larval survey and combines them in a statistical model. Similar to the MLAI, the last year's value is the highest observed in its time-series, but only 40% higher than the value in 2008 compared to 250% for the MLAI. The survey weighting for the SCAI was kept the same as the MLAI. Using the SCAI still results in a poor fit of the assessment to the 2009 data point. The SCAI resulted in an estimate of $F_{2\text{-}6}$ of 0.119 for 2009 compared to 0.111 when using the MLAI. One clear effect of using the SCAI, which assumes autocorrelation between years, is the clear patterns in the residuals caused by the between year effects in the index.

2.6.3 Final Assessment for NS herring

In accordance with the settings described in the stock annex, the final assessment of North Sea herring was carried out by fitting the integrated catch-at-age model (ICA, in the FLR environment - version 1.4-12 – 08 October 2009 15:16:26). The input data and model settings are shown in Tables 2.6.3.1 – 2.6.3.11, the ICA output is presented in Tables 2.6.3.13 – 2.6.3.21, the stock summary in Table 2.6.3.12 and Figure 2.6.3.1 and model fit and parameter estimates in Table 2.6.3.21. Diagnostics of the catch for the separable period are shown in Figure 2.6.3.2. The reference point estimates are shown in Figure 2.6.3.3 while Figure 2.6.3.4 shows the agreed management plan including the biomass trigger points and contains the $F_{2\text{-}6}$ estimates of the past 8 years, as well as including the prognosis for 2010.

The spawning stock at spawning time in 2009 is estimated at approximately 1.29 million tonnes, increasing from 1.0 million tonnes in 2008. The estimate of 0-wr fish in 2010 (2009 year class) is estimated to be at approximately 2.7 billion, slightly above the geometric mean of the past 8 years (see Table 2.6.3.15 and Figure 2.6.3.5). The strong 2000 year class is still in the population, at age 8-wr in 2009 but its influence on the population has reduced. The 2006 year class (2 wr in 2009) is now estimated to be 75% larger than the estimate from the HAWG 2009 stock assessment. Mean $F_{2\text{-}6}$ in 2009 is estimated at approximately 0.11, which is below the management agreement target F, while mean $F_{0\text{-}1}$ is 0.03, also below the agreed target, and lower than 2008.

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 highest yield	Fishing mortality in relation to agreed target	Comment
At risk of having reduced reproductive capacity	Harvested sustainably	Appropriate	Below target	The estimated SSB is 99.15% of the Bpa

Based on the most recent estimates of SSB and fishing mortality, ICES classifies the stock as being at risk of having reduced reproductive capacity and is being harvested sustainably. The SSB in autumn 2009 was estimated at 1.29 million t, 0.85% below Bpa. $F_{2\text{-}6}$ in 2009 was estimated at 0.11, below the target $F_{2\text{-}6}$ of 0.2. The year classes from 2002 are estimated to be among the weakest since the late 1970s.

2.7 Short term predictions

Short term predictions for the years 2010, 2011 and 2012 were done with code developed in R software, mimicking the MFSP programme. In 2009 the results of both methods were extensively compared to ensure that they both gave identical results. In the short term predictions, recruitment is assumed constant for the years 2011 and 2012 at the low level of recruitment since 2002 (geometric mean of 2001 to 2008 year classes).

For the intermediate year, no overshoot for the A fleet was assumed, as the catches equalled the TAC in 2009. New information suggests that the agreement between catch and TAC will continue. For the B-fleet the agreed by-catch ceiling in 2010 has been used. For the C and D fleets the same fraction of the TAC as last year was assumed. Transfers of Norwegian quota from the C-fleet to the A-fleet as well as transfers of herring into IIIa have been taken into account. See Table 2.7.1 – 2.7.11 for other inputs.

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

a) No fishing;

b) The EU–Norway management plan (no restriction on TAC change);

c) A roll over TAC from 2010 to 2011 of 164 kt for the A fleet;

d) Fishing at Fpa ($F_{2\text{-}6}$ = 0.25) in 2011

e) A 15% decrease in the A fleet TAC between 2010 and 2011;

f) A 15% increase in the A fleet TAC between 2010 and 2011;

g) Fishing at candidate Fmsy ($F_{2\text{-}6}$ = 0.25) in 2011

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 2011. The consequence of other combinations of catch options can be explored on request.

For options b, c, e and f, the C and D fleets are assumed to have a North Sea autumn spawner catch for 2010 of 4.3 and 1.0 thousand tonnes respectively. In 2011 and 2012 they are assumed to have a North Sea autumn spawner catch of 1.7 and 0.5 thousand tonnes respectively. **All predictions are for North Sea autumn spawning herring only.** The results are presented in Table 2.7.12.

2.7.1 Comments on the short-term projections

HAWG assumed that recruitment was likely to remain poor in 2011. A slight increase in SSB is expected from 2009 to 2010. The SSB is expected to increase under the management plan both in 2011 and further in 2012. This estimated increase in SSB indicates the end of the decline in SSB observed from 2004 onwards. SSB is expected to be above Bpa in 2011, and may increase above $B_{trigger}$ in 2012 as long as the management plan is adhered to (i.e. maximum change in TAC of 15%).

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

The methods used for the predictions this year are slightly different from those obtained last year. The assumption of a 13% over catch in 2009 in last years short term forecast was not realised and the realised catch equalled the TAC in 2009. This difference in catch, as well as the slight improvement in recruitment, has led to a significant increase in SSB of the stock in 2009. The predicted catch according to the management plan for 2010 implies an increase in TAC of 15%.

2.8 Medium term predictions and HCR simulations

Medium term predictions were not done.

2.9 Precautionary and Limit Reference Points and FMSY targets

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

The Blim

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

Fpa and Bpa

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

F_{MSY} and consideration of fisheries on both juvenile and adult herring (ICES CM 1997/ACFM:08).

B trigger

The higher inflection point ($B_{trigger}$) in the earlier rule (1.3 million tonnes) was derived largely as a compromise, allowing higher exploitation at higher biomass but reflecting an ambition to maintain the stock at a high level, by reducing the fishing mortality at an early stage of decline. This trigger was changed in November 2008 to 1.5 million tonnes after WKHMP and consultation with the stakeholders. Thus currently the trigger and Bpa are different at 1.5 million tonnes and 1.3 million tonnes respectively. The lower B trigger of 800 000 tonnes relates to the Blim (see above).

FMSY target and trigger for new advisory framework

HAWG met before the new ICES framework had been developed. However HAWG was expected to comment on new FMSY targets to inform the new advisory framework. The matter is discussed in detail in section 1.3 of this report.

At present HAWG considers that the parameters of the management plan do conform to the MSY approach.

2.10 Quality of the assessment

The assessment this year was classified as an update, following the procedures and settings specified in the Stock Annex 3. In previous years, the assessment of North Sea herring has been regarded as consistent, and the diagnostics indicate a similar classification for this year. Extra attention was given to the cluster of negative residuals in the acoustic survey, ages 6-9+ over the past 5 years. The reason for this cluster of residuals is not clear. This year however, the residuals in the last year were small, which may point to causes that might have a temporary impact.

This year the larval index (MLAI) was the highest of the entire series. This is due to patchy high larval observations during the survey, driving up the total index. The poor fit of the assessment to this data point was viewed as appropriate by the WG. A state-space model, designed to smooth the time series of larval abundances by spawning component, has been used to evaluate the quality of the MLAI index. This newly generated time series also indicated a high larval abundance, however, it indicated less of an increase compared to the MLAI index.

The IBTS-Q1 survey continued to give rather noisy signals, as it did in the past 3-4 years. The WG still shares the opinion however that the assessment is best executed including all surveys (Simmonds 2009). As noted in Section 3.2.1, sampling for splitting the catches between NSAS and WBSS in IVaE is becoming problematic as sampling was insufficient in 2009. Hence, the split in the transfer area was calculated as a three year mean (2006-2008) proportions by age. The impact on the assessment of split factors has not been explored.

An eight year analytic retrospective shows the current consistency of the assessment. The data from the stock summary table is compared with the stock summary from the 2009 assessment and the first year (intermediate year) of the 2010 short term prediction. The projected $F_{2\text{-}6}$ for 2009 for the intermediate year, from HAWG 2009 was 0.19 (see text table below). The estimated F_{2-6} from this working group for 2009 is 0.11. HAWG 2009 assumed an over-catch of 13%, this appeared not to happen. However the biomass of herring has also increased more than projected. The 2006 year class (2 wr in 2009) is now estimated to be 75% greater in abundance than estimated in 2009. It is also more mature than projected (89% co pared to 74% mature). These two factors, plus increased size at age, have an effect on the estimates of SSB (Figure 2.10.1) resulting in a difference of 316 kt SSB compared to the projected estimate from HAWG 2009. This highlights the importance of understanding the productivity and biology of North Sea herring to the effective provision of operational advice to populate the management plan (see Dickey-Collas *et al.*, 2010).

	2009 Assessment				**2010 Assessment**				**Percentage change in estimate 2009-2010**			
Year	Rec	SSB	Catch	F_{2-6}	Rec	SSB	Catch	F_{2-6}	Rec	SSB	Catch	F_{2-6}
2007	19044	953	NA	0.33	30374	1047	406	0.31	-59%	-10%	NA	6%
2008	22909	1000	NA	0.23	16409	1038	258	0.22	28%	-4%	NA	4%
2009*	31163	971	211	0.19	29750	1289	168	0.111	5%	-32%	20%	42%

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

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

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

Historically, the TAC for herring in IVc and VIId has been set as a proportion of the total North Sea TAC and this has varied between 6 and 16% since 1986. The proportion has been relatively high, particularly between 2002 and 2005. However, ICES in 2005 expressed concerns regarding Downs herring and recommended that the proportion used to determine the TAC should be set to the long term average of the proportions used since 1986 (11%). For 2009, it was set at 23 567 tonnes and at 15 319 tonnes for 2009, representing respectively 14% and 9 % of the total human consumption TAC for Divisions IV and VIId (Figure 2.11.1).

In the past there was a persistent tendency to overfish the Downs TAC, but this tendency has been markedly reduced since 2005 (Figure 2.11.2). For 2009, landings are under the TAC and amounted to 21 900 tonnes which is less than 2008 (29 600 tonnes).

Historically, the Downs herring has been considered highly sensitive to overexploitation (Burd, 1985; Cushing 1968; 1992). It is less fecund and expresses different growth dynamics and recruitment patterns to the more northern spawning components. However, recent studies indicate that in recent years, the Downs component has come to make up the largest component of the stock, whilst the Buchan component is now the smallest (WD04). Furthermore, the directed fishery in Q4 and Q1 targets aggregations of spawning herring. Preliminary studies undertaken by HAWG in 2006 (ICES CM 2006/ACFM:20) based on population profiles suggested that total mortality (Z) was significantly higher for the 1998 and 1999 year classes of Downs herring compared to herring caught in the northern part of the North Sea.

Downs herring is also taken in other herring fisheries in the North Sea. Downs herring mixes with other components of North Sea herring in the summer whilst feeding. There is also a summer industrial fishery in the eastern North Sea exploiting Downs and North Sea autumn spawning herring juveniles. Tagging experiments in the Eastern North Sea (Aasen et al, 1962) estimated that around 15% of those catches comprised Downs recruits. Otolith microstructure studies of catches from the northern North Sea suggested that the proportion of Downs herring may vary considerably from year to year (26 to 60 %) and may also vary between fleets (Bierman and al. 2010).

The proportion of the autumn and winter spawning components in recruiting year classes of North Sea herring has traditionally 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. The separation of this smaller sized components has been set as <13 cm. Both the total abundance and the relative proportion of this smaller sized 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). These size data suggest that around 70% of the 2002 year class came from Downs production (Figure 2.11.4). Since this period a generally lower level is indicated. For the 2008 year class, the proportion (25%) and abundance estimate show a decline from the 2007 year class. For the proportion this corresponds to the mean value of the time series, while the abundance of small herring in the 2008 year class is lower than the overall mean of the series (Figure 2.11.4).

As mentioned in section 2.3.3.1 the ring net hauls for 0-ringers during the IBTS in this area also include Downs herring larvae. However, at the time of the IBTS survey (January/February) these herring larvae are relatively small compared to larvae from other stocks. Accordingly, their accumulated mortality to recruitment will be comparatively higher than for larvae from the other stocks. Therefore these small larvae (separated as <20 mm) have until now been excluded from the standard estimation of 0-ringer recruitment (IBTS-0 index). Since 2007, the IBTS 1st quarter survey area has been extended to the eastern English Channel, and both additional GOV hauls and ring-net sampling are carried out in this area to provide more information on Downs herring (ICES CM 2007/ACFM:11). However the time series of data, including this improved coverage of Downs herring larval distributions, is not of sufficient length and consistency to be incorporated in the IBTS-0 index estimation. The possibilities and consequences of including these larvae in the IBTS-0 index were investigated during the HAWG meeting in 2009 (ICES 2009/ACOM 03, section 2.3.3.1 and 2.10.2).

Acoustic data recorded at the same time (January) show large herring schools along the French coast at this time of the year. Figure 2.11.5 shows the catch composition (percentage by age) of the pelagic hauls carried out on these schools since 2007. In 2010, the age-group 3 dominated the catch (52%) and was of a mean length of 24 cm. The mean density of these schools of herring, which were regularly found during the survey in a localised area, could however, not be precisely estimated, and could not be raised to the whole area due to the spatial heterogeneity. Experiments carried out in 2010 with a horizontal echo sounder showed very large schools close to the coast in shallow and inaccessible waters.

In conclusion, the TAC is set up in order to the conserve the spawning aggregation of Downs herring. Because of the uncertainties concerning the status of and recruitment to this component of the North Sea herring stock for the coming years, HAWG recommends that the IVc-VIId TAC should be maintained at 11% of the total North Sea TAC (as recommended by ICES). This recommendation should be seen as an interim measure prior to the development of a more robust harvest control rule for setting the TAC of Downs herring, supported by increased research effort into the dynamics of this component in fisheries in the central and northern North Sea. Any new approach should provide an appropriate balance of F across stock components and be similarly conservative until the uncertainty about contribution of the Downs herring to the catch in all fisheries in the North Sea is reduced. Possible methods are illustrated 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 risk of having reduced reproductive capacity and is being harvested sustainably. The SSB in autumn 2009 was estimated at 1.29 million t, and is expected to rise above Bpa (1.3 million t) in 2010. F_{2-6} in 2009 was estimated at 0.11, well below the target F_{2-6} of 0.20. The year classes from 2002 are estimated to be among the weakest since the late 1970s.

The stock is managed according to the EU-Norway Management agreement which was updated in November 2008 (see Stock Annex 3). WKHMP examined the performance of this management plan and the plan is consistent with the precautionary approach. HAWG also considers that the plan is consistent with the proposed MSY framework (see section 1.3).

SSB and fishing mortality are reliably estimated. Fishing mortality is now below the target set by the management plan. This difference from the projection of HAWG 2009 was caused by a change in the fishing practices of the fleets (zero un-allocated catch in 2009), slightly higher recruitment for incoming year classes and an unexpected increase in size-at-age of herring aged 4wr to 6wr (increase in over 50g in the last 3 years).

The 2009 year class is estimated within the range of low recruitment. Therefore HAWG assumes that the recruitment will remain at the lower level. The management plan has proved to be an effective tool for maintaining exploitation and conserving the North Sea herring stock. Thus the management plan should be followed.

North Sea herring and Western Baltic Spring Spawning herring are managed under mixed quotas in some areas of the North Sea, Skagerrak and Kattegat. The management of these mixed components was discussed in detail in 2007 (ICES CM 2007 ACFM:11). With the decline of 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 heavily exploited in the area of overlap.

One of the objectives of the revised EU-Norway management plan was the conservation of juvenile herring. Recruitment of North Sea herring has been below average for the last eight years. There is now a restriction of 15% change of the TAC (the A fleet catch). There is no limit to the change of the by-catch ceiling (the B fleet catch). It is possible that in the future, the B fleet could catch a larger proportion of the stock as the herring biomass increases. The by-catch ceiling for the B fleet is mostly driven by the target F_{0-1}= 0.05 with no restrictions on the size of the TAC change.

Catches in the transfer area in IVa (east) are generally assumed to be dominated by western Baltic spring spawners. Sampling of these catches has declined in 2009 to a very low level and the proportions of the catch from each stock are now poorly estimated. This impacts markedly on the quality of the western Baltic spring spawning herring assessment and provision of advice. Managers should note that these catches are not accounted for when setting the IIIa subdivision 22-24 herring TAC. This should be taken into account when setting the area based TACs.

The options selected for the C- and D-fleets are compatible with the advised exploitation of Western Baltic spring spawners assuming a TAC for 2011 of 21 000 tonnes (see Section 6.4.7) and are 1.68 and 0.49 thousand tonnes of North Sea autumn spawning herring for C and D fleets respectively.

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

2.13 Ecosystem considerations

Herring is considered to have a major impact on most other fish stocks as prey and predator and is itself prey for seabirds and sea mammals in the North Sea area (Dickey-Collas et al., 2010). 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 the lack of spawning in recent years does not mean that the spawning ground is not required to maintain a resilient herring population.

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

2.14 Changes in the environment

This stock has recently produced eight poor year classes in a row, which has never been observed before. Larval surveys show a large abundance of larvae in recent years across all main spawning locations. However, survival of these larvae seems to be very poor and it is a change in larval mortality rate that has produced the recent poor year classes. The specific reasons for this are not known. An ICES study group has reviewed the hypotheses for the serial poor recruitment in North Sea herring (Payne et al., 2009) and commented that the reduction in herring recruitment follows the trends in the warming of the water on the spawning grounds and changes in the hydrography. The pattern in the recruitment time series also shows a link to the climatic forcing of the North Atlantic, via the NAO (North Atlantic Oscillation) and the AMO (Atlantic Multidecadal Oscillation; Gröger et al., 2010). It is thought that the climatic signal integrates many of the local processes affecting the larvae including changes in temperature, salinity, water column stability, turbulence, primary production and zooplankton community. Whilst studies of the specific processes are ongoing, the apparent link with the climate can be used to investigate future trends in recruitment. Using the climate driven ARIMA model (CDR-ARM) described in Gröger *et al*. (2010) climate driven estimates for the year classes of 2009 and 2010 can be made (2010 and 2011 recruitment). These are 34 136 and 38 771 million 0wr recruits respectively. Using these estimates in the projections, instead of the IBTS0 derived estimate for 2010 and the geometric mean recruitment estimate for 2011 results in no major change to the catching opportunities of the A fleet in the management rule, but increases the potential catch for the B fleet (Table 2.14.1). The projected SSBs in 2012 from both approaches (following stock annex approach or replacing recruitment with estimates from CDR-ARM) are extremely similar (Table 2.14.1). Further investigation of the causes of the poor recruitment will require targeted research projects on the processes that determine the spatial and temporal variability in larval survival.

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

Table 2.1.1: Herring caught in the North Sea (Sub-area IV and Division VIId). Catch in tonnes by country, 2000 – 2009. These figures do not in all cases correspond to the official statistics and cannot be used for legal purposes.

Country	2000	2001	2002	2003	2004
Belgium	-	-	23	5	8
Denmark [6]	64123	67096	70825	78606	99037
Faroe Islands	915	1082	1413	627	402
France	20952	24880	25422	31544	34521
Germany	26687	29779	27213	43953	41858
Netherlands	54341	51293	55257	81108	96162
Norway [1]	72072	75886	74974	112481	137638
Poland		-	-	-	-
Sweden	3046	3695	3418	4781	5692
USSR/Russia	-	-	-	-	-
UK (England)	11179	14582	13757	18639	20855
UK (Scotland)	30033	26719	30926	40292	45331
UK (N.Ireland)	996	1018	944	2010	2656
Unallocated landings	61673 [5]	27362 [5]	31552 [5]	31875 [5]	48898 [5]
Total landings	346017	323392	335724	445921	533058
Discards	-	-	17093	4125	17059
Total catch	**346017**	**323392**	**352817**	**450046**	**550117**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	6649	6449	6652	2821	7079
Thames estuary [2]	76	107	60	84	62
Others [3]	378	1097	0	308	0
Norw. Spring Spawners [4]	25678	7108	4069	979	452

Country	2005	2006	2007	2008	2009
Belgium	6	3	1	-	-
Denmark [6]	128380	102322	84697	62864	46238
Faroe Islands	738	1785	2891	2014	1803
France	38829	49475	24909	30347	18114
Germany	46555	40414	14893	8095	5368
Netherlands	81531	76315	66393	23122	24552
Norway [1]	156802	135361	100050	59321	50445
Poland	458	-	-	-	-
Sweden	13464	10529	15448	13840	5299
Russia	99	-	-	-	-
UK (England)	25311	22198	15993	11717	652
UK (Scotland)	73227	48428	35115	16021	14006
UK (N.Ireland)	2912	3531	638	331	-
Unallocated landings	57788	18764	26641	17151	-726
Total landings	626101	509125	387669	244823	165751
Discards	12824	1492	93	224	91
Total catch	**638925**	**510617**	**387762**	**245047**	**165842**
Estimates of the parts of the catches which have been allocated to spring spawning stocks					
IIIa type (WBSS)	7039	10954	1070	124	3941
Thames estuary [2]	74	65	2	7	48
Others [3]	0	0	0	0	0
Norw. Spring Spawners [4]	417	626	685	2721	44560

[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	2000	2001	2002	2003	2004
Denmark [1]	25530	17770	26422	48358	48128
Faroe Islands	205	192	-	95	-
France	3210	8164	10522	11237	10941
Germany	5811	17753	15189	25796	17559
Netherlands	15117	17503 [3]	18289	25045	43876
Norway	33164	11653	10836	34443	36119
Poland	1479	-	-	-	-
Sweden		1418	2397	2647	2178
Russia	-	-	-	-	-
UK (England)	8859	12283	10142	12030	13480
UK (Scotland)	29055	25105	30014	39970	43490
UK (N. Ireland)	996	1018	944	2010	2656
Unallocated landings	44334 [2]	24725 [2]	14201 [2]	14115 [2]	28631 [2]
Misreporting from VIa North					
Total Landings	167760	137584	138956	215746	247058
Discards			17093	4125	15794
Total catch	**167760**	**137584**	**156049**	**219871**	**262852**

Country	2005	2006	2007	2008	2009
Denmark [1]	80990	60462	45948	28426	16550
Faroe Islands		580	1118	2	288
France	13474	18453	8570	13068	7067
Germany	22278	18605	4985	498	-
Netherlands	36619	39209	42622	11634	11017
Norway	66232	38363	40279	40304	25926
Poland	458	-	-	-	-
Sweden	8261	4957	7658	7025	1435
Russia	99	-	-	-	-
UK (England)	15523	12031	11833	8355	578
UK (Scotland)	71941	47368	35115	14727	10249
UK (N. Ireland)	2912	3531	638	331	-
Unallocated landings	39324 [2]	10981 [2]	22215	14952	-977
Misreporting from VIa North					
Total Landings	358111	253048	220981	139322	72133
Discards	10861	1492	93	194	91
Total catch	**368972**	**254540**	**221074**	**139516**	**72224**

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

[2] May include misreported catch from VIaN and discards

[3] Including 1057 t of local spring spawners

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

Country	2000	2001	2002	2003	2004
Denmark 1	11300	18466	17846	7401	16278
Faroe Islands	710	890	1365	359	-
France	-	-	-	-	-
Germany	29	-	81	54	888
Netherlands	38	-	-	-	-
Norway 2	38655	56904	63482	62306	100443
Sweden	1177	517	568	1529	1720
Unallocated landings	338	0	3959	9988	0
Total landings	52247	76777	87301	81637	119329
Discards	-	-	-	-	-
Total catch	**52247**	**76777**	**89303**	**83640**	**119329**
Norw. Spring Spawners 4	25678	7108	4069	979	452

Country	2005	2006	2007	2008	2009
Denmark 1	5761	8614	2646	1587	499
Faroe Islands	738	975	577	400	700
France		-	-	-	-
Germany		34	-	-	-
Netherlands		-	263	-	-
Norway 2	89925	90065	54424	17474	6981
UK (Scotland)	-	83	-	-	-
Sweden	3510	2857	640	-	1735
Unallocated landings	0	0	-96 3	0 3	0
Total landings	99934	102628	58454	19461	9915
Discards	-	-	-	-	-
Total catch	**99934**	**102628**	**58454**	**19461**	**9915**
Norw. Spring Spawners 4	417	626	685	2721	44560

[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	2000	2001	2002	2003	2004
Belgium	-	-	-	-	-
Denmark 1	26825	30277	26387	22574	33857
Faroe Islands	-	-	48	173	402
France	10863	7796	4214	7918	10592
Germany	18818	8340	7577	12116	13823
Netherlands	26839	24160	13154	19115	23649
Norway	253	7329	656	15732	1076
Sweden	390	1760	453	605	1794
UK (England)	669	814	317	2632	2864
UK (Scotland)	978	1614	289	322	1841
Unallocated landings [3]	-9820 4	-22885 4	4052	-2401	8300
Total landings	75815	59205	57147	78786	98198
Discards 2					1265
Total catch	**75815**	**59205**	**57147**	**78786**	**99463**

Country	2005	2006	2007	2008	2009
Belgium	-	-	-	-	-
Denmark 1	41423	32277	35990	32230	29164
Faroe Islands	-	200	1196	1612	815
France	10205	17385	8421	9687	4316
Germany	14381	14222	2205	2415	1061
Netherlands	10038	13363	8550	904	3164
Norway	645	6933	5347	1543	17538
Sweden	1694	2715	7150	6815	2129
UK (England)	3869	4924	577	833	2
UK (Scotland)	1286	977	-	1293	3757
Unallocated landings [3]	10233	2364	-203	-904	-166
Total landings	93774	95360	69233	56428	61780
Discards 2	1963			30	
Total catch	**95737**	**95360**	**69233**	**56458**	**61780**

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

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

Country	2000	2001	2002	2003	2004
Belgium	1	-	23	5	8
Denmark	468	583	170	273	774
France	6879	8750	10686	12389	12988
Germany	2029	3686	4366	5987	9588
Netherlands	12348	9630	23814	36948	28637
UK (England)	1651	1485	3298	3977	4511
UK (Scotland)	-	-	623	-	-
Unallocated landings	26822 [3]	25522 [3]	5336	8170	9963
Total landings	50198	49656	50318	67749	68473
Discards [2]			-	-	-
Total catch	**50198**	**49656**	**50318**	**67749**	**68473**
Coastal spring spawners included above [1]	76	147 [4]	60	84	62

Country	2005	2006	2007	2008	2009
Belgium	6	3	1	-	-
Denmark	206	969	113	621	25
Faroe Islands	-	30	-	-	-
France	15150	13637	7918	7592	6731
Germany	9896	7553	7703	5182	4307
Netherlands	34874	23743	14958	10584	10371
UK (England)	5919	5243	3583	2529	72
UK (Scotland)	-	-	-	1	
Unallocated landings	8231	5419	4725	3103	417
Total landings	74282	56597	39001	29612	21923
Discards [2]	-	-	-	-	
Total catch	**74282**	**56597**	**39001**	**29612**	**21923**
Coastal spring spawners included above [1]	74	65	2	7	48

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

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

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sub-Area IV and Division VIId: TAC (IV and VIId)														
Recommended Divisions IVa, b	159	254	265	265	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	-
Recommended Divisions IVc, VIId	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	- [11]	-
Expected catch of spring spawners														
Agreed Divisions IVa,b [1]	134	229	240	240	240	223	340.5	393.9	460.7	404.7	303.5	174.6	147.4	149.0
Agreed Div. IVc, VIId	25	25	25	25	25	42.7	59.5	66.1	74.3	50.0	37.5	26.7	23.6	15.3
Bycatch ceiling in the small mesh fishery	24	22	30	36	36	36	52.0	38.0	50.0	42.5	31.9	18.8	16.0	13.6
CATCH (IV and VIId)														
National landings Divisions IVa,b [2]	149	245	261	261	272	261	354.5	427.7	502.3	439.2	326.8	201.2	145	
Unallocated landings Divisions IVa,b	36	44	22	35	2	24	23.7	36.9	49.6	13.3	21.9	14.0	-1.1	
Discard/slipping Divisions IVa,b [3]	-	-	-	-	-	17	4.1	17.1	12.8	1.5	0.1	0.2	0.1	
Total catch Divisions IVa,b [4]	185	289	283	296	273	303	382.3	481.6	564.6	454.0	348.8	215.4	143.9	
National landings Divisions IVc, VIId [3]	26	23	29	23	24	43	59.5	56.5	66.1	51.2	34.3	26.5	21.5	
Unallocated landings Divisions IVc,VIId	27	27	22	27	26	7	8.2	12.0	8.2	5.4	4.7	3.1	0.4	
Discard/slipping Divisions IVc, VIId [3]	-	-	-	-	-	0	-	-	-	-	-	-	-	
Total catch Divisions IVc, VIId	53	49	50	50	50	50	67.7	68.5	74.3	56.6	39.0	29.6	21.9	
Total catch IV and VIId as used by ICES [4]	**238**	**338**	**333**	**346**	**323**	**353**	**450.0**	**550.1**	**638.9**	**510.6**	**387.8**	**245.0**	**165.8**	
CATCH BY FLEET/STOCK (IV and VIId) [7]														
North Sea autumn spawners directed fisheries (Fleet A)	225	316	313	322	296	323	434.9	529.5	610.0	487.1	379.6	236.3	152.1	
North Sea autumn spawners industrial (Fleet B)	13	14	15	18	20	22	12.3	13.6	21.8	11.9	7.1	8.6	9.8	
North Sea autumn spawners in IV and VIId total	**237**	**330**	**329**	**339**	**317**	**346**	**447.2**	**543.0**	**631.9**	**499.0**	**386.7**	**244.9**	**161.9**	
Baltic-IIIa-type spring spawners in IV	1	8	5	7	6	7	2.8	7.1	7.0	11.0	1.1	0.1	3.9	
Coastal-type spring spawners	0.2	0.1	0.1	0.1	1.2	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	
Norw. Spring Spawners caught under a separate quota in IV [14]	55	29	32	26	7	4	1.0	0.5	0.4	0.6	0.7	2.7	44.6	
Division IIIa: TAC (IIIa)														
Predicted catch of autumn spawners	35	58	43	53	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	- [15]	[15]	
Recommended spring spawners	- [12]	- [12]	- [12]	- [12]	- [12]	- [12]	- [12]	- [15]	- [15]	- [15]	- [15]	- [15]	[15]	
Recommended mixed clupeoids	-	-	-	-	-	-	-	-	-	-	-	-		
Agreed herring TAC	80	80	80	80	80	80	80.0	70.0	96.0	81.6	69.4	51.7	37.7	33.9
Agreed mixed clupeoid TAC														
Bycatch ceiling in the small mesh fishery	20	17	19	21	21	21	21.0	21.0	24.2	20.5	15.4	11.5	8.4	7.5
CATCH (IIIa)														
National landings	83	120	86	108	90	79	76.0	61.1	90.8	88.9	47.3	38.2	38.8	
Catch as used by ICES	74	108	79	99	82	73	68.1	52.7	69.6	51.2	47.4	38.2	38.8	
CATCH BY FLEET/STOCK (IIIa) [7]														
Autumn spawners human consumption (Fleet C)	21	59	28	36	34	17	24.1	13.4	22.9	11.6	16.4	9.2	5.1	
Autumn spawners mixed clupeoid (Fleet D) [13]	4	6	8	13	12	9	8.4	10.8	9.0	3.4	3.4	3.7	1.5	
Autumn spawners other industrial landings (Fleet E)	2													
Autumn spawners in IIIa total	**27**	**61**	**34**	**49**	**46**	**26**	**32.5**	**24.2**	**31.9**	**15.0**	**19.8**	**12.9**	**6.5**	
Spring spawners human consumption (Fleet C)	43	40	40	45	33	38	31.6	16.8	32.5	30.2	25.3	23.0	29.4	
Spring spawners mixed clupeoid (Fleet D) [13]	3	3	3	5	3	9	4.0	11.2	5.1	5.9	2.3	2.2	2.9	
Spring spawners other industrial landings (Fleet E)	1													
Spring spawners in IIIa total	**47**	**43**	**43**	**50**	**36**	**47**	**35.6**	**28.0**	**37.6**	**36.1**	**27.6**	**25.2**	**32.3**	
North Sea autumn spawners Total as used by ICES	**264**	**392**	**363**	**388**	**363**	**372**	**479.7**	**567.2**	**663.8**	**514.6**	**406.5**	**257.9**	**168.4**	

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

Table 2.2.1: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea and Div IIIa in 2009. 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	116.8	0.1	0.0	0.1	38.7	493.8	0.8	0.0	532.5	0.8	650.0	533.3
1	77.5	0.5	0.0	0.5	14.6	83.1	0.1	0.1	98.2	0.2	175.9	98.4
2	7.0	20.4	1.0	19.4	49.4	134.7	5.5	43.3	203.5	48.9	259.4	253.4
3	0.4	6.7	2.1	4.6	43.8	46.9	1.0	10.1	95.3	11.1	106.7	108.5
4	0.2	3.3	3.4	-0.1	56.8	30.6	0.9	4.9	87.3	5.8	93.3	96.5
5	0.0	5.8	1.4	4.3	40.8	22.7	0.7	17.6	67.8	18.3	86.1	87.6
6	0.0	3.4	1.7	1.7	16.8	10.0	1.0	8.5	28.5	9.5	38.0	39.7
7	0.0	3.2	4.5	-1.3	35.5	13.8	0.9	4.2	48.0	5.1	53.1	57.6
8	0.1	5.7	1.8	3.9	58.3	32.0	1.9	14.2	94.1	16.1	110.4	112.1
9+	0.0	3.5	1.4	2.2	23.3	3.3	0.1	3.8	28.8	3.9	32.7	34.1
Sum	202.0	52.6	17.2	35.4	377.9	870.8	12.9	106.8	1284.1	119.7	1605.8	1421.1
Quarter: 1												
0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3	0.3	0.3
1	29.3	0.2	0.0	0.2	0.0	0.2	0.0	0.0	0.4	0.0	29.8	0.4
2	3.7	5.9	0.0	5.9	6.2	4.2	0.2	3.9	16.3	4.1	24.1	20.4
3	0.3	1.0	0.0	1.0	12.6	1.5	0.1	3.9	15.0	4.0	19.3	19.0
4	0.0	0.1	0.0	0.1	16.5	0.5	0.0	1.5	17.1	1.5	18.6	18.6
5	0.0	0.4	0.0	0.4	12.9	0.9	0.1	5.8	14.2	6.0	20.2	20.2
6	0.0	0.4	0.0	0.4	0.5	0.2	0.0	1.5	1.1	1.5	2.6	2.6
7	0.0	0.4	0.0	0.4	6.8	0.1	0.1	2.4	7.3	2.5	9.8	9.8
8	0.0	0.2	0.0	0.2	7.2	0.5	0.1	3.9	8.0	4.0	12.0	12.0
9+	0.0	0.0	0.0	0.0	1.0	0.4	0.0	1.0	1.4	1.0	2.3	2.3
Sum	33.3	8.6	0.0	8.6	63.6	8.6	1.0	23.9	80.8	24.9	139.0	105.7
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	38.9	0.0	0.0	38.9	0.0	39.0	39.0
1	2.9	0.3	0.0	0.3	0.1	2.4	0.0	0.0	2.8	0.0	5.6	2.8
2	1.0	13.2	1.0	12.2	17.5	93.1	0.0	0.0	122.8	0.1	123.8	123.9
3	0.0	5.3	1.7	3.6	9.1	22.9	0.0	0.0	35.6	0.0	35.7	37.3
4	0.0	2.8	3.1	-0.3	6.2	4.6	0.0	0.0	10.5	0.0	10.5	13.7
5	0.0	3.7	1.3	2.4	7.0	9.0	0.0	0.0	18.4	0.0	18.4	19.7
6	0.0	1.6	1.1	0.5	2.4	3.9	0.0	0.0	6.7	0.0	6.7	7.8
7	0.0	1.6	3.5	-1.9	2.9	1.2	0.0	0.0	2.1	0.0	2.1	5.6
8	0.0	2.8	0.4	2.5	5.3	4.1	0.0	0.0	11.9	0.0	11.9	12.2
9+	0.0	0.5	0.3	0.3	0.9	0.5	0.0	0.0	1.7	0.0	1.7	2.0
Sum	3.9	31.9	12.4	19.5	51.4	180.5	0.1	0.1	251.4	0.2	255.5	264.1
Quarter: 3												
0	95.1	0.1	0.0	0.1	11.0	384.2	0.0	0.0	395.3	0.0	490.4	395.3
1	39.1	0.1	0.0	0.1	5.5	57.6	0.0	0.0	63.2	0.0	102.3	63.2
2	2.4	1.3	0.0	1.3	20.3	29.2	0.0	0.9	50.8	0.9	54.1	51.7
3	0.0	0.4	0.0	0.4	13.6	17.8	0.0	0.2	31.8	0.2	31.9	32.0
4	0.2	0.3	0.1	0.2	21.9	19.1	0.0	0.1	41.2	0.1	41.5	41.3
5	0.0	1.5	0.0	1.5	14.8	10.0	0.0	0.3	26.4	0.3	26.6	26.7
6	0.0	1.1	0.0	1.1	8.5	3.4	0.0	0.2	13.0	0.2	13.1	13.2
7	0.0	0.8	0.1	0.7	20.5	5.8	0.0	0.0	27.0	0.0	27.0	27.1
8	0.1	1.9	0.0	1.9	31.9	13.9	0.0	0.2	47.7	0.3	48.1	48.0
9+	0.0	0.7	0.0	0.7	12.0	2.0	0.0	0.1	14.8	0.1	14.8	14.8
Sum	136.9	8.2	0.3	7.9	160.1	542.9	0.1	1.9	711.0	2.0	849.9	713.3
Quarter: 4												
0	21.7	0.0	0.0	0.0	27.7	70.6	0.4	0.0	98.2	0.4	120.3	98.7
1	6.2	0.0	0.0	0.0	8.9	22.9	0.1	0.1	31.7	0.2	38.2	32.0
2	0.0	0.0	0.0	0.0	5.4	8.3	5.3	38.5	13.7	43.8	57.4	57.4
3	0.0	0.0	0.3	-0.3	8.5	4.7	0.9	6.1	12.9	6.9	19.8	20.1
4	0.0	0.0	0.2	-0.1	12.1	6.5	0.9	3.3	18.5	4.2	22.7	22.8
5	0.0	0.1	0.1	0.0	6.1	2.8	0.6	11.5	8.9	12.0	20.9	21.0
6	0.0	0.3	0.6	-0.3	5.5	2.6	0.9	6.9	7.7	7.8	15.5	16.1
7	0.0	0.4	0.9	-0.5	5.4	6.7	0.8	1.7	11.6	2.6	14.1	15.0
8	0.0	0.8	1.4	-0.6	13.8	13.4	1.8	10.1	26.6	11.9	38.5	39.9
9+	0.0	2.3	1.1	1.2	9.4	0.4	0.1	2.8	11.0	2.8	13.9	14.9
Sum	27.9	3.8	4.5	-0.7	102.8	138.8	11.7	80.9	240.9	92.6	361.4	338.0

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 2009. Mean weight-at-age (kg) in the catch (WECA), by quarter and division.

Quarters: 1-4

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
0	0.009	0.008	0.000	0.014	0.009	0.012	0.000	0.009	0.012	0.009	0.010
1	0.060	0.071	0.000	0.071	0.040	0.061	0.124	0.045	0.087	0.051	0.045
2	0.101	0.139	0.138	0.152	0.140	0.177	0.154	0.142	0.156	0.144	0.145
3	0.082	0.167	0.170	0.180	0.188	0.192	0.159	0.183	0.162	0.181	0.181
4	0.206	0.208	0.211	0.211	0.228	0.216	0.194	0.217	0.197	0.216	0.216
5	0.000	0.219	0.211	0.223	0.219	0.226	0.196	0.221	0.197	0.216	0.216
6	0.000	0.232	0.248	0.266	0.223	0.246	0.208	0.248	0.211	0.239	0.239
7	0.000	0.245	0.248	0.251	0.243	0.233	0.183	0.248	0.192	0.243	0.243
8	0.269	0.253	0.280	0.252	0.255	0.259	0.214	0.253	0.219	0.248	0.248
9+	0.000	0.288	0.291	0.278	0.255	0.245	0.244	0.277	0.244	0.272	0.273

Quarter: 1

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
0	0.000	0.000	0.000	0.000	0.006	0.006	0.000	0.006	0.006	0.006	0.006
1	0.014	0.069	0.069	0.000	0.062	0.031	0.000	0.065	0.031	0.015	0.065
2	0.070	0.128	0.128	0.113	0.127	0.094	0.090	0.122	0.090	0.109	0.116
3	0.072	0.150	0.150	0.146	0.165	0.109	0.102	0.148	0.102	0.137	0.138
4	0.000	0.171	0.171	0.168	0.171	0.141	0.137	0.168	0.137	0.165	0.165
5	0.000	0.176	0.176	0.183	0.202	0.137	0.133	0.184	0.133	0.169	0.169
6	0.000	0.182	0.182	0.206	0.197	0.147	0.142	0.196	0.142	0.164	0.164
7	0.000	0.205	0.205	0.189	0.221	0.144	0.141	0.190	0.141	0.178	0.178
8	0.000	0.217	0.217	0.197	0.218	0.168	0.165	0.199	0.165	0.187	0.187
9+	0.000	0.274	0.274	0.277	0.234	0.169	0.166	0.265	0.166	0.223	0.223

Quarter: 2

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
0	0.000	0.000	0.000	0.000	0.006	0.006	0.000	0.006	0.006	0.006	0.006
1	0.067	0.064	0.064	0.058	0.065	0.061	0.000	0.064	0.061	0.066	0.064
2	0.090	0.138	0.138	0.135	0.132	0.122	0.090	0.133	0.111	0.133	0.133
3	0.141	0.170	0.170	0.166	0.168	0.185	0.102	0.168	0.129	0.168	0.168
4	0.000	0.208	0.208	0.202	0.185	0.237	0.137	0.197	0.179	0.194	0.197
5	0.000	0.208	0.208	0.206	0.189	0.225	0.133	0.199	0.145	0.198	0.199
6	0.000	0.205	0.205	0.207	0.199	0.220	0.142	0.203	0.159	0.202	0.203
7	0.000	0.233	0.233	0.225	0.205	0.253	0.141	0.223	0.156	0.206	0.223
8	0.000	0.237	0.237	0.233	0.209	0.269	0.165	0.225	0.183	0.225	0.225
9+	0.000	0.272	0.272	0.273	0.217	0.272	0.166	0.257	0.177	0.255	0.257

Quarter: 3

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
0	0.008	0.008	0.008	0.008	0.008	0.000	0.000	0.008	na	0.008	0.008
1	0.091	0.103	0.103	0.085	0.030	0.083	0.124	0.035	0.122	0.056	0.035
2	0.153	0.198	0.198	0.176	0.159	0.167	0.161	0.166	0.161	0.166	0.166
3	0.000	0.173	0.173	0.221	0.214	0.182	0.197	0.217	0.196	0.217	0.217
4	0.203	0.226	0.226	0.247	0.237	0.236	0.216	0.242	0.217	0.242	0.242
5	0.000	0.253	0.253	0.267	0.247	0.249	0.227	0.259	0.227	0.258	0.258
6	0.000	0.266	0.266	0.270	0.235	0.248	0.221	0.261	0.221	0.260	0.260
7	0.000	0.259	0.259	0.280	0.254	0.251	0.241	0.274	0.242	0.274	0.274
8	0.269	0.266	0.266	0.275	0.274	0.259	0.232	0.274	0.233	0.274	0.274
9+	0.000	0.276	0.276	0.297	0.266	0.279	0.268	0.292	0.268	0.292	0.292

Quarter: 4

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
0	0.013	0.000	0.069	0.017	0.017	0.017	0.000	0.017	0.017	0.016	0.017
1	0.076	0.000	0.128	0.062	0.063	0.062	0.124	0.062	0.088	0.065	0.063
2	0.000	0.000	0.150	0.166	0.163	0.181	0.160	0.164	0.162	0.163	0.163
3	0.000	0.000	0.171	0.182	0.198	0.202	0.196	0.187	0.196	0.191	0.191
4	0.222	0.260	0.260	0.212	0.235	0.219	0.218	0.220	0.218	0.220	0.220
5	0.000	0.246	0.246	0.218	0.220	0.248	0.227	0.219	0.228	0.224	0.224
6	0.000	0.330	0.330	0.291	0.244	0.250	0.221	0.278	0.224	0.249	0.252
7	0.000	0.308	0.308	0.230	0.240	0.239	0.243	0.238	0.241	0.234	0.238
8	0.000	0.291	0.291	0.234	0.252	0.263	0.233	0.244	0.238	0.241	0.242
9+	0.000	0.296	0.296	0.255	0.265	0.277	0.271	0.263	0.271	0.262	0.265

Table 2.2.3: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2009. 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.	11.4	n.d.	13.4	11.7	12.3	0.0	11.8	12.3
1	n.d.	20.5	n.d.	20.6	17.8	20.2	23.6	18.3	21.6
2	n.d.	24.2	n.d.	25.5	24.3	26.2	25.8	24.6	25.9
3	n.d.	25.9	n.d.	27.6	26.8	26.6	25.9	27.1	26.0
4	n.d.	27.4	n.d.	29.1	28.9	28.0	27.6	29.0	27.7
5	n.d.	27.9	n.d.	29.4	28.4	28.4	27.9	29.0	27.9
6	n.d.	28.1	n.d.	30.0	28.4	28.5	28.1	29.2	28.1
7	n.d.	28.9	n.d.	30.5	29.8	28.3	28.0	30.2	28.0
8	n.d.	29.1	n.d.	30.7	30.3	29.0	28.8	30.4	28.9
9+	n.d.	31.6	n.d.	31.4	29.2	29.5	29.4	31.2	29.4
Quarter: 1									
0	n.d.	-	n.d.	0.0	10.1	10.1	0.0	-	10.1
1	n.d.	20.4	n.d.	0.0	19.6	15.8	0.0	20.0	15.8
2	n.d.	23.9	n.d.	23.9	23.9	22.6	22.8	23.9	22.8
3	n.d.	25.3	n.d.	26.9	26.3	24.0	23.8	26.8	23.8
4	n.d.	26.5	n.d.	28.3	26.7	26.1	26.1	28.2	26.1
5	n.d.	26.8	n.d.	29.2	28.3	26.5	26.5	29.1	26.5
6	n.d.	27.2	n.d.	27.1	27.9	26.9	26.8	27.3	26.8
7	n.d.	28.0	n.d.	29.4	29.1	27.3	27.3	29.3	27.3
8	n.d.	28.5	n.d.	29.6	28.7	28.5	28.5	29.6	28.5
9+	n.d.	30.1	n.d.	32.0	29.6	27.5	27.5	31.3	27.5
Quarter: 2									
0	n.d.	0.0	n.d.	0.0	10.1	10.1	0.0	10.1	10.1
1	n.d.	20.0	n.d.	19.5	19.0	18.6	0.0	19.1	18.6
2	n.d.	24.2	n.d.	24.1	23.7	23.3	22.8	23.8	23.1
3	n.d.	25.9	n.d.	26.0	25.6	26.6	23.8	25.7	24.7
4	n.d.	27.3	n.d.	27.6	26.7	29.0	26.1	27.2	27.3
5	n.d.	27.6	n.d.	28.0	27.1	28.4	26.5	27.5	26.8
6	n.d.	27.3	n.d.	27.2	27.2	28.1	26.8	27.2	27.1
7	n.d.	28.3	n.d.	28.5	27.8	29.5	27.3	28.3	27.6
8	n.d.	28.5	n.d.	28.7	27.4	30.2	28.5	28.2	28.8
9+	n.d.	30.1	n.d.	30.1	27.9	29.8	27.5	29.5	27.7
Quarter: 3									
0	n.d.	11.4	n.d.	11.4	11.4	-	-	11.4	-
1	n.d.	22.5	n.d.	21.2	16.8	20.8	23.6	17.2	23.5
2	n.d.	26.1	n.d.	26.8	25.6	25.9	26.1	26.1	26.0
3	n.d.	26.9	n.d.	28.8	28.1	26.3	27.4	28.4	27.3
4	n.d.	28.6	n.d.	29.9	29.2	28.7	28.2	29.5	28.2
5	n.d.	28.6	n.d.	30.2	29.6	29.0	28.6	29.8	28.6
6	n.d.	28.7	n.d.	30.1	28.5	28.5	28.4	29.6	28.4
7	n.d.	28.9	n.d.	31.2	29.7	29.1	28.9	30.8	28.9
8	n.d.	28.7	n.d.	31.3	30.6	29.1	28.9	31.0	28.9
9+	n.d.	29.2	n.d.	31.5	29.6	30.3	29.9	31.1	29.9
Quarter: 4									
0	n.d.	0.0	n.d.	14.2	14.2	14.2	0.0	14.2	14.2
1	n.d.	0.0	n.d.	20.3	20.3	20.3	23.6	20.3	21.7
2	n.d.	0.0	n.d.	26.9	26.0	26.3	26.1	26.4	26.2
3	n.d.	0.0	n.d.	28.3	28.0	26.9	27.3	28.2	27.2
4	n.d.	31.2	n.d.	29.8	30.0	28.1	28.3	29.9	28.2
5	n.d.	31.2	n.d.	29.9	28.7	28.9	28.6	29.5	28.6
6	n.d.	32.3	n.d.	31.2	30.1	28.5	28.4	30.9	28.4
7	n.d.	32.3	n.d.	30.4	30.2	28.4	28.9	30.4	28.7
8	n.d.	32.4	n.d.	30.5	30.9	29.0	29.0	30.7	29.0
9+	n.d.	32.6	n.d.	31.3	28.5	30.3	30.0	31.5	30.0

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 2009. 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	1.0	0.0	0.0	0.0	0.6	4.5	0.0	0.0	5.1	0.0	6.1	5.1
1	4.6	0.0	0.0	0.0	1.0	3.3	0.0	0.0	4.4	0.0	9.0	4.4
2	0.7	2.8	0.1	2.7	7.5	18.8	1.0	6.7	29.0	7.6	37.3	36.8
3	0.0	1.1	0.4	0.8	7.9	8.8	0.2	1.6	17.5	1.8	19.3	19.7
4	0.0	0.7	0.7	0.0	12.0	7.0	0.2	0.9	18.9	1.1	20.1	20.8
5	0.0	1.3	0.3	1.0	9.1	5.0	0.2	3.4	15.0	3.6	18.6	18.9
6	0.0	0.8	0.4	0.4	4.5	2.2	0.2	1.8	7.1	2.0	9.1	9.5
7	0.0	0.8	1.1	-0.3	8.9	3.3	0.2	0.8	11.9	1.0	12.9	14.0
8	0.0	1.4	0.5	0.9	14.7	8.2	0.5	3.0	23.8	3.5	27.3	27.8
9+	0.0	1.0	0.4	0.6	6.5	0.8	0.0	0.9	8.0	0.9	8.9	9.3
Sum	6.5	10.0	3.9	6.0	72.6	62.0	2.5	19.2	140.6	21.7	168.8	166.2
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	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0
2	0.3	0.8	0.0	0.8	0.7	0.5	0.0	0.4	2.0	0.4	2.6	2.4
3	0.0	0.1	0.0	0.1	1.8	0.2	0.0	0.4	2.2	0.4	2.7	2.6
4	0.0	0.0	0.0	0.0	2.8	0.1	0.0	0.2	2.9	0.2	3.1	3.1
5	0.0	0.1	0.0	0.1	2.4	0.2	0.0	0.8	2.6	0.8	3.4	3.4
6	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.2	0.2	0.2	0.4	0.4
7	0.0	0.1	0.0	0.1	1.3	0.0	0.0	0.3	1.4	0.4	1.7	1.7
8	0.0	0.0	0.0	0.0	1.4	0.1	0.0	0.6	1.6	0.7	2.2	2.2
9+	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.2	0.4	0.2	0.5	0.5
Sum	0.7	1.2	0.0	1.2	10.7	1.3	0.1	3.1	13.3	3.2	17.1	16.4
Quarter: 2												
0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.2	0.2
1	0.2	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.4	0.2
2	0.1	1.8	0.1	1.7	2.4	12.3	0.0	0.0	16.3	0.0	16.4	16.5
3	0.0	0.9	0.3	0.6	1.5	3.9	0.0	0.0	6.0	0.0	6.0	6.3
4	0.0	0.6	0.7	-0.1	1.3	0.8	0.0	0.0	2.0	0.0	2.0	2.7
5	0.0	0.8	0.3	0.5	1.4	1.7	0.0	0.0	3.6	0.0	3.6	3.9
6	0.0	0.3	0.2	0.1	0.5	0.8	0.0	0.0	1.4	0.0	1.4	1.6
7	0.0	0.4	0.8	-0.4	0.6	0.2	0.0	0.0	0.4	0.0	0.4	1.3
8	0.0	0.7	0.1	0.6	1.2	0.9	0.0	0.0	2.7	0.0	2.7	2.8
9+	0.0	0.1	0.1	0.1	0.2	0.1	0.0	0.0	0.4	0.0	0.4	0.5
Sum	0.3	5.6	2.6	3.1	9.2	21.1	0.0	0.0	33.3	0.0	33.6	35.9
Quarter: 3												
0	0.8	0.0	0.0	0.0	0.1	3.1	0.0	0.0	3.2	0.0	3.9	3.2
1	3.6	0.0	0.0	0.0	0.5	1.7	0.0	0.0	2.2	0.0	5.8	2.2
2	0.4	0.3	0.0	0.3	3.6	4.6	0.0	0.1	8.4	0.2	9.0	8.6
3	0.0	0.1	0.0	0.1	3.0	3.8	0.0	0.0	6.9	0.0	6.9	6.9
4	0.0	0.1	0.0	0.0	5.4	4.5	0.0	0.0	10.0	0.0	10.0	10.0
5	0.0	0.4	0.0	0.4	4.0	2.5	0.0	0.1	6.8	0.1	6.9	6.9
6	0.0	0.3	0.0	0.3	2.3	0.8	0.0	0.0	3.4	0.0	3.4	3.4
7	0.0	0.2	0.0	0.2	5.7	1.5	0.0	0.0	7.4	0.0	7.4	7.4
8	0.0	0.5	0.0	0.5	8.8	3.8	0.0	0.1	13.1	0.1	13.2	13.1
9+	0.0	0.2	0.0	0.2	3.6	0.5	0.0	0.0	4.3	0.0	4.3	4.3
Sum	4.7	2.0	0.1	1.9	36.9	26.8	0.0	0.4	65.6	0.4	70.8	66.1
Quarter: 4												
0	0.3	0.0	0.0	0.0	0.5	1.2	0.0	0.0	1.7	0.0	2.0	1.7
1	0.5	0.0	0.0	0.0	0.6	1.4	0.0	0.0	2.0	0.0	2.5	2.0
2	0.0	0.0	0.0	0.0	0.9	1.3	0.9	6.2	2.2	7.1	9.3	9.3
3	0.0	0.0	0.1	-0.1	1.5	0.9	0.2	1.2	2.4	1.4	3.8	3.8
4	0.0	0.0	0.0	0.0	2.6	1.5	0.2	0.7	4.1	0.9	5.0	5.0
5	0.0	0.0	0.0	0.0	1.3	0.6	0.1	2.6	1.9	2.7	4.7	4.7
6	0.0	0.1	0.2	-0.1	1.6	0.6	0.2	1.5	2.1	1.7	3.9	4.1
7	0.0	0.1	0.3	-0.1	1.2	1.6	0.2	0.4	2.7	0.6	3.3	3.6
8	0.0	0.2	0.4	-0.2	3.2	3.4	0.5	2.3	6.4	2.8	9.3	9.7
9+	0.0	0.7	0.3	0.4	2.4	0.1	0.0	0.7	2.9	0.8	3.6	4.0
Sum	0.8	1.1	1.3	-0.2	15.8	12.8	2.4	15.7	28.4	18.1	47.3	47.8

Table 2.2.5: North Sea autumn spawning herring (NSAS), and western Baltic spring spawners (WBSS) caught in the North Sea in 2009. 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	57.8%	0.2%	0.0%	0.2%	10.2%	56.7%	5.9%	0.0%	41.5%	0.6%	40.5%	37.5%
1	38.4%	1.0%	0.0%	1.5%	3.9%	9.5%	1.1%	0.1%	7.6%	0.2%	11.0%	6.9%
2	3.5%	38.8%	5.9%	54.9%	13.1%	15.5%	42.8%	40.6%	15.9%	40.8%	16.2%	17.8%
3	0.2%	12.7%	12.0%	13.0%	11.6%	5.4%	7.7%	9.5%	7.4%	9.3%	6.6%	7.6%
4	0.1%	6.3%	19.6%	-0.2%	15.0%	3.5%	7.1%	4.6%	6.8%	4.8%	5.8%	6.8%
5	0.0%	11.0%	8.3%	12.3%	10.8%	2.6%	5.5%	16.5%	5.3%	15.3%	5.4%	6.2%
6	0.0%	6.5%	10.1%	4.8%	4.4%	1.1%	7.4%	8.0%	2.2%	7.9%	2.4%	2.8%
7	0.0%	6.1%	25.9%	-3.6%	9.4%	1.6%	7.1%	3.9%	3.7%	4.3%	3.3%	4.1%
8	0.1%	10.8%	10.3%	11.0%	15.4%	3.7%	14.8%	13.3%	7.3%	13.5%	6.9%	7.9%
9+	0.0%	6.7%	7.9%	6.2%	6.2%	0.4%	0.6%	3.6%	2.2%	3.2%	2.0%	2.4%
Sum 3+	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Quarter: 1												
0	0.0%	0.0%	0.0%	0.0%	0.0%	0.6%	30.2%	0.0%	0.1%	1.2%	0.2%	0.3%
1	88.1%	2.4%	0.0%	2.4%	0.0%	2.8%	0.4%	0.0%	0.5%	0.0%	21.4%	0.4%
2	11.0%	68.6%	7.9%	68.6%	9.7%	49.4%	20.3%	16.3%	20.2%	16.5%	17.3%	19.3%
3	0.9%	11.3%	16.7%	11.2%	19.8%	17.1%	10.4%	16.3%	18.6%	16.1%	13.9%	18.0%
4	0.0%	1.7%	26.5%	1.7%	26.0%	5.4%	3.7%	6.1%	21.2%	6.0%	13.4%	17.6%
5	0.0%	4.7%	10.4%	4.7%	20.2%	10.6%	14.1%	24.5%	17.5%	24.1%	14.5%	19.1%
6	0.0%	4.5%	10.4%	4.5%	0.8%	1.8%	3.6%	6.1%	1.3%	6.0%	1.8%	2.4%
7	0.0%	4.7%	23.5%	4.7%	10.6%	1.7%	5.8%	10.2%	9.0%	10.0%	7.1%	9.3%
8	0.0%	2.2%	2.6%	2.2%	11.4%	6.3%	9.2%	16.3%	9.9%	16.0%	8.6%	11.3%
9+	0.0%	0.0%	2.0%	0.0%	1.5%	4.4%	2.3%	4.1%	1.7%	4.0%	1.7%	2.2%
Sum 3+	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Quarter: 2												
0	0.0%	0.0%	0.0%	0.0%	0.0%	21.6%	45.5%	0.0%	15.5%	22.8%	15.3%	14.8%
1	73.3%	0.8%	0.0%	1.4%	0.3%	1.3%	1.5%	0.0%	1.1%	0.7%	2.2%	1.1%
2	25.4%	41.3%	8.1%	62.6%	34.1%	51.6%	29.8%	16.3%	48.8%	23.1%	48.5%	46.9%
3	1.3%	16.6%	13.7%	18.4%	17.7%	12.7%	7.8%	16.3%	14.2%	12.1%	14.0%	14.1%
4	0.0%	8.9%	25.2%	-1.5%	12.1%	2.5%	4.4%	6.1%	4.2%	5.3%	4.1%	5.2%
5	0.0%	11.7%	10.6%	12.4%	13.6%	5.0%	3.8%	24.5%	7.3%	14.1%	7.2%	7.5%
6	0.0%	5.1%	9.0%	2.6%	4.6%	2.1%	1.7%	6.1%	2.7%	3.9%	2.6%	3.0%
7	0.0%	5.0%	28.2%	-9.8%	5.6%	0.6%	1.6%	10.2%	0.8%	5.9%	0.8%	2.1%
8	0.0%	8.8%	3.0%	12.6%	10.2%	2.3%	3.4%	16.3%	4.7%	9.8%	4.6%	4.6%
9+	0.0%	1.7%	2.2%	1.3%	1.8%	0.3%	0.5%	4.1%	0.7%	2.3%	0.7%	0.8%
Sum 3+	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Quarter: 3												
0	69.5%	1.0%	0.0%	1.1%	6.9%	70.8%	0.0%	0.0%	55.6%	0.0%	57.7%	55.4%
1	28.6%	0.8%	0.0%	0.9%	3.5%	10.6%	0.2%	0.1%	8.9%	0.1%	12.0%	8.9%
2	1.7%	16.0%	3.0%	16.5%	12.7%	5.4%	59.5%	46.5%	7.1%	46.9%	6.4%	7.3%
3	0.0%	4.9%	15.3%	4.5%	8.5%	3.3%	13.9%	8.1%	4.5%	8.2%	3.8%	4.5%
4	0.1%	3.5%	26.3%	2.7%	13.7%	3.5%	4.0%	4.1%	5.8%	4.1%	4.9%	5.8%
5	0.0%	18.8%	11.1%	19.0%	9.3%	1.8%	2.3%	14.5%	3.7%	14.1%	3.1%	3.7%
6	0.0%	13.9%	9.5%	14.1%	5.3%	0.6%	2.7%	8.7%	1.8%	8.5%	1.5%	1.8%
7	0.0%	9.7%	29.4%	9.1%	12.8%	1.1%	5.6%	2.1%	3.8%	2.2%	3.2%	3.8%
8	0.1%	23.0%	3.1%	23.6%	19.9%	2.6%	11.2%	12.5%	6.7%	12.5%	5.7%	6.7%
9+	0.0%	8.4%	2.3%	8.6%	7.5%	0.4%	0.6%	3.3%	2.1%	3.2%	1.7%	2.1%
Sum 3+	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Quarter: 4												
0	77.6%	0.0%	0.0%	0.0%	26.9%	50.9%	3.5%	0.0%	40.8%	0.4%	33.3%	29.2%
1	22.2%	0.0%	0.0%	0.0%	8.7%	16.5%	1.1%	0.1%	13.2%	0.2%	10.6%	9.5%
2	0.0%	0.0%	0.0%	0.0%	5.2%	6.0%	44.7%	47.6%	5.7%	47.2%	15.9%	17.0%
3	0.0%	0.0%	7.2%	48.9%	8.3%	3.4%	7.5%	7.5%	5.3%	7.5%	5.5%	6.0%
4	0.1%	0.7%	3.8%	21.6%	11.8%	4.7%	7.4%	4.1%	7.7%	4.5%	6.3%	6.8%
5	0.0%	2.1%	1.5%	-1.7%	5.9%	2.0%	4.9%	14.2%	3.7%	13.0%	5.8%	6.2%
6	0.0%	6.8%	13.0%	48.4%	5.3%	1.9%	7.8%	8.5%	3.2%	8.4%	4.3%	4.8%
7	0.0%	10.3%	19.5%	72.7%	5.2%	4.8%	7.2%	2.1%	4.8%	2.8%	3.9%	4.4%
8	0.0%	19.9%	31.0%	95.1%	13.5%	9.7%	15.4%	12.5%	11.1%	12.8%	10.7%	11.8%
9+	0.0%	60.3%	24.0%	-185.0%	9.2%	0.3%	0.5%	3.4%	4.6%	3.0%	3.8%	4.4%
Sum 3+	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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

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

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

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

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

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

Figures for A fleet include 293 t unsampled bycatch in the industrial fishery

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

Figures for A fleet include 3576 t unsampled bycatch in the industrial fishery

Table 2.2.7: Catch at age (numbers in millions) of North Sea herring, 1994-2009.
SG Rednose's revisions for 1995-2001 are included.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1994	3834	497	1438	504	355	117	98	78	71	46	7038
1995	6294	484	1319	818	244	122	57	43	69	29	9480
1996	1795	645	488	516	170	57	22	9	17	4	3723
1997	364	174	565	428	285	109	31	12	19	6	1993
1998	208	254	1084	525	267	179	89	14	17	4	2642
1999	968	73	487	1034	289	134	70	28	10	2	3096
2000	873	194	516	453	636	212	82	36	15	3	3019
2001	1025	58	678	473	279	319	92	39	18	2	2982
2002	319	490	513	913	294	136	164	47	34	7	2917
2003	347	172	1022	507	809	244	106	121	37	8	3375
2004	627	136	274	1333	517	721	170	100	70	22	3970
2005	919	408	203	487	1326	480	577	116	108	39	4664
2006	844	72	354	309	475	1017	257	252	65	44	3689
2007	553	46	142	413	284	307	628	147	133	23	2677
2008	713	148	260	183	199	137	118	215	74	43	2090
2009	533	98	253	108	96	88	40	58	112	34	1421

Table 2.2.8: Catch at age (numbers in millions) of Baltic Spring spawning Herring taken in the North Sea, and transfered to the assessment of the spring spawning stock in IIIa, 1994-2009.

Year/rings	0	1	2	3	4	5	6	7	8	9+	Total
1994	0.0	0.0	8.8	28.2	16.3	11.0	8.6	3.4	3.2	0.7	80.2
1995	0.0	0.0	22.4	11.0	14.9	4.0	2.9	1.9	0.7	0.0	57.8
1996	0.0	0.0	0.0	2.8	0.8	0.4	0.1	0.1	0.3	0.0	4.5
1997	0.0	0.0	2.2	1.3	1.5	0.4	0.2	0.1	0.2	0.0	5.9
1998	0.0	5.1	9.5	12.0	10.1	6.0	3.0	0.4	0.9	0.0	47.0
1999	0.0	0.0	3.3	14.3	5.6	3.6	1.4	0.6	0.4	0.0	29.3
2000	0.0	0.0	8.2	9.8	10.2	5.7	2.5	0.6	0.7	0.1	37.6
2001	0.0	0.0	11.3	10.2	6.1	7.2	2.7	1.6	0.4	0.0	39.9
2002	0.0	0.0	7.6	14.8	10.6	3.3	2.9	1.0	0.5	0.1	40.8
2003	0.0	0.0	0.0	3.1	6.0	3.5	1.2	1.3	0.5	0.1	15.7
2004	0.0	0.0	15.1	27.9	3.5	4.1	1.0	0.5	0.1	0.0	52.3
2005	0.0	0.0	6.6	17.4	12.7	2.6	3.8	1.1	0.4	0.3	44.8
2006	0.0	0.1	3.5	8.8	14.0	22.4	5.1	5.3	2.1	1.0	62.2
2007	0.0	0.0	0.1	2.6	1.3	0.6	0.8	0.4	0.5	0.2	6.3
2008	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.2	0.0	0.0	0.7
2009	0.0	0.0	1.0	2.1	3.4	1.4	1.7	4.5	1.8	1.4	17.2

Table 2.2.9: Catch at age (numbers in millions) of North Sea Autumn Spawners taken in IIIa, and transfered to the assessment of NSAS, 1994 - 2009. SG Rednose's revisions and revision of 2002 splitting are included.

Year/rings	0	1	2	3	4	5	6	7	8+	Total
1994	482	1087	201	27	6	3	2	0	0	1807
1995	1145	1181	147	10	3	1	1	0	0	2487
1996	516	961	154	13	3	1	1	0	0	1649
1997	68	305	125	20	1	1	0	0	0	521
1998	51	729	145	25	19	3	3	1	0	977
1999	598	231	133	39	10	5	1	1	0	1017
2000	232	978	115	20	21	7	3	1	0	1377
2001	808	557	140	15	1	0	0	0	0	1521
2002	411	345	48	5	1	0	0	0	0	811
2003	22	445	182	13	16	2	1	1	0	682
2004	88	71	180	21	6	10	2	2	1	380
2005	96	307	159	16	5	2	2	0	0	590
2006	35	150	50	10	3	3	1	0	0	253
2007	68	189	77	2	0	1	0	1	0	339
2008	86	87	72	2	0	0	0	0	0	247
2009	117	78	7	0	0	0	0	0	0	202

Table 2.2.10: Catch at age (numbers in millions) of the total North Sea Autumn Spawning stock 1994 - 2009.
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
1994	4437	1890	1839	449	332	103	88	74	68	45	9325
1995	7438	1665	1444	817	232	119	55	41	69	29	11909
1996	2311	1606	642	526	172	58	23	9	17	4	5368
1997	431	480	688	447	285	109	31	12	19	6	2507
1998	260	978	1220	538	276	176	89	15	17	4	3572
1999	1566	304	616	1059	294	136	69	28	10	2	4084
2000	1105	1172	623	463	647	213	82	36	15	2	4358
2001	1833	614	806	477	274	312	89	37	17	2	4463
2002	730	835	553	903	284	133	161	46	33	7	3687
2003	369	617	1204	517	820	243	106	120	37	8	4042
2004	716	207	439	1326	520	726	171	101	71	22	4298
2005	1016	716	355	486	1318	480	576	115	108	39	5209
2006	879	222	401	311	465	999	253	249	63	44	3885
2007	621	236	219	412	283	308	628	147	132	23	3009
2008	798	235	332	185	199	137	118	215	74	43	2336
2009	650	176	259	107	93	86	38	53	110	33	1606

Table 2.2.11: Comparison of mean weights (kg) at age (rings) in the catch of adult North Sea herring (by Div.) and North Sea autumn spawners caught in Div. IIIa in 1999 – 2009. SG Rednose's revisions are included.

		Age (Rings)							
Div.	**Year**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
IIIa	1999	0.084	0.113	0.141	0.161	0.181	0.206	0.199	-
	2000	0.076	0.103	0.162	0.190	0.184	0.186	0.177	-
	2001	0.073	0.105	0.128	0.133	0.224	0.170	0.192	-
	2002	0.104	0.126	0.144	0.164	0.180	0.180	0.218	-
	2003	0.067	0.123	0.150	0.163	0.191	0.214	0.187	-
	2004	0.070	0.121	0.141	0.152	0.170	0.187	0.178	-
	2005	0.071	0.106	0.155	0.173	0.185	0.200	0.209	-
	2006	0.079	0.117	0.140	0.186	0.191	0.216	0.207	-
	2007	0.071	0.108	0.125	0.152	0.184	0.175	0.154	-
	2008	0.087	0.109	0.139	0.168	0.176	0.204	0.198	-
	2009	0.101	0.082	0.206	0.000	0.000	0.000	0.269	-
IVa(E)	1999	0.125	0.143	0.162	0.191	0.207	0.226	0.232	0.272
	2000	0.130	0.154	0.172	0.195	0.202	0.218	0.261	0.256
	2001	0.121	0.148	0.165	0.177	0.197	0.220	0.262	0.238
	2002	0.130	0.154	0.167	0.189	0.198	0.212	0.229	0.238
	2003	0.122	0.154	0.162	0.177	0.189	0.203	0.213	0.218
	2004	0.119	0.133	0.171	0.185	0.212	0.192	0.218	0.252
	2005	0.117	0.146	0.153	0.202	0.209	0.233	0.262	0.265
	2006	0.125	0.149	0.164	0.175	0.214	0.224	0.229	0.254
	2007	0.156	0.148	0.156	0.186	0.184	0.204	0.226	0.239
	2008	0.138	0.173	0.172	0.174	0.216	0.210	0.253	0.266
	2009	0.139	0.167	0.208	0.219	0.232	0.245	0.253	0.288
IVa(W)	1999	0.129	0.162	0.192	0.227	0.250	0.261	0.272	0.309
	2000	0.127	0.159	0.187	0.214	0.237	0.271	0.293	0.265
	2001	0.138	0.168	0.193	0.222	0.235	0.266	0.285	0.296
	2002	0.144	0.161	0.191	0.211	0.230	0.242	0.261	0.263
	2003	0.130	0.167	0.184	0.202	0.224	0.237	0.259	0.276
	2004	0.131	0.155	0.193	0.220	0.242	0.251	0.246	0.299
	2005	0.122	0.158	0.174	0.213	0.229	0.245	0.275	0.267
	2006	0.145	0.156	0.180	0.193	0.230	0.251	0.247	0.286
	2007	0.150	0.156	0.166	0.196	0.191	0.227	0.241	0.264
	2008	0.142	0.187	0.187	0.188	0.230	0.219	0.262	0.281
	2009	0.152	0.180	0.211	0.223	0.266	0.251	0.252	0.278
IVb	1999	0.118	0.148	0.154	0.207	0.226	0.209	0.287	0.345
	2000	0.118	0.173	0.194	0.224	0.229	0.251	0.240	0.268
	2001	0.105	0.150	0.176	0.188	0.199	0.206	0.244	0.275
	2002	0.086	0.149	0.161	0.206	0.214	0.189	0.270	0.241
	2003	0.098	0.161	0.178	0.195	0.214	0.214	0.222	0.281
	2004	0.118	0.143	0.186	0.214	0.234	0.239	0.297	0.308
	2005	0.132	0.172	0.187	0.217	0.220	0.245	0.253	0.252
	2006	0.097	0.141	0.172	0.183	0.202	0.220	0.232	0.239
	2007	0.145	0.160	0.180	0.201	0.210	0.246	0.234	0.252
	2008	0.142	0.172	0.185	0.191	0.222	0.228	0.265	0.223
	2009	0.140	0.188	0.228	0.219	0.223	0.243	0.255	0.255
IVa & IVb	1999	0.124	0.155	0.179	0.213	0.236	0.250	0.264	0.301
	2000	0.125	0.162	0.185	0.210	0.227	0.258	0.275	0.263
	2001	0.129	0.156	0.180	0.202	0.217	0.242	0.275	0.285
	2002	0.119	0.157	0.177	0.203	0.219	0.228	0.253	0.253
	2003	0.113	0.163	0.178	0.190	0.210	0.225	0.239	0.255
	2004	0.122	0.147	0.187	0.210	0.227	0.233	0.247	0.266
	2005	0.121	0.157	0.172	0.212	0.225	0.242	0.269	0.265
	2006	0.123	0.150	0.174	0.187	0.222	0.239	0.238	0.269
	2007	0.149	0.155	0.165	0.196	0.192	0.227	0.238	0.257
	2008	0.142	0.182	0.185	0.188	0.226	0.220	0.262	0.275
	2009	0.142	0.183	0.217	0.221	0.248	0.248	0.253	0.277
IVc & VIId	1999	0.116	0.139	0.159	0.189	0.198	0.217	-	-
	2000	0.106	0.133	0.150	0.180	0.194	0.203	-	-
	2001	0.113	0.138	0.171	0.167	0.171	0.168	0.180	-
	2002	0.108	0.123	0.153	0.170	0.187	0.219	0.208	-
	2003	0.103	0.127	0.144	0.168	0.176	0.188	0.200	0.227
	2004	0.099	0.113	0.135	0.162	0.184	0.191	0.186	0.224
	2005	0.122	0.132	0.139	0.170	0.207	0.228	0.237	0.245
	2006	0.119	0.125	0.153	0.152	0.178	0.205	0.209	0.219
	2007	0.129	0.131	0.154	0.158	0.173	0.196	0.209	0.218
	2008	0.120	0.157	0.156	0.173	0.188	0.192	0.215	0.247
	2009	0.156	0.162	0.197	0.197	0.211	0.192	0.219	0.244
Total North Sea Catch	1999	0.123	0.152	0.172	0.208	0.233	0.246	0.264	0.301
	2000	0.122	0.159	0.180	0.202	0.217	0.247	0.275	0.263
	2001	0.118	0.149	0.177	0.198	0.213	0.238	0.267	0.288
	2002	0.118	0.153	0.170	0.199	0.214	0.228	0.250	0.252
	2003	0.104	0.158	0.174	0.184	0.205	0.222	0.232	0.256
	2004	0.100	0.138	0.183	0.201	0.216	0.228	0.246	0.272
	2005	0.099	0.153	0.166	0.208	0.223	0.240	0.257	0.278
	2006	0.122	0.145	0.172	0.181	0.220	0.237	0.235	0.262
	2007	0.149	0.152	0.164	0.194	0.190	0.224	0.235	0.252
	2008	0.141	0.180	0.181	0.183	0.216	0.216	0.256	0.273
	2009	0.145	0.181	0.216	0.216	0.239	0.243	0.248	0.273

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

Table 2.2.12: Sampling of commercial landings of North Sea herring (Div. IV and VIId) in 2009 by quarter. Sampled catch means the proportion of the reported catch to which sampling was applied. It is limited by 100 % but might exceed the official landings due to sampling of discards, unallocated and misreported catches. It is not possible to judge the quality of the sampling by this figure alone. Note that only one nation sampled their by-catches in the industrial fishery (Denmark, fleet B). Metiers are each *reported* combination of nation/fleet/area/quarter.

Country (fleet)	Quarter	No of metiers	Metiers sampled	Sampled Catch %	Official Catch	No. of samples	No. fish aged	No. fish measured	>1 sample per 1 kt catch
Denmark (A)	1	3	2	93%	7589	3	85	385	n
	2	2	1	75%	1712	2	56	218	y
	3	2	1	65%	19645	5	130	630	n
	4	2	1	100%	7522	3	79	380	n
total		**9**	**5**	**78%**	**36468**	**13**	**350**	**1613**	**n**
Denmark (B)	1	2	0	0%	7	0	0	0	n
	2	2	1	100%	785	1	52	106	y
	3	3	1	97%	4706	15	364	846	y
	4	3	1	72%	4270	11	224	225	y
total		**10**	**3**	**86%**	**9769**	**27**	**640**	**1177**	**y**
England and Wales*	1	2	0	0%	18	0	0	0	n
	2	1	0	0%	5	0	0	0	n
	3	3	2	100%	588	2	50	50	y
	4	2	0	0%	40	0	0	0	n
total		**8**	**2**	**90%**	**651**	**2**	**50**	**50**	**y**
Faroe Island	1	3	0	0%	1595	0	0	0	n
	4	2	0	0%	208	0	0	0	n
total		**5**	**0**	**0%**	**1803**	**0**	**0**	**0**	**n**
France **	1	2	0	0%	694	0	0	0	n
	2	2	0	0%	17	0	0	0	n
	3	4	0	0%	11773	0	0	0	n
	4	2	0	0%	5631	0	0	0	n
total		**10**	**0**	**0%**	**18115**	**0**	**0**	**0**	**n**
Germany	3	1	0	0%	1040	0	0	0	n
	4	2	1	100%	4328	10	239	1275	y
total		**3**	**1**	**80%**	**5367**	**10**	**239**	**1275**	**y**
Netherlands	1	1	1	100%	520	2	50	384	y
	2	2	2	88%	901	18	450	2714	y
	3	2	2	91%	11772	47	1175	5457	y
	4	4	2	73%	11359	5	125	668	n
total		**9**	**7**	**91%**	**24552**	**72**	**1800**	**9223**	**y**
Norway	1	2	0	0%	3629	0	0	0	n
	2	3	2	86%	27170	15	430	1276	n
	3	3	2	56%	4538	5	171	282	y
	4	3	2	94%	15108	6	234	473	n
total		**11**	**6**	**80%**	**50445**	**26**	**835**	**2031**	**n**
Scotland	1	1	1	100%	385	1	136	653	y
	2	1	1	100%	1956	5	379	1174	y
	3	3	3	85%	11752	14	1015	3458	y
	4	1	0	0%	4	0	0	0	n
total		**6**	**5**	**87%**	**14096**	**20**	**1530**	**5285**	**y**
Sweden	2	3	0	0%	3290	0	0	0	n
	3	1	0	0%	960	0	0	0	n
	4	1	0	0%	1049	0	0	0	n
total		**5**	**0**	**0%**	**5299**	**0**	**0**	**0**	**n**
grand total		**76**	**29**	**70%**	**166566**	**170**	**5444**	**20654**	**y**
Period total	**1**	16	4	69%	14437	6	271	1422	n
Period total	**2**	16	7	79%	35836	41	1367	5488	y
Period total	**3**	22	11	62%	66773	88	2905	10723	y
Period total	**4**	22	7	76%	49520	35	901	3021	n
Total for stock 2009		**76**	**29**	**70%**	**166566**	**170**	**5444**	**20654**	**y**
Human Cons. only		66	26	69%	156797	143	4804	19477	n
Total for stock 2007		100	30	86%	361114	335	10342	54639	n
Total for stock 2008		93	29	76%	227895	217	8663	36232	n
Human Cons. only 2008		84	26	76%	219290	192	8181	36232	n

* majority of catches landed to Ijmuiden, the Netherlands

** preliminary data

Table 2.3.1.1: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2009. Vessels, areas and cruise dates.

Vessel	Period	Area	Rectangles
Celtic Explorer (IR)	3 July – 22 July	53°-56°N ,12°-7°W	35D8-D9, 36D8-D9, 37D9-E1, 38D9-E1, 39E0-E2, 40E0-E2
Charter west Sco (SCO)	29 June – 18 July	55°30'-60°30'N, 4°-10°W	41E0-E3, 42E0-E3, 43E0-E3, 44E0-E3, 45E0-E4, 46E2-E5, 47E2-E5, 48E4-E5, 49E5
Johan Hjort (NOR)	13 July – 21 July	57°-62°N, 2°-5°E	43F2, 44F3-F4, 45F2-F4, 46F2, 47F2-F3, 48F2, 49F3, 50F2, 51F2-F3, 52F2-F3
Scotia (SCO)	28 June – 16 July	58°30'-62°N, 4°W-2°E	46E6-F1, 47E6-F1, 48E6-F1, 49E6-F1, 50E7-F1, 51E6-F1
Tridens (NED)	29 June – 24 July	54°– 58°30'N, 4° W–2°/ 6°E	37E9-F1, 38E8-F1, 39E8-F1, 40E8-F5, 41E7-F5, 42E7-F2, 43E7-F1, 44E6-F1, 45E6-F1
Solea (GER) DBFH	26 June – 15 July	52°-56°N, Eng to Den/Ger coasts	33F1-F4, 34F2-F4, 35F2-F4, 36F0-F7, 37F2-F8, 38F2-F7, 39F2-F7, 40F6-F7
Dana (DEN) OXBH	30 June – 13 July	Kattegat and North of 56°N, east of 6°E	41 F6-F7, 41G1-G2, 42F6-F7, 42G0-G2, 43F6-G1, 44F6-G1, 45F8-G1, 46F9-G0

Table 2.3.1.2: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2009. 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 weights and mean lengths by age ring.

Age (ring)	Numbers	Biomass	Maturity	Weight(g)	Length (cm)
0	13,554	95	0.00	7.0	10.0
1	4,655	260	0.04	55.9	18.3
2	5,632	832	0.89	147.7	24.8
3	2,553	532	1.00	208.3	27.4
4	1,023	242	1.00	236.3	28.4
5	1,077	249	1.00	231.5	28.3
6	674	162	1.00	239.6	28.5
7	638	169	1.00	265.5	29.4
8	1,142	285	1.00	249.2	28.8
9+	578	174	1.00	262.7	29.5
Immature	18,639	407		21.8	12.4
Mature	12,888	2,591		201.1	27.0
Total	31,526	2,998	0.41	95.1	18.4

Table 2.3.1.3: Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1985-2009. For 1985-1986 the estimates are the sum of those from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc, VIId winter survey. The 1987 to 2008 estimates are from the summer survey in Divisions IVa,b and IIIa excluding estimates of Division IIIa/Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed.

Years / Age (rings)	1	2	3	4	5	6	7	8	9+	Total	SSB ('000t)
1985	726	2,789	1,433	323	113	41	17	23	19	5,484	697
1986	1,639	3,206	1,637	833	135	36	24	6	8	7,542	942
1987	13,736	4,303	955	657	368	77	38	11	20	20,165	817
1988	6,431	4,202	1,732	528	349	174	43	23	14	13,496	897
1989	6,333	3,726	3,751	1,612	488	281	120	44	22	16,377	1,637
1990	6,249	2,971	3,530	3,370	1,349	395	211	134	43	18,262	2,174
1991	3,182	2,834	1,501	2,102	1,984	748	262	112	56	12,781	1,874
1992	6,351	4,179	1,633	1,397	1,510	1,311	474	155	163	17,173	1,545
1993	10,399	3,710	1,855	909	795	788	546	178	116	19,326	1,216
1994	3,646	3,280	957	429	363	321	238	220	132	13,003	1,035
1995	4,202	3,799	2,056	656	272	175	135	110	84	11,220	1,082
1996	6,198	4,557	2,824	1,087	311	99	83	133	206	18,786	1,446
1997	9,416	6,363	3,287	1,696	692	259	79	78	158	22,028	1,780
1998	4,449	5,747	2,520	1,625	982	445	170	45	121	16,104	1,792
1999	5,087	3,078	4,725	1,116	506	314	139	54	87	15,107	1,534
2000	24,735	2,922	2,156	3,139	1,006	483	266	120	97	34,928	1,833
2001	6,837	12,290	3,083	1,462	1,676	450	170	98	59	26,124	2,622
2002	23,055	4,875	8,220	1,390	795	1,031	244	121	150	39,881	2,948
2003	9,829	18,949	3,081	4,189	675	495	568	146	178	38,110	2,999
2004	5,183	3,415	9,191	2,167	2,590	317	328	342	186	23,722	2,584
2005	3,113	1,890	3,436	5,609	1,211	1,172	140	127	107	16,805	1,868
2006	6,823	3,772	1,997	2,098	4,175	618	562	84	70	20,199	2,130
2007	6,261	2,750	1,848	898	806	1,323	243	152	65	14,346	1,203
2008	3,714	2,853	1,709	1,485	809	712	1,749	185	270	20,355	1,784
2009	4,655	5,632	2,553	1,023	1,077	674	638	1,142	578	31,526	2,591

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

	Orkney/ Shetland		Buchan		Central North Sea			Southern North Sea			MLAI Assess
Period	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Sep.	16–30 Sep.	1–15 Oct.	16–31 Dec.	1–15 Jan.	16–31 Jan.	
1972	1133	4583	30		165	88	134	2	46		
1973	2029	822	3	4	492	830	1213			1	12.8
1974	758	421	101	284	81		1184		10		7.7
1975	371	50	312			90	77	1	2		2.7
1976	545	81		1	64	108			3		2.4
1977	1133	221	124	32	520	262	89	1			6.0
1978	3047	50		162	1406	81	269	33	3		7.2
1979	2882	2362	197	10	662	131	507		111	89	13.8
1980	3534	720	21	1	317	188	9	247	129	40	9.3
1981	3667	277	3	12	903	235	119	1456		70	13.7
1982	2353	1116	340	257	86	64	1077	710	275	54	20.0
1983	2579	812	3647	768	1459	281	63	71	243	58	25.7
1984	1795	1912	2327	1853	688	2404	824	523	185	39	46.2
1985	5632	3432	2521	1812	130	13039	1794	1851	407	38	70.6
1986	3529	1842	3278	341	1611	6112	188	780	123	18	36.7
1987	7409	1848	2551	670	799	4927	1992	934	297	146	64.9
1988	7538	8832	6812	5248	5533	3808	1960	1679	162	112	128.7
1989	11477	5725	5879	692	1442	5010	2364	1514	2120	512	126.4
1990		10144	4590	2045	19955	1239	975	2552	1204		163.7
1991	1021	2397		2032	4823	2110	1249	4400	873		87.1
1992	189	4917		822	10	165	163	176	1616		40.3
1993		66		174		685	85	1358	1103		28.5
1994	26	1179				1464	44	537	595		19.8
1995		8688					43	74	230	164	20.8
1996		809		184		564		337	675	691	41.4
1997		3611		23				9374	918	355	53.6
1998		8528		1490	205	66		1522	953	170	68.3
1999		4064		185		134	181	804	1260	344	57.0
2000		3352	28	83		376		7346	338	106	38.0
2001		11918		164		1604		971	5531	909	123.4
2002		6669		1038			3291	2008	260	925	104.7
2003		3199		2263		12018	3277	12048	3109	1116	253.9
2004		7055		3884		5545		7055	2052	4175	307.8
2005		3380		1364		5614		498	3999	4822	183.4
2006	6311	2312		280		2259		10858	2700	2106	113.1
2007		1753		1304		291		4443	2439	3854	163.5
2008	4978	6875		533		11201		8426	2317	4008	181.3
2009		7543		4629		4219		15295	14712	1689	477.9

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)	Prop. of small total area vs. all sizes	Small<13cm 1-ringers North Sea (no/hour)	Prop.of small North Sea vs. all sizes	Prop. of small IIIa vs small total area
1977	1979	168	11	0.07	12	0.07	0
1978	1980	316	108	0.34	106	0.34	0.09
1979	1981	495	51	0.1	41	0.08	0.26
1980	1982	798	177	0.22	185	0.23	0.03
1981	1983	1270	192	0.15	185	0.15	0.11
1982	1984	1516	346	0.23	297	0.2	0.2
1983	1985	2097	315	0.15	298	0.14	0.12
1984	1986	2663	596	0.22	390	0.15	0.39
1985	1987	3693	628	0.17	529	0.14	0.22
1986	1988	4394	2371	0.54	720	0.16	0.72
1987	1989	2332	596	0.26	531	0.23	0.17
1988	1990	1062	70	0.07	62	0.06	0.18
1989	1991	1287	330	0.26	337	0.26	0.05
1990	1992	1268	125	0.1	130	0.1	0.03
1991	1993	2794	676	0.24	176	0.06	0.76
1992	1994	1752	283	0.16	240	0.14	0.21
1993	1995	1346	449	0.33	445	0.33	0.08
1994	1996	1891	604	0.32	467	0.25	0.28
1995	1997	4405	1356	0.31	1089	0.25	0.25
1996	1998	2276	1322	0.58	1399	0.61	0.02
1997	1999	753	152	0.2	149	0.2	0.09
1998	2000	3725	1117	0.3	991	0.27	0.17
1999	2001	2499	328	0.13	307	0.12	0.13
2000	2002	4065	1553	0.38	1471	0.36	0.12
2001	2003	2765	717	0.26	237	0.09	0.69
2002	2004	979	665	0.68	710	0.73	0.01
2003	2005	1002	340	0.34	356	0.36	0.03
2004	2006	922	122	0.13	128	0.14	0.02
2005	2007	1321	302	0.23	302	0.23	0.07
2006	2008	1816	436	0.24	464	0.26	0.01
2007	2009	2344	737	0.31	626	0.27	0.21
2008	2010	**1202**	292	0.24	301	0.25	0.04

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

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

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	240	261	266

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 2009.

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

Table 2.6.1 North Sea herring. Years of duration of survey and years used in the assessment.

Survey	Age range	Years survey has been running	Years used in assessment
MLAI (Larvae survey)	SSB	1972-2009	1973-2009
IBTS 1st Quarter (Trawl survey)	1-5wr	1971-2010	1984-2010
Acoustic (+trawl)	1wr	1995-2009	1997-2009
	2-9+wr	1984-2009	1989-2009
IBTS0	0wr	1977-2010	1992-2010

Table 2.6.3.1 NORTH SEA HERRING. CATCH IN NUMBER

Units : thousands

year

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

year

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

year

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

year

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

Table 2.6.3.1 cont NORTH SEA HERRING. CATCH IN NUMBER

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

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

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

Units : kg

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

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

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

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

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

age \ year	2008	2009
0	0.0079	0.0094
1	0.0535	0.0514
2	0.1288	0.1440
3	0.1796	0.1811
4	0.1812	0.2158
5	0.1832	0.2162
6	0.2157	0.2390
7	0.2161	0.2428
8	0.2560	0.2476
9	0.2726	0.2724

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

Units : kg

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

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

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

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

age	2008	2009
0	0.008	0.007
1	0.058	0.061
2	0.130	0.137
3	0.164	0.181
4	0.181	0.197
5	0.195	0.210
6	0.218	0.223
7	0.226	0.234
8	0.253	0.255
9	0.260	0.259

Table 2.6.3.4 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA

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

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

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

age	2005	2006	2007	2008	2009
0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1

Table 2.6.3.5 NORTH SEA HERRING. PROPORTION MATURE

Units : NA

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

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

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

age	2005	2006	2007	2008	2009
0	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00
2	0.76	0.66	0.71	0.86	0.89
3	0.96	0.88	0.92	0.98	1.00
4	0.96	0.98	0.93	0.99	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
9	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	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

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

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

age \ year	2005	2006	2007	2008	2009
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
9	0.67	0.67	0.67	0.67	0.67

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

Units : NA

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

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

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

age \ year	2005	2006	2007	2008	2009
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
9	0.67	0.67	0.67	0.67	0.67

Table 2.6.3.8 NORTH SEA HERRING. SURVEY INDICES

```
MLAI - Configuration

"Herring" "in" "Sub-area" "IV," "Divisions" "VIId" "&" "IIIa" "(autumn-spawners)"
      min       max plusgroup   minyear   maxyear    startf      endf
       NA        NA        NA      1973      2009        NA        NA
Index type : biomass

MLAI - Index Values

Units  :  NA
     year
age    1973  1974  1975  1976  1977  1978   1979  1980   1981  1982   1983
  all 12.79 7.661 2.737 2.422 5.999 7.184 13.844 9.332 13.704 19.98 25.669
     year
age     1984 1985   1986  1987    1988    1989    1990   1991   1992  1993
  all 46.198 70.6 36.704 64.93 128.721 126.428 163.659 87.107 40.277 28.52
     year
age     1994   1995   1996  1997   1998   1999   2000    2001    2002    2003
  all 19.823 20.849 41.395 53.55 68.327 56.982 38.038 123.398 104.674 253.943
     year
age      2004    2005    2006    2007    2008    2009
  all 307.772 183.443 113.057 163.456 181.327 477.868

MLAI - Index Variance (Inverse Weights)

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

TABLE 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

```
MIK 0-wr (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   2010.00      0.08      0.17
Index type : number

MIK 0-wr - Index Values

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

MIK 0-wr - Index Variance (Inverse Weights)

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

IBTS1: 1-5+ wr - Configuration

"Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners) . Imported from
VPA file."
      min       max plusgroup   minyear   maxyear    startf      endf
     1.00      5.00      5.00   1984.00   2010.00      0.08      0.17
Index type : number
```

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

IBTS1: 1-5+ wr - Index Values

Units : NA

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

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

age	2000	2001	2002	2003	2004	2005	2006	2007
1	3725.131	2499.391	4064.829	2765.059	979.036	1001.585	921.995	1321.005
2	199.374	1129.308	658.154	1556.082	451.015	214.191	1464.322	50.033
3	154.691	317.069	338.153	611.890	777.324	356.007	330.037	18.250
4	58.838	93.886	25.048	359.989	112.374	388.922	251.689	7.937
5	8.952	68.284	19.936	53.166	171.231	131.481	338.811	41.284

age	2008	2009	2010
1	1815.860	2344.155	1201.516
2	232.906	136.269	49.555
3	146.192	21.459	34.853
4	202.100	11.223	45.944
5	232.335	46.427	89.938

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

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

Units : NA

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

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

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

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

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

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

Acoustic survey 1-9+ wr - Configuration

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

min	max	plusgroup	minyear	maxyear	startf	endf
1.00	9.00	9.00	1989.00	2009.00	0.54	0.56

Index type : number

Acoustic survey 1-9+ wr - Index Values

Units : NA

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

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

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

Table 2.6.3.8 cont NORTH SEA HERRING. SURVEY INDICES

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

Units : NA

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

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

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

Table 2.6.3.9 NORTH SEA HERRING. STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
0	9	9	1960	2009	2	6

Table2.6.3.10 NORTH SEA HERRING. FLICA CONFIGURATION SETTINGS

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

Table 2.6.3.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

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

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

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

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

Table 2.6.3.12 NORTH SEA HERRING. STOCK SUMMARY

Year	Recruitment Age 0	TSB	SSB	Fbar (Ages 2-6) f	Landings tonnes	Landings SOP
1960	12090768	3746478	1882223	0.3364	696200	1.1830
1961	108861543	4360094	1658653	0.4320	696700	1.1348
1962	46276860	4397070	1114267	0.5295	627800	1.1705
1963	47657612	4625545	2185898	0.2263	716000	0.8602
1964	62786327	4794715	2028969	0.3433	871200	1.0656
1965	34895460	4341788	1447015	0.6940	1168800	1.1496
1966	27859161	3315305	1279490	0.6193	895500	1.0707
1967	40256722	2817459	922768	0.7976	695500	1.1757
1968	38698764	2521395	412929	1.3357	717800	1.2551
1969	21581831	1905582	424352	1.1052	546700	0.9674
1970	41074820	1922063	374804	1.1050	563100	0.9657
1971	32310757	1849600	266152	1.4043	520100	1.0747
1972	20859936	1549634	288381	0.6959	497500	0.9197
1973	10110449	1156221	233492	1.1344	484000	0.9575
1974	21699013	912254	162118	1.0518	275100	0.9680
1975	2834714	680760	81865	1.4685	312800	0.9343
1976	2730340	359143	78149	1.4356	174800	0.9530
1977	4336046	211132	47923	0.7992	46000	1.1979
1978	4605743	225743	65348	0.0529	11000	1.2152
1979	10608119	383013	107676	0.0639	25100	1.0056
1980	16733214	631546	131652	0.2824	70764	1.0936
1981	37880853	1160044	196399	0.3492	174879	1.0081
1982	64779774	1844956	279373	0.2631	275079	0.9786
1983	61831800	2721495	433963	0.3368	387202	1.0771
1984	53478738	2867348	680726	0.4537	428631	1.0543
1985	80963167	3465361	701031	0.6414	613780	1.0419
1986	97640362	3475714	681122	0.5698	671488	1.1373
1987	86228282	3939554	902635	0.5503	792058	1.0173
1988	42291325	3624335	1196740	0.5350	887686	1.1641
1989	39180848	3313394	1252458	0.5436	787899	1.0335
1990	35881785	2979597	1187888	0.4408	645229	1.0515
1991	33640152	2717680	982873	0.4891	658008	1.0197
1992	62154204	2438944	705749	0.5816	716799	0.9950
1993	50268847	2520666	475182	0.6897	671397	1.0231
1994	34550246	2026648	511922	0.7063	568234	1.0498
1995	41706539	1845906	463485	0.7373	579371	1.0084
1996	49899002	1628068	464038	0.4006	275098	0.9987
1997	29076345	1954866	562971	0.4192	264313	1.0006
1998	27653633	2080662	738121	0.4832	391628	1.0018
1999	67851681	2349729	866536	0.3665	363163	1.0000
2000	40805354	2878784	878518	0.3570	388157	1.0004
2001	93831762	3276485	1317450	0.2889	374065	0.9901
2002	32100605	4019388	1605297	0.2397	394709	0.9974
2003	18624711	3739946	1744930	0.2394	482281	1.0153
2004	23855772	3434390	1814302	0.2946	587698	0.9985
2005	16406534	2957906	1710000	0.3350	663813	1.0033
2006	23687684	2422618	1331695	0.3193	514597	0.9950
2007	30374327	2217142	1046787	0.3055	406482	1.0056
2008	16408903	2129446	1037697	0.2215	257870	1.0040
2009	29750666	2168294	1288866	0.1115	168443	1.0023

Table 2.6.3.13 NORTH SEA HERRING. ESTIMATED FISHING MORTALITY

Units : f

age	1960	1961	1962	1963	1964	1965
0	0.02573653	0.01858764	0.004857288	0.01478961	0.01258596	0.007143373
1	0.25584452	0.12934581	0.089669635	0.12405851	0.30843519	0.246123844
2	0.43597526	0.61703092	0.250154070	0.29751197	0.38894737	0.775346878
3	0.32798128	0.35221999	0.626820000	0.27544715	0.41236706	0.738803161
4	0.33721711	0.40790264	0.421247047	0.22690533	0.37020635	0.776634579
5	0.26594504	0.40212515	0.533032221	0.15031871	0.30759125	0.659702462
6	0.31476022	0.38086150	0.816366497	0.18116792	0.23716475	0.519296325
7	0.60237789	0.25161997	0.634480591	0.28411288	0.28066980	0.454932760
8	0.56123409	0.52231905	0.585560249	0.33427442	0.55411259	0.854099024
9	0.56123409	0.52231905	0.585560249	0.33427442	0.55411259	0.854099024

age	1966	1967	1968	1969	1970	1971
0	0.02145712	0.02563499	0.03481121	0.008238046	0.03509943	0.03396689
1	0.18523485	0.29803787	0.30024224	0.329102536	0.26805613	0.60213401
2	0.59205917	0.42222287	1.32717592	0.784373633	0.97282657	0.88259020
3	0.70823916	0.80456789	1.87204183	0.912348709	1.26689231	1.21471911
4	0.57170050	0.92443571	1.07143565	0.874119133	1.33010461	1.22627509
5	0.83447694	0.82736910	1.23398059	1.054051823	0.87553462	1.08386974
6	0.39015505	1.00949903	1.17382272	1.900860456	1.07978275	2.61426500
7	0.38763531	1.52988270	1.59796416	1.296406855	4.11721707	2.70800341
8	0.72540111	1.06526152	1.64008174	1.317697105	1.72782551	1.93133669
9	0.72540111	1.06526152	1.64008174	1.317697105	1.72782551	1.93133669

age	1972	1973	1974	1975	1976	1977	1978
0	0.0583051	0.04616063	0.0749147	0.1570565	0.1466134	0.09755475	0.04550609
1	0.5781598	0.67390646	0.4515598	0.6879579	0.2487292	0.29690397	0.20011042
2	0.8120990	1.02195881	1.0285865	1.3108119	1.3388979	0.22468924	0.02419261
3	0.8013913	1.33355124	0.9726124	1.5041384	1.4327860	1.41086129	0.04242618
4	0.7995805	0.98777354	0.9934177	1.3713496	1.7373748	0.42831000	0.10407434
5	0.5493831	0.95134337	1.1860201	1.8805891	1.5931318	1.20197066	0.01660698
6	0.5169429	1.37718071	1.0782553	1.2756690	1.0756273	0.73019220	0.07703225
7	0.0981201	0.80361731	0.7716244	2.0296790	1.5061028	0.74733816	0.06006941
8	1.0286163	1.55295827	1.3240528	2.0108919	1.6357614	0.96639022	0.17976417
9	1.0286163	1.55295827	1.3240528	2.0108919	1.6357614	0.96639022	0.17976417

age	1979	1980	1981	1982	1983	1984	1985
0	0.08368214	0.12574114	0.4819020	0.3343207	0.3995417	0.2262891	0.08524092
1	0.16659835	0.11320732	0.2854074	0.2249896	0.2516333	0.2051209	0.38270346
2	0.09471515	0.36364523	0.3241458	0.2605368	0.3020856	0.3144082	0.40420282
3	0.06642856	0.41938438	0.2753424	0.5084251	0.3244796	0.4295820	0.67098926
4	0.09357098	0.29696143	0.3037463	0.2471078	0.4366364	0.5371487	0.73748037
5	0.05227661	0.26471829	0.4123330	0.1545225	0.2754841	0.6276824	0.66375522
6	0.01241504	0.06715745	0.4306169	0.1448747	0.3452256	0.3597517	0.73067289
7	0.43532373	0.10155905	0.9665230	0.2290673	0.3910448	0.6975265	0.55687252
8	0.22938221	0.35897045	0.6201374	0.4277968	0.5113002	0.6120880	0.86459375
9	0.22938221	0.35897045	0.6201374	0.4277968	0.5113002	0.6120880	0.86459375

age	1986	1987	1988	1989	1990	1991	1992
0	0.06192094	0.1613442	0.1246397	0.1302858	0.05886135	0.1178355	0.2966463
1	0.31564667	0.3722177	0.5798632	0.4306860	0.45258827	0.3080990	0.3871329
2	0.45925244	0.4060541	0.3555465	0.3981703	0.37681465	0.5739059	0.5724119
3	0.52234398	0.5052709	0.4005383	0.4099049	0.36934058	0.4544153	0.4977866
4	0.58164944	0.5887661	0.5814643	0.5552764	0.46712122	0.4573225	0.5722693
5	0.55375405	0.6160072	0.6635026	0.6555182	0.49930023	0.4828682	0.5457022
6	0.73195799	0.6352591	0.6737688	0.6993101	0.49117812	0.4768081	0.7196872
7	0.81865802	0.6116233	0.6906228	0.7051044	0.67751248	0.4211040	0.6937771
8	0.80602414	0.7913245	0.9107549	0.8292803	0.76375318	0.7008746	0.8561446
9	0.80602414	0.7913245	0.9107549	0.8292803	0.76375318	0.7008746	0.8561446

Table 2.6.3.13 cont. NORTH SEA HERRING. ESTIMATED FISHING MORTALITY

age	1993	1994	1995	1996	1997	1998	1999
0	0.3759461	0.2259445	0.3214192	0.07560997	0.02369220	0.01493954	0.03708835
1	0.4219642	0.2459028	0.2925521	0.25329178	0.04543859	0.15801562	0.04889373
2	0.6683223	0.6832099	0.5993743	0.30776621	0.28615318	0.26719187	0.24348893
3	0.6402329	0.7157302	0.8655753	0.48950915	0.39028126	0.40566750	0.41836395
4	0.7318605	0.9097573	0.8655656	0.41707655	0.51045556	0.42221067	0.38460387
5	0.7102187	0.5552258	0.8200300	0.47657166	0.45057360	0.60491189	0.33575493
6	0.6976661	0.6673680	0.5361345	0.31204457	0.45862843	0.71597029	0.45018364
7	0.8727817	0.4742991	0.6410212	0.14176692	0.23907210	0.37439100	0.45381586
8	1.0005511	0.8522456	0.9242052	0.53216645	0.41593387	0.54794334	0.40814844
9	1.0005511	0.8522456	0.9242052	0.53216645	0.41593387	0.54794334	0.40814844

age	2000	2001	2002	2003	2004	2005
0	0.04362811	0.03130443	0.03654152	0.03176682	0.04842005	0.07709880
1	0.07965274	0.06962771	0.04027525	0.08895376	0.05029439	0.08571588
2	0.22836981	0.12668706	0.14566936	0.12700557	0.14480730	0.20171209
3	0.31035411	0.29782166	0.22321872	0.20375629	0.21656723	0.26679935
4	0.46256824	0.29515534	0.27901077	0.28872997	0.31479015	0.38512820
5	0.47162832	0.39085335	0.21265617	0.35347893	0.40521589	0.41817216
6	0.31221805	0.33403439	0.33812994	0.22381073	0.39163870	0.40343780
7	0.39146934	0.20823582	0.26906249	0.37676956	0.31442704	0.39278481
8	0.40296099	0.30897285	0.26325281	0.30480682	0.31217466	0.38512820
9	0.40296099	0.30897285	0.26325281	0.30480682	0.31217466	0.38512820

age	2006	2007	2008	2009
0	0.07347715	0.07029336	0.05096677	0.02564845
1	0.08168946	0.07814982	0.05666316	0.02851510
2	0.19223686	0.18390716	0.13334337	0.06710355
3	0.25426670	0.24324923	0.17636982	0.08875613
4	0.36703716	0.35113330	0.25459204	0.12812058
5	0.39852892	0.38126051	0.27643601	0.13911331
6	0.38448668	0.36782673	0.26669574	0.13421163
7	0.37433411	0.35811407	0.25965350	0.13066770
8	0.36703716	0.35113330	0.25459204	0.12812058
9	0.36703716	0.35113330	0.25459204	0.12812058

Table 2.6.3.14 NORTH SEA HERRING. ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1960	1961	1962	1963	1964	1965
0	12090767.8	108861543.0	46276860.4	47657612.3	62786326.88	34895459.7
1	16422598.7	4334930.8	39310402.9	16941814.1	17274868.62	22808912.7
2	3701481.1	4677734.2	1401243.2	13221172.9	5505382.57	4668405.5
3	7718021.8	1773150.3	1869709.2	808322.4	7274009.01	2764276.4
4	607328.5	4552046.0	1020750.2	817882.1	502458.92	3942994.8
5	752981.9	392231.7	2739222.6	606100.6	589817.32	313973.2
6	438197.3	522223.8	237395.5	1454470.5	471881.23	392376.4
7	290696.8	289428.7	322865.1	94951.0	1097982.09	336824.7
8	313183.4	144012.9	203626.8	154896.0	64666.81	750364.8
9	345816.8	225020.2	204806.6	188088.0	141873.58	142442.1

age \ year	1966	1967	1968	1969	1970	1971
0	27859160.6	40256722.29	38698763.57	21581830.71	41074819.636	32310757.0384
1	12745947.2	10031244.99	14434800.73	13749417.17	7874374.424	14589408.8431
2	6560242.2	3896109.56	2739202.58	3932989.27	3639673.208	2215676.1513
3	1592763.7	2688459.51	1892229.26	538208.60	1329796.776	1019250.2736
4	1081096.4	642255.89	984521.51	238285.39	176955.360	306705.8357
5	1641000.2	552266.38	230569.22	305124.56	89958.635	42342.5668
6	146878.4	644570.55	218472.77	60738.06	96222.986	33913.5733
7	211225.3	89967.64	212530.45	61119.97	8212.933	29573.7020
8	193374.7	129708.55	17629.39	38904.93	15126.253	121.0554
9	478475.9	274676.92	118129.77	35639.19	15378.357	15010.8692

age \ year	1972	1973	1974	1975	1976
0	20859935.9580	10110449.2154	21699013.095	2834713.687	2730340.2863
1	11489497.1254	7239305.5620	3551637.740	7406456.247	891263.1608
2	2939271.7204	2370909.3413	1357464.778	831810.227	1369429.4009
3	679068.9681	966632.1969	632114.180	359526.407	166133.6268
4	247671.5579	249468.1862	208568.354	195675.486	65408.3065
5	81419.4351	100737.9927	84062.272	69884.868	44930.1040
6	12960.7188	42530.9003	35204.702	23232.166	9643.2676
7	2246.8974	6993.4939	9708.970	10836.546	5870.0834
8	1784.0430	1843.0655	2833.076	4060.986	1288.1993
9	648.7429	789.8852	1558.192	1672.171	515.2797

age \ year	1977	1978	1979	1980	1981
0	4336045.9557	4605742.737	10608119.1217	16733214.2875	37880853.273
1	867458.9261	1446877.973	1618982.4787	3589229.3794	5428454.588
2	255675.8773	237143.203	435743.1517	504190.8047	1179074.968
3	265934.9057	151293.446	171480.8465	293635.0924	259643.502
4	32459.9322	53111.330	118723.2458	131373.3164	158056.638
5	10415.2851	19138.394	43307.0716	97829.3012	88330.157
6	8264.5581	2832.908	17031.9245	37189.9786	67931.908
7	2976.1567	3603.062	2373.2766	15220.9757	31465.191
8	1177.9386	1275.444	3070.1139	1389.5053	12442.467
9	317.8919	1913.166	511.6856	347.3763	2488.493

Table 2.6.3.14 cont. NORTH SEA HERRING. ESTIMATED POPULATION ABUNDANCE

age \ year	1982	1983	1984	1985	1986	1987
0	64779774.265	61831800.03	53478737.71	80963167.20	97640361.62	86228281.53
1	8606723.884	17058911.37	15254522.98	15689552.07	27351008.70	33763151.28
2	1501173.364	2528317.61	4879483.88	4571105.95	3936498.25	7338296.57
3	631652.658	857023.64	1384679.18	2639610.16	2260423.90	1842344.82
4	161413.140	311037.84	507240.83	737777.10	1104775.31	1097690.45
5	105552.363	114075.37	181867.47	268227.94	319309.67	558775.52
6	52918.268	81833.33	78364.84	87846.92	124971.03	166069.66
7	39960.400	41424.56	52428.96	49482.72	38279.82	54386.93
8	10830.421	28755.29	25351.28	23616.19	25655.32	15275.72
9	3309.295	31630.82	42480.52	29024.48	27919.03	15657.62

age \ year	1988	1989	1990	1991	1992	1993
0	42291325.49	39180848.48	35881784.79	33640152.09	62154204.04	50268846.66
1	26995064.71	13734931.34	12653100.79	12445615.95	10999885.90	16995901.11
2	8560446.57	5561071.78	3284637.63	2960369.33	3364466.61	2747666.42
3	3622095.17	4444226.65	2766604.05	1669362.28	1235416.49	1406152.92
4	910071.80	1986778.14	2415004.04	1565617.03	867644.13	614849.10
5	551255.04	460383.22	1031730.91	1369683.57	896692.32	442974.57
6	273073.39	256902.06	216272.90	566622.29	764687.14	470130.64
7	79610.68	125960.93	115513.20	119744.81	318265.14	336897.80
8	26695.65	36108.40	56309.73	53083.83	71112.20	143898.43
9	14830.92	16109.90	23266.87	26956.63	42268.22	68734.99

age \ year	1994	1995	1996	1997	1998	1999
0	34550246.23	41706538.97	49899001.69	29076344.53	27653632.643	67851680.605
1	12697935.81	10139819.29	11125488.82	17020032.47	10446142.178	10022349.630
2	4100086.08	3652955.90	2784081.71	3177030.59	5983181.429	3281225.943
3	1043342.72	1533876.33	1486110.63	1516116.13	1767902.472	3393156.368
4	606909.65	417571.10	528465.78	745763.49	840188.192	964762.140
5	267606.17	221101.66	158997.62	315103.61	405026.687	498406.112
6	197017.72	138974.51	88110.58	89328.23	181694.717	200144.793
7	211736.92	91462.19	73564.02	58355.18	51095.126	80347.229
8	127357.47	119228.94	43593.35	57765.35	41574.041	31794.653
9	84783.69	50567.04	10009.10	17532.72	9383.047	6418.932

age \ year	2000	2001	2002	2003	2004	2005
0	40805353.693	93831762.35	32100604.85	18624711.28	23855771.6	16406534.2
1	24052424.484	14370610.52	33454924.29	11385417.27	6637414.1	8361234.9
2	3511080.531	8170932.71	4931077.27	11821545.26	3831972.1	2321998.1
3	1905469.031	2070011.22	5332904.42	3157839.59	7713084.5	2456094.0
4	1828318.367	1143820.62	1258263.22	3492707.72	2108826.9	5085284.3
5	594236.691	1041673.32	770449.43	861329.29	2367767.0	1392835.6
6	322357.216	335509.20	637612.23	563584.82	547300.5	1428652.1
7	115452.297	213458.46	217373.05	411414.15	407690.0	334741.7
8	46179.767	70625.28	156836.90	150287.86	255400.0	269368.4
9	7777.678	10615.48	39422.15	36080.89	124301.3	191700.0

age \ year	2006	2007	2008	2009
0	23687684.4	30374326.5	16408902.6	29750665.8
1	5587773.4	8096874.4	10415596.7	5736545.8
2	2823254.4	1894379.7	2754754.4	3620605.2
3	1405953.8	1725735.6	1167639.6	1786011.5
4	1539985.4	892658.9	1107831.1	801407.6
5	3130593.9	965350.3	568539.8	777098.7
6	829584.4	1901596.6	596590.3	390190.6
7	863547.5	511035.0	1191087.9	413449.3
8	204501.3	537385.0	323217.0	831281.8
9	147919.5	82665.4	200230.7	285768.6

Table 2.6.3.15 NORTH SEA HERRING. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2010
0	26718800.8
1	10667514.1
2	2051030.1
3	2508130.5
4	1338070.7
5	637943.1
6	611829.8
7	308716.6
8	328280.1
9	889203.7

Table 2.6.3.16 NORTH SEA HERRING. FITTED SELECTION PATTERN

Units : NA

age	2005	2006	2007	2008	2009
0	0.2001900	0.2001900	0.2001900	0.2001900	0.2001900
1	0.2225645	0.2225645	0.2225645	0.2225645	0.2225645
2	0.5237531	0.5237531	0.5237531	0.5237531	0.5237531
3	0.6927546	0.6927546	0.6927546	0.6927546	0.6927546
4	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
5	1.0857999	1.0857999	1.0857999	1.0857999	1.0857999
6	1.0475416	1.0475416	1.0475416	1.0475416	1.0475416
7	1.0198807	1.0198807	1.0198807	1.0198807	1.0198807
8	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
9	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000

Table 2.6.3.17 NORTH SEA HERRING. PREDICTED CATCH IN NUMBERS

Units : NA

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

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

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

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

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

age \ year	1997	1998	1999	2000	2001	2002	2003	2004	2005
0	431175	259526	1566349	1105085	1832691	730279	369074	715597	774407.55
1	479702	977680	303520	1171677	614469	837557	617021	206648	437216.49
2	687920	1220105	616354	622853	842635	579592	1221992	447918	368293.29
3	446909	537932	1058716	463170	485628	970577	529386	1366155	523602.23
4	284920	276333	294066	646814	278884	292205	835552	543376	1551767.94
5	109178	175817	135648	213466	321743	140701	244780	753231	454551.62
6	31389	88927	69299	82481	90918	174570	107751	169324	452855.47
7	11832	15232	27998	35706	38252	48908	123291	104945	103810.93
8	18770	16766	10174	14624	17910	34620	37671	65341	82197.43
9	5697	3784	2054	2463	2692	8702	9044	31801	58497.00

age \ year	2006	2007	2008	2009
0	1067156.70	1310824.0	517557.31	477213.53
1	278926.02	387224.2	364378.84	102179.19
2	428622.02	276194.9	298090.27	203351.36
3	287306.57	339097.7	171619.13	137685.36
4	451596.68	252273.6	237461.16	91807.44
5	982472.58	292136.3	130970.84	96151.54
6	252799.47	558634.3	133197.41	46687.51
7	257400.31	146819.9	259763.65	48246.30
8	59969.48	151869.9	69280.86	95229.76
9	43377.00	23362.0	42919.00	32737.00

Table2.6.3.18 NORTH SEA HERRING. CATCH RESIDUALS

Units : thousands NA

age	2005	2006	2007	2008
0	0.27109127	-0.19438125	-0.74707207	0.4333
1	0.49261881	-0.22776933	-0.49706800	-0.4385
2	-0.03548658	-0.06639710	-0.23151016	0.10705
3	-0.07504644	0.07796250	0.20788136	0.07383
4	-0.16278867	0.02843038	0.12458905	-0.17635
5	0.05439337	0.01546238	0.05758911	0.04886
6	0.24080196	-0.00257243	0.11893339	-0.11819
7	0.10420265	-0.04107413	0.00685632	-0.18661
8	0.07174065	0.04985443	-0.12976234	0.070467
9	0.00000000	0.00000000	0.00000000	0.000000

age	2009
0	0.3090744
1	0.5433183
2	0.2435670
3	-0.2545938
4	0.0163518
5	-0.1099863
6	-0.2071807
7	0.0964225
8	0.1477632
9	-0.0000000

Table 2.6.3.19 NORTH SEA HERRING. PREDICTED INDEX VALUES

MLAI

Units : NA NA

age	1973	1974	1975	1976	1977	1978	1979	1980
all	16.46710	10.67595	4.741524	4.486995	2.509997	3.627977	6.566046	8.33715

age	1981	1982	1983	1984	1985	1986	1987	1988
all	13.40809	20.37830	34.38535	58.69885	60.78452	58.73945	82.07175	114.7349

age	1989	1990	1991	1992	1993	1994	1995	1996
all	121.1079	113.7275	90.80888	61.27078	38.29888	41.84142	37.18153	37.23421

age	1997	1998	1999	2000	2001	2002	2003	2004
all	46.84307	64.62347	78.18756	79.47348	128.6090	162.6364	179.5752	188.0872

age	2005	2006	2007	2008	2009
all	175.3131	130.2626	97.86554	96.85693	125.3012

Table 2.6.3.19 cont NORTH SEA HERRING. PREDICTED INDEX VALUES

MIK 0-wr (IBTS0)

Units : NA NA

age \ year	1992	1993	1994	1995	1996	1997	1998	1999
0	173.3789	138.8417	97.23332	115.9805	143.0925	83.92347	79.90445	195.5136

age \ year	2000	2001	2002	2003	2004	2005	2006	2007
0	117.4839	270.5704	92.50374	53.70254	68.64275	47.03934	67.94595	87.16065

age \ year	2008	2009	2010
0	47.20005	85.84878	77.1

IBTS1: 1-5+ wr

Units : NA NA

age \ year	1984	1985	1986	1987	1988	1989
1	2222.41636	2235.61464	3930.06784	4817.24369	3752.90525	1945.39625
2	610.83850	565.84716	483.94883	908.18141	1066.14351	688.91214
3	119.03575	220.17236	192.08010	156.88819	312.51062	382.99459
4	27.99717	39.71456	60.63984	60.19739	49.95395	109.41206
5	11.67363	13.86704	16.32549	24.70814	28.64346	27.10958

age \ year	1990	1991	1992	1993	1994	1995
1	1787.26744	1789.99919	1566.51342	2409.90129	1840.54314	1461.20331
2	407.99245	358.76586	407.81438	329.08164	490.14482	441.29300
3	239.63241	143.06411	105.30258	117.74032	86.54085	124.86764
4	134.46812	87.28085	47.67986	33.12060	31.97395	22.12084
5	44.56288	66.29947	63.65899	43.73044	27.08292	18.64149

age \ year	1996	1997	1998	1999	2000	2001	2002
1	1611.13098	2529.62310	1530.87566	1488.94075	3559.5649	2129.40125	4975.48919
2	348.81493	399.12395	753.43868	414.41802	444.2875	1047.16454	630.45576
3	126.80201	130.97675	152.43503	292.10642	166.2657	180.90634	470.42982
4	29.60978	41.30001	47.04529	54.27519	101.8593	65.07211	71.72737
5	11.77317	16.83087	21.04238	25.70360	34.0194	52.76743	58.09796

age \ year	2003	2004	2005	2006	2007	2008	2009
1	1682.9921	985.8952	1236.4579	826.7349	1198.49727	1545.86030	854.40666
2	1514.9568	489.9841	294.8033	358.8681	241.04827	352.74822	467.47573
3	279.2400	680.9578	215.4816	123.5426	151.85109	103.60558	160.21930
4	198.8603	119.6774	286.0671	86.8263	50.42938	63.34504	46.55413
5	64.1161	116.3943	113.4020	162.5904	125.94343	91.89725	87.51390

age \ year	2010
1	1588.82982
2	264.81948
3	224.99907
4	77.72913
5	90.41637

Table 2.6.3.19 cont NORTH SEA HERRING. PREDICTED INDEX VALUES

Acoustic survey 1-9+ wr

Units : NA NA

age	1989	1990	1991	1992	1993	1994	1995
1	NA	NA	NA	NA	NA	NA	NA
2	5874737.75	3510900.25	2839221.82	3229434.71	2501871.2	3702864.6	3454732.50
3	5568714.61	3544827.02	2041162.19	1474961.12	1552296.7	1104932.5	1495914.53
4	2417698.04	3084803.26	2010646.33	1046008.88	678956.6	607721.7	428417.13
5	543811.90	1328037.05	1779053.36	1125132.17	507740.9	334026.8	238575.38
6	289029.52	272829.63	720469.37	850728.71	529402.4	225584.7	171035.48
7	129970.59	121012.86	144445.11	330448.65	316997.4	248048.4	97759.26
8	35172.94	56863.80	55492.46	68253.94	127569.4	122500.9	110232.13
9	37687.28	56427.63	67676.65	97431.43	146342.3	195852.3	112278.23

age	1996	1997	1998	1999	2000	2001
1	NA	10962077.00	6324089.76	6442830.60	15202634.91	9133344.17
2	3091050.15	3569505.04	6792785.68	3774101.78	4072205.11	10021866.88
3	1782360.21	1920341.97	2220389.80	4231965.26	2521967.92	2758696.27
4	693873.41	930164.59	1100052.99	1289555.73	2341256.34	1605992.97
5	207235.12	416616.12	491927.14	701926.86	776627.89	1423243.23
6	122660.77	114723.67	202552.41	258241.32	448718.09	461455.17
7	103474.80	77804.73	63238.79	95192.65	141555.68	289471.38
8	50002.29	70631.86	47274.11	39043.34	56870.06	91588.78
9	27571.88	51485.40	25623.98	18930.28	23002.94	33061.55

age	2002	2003	2004	2005	2006	2007	2008
1	21608560.7	7159575.9	4263551.5	5267228.7	3527867.7	5121962.5	6667077.4
2	5985282.5	14496900.7	4653407.7	2732865.3	3340178.3	2251522.6	3366432.7
3	7404824.9	4431899.4	10748995.2	3329555.2	1919136.5	2369958.4	1663605.0
4	1782434.3	4921332.8	2929116.5	6795319.2	2078416.1	1215346.9	1590553.6
5	1161064.2	1201279.7	3209636.7	1874657.9	4259326.4	1325940.1	827253.0
6	874990.7	823592.9	729275.2	1891358.0	1109773.9	2567271.3	851502.4
7	285081.3	508528.4	521503.6	410128.9	1068818.4	638179.3	1570197.7
8	208569.7	195344.5	330626.9	334994.9	256867.3	680921.6	431882.8
9	125905.5	112630.5	386451.2	572552.2	446210.4	251557.3	642545.3

age	2009
1	3729282.7
2	4588707.8
3	2670258.1
4	1233495.1
5	1219424.5
6	599007.0
7	585116.8
8	1190773.4
9	983098.0

Table 2.6.3.20 NORTH SEA HERRING. INDEX RESIDUALS

```
MLAI

Units  :  NA
     year
age        1973      1974       1975       1976      1977      1978    1979
  all -0.252701 -0.331851 -0.5494961 -0.6165895 0.8713111 0.6831811 0.74594
     year
age       1980       1981        1982       1983       1984      1985
  all 0.112728 0.02182936 -0.01973869 -0.2923465 -0.2394837 0.1496950
     year
age         1986       1987       1988       1989      1990        1991
  all -0.4702258 -0.2342842 0.1150229 0.04299075 0.3639796 -0.04161979
     year
age         1992      1993       1994       1995      1996      1997       1998
  all -0.4195225 -0.294815 -0.7470439 -0.5785061 0.1059321 0.1338127 0.05572738
     year
age         1999       2000        2001       2002      2003      2004
  all -0.3163752 -0.7368377 -0.04136227 -0.4406661 0.3465158 0.4924538
     year
age         2005       2006      2007      2008     2009
  all 0.04533035 -0.1416604 0.5129494 0.6270671 1.338614

MIK 0-wru

Units  :  NA
   year
age      1992      1993       1994       1995       1996      1997       1998
  0 0.1463317 0.3142161 0.04491382 0.09076468 -0.2953466 0.5679824 -0.4086546
   year
age      1999      2000       2001     2002       2003       2004      2005
  0 0.2215382 0.1544089 -0.2308249 0.559112 0.01290387 -0.3724053 0.2647956
   year
age      2006       2007      2008      2009                  2010
  0 0.2013322 -0.8514442 -0.529359 0.1096754 0.00000000000004796163

IBTS1: 1-5+ wr

Units  :  NA
   year
age        1984        1985       1986        1987       1988       1989
  1 -0.38276584 -0.06387493 -0.3892740 -0.26577226  0.1577479  0.1810745
  2 -1.33045130  0.24321071  0.4800316  0.01026292  1.3622803  0.2394941
  3 -0.66155808  0.24746092  0.3626007 -0.29923134  0.9293268 -0.1234554
  4 -0.04042330  0.05804488  0.2645843 -0.01416002  0.1485998 -0.2022130
  5 -0.13122650  0.70058040  0.5421877  0.67983915 -0.1338916 -1.1575882
   year
age       1990       1991        1992      1993        1994        1995
  1 -0.5209371 -0.3300978 -0.21129719 0.1478910 -0.04927247 -0.08230583
  2  0.1245261  0.6583889  0.06812057 0.8724572  0.86768008  1.14940325
  3  0.1548975  0.5920051  0.60629257 0.6368275  0.90095257  0.80232176
  4  0.6937856  0.9313954  0.13936358 0.3074400  0.76924311  0.50543876
  5  0.4700371  0.7900820  0.37115689 0.4045246  0.45067153 -1.04577185
   year
age       1996       1997        1998       1999        2000       2001
  1  0.1601017  0.5545898  0.39651151 -0.6819383  0.04546370 0.16020627
  2 -0.5686915  0.2383234  0.04939974  0.0837559 -0.80128932 0.07551898
  3 -1.3499144  0.2166423 -0.46593823  0.5401364 -0.07215746 0.56113999
  4 -1.0664034 -0.3020874 -0.81567702  0.5927252 -0.54880405 0.36658525
  5 -0.3765550  0.1692625 -0.16503911  0.3247589 -1.33505389 0.25778124
```

Table 2.6.3.20 cont NORTH SEA HERRING. INDEX RESIDUALS

```
   year
age        2002        2003         2004       2005      2006        2007
  1 -0.20215202  0.49648873 -0.006981622 -0.2106670 0.1090557  0.09732431
  2  0.04299597  0.02678419 -0.082872253 -0.3194401 1.4061928 -1.57231442
  3 -0.33014832  0.78448084  0.132356877  0.5020749 0.9826190 -2.11873527
  4 -1.05207841  0.59347107 -0.062966838  0.3071525 1.0642845 -1.84903859
  5 -1.06960349 -0.18727631  0.386029785  0.1479233 0.7342081 -1.11535780
   year
age       2008       2009         2010
  1  0.1609786  1.0092730 -0.279413690
  2 -0.4151196 -1.2327166 -1.675965226
  3  0.3443297 -2.0103994 -1.864957031
  4  1.1601661 -1.4226505 -0.525806825
  5  0.9275092 -0.6339164 -0.005304806

Acoustic survey 1-9+ wr
Units  :  NA
   year
age        1989         1990        1991         1992        1993       1994
  1          NA           NA          NA           NA          NA         NA
  2 -0.36211645 -0.060133488 -0.07502641  0.145172935  0.17622574 -0.1506545
  3 -0.35541877 -0.006744322 -0.18289110 -0.067998456  0.05312975 -0.2753288
  4 -0.39239705  0.101396742 -0.02602209  0.092167982  0.28405733 -0.4207556
  5 -0.10012470  0.028184813  0.03856355  0.007850696  0.37802934  0.1315780
  6 -0.02108192  0.362414317 -0.11220418  0.381600415  0.38369162  0.3527454
  7 -0.07981649  0.551210699  0.45644603  0.178434495  0.55284127  0.2732734
  8  0.22391262  0.849690249  0.52704771  0.512963272  0.34429647  0.5809531
  9 -0.53828022 -0.271758878 -0.28291555  0.065242007 -0.23235795 -0.4021637
   year
age       1995       1996        1997        1998       1999        2000
  1         NA         NA -0.15788965 -0.35168676 -0.2362797  0.48679091
  2  0.1080683  0.3748996  0.51264354 -0.16718314 -0.2038824 -0.33157416
  3  0.3107021  0.4602159  0.42420417  0.12657614  0.1102011 -0.15678487
  4  0.4501610  0.4488873  0.43773104  0.39014947 -0.1445469  0.29353512
  5  0.2257583  0.4059389  0.36642972  0.69126070 -0.3272925  0.25976957
  6  0.1713349 -0.2143027  0.62811167  0.78707560  0.1954985  0.07362183
  7  0.3447458 -0.2204875 -0.52556087  0.98888049  0.3785712  0.63080314
  8  0.0765351  0.9782804  0.09922756 -0.04930039  0.3243118  0.74672278
  9 -0.1883805  2.0110799  1.12760597  1.55226194  1.5251451  1.43908880
   year
age        2001       2002       2003        2004        2005         2006
  1 -0.28958287  0.0647931  0.3169271  0.19541660 -0.52556418  0.659576296
  2  0.20401653 -0.2051834  0.2678374 -0.30915878 -0.28502610  0.121660707
  3  0.11114494  0.1044384 -0.3635740 -0.15650050  0.09147739  0.039870840
  4 -0.09393688 -0.2486763 -0.1611412 -0.30121869 -0.16017082  0.009140065
  5  0.16347177 -0.3792535 -0.5762818 -0.21422966 -0.43541200 -0.019972721
  6 -0.02513733  0.1640712 -0.5095228 -0.83283392 -0.47611204 -0.585099538
  7 -0.53225799 -0.1539683  0.1111285 -0.46492277 -1.07554359 -0.642629250
  8  0.06765869 -0.5444826 -0.2945884  0.03396641 -0.97387303 -1.114177892
  9  0.57916635  0.1717648  0.4559841 -0.73341183 -1.68008272 -1.846597242
   year
age       2007        2008        2009
  1  0.2008022 -0.58507213  0.22172599
  2  0.1999942 -0.16548257  0.20486616
  3 -0.2487684  0.02692145 -0.04490600
  4 -0.3026147 -0.06866737 -0.18711224
  5 -0.4977932 -0.02231170 -0.12419960
  6 -0.6629417 -0.17892443  0.11795684
  7 -0.9655578  0.10784265  0.08652684
  8 -1.4995667 -0.84779836 -0.04182193
  9 -1.3532833 -0.86701530 -0.53113498
```

Table 2.6.3.21 NORTH SEA HERRING. FIT PARAMETERS

	Value	Std.dev
F, 2005	0.385127198213	0.09613405
F, 2006	0.367036162732	0.09915385
F, 2007	0.351132303949	0.10581213
F, 2008	0.254591035684	0.11151484
F, 2009	0.128119579604	0.11382501
Selectivity at age 0	0.200188955568	0.32533050
Selectivity at age 1	0.222563544460	0.32000737
Selectivity at age 2	0.523752110371	0.09499432
Selectivity at age 3	0.692753647255	0.09379766
Selectivity at age 5	1.085798901158	0.09739734
Selectivity at age 6	1.047540564799	0.10462344
Selectivity at age 7	1.019879672369	0.12077228
Terminal year pop, age 0	29750664.775947965682	0.20554052
Terminal year pop, age 1	5736544.837425526232	0.15621731
Terminal year pop, age 2	3620604.248853356112	0.11284001
Terminal year pop, age 3	1786010.494761534734	0.10329279
Terminal year pop, age 4	801406.638239621185	0.09961968
Terminal year pop, age 5	777097.731002684333	0.10373307
Terminal year pop, age 6	390189.555837564636	0.11325649
Terminal year pop, age 7	413448.265405998507	0.13402472
Terminal year pop, age 8	831280.826170201995	0.14939942
Last true age pop, 2005	269367.432158573240	0.23782458
Last true age pop, 2006	204500.320499489084	0.18781756
Last true age pop, 2007	537384.007890093839	0.16594734
Last true age pop, 2008	323216.038465606631	0.15807537
Recruitment prediction	26718800.770215295255	0.29473292
Index 1, biomass, K	1.187890633621	0.04851129
Index 1, biomass, Q	0.000006913480	0.63846018
Index 2, age 0 numbers, Q	0.000003280323	0.07021656
Index 3, age 1 numbers, Q	0.000169374865	0.06535943
Index 3, age 2 numbers, Q	0.000135178236	0.08359855
Index 3, age 3 numbers, Q	0.000093004986	0.43744271
Index 3, age 4 numbers, Q	0.000059770748	0.43744781
Index 3, age 5 numbers, Q	0.000033395953	0.43762484
Index 4, age 1 numbers, Q	1.144584816555	0.08280620
Index 4, age 2 numbers, Q	1.550944668965	0.06453140
Index 4, age 3 numbers, Q	1.752434716953	0.12106803
Index 4, age 4 numbers, Q	1.744911072122	0.15747953
Index 4, age 5 numbers, Q	1.789755813060	0.16616129
Index 4, age 6 numbers, Q	1.746221737158	0.17651591
Index 4, age 7 numbers, Q	1.606638121615	0.18916946
Index 4, age 8 numbers, Q	1.623940761397	0.18985950
Index 4, age 9 numbers, Q	3.900063619777	0.22274145
SRR, a	55355510.369478613138	0.22186003
SRR, b	373888.386506047042	0.49121475

	Lower.95.pct.CL	Upper.95.pct.CL
F, 2005	0.318987187053	0.464980929717
F, 2006	0.302209000622	0.445769465753
F, 2007	0.285365640411	0.432055851919
F, 2008	0.204606656695	0.316786347510
F, 2009	0.102500433820	0.160142021514
Selectivity at age 0	0.105806707731	0.378762545314
Selectivity at age 1	0.118866165506	0.416725239781
Selectivity at age 2	0.434775422724	0.630937856146
Selectivity at age 3	0.576416815284	0.832570464740
Selectivity at age 5	0.897104646068	1.314182530346
Selectivity at age 6	0.853323253284	1.285961950147
Selectivity at age 7	0.804906620008	1.292267351585

Table 2.6.3.21 cont NORTH SEA HERRING. FIT PARAMETERS

Terminal year pop, age 0	19885524.584381010383	44509867.006778903306
Terminal year pop, age 1	4223529.525653629564	7791574.907174505293
Terminal year pop, age 2	2902215.815435534809	4516816.102060881443
Terminal year pop, age 3	1458677.919247438433	2186797.678437500261
Terminal year pop, age 4	659257.309930498479	974206.262320003589
Terminal year pop, age 5	634127.041059679817	952302.684522622381
Terminal year pop, age 6	312514.211422734486	487171.091489250481
Terminal year pop, age 7	317934.041069948929	537657.017134634079
Terminal year pop, age 8	620263.766213852679	1114087.021681616316
Last true age pop, 2005	169007.009622987913	429324.284652831906
Last true age pop, 2006	141520.859389644756	295506.833867162059
Last true age pop, 2007	388174.952823438973	743946.949269991834
Last true age pop, 2008	237102.664803775988	440604.948948413483
Recruitment prediction	14994611.978768020868	47610055.906035661697
Index 1, biomass, K	1.092808496111	1.282972771131
Index 1, biomass, Q	0.000001978010	0.000024163786
Index 2, age 0 numbers, Q	0.000002858558	0.000003764317
Index 3, age 1 numbers, Q	0.000149009477	0.000192523625
Index 3, age 2 numbers, Q	0.000114748297	0.000159245548
Index 3, age 3 numbers, Q	0.000039459128	0.000219212333
Index 3, age 4 numbers, Q	0.000025358619	0.000140880790
Index 3, age 5 numbers, Q	0.000014163809	0.000078742214
Index 4, age 1 numbers, Q	0.973109962404	1.346275809419
Index 4, age 2 numbers, Q	1.366677582662	1.760056209823
Index 4, age 3 numbers, Q	1.382250189612	2.221759461683
Index 4, age 4 numbers, Q	1.281515952632	2.375869487509
Index 4, age 5 numbers, Q	1.292273489051	2.478752290070
Index 4, age 6 numbers, Q	1.235509277157	2.468043269040
Index 4, age 7 numbers, Q	1.108903554341	2.327782288839
Index 4, age 8 numbers, Q	1.119330947209	2.356035632807
Index 4, age 9 numbers, Q	2.520405073069	6.034941129439
SRR, a	35835196.713758006692	85509019.323703631759
SRR, b	142761.643774853059	979202.269375376636

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

Units : kg

, , unit = A

age	2007	2008	2009	2010	2011	2012
0	0.01152138	0.01152138	0.01152138	0.01152138	0.01152138	0.01152138
1	0.07879672	0.07879672	0.07879672	0.07879672	0.07879672	0.07879672
2	0.14580705	0.14580705	0.14580705	0.14580705	0.14580705	0.14580705
3	0.17107554	0.17107554	0.17107554	0.17107554	0.17107554	0.17107554
4	0.18676667	0.18676667	0.18676667	0.18676667	0.18676667	0.18676667
5	0.19763333	0.19763333	0.19763333	0.19763333	0.19763333	0.19763333
6	0.21491004	0.21491004	0.21491004	0.21491004	0.21491004	0.21491004
7	0.22763333	0.22763333	0.22763333	0.22763333	0.22763333	0.22763333
8	0.24640000	0.24640000	0.24640000	0.24640000	0.24640000	0.24640000
9	0.26603333	0.26603333	0.26603333	0.26603333	0.26603333	0.26603333

, , unit = B

age	2007	2008	2009	2010	2011	2012
0	0.008804865	0.008804865	0.008804865	0.008804865	0.008804865	0.008804865
1	0.040531107	0.040531107	0.040531107	0.040531107	0.040531107	0.040531107
2	0.028570083	0.028570083	0.028570083	0.028570083	0.028570083	0.028570083
3	0.049733333	0.049733333	0.049733333	0.049733333	0.049733333	0.049733333
4	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000
5	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000
6	0.104000000	0.104000000	0.104000000	0.104000000	0.104000000	0.104000000
7	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000
8	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000
9	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000	0.000000000

, , unit = C

age	2007	2008	2009	2010	2011	2012
0	0.03406046	0.03406046	0.03406046	0.03406046	0.03406046	0.03406046
1	0.07591265	0.07591265	0.07591265	0.07591265	0.07591265	0.07591265
2	0.08795673	0.08795673	0.08795673	0.08795673	0.08795673	0.08795673
3	0.10020704	0.10020704	0.10020704	0.10020704	0.10020704	0.10020704
4	0.15616340	0.15616340	0.15616340	0.15616340	0.15616340	0.15616340
5	0.10656046	0.10656046	0.10656046	0.10656046	0.10656046	0.10656046
6	0.11818727	0.11818727	0.11818727	0.11818727	0.11818727	0.11818727
7	0.12597492	0.12597492	0.12597492	0.12597492	0.12597492	0.12597492
8	0.20374032	0.20374032	0.20374032	0.20374032	0.20374032	0.20374032
9	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

, , unit = D

age	2007	2008	2009	2010	2011	2012
0	0.01514308	0.01514308	0.01514308	0.01514308	0.01514308	0.01514308
1	0.02438693	0.02438693	0.02438693	0.02438693	0.02438693	0.02438693
2	0.07739506	0.07739506	0.07739506	0.07739506	0.07739506	0.07739506
3	0.09832758	0.09832758	0.09832758	0.09832758	0.09832758	0.09832758
4	0.15008163	0.15008163	0.15008163	0.15008163	0.15008163	0.15008163
5	0.11052221	0.11052221	0.11052221	0.11052221	0.11052221	0.11052221
6	0.11736989	0.11736989	0.11736989	0.11736989	0.11736989	0.11736989
7	0.11644276	0.11644276	0.11644276	0.11644276	0.11644276	0.11644276
8	0.21250198	0.21250198	0.21250198	0.21250198	0.21250198	0.21250198
9	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000

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

Units : kg

, , unit = A

age \ year	2007	2008	2009	2010	2011	2012
0	0.007	0.007	0.007	0.007	0.007	0.007
1	0.061	0.061	0.061	0.061	0.061	0.061
2	0.137	0.137	0.137	0.137	0.137	0.137
3	0.181	0.181	0.181	0.181	0.181	0.181
4	0.197	0.197	0.197	0.197	0.197	0.197
5	0.210	0.210	0.210	0.210	0.210	0.210
6	0.223	0.223	0.223	0.223	0.223	0.223
7	0.234	0.234	0.234	0.234	0.234	0.234
8	0.255	0.255	0.255	0.255	0.255	0.255
9	0.259	0.259	0.259	0.259	0.259	0.259

, , unit = B

age \ year	2007	2008	2009	2010	2011	2012
0	0.007	0.007	0.007	0.007	0.007	0.007
1	0.061	0.061	0.061	0.061	0.061	0.061
2	0.137	0.137	0.137	0.137	0.137	0.137
3	0.181	0.181	0.181	0.181	0.181	0.181
4	0.197	0.197	0.197	0.197	0.197	0.197
5	0.210	0.210	0.210	0.210	0.210	0.210
6	0.223	0.223	0.223	0.223	0.223	0.223
7	0.234	0.234	0.234	0.234	0.234	0.234
8	0.255	0.255	0.255	0.255	0.255	0.255
9	0.259	0.259	0.259	0.259	0.259	0.259

, , unit = C

age \ year	2007	2008	2009	2010	2011	2012
0	0.007	0.007	0.007	0.007	0.007	0.007
1	0.061	0.061	0.061	0.061	0.061	0.061
2	0.137	0.137	0.137	0.137	0.137	0.137
3	0.181	0.181	0.181	0.181	0.181	0.181
4	0.197	0.197	0.197	0.197	0.197	0.197
5	0.210	0.210	0.210	0.210	0.210	0.210
6	0.223	0.223	0.223	0.223	0.223	0.223
7	0.234	0.234	0.234	0.234	0.234	0.234
8	0.255	0.255	0.255	0.255	0.255	0.255
9	0.259	0.259	0.259	0.259	0.259	0.259

, , unit = D

age \ year	2007	2008	2009	2010	2011	2012
0	0.007	0.007	0.007	0.007	0.007	0.007
1	0.061	0.061	0.061	0.061	0.061	0.061
2	0.137	0.137	0.137	0.137	0.137	0.137
3	0.181	0.181	0.181	0.181	0.181	0.181
4	0.197	0.197	0.197	0.197	0.197	0.197
5	0.210	0.210	0.210	0.210	0.210	0.210
6	0.223	0.223	0.223	0.223	0.223	0.223
7	0.234	0.234	0.234	0.234	0.234	0.234
8	0.255	0.255	0.255	0.255	0.255	0.255
9	0.259	0.259	0.259	0.259	0.259	0.259

Table 2.7.3 NORTH SEA HERRING. STOCK IN NUMBER

```
Units  :  NA
, , unit = A

   year
age             2007             2008             2009             2010
  0 29750665.7759480 29750665.7759480 29750665.7759480 26718800.7702153
  1 5736545.83742553 5736545.83742553 5736545.83742553 10667514.0976044
  2 3620605.24885336 3620605.24885336 3620605.24885336 2051030.11133305
  3 1786011.49476153 1786011.49476153 1786011.49476153 2508130.50174983
  4 801407.638239621 801407.638239621 801407.638239621 1338070.68818545
  5 777098.731002684 777098.731002684 777098.731002684 637943.135251247
  6 390190.555837565 390190.555837565 390190.555837565 611829.773870712
  7 413449.265405999 413449.265405999 413449.265405999  308716.56545844
  8 831281.826170202 831281.826170202 831281.826170202 328280.067557337
  9 285768.574946912 285768.574946912 285768.574946912 889203.697493638

, , unit = B

   year
age             2007             2008             2009             2010
  0 29750665.7759480 29750665.7759480 29750665.7759480 26718800.7702153
  1 5736545.83742553 5736545.83742553 5736545.83742553 10667514.0976044
  2 3620605.24885336 3620605.24885336 3620605.24885336 2051030.11133305
  3 1786011.49476153 1786011.49476153 1786011.49476153 2508130.50174983
  4 801407.638239621 801407.638239621 801407.638239621 1338070.68818545
  5 777098.731002684 777098.731002684 777098.731002684 637943.135251247
  6 390190.555837565 390190.555837565 390190.555837565 611829.773870712
  7 413449.265405999 413449.265405999 413449.265405999  308716.56545844
  8 831281.826170202 831281.826170202 831281.826170202 328280.067557337
  9 285768.574946912 285768.574946912 285768.574946912 889203.697493638

, , unit = C

   year
age             2007             2008             2009             2010
  0 29750665.7759480 29750665.7759480 29750665.7759480 26718800.7702153
  1 5736545.83742553 5736545.83742553 5736545.83742553 10667514.0976044
  2 3620605.24885336 3620605.24885336 3620605.24885336 2051030.11133305
  3 1786011.49476153 1786011.49476153 1786011.49476153 2508130.50174983
  4 801407.638239621 801407.638239621 801407.638239621 1338070.68818545
  5 777098.731002684 777098.731002684 777098.731002684 637943.135251247
  6 390190.555837565 390190.555837565 390190.555837565 611829.773870712
  7 413449.265405999 413449.265405999 413449.265405999  308716.56545844
  8 831281.826170202 831281.826170202 831281.826170202 328280.067557337
  9 285768.574946912 285768.574946912 285768.574946912 889203.697493638

, , unit = D

   year
age             2007             2008             2009             2010
  0 29750665.7759480 29750665.7759480 29750665.7759480 26718800.7702153
  1 5736545.83742553 5736545.83742553 5736545.83742553 10667514.0976044
  2 3620605.24885336 3620605.24885336 3620605.24885336 2051030.11133305
  3 1786011.49476153 1786011.49476153 1786011.49476153 2508130.50174983
  4 801407.638239621 801407.638239621 801407.638239621 1338070.68818545
  5 777098.731002684 777098.731002684 777098.731002684 637943.135251247
  6 390190.555837565 390190.555837565 390190.555837565 611829.773870712
  7 413449.265405999 413449.265405999 413449.265405999  308716.56545844
  8 831281.826170202 831281.826170202 831281.826170202 328280.067557337
  9 285768.574946912 285768.574946912 285768.574946912 889203.697493638
```

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

Units : f

, , unit = A

age \ year	2007	2008	2009	2010
0	0.00156070868083701	0.00156070868083701	0.00156070868083701	0.00167089470581655
1	0.00338698162266224	0.00338698162266224	0.00338698162266224	0.00362610250810498
2	0.0620318086713087	0.0620318086713087	0.0620318086713087	0.066411254050005
3	0.0881207102541039	0.0881207102541039	0.0881207102541039	0.0943420319526968
4	0.127826965443445	0.127826965443445	0.127826965443445	0.136851548557737
5	0.139113312670730	0.139113312670730	0.139113312670730	0.148934711842229
6	0.133531163721803	0.133531163721803	0.133531163721803	0.142958463205719
7	0.130667702871240	0.130667702871240	0.130667702871240	0.139892842033578
8	0.128003390715097	0.128003390715097	0.128003390715097	0.137040429452675
9	0.128120579604428	0.128120579604428	0.128120579604428	0.137165891877001

, , unit = B

age \ year	2007	2008	2009	2010
0	0.0194811225126470	0.0194811225126470	0.0194811225126470	0.0248745136684416
1	0.0125628994748669	0.0125628994748669	0.0125628994748669	0.0160409655295769
2	0.00326001816487143	0.00326001816487143	0.00326001816487143	0.0041625612871547
3	0.000348704273353532	0.000348704273353532	0.000348704273353532	0.000445243810162654
4	0	0	0	0
5	0	0	0	0
6	0.000680468719928342	0.000680468719928342	0.000680468719928342	0.00086885796564423
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0

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

, , unit = C

age	2007	2008	2009	2010
0	3.81742341369332e-05	3.81742341369332e-05	3.81742341369332e-05	3.63825792911134e-05
1	0.00804133193045392	0.00804133193045392	0.00804133193045392	0.00766392314555563
2	0.00165724202904424	0.00165724202904424	0.00165724202904424	0.00157946166804518
3	0.000280431647202209	0.000280431647202209	0.000280431647202209	0.000267269975960062
4	0.000287916774285392	0.000287916774285392	0.000287916774285392	0.000274403798963062
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0.000117074670141016	0.000117074670141016	0.000117074670141016	0.000111579932530080
9	0	0	0	0

, , unit = D

age	2007	2008	2009	2010
0	0.00456844771075710	0.00456844771075710	0.00456844771075710	0.00231469852043537
1	0.00452388540759208	0.00452388540759208	0.00452388540759208	0.00229212010786858
2	0.000154483205169990	0.000154483205169990	0.000154483205169990	7.82721110273642e-05
3	6.28075533291741e-06	6.28075533291741e-06	6.28075533291741e-06	3.18227459232781e-06
4	5.69738669777811e-06	5.69738669777811e-06	5.69738669777811e-06	2.8866988077028e-06
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	1.14219190381479e-07	1.14219190381479e-07	1.14219190381479e-07	5.78715151666955e-08
9	0	0	0	0

Table 2.7.5 NORTH SEA HERRING. NATURAL MORTALITY

Units : NA

, , unit = A

age \ year	2007	2008	2009	2010	2011	2012
0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1

, , unit = B

age \ year	2007	2008	2009	2010	2011	2012
0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1

, , unit = C

age \ year	2007	2008	2009	2010	2011	2012
0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1

, , unit = D

age \ year	2007	2008	2009	2010	2011	2012
0	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1

Table 2.7.6 NORTH SEA HERRING. PROPORTION MATURE

```
Units  :  NA
, , unit = A

   year
age      2007      2008      2009      2010      2011      2012
  0 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  1 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  2 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000
  3 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667
  4 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333
  5 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  6 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  7 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  8 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  9 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000

, , unit = B

   year
age      2007      2008      2009      2010      2011      2012
  0 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  1 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  2 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000
  3 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667
  4 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333
  5 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  6 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  7 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  8 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  9 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000

, , unit = C

   year
age      2007      2008      2009      2010      2011      2012
  0 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  1 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  2 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000
  3 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667
  4 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333
  5 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  6 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  7 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  8 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  9 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000

, , unit = D

   year
age      2007      2008      2009      2010      2011      2012
  0 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  1 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000 0.0000000
  2 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000 0.8200000
  3 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667 0.9666667
  4 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333 0.9733333
  5 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  6 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  7 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  8 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
  9 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000 1.0000000
```

Table 2.7.7 NORTH SEA HERRING. FRACTION OF HARVEST BEFORE SPAWNING

```
Units  :  NA
, , unit = A

   year
age 2007 2008 2009 2010 2011 2012
  0 0.67 0.67 0.67 0.67 0.67 0.67
  1 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = B

   year
age 2007 2008 2009 2010 2011 2012
  0 0.67 0.67 0.67 0.67 0.67 0.67
  1 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = C

   year
age 2007 2008 2009 2010 2011 2012
  0 0.67 0.67 0.67 0.67 0.67 0.67
  1 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67

, , unit = D

   year
age 2007 2008 2009 2010 2011 2012
  0 0.67 0.67 0.67 0.67 0.67 0.67
  1 0.67 0.67 0.67 0.67 0.67 0.67
  2 0.67 0.67 0.67 0.67 0.67 0.67
  3 0.67 0.67 0.67 0.67 0.67 0.67
  4 0.67 0.67 0.67 0.67 0.67 0.67
  5 0.67 0.67 0.67 0.67 0.67 0.67
  6 0.67 0.67 0.67 0.67 0.67 0.67
  7 0.67 0.67 0.67 0.67 0.67 0.67
  8 0.67 0.67 0.67 0.67 0.67 0.67
  9 0.67 0.67 0.67 0.67 0.67 0.67
```

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

Units : NA

, , unit = A

age \ year	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = B

age \ year	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = C

age \ year	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

, , unit = D

age \ year	2007	2008	2009	2010	2011	2012
0	0.67	0.67	0.67	0.67	0.67	0.67
1	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67

Table 2.7.9 NORTH SEA HERRING. Recruitment in 2011

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23139412
```

Table 2.7.10 NORTH SEA HERRING. Recruitment in 2012

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23139412
```

Table 2.7.11 NORTH SEA HERRING. FLR, R SOFTWARE VERSIONS

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

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

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

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

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

Outlook assuming a TAC constraint for fleet A in 2010, proportion of 2009 by-catch ceiling taken applied to 2010 for fleet B

Basis: Intermediate year (2010) 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 2010
0.118	0.02	0.004	0.002	0.029	0.12	165.2[1]	8.3	4.3	1.0	1317

[1]Includes a transfer of 20% of the Norwegian quota from the C-fleet to the A-fleet

Scenarios for prediction year (2011)

	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 2011**[1)]	**SSB 2012**	**%SSB change** [2)]	**%TAC change fleet A** [3)]
a	0	0	0	0	0	0	0	0	0	0	1608	1959	22%	-100%
b	0.223	0.042	0.002	0.001	0.050	0.225	337.9	15.4	1.7	0.5	1384	1401	5%	+106%
c	0.102	0.045	0.002	0.001	0.050	0.105	164.3	16.3	1.7	0.5	1499	1666	14%	0%
d	0.248	0.042	0.002	0.001	0.050	0.25	371.2	15.2	1.7	0.5	1361	1353	3%	+126%
e	0.086	0.045	0.002	0.001	0.050	0.089	139.7	16.5	1.7	0.5	1515	1706	15%	-15%
f	0.118	0.044	0.002	0.001	0.050	0.121	188.9	16.2	1.7	0.5	1483	1627	13%	+15%
g	0.248	0.042	0.002	0.001	0.050	0.25	371.2	15.2	1.7	0.5	1361	1353	3%	+126%

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 (2011) relative to SSB (2010).

[3)] Calculated landings (2010) relative to TAC 2009.

Table 2.14.1 North Sea Herring. Comparison of projections using the normal protocol and the recruitment from CDR-ARM (taken fromGröger et al., 2010). Note the management options described are all similar in there impact on the B fleet catches.

Recruitment from CDR ARM				
	Catch A	Catch B	SSB 2010	
intermediate year	165203	8329	1317215	
	Catch A	Catch B	SSB 2011	SSB 2012
mp	338279	19923	1383526	1400987
-15%	139655	21322	1515265	1706099
15%	188945	20990	1483050	1627640
fmsy	371569	19653	1360923	1352754

Geometric mean				
	Catch A	Catch B	SSB 2010	
intermediate year	164300	8329	1317215	
	Catch A	Catch B	SSB 2011	SSB 2012
mp	337894	15359	1383562	1401066
-15%	139655	16477	1515190	1705892
15%	188945	16218	1482941	1627356
fmsy	371191	15176	1360924	1352737

% difference CRD ARM & Geo mean recruitment				
	Catch A	Catch B	SSB 2010	
intermediate year	0.5466	0	0	
	Catch A	Catch B	SSB 2011	SSB 2012
mp	0.11	22.91	0.00	-0.01
-15%	0.00	22.72	0.00	0.01
15%	0.00	22.73	0.01	0.02
fmsy	0.10	22.78	0.00	0.00

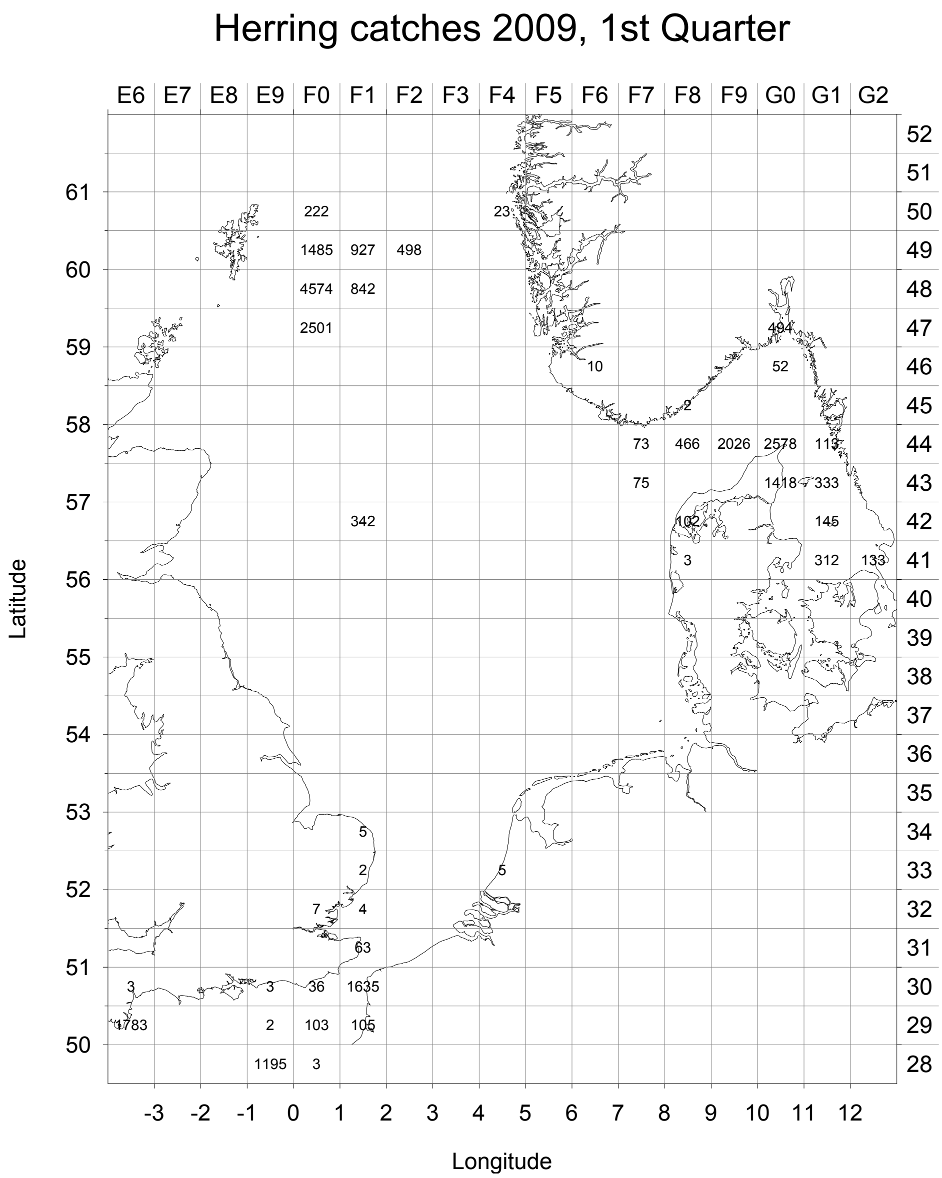


Figure 2.1.1a: : Herring catches in the 1st quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2009 by statistical rectangle. Working group estimates (if available).

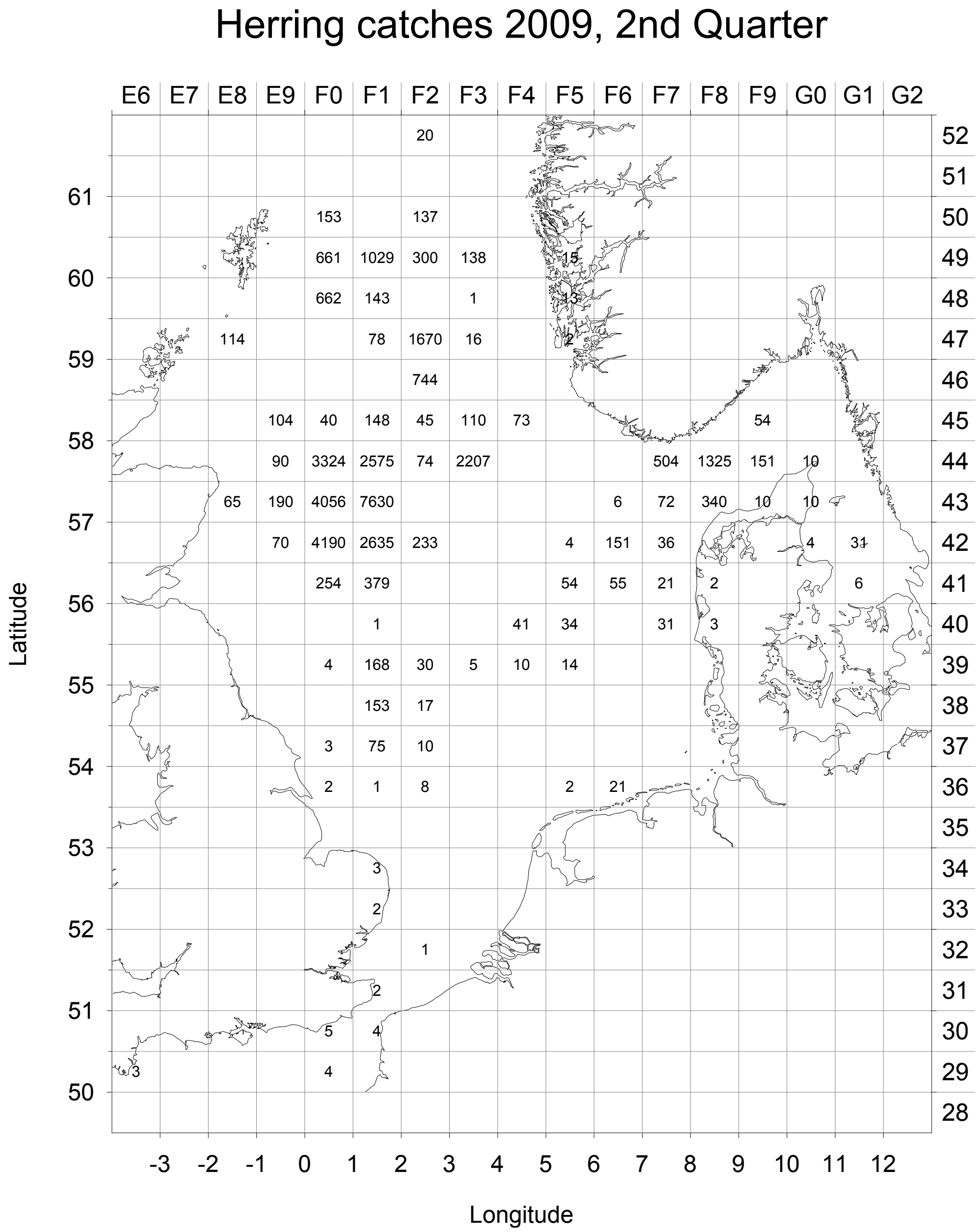


Figure 2.1.1b: Herring catches in the 2nd quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2009 by statistical rectangle. Working group estimates (if available).

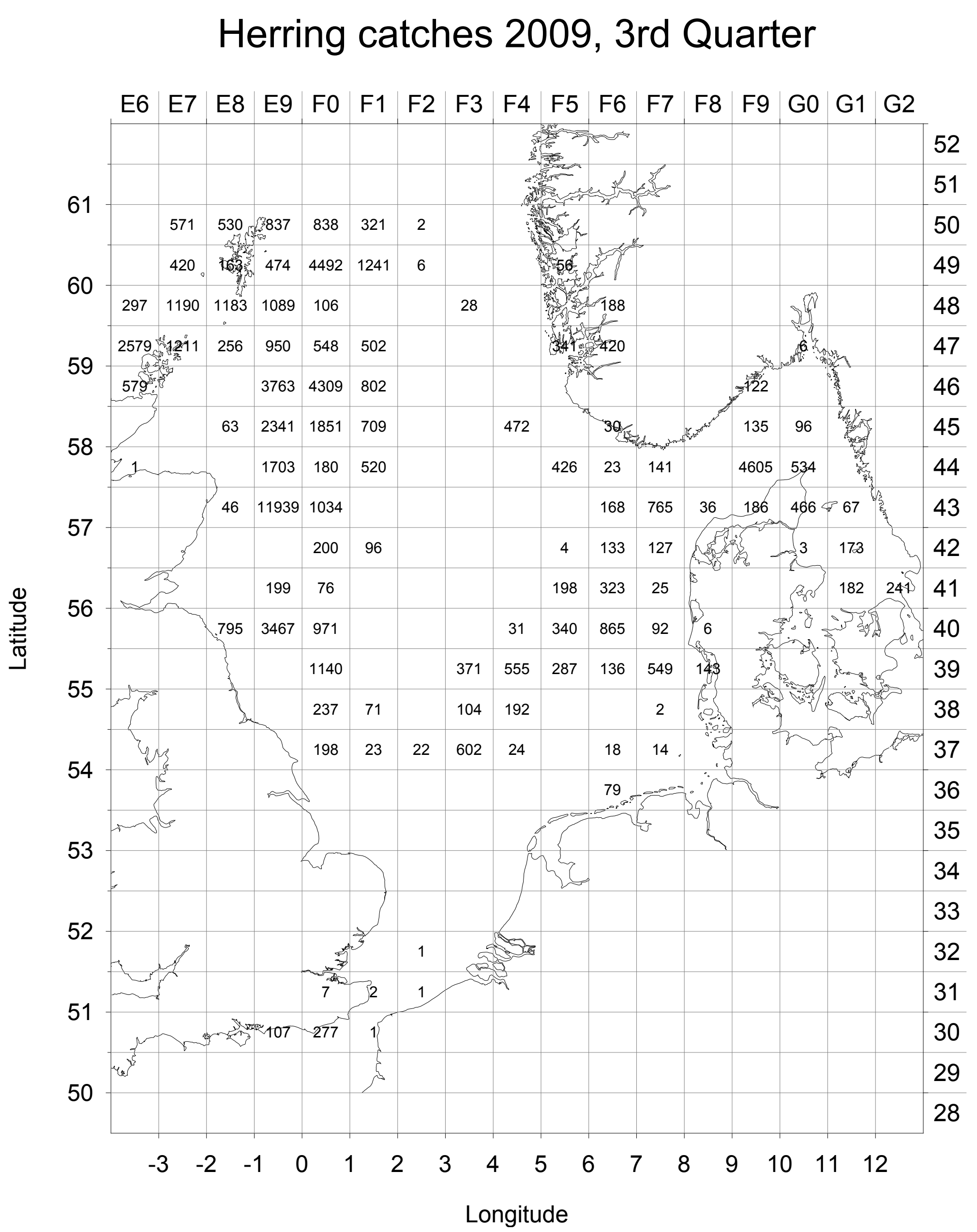


Figure 2.1.1c: Herring catches in the 3rd quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2009 by statistical rectangle. Working group estimates (if available).

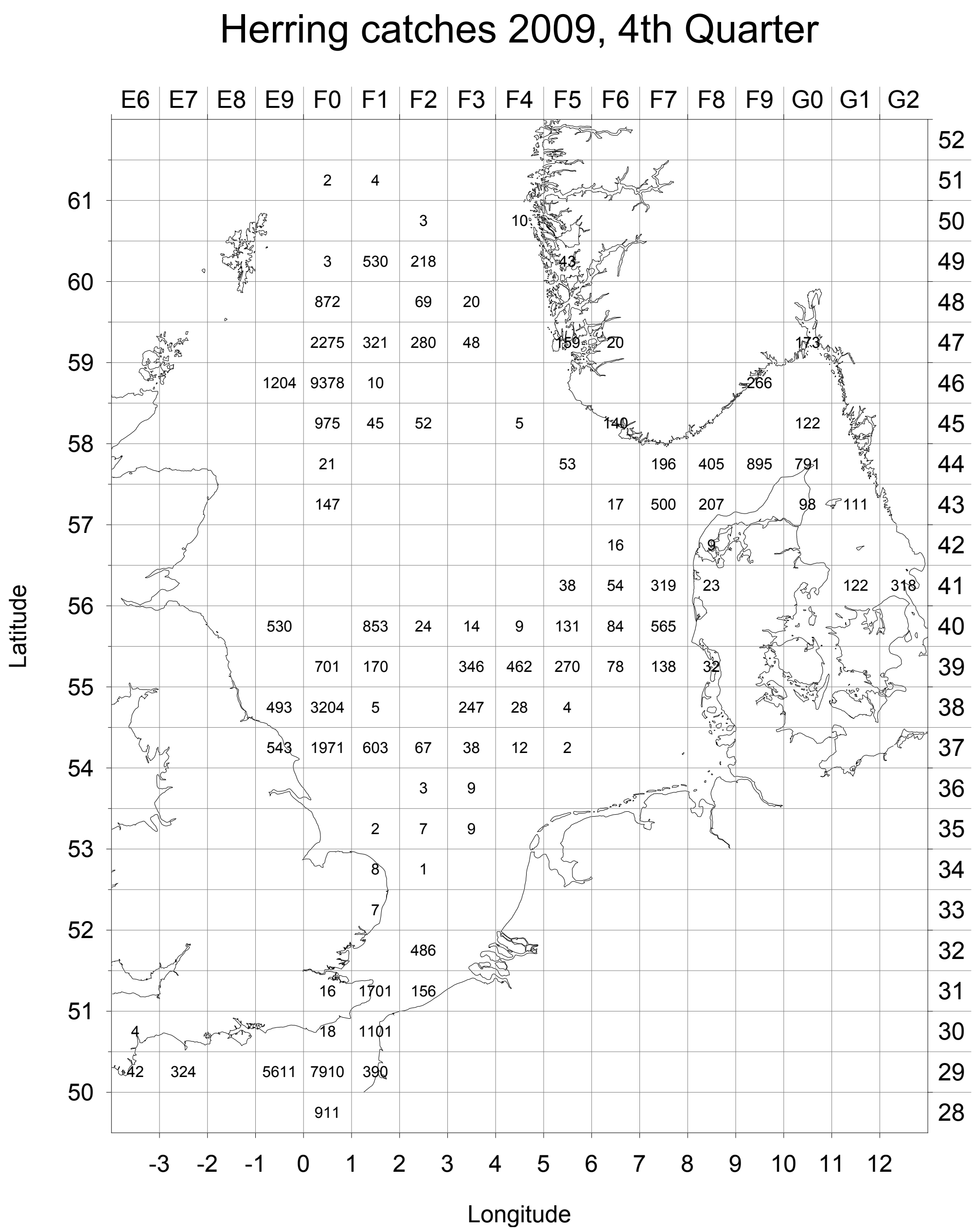


Figure 2.1.1d: Herring catches in the 4th quarter in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2009 by statistical rectangle. Working group estimates (if available).

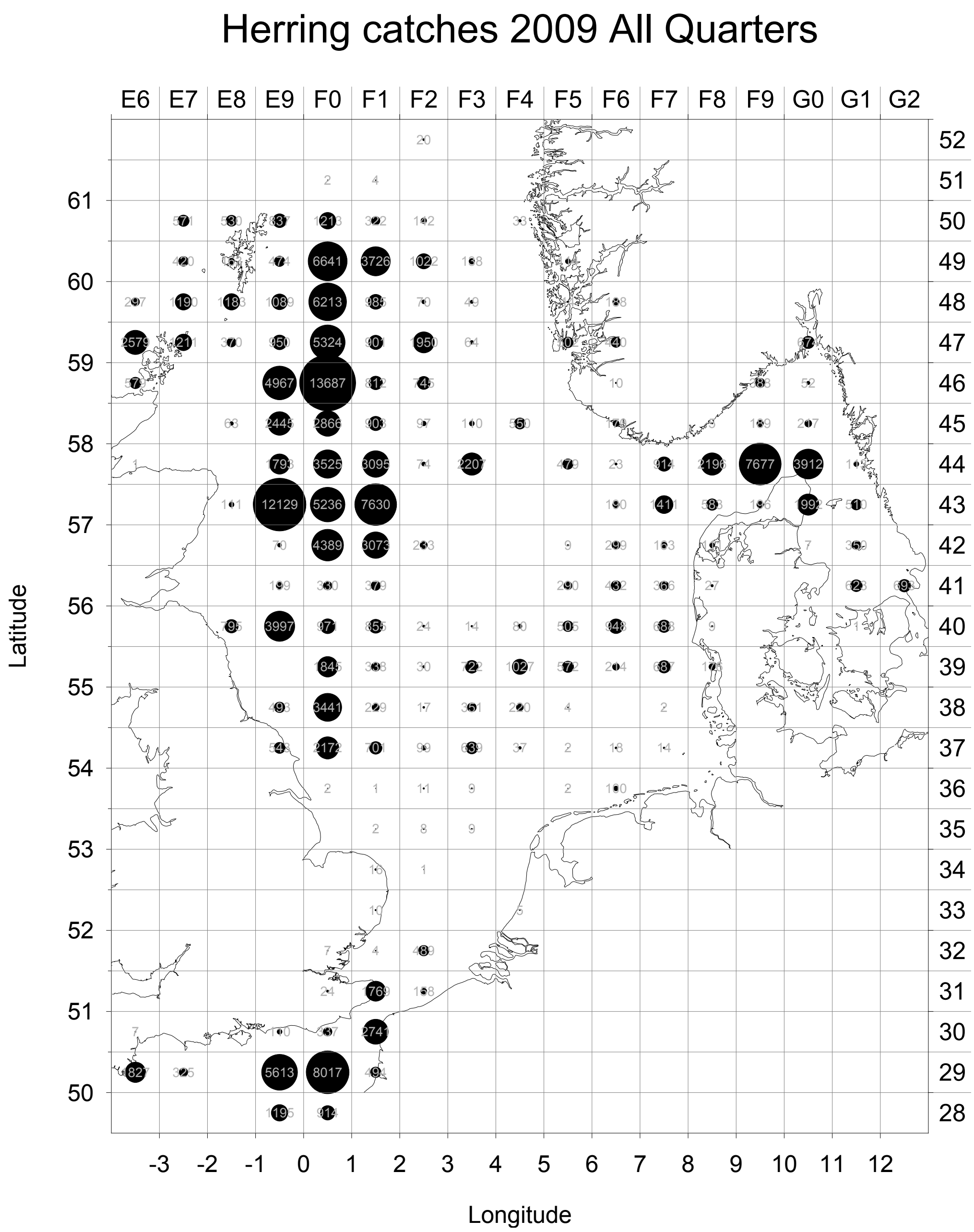


Figure 2.1.1e: Herring catches in all quarters in the North Sea, in Div VIId, Div IIIa, SD 22 and SD 24 (in tonnes) in 2009 by statistical rectangle. Working group estimates (if available).

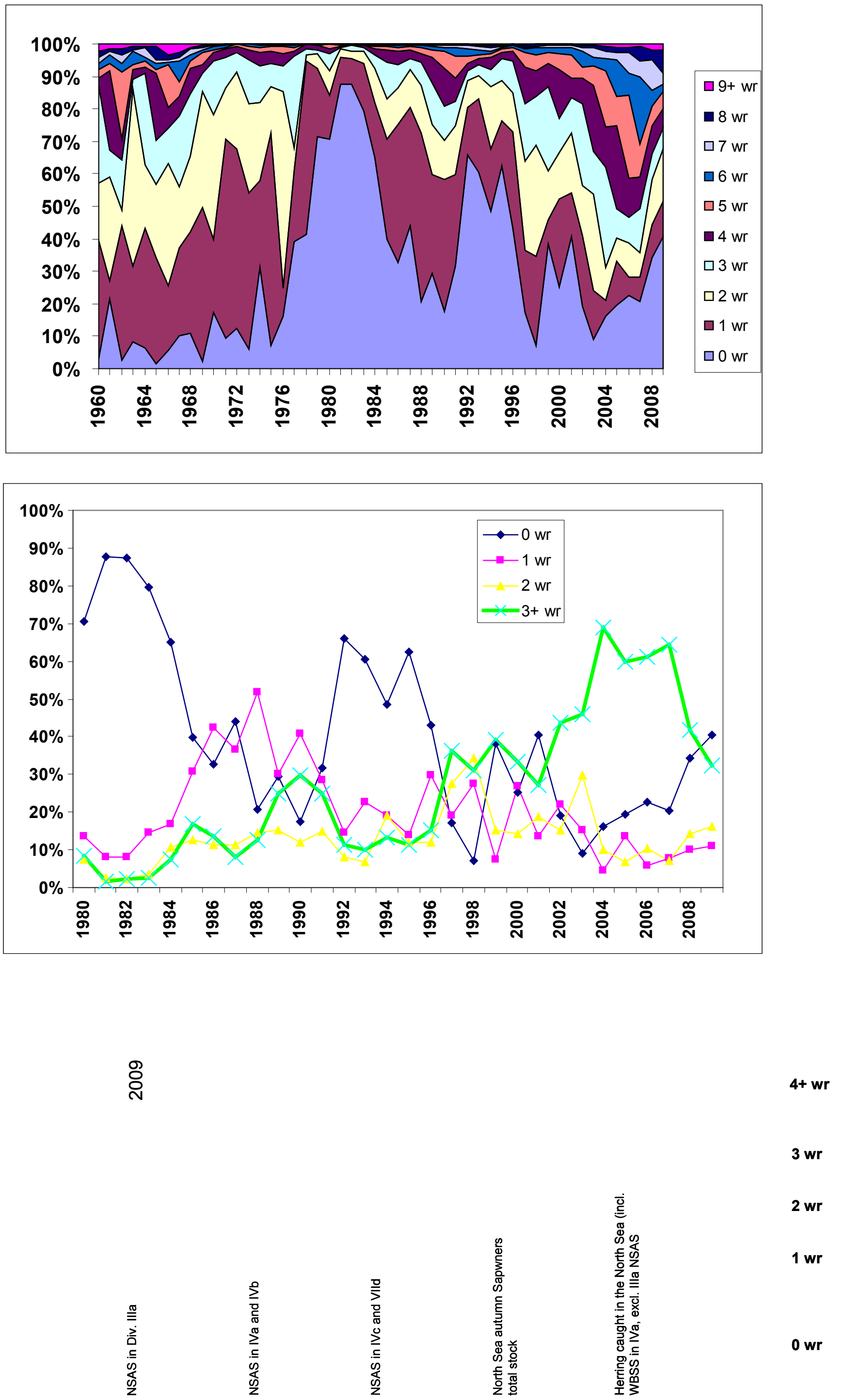


Figure 2.2.1: Proportions of age groups (numbers) in the total catch of herring in the North Sea (upper, 1960-2009, and middle panel, 1980-2009), and in the total catch of North Sea autumn spawners in 2009 (lower panel).

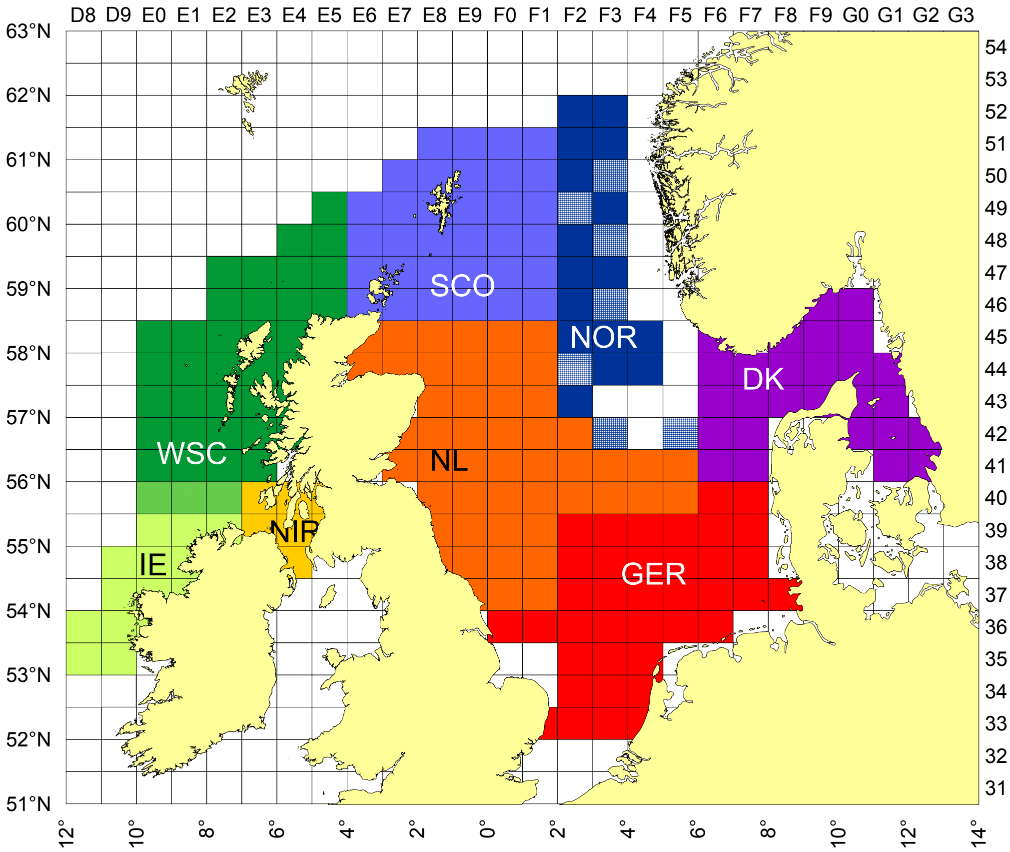


Figure 2.3.1.1: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2009. Survey area coverage by rectangle and nation (IR = Celtic Explorer; NIR = Corystes; WSC = West of Scotland charter vessel; SCO = Scotia; NOR = Johan Hjort; DK = Dana; NL = Tridens; GER = Solea). Multi-coloured rectangles indicate overlapping coverage by two or more nations (e.g. 40E1–40E3). Checked rectangles were interpolated from surrounding ones. Blank rectangles were not surveyed.

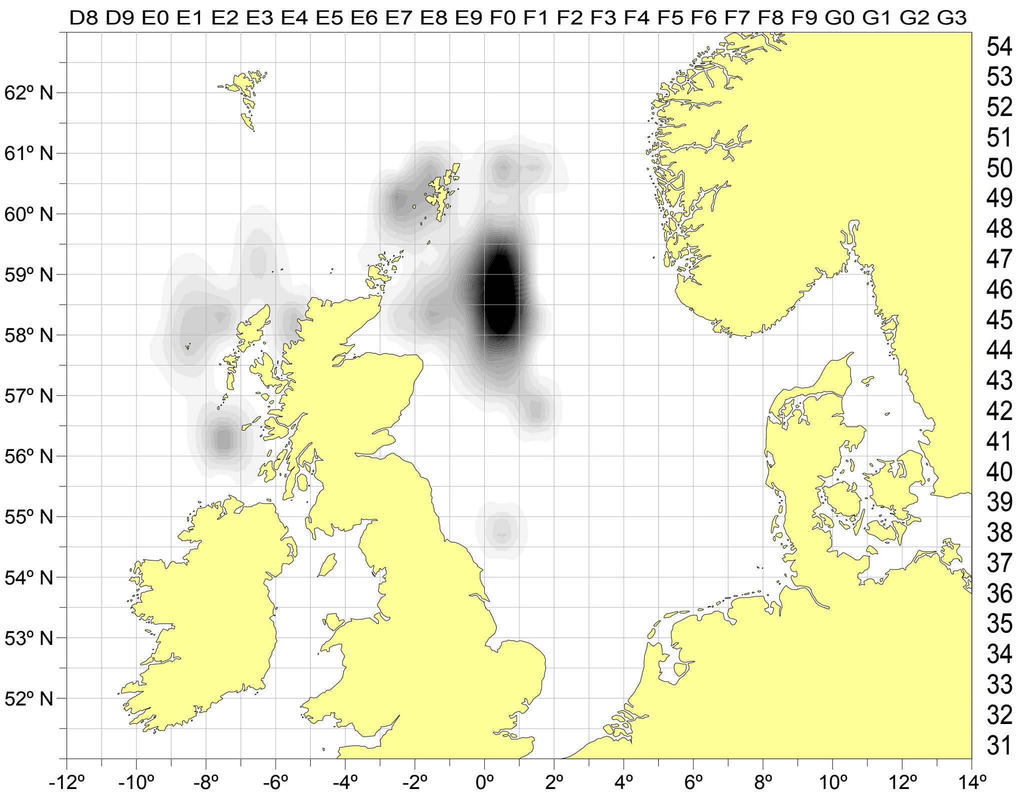


Figure 2.3.1.2: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2009. Biomass of mature autumn spawning herring from the combined acoustic survey (maximum value = 220 000 t).

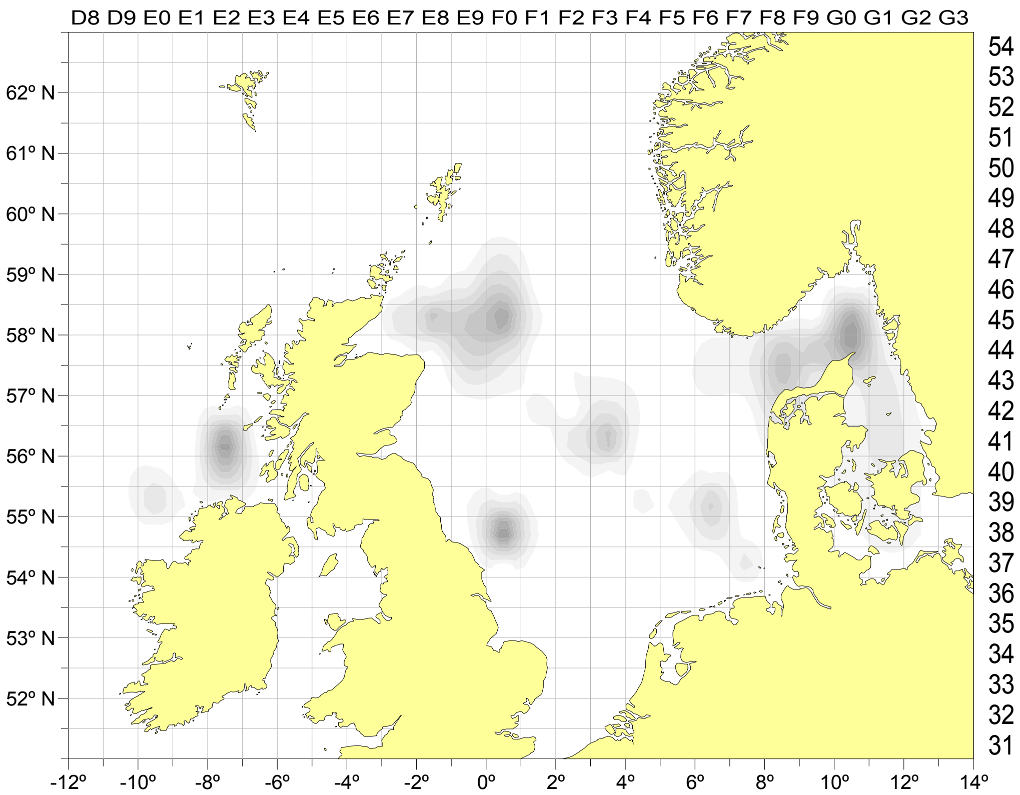


Figure 2.3.1.3: Acoustic Surveys in the North Sea, West of Scotland VIa(N) and the Malin Shelf area in June-July 2009. Biomass of immature autumn spawning herring from the combined acoustic survey (maximum value = 57 500 t).

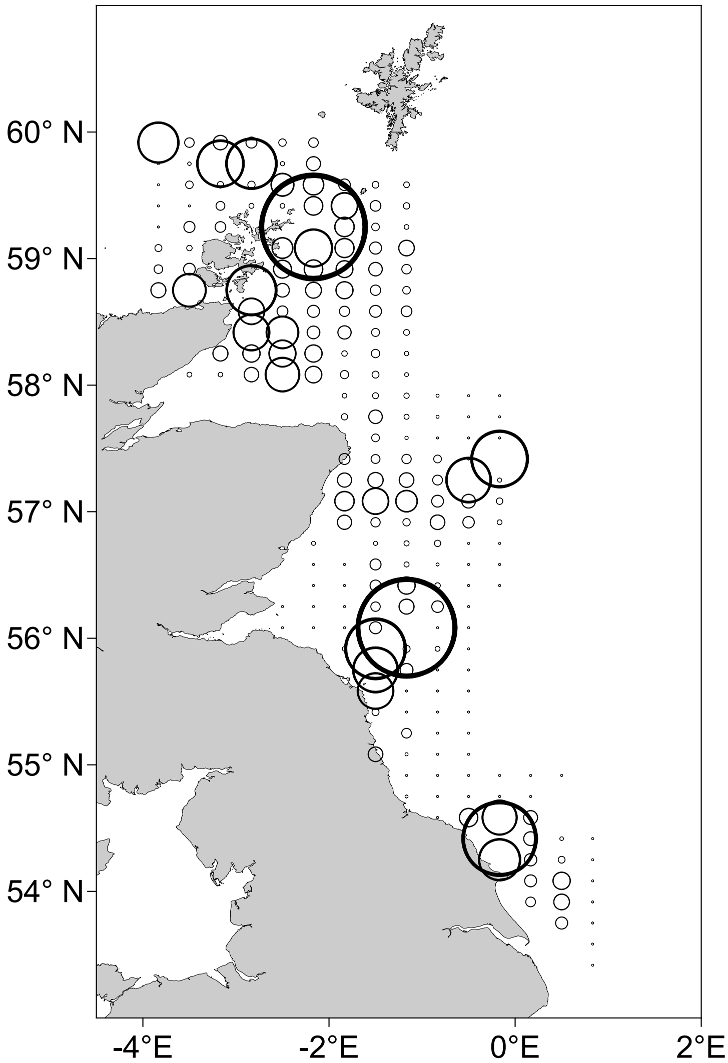


Figure 2.3.2.1: North Sea herring - Abundance of larvae < 10 mm (n/m²) in the Orkney/Shetland, Buchan and Central North Sea area (16-30 September 2009, maximum value = 7 300 n/m²).

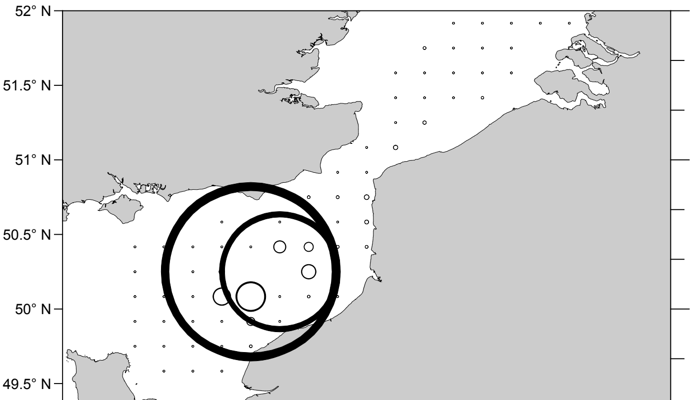


Figure 2.3.2.2: North Sea herring - Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 December 2009, maximum value = 23 000 n/m²).

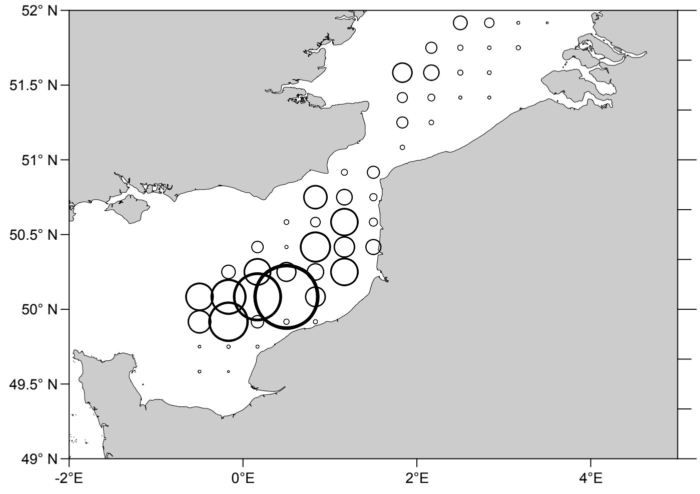


Figure 2.3.2.3: North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (01-15 January 2010, maximum value = 8 000 n/m²).

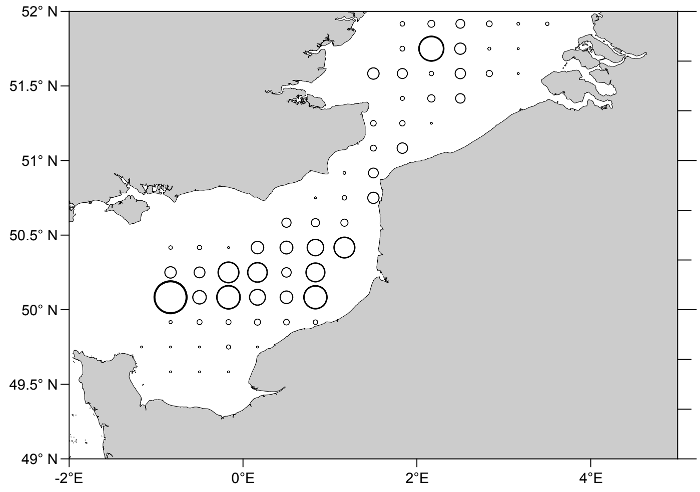


Figure2.3.2.4: North Sea herring – Abundance of larvae < 11 mm (n/m²) in the Southern North Sea (16-31 January 2010, maximum value = 740 n/m²).

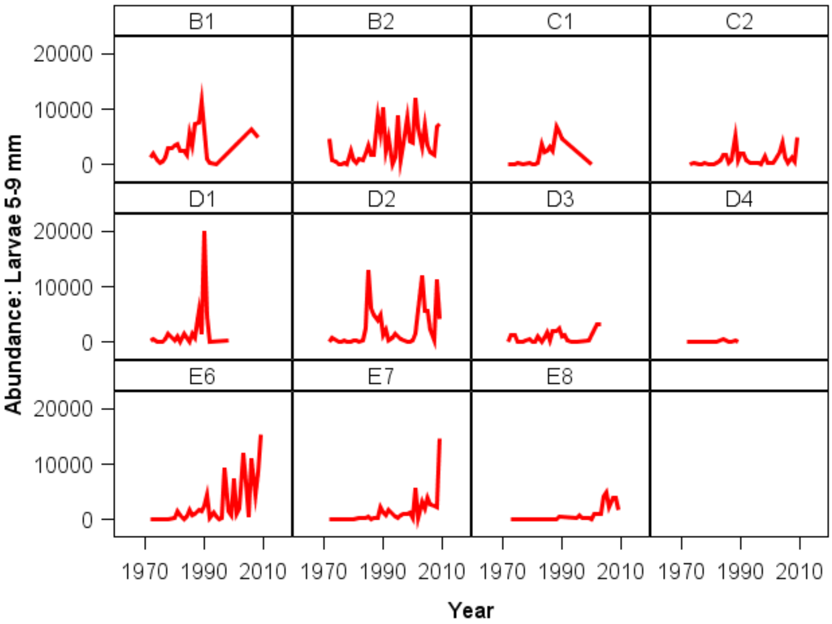


Figure 2.3.2.5: North Sea herring. Larval Abundance Index time-series (B = Orkney/Shetland 1st and 2nd fortnight, C = Buchan 2nd fortnight, D = Central North Sea 2nd fortnight, E = Southern North Sea all 3 fortnights).

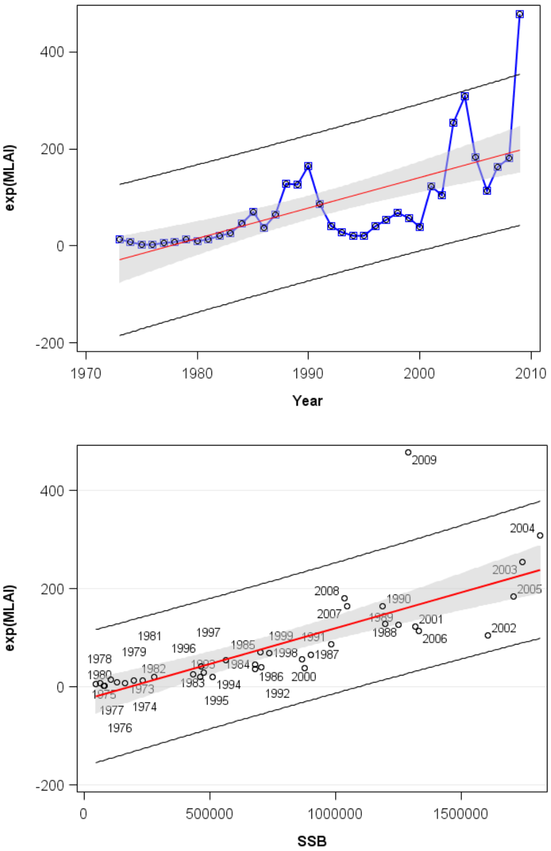


Figure 2.3.2.6: North Sea herring. Time series (upper panel) and scatter plot (lower panel) of the MLAI estimates (r = 0.85103, p < 0.0001). Both panels with correspondence and regression line, respectively, as well as with 95% confidence limits for the individual values and 95% confidence bands for the mean. The SSB estimates of the lower panel are taken from the ICA-output of the previous year.

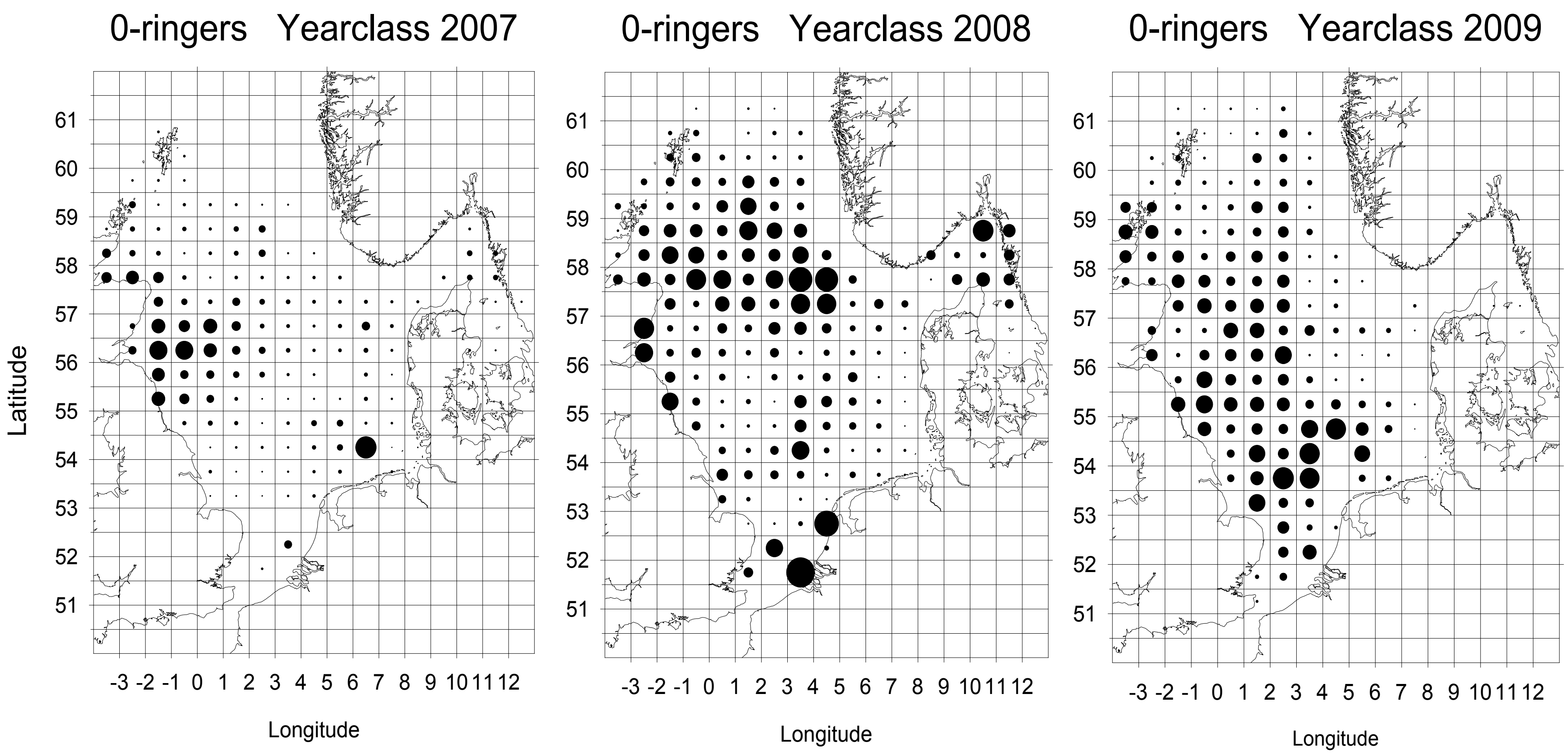


Figure 2.3.3.1. North Sea herring. Distribution of 0-ringer herring, year classes 2007-2009. Density estimates of 0-ringers within each statistical rectangle are based on MIK catches during IBTS in February 2008-20010. Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1 m^{-2}

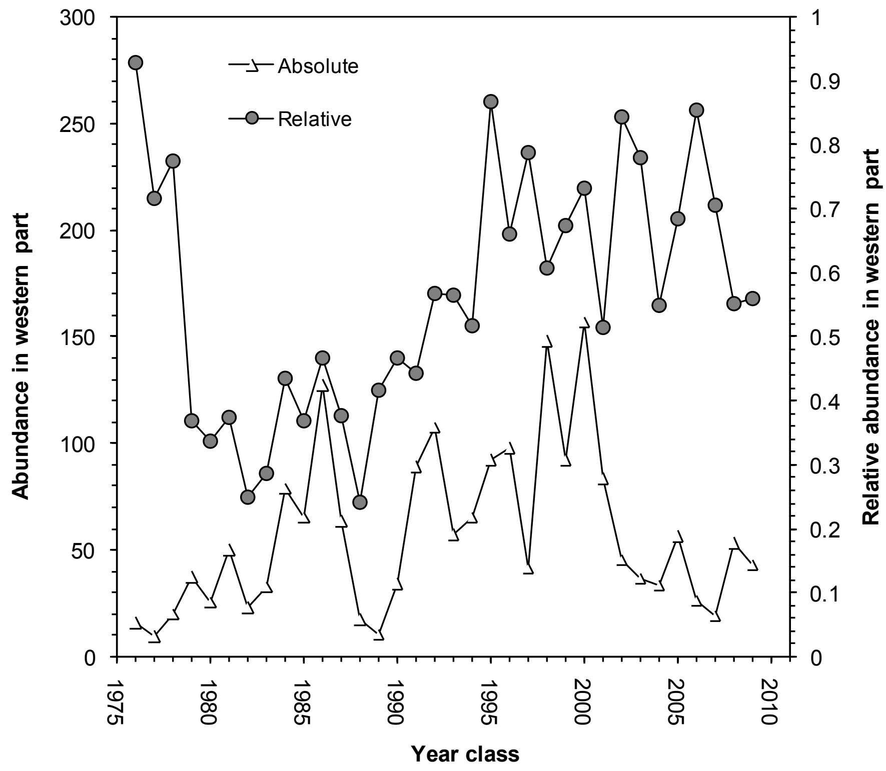


Figure 2.3.3.2 North Sea herring. Absolute (no * 10^9) and relative abundance of 0-ringers in the area west of 2°E in the North Sea. Abundances are based on MIK sampling during IBTS, the relative abundance in the western part is estimated as the number of 0-ringers west of 2°E relative to total number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

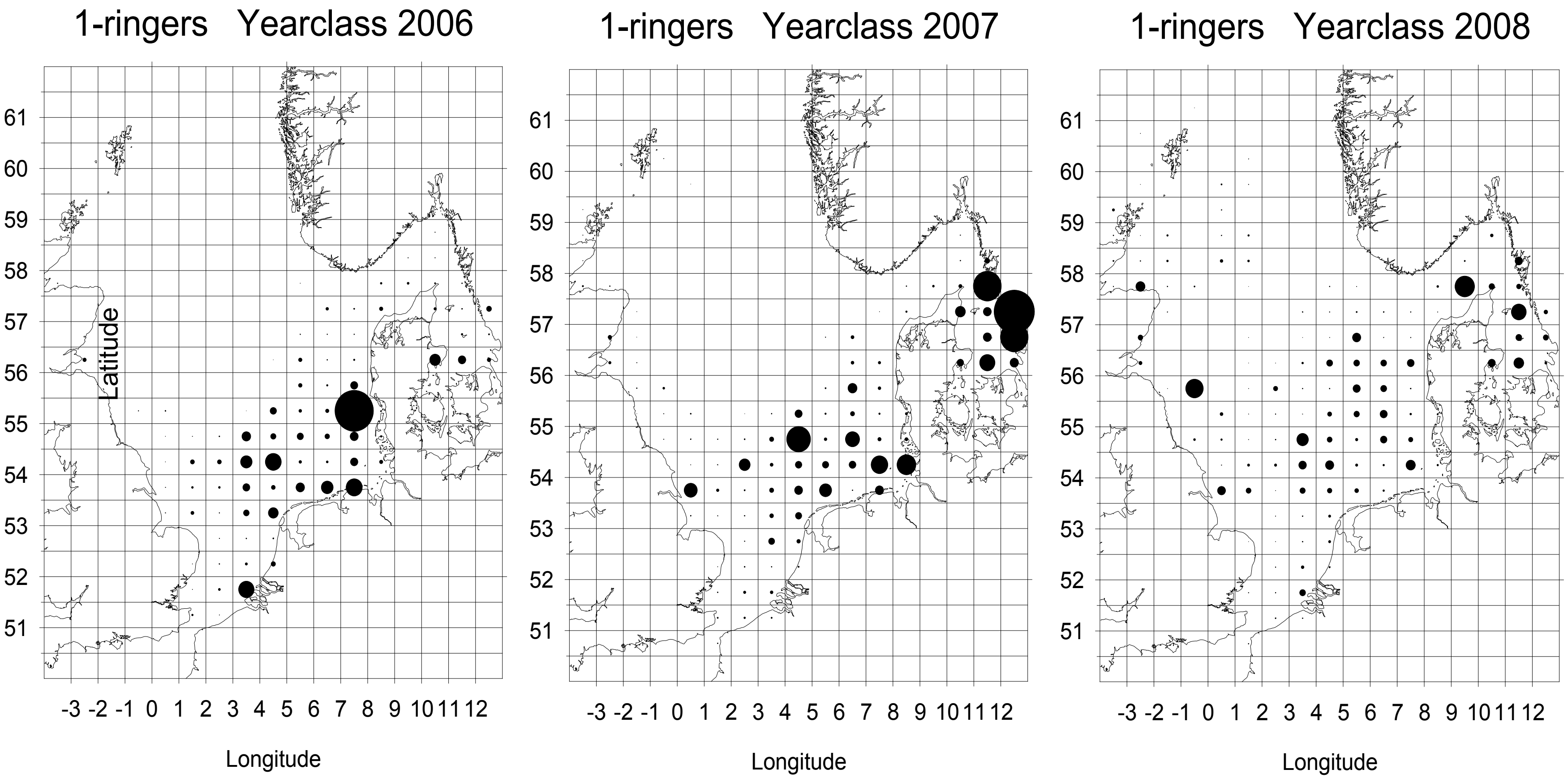


Figure 2.3.3.3. North Sea herring. Distribution of 1-ringer herring, year classes 2006-2008. Density estimates of 1-ringers within each statistical rectangle are based on GOV catches during IBTS in February 2008-2010. Areas of filled circles illustrate numbers per hour, the area of a circle extending to the border of a rectangle represents 45000 h^{-1}.

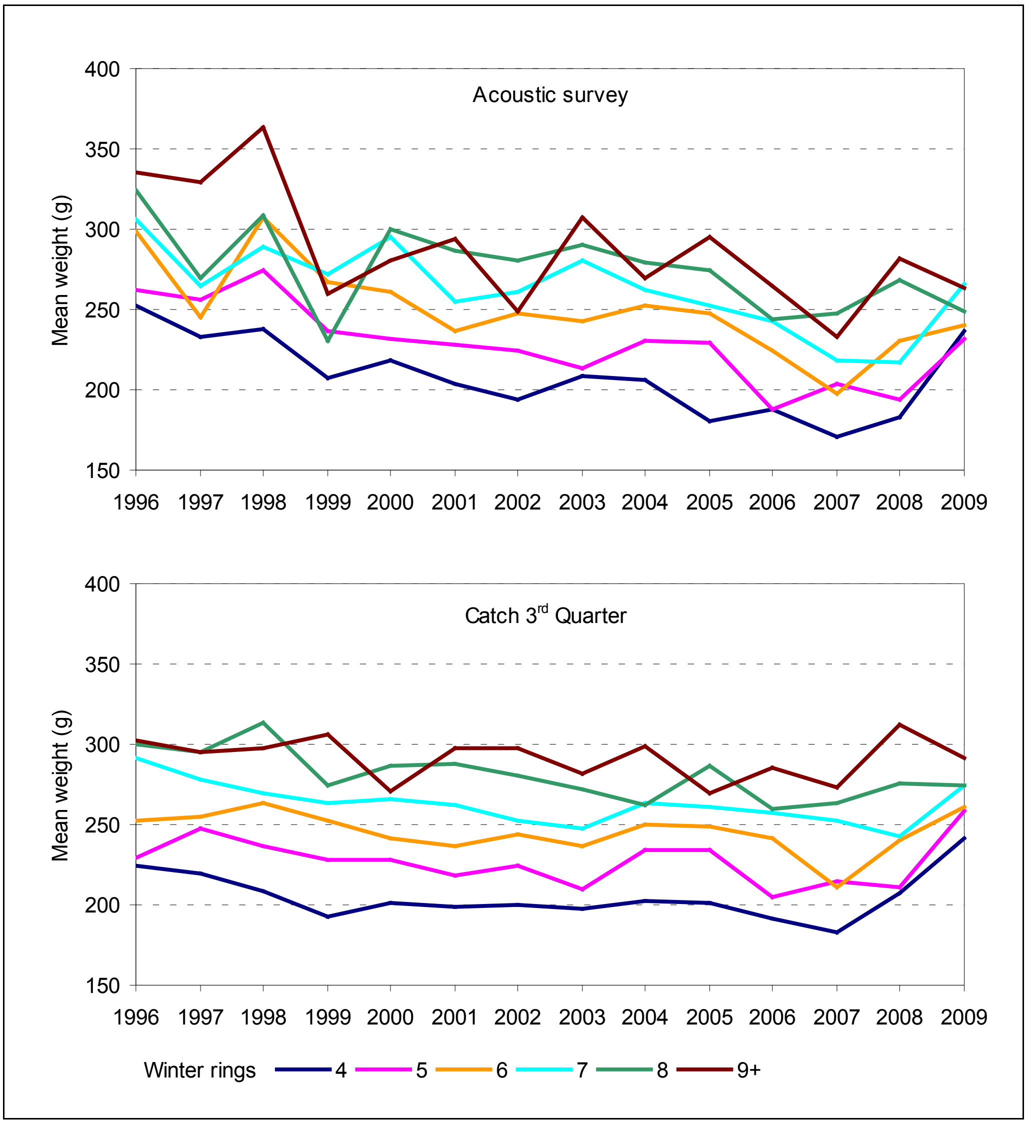


Figure 2.4.1.1. North Sea Herring. Mean weights for 4-ringers and older for the 3rd quarter in Divisions IV and IIIa from the acoustic survey and mean weights-in-the-catch for comparison.

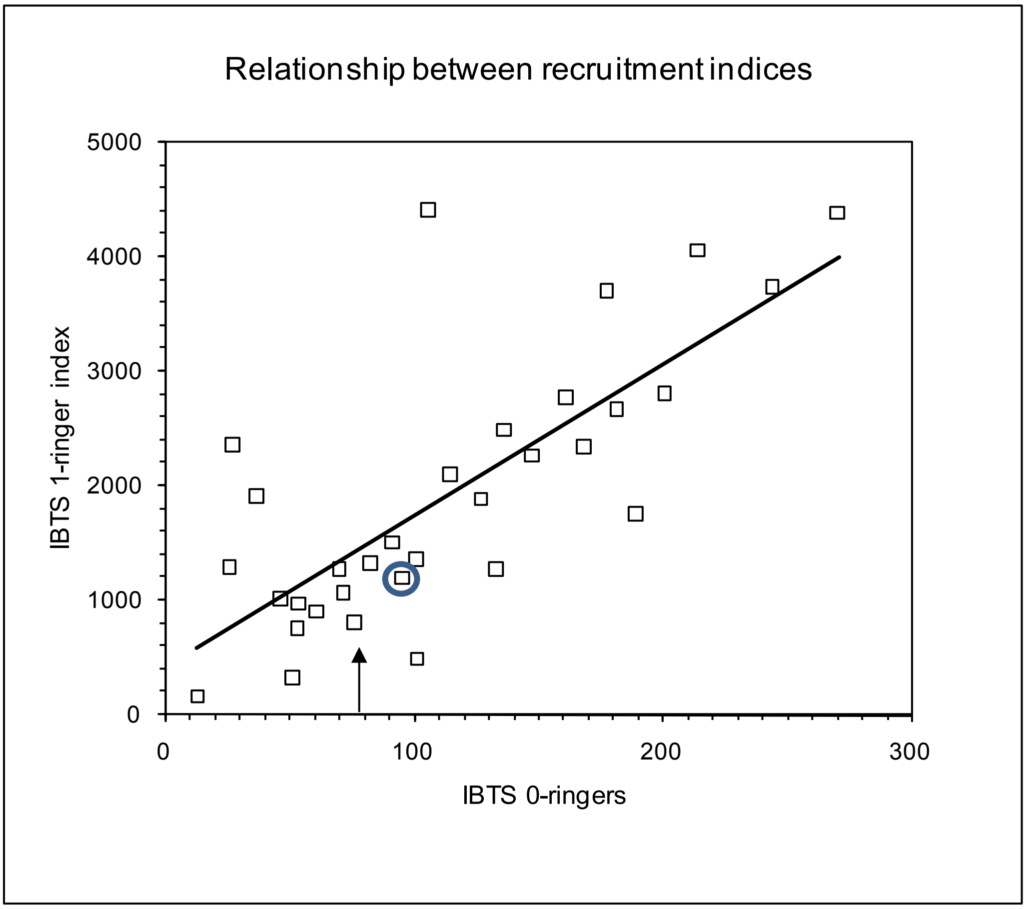


Figure 2.5.1 North Sea herring. Relationship between indices of 0-ringers and 1-ringers for year classes 1977 to 2008. The 2008 relation is circled, the present 0-ringer index for year class 2009 is indicated by an arrow.

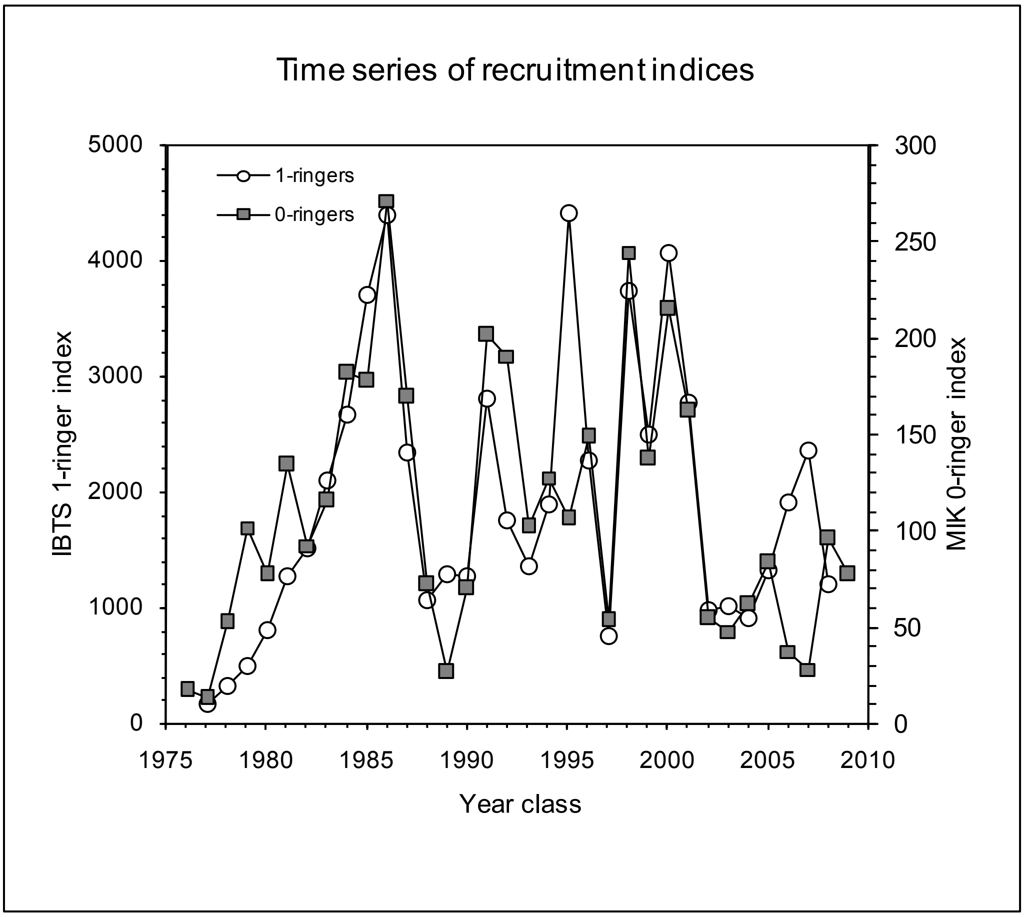


Figure 2.5.2 North Sea herring. Time series of 0-ringer and 1-ringer indices. Year classes 1976 to 2009 for 0-ringers, year classes 1977-2008 for 1-ringers.

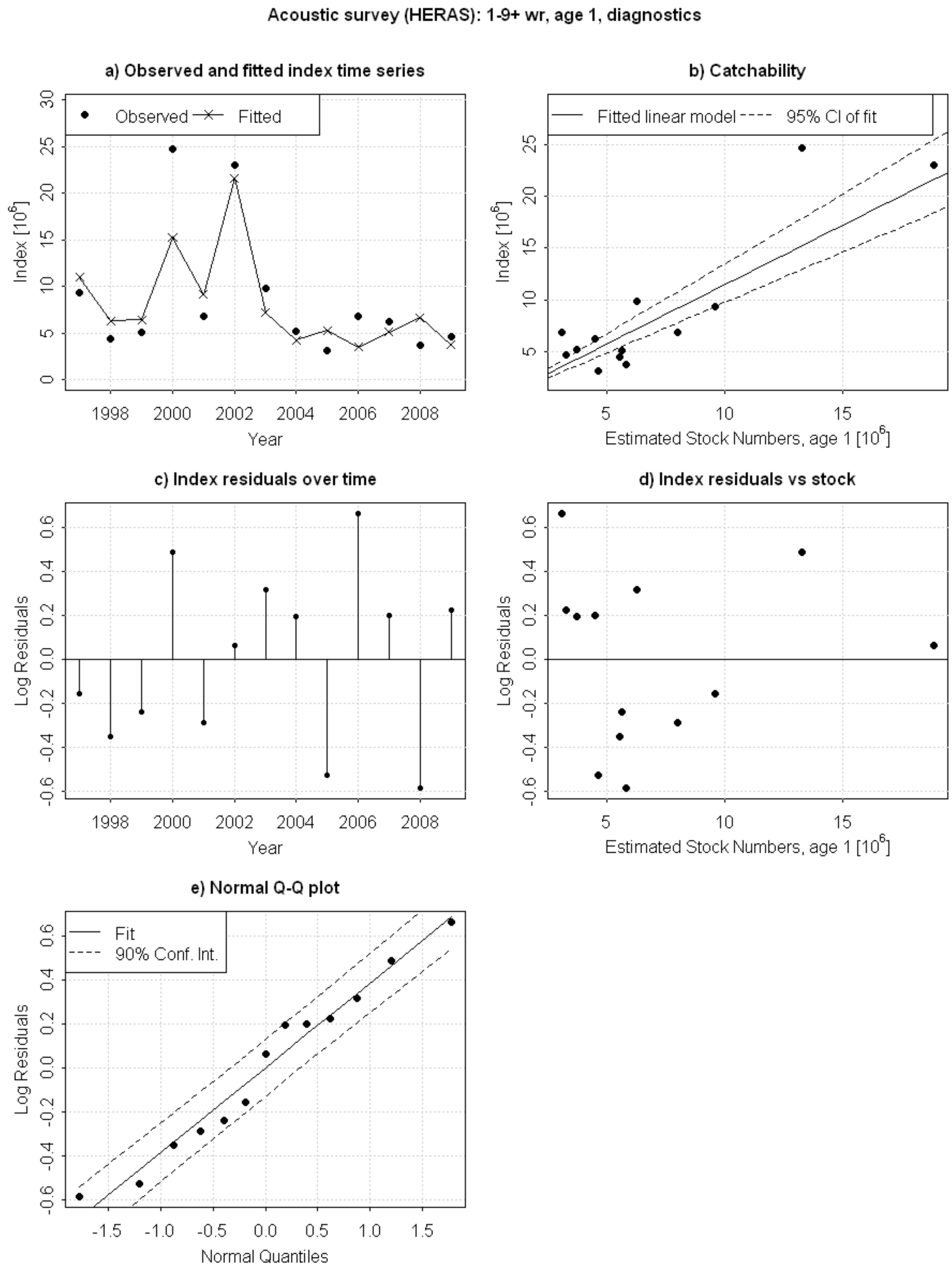


Figure 2.6.1.1 North Sea herring. Diagnostics of Acoustic survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1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

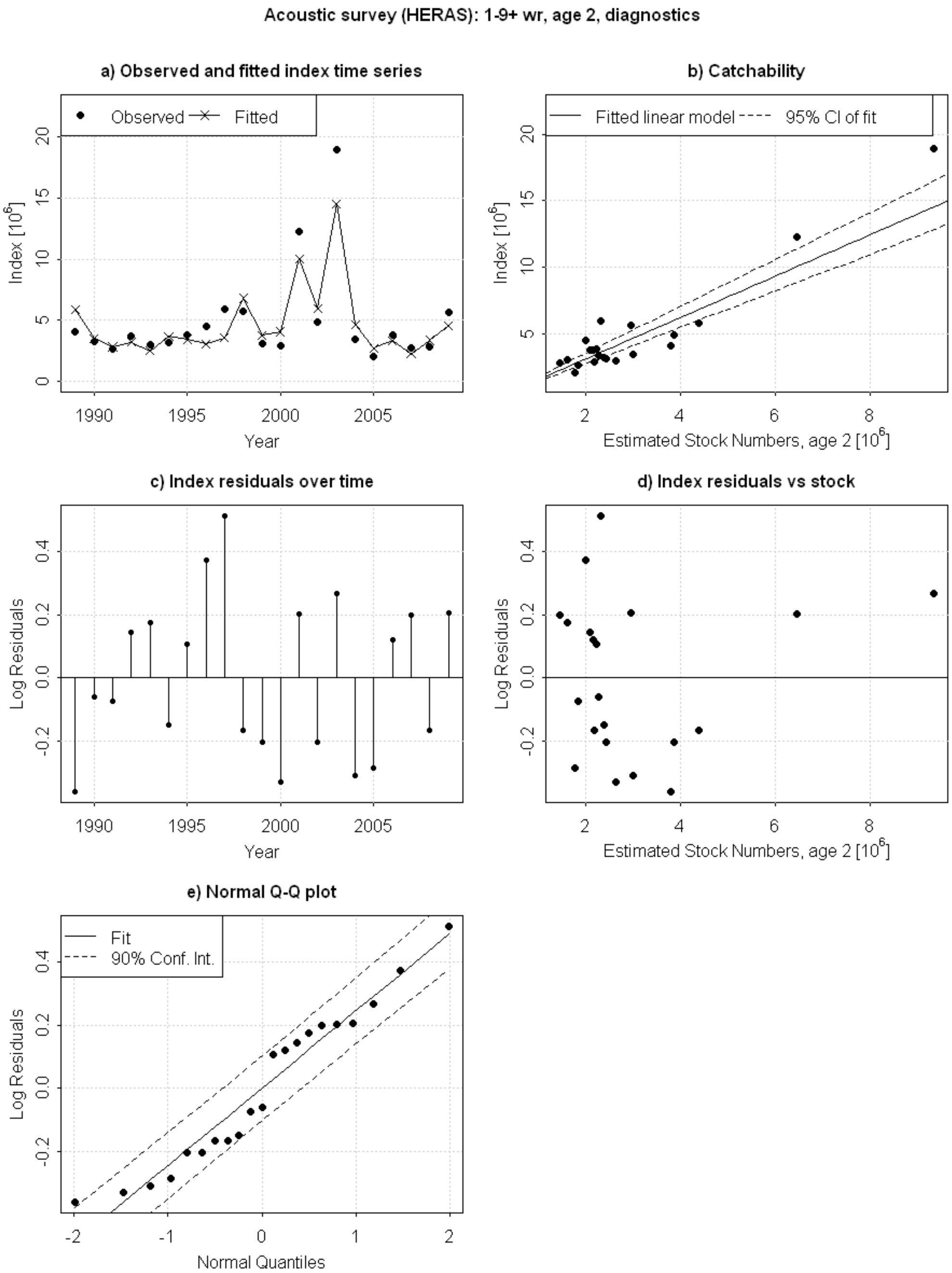


Figure 2.6.1.2. North Sea herring. Diagnostics of Acoustic survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2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

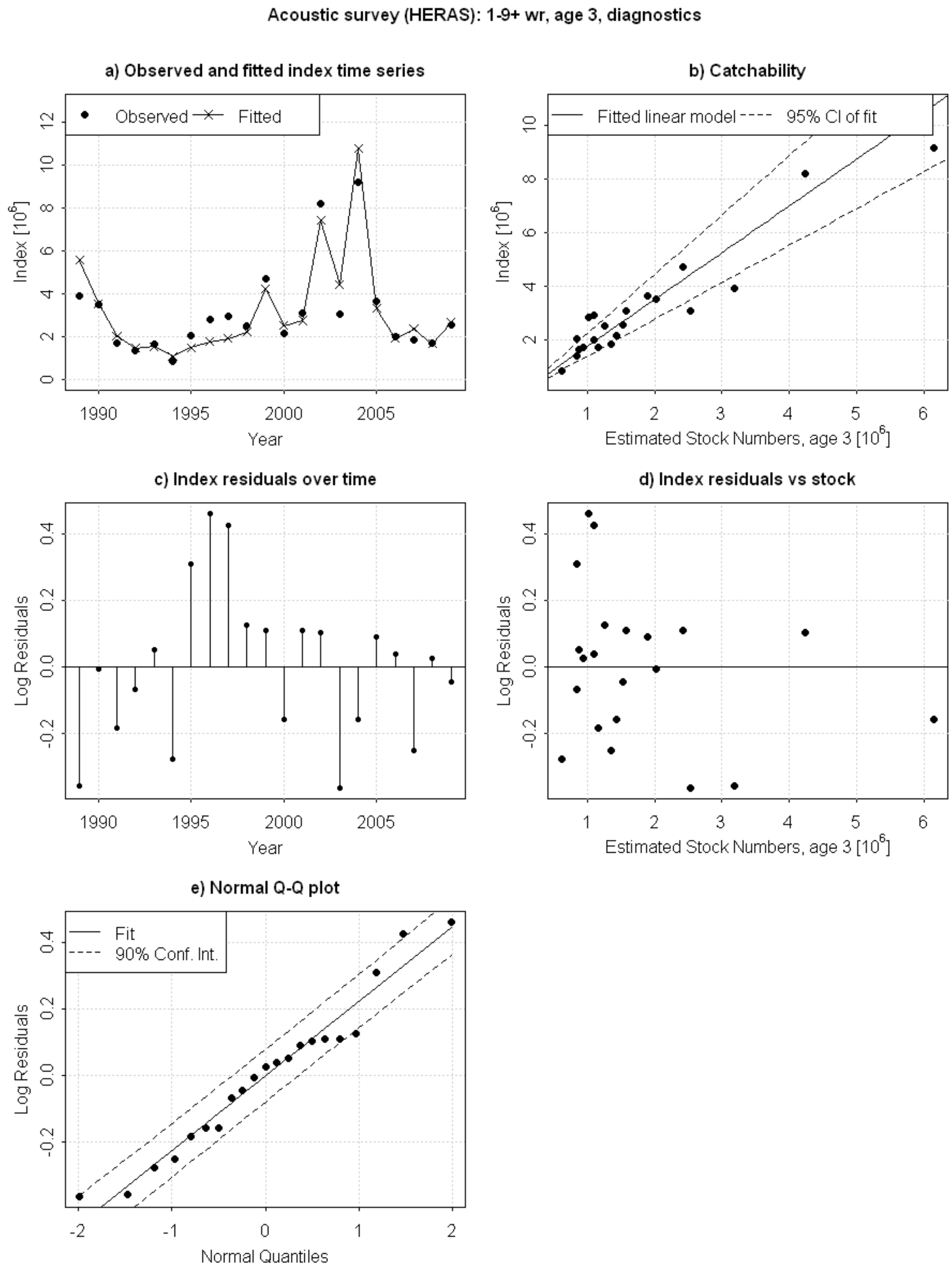


Figure 2.6.1.3. North Sea herring. Diagnostics of Acoustic survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr . Top right: scatterplot of index observations versus VPA estimates of numbers at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

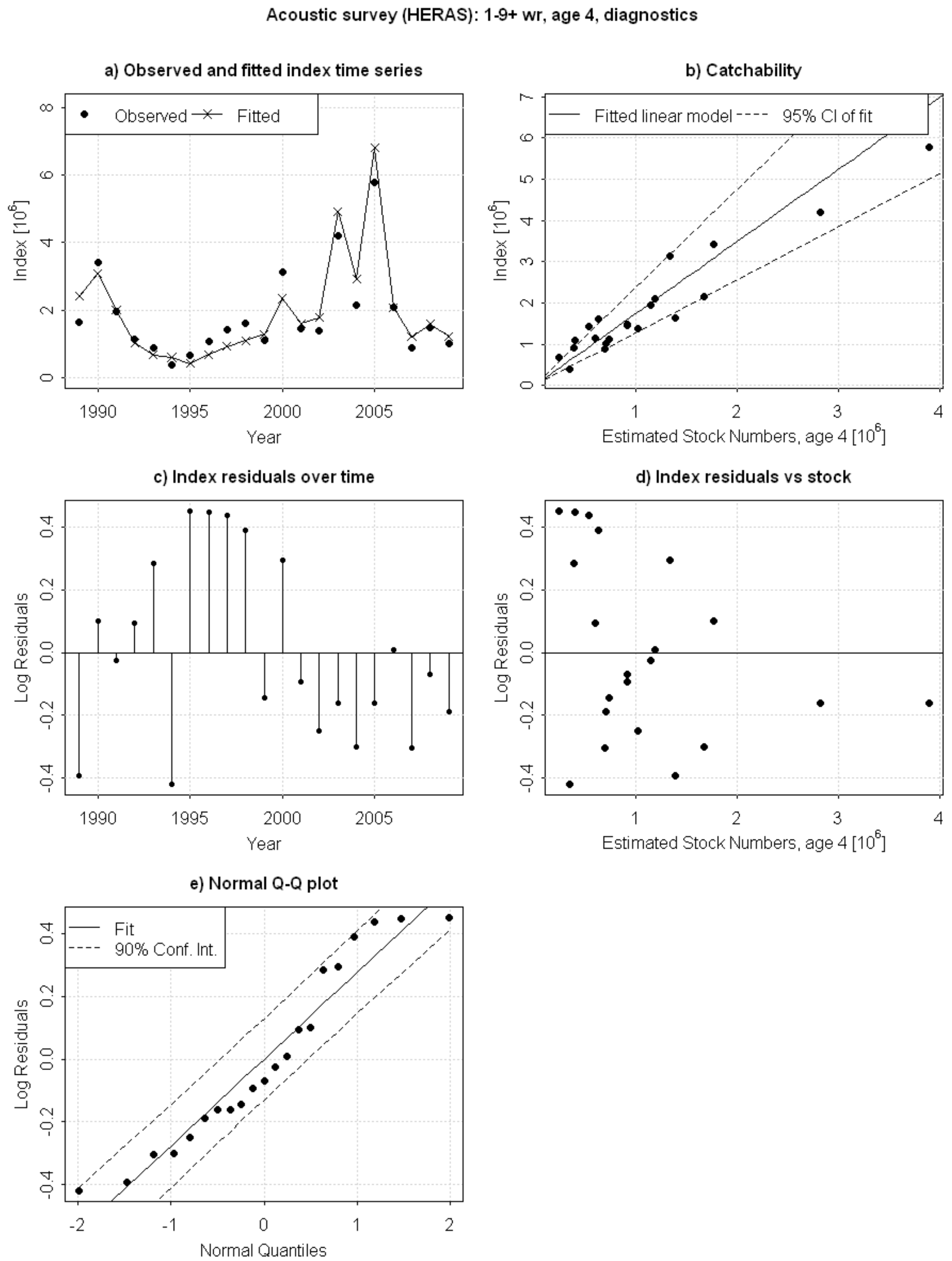


Figure 2.6.1.4. North Sea herring. Diagnostics of Acoustic survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4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

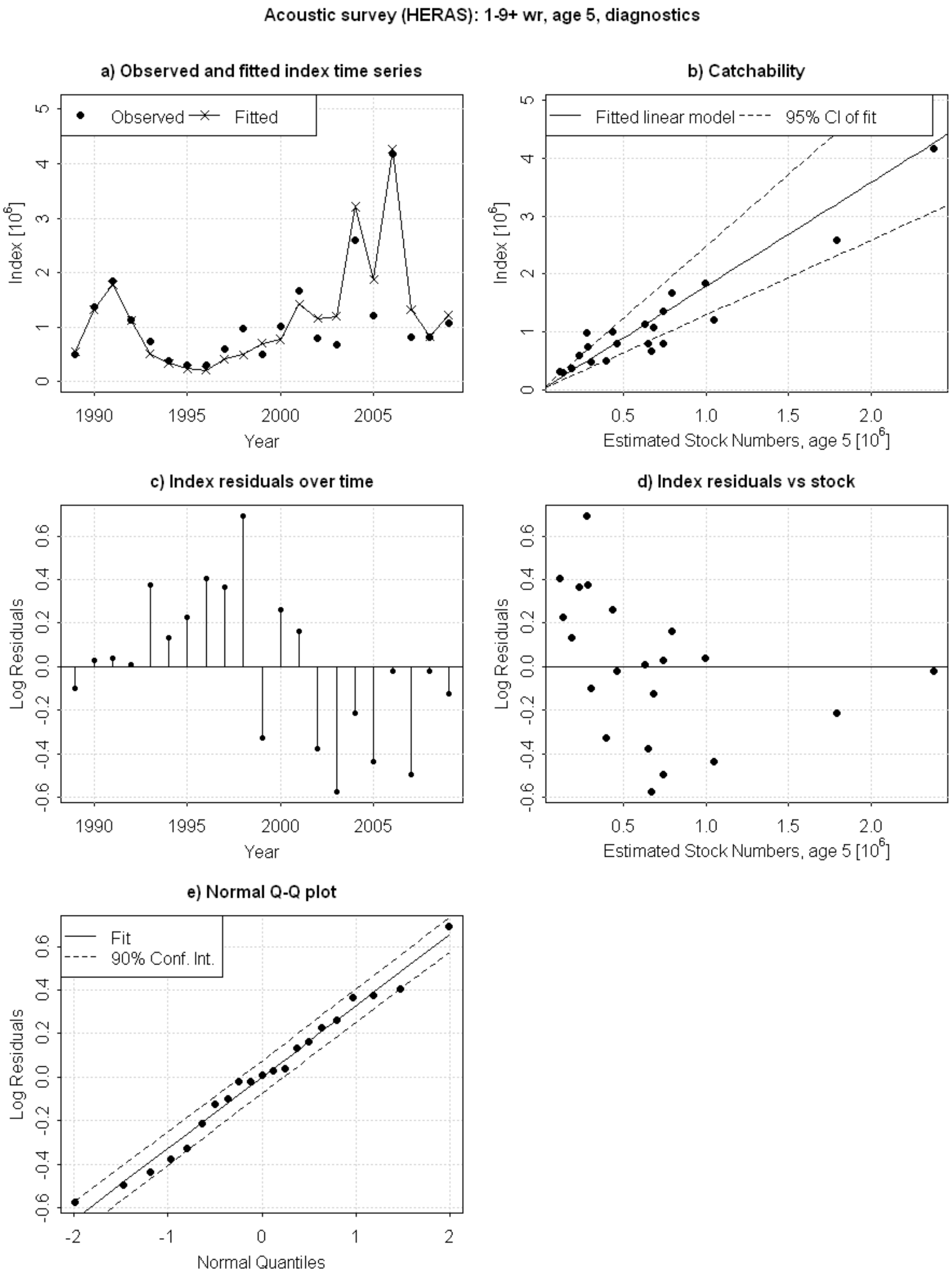


Figure 2.6.1.5. North Sea herring. Diagnostics of Acoustic survey catchability at 5 wr from the final ICA assessment. Top left: VPA estimates of numbers at 5 wr (line) and numbers predicted from index abundance at 5 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5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

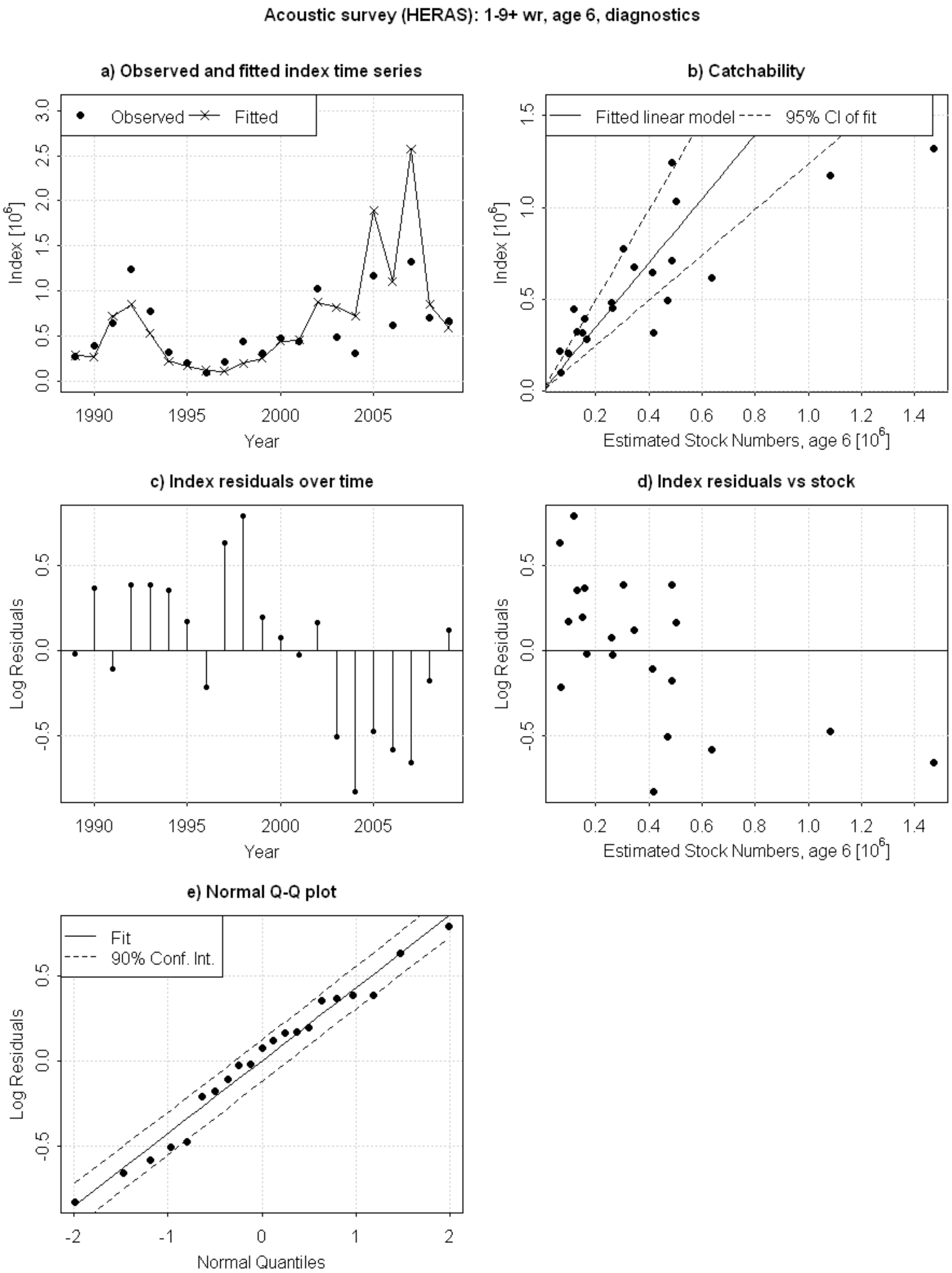


Figure 2.6.1.6. North Sea herring. Diagnostics of Acoustic survey catchability at 6 wr from the final ICA assessment. Top left: VPA estimates of numbers at 6 wr (line) and numbers predicted from index abundance at 6 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 6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

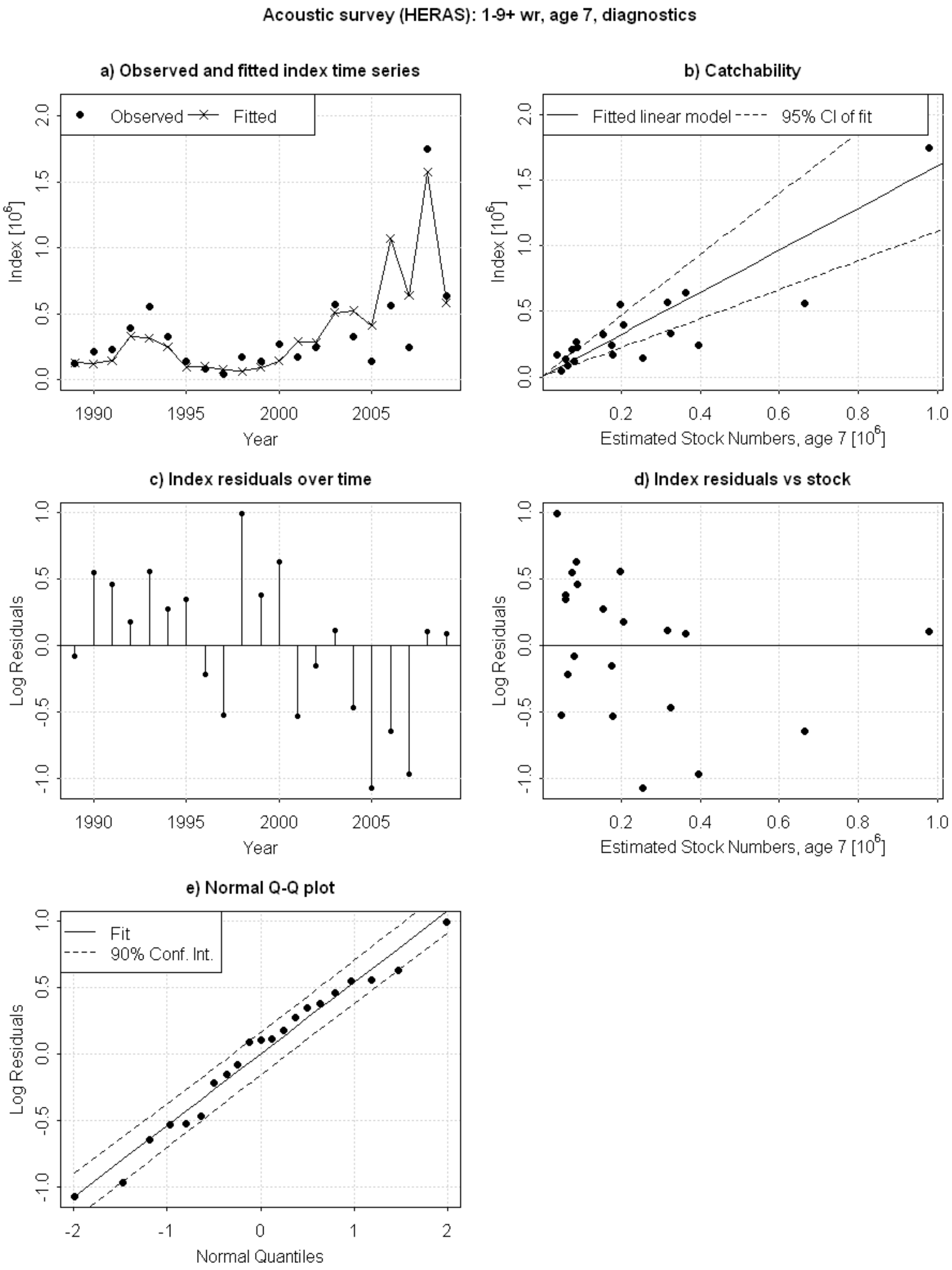


Figure 2.6.1.7. North Sea herring. Diagnostics of Acoustic survey catchability at 7 wr from the final ICA assessment. Top left: VPA estimates of numbers at 7 wr (line) and numbers predicted from index abundance at 7 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 7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

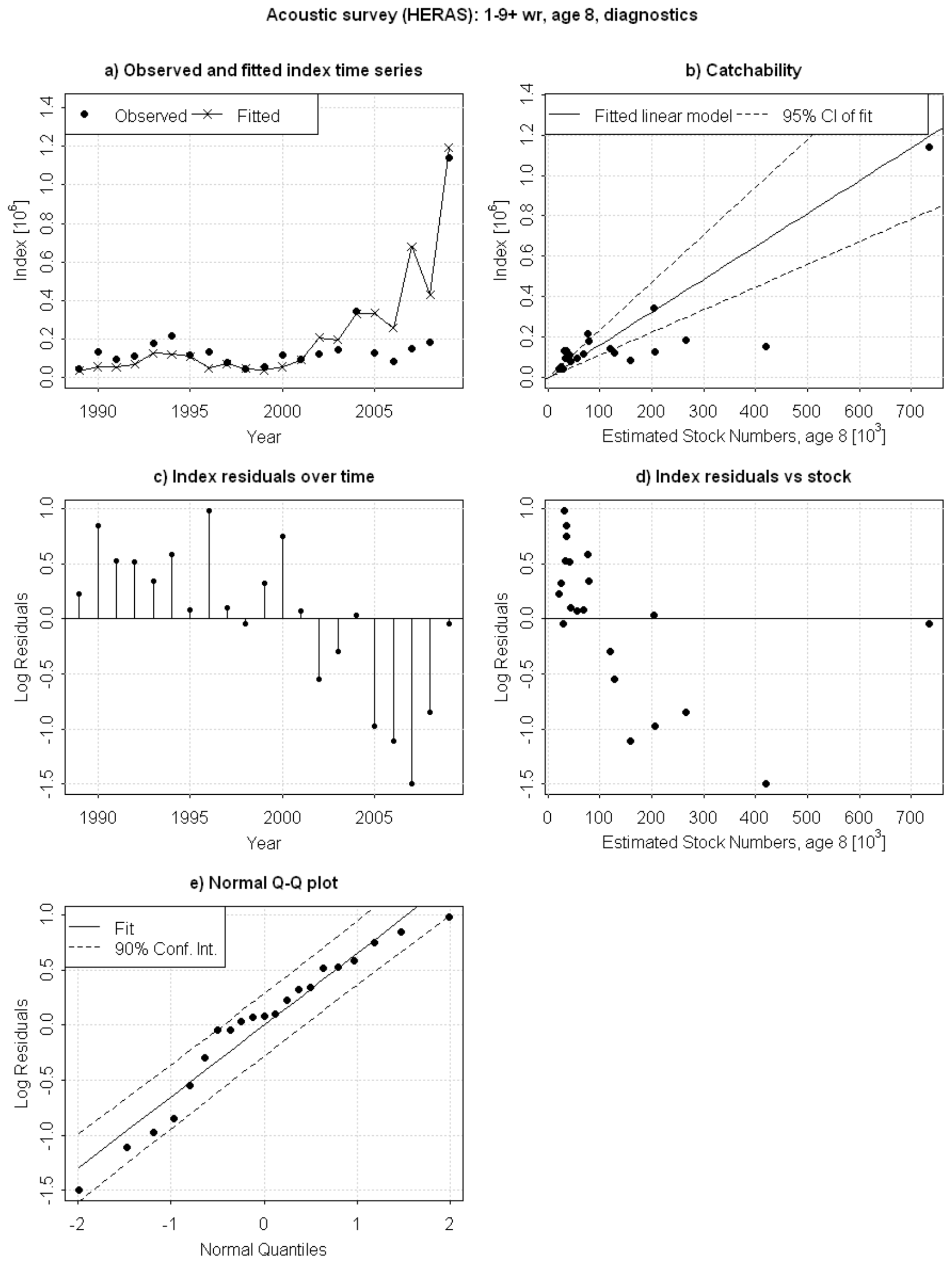


Figure 2.6.1.8. North Sea herring. Diagnostics of Acoustic survey catchability at 8 wr from the final ICA assessment. Top left: VPA estimates of numbers at 8 wr (line) and numbers predicted from index abundance at 8 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 8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

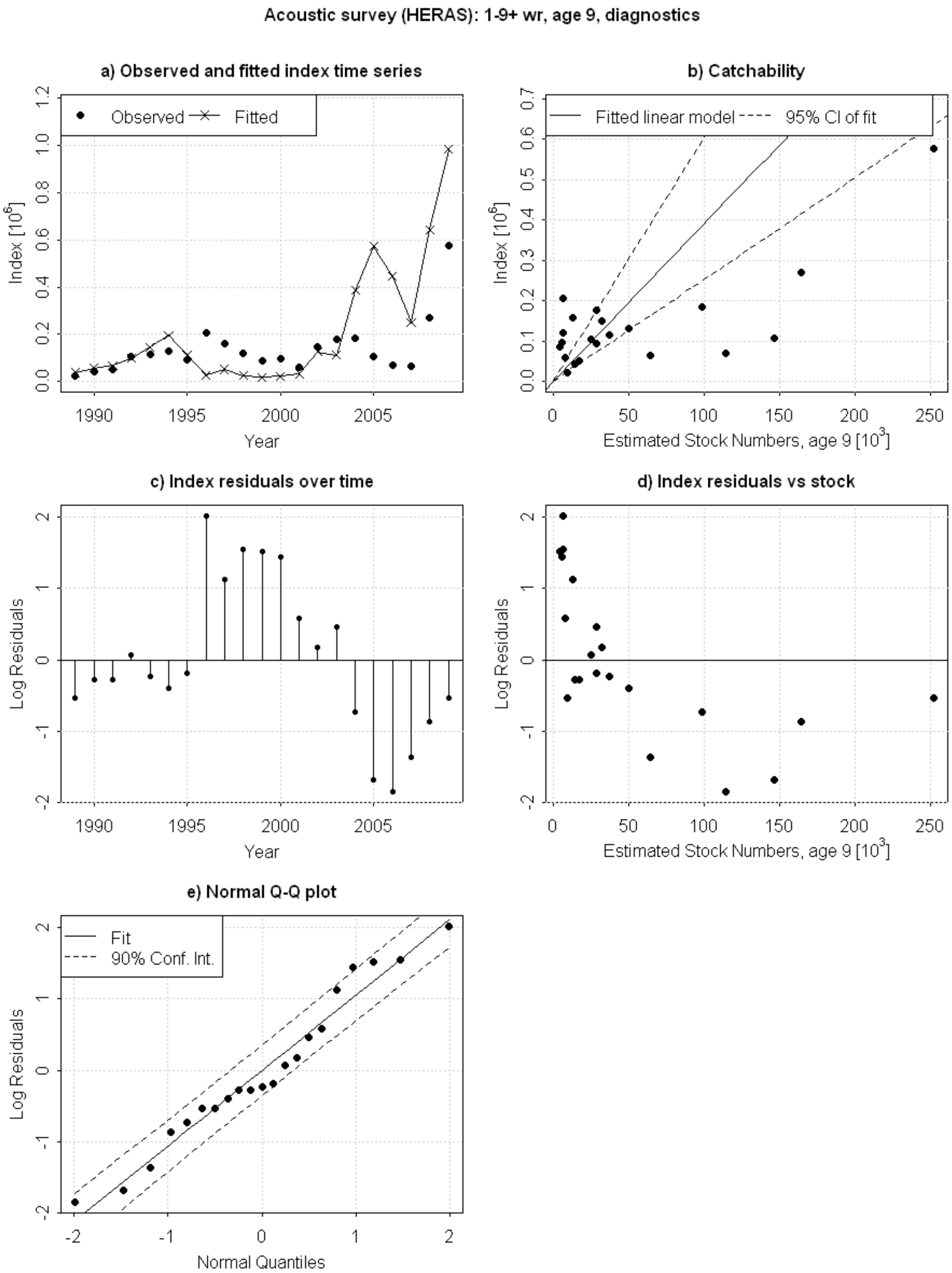


Figure 2.6.1.9. North Sea herring. Diagnostics of Acoustic survey catchability at 9+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 9+ wr (line) and numbers predicted from index abundance at 9+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at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

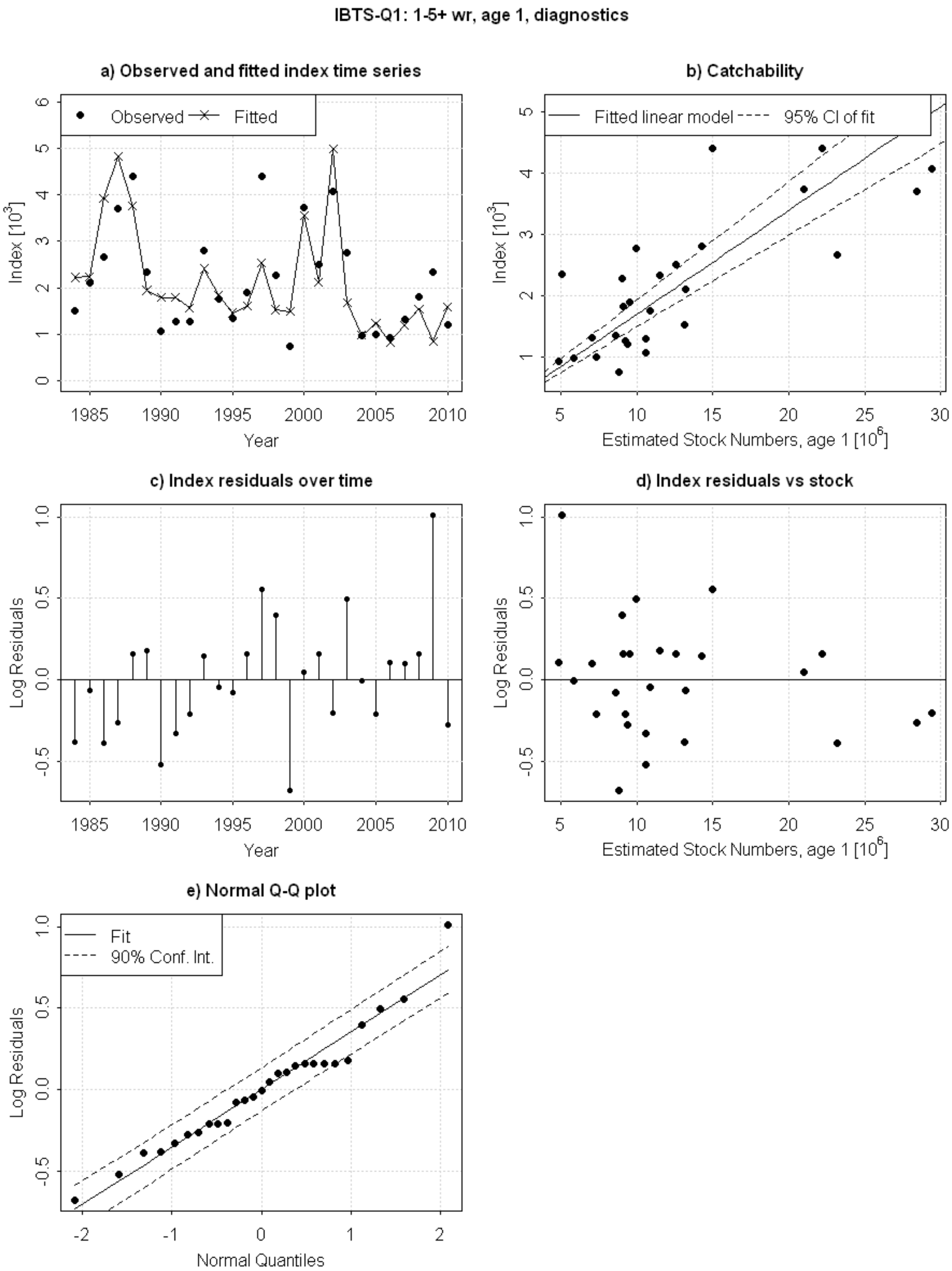


Figure 2.6.1.10. North Sea herring. Diagnostics of IBTS survey catchability at 1 wr from the final ICA assessment. Top left: VPA estimates of numbers at 1 wr (line) and numbers predicted from index abundance at 1 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 1 wr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

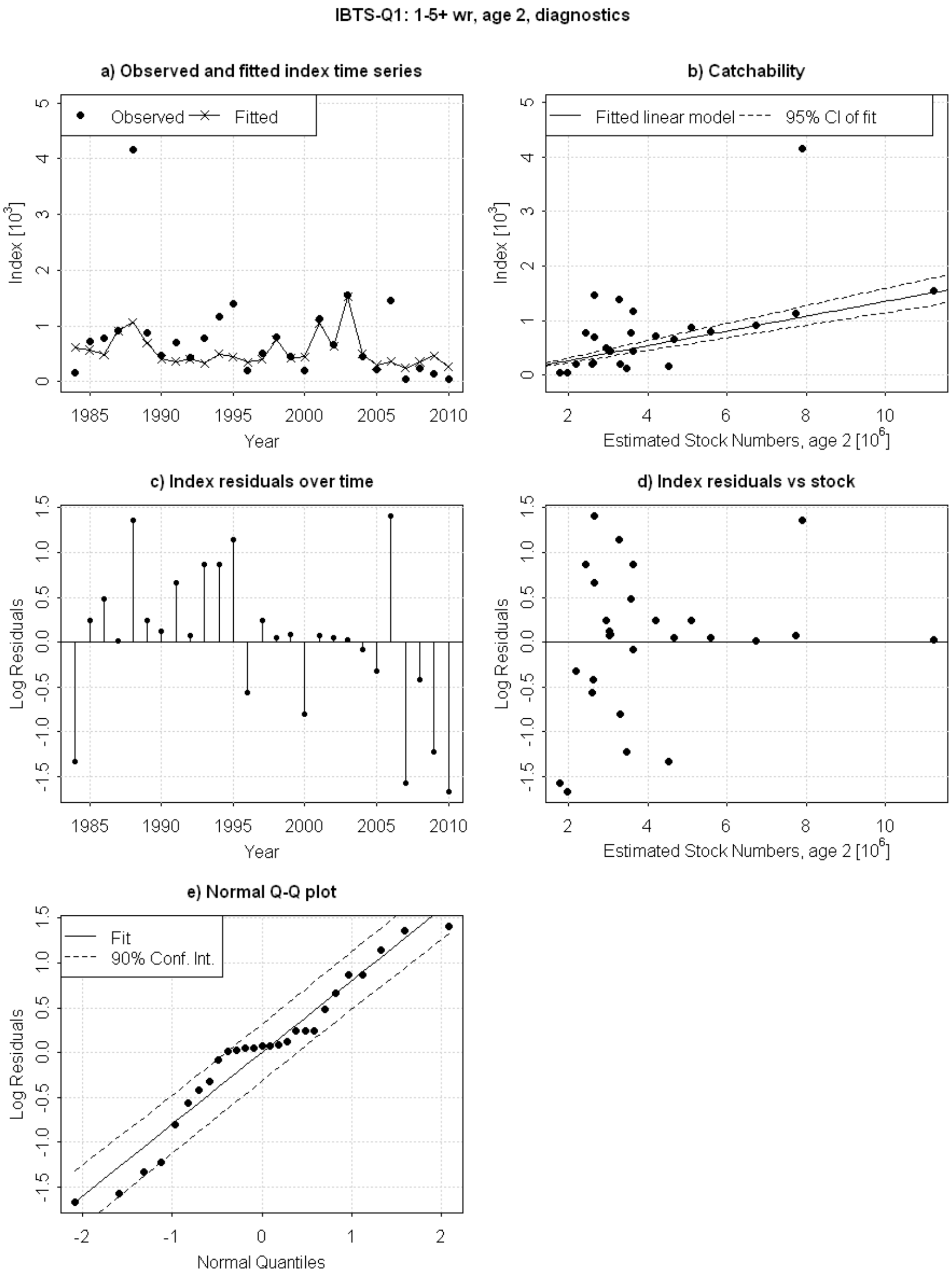


Figure 2.6.1.11. North Sea herring. Diagnostics of IBTS survey catchability at 2 wr from the final ICA assessment. Top left: VPA estimates of numbers at 2 wr (line) and numbers predicted from index abundance at 2 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 2 wr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

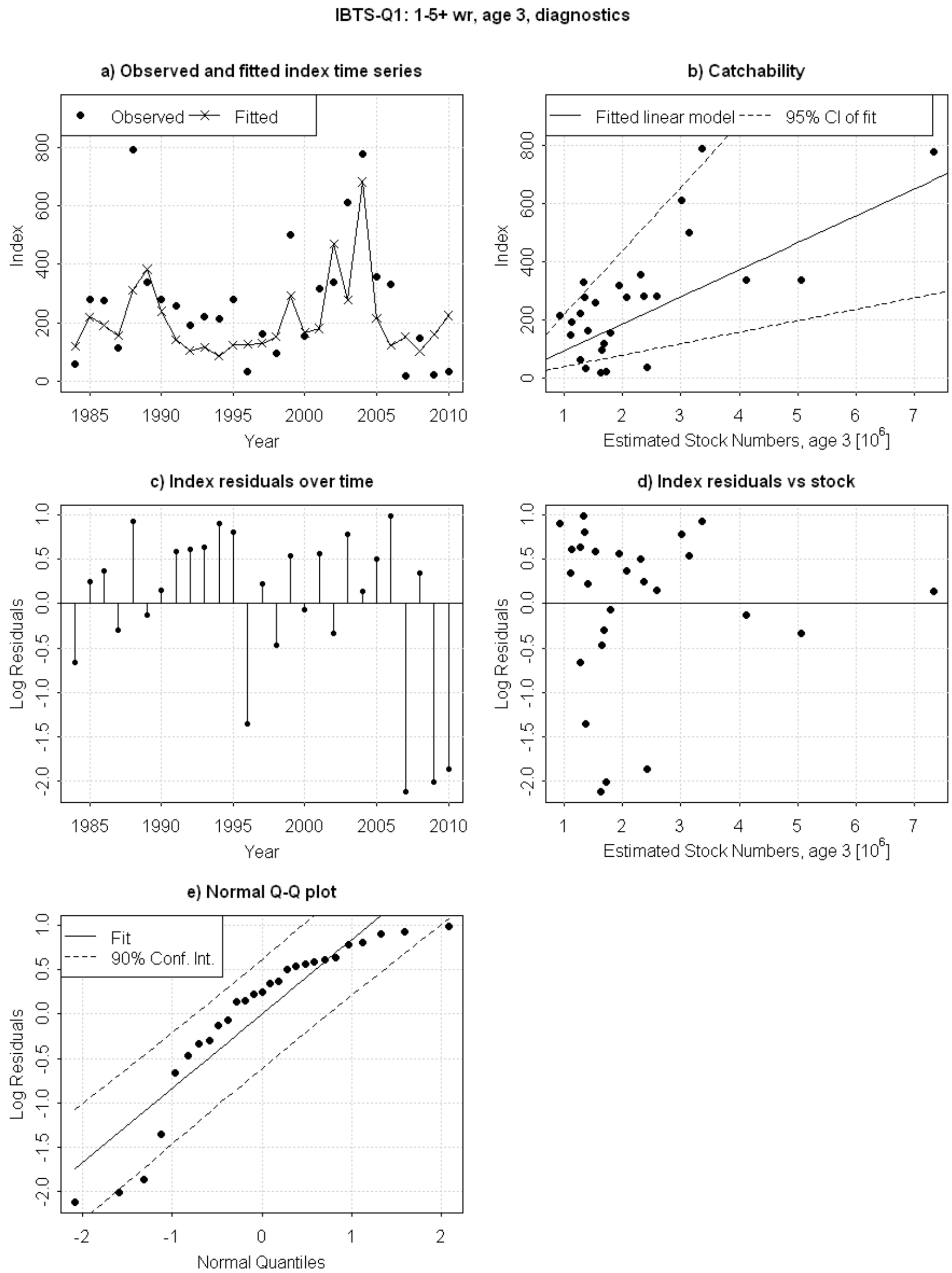


Figure 2.6.1.12. North Sea herring. Diagnostics of IBTS survey catchability at 3 wr from the final ICA assessment. Top left: VPA estimates of numbers at 3 wr (line) and numbers predicted from index abundance at 3 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 3 wr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

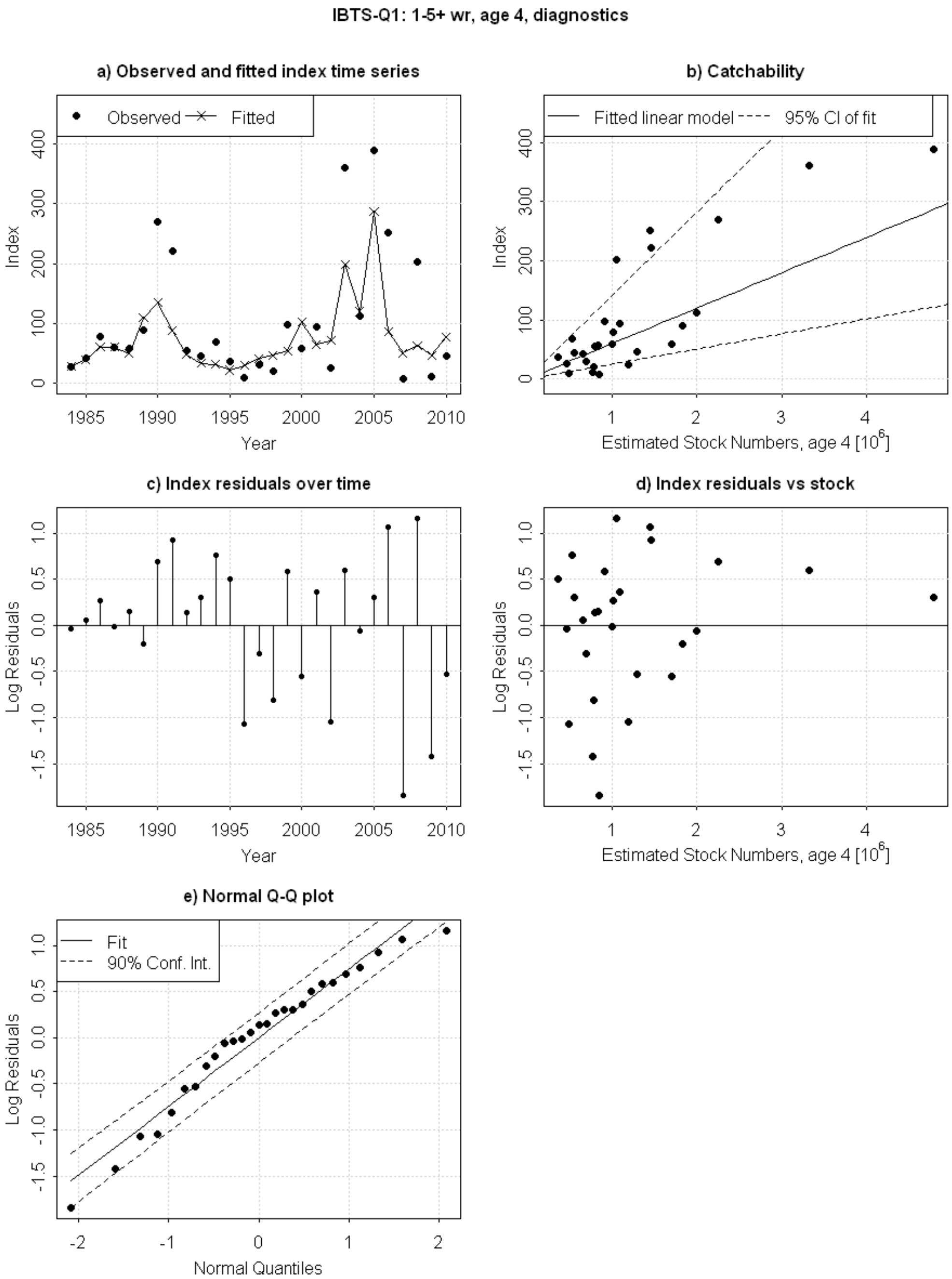


Figure 2.6.1.13. North Sea herring. Diagnostics of IBTS survey catchability at 4 wr from the final ICA assessment. Top left: VPA estimates of numbers at 4 wr (line) and numbers predicted from index abundance at 4 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 4 wr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

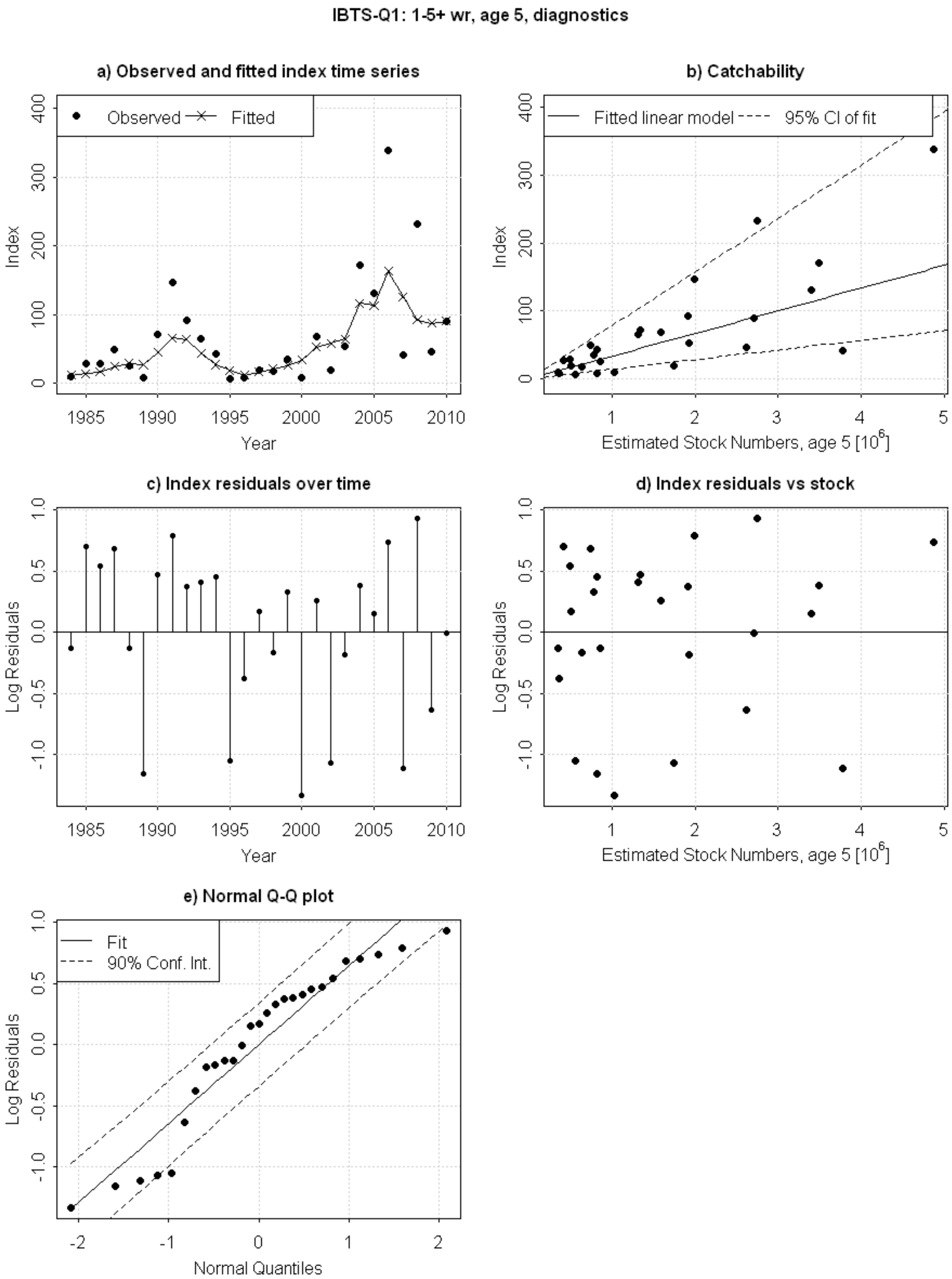


Figure 2.6.1.14. North Sea herring. Diagnostics of IBTS survey catchability at 5+ wr from the final ICA assessment. Top left: VPA estimates of numbers at 5+ wr (line) and numbers predicted from index abundance at 5+ wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 5+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

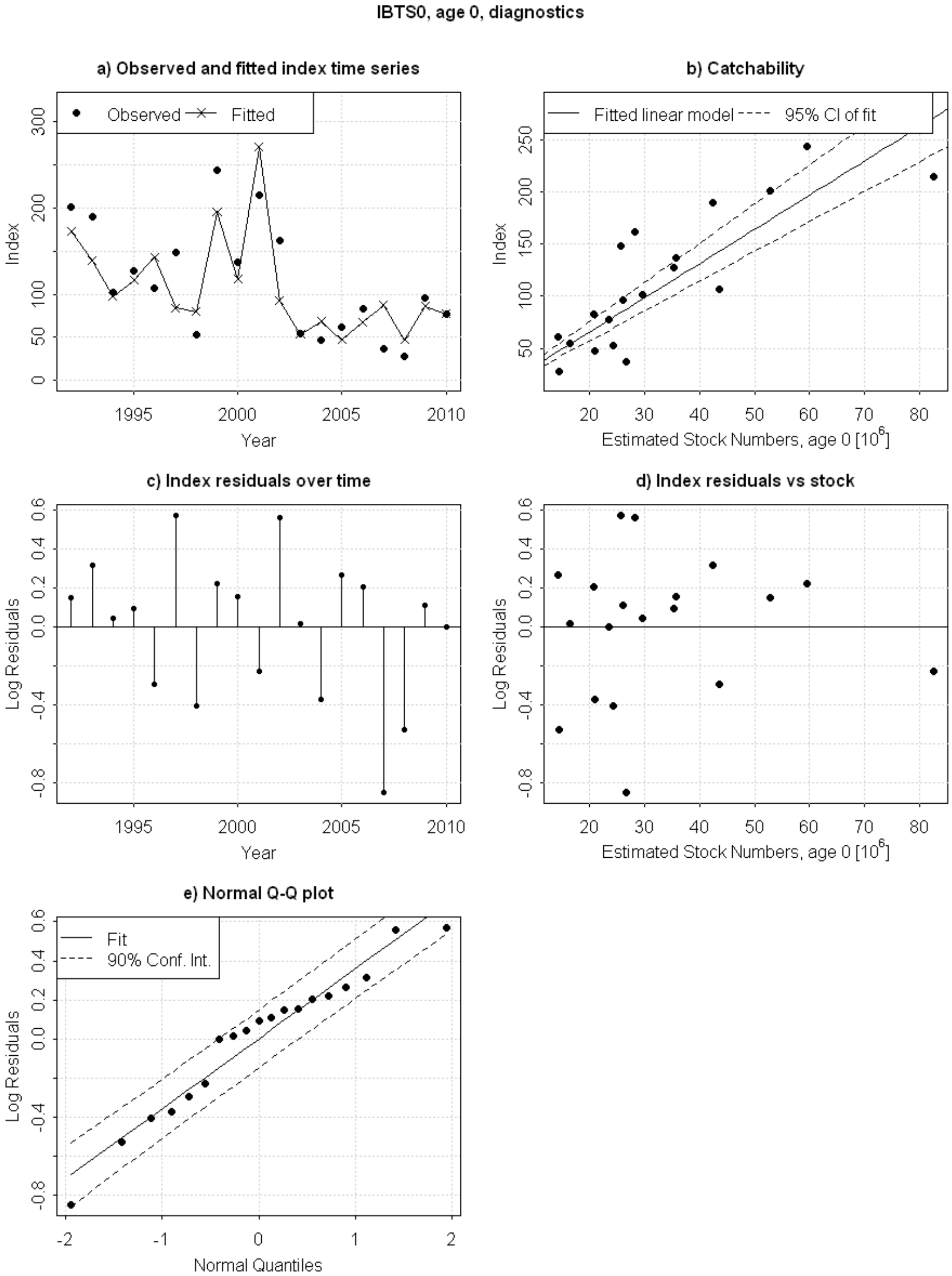


Figure 2.6.1.15. North Sea herring. Diagnostics of IBTS0 survey catchability at 0 wr from the final ICA assessment. Top left: VPA estimates of numbers at 0 wr (line) and numbers predicted from index abundance at 0 wr. Top right: scatterplot of index observations versus VPA estimates of numbers at 0 wr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

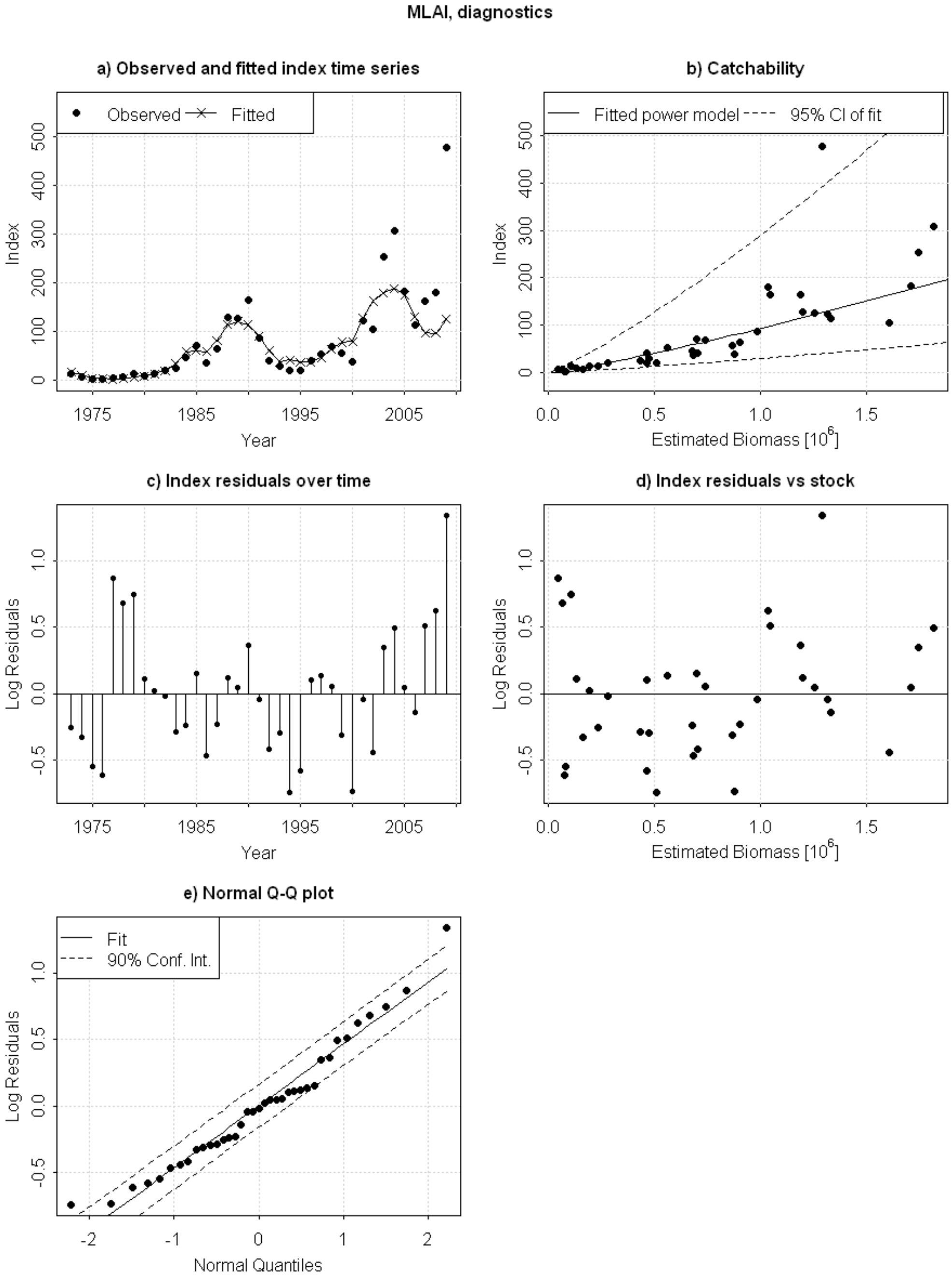


Figure 2.6.1.16. North Sea herring. Diagnostics of MLAI survey catchability at all ages from the final ICA assessment. Top left: VPA estimates of biomass of all ages and biomass predicted from index abundance for all ages. Top right: scatterplot of index observations versus VPA estimates of all ages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

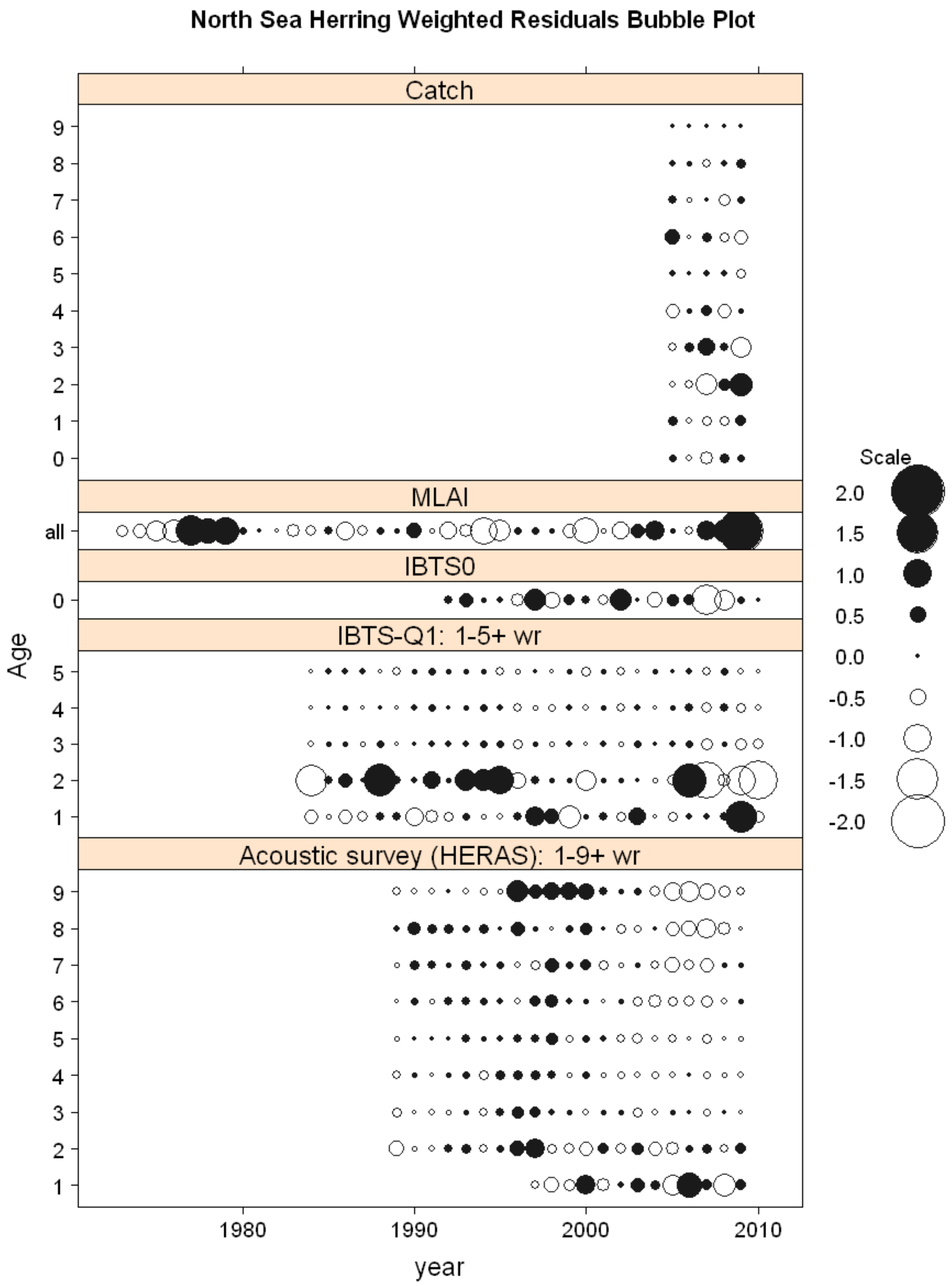


Figure 2.6.1.17. North Sea herring. Weighted Residuals of surveys and catch for the assessment up to 2009.

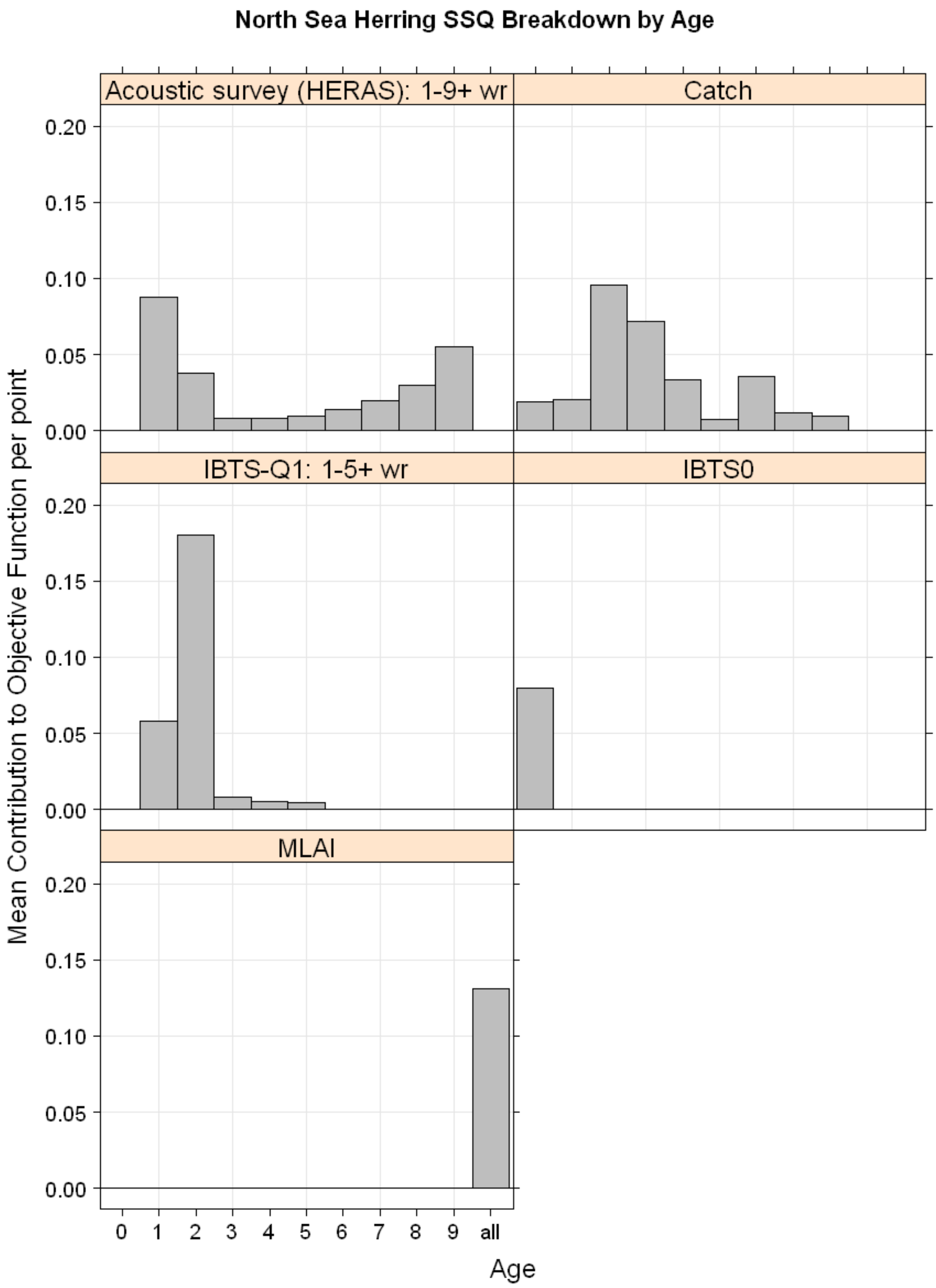


Figure 2.6.1.18. North Sea herring. Mean contribution of each indices or catch to the objective function by age.

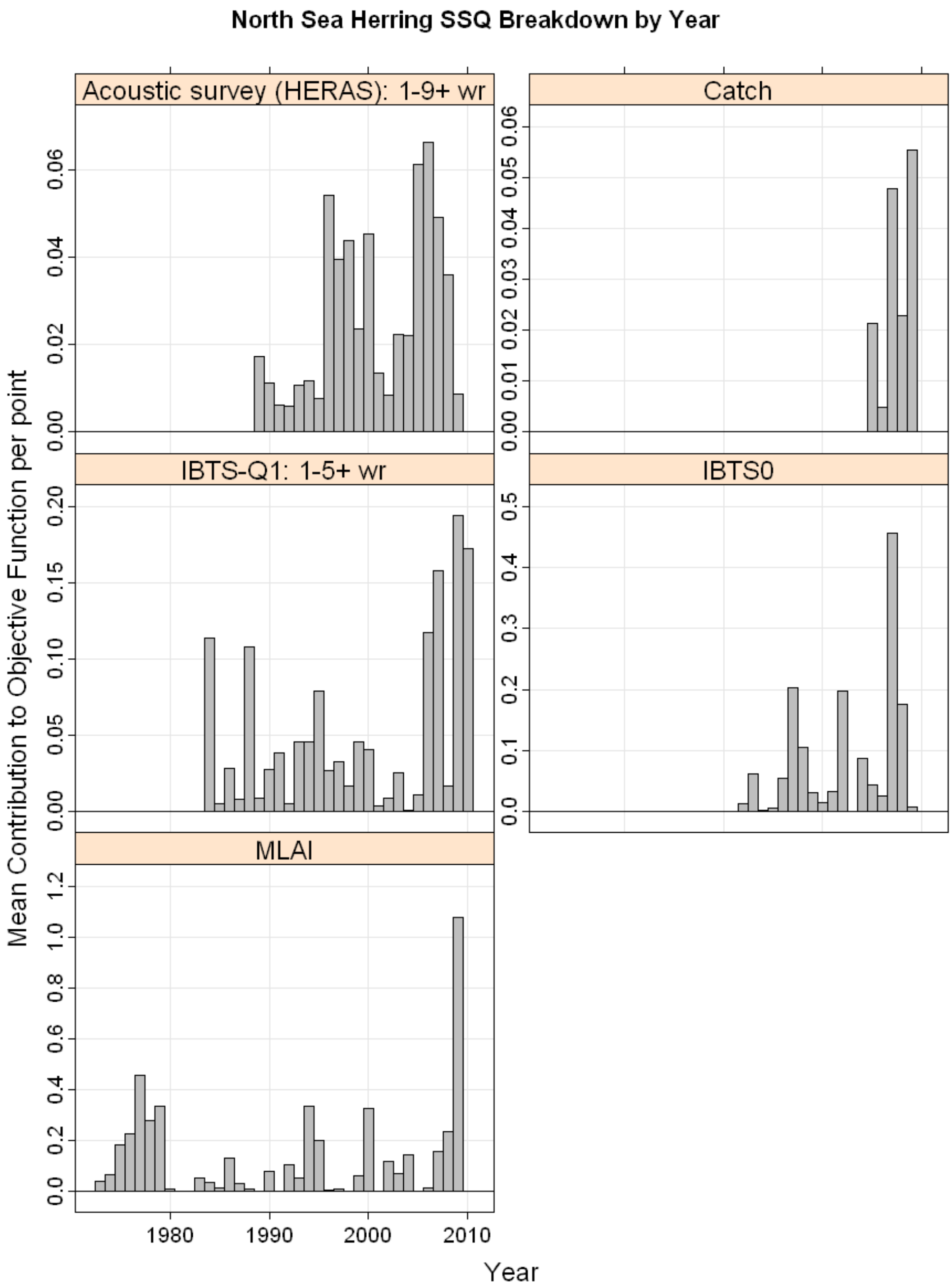


Figure 2.6.1.19. North Sea herring. Mean contribution of each indices or catch to the objective function by year.

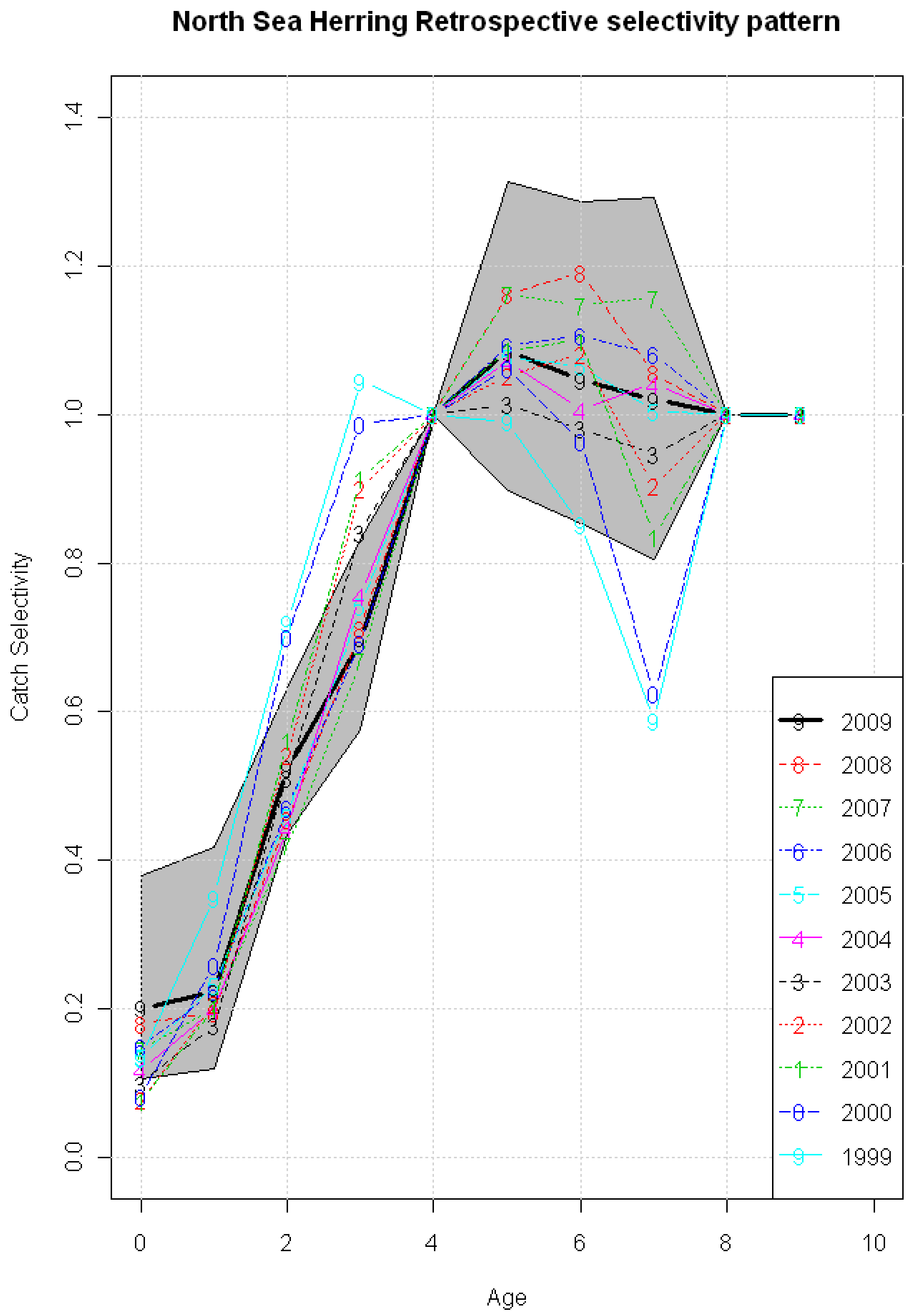


Figure 2.6.1.20. North Sea herring. Retrospective selectivity pattern for the year 2000 till 2009.

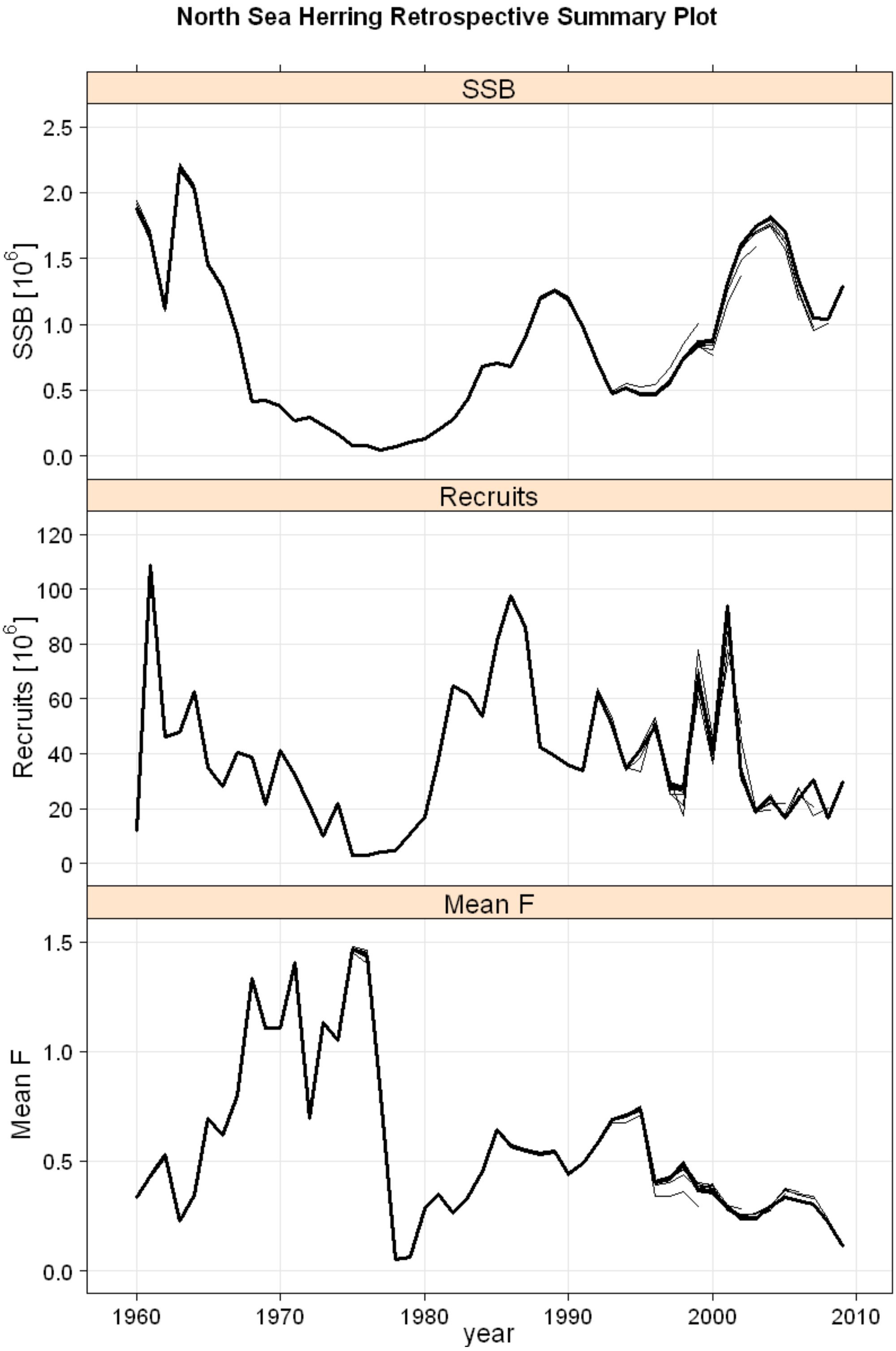


Figure 2.6.1.21. North Sea herring. Retrospective pattern plots for SSB, Recruits and $F_{2\text{-}6}$

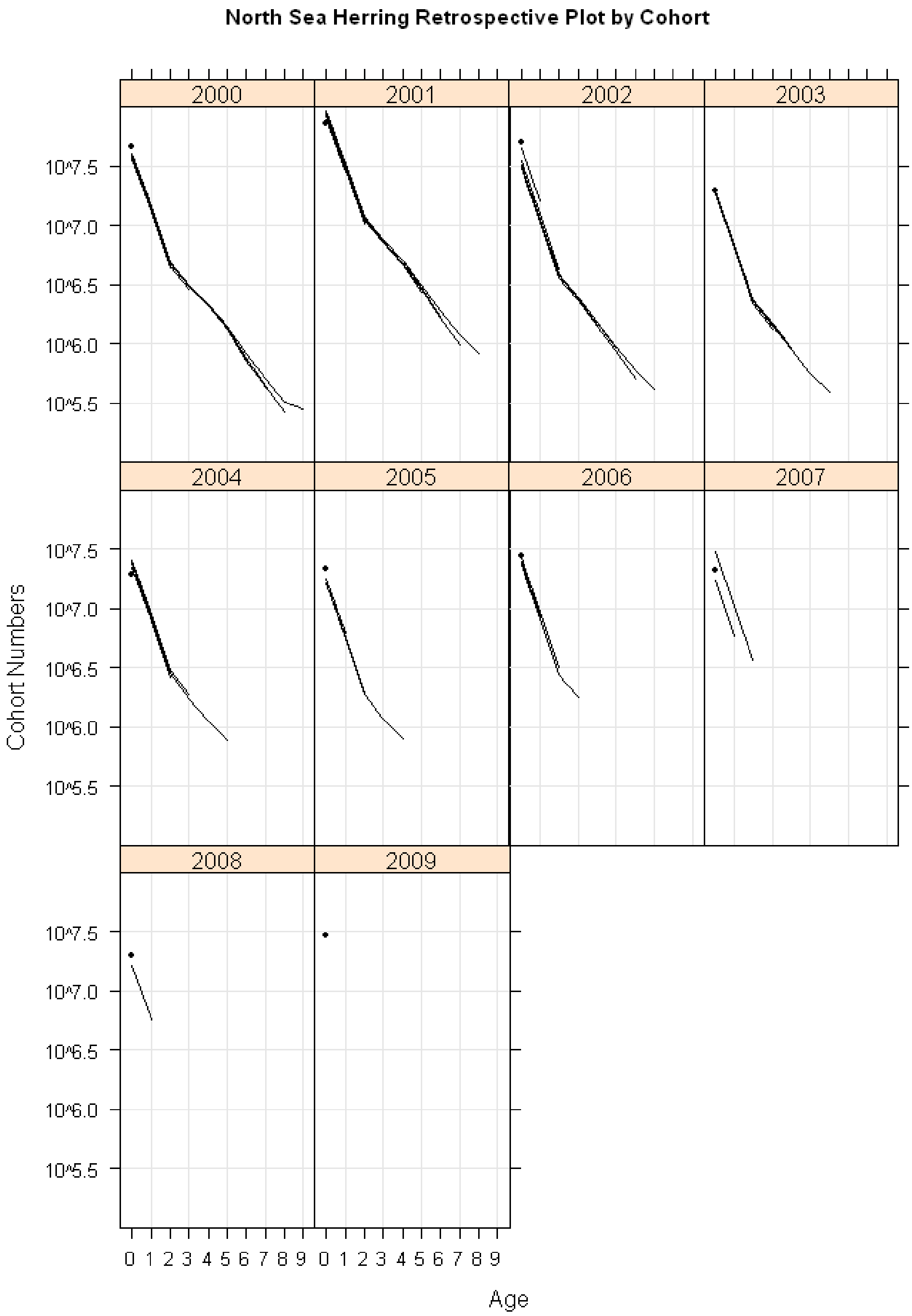


Figure 2.6.1.22. North Sea Herring. Year class cohort retrospectives for cohorts that contribute the current stock of North Sea herring.

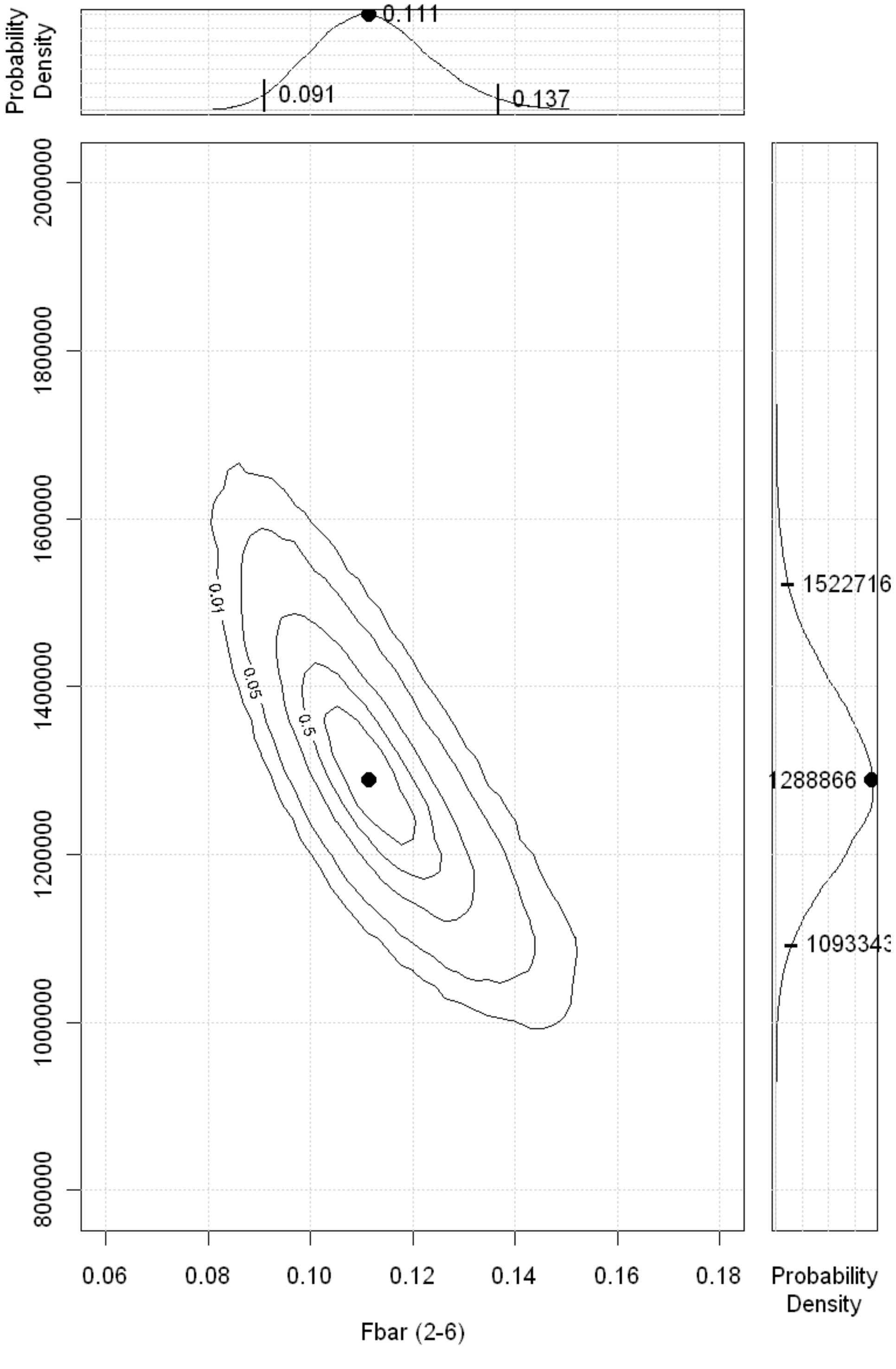


Figure 2.6.1.23 Model uncertainty; distribution and quantiles of estimated SSB and F2-6 in the terminal year of the assessment. Estimates of precision are based on a parametric bootstrap from the FLICA estimated variance/covariance estimates from the model.

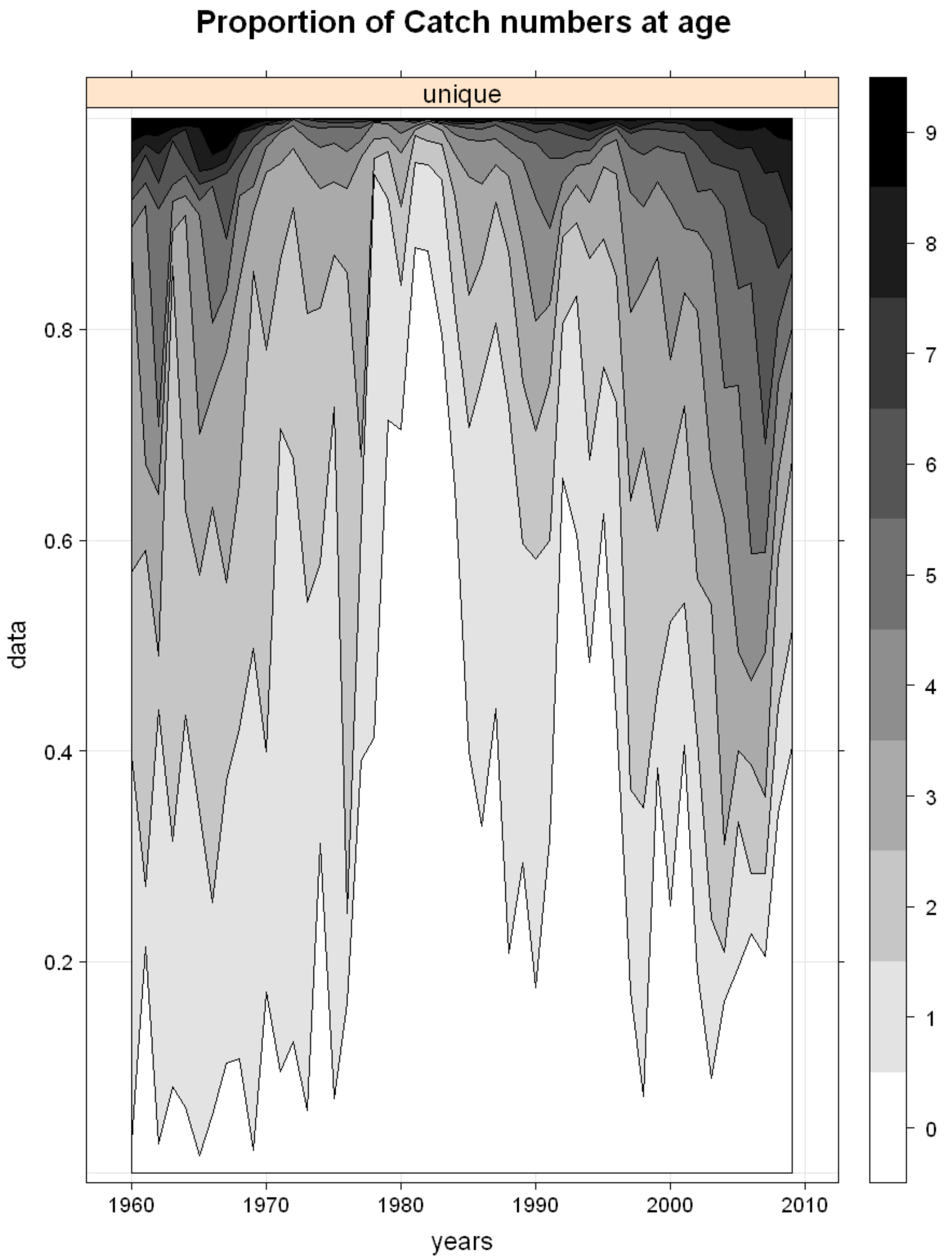


Figure 2.6.1.24 North Sea Herring. Proportion of catch numbers at age.

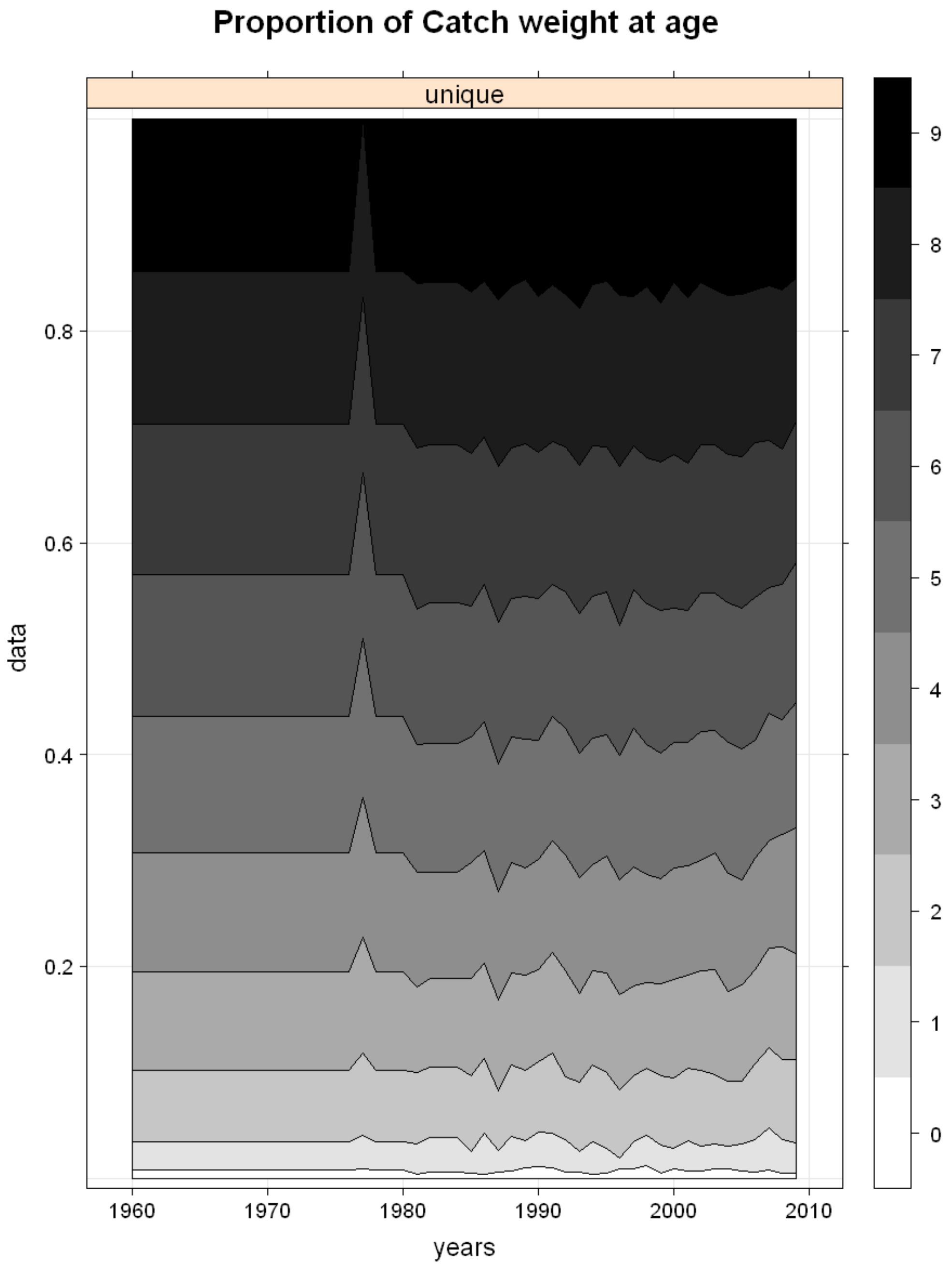


Figure 2.6.1.25 North Sea Herring. Proportion of catch weight at age.

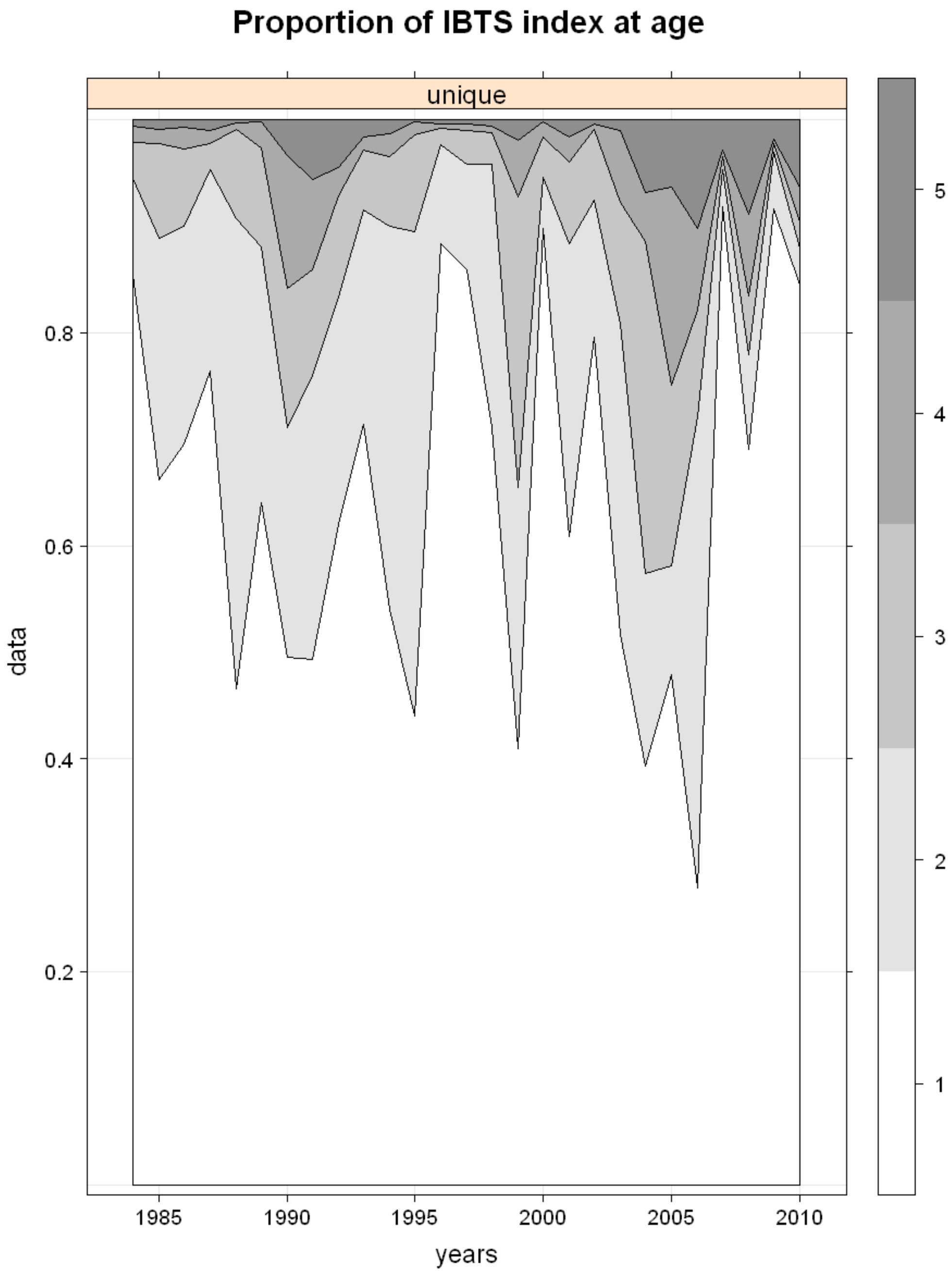


Figure 2.6.1.26 North Sea Herring. Proportion of IBTS index at age.

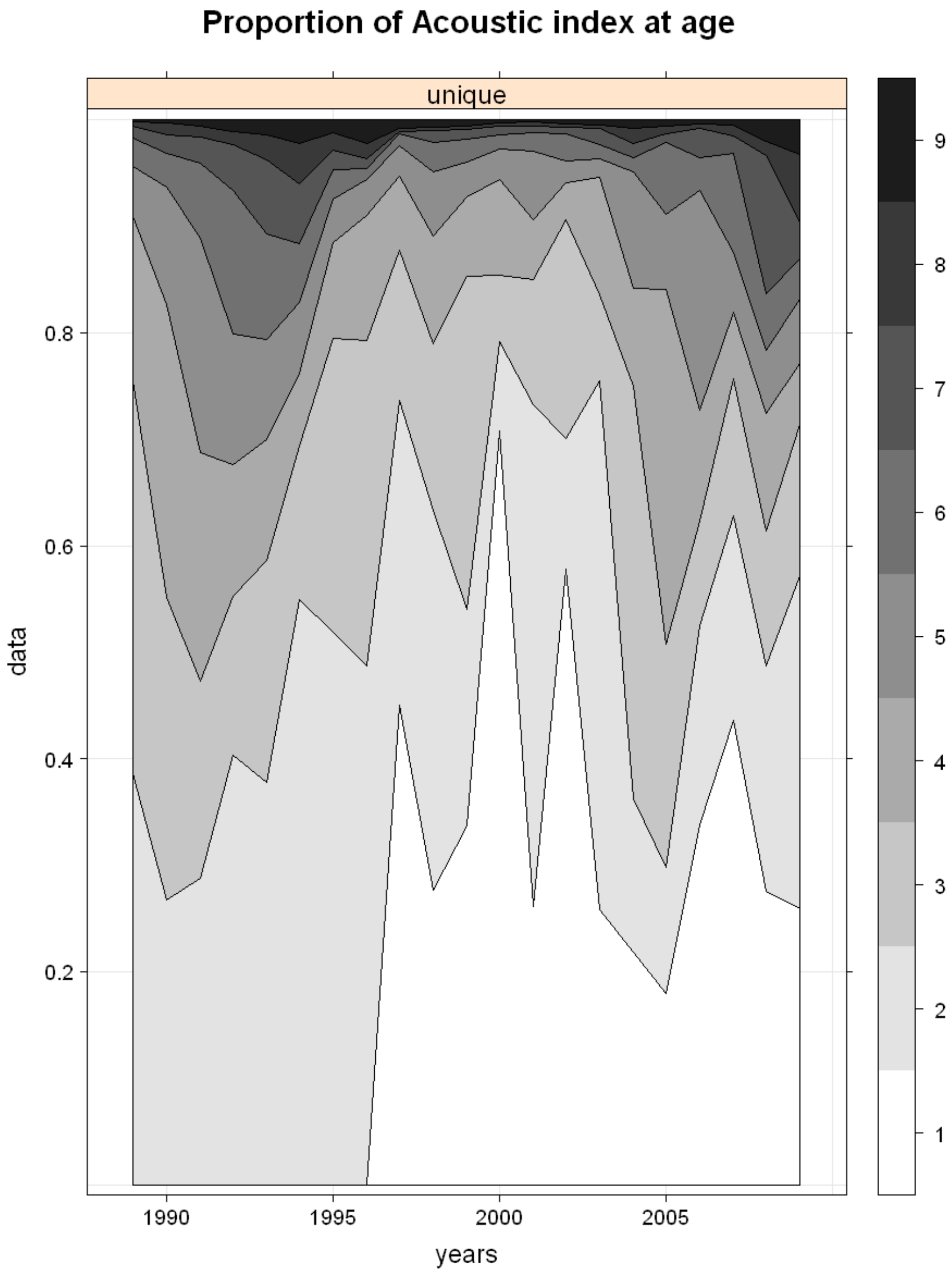


Figure 2.6.1.27 North Sea Herring. Proportion of Acoustic index at age.

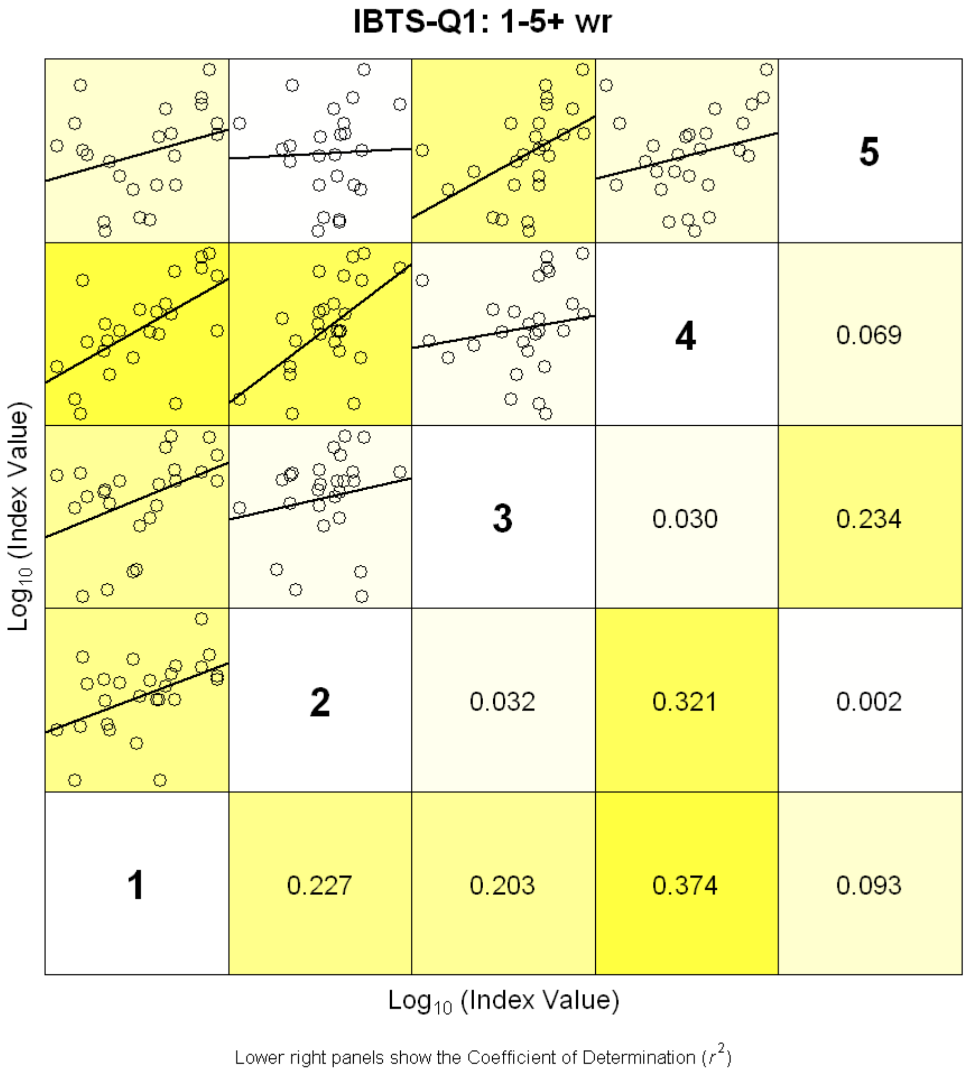


Figure 2.6.1.28 North Sea Herring. Correlation coefficient diagram for IBTS survey.

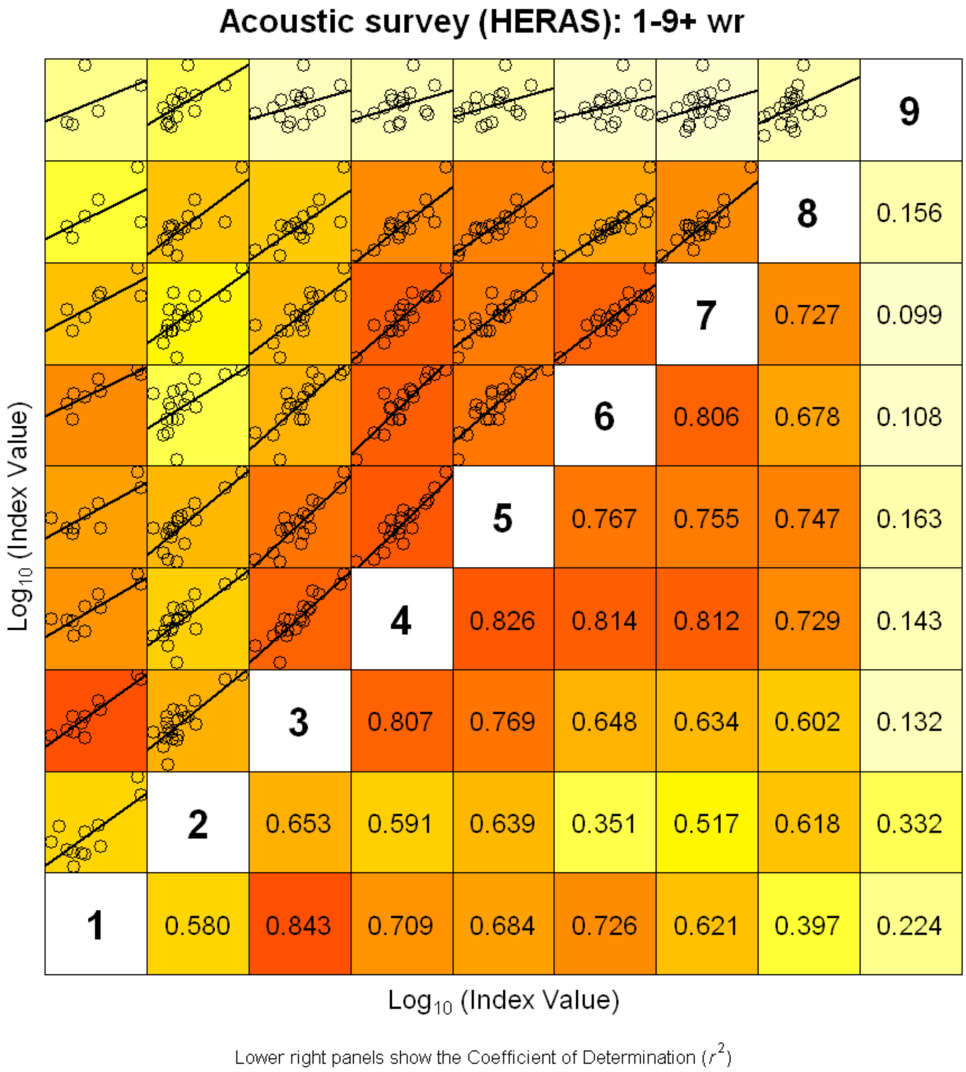


Figure 2.6.1.29 North Sea Herring. Correlation coefficient diagram for Acoustic survey.

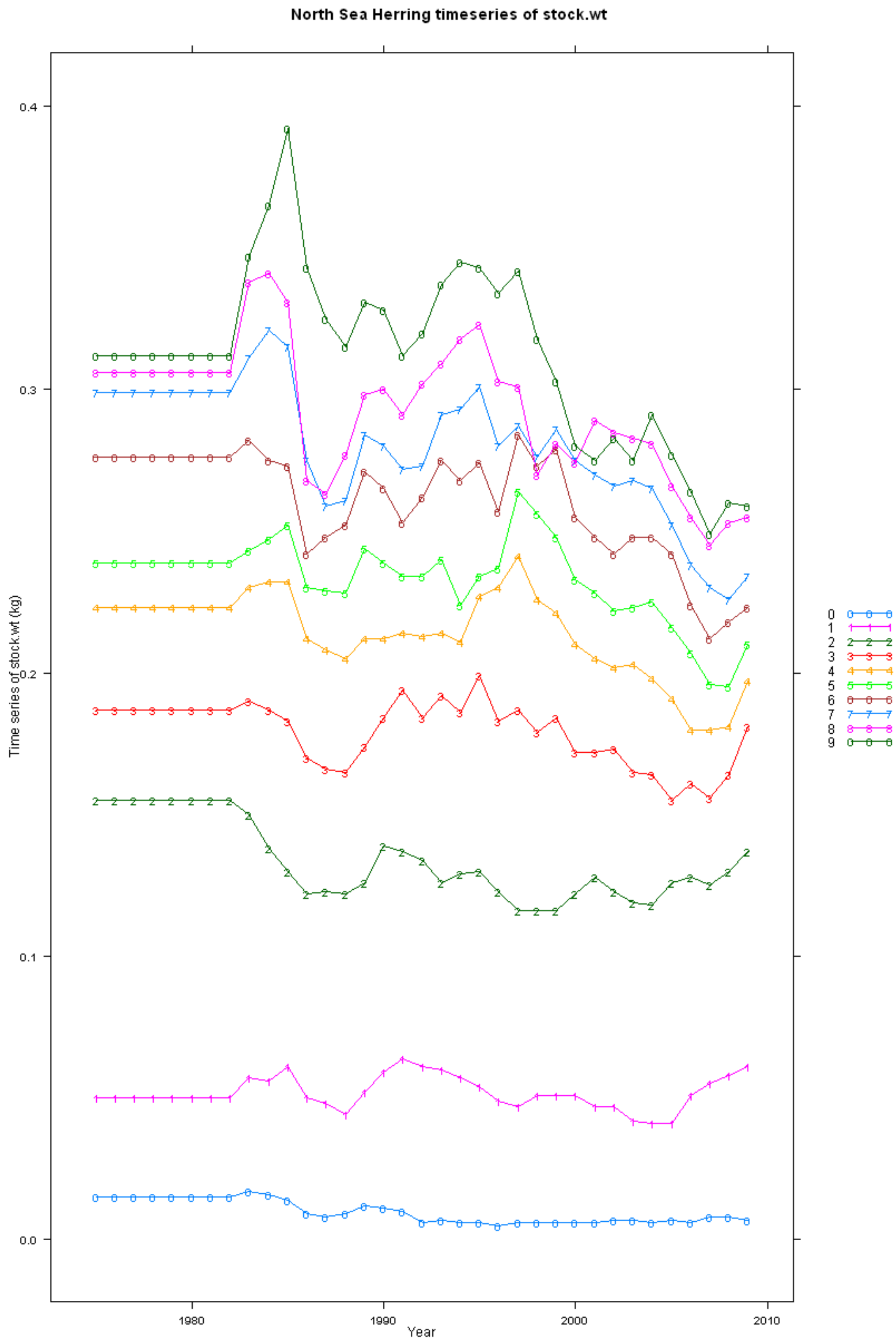


Figure 2.6.1.30 North Sea Herring. Weight at age in the stock over time.

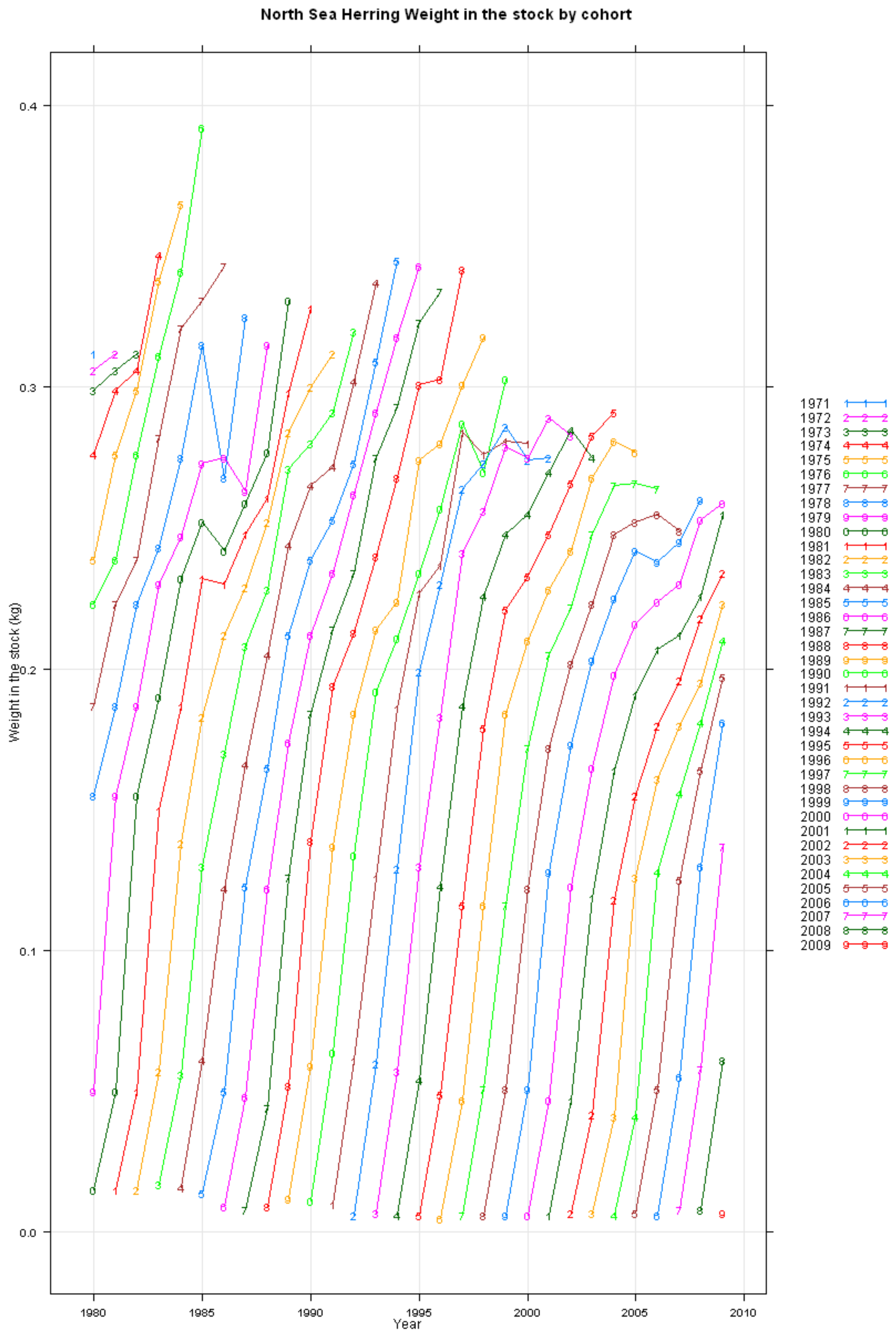


Figure 2.6.1.31 North Sea Herring. Weight at age in the cohort over time.

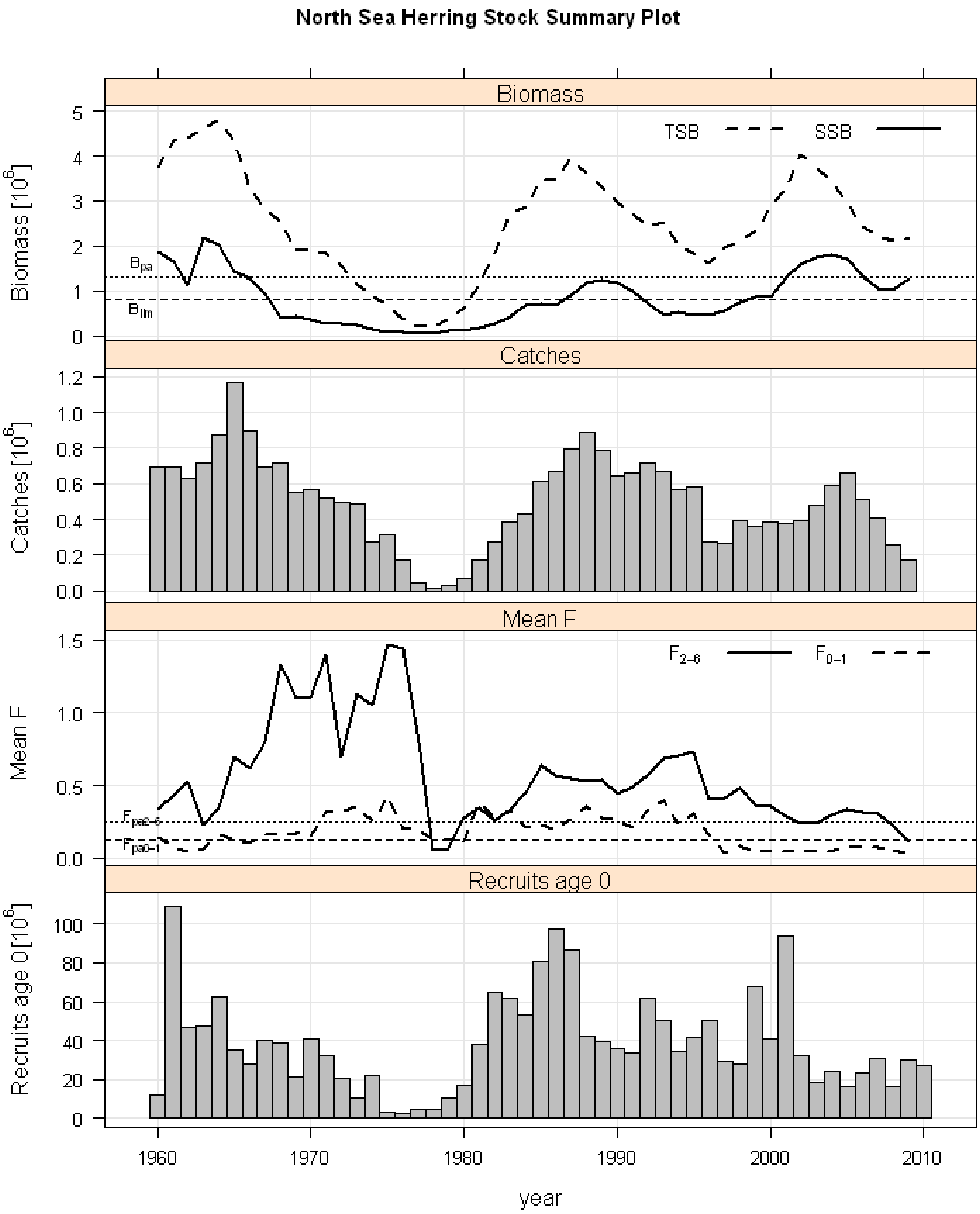


Figure 2.6.3.1. North Sea herring. Stock summary plot for SSB, recruitment and mean F on ages 2-6.

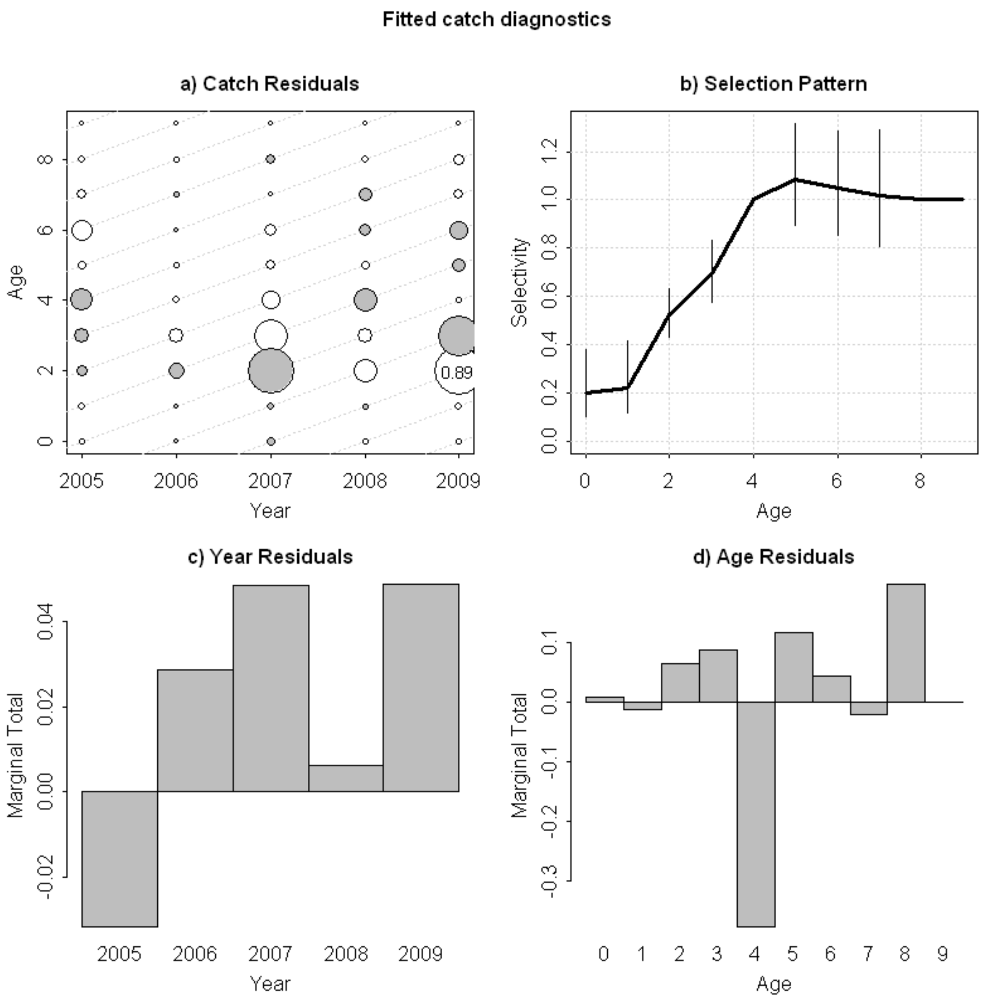


Figure 2.6.3.2. North Sea herring. Diagnostics of selection pattern from the final ICA assessment. Top left: bubbles plot of log catch residuals by age (weighting applied) and year (5 yr separable period). Top right: estimated selection parameters (relative to 4 wr) with 95% confidence intervals. Bottom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

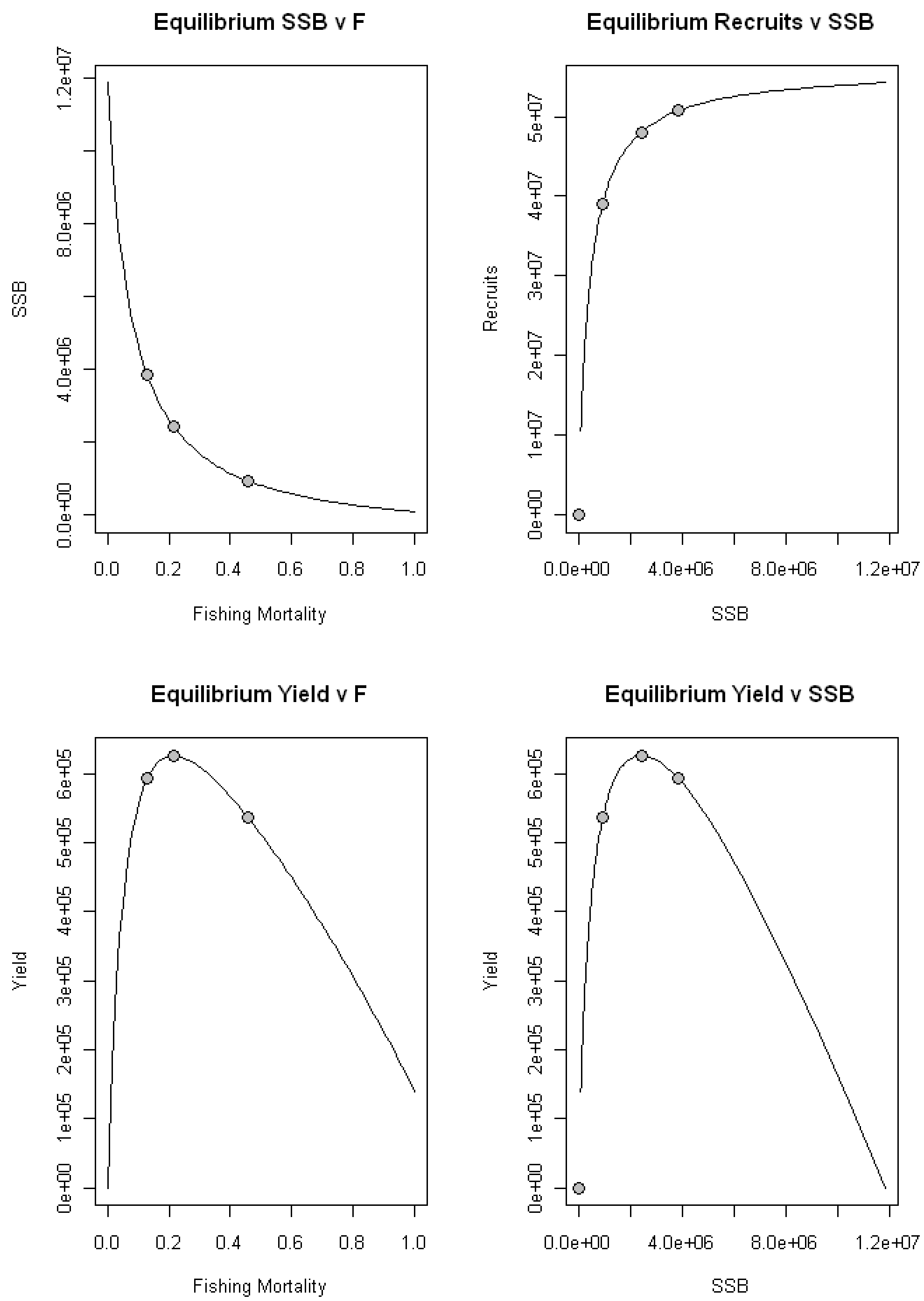


Figure 2.6.3.3 North Sea Herring. Reference diagrams including indication of reference points assuming a Beverton and Holt stock to recruit relationship. Upper left panel: Equilibrium SSB versus Fishing mortality (ages 2-6). Upper right panel: Recruit versus SSB relationship. Bottom right panel: Yield versus Fishing mortality (ages 2-6). Bottom right: Yield versus SSB. Grey points indicate B_{MSY} and F_{MSY}

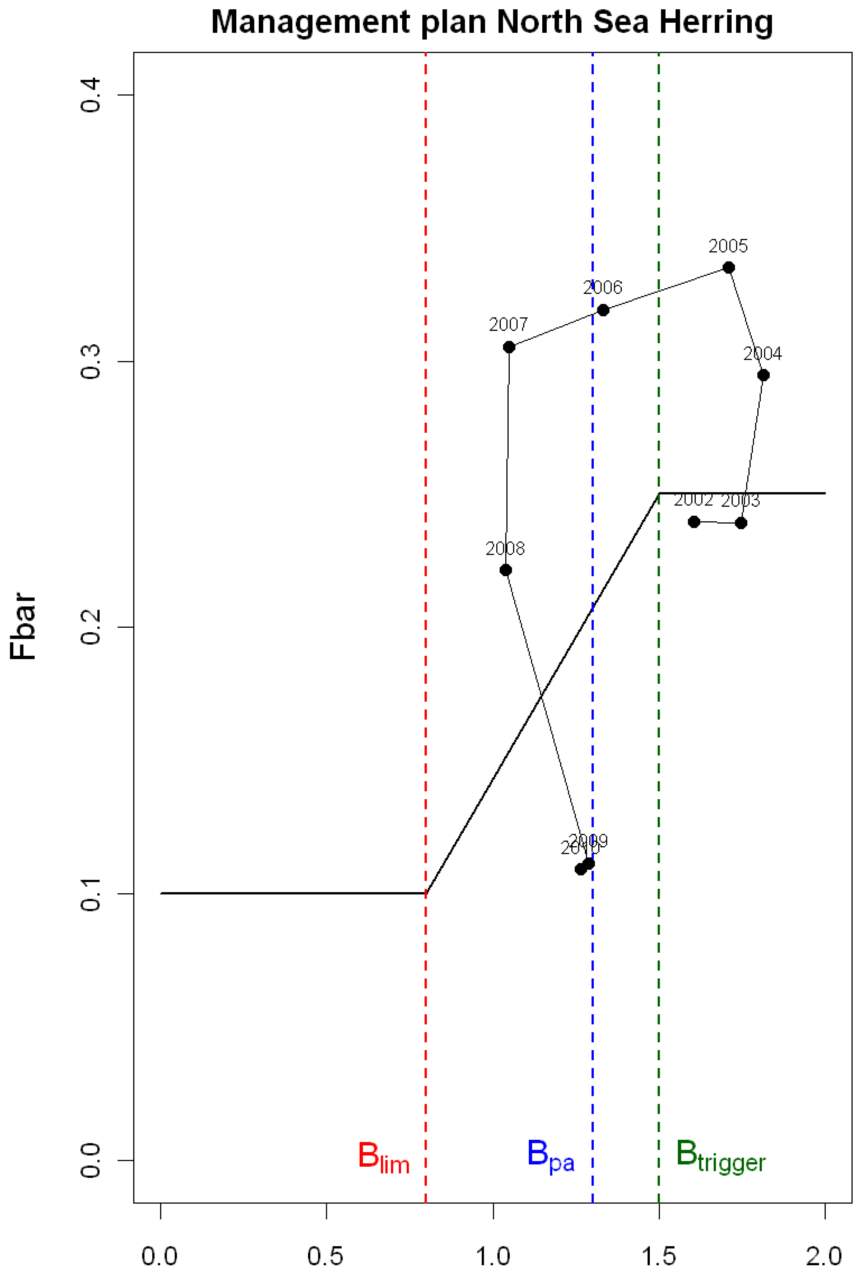


Figure 2.6.3.4. North Sea herring. Agreed management plan for adult fishery (A-fleet, ages 2-6) including trigger biomass points (B_{lim} and $B_{trigger}$) and B_{pa}. Black dots represent realised estimated fishing mortalities from 2002 untill 2008. Fishing mortality in 2009 is estimated based on the agreed TACS for the A-fleet from the short term prediction (see section 2.7).

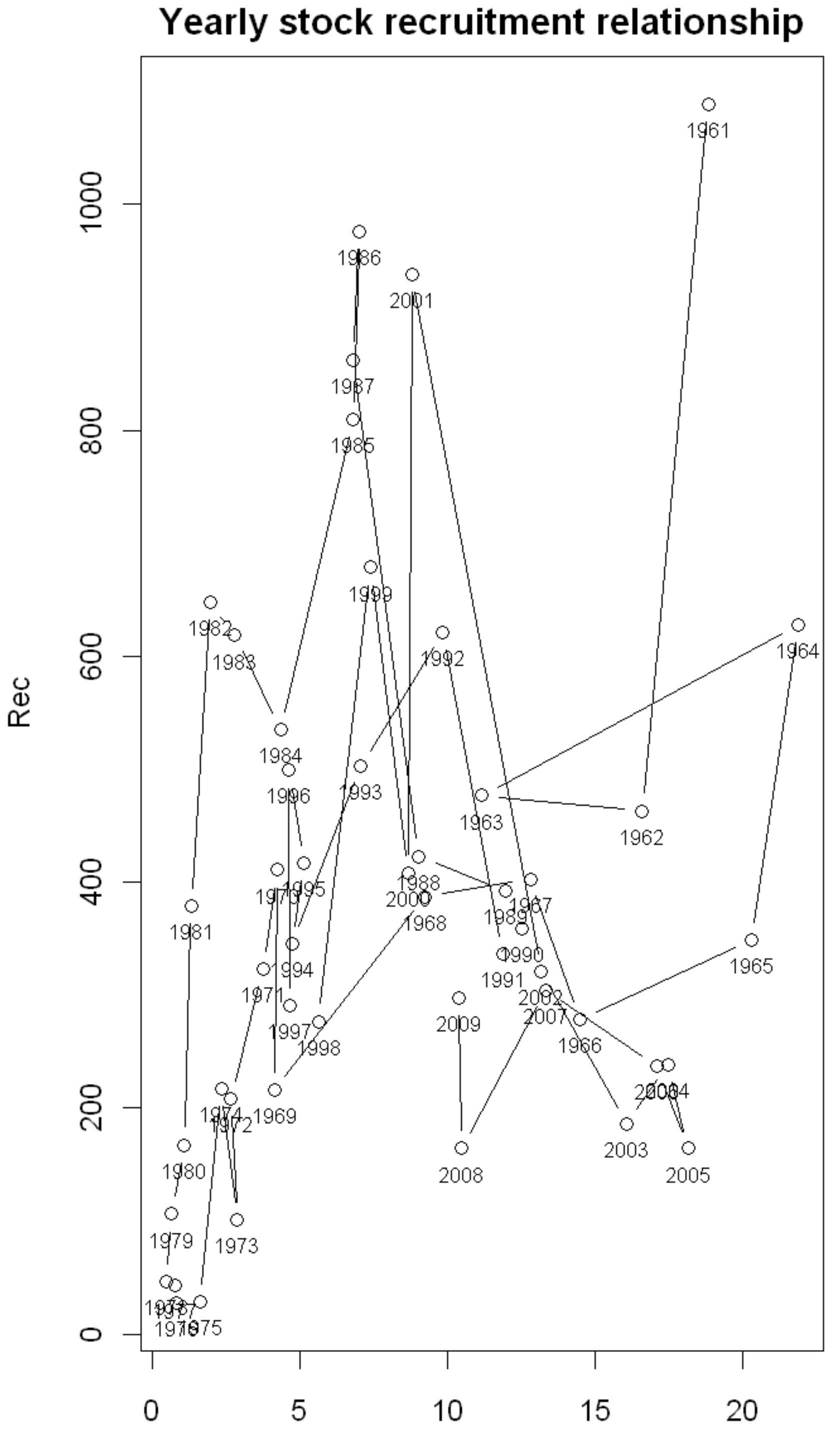


Figure 2.6.3.5. North Sea herring. Stock and recruit plot. Each point labelled by year class.

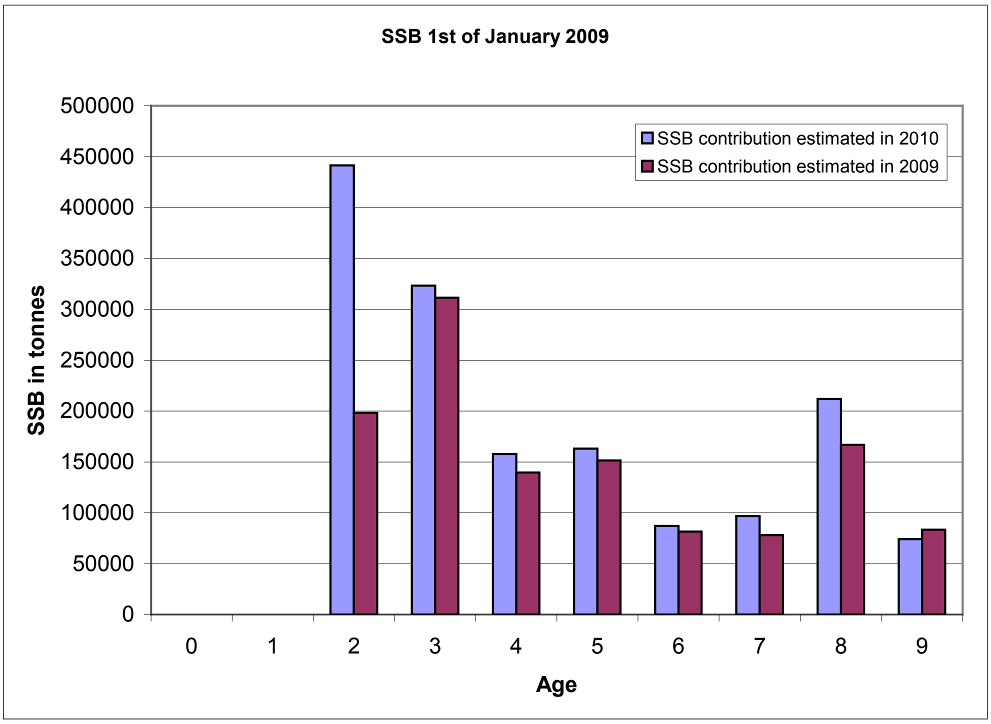


Figure 2.10.1. North Sea Herring. Contributions to SSB in 2009 by age estimated in 2009 and 2010. The estimate from 2009 is from the intermediate year projections. The estimate from 2010 is from the terminal year of the stock assessment. Information for 1 January, not time of spawning.

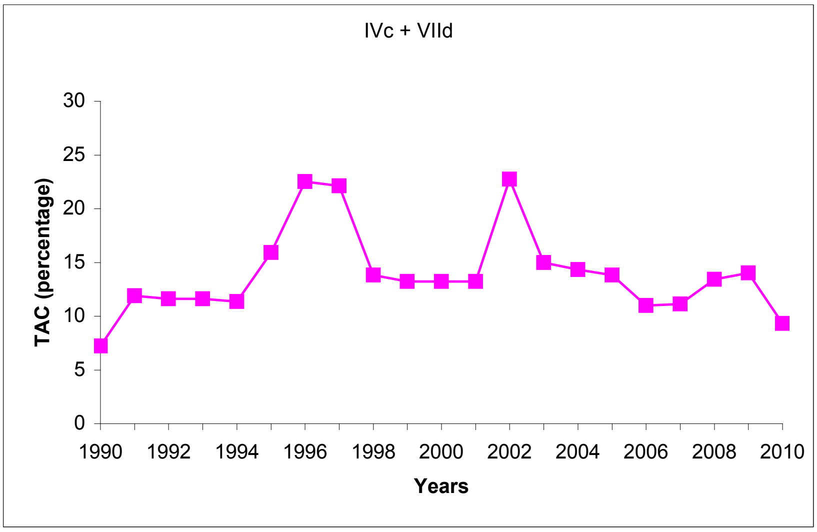


Figure 2.11.1. North Sea herring. TACs (percentage) for divisions IVc and VIId

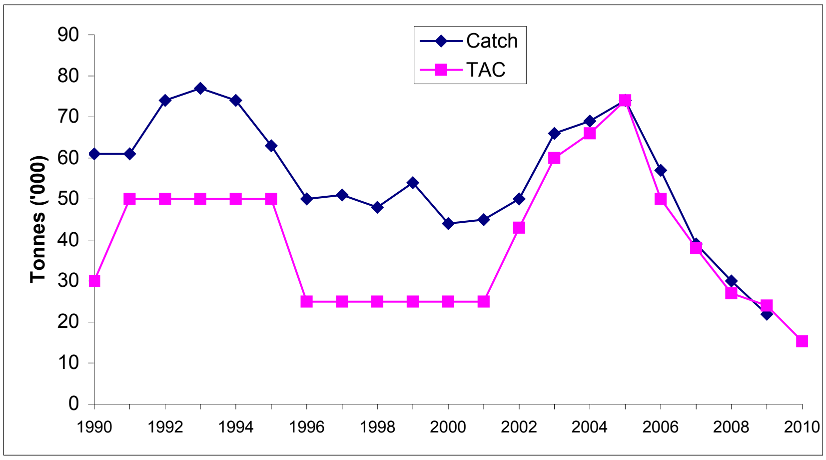


Figure 2.11.2. Downs herring in IVc and VIId. Comparison of historical catches and TACs

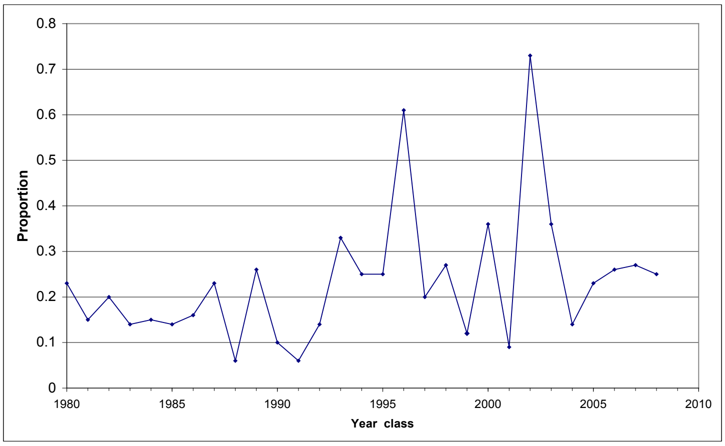


Figure 2.11.3. Downs herring. Proportion of small 1-ringers versus all sizes in the North sea (from table 2.3.3.2).

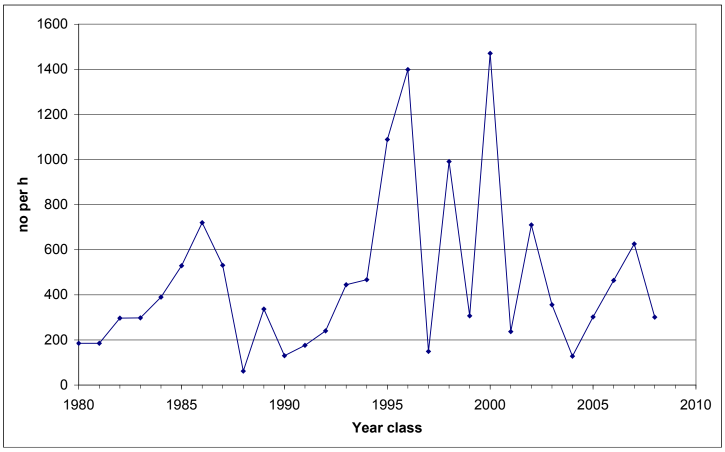


Figure 2.11.4. Downs herring. Index (Nos per hr) of small (<13cm) 1-ringers in the North from table 2.3.3.2).

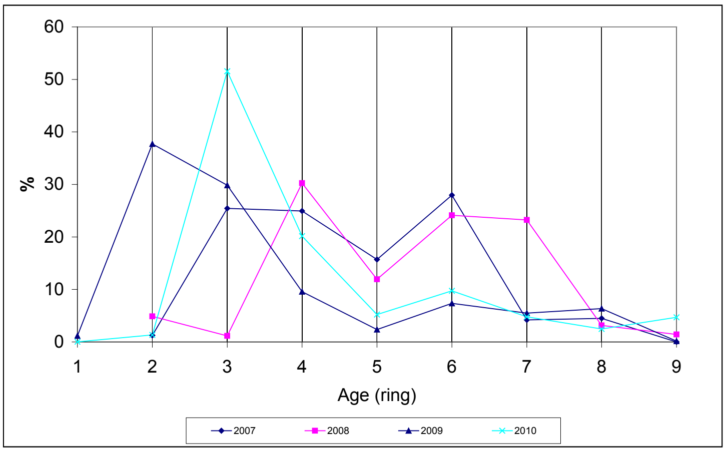


Figure 2.11.5. Downs herring. Catch composition (percentage by age) from pelagics hauls in the Eastern English Channel during IBTS 2007 to 2010.

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

3.1 The Fishery

3.1.1 Advice and management applicable to 2009 and 2010

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 32 800 t in 2010.

The EU and Norway agreement on a herring TAC for 2009 was 37 722 t in Division IIIa for the human consumption fleet and a by-catch ceiling of 8 373 t to be taken in the small mesh fishery. For 2010, the EU and Norway agreement on herring TACs in Division IIIa was 33 855 t for the human consumption fleet and a by-catch ceiling of 7 515 t to be taken in the small mesh fishery.

Previous to 2006 no special TAC for Subdivisions 22-24 was set. In 2009, a TAC (27 176 t) was set on the Western Baltic stock component. The TAC for 2010 was set at 22 692 t.

3.1.2 Catches in 2009

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 1988 to 2009 are given in Table 3.1.1 and Figure 3.1.1. In 2009 the total landings in Division IIIa and Subdivisions 22–24 have decreased to 69 900 t, which is the lowest value of the time series (1986-2009). The decrease in landings in 2009 is particularly evident in the Subdivisions 22-24, where all landings were decreased due to TAC regulations. As in previous years the 2009 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 2009 in thousands of tonnes by fleet (as defined by HAWG) and quarter.

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

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

	TAC	DK	GER	SF	PL	SWE	EC	NOR	FAROE
	2009								
Div. IIIa fleet-C	37,722	15,611	250			16,329	32,190	5,032	500
Div. IIIa fleet-D	8,373	7,157	64			1,152	8,373		
SD 22-24 fleet-F	27,176	3,809	14,994	2	3,536	4,835	27,176		
% of IIIa taken in IV								-20%	
	2010								
Div. IIIa fleet-C	33,855	13,986	224			14,630	29,340	4,515	500
Div. IIIa fleet-D	7,515	6,424	57			1,034	7,515		
SD 22-24 fleet-F	22,692	3,809	14,994	2	3,536	4,835	22,692		
% of IIIa taken in IV								-20%	

3.1.3 Regulations and their effects

In recent years, HAWG has calculated a substantial part of the catch reported as taken in Division IIIa in fleet C actually has been taken in Subarea IV. These catches have been allocated to the North Sea stock and accounted under the A-fleet. Estimates based on VMS and Industry information suggest that 36%, 28% and 30% of the official landings for human consumption in Division IIIa have been misreported in 2006, 2007 and 2008, respectively. These figures are probably underestimating the problem since only a subset of countries supply this information to the HAWG. Misreported catches have been moved to the appropriate stock for the assessment. However, for 2009 this pattern of misreporting of catches into Division IIIa was not thought to occur, based on information from both the industry and VMS estimates. Thus no catches were moved out of Division IIIa to the North Sea in 2009.

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

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

3.1.3.1 Changes in fishing technology and fishing patterns

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

3.2 Biological composition of the catch

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

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

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

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

The total catch, expressed as SOP, of the WBSS taken in the North Sea + Div. IIIa in 2009 was estimated to be 36 200 t, and has thereby increased compared to 2007 and 2008, but is still in the lower end of the timeseries (Table 3.2.13).

Total catches of WBSS from the North Sea, Division IIIa, and Subdivisions 22-24 respectively, by quarter, was estimated for 2009 (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 1993–2009, are presented in Tables 3.2.15 and 3.2.16.

The total catch of NSAS in Div. IIIa amounted to 6 542 t in 2009, which is the lowest value observed in the time series (Table 3.2.17).

The transfer of WBSS from Division IV into IIIa and the transfer of NSAS from Division IIIa into Division IV in 2009 are shown in the text table below

Year	Stock	Transfer route	Tonnes
2009	WBSS	IVaE to IIIa	3 941
2009	NSAS	IIIa to IVaE	6 542

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 2009 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 2009 more than meets the recommended level of one sample per 1 000 t landed per quarter and the coverage of areas, times of the year and gear (mesh size) was acceptable.

Splitting of catches into WBSS and NSAS in Division IIIa were based on Danish and Swedish analyses of otolith micro-structure of hatch type and extended with discriminant analysis calibrated with hatch type and applied on production samples with classification parameters: herring length weight and age as well as otolith metrics. The total sample size for hatch type was 3903 with 63% of the samples in Division IIIa North and 37% in IIIa South.

Sampling for split of catches in the transfer area in Division IVa East was considered insufficient in 2009, with a total of 48 micro-structure and 50 vs observations. The split in the transfer area was therefore calculated as a three years mean (2006-2008) proportions by age.

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 2 and 21 October 2009 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 2010/SSGESST:03). The results for 2009 are presented in Table 3.3.1. The time series has been revised in 2008 (ICES 2008/ACOM:62) 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:62). The Western Baltic spring spawning herring stock in 2009 was estimated to be 3465 x 10^6 fish or about 65 x 10^3 tonnes in Subdivisions 21–24. Estimates of total biomass are comparable to levels of abundance and biomass observed in 2008 (Table 3.3.1). However, the amount of 3+ herring individuals (238 x 10^6) as well as the total biomass and the biomass of 3+ herring are the lowest observed. Only ages 1-3 are included in the assessment.

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

The Herring acoustic survey (HERAS) was conducted from 30 June to 13 July 2009 and covered the Skagerrak and the Kattegat. Details of the survey are given in the 'Report of the Working Group for International Pelagic Surveys (WGIPS)' (ICES CM 2010/SSGESST:03). The 1999 was excluded from the assessment due to different survey area coverage. The estimates of the Western Baltic spring spawning herring stock are 204 900 tonnes and 1 601 million individuals, which is among the lowest observed values in the time series. The stock is dominated by 1 and 2 ringer fish, although the 1 ringers are only 10% compared to 2008. 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 2009 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, 2007, WD 7 in HAWG 2008 (ICES 2008/ACOM:62)). The values estimated for N20 in 2009 is the largest since 2003 and it is about 5 times larger than the 2008 estimate (Table 3.3.3).

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

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

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

The same maturity ogive was used as in the HAWG 2009:

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 2009 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 2009 were available for Subdivision IVa (East), Division IIIa and Subdivisions 22-24 (Table 3.6.1; Figure 3.6.1.1). Years before 1991 are excluded due to lack of reliable data for splitting spawning type and also due to a large change in fishing pattern caused by changes in the German fishing fleets (ICES 2008/ACOM:62).

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

3.6.1.2 Biological data

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

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

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

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

3.6.1.3 Surveys

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

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

3.6.2 Assessment method

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

3.6.3 Assessment configuration

Following the procedure in the WBSS stock annex (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 (2005-2009)
- The weighing factor to all indices: lambda = 1
- A linear catchability model for all indices
- The reference F set at age 4 and the selection=1 for the oldest age
- The catch data were down-weighted to 0.1 for 0-ringer herring
- No stock-recruitment model was fitted
- Errors in index values are assumed to be correlated.
- Plus group is set to age 8+.

3.6.4 Assessment Results

The results of the assessment are given in Tables 3.6.12-21. The estimated SSB for 2009 is 105 234 tonnes. The mean fishing mortality (ages 3-6) is estimated as 0.52. Parametric bootstrap estimates of these values give 95% confidence intervals of 79 279, 140 414] for SSB and [0.34, 0.80] for the mean fishing mortality (Figure 3.6.4.1).

After a marked decline from over 300 000 tonnes in the early 1990s to a low of 120 000 tonnes in the late 1990s, the SSB of this stock recovered somewhat, reaching a secondary peak of around 200 000 tonnes in the early 2000s (Figure 3.6.4.2). After a small peak in 2006 coinciding with the maturing of the 2003 year-class; the SSB has declined three years in a row to the lowest observed SSB in the time series.

Fishing mortality on this stock was high in the mid 1990s, reaching a maximum of over 0.7 yr^{-1}. In 1999-2007 F_{3-6} stabilised around 0.4, but for the last two years it has increased to 0.52 (Figure 3.6.4.2).

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

After 9 years of decreasing recruitment ending in 2008 on 1.1 billion individuals - the lowest value observed in the time series; the 2009 recruitment increased to 3.5 billions. This is close to 3.3 billions; the geometric mean of the time series consisting of 19 years (Figure 3.6.4.2).

The catch residuals are generally free from patterns (Figure 3.6.4.3). The marginal totals of residuals between the catch and the separable model are small overall; the apparent pattern of decreasing residuals through time and negative age residuals on either side of the reference age, is therefore without significant effect.

The individual diagnostics for the three surveys generally show good quality fits (Figures 3.6.4.4 – 3.6.4.11). The residuals appear to be distributed randomly, and the assumption of normal distribution is generally held up. Most survey-ages appear to have at least one significant outlier. Generally, however, the agreement between the data and the fitted model appears good through all data sources.

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

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

Retrospective analysis suggests the assessment method gives a relatively consistent perception of the stock and its development (Figure 3.6.4.14). The changes from year-to-year are generally less than the uncertainty of the estimated values (ICES 2008/ACOM:62), and are not a cause for great concern.

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

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

3.6.5 State of the stock

After three years of decreasing SSB, the stock is now at the lowest observed level in the time series. This is an effect of an increasing and very high F and a decreasing trend in recruitment. F is now at 0.52 more than double the proxy for F_{msy} (0.25).

The larval survey in 2009 showed a medium number of larvae. This survey is conducted before the main mortality, so whether 2009 will come out as a strong year class will not be known before they enter the acoustic survey and parts of the fishery as 1 ringers in 2010.

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

3.6.6 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 only difference between the two is the addition of a further year of data. The addition of this extra year of data has modified the perception of the stock, decreasing the SSBs and increasing the fishing pressures substantially.

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

Category	**Parameter**	**Assessment in 2009**	**Assessment in 2010**	**Diff. 09-10 (+/-) %**
ICA results	SSB 2007	161 537	143 097	-11.4%
	F(3-6) 2007	0.358	0.402	+12.3%
	SSB 2008	159 406	120 154	-24.6%
	F(3-6) 2008	0.367	0.446	+21.5 %

3.7 Short term predictions

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

3.7.1 Input data

Stock numbers at age at the start of 2009 were taken from the ICA assessment, except for age 0. For age 0, the geometric mean recruitment (2004-2008) was assumed considering the recent low recruitment. The selection at age was taken from the ICA assessment. Arithmetic averages over the years 2007-2009 were used for mean weights at age in the catch and in the stock, as well as maturities at age. The input data are shown in Table 3.7.1.

3.7.2 Intermediate year 2010

A catch constraint was assumed for the intermediate year.

-1006 t were subtracted from the Division IIIa TAC in 2009 and 903 t subtracted from the TAC in 2010, to account for the agreed transfer of the Norwegian quota from IIIa to the North Sea.

-Misreporting of catches from the North Sea into Division IIIa is no longer assumed to occur after 2008.

-The catch by each of the two fleets fishing for human consumption (C- and F-fleet) in 2009 was close to the TACs. The proportion of the TAC taken in the small meshed fishery (D-fleet) has varied slightly between 37% and 58% during the last five years.

-The fractions of the total catch of WBSS in Division IIIa and Subdivisions 22-24 taken by each of the three fleets C, D, and F, in 2009 are assumed constant for the intermediate and advice years as well. An additional amount of 3 941 t of WBSS taken in the transfer area in Division IVaE in 2009 is assumed constant for the intermediate and advice years for catch options 2-7.

-The 2010 total catch was calculated from the EU agreed TACs for Subdivisions 22-24 and by fleet, and for Division IIIa from the "conclusions from the fisheries consultations between EC and Norway (January 20, 2010)". The Division IIIa TAC includes both WBSS and NSAS herring, while the Subdivision 22-24 TAC is assumed to be only WBSS herring.

-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 2010 as that in 2009 in Division IIIa, and further the afore mentioned constant amount of 3 941 t WBSS taken in Division IVaE by the A-fleet in 2009 is assumed to be taken in this area in 2010.

-The shares of the WBSS catches in IIIa and other areas in the assessment year is used to translate the total recommended TAC for WBSS into outtake of WBSS in Division IIIa and Subdivisions 22-24. The mix of the two stocks in the Division IIIa catches is used to derive the outtake of NSAS and total catches in Division IIIa.

-Summarising: predicted catches of WBSS and NSAS by fleet in IIIa is based on assessment year patterns of 1) fraction of WBSS catches taken by each fleet plus a constant catch of WBSS in IVaE and 2) proportion of the two stocks in catches of the different fleets. These assumptions give the expected catch by fleet in 2010.

The resulting expected catch of WBSS in 2010 following this scheme was 57 323 t.

	2009				2010				
Calculation of Intermediate year catch constraint (2010)	Catch of WBSS	Catch of NSAS	TAC-catch WBSS+ NSAS*	Catch of NSAS+ WBSS	Catch as asssumed proportion of TAC	TAC-catch WBSS+ NSAS *	Realised TAC catch in 2010	proportion of WBSS in catch	catch of WBSS in 2010
A-fleet	3,941			3,941				100.00%	3,941
C-fleet	29,426	5,056	36,716	34,482	1.00	32,952	32,952	85.34%	28,120
D-fleet	2,863	1,486	8,373	4,349	0.52	7,515	3,903	65.83%	2,570
F-fleet	31,032		27,176	31,032	1.00	22,692	22,692	100.00%	22,692
Total (Div. IIIa, SD 22-24 and IVaE)	67,262	6,542	72,265	73,804			59,547		57,323

*After accounting for Norwegian transfer of quota from Division IIIa to the North Sea (1 006 t in 2009, 903 t in 2010).

3.7.3 Catch options for 2011

The output of the short-term prediction, based on a catch constraint in the intermediate year 2010 of 57 323 t, is given in Table 3.7.2.

1) ***Zero catch.*** After a continued low SSB in 2011 the SSB increases to 134 800 t in 2012.

2) ***F_{2011} = 0.170***, which is the F calculated by scaling the FMSY to the proportion of $SSB_{AY}/SSB_{BREAKPOINT}$, when SSB in the advice year is predicted to be below the break-point of 110 000 t.

This option will give a yield of 26 500 t in 2011 and lead to an SSB of 76 000 t in 2011 and 113 700 t 2012, a little above the breakpoint of 110 000 tonnes.

3) ***F2011* = 0.25**, which is a candidate of FMSY within a range of values (0.2 – 0.3)

This option will give a yield of 37 200 t in 2011, with an SSB of 75 400 t in 2011 and 105 300 t in 2012.

4) ***A 15% reduction of all fleet-wise WBSS TACs for 2011***, converted into a total herring catch by assuming that the TAC is completely taken. The catches of WBSS herring are then calculated by assuming that the proportion of WBSS in each fleet's catch is the same as that in 2009, to give a yield in 2011 of 51 300 t, and a SSB of 74 500 t.

With this assumption the SSB increase in 2012 to 92 700 t, still considerably below the suggested breakpoint of 110 000 t.

5) As for option 4, but with no change in the WBSS TAC, to give a catch in 2011 of 59 700 t.

With this assumption SSB only show a small increase from 73 900 t in 2011 to 85 700 t in 2012, way below the suggested breakpoint of 110 000 t.

6) As for option 4, but with a 15% increase in the WBSS TAC, to give a catch in 2011 of 68 100 t.

With this assumption the decline in SSB in 2010 and 2011 is essentially not reversed in 2012 leaving an SSB of 78 700 t.

7) F_{2011} = 0.109, calculated as for option 2, but assuming a break-point for the MSY framework of 170 000 t. This option will give a yield of 17 100 t in 2011 and lead to an SSB of 76 500 t in 2011 and 121 000 t 2012.

3.8 Reference points

No precautionary reference points are defined for this stock. No new information was available (ICES 2009 ACOM:38).

For analysis of management of the WBSS under the MSY concept see section 1.3. Further within an international collaborative EU supported effort, JAKFISH involving scientists and stakeholders, long term management plans for the WBSS herring are being developed based on F_{MSY}. 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. The results will be fed into ICES work e.g. in WKFRAME.

3.9 Quality of the Assessment

The assessment this year was classified as an update, following the procedures and settings specified in the Stock annex 4. In 2009, the assessment of WBSS was regarded as reliable and consistent, and the diagnostics indicate a similar classification for this year.

Some historical retrospective variation was observed and discussed (see Section 3.6.6). No alarming residual patterns in the model fit were observed for neither catch nor survey indices.

The recruitment index this year turned out to be about average for the entire time series, which is in contrast to the decline observed since 2004. However, this optimistic recruitment was not seen in the GERAS survey (BIAS) 0-group index for 2009 and thus the increase observed in recruitment is taken with some caution. However, this is not an issue for the current assessment as the recruitment of the assessment year is not used for the assessment.

As noted in Section 3.2.1, sampling for splitting the catches between NSAS and WBSS in IVaE is becoming problematic as sampling was insufficient in 2009. Hence, the split in the transfer area was calculated as three year mean (2006-2008) proportions by age. The impact on the assessment of split factors has not been explored.

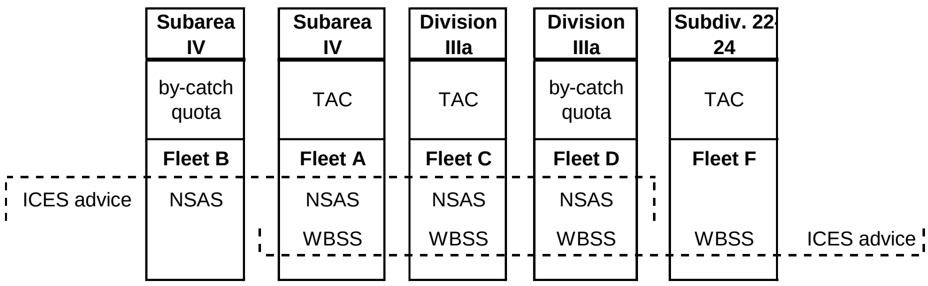
3.10 Management Considerations

Quotas in Division IIIa

The quota for the C-fleet and the by-catch quota for the D-fleet are set for both stocks of North Sea autumn spawners (NSAS) and Western Baltic spring spawners (WBSS) together (see Section 2.7). A fraction of 20% of the Norwegian quota can be transferred from Division IIIa and taken in Division IVa as NSAS.

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).



Development of a management plan for WBSS herring

ICES has in 2009 further explored management options under different assumptions of fishing mortality and recruitment using stochastic simulation with and without TAC constraints, including changes in selection pattern and different levels of uncertainty in the assessment. A proxy for F_{MSY}=0.25, a SSB breakpoint of 110 000 t equal to the lowest observed SSB below which the state of the stock is uncertain, and a maximum TAC variation of +/- 15% was supported by WKMAMPEL in 2009 (ICES 2009 ACOM:38). These results are corroborated by the analysis of F_{MSY} and risk to the SSB in section 1.3.

Further development of the management plan within the EU FP7-project "JAKFISH" suggests that the most robust harvest control rules include a sloping change in F at SSB below a breakpoint.

Data used for catch options in 2010 (intermediate year)

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

The procedure of deriving separate catches by stock and fleet is described in the stock annex for North Sea herring. The catch options for 2011 are based on the share by fleet based on areal TACs and the stock composition in catches for the most recent year 2009.

Exploring a range of total WBSS catches for 2011 (advice year)

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

- The TAC distribution by fleet in 2011 will be equal to 2010.
- There will be allowed a subtraction of 20% of the Norwegian quota that is transferred to the A-fleet (as NSAS).
- The total TAC is taken
- Each of the fleets C, D, and F takes the same fraction of the total catch after a reduction of WBSS caught by the A-fleet in Division IVa East.
- The 2009 proportions of WBSS by fleet hold for 2011. (The proportions of WBSS in catches were 0.85 in the C-fleet, 0.66 in the D-fleet and 1.00 in the F-fleet).
- A constant catch of 3900 t of WBSS caught in the A-fleet in Division IVa East.

The table below gives the 2011 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)** $F_{MSY\text{-}slope}$ = 0.167, **3)** F_{MSY}=0.25 **4)** $F_{-15\%TAC}$=0.38, **5)** F_{TAC}=0.46,
6) $F_{+15\%TAC}$=0.55, and **7)** $F_{MSY\text{-}slope2}$ = 0.109.

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		SD 22-24	Division IIIa		Division IIIa		SD 22-24	TAC develop-ment
		Fleet A*	Fleet C	Fleet D	Fleet F	Fleet C	Fleet D	Fleet C**	Fleet D	Fleet F	Total area
2	26,500	3,900	11,400	2,000	9,200	1,900	1,000	13,300	3,000	9,200	-60%
3	37,200	3,900	16,800	3,000	13,500	2,900	1,500	19,700	4,500	13,500	-40%
4	51,300	3,900	23,900	4,200	19,300	4,100	2,200	28,000	6,400	19,300	-15%
5	59,700	3,900	28,100	4,900	22,700	4,900	2,600	33,000	7,500	22,700	0%
6	68,100	3,900	32,300	5,700	26,100	5,600	2,900	37,900	8,600	26,100	15%
7	17,100	3,900	6,600	1,200	5,400	1,200	600	7,800	1,800	5,400	-76%

* total catches of WBSS herring include a constant catch of 3 900 t WBSS taken by the A-fleet in Div. IVa East
** total C-fleet catches in Division IIIa, the 20% of the Norwegian quota that can be transferred to the North Sea is subtracted

One major change in the fishing pattern in 2009 had a dramatic effect on the development of the WBSS stock. A Danish regulation and control initiative, that prohibits catches in the North Sea and the Skagerrak during the same fishing trip has 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 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% of the Norwegian quota) the total TAC of the C-fleet is now taken within Division IIIa. This results in a considerable increase in Fishing mortality and subsequent decrease in SSB to an expected value in 2010 of about 76 200 t way below the break-point of 110 000 (earlier the lowest observed SSB).

Applying an F_{MSY} framework for WBSS herring in the situation when SSB is below the break-point, fishing mortality should be set to a ratio of F_{MSY} equal to the ratio of advice year SSB and break-point SSB. Adopting a fishing mortality of 0.25 (candidate within a range of 0.22-0.3 for F_{msy} see section 1.3) is then leading to a fishing mortality of $F_{MSY\text{-}slope}$ = 0.170. This level will increase SSB to 113 700 t in 2012. A F_{MSY} of 0.25 will to some degree mediate the negative development of SSB to 105 300 t in 2012. Catches corresponding to a -15% TAC reduction will only increase SSB in 2012 to 92 700 t. With a F (0.380) well above 0.3 managers should here be aware of the risk of recruitment failure.

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 4% of the total out-take of the NSAS stock. The WBSS stock experience a drastic decline in spawning stock biomass due to the recent increase in fishing mortality as well as an environmentally driven severe decline in recruitment. The NSAS stock on the other hand has experienced a decline in fishing mortality and subsequent increase in SSB. With opposite trends in the two mixing stocks the poor state of the WBSS stock has to be considered in the management of both stocks. Thus the resulting catch options were also used as constraints for short term predictions for the NSAS herring (see Section 2.7).

3.11 Ecosystem considerations

Herring in Division IIIa and Subdivisions 22–24 is a migratory stock. There are feeding migrations from the Western Baltic into more saline waters of Division IIIa and the eastern parts of Division IVa. There are indications from parasite infections that yet unknown proportions of stock components spawning at the southern coast in the Baltic Sea may perform similar migrations. Herring in Division IIIa and Subdivisions 22–24 migrate back to Rügen area (SD 24) in the beginning of the winter for spawning.

Similarly to the North Sea herring, the Western Baltic herring has produced several poor year classes in the last decade. However, indications suggest that the declining trend might be now reversed and that the 2009 year class is around the level observed in 2003.

In a recent recruitment analysis for different Baltic herring stocks, the Baltic Sea Index (BSI) reflecting Sea Surface Temperature (SST) was the main predictor for Western Baltic herring (Cardinale et al. 2009). There are no indications of systematic changes in growth or age at maturity, and a candidate key stage for reduced recruitment is probably the larval stage. Recruitment failure appears to have been initiated before the observed occurrence of the Ctenophore (*Mnemiopsis leidyi*) in the Western Baltic. The specific reasons for reduced larval survival are not known. Further investigation of the causes of the poor recruitment will require targeted research projects.

3.12 Changes in the Environment

There are no evident changes in the environment in the last decade that is thought to strongly affect productivity, migration patterns or growth of Western Baltic herring. Although there are indications that higher SST observed in the last decades might affect recruitment negatively the analyses were inconclusive and the observed SST effect rather weak (Cardinale et al. 2009).

Table 3.1.1 WESTERN BALTIC HERRING.
Total landings (both WBSS and NSAS) in 1988-2009 (1000 tonnes).
(Data provided by Working Group members 2010).

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998 [2]
Skagerrak											
Denmark	144.4	47.4	62.3	58.7	64.7	87.8	44.9	43.7	28.7	14.3	10.3
Faroe Islands											
Germany											
Norway	5.7	1.6	5.6	8.1	13.9	24.2	17.7	16.7	9.4	8.8	8.0
Sweden	57.2	47.9	56.5	54.7	88.0	56.4	66.4	48.5	32.7	32.9	46.9
Total	207.3	96.9	124.4	121.5	166.6	168.4	129.0	108.9	70.8	56.0	65.2
Kattegat											
Denmark	76.2	57.1	32.2	29.7	33.5	28.7	23.6	16.9	17.2	8.8	23.7
Sweden	49.7	37.9	45.2	36.7	26.4	16.7	15.4	30.8	27.0	18.0	29.9
Total	125.9	95.0	77.4	66.4	59.9	45.4	39.0	47.7	44.2	26.8	53.6
Sub. Div. 22+24											
Denmark	33.1	21.7	13.6	25.2	26.9	38.0	39.5	36.8	34.4	30.5	30.1
Germany	54.7	56.4	45.5	15.8	15.6	11.1	11.4	13.4	7.3	12.8	9.0
Poland	6.6	8.5	9.7	5.6	15.5	11.8	6.3	7.3	6.0	6.9	6.5
Sweden	4.6	6.3	8.1	19.3	22.3	16.2	7.4	15.8	9.0	14.5	4.3
Total	99.0	92.9	76.9	65.9	80.3	77.1	64.6	73.3	56.7	64.7	49.9
Sub. Div. 23											
Denmark	0.1	1.5	1.1	1.7	2.9	3.3	1.5	0.9	0.7	2.2	0.4
Sweden	0.1	0.1	0.1	2.3	1.7	0.7	0.3	0.2	0.3	0.1	0.3
Total	0.2	1.6	1.2	4.0	4.6	4.0	1.8	1.1	1.0	2.3	0.7
Grand Total	432.4	286.4	279.9	257.8	311.4	294.9	234.4	231.0	172.7	149.8	169.4

Year	1999 2	2000	2001 [5]	2002 [4]	2003	2004	2005	2006 [1,3]	2007	2008 [1]	2009
Skagerrak											
Denmark	10.1	16.0	16.2	26.0	15.5	11.8	14.8	5.2	3.6	3.9	12.7
Faroe Islands							0.4			0.0	0.6
Germany					0.7	0.5	0.8	0.6	0.5	1.6	0.3
Norway	7.4	9.7							3.5	4.0	3.3
Sweden	36.4	45.8	30.8	26.4	25.8	21.8	32.5	26.0	19.4	16.5	12.9
Total	53.9	71.5	47.0	52.3	42.0	34.1	48.5	31.8	26.9	26.0	29.7
Kattegat											
Denmark	17.9	18.9	18.8	18.6	16.0	7.6	11.1	8.6	9.2	7.0	4.9
Sweden	14.6	17.3	16.2	7.2	10.2	9.6	10.0	10.8	11.2	5.2	3.6
Germany											0.6
Total	32.5	36.2	35.0	25.9	26.2	17.2	21.1	19.4	20.3	12.2	9.1
Sub. Div. 22+24											
Denmark	32.5	32.6	28.3	13.1	6.1	7.3	5.3	1.4	2.8	3.1	2.1
Germany	9.8	9.3	11.4	22.4	18.8	18.5	21.0	22.9	24.6	**22.8**	16.0
Poland	5.3	6.6	9.3	-	4.4	5.5	6.3	5.5	2.9	5.5	5.2
Sweden	2.6	4.8	13.9	10.7	9.4	9.9	9.2	9.6	7.2	7.0	4.1
Total	50.2	53.3	62.9	46.2	38.7	41.2	41.8	39.4	37.6	38.5	27.4
Sub. Div. 23											
Denmark	0.5	0.9	0.6	4.6	2.3	0.1	1.8	1.8	2.9	5.3	2.8
Sweden	0.1	0.1	0.2	-	0.2	0.3	0.4	0.7		0.3	0.8
Total	0.6	1.0	0.8	4.6	2.6	0.4	2.2	2.5	2.9	5.7	3.6
Grand Total	137.2	162.0	145.7	128.9	109.5	92.8	113.6	93.0	87.7	82.3	69.9

[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
[4] The Danish national management regime for herring and sprat fishery in Subdivision 22 was changed in 2002
[5] The total landings in Skagerrak have been updated for 1995-2001 due to Norwegian misreportings into Skagerrak.

Table 3.1.2 **WESTERN BALTIC HERRING.**
Landings (SOP) in 2003-2009 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

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: 2009 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	14.26	65	5.74	55	20.00	62
	2	26.99	100	8.05	95	35.04	99
	3	8.84	142	1.64	136	10.48	141
	4	6.79	163	0.72	161	7.52	163
	5	3.97	172	0.31	179	4.28	172
	6	1.95	191	0.15	209	2.10	193
	7	1.24	189	0.13	203	1.37	190
	8+	0.58	199	0.18	198	0.76	199
	Total	64.62		16.92		81.54	
	SOP		7,401		1,569		8,970
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	5.42	69	0.40	61	5.82	68
	2	14.70	90	0.14	112	14.85	90
	3	3.26	141	0.09	148	3.35	141
	4	2.46	165	0.03	178	2.50	165
	5	1.65	172	0.03	180	1.67	172
	6	0.89	188	0.01	222	0.90	189
	7	0.46	181	0.01	184	0.46	181
	8+	0.19	213	0.01	216	0.20	213
	Total	29.03		0.73		29.75	
	SOP		3,134		71		3,205
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.04	16	25.87	11	25.91	11
	1	52.94	93	0.02	91	52.96	93
	2	31.44	153	0.01	159	31.45	153
	3	6.59	173	0.00	170	6.60	173
	4	4.61	203	0.00	204	4.61	203
	5	1.92	210	0.00	208	1.92	210
	6	1.65	234	0.00	234	1.65	234
	7	0.69	239	0.00	227	0.69	239
	8+	0.51	269	0.00	263	0.51	269
	Total	100.40		25.91		126.31	
	SOP		12,917		278		13,195
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.69	24	13.47	16	14.16	16
	1	29.13	86	0.89	79	30.02	86
	2	5.95	114	0.66	124	6.61	115
	3	1.90	161	0.22	159	2.13	161
	4	0.69	226	0.09	186	0.78	222
	5	0.15	210	0.03	210	0.18	210
	6	0.50	240	0.05	210	0.55	237
	7	0.21	238	0.02	234	0.24	238
	8+	0.03	276	0.01	276	0.03	276
	Total	39.26		15.43		54.70	
	SOP		3,878		444		4,322
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.74	23	39.34	12	40.07	13
	1	101.75	86	7.06	58	108.81	84
	2	79.08	120	8.86	98	87.95	118
	3	20.59	154	1.96	139	22.55	152
	4	14.56	179	0.85	164	15.40	178
	5	7.69	182	0.37	182	8.06	182
	6	4.99	210	0.21	210	5.20	210
	7	2.60	205	0.16	207	2.75	205
	8+	1.31	230	0.20	201	1.51	226
	Total	233.31		59.00		292.31	
	SOP		27,329		2,362		29,691

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: 2009 Country: ALL

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	4.36	32	77.28	12	81.63	13
	2	39.50	30	2.86	57	42.36	32
	3	19.28	71	0.41	90	19.69	72
	4	5.10	109	0.04	134	5.14	110
	5	0.86	118	0.09	137	0.95	120
	6	0.53	181	0.01	215	0.54	182
	7	0.44	182	0.01	212	0.45	182
	8+	0.67	225	0.02	255	0.69	226
	Total	70.73		80.72		151.45	
	SOP		3,673		1,135		4,808
2	1	0.00	11	1.58	27	1.58	27
	2	0.09	18	0.03	41	0.12	24
	3	0.05	68	0.03	54	0.08	63
	4	0.01	106	0.03	98	0.04	100
	5	0.00	111			0.00	111
	6	0.00	162			0.00	162
	7	0.00	172			0.00	172
	8+	0.00	204			0.00	204
	Total	0.16		1.67		1.83	
	SOP		7		48		55
3	0	0.37	14	72.74	8	73.11	8
	1	14.06	57	0.16	26	14.21	56
	2	2.93	99	0.15	46	3.08	97
	3	0.84	149	0.00	137	0.84	149
	4	0.37	167	0.00	156	0.37	167
	5	0.22	221	0.00	187	0.22	221
	6	0.18	152	0.00	211	0.18	152
	7						
	8+	0.01	202	0.00	202	0.01	202
	Total	18.99		73.05		92.04	
	SOP		1,362		575		1,937
4	0	0.30	17	18.06	12	18.36	12
	1	20.75	66	0.13	71	20.89	66
	2	4.77	102	0.03	104	4.80	102
	3	0.96	137	0.00	125	0.96	137
	4	0.33	149	0.00	130	0.33	149
	5	0.23	196	0.00	159	0.23	196
	6	0.14	150	0.00	163	0.14	150
	7						
	8+	0.03	149	0.00	149	0.03	149
	Total	27.51		18.24		45.75	
	SOP		2,112		228		2,340
Total	0	0.67	15	90.81	9	91.48	9
	1	39.17	59	79.14	12	118.31	28
	2	47.29	41	3.07	57	50.36	42
	3	21.13	77	0.45	87	21.58	78
	4	5.81	115	0.07	118	5.88	115
	5	1.31	149	0.09	137	1.40	148
	6	0.86	170	0.01	214	0.87	170
	7	0.44	182	0.01	212	0.45	182
	8+	0.71	221	0.02	253	0.73	222
	Total	117.39		173.68		291.07	
	SOP		7,154		1,986		9,140

Table 3.2.3 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age and quarter (both WBSS and NSAS).
Division: 22-24 Year: 2009 Country: ALL

Quarter	W-rings	Sub-division 22 Numbers	Sub-division 22 Mean W.	Sub-division 23 Numbers	Sub-division 23 Mean W.	Sub-division 24 Numbers	Sub-division 24 Mean W.	Total Numbers	Total Mean W.
1	1	14.46	12	0.00	28	3.29	12	17.75	12
	2	19.50	42	14.32	74	40.27	31	74.09	42
	3	4.36	67	6.28	103	19.84	82	30.47	84
	4	1.12	105	0.75	163	23.18	125	25.05	125
	5	0.76	112	0.00	133	23.68	157	24.44	155
	6	0.26	162	0.00	135	22.58	172	22.84	172
	7	0.23	175	0.00	139	9.35	184	9.58	184
	8+	0.22	214	0.00	129	4.59	194	4.81	195
	Total	40.91		21.36		146.77		209.04	
	SOP		1,607		1,830		16,023		19,460
2	1	1.89	21			1.00	14	2.90	18
	2	1.66	42	1.90	74	20.90	37	24.45	40
	3	0.41	67	0.83	104	16.24	82	17.48	83
	4	0.10	105	0.10	164	14.64	106	14.84	106
	5	0.07	112			10.51	114	10.58	114
	6	0.02	162			7.32	117	7.34	117
	7	0.02	175			3.10	126	3.12	126
	8+	0.02	214			2.05	145	2.08	145
	Total	4.20		2.83		75.76		82.79	
	SOP		167		242		6,411		6,820
3	0	0.14	12	0.02	24	0.19	11	0.34	12
	1	0.02	38	0.66	59	2.51	59	3.19	59
	2			1.31	106	1.25	102	2.56	104
	3			1.42	149	0.72	139	2.14	146
	4			1.29	166	0.60	174	1.89	169
	5			0.53	176	0.31	194	0.84	182
	6			0.41	192	0.28	178	0.69	186
	7			0.08	199	0.08	216	0.16	208
	8+			0.09	185	0.04	216	0.13	195
	Total	0.16		5.79		5.98		11.94	
	SOP		3		807		620		1,429
4	0	5.17	10	0.03	24	0.39	14	5.59	10
	1	0.11	30	1.34	57	6.19	58	7.64	58
	2			2.37	102	7.25	97	9.62	98
	3			1.27	130	4.12	129	5.39	129
	4			0.89	166	2.82	160	3.71	162
	5			0.20	188	1.14	188	1.34	188
	6			0.20	203	0.88	185	1.08	189
	7			0.07	218	0.30	199	0.37	202
	8+			0.07	256	0.16	207	0.23	222
	Total	5.29		6.44		23.24		34.97	
	SOP		55		744		2,523		3,323
Total	0	5.31	10	0.05	24	0.57	13	5.93	11
	1	16.49	13	2.00	58	12.99	43	31.48	28
	2	21.15	42	19.90	79	69.67	41	110.72	48
	3	4.76	67	9.79	114	40.92	88	55.48	90
	4	1.22	105	3.03	165	41.24	121	45.50	124
	5	0.83	112	0.73	179	35.64	145	37.21	145
	6	0.28	162	0.61	196	31.06	160	31.95	160
	7	0.25	175	0.15	208	12.82	171	13.23	171
	8+	0.24	214	0.16	216	6.84	180	7.24	182
	Total	50.55		36.42		251.76		338.74	
	SOP		1,832		3,623		25,577		31,032

Table 3.2.4 HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2009 available to the Working Group.

	Country	Quarter	Landings in '000 tons	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Skagerrak	**Denmark**	**1**	4.4	No data available		
		2	1.2	4	445	312
		3	5.4	27	2646	1211
		4	1.8	6	415	306
	Total		12.7	37	3,506	1,829
	Germany	**1**	-	No data available		
		2	-			
		3	0.1			
		4	0.1			
	Total		0.3	0	0	0
	Norway	**1**	0.8	No data available		
		2	0.9			
		3	0.4			
		4	1.1			
	Total		3.3	0	0	0
	Faroese	**1**	0.6	No data available		
		2	-			
		3	-			
		4	-			
	Total		0.6	0	0	0
	Sweden	**1**	3.2	14	728	728
		2	1.1	7	749	749
		3	7.3	14	667	667
		4	1.3	10	693	693
	Total		12.9	45	2,837	2,837
Kattegat	**Denmark**	**1**	3.0	14	1,739	582
		2	0.1	3	51	51
		3	1.1	11	688	234
		4	0.7	4	544	93
	Total		4.9	32	3,022	960
	Germany	**1**	0.6	No data available		
		2	-			
		3	0.1			
		4	-			
	Total		0.6	0	0	0
	Sweden	**1**	1.2	14	686	686
		2	0.0	No data available		
		3	0.7	4	718	718
		4	1.7	13	750	750
	Total		3.6	31	2,154	2,154

Table 3.2.4 (cont.) **HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of commercial landings by quarter and area for 2009 available to the Working Group.**

	Country	Quarter	Landings in '000 tons	Numbers of samples	Numbers of fish meas.	Numbers of fish aged
Subdivision 22	**Denmark**	**1**	0.2	2	184	60
		2	0.0	1	29	29
		3	0.0	1	47	47
		4	0.0	5	379	226
	Total		0.2	9	639	362
	Germany	**1**	1.4	3	1,086	297
		2	0.1	1	393	63
		3	0.0		No data available	
		4	0.1			
	Total		1.6	4	1,479	360
Subdivision 23	**Denmark**	**1**	1.8	1	115	114
		2	0.2		No data available	
		3	0.5	2	249	101
		4	0.2	2	215	140
	Total		2.8	5	579	355
	Sweden	**1**	0.0			
		2	-		No data available	
		3	0.3			
		4	0.5			
	Total		0.8	0	0	0
Subdivision 24	**Denmark**	**1**	1.1		No data available	
		2	0.4	1	33	33
		3	0.0		No data available	
		4	0.4	6	1,332	200
	Total		1.9	7	1,365	233
	Germany	**1**	11.3	17	6,396	1,399
		2	2.0	6	2,658	566
		3	0.3		No data available	
		4	0.8	6	2,028	555
	Total		14.4	29	11,082	2,520
	Poland	**1**	1.1	6	687	209
		2	3.8	5	671	257
		3	0.3		No data available	
		4	-			
	Total		5	11	1358	466
	Sweden	**1**	2.5	9	650	650
		2	0.1	2	157	157
		3	0.0		No data available	
		4	1.4	8	665	665
	Total		4.1	19	1,472	1,472

Table 3.2.5 HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-24. Samples of landings by quarter and area used to to estimate catch in numbers and mean weight by age for 2009.

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

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

Table 3.2.5 continued. HERRING IN DIVISION IIIa AND SUBDIVISIONS 22-
Samples of landings by quarter and area used to
to estimate catch in numbers and mean weight by age for 2009.

	Country	Quarter	Fleet	Sampling
Subdivision 22	**Denmark**	**1**	**F**	Danish sampling in Q1
		2	**F**	Danish sampling in Q2
		3	**F**	Danish sampling in Q3
		4	**F**	Danish sampling in Q4
	Germany	**1**	**F**	German sampling in Q1
		2	**F**	German sampling in Q1
		3	**F**	Danish sampling in Q3
		4	**F**	Danish sampling in Q4
Subdivision 23	**Denmark**	**1**	**F**	Danish sampling in Q1
		2	**F**	Danish sampling in Q1
		3	**F**	Danish sampling in Q3
		4	**F**	Danish sampling in Q4
	Sweden	**1**	**F**	Swedish sampling in Q1 in Sub-division 24
		2	**F**	No landings
		3	**F**	Swedish sampling in Q4 in Sub-division 24
		4	**F**	Swedish sampling in Q4 in Sub-division 24
Subdivision 24	**Denmark**	**1**	**F**	Danish sampling in Q2
		2	**F**	Danish sampling in Q2
		3	**F**	Danish sampling in Q4
		4	**F**	Danish sampling in Q4
	Germany	**1**	**F**	German sampling in Q1
		2	**F**	German sampling in Q2
		3	**F**	German sampling in Q4
		4	**F**	German sampling in Q4
	Poland	**1**	**F**	Polish sampling in Q1
		2	**F**	Polish sampling in Q2
		3	**F**	Danish sampling in Q4
		4	**F**	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 and Baltic spring spawners given in % in Skagerrak and Kattegat by age and quarter.

Year: 2009

		Skagerrak			Kattegat		
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP	n	North Sea autumn SP	ltic Spring	n
1	1	2.04%	97.96%	49	35.44%	64.56%	412
	2	6.00%	94.00%	50	3.70%	96.30%	162
	3	0.00%	100.00%	49	1.54%	98.46%	65
	4	0.00%	100.00%	22	0.00%	100.00%	29
	5	0.00%	100.00%	3	0.00%	100.00%	7
	6	0.00%	100.00%	14	0.00%	100.00%	9
	7	0.00%	100.00%	9	0.00%	100.00%	6
	8	0.00%	100.00%	2	0.00%	100.00%	13
		Skagerrak			Kattegat		
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP		North Sea autumn SP	ltic Spring SP	
2	1	47.85%	52.15%	163	4.55%	95.45%	44
	2	6.67%	93.33%	120	0.00%	100.00%	1
	3	1.45%	98.55%	69	0.00%	100.00%	1
	4	0.00%	100.00%	36	0.00%	100.00%	1
	5	0.00%	100.00%	31	0.00%	100.00%	0
	6	0.00%	100.00%	21	0.00%	100.00%	0
	7	0.00%	100.00%	7	0.00%	100.00%	0
	8	0.00%	100.00%	3	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP		North Sea autumn SP	ltic Spring SP	
3	0	94.54%	5.46%	183	96.57%	3.43%	233
	1	70.73%	29.27%	731	11.76%	88.24%	51
	2	7.54%	92.46%	398	0.00%	100.00%	51
	3	0.00%	100.00%	98	0.00%	100.00%	23
	4	4.00%	96.00%	50	0.00%	100.00%	13
	5	0.00%	100.00%	22	0.00%	100.00%	4
	6	0.00%	100.00%	14	0.00%	100.00%	1
	7	0.00%	100.00%	5	0.00%	100.00%	0
	8	20.00%	80.00%	5	0.00%	100.00%	0
		Skagerrak			Kattegat		
Quarter	W-rings	North Sea autumn SP	Baltic Spring SP		North Sea autumn SP	ltic Spring SP	
4	0	46.15%	53.85%	91	82.31%	17.69%	147
	1	10.00%	90.00%	50	15.29%	84.71%	85
	2	0.00%	100.00%	50	0.00%	100.00%	59
	3	0.00%	100.00%	50	0.00%	100.00%	25
	4	4.76%	95.24%	21	0.00%	100.00%	8
	5	0.00%	100.00%	9	0.00%	100.00%	5
	6	0.00%	100.00%	13	0.00%	100.00%	2
	7	0.00%	100.00%	6	0.00%	100.00%	0
	8	0.00%	100.00%	1	0.00%	100.00%	1

Table 3.2.7 WESTERN BALTIC HERRING
Landings in numbers (mill.), mean weight (g.) and SOP (t) by age, quarter and fleet. ***North Sea Autumn spawners***
Division: Kattegat Year: 2009 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	1.54	32	27.38	12	28.93	13
	2	1.46	30	0.11	57	1.57	32
	3	0.30	71	0.01	90	0.30	72
	4						
	5						
	6						
	7						
	8+						
	Total	3.30		27.50		30.80	
	SOP		113		329		442
2	1	0.00	11	0.07	27	0.07	27
	2						
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	0.00		0.07		0.07	
	SOP		0		2		2
3	0	0.36	14	70.25	8	70.60	8
	1	1.65	57	0.02	26	1.67	56
	2						
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	2.01		70.26		72.28	
	SOP		99		545		644
4	0	0.25	17	14.87	12	15.12	12
	1	3.17	66	0.02	71	3.19	66
	2						
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	3.42		14.89		18.31	
	SOP		214		178		391
Total	0	0.61	15	85.11	8	85.72	9
	1	6.37	55	27.50	12	33.87	20
	2	1.46	30	0.11	57	1.57	32
	3	0.30	71	0.01	90	0.30	72
	4						
	5						
	6						
	7						
	8+						
	Total	8.74		112.72		121.46	
	SOP		426		1,053		1,479

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: 2009 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	0.29	65	0.12	55	0.41	62
	2	1.62	100	0.48	95	2.10	99
	3						
	4						
	5						
	6						
	7						
	8+						
	Total	1.91		0.60		2.51	
	SOP		181		52		233
2	1	2.59	69	0.19	61	2.79	68
	2	0.98	90	0.01	112	0.99	90
	3	0.05	141	0.00	148	0.05	141
	4						
	5						
	6						
	7						
	8+						
	Total	3.62		0.20		3.82	
	SOP		273		13		286
3	0	0.04	16	24.45	11	24.50	11
	1	37.44	93	0.02	91	37.46	93
	2	2.37	153	0.00	159	2.37	153
	3						
	4	0.18	203	0.00	204	0.18	203
	5						
	6						
	7						
	8+	0.10	269	0.00	263	0.10	269
	Total	40.14		24.47		64.61	
	SOP		3,911		259		4,170
4	0	0.32	24	6.22	16	6.54	16
	1	2.91	86	0.09	79	3.00	86
	2						
	3						
	4	0.03	226	0.00	186	0.04	222
	5						
	6						
	7						
	8+						
	Total	3.27		6.31		9.58	
	SOP		266		108		374
Total	0	0.36	23	30.67	12	31.03	12
	1	43.24	91	0.41	64	43.65	91
	2	4.97	123	0.49	96	5.46	121
	3	0.05	141	0.00	148	0.05	141
	4	0.22	207	0.00	186	0.22	206
	5						
	6						
	7						
	8+	0.10	269	0.00	263	0.10	269
	Total	48.94		31.58		80.52	
	SOP		4,631		432		5,063

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: 2009 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	2.81	32	49.89	12	52.70	13
	2	38.04	30	2.76	57	40.79	32
	3	18.98	71	0.41	90	19.39	72
	4	5.10	109	0.04	134	5.14	110
	5	0.86	118	0.09	137	0.95	120
	6	0.53	181	0.01	215	0.54	182
	7	0.44	182	0.01	212	0.45	182
	8+	0.67	225	0.02	255	0.69	226
	Total	67.43		53.22		120.65	
	SOP		3,559		806		4,366
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	0.00	11	1.50	27	1.51	27
	2	0.09	18	0.03	41	0.12	24
	3	0.05	68	0.03	54	0.08	63
	4	0.01	106	0.03	98	0.04	100
	5	0.00	111			0.00	111
	6	0.00	162			0.00	162
	7	0.00	172			0.00	172
	8+	0.00	204			0.00	204
	Total	0.16		1.60		1.76	
	SOP		7		46		53
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.01	14	2.50	8	2.51	8
	1	12.40	57	0.14	26	12.54	56
	2	2.93	99	0.15	46	3.08	97
	3	0.84	149	0.00	137	0.84	149
	4	0.37	167	0.00	156	0.37	167
	5	0.22	221	0.00	187	0.22	221
	6	0.18	152	0.00	211	0.18	152
	7						
	8+	0.01	202	0.00	202	0.01	202
	Total	16.98		2.79		19.77	
	SOP		1,263		30		1,293
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.05	17	3.19	12	3.25	12
	1	17.58	66	0.11	71	17.69	66
	2	4.77	102	0.03	104	4.80	102
	3	0.96	137	0.00	125	0.96	137
	4	0.33	149	0.00	130	0.33	149
	5	0.23	196	0.00	159	0.23	196
	6	0.14	150	0.00	163	0.14	150
	7						
	8+	0.03	149	0.00	149	0.03	149
	Total	24.09		3.35		27.44	
	SOP		1,899		50		1,949
		Fleet C		**Fleet D**		**Total**	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.07	16	5.69	10	5.76	10
	1	32.80	60	51.65	12	84.45	31
	2	45.82	42	2.97	57	48.79	43
	3	20.83	77	0.45	87	21.28	78
	4	5.81	115	0.07	118	5.88	115
	5	1.31	149	0.09	137	1.40	148
	6	0.86	170	0.01	214	0.87	170
	7	0.44	182	0.01	212	0.45	182
	8+	0.71	221	0.02	253	0.73	222
	Total	108.65		60.96		169.61	
	SOP		6,728		933		7,661

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: 2009 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	13.97	65	5.62	55	19.59	62
	2	25.37	100	7.57	95	32.94	99
	3	8.84	142	1.64	136	10.48	141
	4	6.79	163	0.72	161	7.52	163
	5	3.97	172	0.31	179	4.28	172
	6	1.95	191	0.15	209	2.10	193
	7	1.24	189	0.13	203	1.37	190
	8+	0.58	199	0.18	198	0.76	199
	Total	62.71		16.32		79.03	
	SOP		7,220		1,517		8,737
2	1	2.83	69	0.21	61	3.04	68
	2	13.72	90	0.13	112	13.86	90
	3	3.21	141	0.09	148	3.30	141
	4	2.46	165	0.03	178	2.50	165
	5	1.65	172	0.03	180	1.67	172
	6	0.89	188	0.01	222	0.90	189
	7	0.46	181	0.01	184	0.46	181
	8+	0.19	213	0.01	216	0.20	213
	Total	25.40		0.52		25.93	
	SOP		2,861		58		2,919
3	0	0.00	16	1.41	11	1.42	11
	1	15.50	93	0.01	91	15.50	93
	2	29.07	153	0.01	159	29.08	153
	3	6.59	173	0.00	170	6.60	173
	4	4.42	203	0.00	204	4.43	203
	5	1.92	210	0.00	208	1.92	210
	6	1.65	234	0.00	234	1.65	234
	7	0.69	239	0.00	227	0.69	239
	8+	0.41	269	0.00	263	0.41	269
	Total	60.26		1.44		61.70	
	SOP		9,005		19		9,024
4	0	0.37	24	7.25	16	7.63	16
	1	26.22	86	0.80	79	27.02	86
	2	5.95	114	0.66	124	6.61	115
	3	1.90	161	0.22	159	2.13	161
	4	0.66	226	0.08	186	0.74	222
	5	0.15	210	0.03	210	0.18	210
	6	0.50	240	0.05	210	0.55	237
	7	0.21	238	0.02	234	0.24	238
	8+	0.03	276	0.01	276	0.03	276
	Total	36.00		9.12		45.12	
	SOP		3,612		336		3,948
Total	0	0.38	24	8.67	15	9.04	16
	1	58.51	82	6.64	58	65.16	80
	2	74.11	120	8.37	98	82.48	118
	3	20.54	154	1.96	139	22.50	153
	4	14.34	179	0.84	164	15.18	178
	5	7.69	182	0.37	182	8.06	182
	6	4.99	210	0.21	210	5.20	210
	7	2.60	205	0.16	207	2.75	205
	8+	1.21	227	0.20	201	1.41	223
	Total	184.37		27.41		211.78	
	SOP		22,698		1,930		24,628

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: 2009 Country: All

Quarter	W-rings	Fleet C Numbers	Fleet C Mean W.	Fleet D Numbers	Fleet D Mean W.	Total Numbers	Total Mean W.
1	1	1.83	37	27.50	12	29.34	14
	2	3.08	67	0.59	88	3.67	70
	3	0.30	71	0.01	90	0.30	72
	4						
	5						
	6						
	7						
	8+						
	Total	5.21		28.10		33.31	
	SOP		294		381		675
2	1	2.59	69	0.26	52	2.86	67
	2	0.98	90	0.01	112	0.99	90
	3	0.05	141	0.00	148	0.05	141
	4						
	5						
	6						
	7						
	8+						
	Total	3.62		0.28		3.90	
	SOP		273		15		288
3	0	0.40	14	94.70	8	95.10	8
	1	39.10	91	0.03	56	39.13	91
	2	2.37	153	0.00	159	2.37	153
	3						
	4	0.18	203	0.00	204	0.18	203
	5						
	6						
	7						
	8+	0.10	269	0.00	263	0.10	269
	Total	42.15		94.74		136.89	
	SOP		4,010		804		4,814
4	0	0.57	21	21.08	13	21.65	13
	1	6.09	76	0.11	78	6.20	76
	2						
	3						
	4	0.03	226	0.00	186	0.04	222
	5						
	6						
	7						
	8+						
	Total	6.69		21.20		27.89	
	SOP		480		285		765
Total	0	0.97	18	115.78	9	116.75	9
	1	49.61	86	27.91	13	77.52	60
	2	6.43	102	0.60	89	7.03	101
	3	0.34	81	0.01	100	0.35	81
	4	0.22	207	0.00	186	0.22	206
	5						
	6						
	7						
	8+	0.10	269	0.00	263	0.10	269
	Total	57.67		144.31		201.98	
	SOP		5,056		1,486		6,542

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: 2009 Country: All

		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
1	1	16.78	60	55.51	16	72.30	26
	2	63.41	58	10.32	85	73.73	62
	3	27.82	94	2.05	127	29.87	96
	4	11.89	140	0.76	160	12.65	141
	5	4.83	162	0.39	169	5.22	163
	6	2.47	189	0.17	210	2.64	190
	7	1.69	187	0.14	203	1.82	188
	8+	1.25	213	0.20	203	1.45	212
	Total	130.14		69.54		199.68	
	SOP		10,779		2,323		13,102
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
2	1	2.83	69	1.71	31	4.54	54
	2	13.81	89	0.17	98	13.98	89
	3	3.26	140	0.12	123	3.38	139
	4	2.47	165	0.07	139	2.54	164
	5	1.65	172	0.03	180	1.68	172
	6	0.89	188	0.01	222	0.91	188
	7	0.46	181	0.01	184	0.46	181
	8+	0.19	213	0.01	216	0.20	213
	Total	25.56		2.13		27.69	
	SOP		2,868		104		2,972
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
3	0	0.02	14	3.91	9	3.93	9
	1	27.90	77	0.15	29	28.05	77
	2	32.00	148	0.16	54	32.17	148
	3	7.44	170	0.00	166	7.44	170
	4	4.80	200	0.00	199	4.80	200
	5	2.15	211	0.00	206	2.15	211
	6	1.83	226	0.00	233	1.83	226
	7	0.69	239	0.00	227	0.69	239
	8+	0.42	266	0.00	258	0.42	266
	Total	77.24		4.23		81.46	
	SOP		10,269		49		10,318
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
4	0	0.43	23	10.45	15	10.87	15
	1	43.80	78	0.92	78	44.72	78
	2	10.72	109	0.69	123	11.41	110
	3	2.86	153	0.23	159	3.09	153
	4	0.99	200	0.08	185	1.08	199
	5	0.38	201	0.03	208	0.41	202
	6	0.65	220	0.05	209	0.69	219
	7	0.21	238	0.02	234	0.24	238
	8+	0.06	211	0.01	271	0.06	217
	Total	60.09		12.47		72.56	
	SOP		5,511		386		5,897
		Fleet C		Fleet D		Total	
Quarter	W-rings	Numbers	Mean W.	Numbers	Mean W.	Numbers	Mean W.
Total	0	0.44	23	14.36	13	14.80	13
	1	91.31	74	58.29	18	149.60	52
	2	119.94	90	11.34	87	131.27	90
	3	41.37	115	2.40	130	43.78	116
	4	20.15	160	0.91	161	21.07	161
	5	9.00	177	0.46	173	9.46	177
	6	5.84	204	0.22	210	6.07	204
	7	3.04	202	0.16	207	3.21	202
	8+	1.92	225	0.22	206	2.14	223
	Total	293.02		88.37		381.39	
	SOP		29,426		2,863		32,289

Table 3.2.13 **WESTERN BALTIC HERRING.**

Total catch in numbers (mill) and mean weight (g), SOP (tonnes) of *Western Baltic Spring spawners* in Division IIIa and the North Sea in the years 1993-2009.

Year	W-rings	0	1	2	3	4	5	6	7	8+	Total
1993	Numbers	161.25	371.50	315.82	219.05	94.08	59.43	40.97	21.71	8.22	1,292.03
	Mean W.	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	
	SOP	2,435	9,612	25,696	27,936	14,120	10,167	8,027	4,541	1,966	104,498
1994	Numbers	60.62	153.11	261.14	221.64	130.97	77.30	44.40	14.39	8.62	972.19
	Mean W.	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	
	SOP	1,225	6,524	24,767	27,206	19,686	13,043	8,642	3,022	1,898	106,013
1995	Numbers	50.31	302.51	204.19	97.93	90.86	30.55	21.28	12.01	7.24	816.86
	Mean W.	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	
	SOP	902	12,551	19,970	13,517	14,823	6,065	4,404	2,747	1,696	76,674
1996	Numbers	166.23	228.05	317.74	75.60	40.41	30.63	12.58	6.73	5.63	883.60
	Mean W.	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	
	SOP	1,748	6,296	28,618	10,197	6,665	5,714	2,568	1,402	1,241	64,449
1997	Numbers	25.97	73.43	158.71	180.06	30.15	14.15	4.77	1.75	2.31	491.31
	Mean W.	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	
	SOP	498	3,648	12,176	22,913	4,656	2,489	879	337	480	48,075
1998	Numbers	36.26	175.14	315.15	94.53	54.72	11.19	8.72	2.19	2.09	699.98
	Mean W.	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	
	SOP	1,009	8,980	22,542	10,287	7,804	1,922	1,695	403	481	55,121
1999	Numbers	41.34	190.29	155.67	122.26	43.16	22.21	4.42	3.02	2.40	584.77
	Mean W.	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	
	SOP	477	9,698	13,012	14,048	5,232	3,225	749	373	366	47,179
2000	Numbers	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.60
	Mean W.	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	
	SOP	2,601	10,145	20,357	10,756	7,131	3,189	1,288	249	294	56,010
2001	Numbers	121.68	36.63	208.10	111.08	32.06	19.67	9.84	4.17	2.42	545.65
	Mean W.	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	
	SOP	1,096	1,875	15,863	12,093	4,657	3,371	1,852	780	492	42,079
2002	Numbers	69.63	577.69	168.26	134.60	53.09	12.05	7.48	2.43	2.02	1,027.26
	Mean W.	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	
	SOP	709	11,795	13,162	15,848	7,632	2,046	1,435	481	435	53,544
2003	Numbers	52.11	63.02	182.53	65.45	64.37	21.47	6.26	4.35	1.81	461.38
	Mean W.	13.0	37.4	76.5	113.3	132.7	142.2	153.5	169.9	162.2	
	SOP	678	2,355	13,957	7,416	8,540	3,053	961	740	294	37,994
2004	Numbers	25.67	209.34	96.02	93.98	18.24	16.84	4.51	1.51	0.59	466.71
	Mean W.	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	
	SOP	695	9,047	7,869	11,005	2,652	2,651	769	279	111	35,078
2005	Numbers	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.51
	Mean W.	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	
	SOP	1,341	5,319	17,415	9,163	6,961	1,519	2,028	618	282	44,645
2006	Numbers	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.49
corrected	Mean W.	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	
	SOP	121	3,847	9,584	12,907	6,972	9,765	2,199	2,159	1,134	48,688
2007	Numbers	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Mean W.	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	
	SOP	41	6,816	7,723	4,269	4,265	2,035	1,802	1,114	567	28,632
2008	Numbers	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.8
	Mean W.	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	98.0
	SOP	94	7,281	6,472	4,456	1,917	2,590	1,402	900	256	25,368
2009	Numbers	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.6
	Mean W.	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	90.9
	SOP	199	7,783	11,946	5,436	4,094	1,974	1,669	1,757	1,371	36,230

Data for 1995 to 2001 was revised in 2003.

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

Division: IV + IIIa + 22-24 **Year: 2009**

Quarter	W-rings	Division IV Numbers	Division IV Mean W.	Division IIIa Numbers	Division IIIa Mean W.	Sub-division 22-24 Numbers	Sub-division 22-24 Mean W.	Total Numbers	Total Mean W.
1	1	0.00	69.00	72.30	26.24	17.75	11.70	90.05	23
	2	0.00	128.10	73.73	61.64	74.09	42.19	147.82	52
	3	0.00	150.20	29.87	96.09	30.47	84.23	60.34	90
	4	0.00	170.70	12.65	141.32	25.05	125.01	37.70	130
	5	0.00	175.70	5.22	162.73	24.44	155.14	29.67	156
	6	0.00	182.30	2.64	190.38	22.84	172.20	25.48	174
	7	0.00	205.30	1.82	188.39	9.58	184.00	11.40	185
	8+	0.00	245.35	1.45	211.53	4.81	195.37	6.26	199
	Total	0.01		199.68		209.04		408.73	
	SOP		2		13,102		19,460		32,564
2	1	0.00	63.50	4.54	54.37	2.90	18.33	7.44	40
	2	1.01	137.60	13.98	89.50	24.45	40.21	39.44	60
	3	1.71	169.90	3.38	139.49	17.48	82.69	22.56	98
	4	3.13	208.10	2.54	164.17	14.84	106.39	20.51	129
	5	1.32	208.30	1.68	171.95	10.58	113.90	13.58	130
	6	1.12	204.80	0.91	188.50	7.34	117.03	9.37	134
	7	3.51	233.20	0.46	181.35	3.12	126.13	7.09	183
	8+	0.65	251.60	0.20	213.19	2.08	145.30	2.92	173
	Total	12.44		27.69		82.79		122.92	
	SOP		2,566		2,972		6,820		12,358
3	0	0.00	8.00	3.93	8.77	0.34	12.15	4.27	9
	1	0.00	103.00	28.05	76.66	3.19	59.07	31.24	75
	2	0.01	197.90	32.17	147.97	2.56	104.07	34.73	145
	3	0.04	173.00	7.44	170.47	2.14	145.68	9.62	165
	4	0.07	226.00	4.80	200.49	1.89	168.62	6.76	192
	5	0.03	253.00	2.15	210.92	0.84	182.32	3.02	203
	6	0.03	266.00	1.83	226.05	0.69	186.23	2.55	216
	7	0.08	259.00	0.69	238.78	0.16	207.67	0.92	235
	8+	0.01	270.29	0.42	266.42	0.13	194.59	0.57	250
	Total	0.27		81.46		11.94		93.67	
	SOP		63		10,318		1,429		11,810
4	0	0.00	69.00	10.87	15.12	5.59	10.44	16.47	14
	1	0.00	128.10	44.72	78.03	7.64	57.67	52.36	75
	2	0.00	150.20	11.41	109.69	9.62	98.29	21.02	104
	3	0.33	170.70	3.09	153.42	5.39	129.25	8.80	139
	4	0.17	260.00	1.08	199.11	3.71	161.72	4.96	173
	5	0.07	246.00	0.41	201.79	1.34	188.32	1.82	194
	6	0.59	330.00	0.69	218.99	1.08	188.63	2.36	233
	7	0.88	308.00	0.24	237.68	0.37	202.46	1.49	270
	8+	2.48	293.18	0.06	217.30	0.23	221.69	2.77	286
	Total	4.52		72.56		34.97		112.05	
	SOP		1,310		5,897		3,323		10,529
Total	0	0.00	0.00	14.80	13.44	5.93	10.53	20.73	13
	1	0.00	0.00	149.60	52.03	31.48	28.27	181.08	48
	2	1.02	138.06	131.27	89.93	110.72	48.05	243.01	71
	3	2.07	170.07	43.78	116.12	55.48	90.49	101.33	103
	4	3.38	211.06	21.07	160.51	45.50	123.75	69.94	139
	5	1.42	211.01	9.46	177.00	37.21	145.22	48.09	153
	6	1.73	248.09	6.07	204.13	31.95	160.38	39.75	171
	7	4.47	248.37	3.21	201.78	13.23	171.16	20.91	192
	8+	3.14	284.53	2.14	222.72	7.24	181.84	12.53	215
	Total	17.24		381.39		338.74		737.37	
	SOP		3,941		32,289		31,032		67,262

Table 3.2.15 **WESTERN BALTIC HERRING.**
Total catch in numbers (mill) of *Western Baltic Spring Spawners* in Division IIIa and the North Sea + in Sub-Divisions 22-24 in the years 1993-2009

	W-rings	0	1	2	3	4	5	6	7	8+	Total
Year	**Area**										
1993	**Div. IV+Div. IIIa**	161.3	371.5	315.8	219.0	94.1	59.4	41.0	21.7	8.2	1130.8
	Sub-div. 22-24	44.9	159.2	180.1	196.1	166.9	151.1	61.8	42.2	16.3	973.7
1994	**Div. IV+Div. IIIa**	60.6	153.1	261.1	221.6	131.0	77.3	44.4	14.4	8.6	911.6
	Sub-div. 22-24	202.6	96.3	103.8	161.0	136.1	90.8	74.0	35.1	24.5	721.6
1995	**Div. IV+Div. IIIa**	50.3	302.5	204.2	97.9	90.9	30.6	21.3	12.0	7.2	816.9
	Sub-div. 22-24	491.0	1,358.2	233.9	128.9	104.0	53.6	38.8	20.9	13.2	1951.5
1996	**Div. IV+Div. IIIa**	166.2	228.1	317.7	75.6	40.4	30.6	12.6	6.7	5.6	883.6
	Sub-div. 22-24	4.9	410.8	82.8	124.1	103.7	99.5	52.7	24.0	19.5	917.1
1997	**Div. IV+Div. IIIa**	26.0	73.4	158.7	180.1	30.2	14.2	4.8	1.8	2.3	491.3
	Sub-div. 22-24	350.8	595.2	130.6	96.9	45.1	29.0	35.1	19.5	21.8	973.2
1998	**Div. IV+Div. IIIa**	36.3	175.1	315.1	94.5	54.7	11.2	8.7	2.2	2.1	700.0
	Sub-div. 22-24	513.5	447.9	115.8	88.3	92.0	34.1	15.0	13.2	12.0	818.4
1999	**Div. IV+Div. IIIa**	41.3	190.3	155.7	122.3	43.2	22.2	4.4	3.0	2.4	584.8
	Sub-div. 22-24	528.3	425.8	178.7	123.9	47.1	33.7	11.1	6.5	3.7	830.5
2000	**Div. IV+Div. IIIa**	114.83	318.22	302.10	99.88	50.85	18.76	8.21	1.35	1.40	915.6
	Sub-div. 22-24	37.7	616.3	194.3	86.7	77.8	53.0	30.1	12.4	9.3	1079.9
2001	**Div. IV+Div. IIIa**	121.7	36.6	208.1	111.1	32.1	19.7	9.8	4.2	2.4	545.6
	Sub-div. 22-24	634.6	486.5	280.7	146.8	76.0	48.7	29.3	14.1	4.3	1721.0
2002	**Div. IV+Div. IIIa**	69.6	577.7	168.3	134.6	53.1	12.0	7.5	2.4	2.0	1027.3
	Sub-div. 22-24	80.6	81.4	113.6	186.7	119.2	45.1	31.1	11.4	6.3	675.4
2003	**Div. IV+Div. IIIa**	52.1	63.0	182.5	64.0	62.2	20.3	5.9	3.8	1.6	455.5
	Sub-div. 22-24	1.4	63.9	82.3	95.8	125.1	82.2	22.9	13.1	7.0	493.6
2004	**Div. IV+Div. IIIa**	25.7	209.3	96.0	94.0	18.2	16.8	4.5	1.5	0.6	466.7
	Sub-div. 22-24	217.9	248.4	101.8	70.8	75.0	74.4	44.5	13.4	10.4	856.5
2005	**Div. IV+Div. IIIa**	95.3	96.9	203.3	75.4	46.9	9.3	11.5	3.5	1.4	543.5
	Sub-div. 22-24	11.6	207.6	115.9	102.5	83.5	51.3	54.2	27.8	11.2	665.5
2006 c	**Div. IV+Div. IIIa**	7.3	104.1	115.6	114.2	48.9	55.7	11.1	10.3	5.2	472.5
	Sub-div. 22-24	0.6	44.8	72.1	119.0	101.7	43.0	31.4	22.1	12.2	446.8
2007	**Div. IV+Div. IIIa**	1.6	103.9	90.9	36.9	30.8	12.8	9.4	6.2	2.7	295.2
	Sub-div. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2008	**Div. IV+Div. IIIa**	4.9	101.8	71.1	38.9	13.5	15.1	7.7	4.5	1.3	258.8
	Sub-div. 22-24	19.0	668.5	158.3	169.7	112.8	65.1	24.6	5.9	1.8	1206.8
2009	**Div. IV+Div. IIIa**	14.8	149.6	132.3	45.9	24.4	10.9	7.8	7.7	5.3	398.6
	Sub-div. 22-24	5.9	31.5	110.7	55.5	45.5	37.2	31.9	13.2	7.2	338.7

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

[c] values have been corrected in 2007

Table 3.2.16 **WESTERN BALTIC HERRING.**
Mean weight (g) and SOP (tons) of *Western Baltic Spring Spawners* in Division IIIa and the North Sea + in Sub-Divisions 22-24 in the years 1993 - 2009

	W-rings	0	1	2	3	4	5	6	7	8+	SOP
Year	**Area**										
1993	**Div. IV+Div. IIIa**	15.1	25.9	81.4	127.5	150.1	171.1	195.9	209.1	239.0	104,498
	Sub-div. 22-24	16.2	24.5	44.5	73.6	94.1	122.4	149.4	168.5	178.7	80,512
1994	**Div. IV+Div. IIIa**	20.2	42.6	94.8	122.7	150.3	168.7	194.7	209.9	220.2	106,013
	Sub-div. 22-24	12.9	28.2	54.2	76.4	95.0	117.7	133.6	154.3	173.9	66,425
1995	**Div. IV+Div. IIIa**	17.9	41.5	97.8	138.0	163.1	198.5	207.0	228.8	234.3	76,674
	Sub-div. 22-24	9.3	16.3	42.8	68.3	88.9	125.4	150.4	193.3	207.4	74,157
1996	**Div. IV+Div. IIIa**	10.5	27.6	90.1	134.9	164.9	186.6	204.1	208.5	220.2	64,449
	Sub-div. 22-24	12.1	22.9	45.8	74.0	92.1	116.3	120.8	139.0	182.5	56,817
1997	**Div. IV+Div. IIIa**	19.2	49.7	76.7	127.2	154.4	175.8	184.4	192.0	208.0	48,075
	Sub-div. 22-24	30.4	24.7	58.4	101.0	120.7	155.2	181.3	197.1	208.8	67,513
1998	**Div. IV+Div. IIIa**	27.8	51.3	71.5	108.8	142.6	171.7	194.4	184.2	230.0	55,121
	Sub-div. 22-24	13.3	26.3	52.2	78.6	103.0	125.2	150.0	162.1	179.5	51,911
1999	**Div. IV+Div. IIIa**	11.5	51.0	83.6	114.9	121.2	145.2	169.6	123.8	152.3	47,179
	Sub-div. 22-24	11.1	26.9	50.4	81.6	112.0	148.4	151.4	167.8	161.0	50,060
2000	**Div. IV+Div. IIIa**	22.6	31.9	67.4	107.7	140.2	170.0	157.0	185.0	210.1	56,010
	Sub-div. 22-24	16.5	22.2	42.8	80.4	123.5	133.2	143.4	155.4	151.4	53,904
2001	**Div. IV+Div. IIIa**	9.0	51.2	76.2	108.9	145.3	171.4	188.2	187.2	203.3	42,079
	Sub-div. 22-24	12.9	22.3	46.8	69.0	93.5	150.8	145.1	146.3	153.1	63,724
2002	**Div. IV+Div. IIIa**	10.2	20.4	78.2	117.7	143.8	169.8	191.9	198.2	215.5	53,544
	Sub-div. 22-24	10.8	27.3	57.8	81.7	108.8	132.1	186.6	177.8	157.7	52,647
2003	**Div. IV+Div. IIIa**	13.0	37.4	76.5	112.7	132.1	140.8	151.9	167.4	158.2	37,075
	Sub-div. 22-24	22.4	25.8	46.4	75.3	95.2	117.2	125.9	157.1	162.6	40,315
2004	**Div. IV+Div. IIIa**	27.1	43.2	81.9	117.1	145.4	157.4	170.7	184.4	187.1	35,078
	Sub-div. 22-24	3.7	14.3	47.4	77.7	96.4	125.5	150.4	165.8	151.0	41,736
2005	**Div. IV+Div. IIIa**	14.1	54.9	85.6	121.6	148.3	162.7	176.3	178.3	200.6	50,765
	Sub-div. 22-24	13.6	14.2	48.3	73.3	89.3	115.5	143.6	159.9	170.2	37,013
2006 c	**Div. IV+Div. IIIa**	16.6	36.9	82.9	113.0	142.5	175.2	198.2	209.5	220.0	25,965
	Sub-div. 22-24	21.2	34.0	56.7	84.0	102.2	125.3	143.9	175.8	170.0	70,911
2007	**Div. IV+Div. IIIa**	25.2	65.6	85.0	115.7	138.4	159.2	190.8	178.6	211.9	28,632
	Sub-div. 22-24	11.9	27.8	57.3	74.9	106.3	121.3	140.8	162.7	185.5	39,548
2008	**Div. IV+Div. IIIa**	19.2	71.5	91.1	114.5	142.2	171.2	181.4	200.0	196.4	25,368
	Sub-div. 22-24	16.3	49.5	65.2	88.1	110.5	133.2	140.3	156.7	172.2	43,116
2009	**Div. IV+Div. IIIa**	13.4	52.0	90.3	118.6	167.5	181.4	213.9	228.9	259.5	36,230
	Sub-div. 22-24	10.5	28.3	48.1	90.5	123.7	145.2	160.4	171.2	181.8	31,032

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

[c] values have been corrected in 2007

Table 3.2.17 WESTERN BALTIC HERRING.
Transfers of *North Sea autumn spawners* from Div. IIIa to the North Sea
Numbers ('000) and mean weight, SOP in (tonnes) 1993-2009.

Year	W-Rings	0	1	2	3	4	5	6	7	8+	Total
1993	**Number**	2,795.4	2,032.5	237.6	26.5	7.7	3.6	2.7	2.2	0.7	5,109.0
	Mean W.	12.5	28.6	79.7	141.4	132.3	233.4	238.5	180.6	203.1	
	SOP	34,903	58,107	18,939	3,749	1,016	850	647	390	133	118,734
1994	**Number**	481.6	1,086.5	201.4	26.9	6.0	2.9	1.6	0.4	0.2	1,807.5
	Mean W.	16.0	42.9	83.4	110.7	138.3	158.6	184.6	199.1	213.9	
	SOP	7,723	46,630	16,790	2,980	831	460	287	75	37	75,811
1995	**Number**	1,144.5	1,189.2	161.5	13.3	3.5	1.1	0.6	0.4	0.3	2,514.4
	Mean W.	11.2	39.1	88.3	145.7	165.5	204.5	212.2	236.4	244.3	
	SOP	12,837	46,555	14,267	1,940	573	225	133	86	65	76,680
1996	**Number**	516.1	961.1	161.4	17.0	3.4	1.6	0.7	0.4	0.3	1,661.9
	Mean W.	11.0	23.4	80.2	126.6	165.0	186.5	216.1	216.3	239.1	
	SOP	5,697	22,448	12,947	2,151	565	307	145	77	66	44,403
1997	**Number**	67.6	305.3	131.7	21.2	1.7	0.8	0.2	0.1	0.1	528.7
	Mean W.	19.3	47.7	68.5	124.4	171.5	184.7	188.7	188.7	192.4	
	SOP	1,304	14,571	9,025	2,643	285	146	40	16	25	28,057
1998	**Number**	51.3	745.1	161.5	26.6	19.2	3.0	3.1	1.2	0.5	1,011.6
	Mean W.	27.4	56.4	79.8	117.8	162.9	179.7	197.2	178.9	226.3	
	SOP	1,409	41,994	12,896	3,137	3,136	547	608	211	108	64,045
1999	**Number**	598.8	303.0	148.6	47.2	13.4	6.2	1.2	0.5	0.5	1,119.4
	Mean W.	10.4	50.5	87.7	113.7	137.4	156.5	188.1	187.3	198.8	
	SOP	6,255	15,297	13,037	5,369	1,841	974	230	90	92	43,186
2000	**Number**	235.3	984.3	116.0	21.9	22.9	7.5	3.3	0.6	0.1	1,391.8
	Mean W.	21.3	28.5	76.1	108.8	163.1	190.3	183.9	189.4	200.2	
	SOP	5,005	28,012	8,825	2,377	3,731	1,436	601	114	13	50,115
2001	**Number**	807.8	563.6	150.0	17.2	1.4	0.3	0.5	0.0	0.0	1,540.8
	Mean W.	8.7	49.4	75.3	108.2	130.1	147.1	219.1	175.8	198.1	
	SOP	7,029	27,849	11,300	1,856	177	43	109	8	5	48,376
2002	**Number**	478.5	362.6	56.7	5.6	0.7	0.2	0.1	0.0	0.0	904.5
	Mean W.	12.2	38.0	100.6	121.5	142.7	160.9	178.7	177.4	218.6	
	SOP	5,859	13,790	5,705	684	106	26	21	8	5	26,205
2003	**Number**	21.6	445.0	182.3	13.0	16.2	1.8	1.1	1.2	0.2	682.4
	Mean W.	20.5	33.7	67.0	123.2	150.3	163.5	190.2	214.6	186.8	
	SOP	442	14,992	12,219	1,606	2,436	293	213	264	33	32,498
2004	**Number**	88.4	70.9	179.9	20.7	6.0	9.7	1.8	2.0	0.9	380.4
	Mean W.	22.5	55.3	70.2	120.6	140.9	151.7	170.6	186.6	178.5	
	SOP	1,993	3,921	12,638	2,498	851	1,479	312	367	154	24,214
2005	**Number**	96.4	307.5	159.2	16.2	5.4	2.4	2.3	0.5	0.2	589.9
	Mean W.	16.5	50.5	71.0	105.9	154.6	173.5	184.5	200.2	208.9	
	SOP	1,595	15,527	11,304	1,712	828	412	420	95	34	31,927
2006	**Number**	35.1	150.1	50.2	10.2	3.3	3.3	0.6	0.4	0.2	253.3
	Mean W.	14.3	53.5	79.2	117.6	140.2	185.5	190.4	215.6	206.9	
	SOP	503	8,035	3,975	1,200	456	620	107	81	37	15,015
2007	**Number**	67.7	189.3	76.9	2.1	0.4	1.4	0.3	0.6	0.0	338.7
	Mean W.	26.7	62.6	71.1	108.1	124.4	151.7	183.7	174.7	153.8	
	SOP	1,807	11,857	5,464	224	55	219	48	110	3	19,788
2008	**Number**	85.7	86.6	72.0	1.9	0.3	0.1	0.1	0.3	0.1	247.0
	Mean W.	16.2	57.6	86.4	109.1	138.7	167.7	175.4	203.1	197.7	
	SOP	1,386	4,986	6,222	205	35	25	10	67	13	12,949
2009	**Number**	116.8	77.5	7.0	0.4	0.2	0.0	0.0	0.0	0.1	202.0
	Mean W.	9.4	59.8	101.0	81.3	206.4	0.0	0.0	0.0	268.5	
	SOP	1,095	4,635	710	29	46	0	0	0	28	6,542

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

Table 3.3.1 **WESTERN BALTIC HERRING. German acoustic survey (GERAS) on the Spring Spawning Herring in Subdivisions 21 (Southern Kattegat, 41G0-42G2) - 24 in autumn 1993-2009 (September/October).**

Year	1993	1994	1995	1996	1997	1998	1999	2000	2001*	2002**	2003	2004	2005	2006	2007	2008	2009
	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
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
2	437	884	329	590	738	679	287	454	1,227	421	223	592	640	274	278	214	135
3	530	560	358	434	395	394	233	329	845	575	217	346	401	376	149	209	92
4	403	444	354	295	162	237	156	202	367	341	260	163	192	353	136	150	61
5	125	189	254	306	119	100	52	79	132	64	97	143	105	183	88	166	32
6	55	60	127	119	99	51	8	39	86	25	38	79	90	131	25	102	34
7	28	24	46	47	33	24	1	6	20	10	9	23	26	85	23	42	16
8+	13	2	27	19	48	9	2	4	10	13	10	12	17	30	11	19	4
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
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
	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
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
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
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
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
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
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
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
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
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
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
	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
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
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
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
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
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
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
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
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
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

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

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

Table 3.3.2 WESTERN BALTIC HERRING. Herring acoustic survey (HERAS) on the Spring Spawning Herring in the North Sea/Division IIIa in 1991-2009 (July).

Year	1991	1992*	1993*	1994*	1995*	1996*	1997	1998	1999**	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
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
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
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
4	866	1,593	598	501	1,270	141	166	282	135	364	153	524	323	307	201	490	499	333	161
5	350	556	434	239	255	119	67	111	28	186	96	88	103	184	103	180	154	274	82
6	88	197	154	186	174	37	69	51	3	56	38	40	25	72	84	27	34	176	86
7	72	122	63	62	39	20	80	31	2	7	23	18	12	22	37	10	26	45	39
8+	10	20	13	34	21	13	77	53	1	10	12	17	5	18	21	0.1	14	44	65
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**
3+ group	**5,177**	**4,287**	**2,536**	**1,957**	**2,781**	**577**	**1,245**	**1,428**	**691**	**1,295**	**774**	**2,079**	**864**	**1,328**	**910**	**2,487**	**1,660**	**1,715**	**638**
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
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
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
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
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
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
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
8+	2.0	5.0	2	7.8	3.8	2.7	13.6	9.0	0.1	1.3	2.7	3.1	0.9	3.2	4.9	0.02	1.94	8.65	19.81
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
3+ group	420.9	560.3	291.0	292.3	319.9	75.2	150.6	153.7	78.5	151.9	104.9	209.6	104.0	179.3	119.3	244.4	178.2	243.2	129.3
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
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
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
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
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
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
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
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
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

* revised in 1997

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

Table 3.3.3 WESTERN BALTIC HERRING.

N20 Larval Abundance Index.

Estimation of 0-Group herring reaching 20 mm in length in Greifswalder Bodden and adjacent waters in March/April to June 1992-2009.

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

* Small revision in 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
0	756285	150271	53489	243554	106906	7946	10721	9610	20734
1	523163	659130	126876	457754	305171	148909	172044	149436	181083
2	488816	281840	264855	197812	319225	187674	184735	136988	243007
3	257837	321311	161251	164766	177833	233214	143904	135753	101330
4	108097	172285	189432	93214	130394	150654	126861	92305	69937
5	68376	57160	103648	91242	60639	98751	64996	89436	48091
6	39092	38532	29117	48957	65695	42459	30199	45930	39750
7	18307	13842	17452	14876	31231	32418	21256	17216	20907
8	6687	8329	8819	11013	12620	17312	14759	17410	12529

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	0.037	0.0209	0.0246	0.0275	0.0333	0.0343	0.0255
2	0.0669	0.0673	0.068	0.0833	0.0684	0.0809	0.0684	0.0663	0.0658	0.0578
3	0.0949	0.0944	0.102	0.1032	0.0984	0.097	0.1181	0.0942	0.0981	0.095
4	0.1234	0.1163	0.1143	0.1221	0.1235	0.1125	0.1342	0.1178	0.1164	0.1301
5	0.139	0.1417	0.1361	0.1411	0.152	0.1328	0.162	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	0.186	0.217	0.191	0.2087	0.187	0.1576	0.1591

age	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	0.0123	0.0105	0.0132	0.00618	0.014	0.017	0.0139	0.0178	0.0126
1	0.0243	0.0213	0.0315	0.02754	0.0272	0.036	0.0506	0.0647	0.0479
2	0.0593	0.07	0.0671	0.06419	0.0721	0.0728	0.0709	0.0788	0.0711
3	0.0862	0.0968	0.0907	0.10017	0.0938	0.0982	0.0854	0.096	0.1032
4	0.1089	0.1196	0.1079	0.10596	0.1106	0.1153	0.1141	0.1153	0.139
5	0.1567	0.14	0.1223	0.13139	0.1228	0.1535	0.1288	0.1404	0.1534
6	0.156	0.1876	0.1319	0.15228	0.1493	0.1581	0.1564	0.1481	0.1709
7	0.1556	0.1814	0.1603	0.16768	0.1619	0.1865	0.1673	0.1667	0.1924
8	0.1713	0.1717	0.1625	0.15295	0.1736	0.1848	0.1903	0.1704	0.2146

TABLE 3.6.3 WBSS HERRING. WEIGHTS AT AGE IN THE STOCK

Units kg

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
0	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1	0.0308	0.0203	0.0156	0.0186	0.0131	0.0181	0.0131	0.0221	0.0211	0.014
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	0.117	0.1333	0.1128	0.1081	0.125
5	0.1245	0.1313	0.1409	0.1392	0.1674	0.1197	0.1662	0.1338	0.148	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	0.171	0.1827	0.1768	0.2097	0.1467	0.2089	0.1683	0.1439	0.165
8	0.164	0.1869	0.1891	0.2028	0.2338	0.128	0.2263	0.1843	0.1504	0.1831

age \ year	2001	2002	2003	2004	2005	2006	2007	2008	2009
0	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	0.015	0.018	0.023
2	0.0509	0.0637	0.0445	0.0456	0.0514	0.0621	0.055	0.068	0.052
3	0.0783	0.0905	0.0793	0.0811	0.08	0.0953	0.08	0.086	0.09
4	0.1159	0.1239	0.1051	0.1092	0.1066	0.1174	0.114	0.11	0.13
5	0.169	0.1736	0.1268	0.144	0.1322	0.1659	0.143	0.139	0.156
6	0.1763	0.1983	0.1506	0.1628	0.1573	0.171	0.171	0.143	0.174
7	0.1681	0.198	0.1729	0.1932	0.1677	0.1858	0.175	0.141	0.185
8	0.1805	0.2036	0.1847	0.2076	0.182	0.1871	0.188	0.158	0.199

TABLE 3.6.4 WBSS HERRING. NATURAL MORTALITY

Units NA

age \ year	1991	1992	1993	1994	1995	1996
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

age \ year	1997	1998	1999	2000	2001	2002
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

age \ year	2003	2004	2005	2006	2007	2008	2009
0	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
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
4	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
6	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
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2

TABLE 3.6.5 WBSS HERRING. PROPORTION MATURE

Units	NA						
	year						
age	1991	1992	1993	1994	1995	1996	
0	0	0	0	0	0	0	
1	0	0	0	0	0	0	
2	0.2	0.2	0.2	0.2	0.2	0.2	
3	0.75	0.75	0.75	0.75	0.75	0.75	
4	0.9	0.9	0.9	0.9	0.9	0.9	
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	
	year						
age	1997	1998	1999	2000	2001	2002	
0	0	0	0	0	0	0	
1	0	0	0	0	0	0	
2	0.2	0.2	0.2	0.2	0.2	0.2	
3	0.75	0.75	0.75	0.75	0.75	0.75	
4	0.9	0.9	0.9	0.9	0.9	0.9	
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	
	year						
age	2003	2004	2005	2006	2007	2008	2009
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
3	0.75	0.75	0.75	0.75	0.75	0.75	0.75
4	0.9	0.9	0.9	0.9	0.9	0.9	0.9
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1

TABLE 3.6.6 WBSS HERRING. FRACTION OF HARVEST BEFORE SPAWNING

Units	NA						
	year						
age	1991	1992	1993	1994	1995	1996	
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	
	year						
	1997	1998	1999	2000	2001	2002	
age	0.1	0.1	0.1	0.1	0.1	0.1	
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	year						
age	2003	2004	2005	2006	2007	2008	2009
0	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
2	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
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 3.6.7 WBSS HERRING. FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units NA

age	1991	1992	1993	1994	1995	1996
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

	1997	1998	1999	2000	2001	2002
	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	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
	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	0.25	0.25	0.25
	0.25	0.25	0.25	0.25	0.25	0.25

age	2003	2004	2005	2006	2007	2008	2009
0	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
2	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
4	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
6	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
8	0.25	0.25	0.25	0.25	0.25	0.25	0.25

TABLE 3.6.8 WBSS HERRING. SURVEY INDICIES

HERAS **3-6 wr** **Configuration**

min	max	plusgroup	minyear	maxyear	startf	endf
3	6	NA	1993	2009	0.58	0.67

Index type: number

HERAS **3-6 wr** **Values**

Units NA

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

age	2000	2001	2002	2003	2004	2005	2006
3	673600000	452300000	1392800000	394600000	726000000	463500000	1.78E+09
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
3	933000000	843000000	205000000
4	499000000	333000000	161000000
5	154000000	274000000	82000000
6	34000000	176000000	86000000

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

Units NA

age \ year	1993	1994	1995	1996	1997	1998	1999
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1

age \ year	2000	2001	2002	2003	2004	2005	2006
3	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1

age \ year	2007	2008	2009
3	1	1	1
4	1	1	1
5	1	1	1
6	1	1	1

GerAS **1-3 wr** **Configuration**

min	max	plusgroup	minyear	maxyear	startf	endf
1	3	NA	1994	2009	0.77	0.83

Index type: number

GerAS **1-3 wr** **Index Values**

Units NA

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

age \ year	2004	2005	2006	2007	2008	2009
1	968860	752980	950450	560000	392780	270930
2	592360	640060	274460	278000	213500	134670
3	346230	401070	376480	149000	209000	92270

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

Units NA

age \ year	1994	1995	1996	1997	1998	1999	2000
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1

age \ year	2001	2002	2003	2004	2005	2006	2007
1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1

age \ year	2008	2009
1	1	1
2	1	1
3	1	1

N20 **Configuration**

min	max	plusgroup	minyear	maxyear	startf	endf
0	0	NA	1992	2009	0.3	0.5

Index type: number

N20 **Index Values**

Units NA

age \ year	1992	1993	1994	1995	1996	1997	1998
0	1060	3044	12515	7930	21012	4872	16743

age \ year	1999	2000	2001	2002	2003	2004	2005
0	20364	3026	4845	11324	5507	5640	3887

age \ year	2006	2007	2008	2009
0	3774	1829	1622	6464

N20 **Index Variance (Inverse Weights)**

Units NA

age \ year	1992	1993	1994	1995	1996	1997
0	1	1	1	1	1	1

age \ year	1998	1999	2000	2001	2002	2003
0	1	1	1	1	1	1

age \ year	2004	2005	2006	2007	2008	2009
0	1	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	2009	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: 08/10/2009 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; 23/03/2009 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; 19/05/2009 19:23:22; windows

TABLE 3.6.12 WBSS HERRING. STOCK SUMMARY

Year	Recruitment Age 0 f	TSB tonnes	SSB	Fbar (Ages 3-6)	Landings	Landings SOP
1991	5020627	624060	316347	0.349	191573	1
1992	3667701	549818	328906	0.466	194411	1
1993	3124936	470662	301059	0.533	185010	1
1994	6202502	382531	235874	0.674	172438	1
1995	4065845	323498	187212	0.501	150831	1
1996	4498746	277243	137360	0.682	121266	1
1997	4011730	280450	154531	0.494	115588	1
1998	5642872	276696	124364	0.476	107032	1
1999	6463434	294143	131238	0.363	97240	1
2000	3418683	299802	145314	0.453	109914	1
2001	4409766	324518	166868	0.439	105803	1
2002	2933490	356017	206794	0.397	106191	1
2003	3995251	268060	165417	0.384	78309	1
2004	2564193	280894	169052	0.34	76815	1
2005	2012424	279957	165396	0.407	88406	1
2006	1515946	292470	181856	0.415	90549	1
2007	1354566	220052	143097	0.402	68997	0.988
2008	1076630	191887	120154	0.446	68484	1.015
2009	3484636	164860	105234	0.523	67262	1

TABLE 3.6.13 WBSS HERRING. ESTIMATED FISHING MORTALITY

Units f

age	1991	1992	1993	1994	1995	1996
0	0.0278	0.0468	0.0792	0.0503	0.167	0.045
1	0.258	0.1735	0.297	0.1592	0.636	0.376
2	0.3178	0.3694	0.3495	0.4189	0.567	0.375
3	0.4179	0.3678	0.4706	0.4996	0.501	0.554
4	0.3921	0.4694	0.4904	0.6365	0.516	0.701
5	0.3615	0.4836	0.6161	0.6862	0.421	0.794
6	0.2267	0.541	0.5545	0.8742	0.565	0.681
7	0.3772	0.432	0.5124	0.5724	0.645	0.64
8	0.3772	0.432	0.5124	0.5724	0.645	0.64

age	1997	1998	1999	2000	2001	2002
0	0.115	0.119	0.107	0.053	0.22	0.061
1	0.306	0.349	0.234	0.318	0.319	0.378
2	0.355	0.403	0.39	0.365	0.332	0.345
3	0.485	0.399	0.425	0.394	0.328	0.38
4	0.417	0.516	0.351	0.413	0.418	0.381
5	0.466	0.479	0.379	0.521	0.403	0.408
6	0.608	0.509	0.297	0.485	0.607	0.418
7	0.492	0.503	0.392	0.47	0.454	0.449
8	0.492	0.503	0.392	0.47	0.454	0.449

age	2003	2004	2005	2006	2007	2008	2009
0	0.0156	0.116	0.0112	0.0114	0.0111	0.0123	0.0144
1	0.0819	0.22	0.2078	0.2119	0.2056	0.2278	0.2674
2	0.3102	0.211	0.3443	0.3511	0.3407	0.3775	0.4431
3	0.34	0.323	0.3652	0.3725	0.3614	0.4004	0.47
4	0.4044	0.337	0.4006	0.4085	0.3964	0.4391	0.5155
5	0.4158	0.347	0.437	0.4457	0.4325	0.4791	0.5624
6	0.3762	0.353	0.4235	0.4319	0.4191	0.4643	0.545
7	0.3388	0.336	0.4006	0.4085	0.3964	0.4391	0.5155
8	0.3388	0.336	0.4006	0.4085	0.3964	0.4391	0.5155

TABLE 3.6.14 WBSS HERRING. ESTIMATED POPULATION ABUNDANCE

Units NA

age	1991	1992	1993	1994	1995	1996	1997	1998	1999
0	5020627	3667701	3124936	6202502	4065845	4498746	4011730	5642872	6463434
1	4566067	3617437	2592832	2138628	4369517	2549814	3186164	2649788	3710318
2	2181912	2139597	1844600	1168575	1106184	1403141	1061701	1423632	1133806
3	1810708	1300047	1210711	1064814	629331	513577	789180	609417	778915
4	945399	976134	736800	619176	528982	312061	241745	397975	334854
5	641609	522943	499820	369422	268238	258557	126768	130388	194455
6	251958	365935	263978	220993	152276	144152	95700	65138	66135
7	46202	164451	174410	124140	75486	70891	59716	42655	32048
8	17213	70496	66943	82974	46972	57976	67945	39087	20572

age	2000	2001	2002	2003	2004	2005	2006	2007	2008
0	3418683	4409766	2933490	3995251	2564193	2012424	1515946	1354566	1076630
1	4301110	2401959	2621871	2044523	2913906	1691359	1474207	1110264	992408
2	1780125	1897851	1058909	1090067	1142608	1417762	833407	723427	548265
3	628212	1011740	1114694	613821	654448	757425	822655	480301	421280
4	416872	346859	596695	624207	357711	387775	430384	464083	273960
5	193094	225907	187010	333882	341081	209135	212698	234206	255621
6	109010	93855	123602	101825	180374	197305	110603	111519	124429
7	40231	54962	41881	66630	57228	103712	105766	58795	60045
8	31214	20076	25201	33670	42367	41908	56576	49436	53656

age	2009
0	3484636
1	787837
2	479313
3	307752
4	231104
5	144582
6	129614
7	64034
8	34029

TABLE 3.6.15 WBSS HERRING. SURVIVORS AFTER TERMINAL YEAR

Units NA

age	2010
0	NA
1	2544477
2	365738
3	251962
4	157474
5	113001
6	67453
7	61531
8	47949

TABLE 3.6.16 WBSS HERRING. FITTED SELECTION PATTERN

Units NA

age	2005	2006	2007	2008	2009
0	0.028	0.028	0.028	0.028	0.028
1	0.519	0.519	0.519	0.519	0.519
2	0.86	0.86	0.86	0.86	0.86
3	0.912	0.912	0.912	0.912	0.912
4	1	1	1	1	1
5	1.091	1.091	1.091	1.091	1.091
6	1.057	1.057	1.057	1.057	1.057
7	1	1	1	1	1
8	1	1	1	1	1

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
0	756285	150271	53489	243554	19403	14904	12924	11374	43170
1	523163	659130	126876	457754	251853	223455	163754	160588	147071
2	488816	281840	264855	197812	376438	224962	190386	157213	156644
3	257837	321311	161251	164766	211325	233300	132836	126830	105421
4	108097	172285	189432	93214	116772	131696	138552	88893	85089
5	68376	57160	103648	91242	67597	69839	75063	88899	56896
6	39092	38532	29117	48957	62177	35411	34845	42212	49807
7	18307	13842	17452	14876	31231	32364	17553	19483	23576
8	6687	8329	8819	11013	12620	17312	14759	17410	12529

TABLE 3.6.18 WBSS HERRING. CATCH RESIDUALS

Units thousands NA

age	2005	2006	2007	2008	2009
0	1.707	-0.62893	-0.1869	-0.16856	-0.7334
1	0.192	-0.40587	0.0494	-0.07197	0.208
2	-0.165	-0.18123	-0.0301	-0.13771	0.4391
3	-0.173	-0.00037	0.08	0.06799	-0.0396
4	0.11	0.13449	-0.0882	0.03766	-0.1961
5	-0.109	0.34641	-0.144	0.00603	-0.1681
6	0.055	0.18153	-0.1431	0.08441	-0.2255
7	0	0.00166	0.1914	-0.12372	-0.1202
8	0	0	0	0	0

TABLE 3.6.19 WBSS HERRING. PREDICTED INDEX VALUES

HERAS 3-6 wr

Units NA NA

age	1993	1994	1995	1996	1997	1998	1999
3	1202420666	1038509254	613073049	484293176	776932200	633008704	NA
4	578918012	444032607	409069226	214971577	198811445	307692907	NA
5	291039003	205885506	176448560	134721365	81083789	82726023	NA
6	129300510	88638608	74117718	65227488	45330194	32819345	NA

age	2000	2001	2002	2003	2004	2005	2006
3	654512474	1098446082	1171644903	661463009	712604266	803423832	868683432
4	343847743	285188935	502124906	517538674	309385641	322276783	355921158
5	119291303	150279318	124027343	220350912	234931961	136198844	137772916
6	55770805	44488578	65935524	55753017	100178259	104884321	58487733

age	2007	2008	2009
3	510686642	437145679	305747154
4	386705700	222260545	178757011
5	152962214	162149745	87061492
6	59445956	64479147	63862239

GerAS 1-3 wr

Units NA NA

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	947487	1322062	949703	1255613	1008690	1547843	1678070	NA	975369	963652
2	430085	361551	534664	411199	530629	426887	684014	NA	413357	437633
3	473058	279174	218532	354836	293477	367289	303705	NA	545006	309843

age	2004	2005	2006	2007	2008	2009
1	1229311	720804	626198	473982	416215	320116
2	496559	553878	323819	283436	208583	173026
3	334770	374680	404602	238320	202613	139995

N20

Units NA NA

age	1992	1993	1994	1995	1996	1997
0	6241	5249	10540	6595	7661	6644

age	1998	1999	2000	2001	2002	2003
0	9328	10736	5803	7002	4963	6884

age	2004	2005	2006	2007	2008	2009
0	4244	3474	2616	2338	1858	6007

TABLE 3.6.20 WBSS HERRING. INDEX RESIDUALS

HERAS **3-6 wr**

Units NA

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
3	0.0578	-0.105	0.511	-0.673	0.0129	0.353	NA	0.02875	-0.887	0.1729
4	0.0324	0.121	1.133	-0.422	-0.1804	-0.0872	NA	0.05668	-0.622	0.0432
5	0.3996	0.149	0.368	-0.124	-0.1908	0.294	NA	0.44256	-0.444	-0.3489
6	0.1748	0.741	0.853	-0.567	0.4201	0.4408	NA	-0.00307	-0.168	-0.5124

age \ year	2003	2004	2005	2006	2007	2008	2009
3	-0.517	0.01862	-0.55	0.718	0.60265	0.657	-0.3997
4	-0.47	-0.00807	-0.471	0.32	0.25494	0.404	-0.1046
5	-0.757	-0.24599	-0.284	0.27	0.00676	0.525	-0.0599
6	-0.794	-0.3289	-0.227	-0.773	-0.55871	1.004	0.2976

GerAS **1-3 wr**

Units NA

age \ year	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1	-0.824	0.2368	0.4159	0.443	-0.23	-0.145	-0.1601	NA	-0.1523	0.251
2	0.72	-0.0955	0.0985	0.585	0.246	-0.396	-0.4099	NA	0.0193	-0.676
3	0.168	0.2486	0.6863	0.106	0.295	-0.457	0.0799	NA	0.0542	-0.355

age \ year	2004	2005	2006	2007	2008	2009
1	-0.2381	0.0437	0.417	0.1668	-0.058	-0.167
2	0.1764	0.1446	-0.165	-0.0194	0.0233	-0.251
3	0.0337	0.0681	-0.072	-0.4697	0.031	-0.417

N20

Units NA

age \ year	1992	1993	1994	1995	1996	1997
0	-1.77	-0.545	0.172	0.184	1.01	-0.31

age \ year	1998	1999	2000	2001	2002	2003
0	0.585	0.64	-0.651	-0.368	0.825	-0.223

age \ year	2004	2005	2006	2007	2008	2009
0	0.284	0.112	0.366	-0.246	-0.136	0.0733

TABLE 3.6.21 WBSS HERRING. FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL	Upper.95.pct.CL
F, 2005	0.40055	0.1916	0.27513	0.58316
F, 2006	0.40848	0.1896	0.28168	0.59236
F, 2007	0.39637	0.1926	0.27173	0.57818
F, 2008	0.43914	0.2031	0.29494	0.65384
F, 2009	0.51547	0.2328	0.32662	0.81351
Selectivity at age 0	0.02801	0.478	0.01097	0.07148
Selectivity at age 1	0.5187	0.2149	0.34037	0.79045
Selectivity at age 2	0.85956	0.2056	0.57446	1.28614
Selectivity at age 3	0.91186	0.2007	0.6153	1.35134
Selectivity at age 5	1.09107	0.1804	0.76614	1.55382
Selectivity at age 6	1.05733	0.1738	0.75208	1.48647
Terminal year pop, age 0	3484635.05	0.3114	1892787.919	6415236.122
Terminal year pop, age 1	787835.881	0.2247	507218.7335	1223703.569
Terminal year pop, age 2	479312.239	0.193	328349.3322	699682.3206
Terminal year pop, age 3	307750.776	0.176	217964.1312	434523.5144
Terminal year pop, age 4	231102.883	0.1738	164392.0052	324885.2791
Terminal year pop, age 5	144580.565	0.1851	100580.5676	207828.8103
Terminal year pop, age 6	129613.343	0.2069	86396.4142	194448.1013
Terminal year pop, age 7	64033.2553	0.2429	39782.01404	103068.1297
Last TRUE age pop, 2005	103710.687	0.3507	52155.99462	206225.7026
Last TRUE age pop, 2006	105765.472	0.2655	62855.50741	177969.0531
Last TRUE age pop, 2007	58793.6441	0.2377	36898.43987	93681.26667
Last TRUE age pop, 2008	60044.4853	0.2384	37627.64855	95816.25106
Index 1, age 3 numbers Q	1510.19296	0.1596	1104.54093	2064.82414
Index 1, age 4 numbers Q	1209.64826	0.1604	883.3087	1656.5544
Index 1, age 5 numbers Q	969.74898	0.1623	705.57862	1332.82537
Index 1, age 6 numbers Q	784.90338	0.1659	567.06705	1086.42059
Index 2, age 1 numbers Q	0.75073	0.1441	0.566	0.99575
Index 2, age 2 numbers Q	0.60384	0.1441	0.45525	0.80092
Index 2, age 3 numbers Q	0.77751	0.1443	0.58598	1.03165
Index 3, age 0 numbers Q	0.00195	0.0795	0.00167	0.00228

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

2010 (Intermediate year)

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1627212	0.30	0.00	0.10	0.25	0.000	0.013	0.015
1	2544477	0.50	0.00	0.10	0.25	0.019	0.234	0.054
2	365738	0.20	0.20	0.10	0.25	0.058	0.387	0.074
3	251962	0.20	0.75	0.10	0.25	0.085	0.411	0.095
4	157474	0.20	0.90	0.10	0.25	0.118	0.450	0.123
5	113001	0.20	1.00	0.10	0.25	0.146	0.491	0.141
6	67453	0.20	1.00	0.10	0.25	0.163	0.476	0.158
7	61531	0.20	1.00	0.10	0.25	0.167	0.450	0.175
8	47949	0.20	1.00	0.10	0.25	0.182	0.450	0.192

2011 (Advice year)

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1627212	0.30	0.00	0.10	0.25	0.000	0.013	0.015
1	-	0.50	0.00	0.10	0.25	0.019	0.234	0.054
2	-	0.20	0.20	0.10	0.25	0.058	0.387	0.074
3	-	0.20	0.75	0.10	0.25	0.085	0.411	0.095
4	-	0.20	0.90	0.10	0.25	0.118	0.450	0.123
5	-	0.20	1.00	0.10	0.25	0.146	0.491	0.141
6	-	0.20	1.00	0.10	0.25	0.163	0.476	0.158
7	-	0.20	1.00	0.10	0.25	0.167	0.450	0.175
8	-	0.20	1.00	0.10	0.25	0.182	0.450	0.192

2012 (Continuation year)

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
0	1627212	0.30	0.00	0.10	0.25	0.000	0.013	0.015
1	-	0.50	0.00	0.10	0.25	0.019	0.234	0.054
2	-	0.20	0.20	0.10	0.25	0.058	0.387	0.074
3	-	0.20	0.75	0.10	0.25	0.085	0.411	0.095
4	-	0.20	0.90	0.10	0.25	0.118	0.450	0.123
5	-	0.20	1.00	0.10	0.25	0.146	0.491	0.141
6	-	0.20	1.00	0.10	0.25	0.163	0.476	0.158
7	-	0.20	1.00	0.10	0.25	0.167	0.450	0.175
8	-	0.20	1.00	0.10	0.25	0.182	0.450	0.192

Input units are thousands and kg - output in tonnes

MAT = Maturity ogive
PF = Proportion of F before spawning
PM = Proportion of M before spawning
SWt = Weight in stock (kg)
Sel = Exploit. Pattern
CWt = Weight in catch (kg)

$N_{2010,2011,2012}$ Age 0:	Geometric Mean from ICA of age 0 (Table 3.6.8) for the years 2004-2008
N_{2010} Age 1-8+:	Output from ICA (Table 3.6.15)
Natural Mortality (M):	Average for 2007-2009
Weight in the Catch/Stock (CW	Average for 2007-2009
Selection pattern (Sel):	Average for 2007-2009

Table 3.7.2 WESTERN BALTIC HERRING. Short-term prediction multiple option table, based on a catch constraint in the intermediate year of 57 323 t.

2010				2011				2012
FMult	**FBar**	**Landings**	**SSB**	**FMult**	**FBar**	**Landings**	**SSB**	**SSB**
0.9335	0.4267	57323	76221	0.000	0.000	0	77285	134789
-	-	-	-	0.100	0.046	7369	76945	128840
-	-	-	-	0.200	0.091	14470	76605	123158
-	-	-	-	0.300	0.137	21311	76268	117730
-	-	-	-	0.400	0.183	27904	75932	112546
-	-	-	-	0.500	0.229	34258	75597	107594
-	-	-	-	0.600	0.274	40382	75264	102864
-	-	-	-	0.700	0.320	46285	74932	98345
-	-	-	-	0.800	0.366	51975	74602	94028
-	-	-	-	0.900	0.411	57462	74273	89904
-	-	-	-	1.000	0.457	62752	73946	85964
-	-	-	-	1.100	0.503	67853	73620	82200
-	-	-	-	1.200	0.549	72773	73295	78604
-	-	-	-	1.300	0.594	77518	72972	75168
-	-	-	-	1.400	0.640	82095	72651	71885
-	-	-	-	1.500	0.686	86511	72331	68748
-	-	-	-	1.600	0.731	90771	72012	65750
-	-	-	-	1.700	0.777	94882	71695	62886
-	-	-	-	1.800	0.823	98849	71379	60149
-	-	-	-	1.900	0.869	102678	71064	57533
-	-	-	-	2.000	0.914	106373	70751	55033

Catches and SSB are given in t

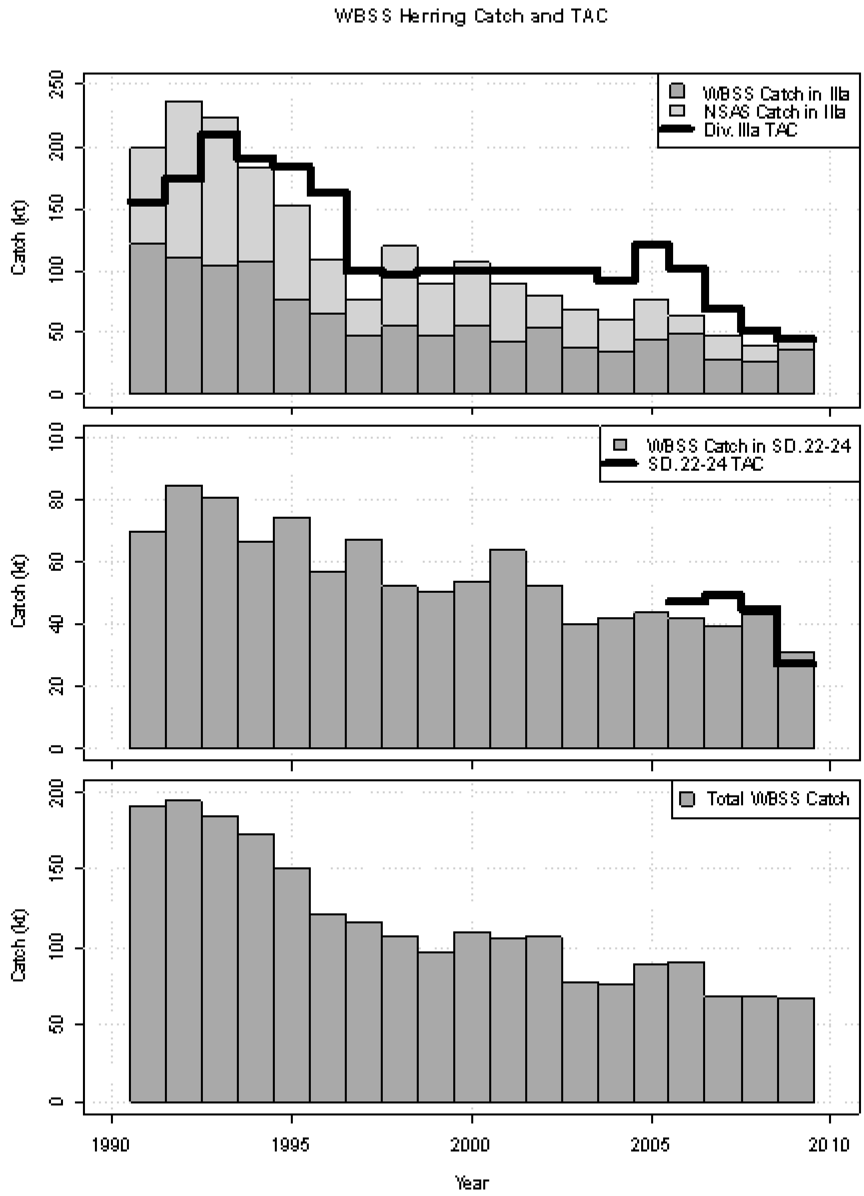


Figure 3.1.1 Western Baltic Spring Spawning Herring. Catches and TACs by area. Top panel) Catches of Western Baltic Spring Spawning (WBSS) and North Sea Autumn Spawning (NSAS) herring in division IIIa, and the total TAC for both stocks. Middle panel) Catches and TACs of WBSS herring in subdivisions 22-24.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

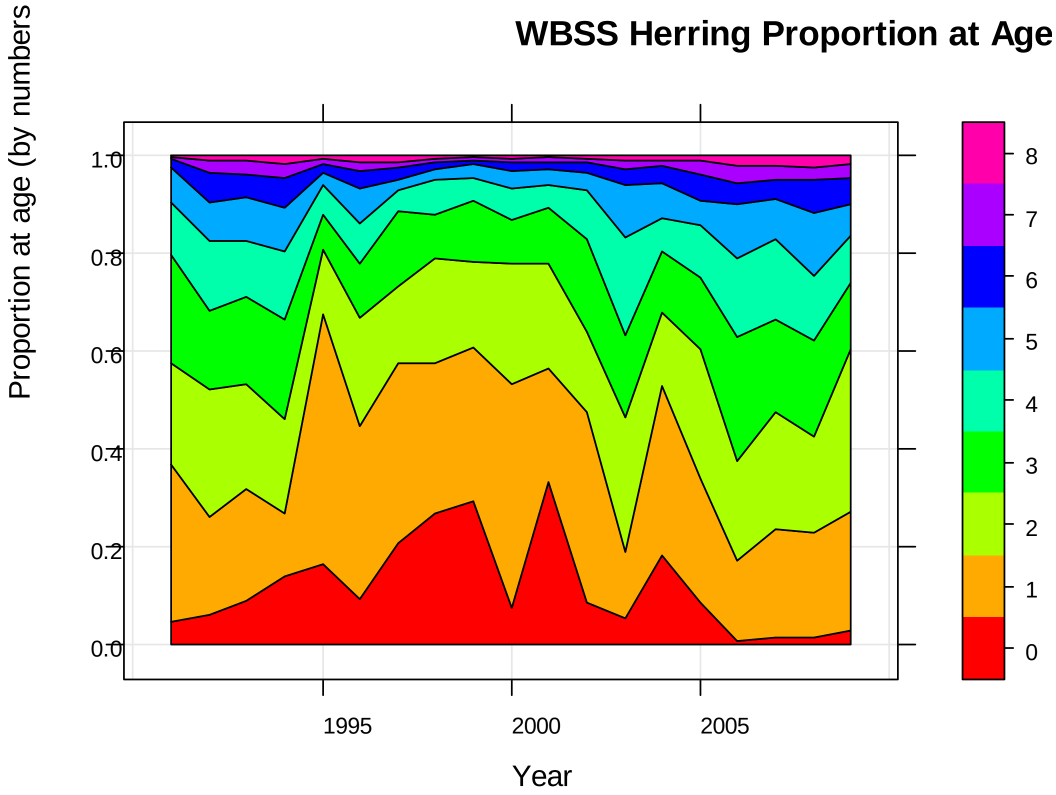


Figure 3.6.1.1 Western Baltic Spring Spawning Herring. Proportion (by numbers) of a given age (in winter rings) in the catch.

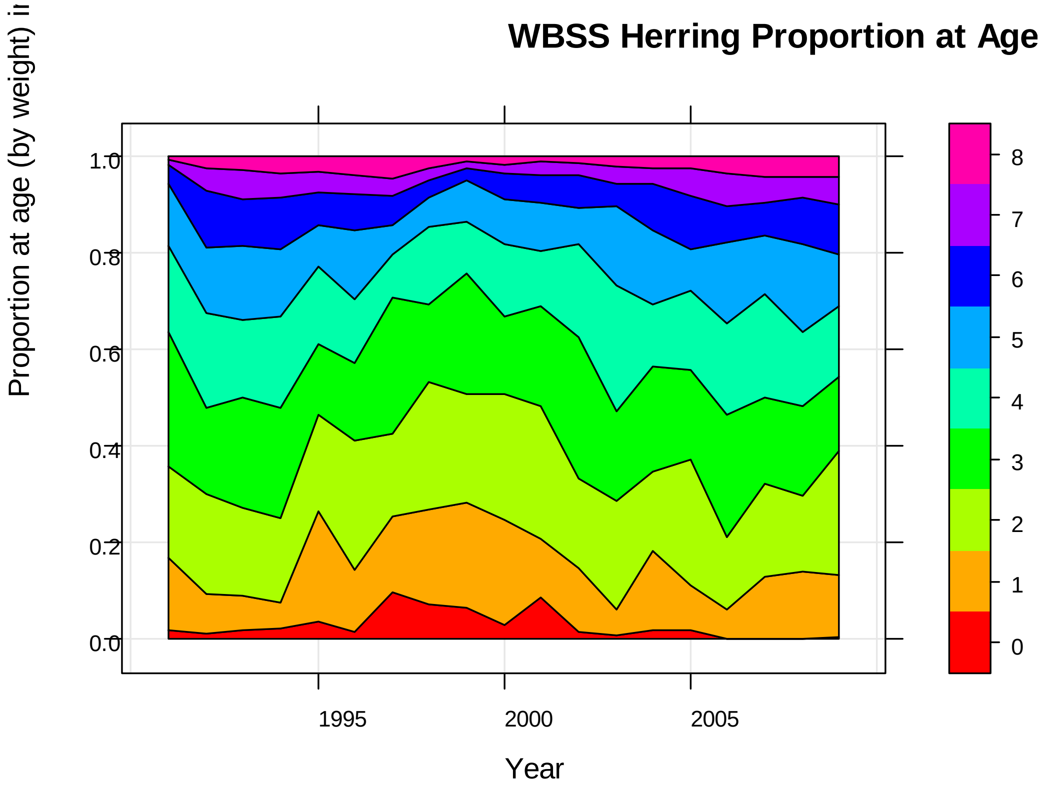


Figure 3.6.1.2 Western Baltic Spring Spawning Herring. Proportion (by weight) of a given age (in winter rings) in the catch.

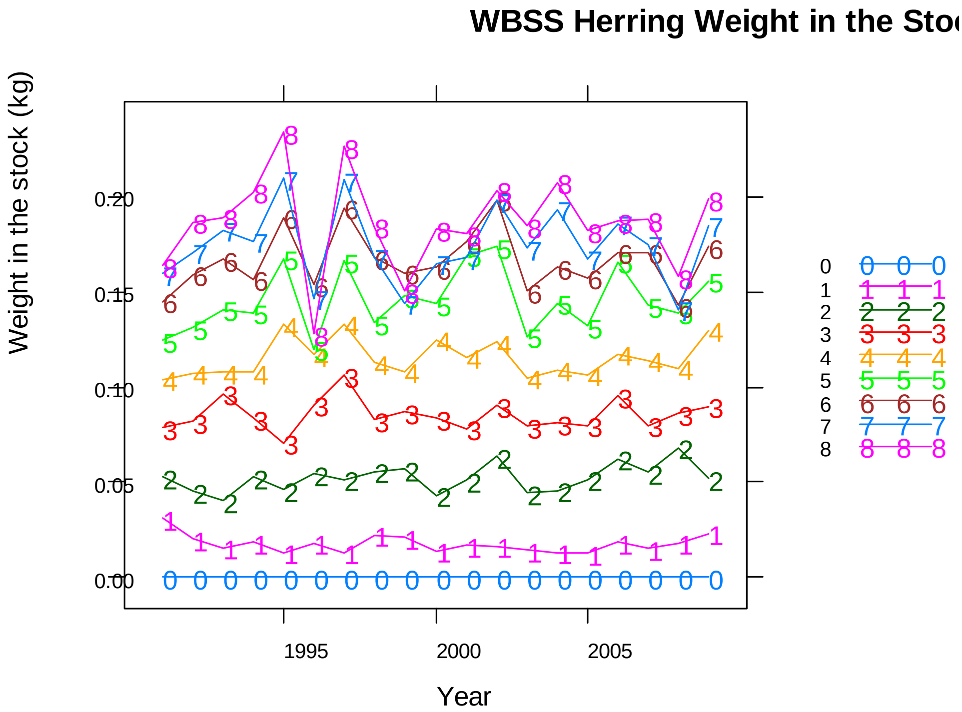


Figure 3.6.1.3 Western Baltic Spring Spawning Herring. Weight at age (in winter rings) in the stock.

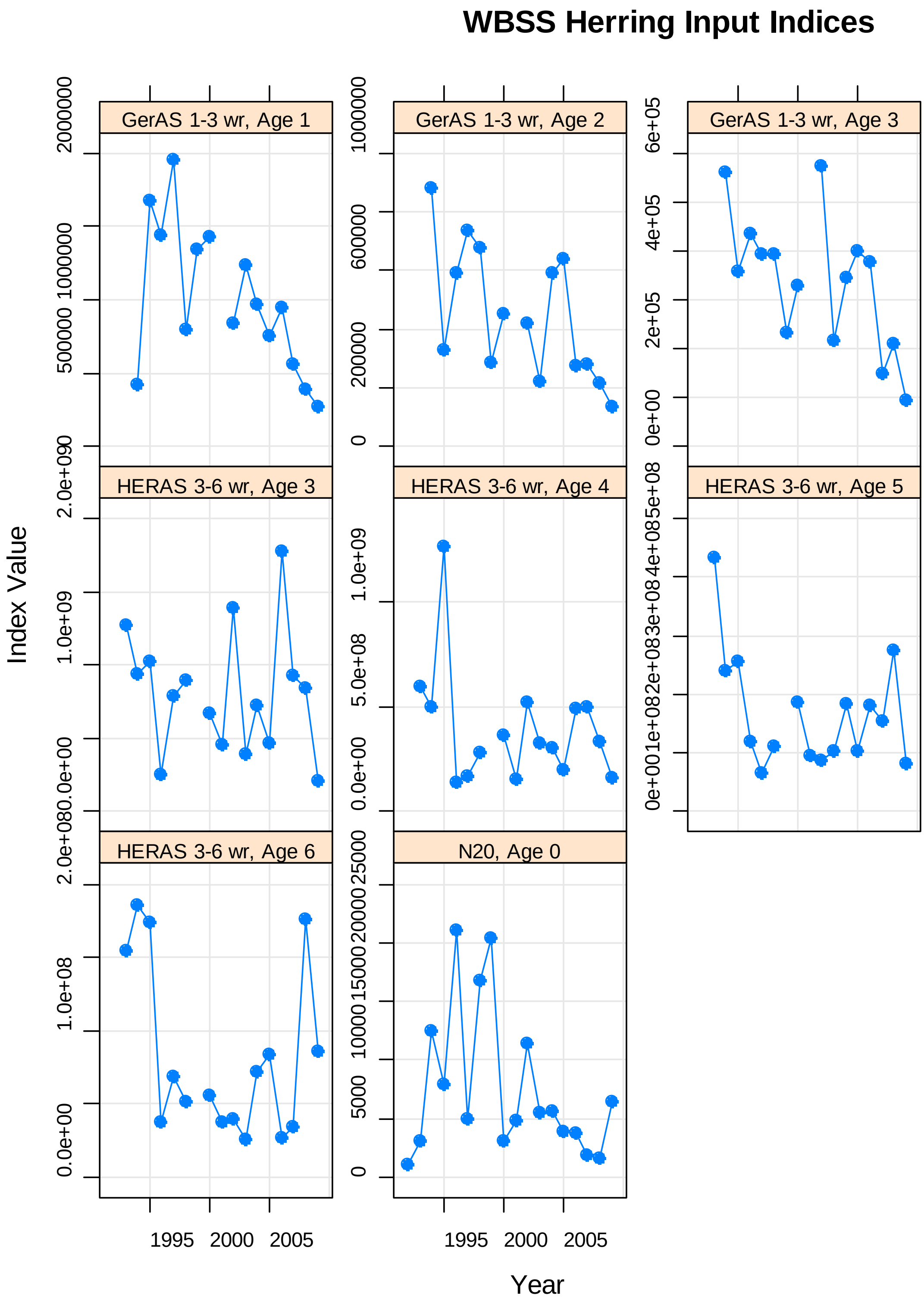


Figure 3.6.1.4 Western Baltic Spring Spawning Herring. Time series of the individual index values used in the assessment, showing the German Acoustic survey (BIAS, the Herring acoustic survey (HerAS) and the N20 larval index.

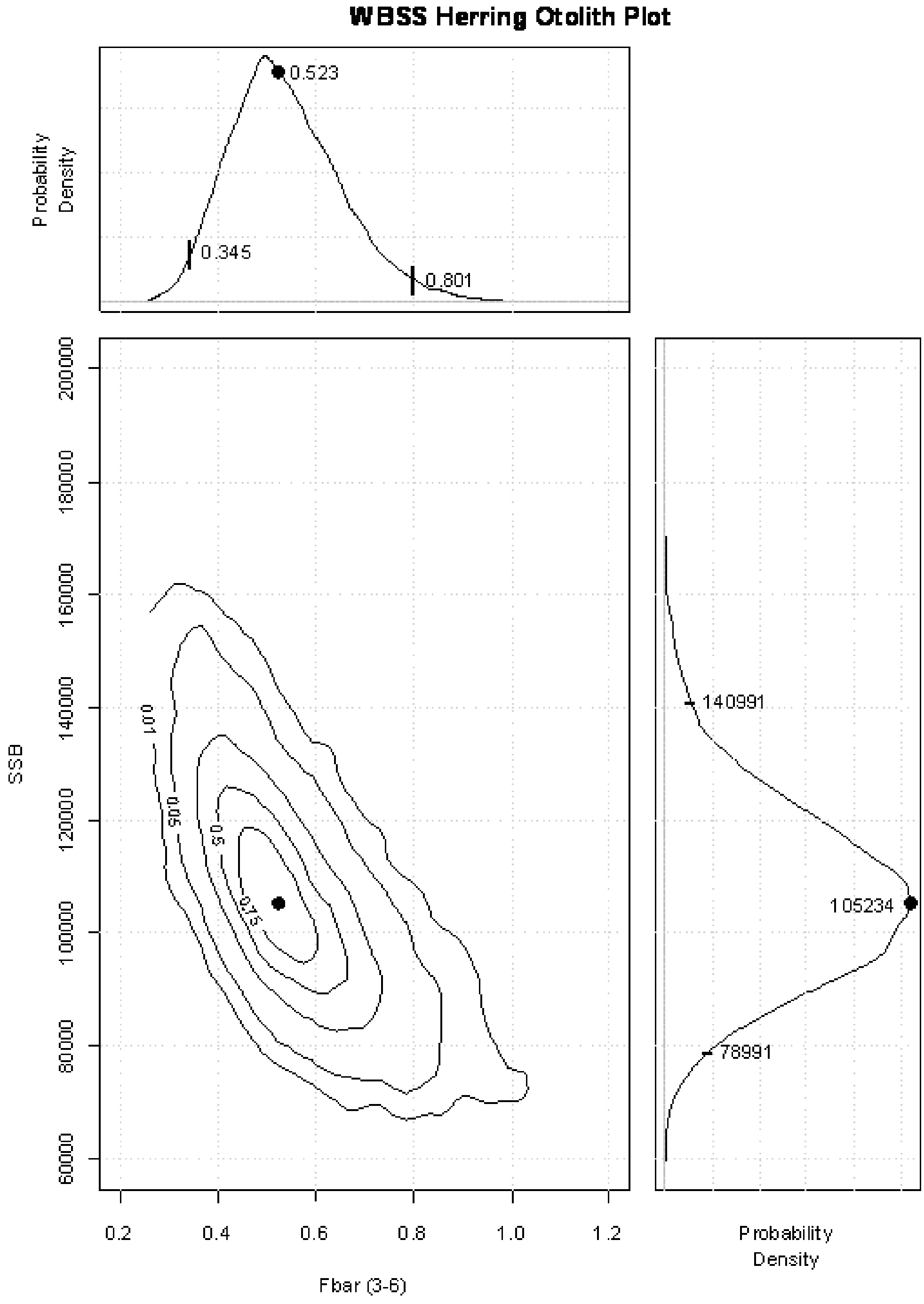


Figure 3.6.4.1 Western Baltic Spring Spawning Herring. "Otolith" plot. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated parameters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

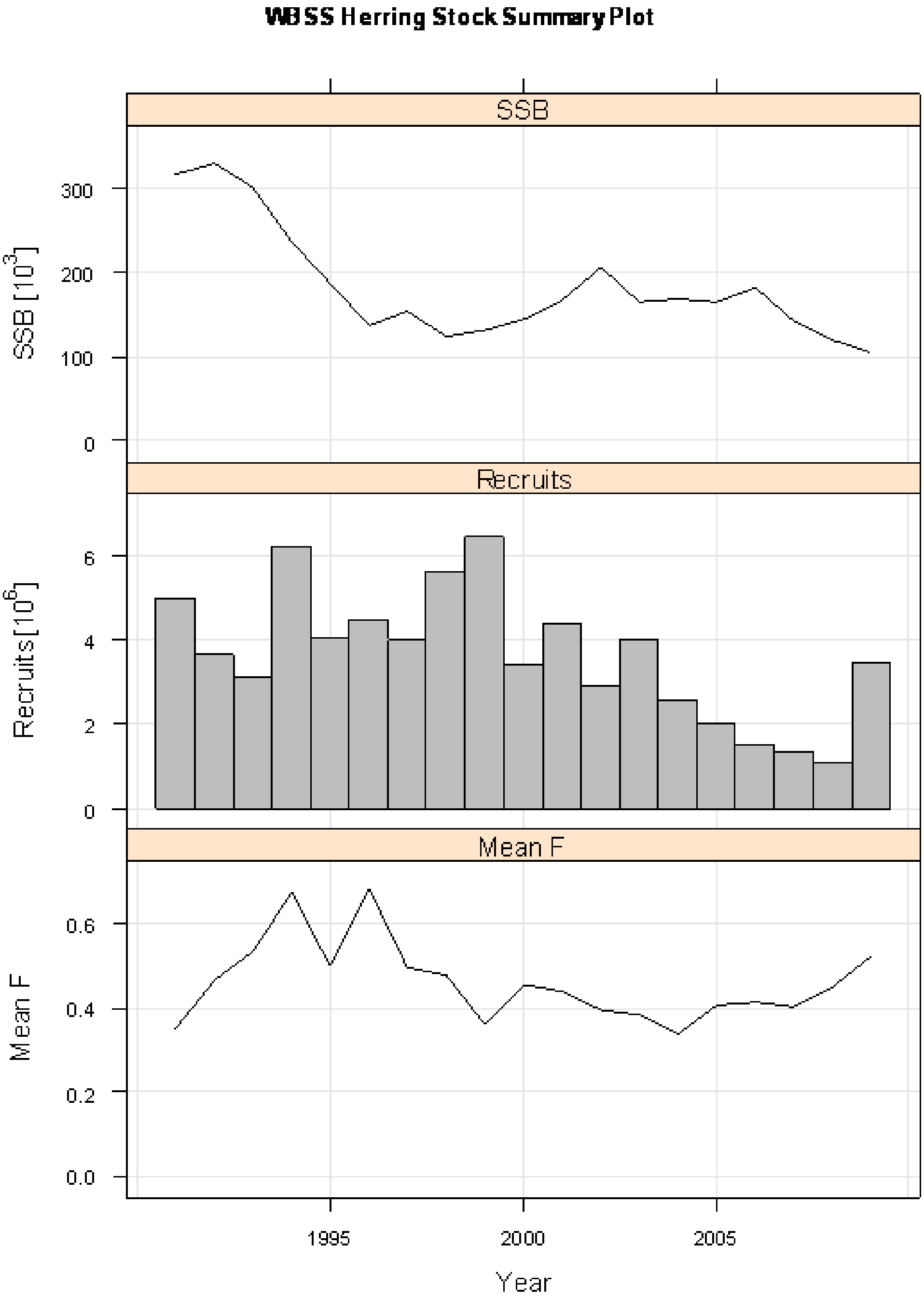


Figure 3.6.4.2 Western Baltic Spring Spawning Herring. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age 0-wr) as a function of time. Bottom panel:: Mean annual fishing mortality on ages 3-6 ringers as a function of time.

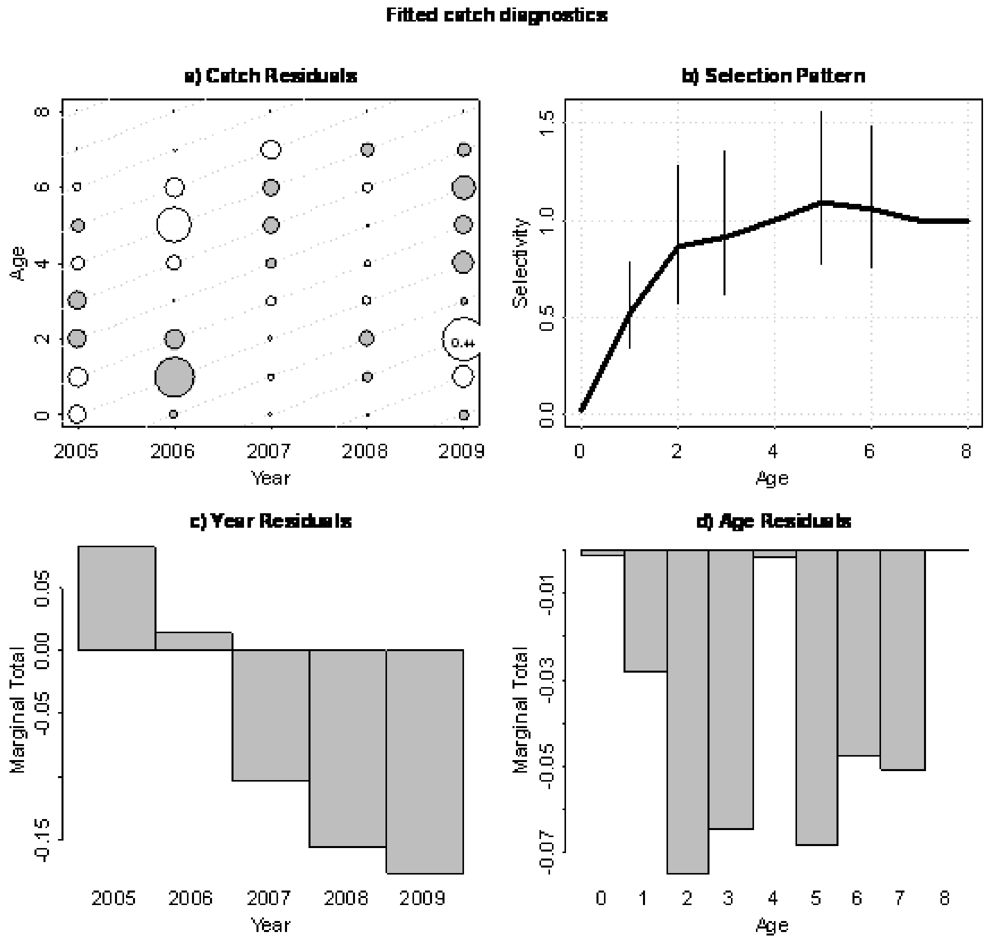


Figure 3.6.4.3 Western Baltic Spring Spawning Herring. Diagnostics of selection pattern. a) Bubbles plot of log catch residuals by age (weighting applied) and year. Grey bubbles correspond to negative log residuals. The largest residual is given. b) Estimated selection parameters (relative to 4 wr) with 95% confidence intervals. c): Marginal totals of residuals by year. d). Marginal totals of residuals by age (wr).

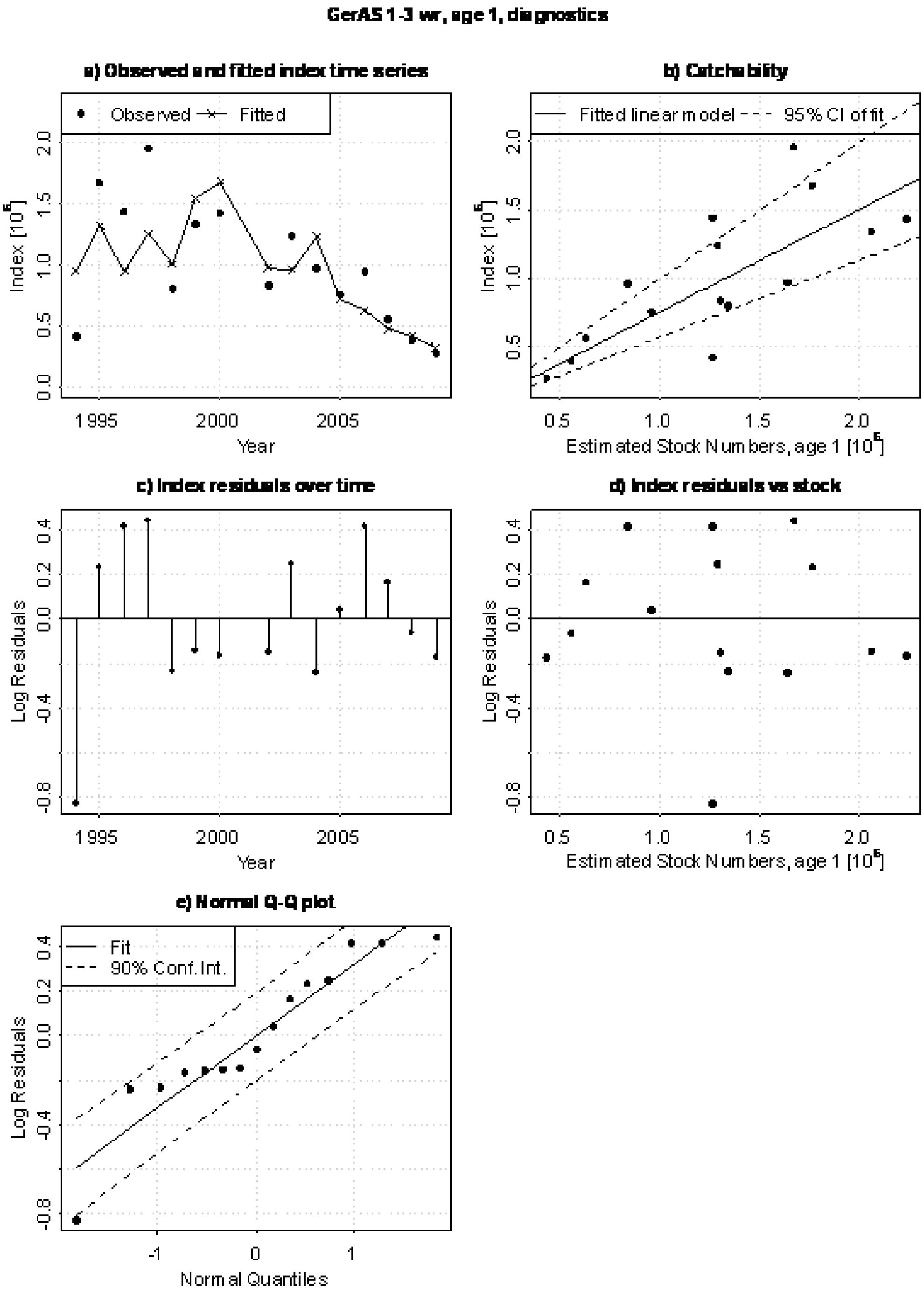


Figure 3.6.4.4 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 1 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

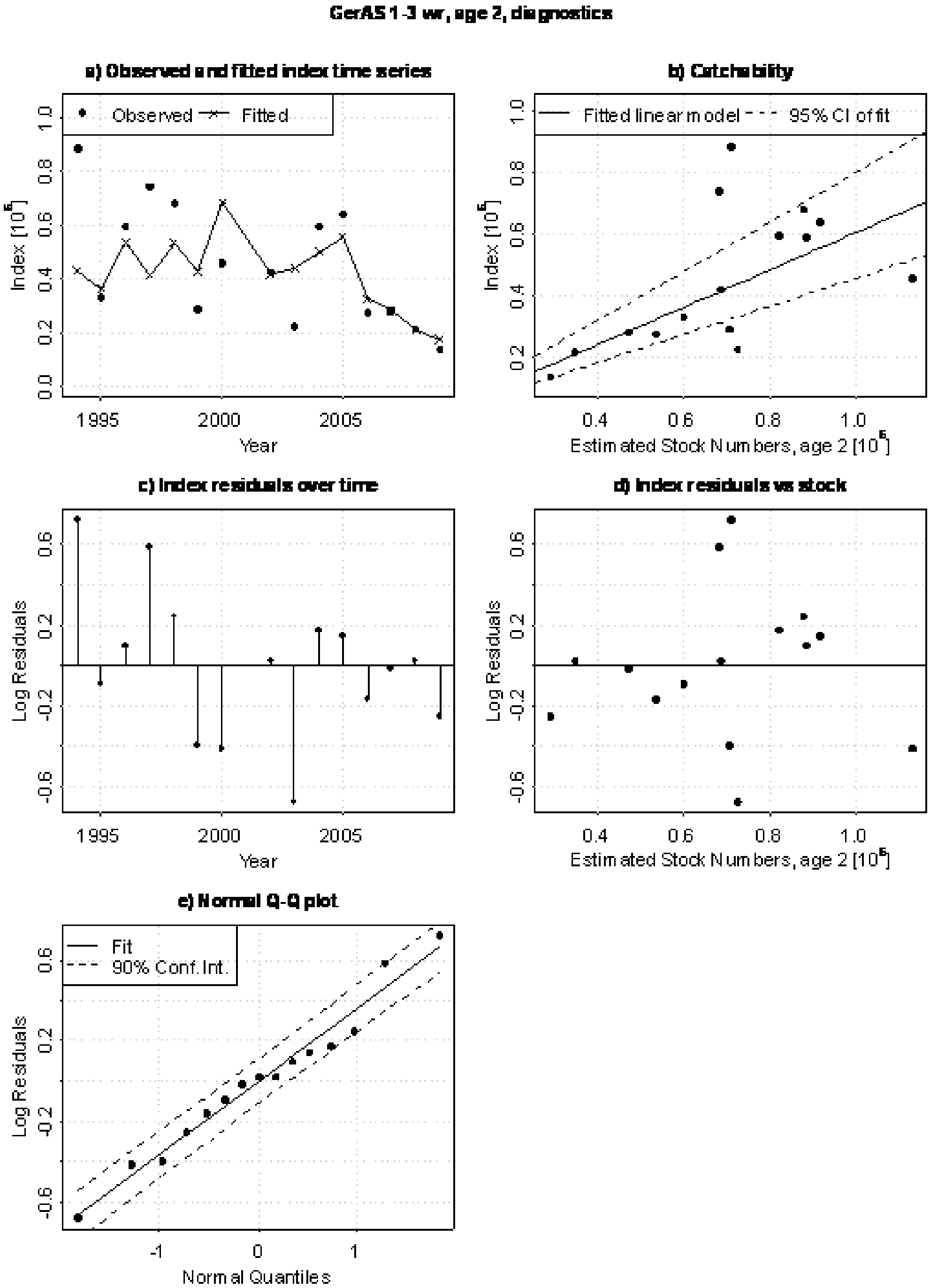


Figure 3.6.4.5 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 2 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

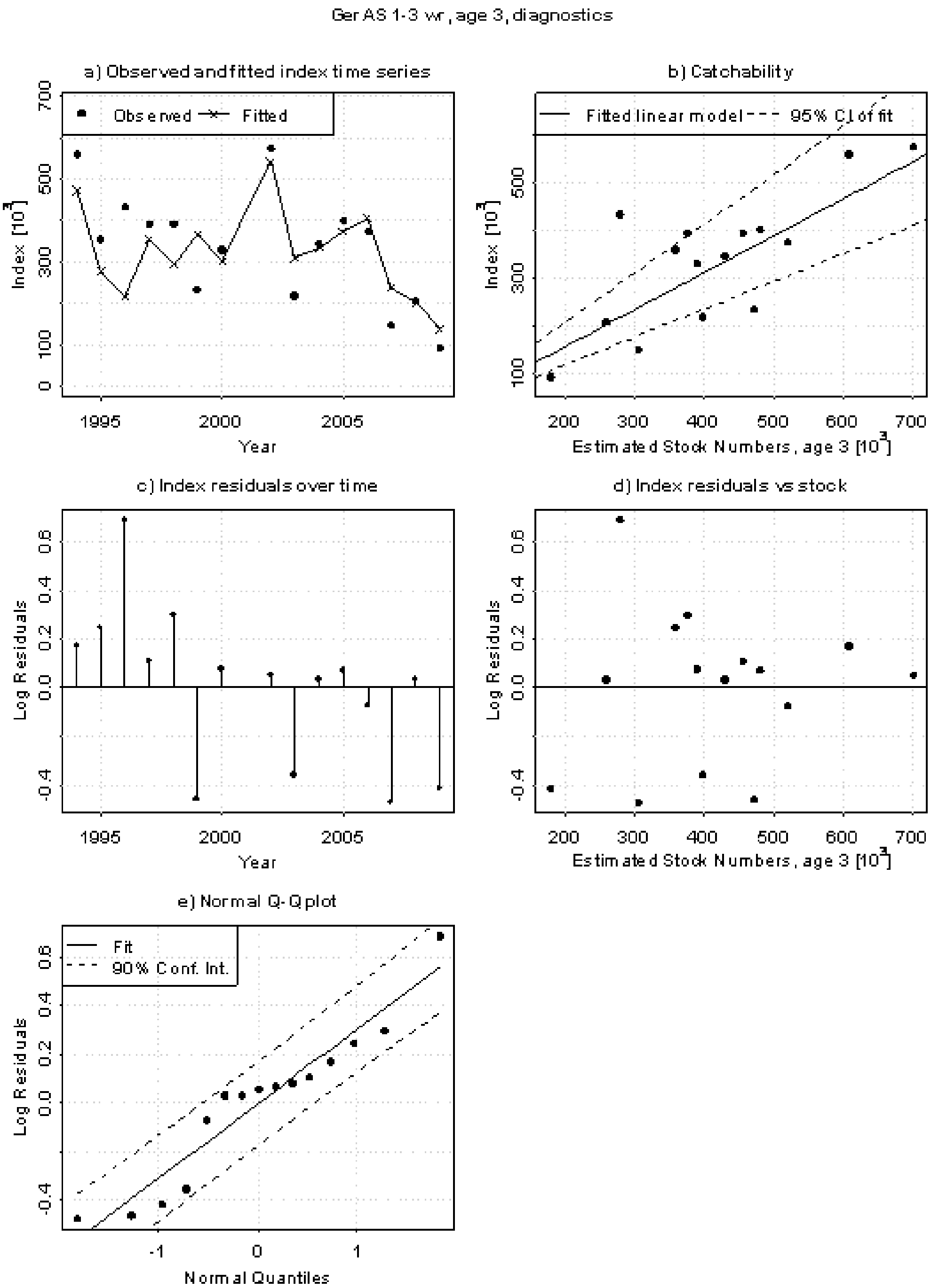


Figure 3.6.4.6 Western Baltic Spring Spawning Herring. Diagnostics of the German acoustic survey in subdivision 21-24 ("Ger AS 1-3 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

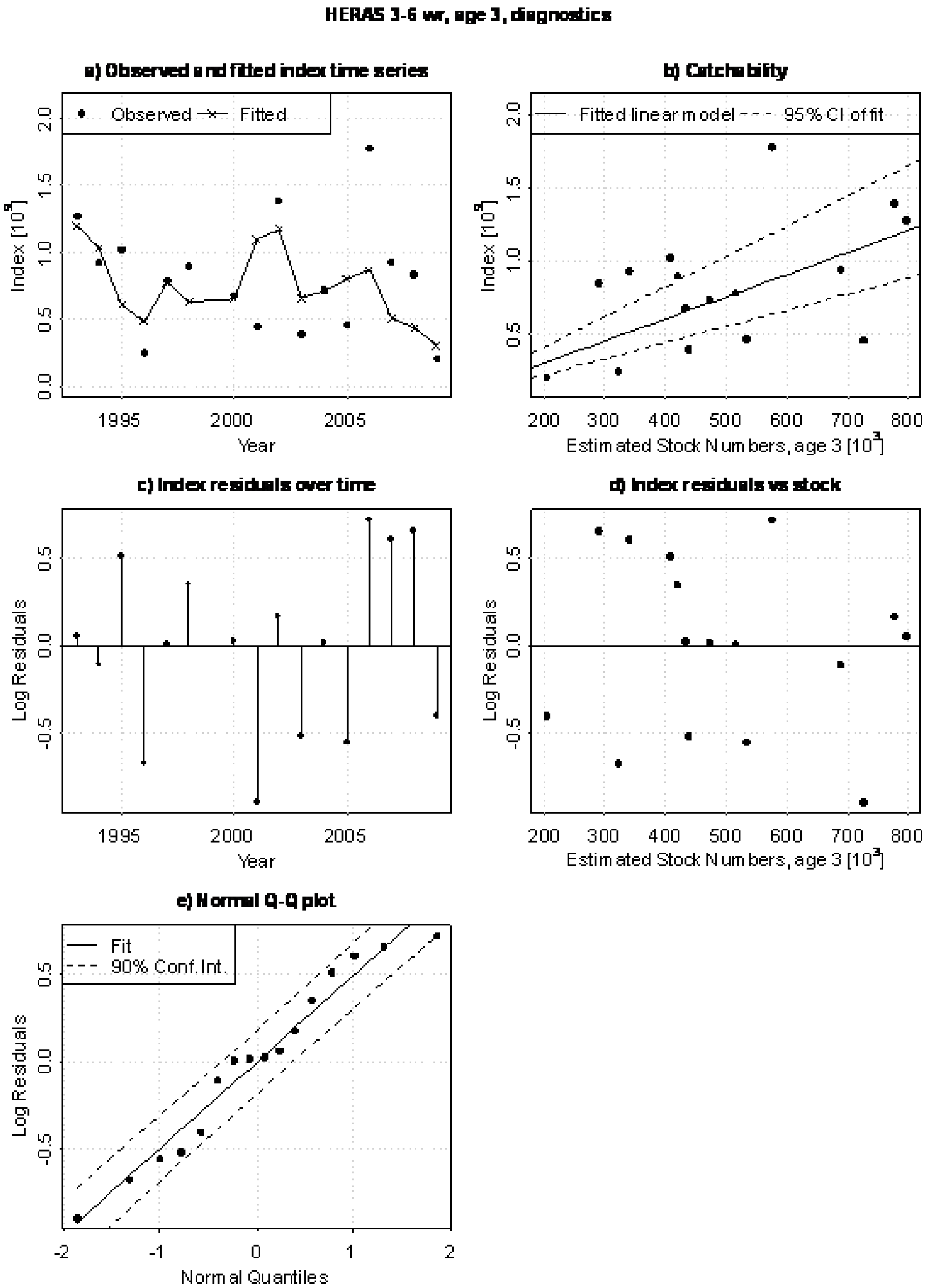


Figure 3.6.4.7 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 3 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

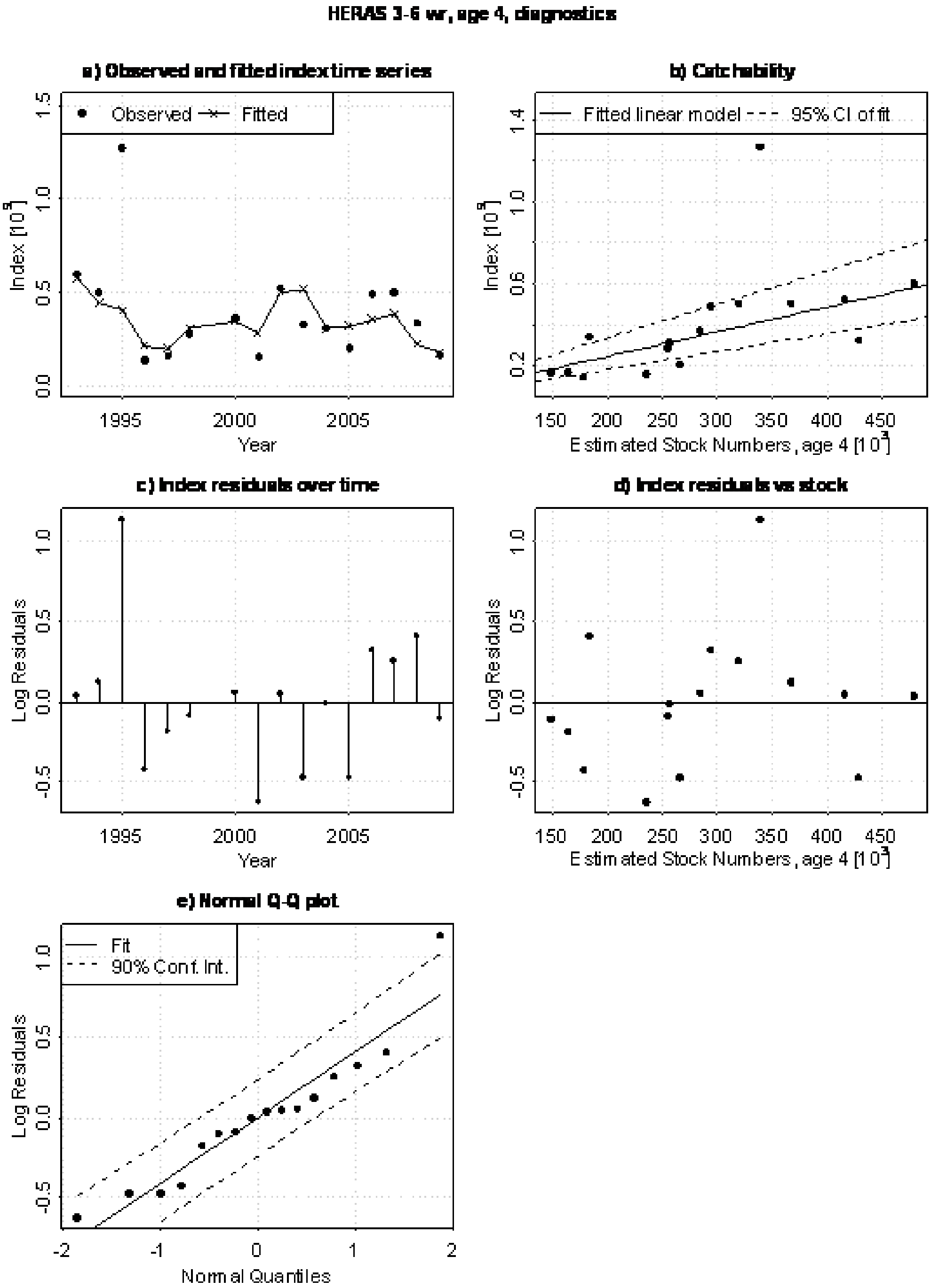


Figure 3.6.4.8 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 4 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

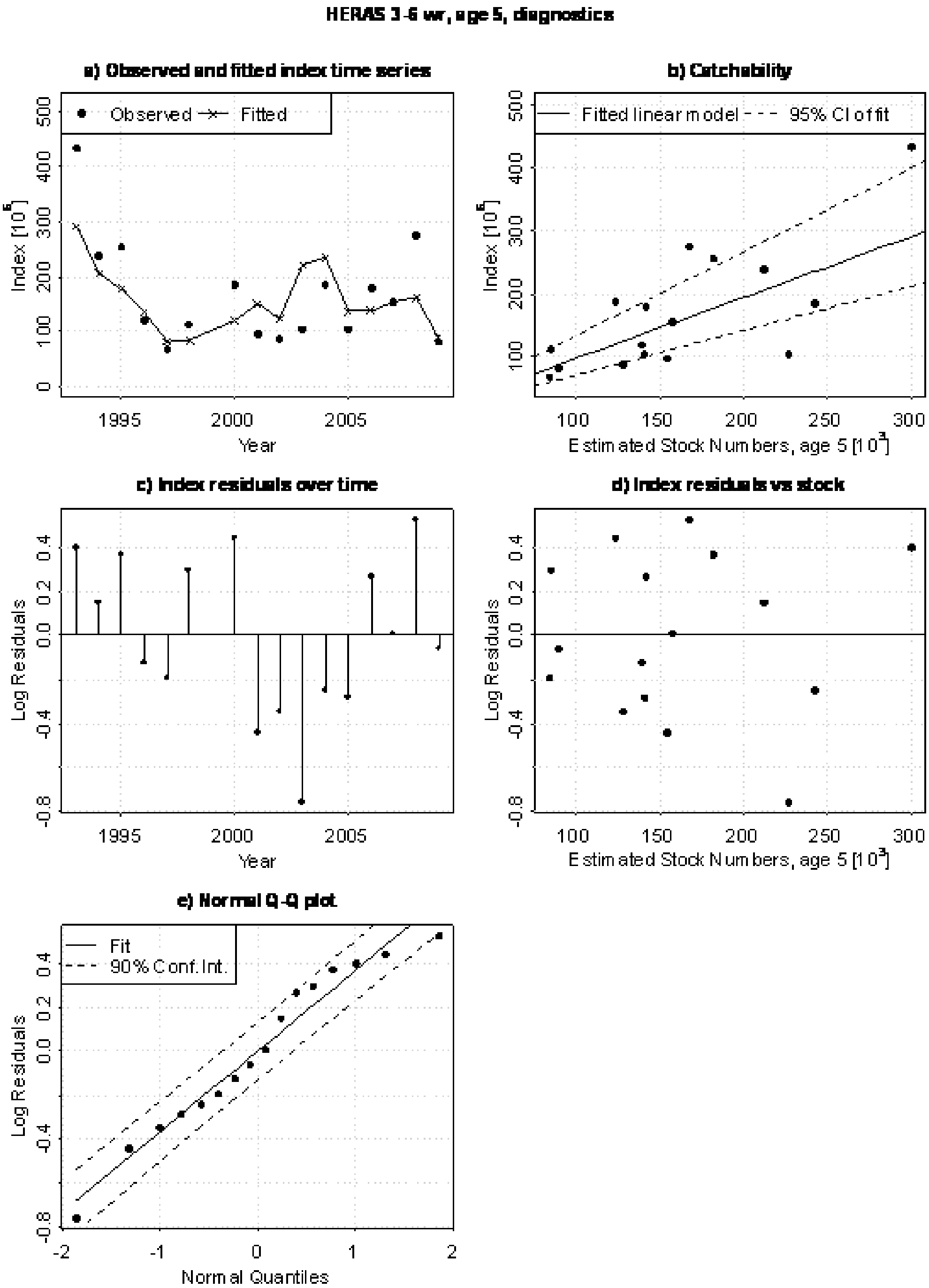


Figure 3.6.4.9 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 5 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

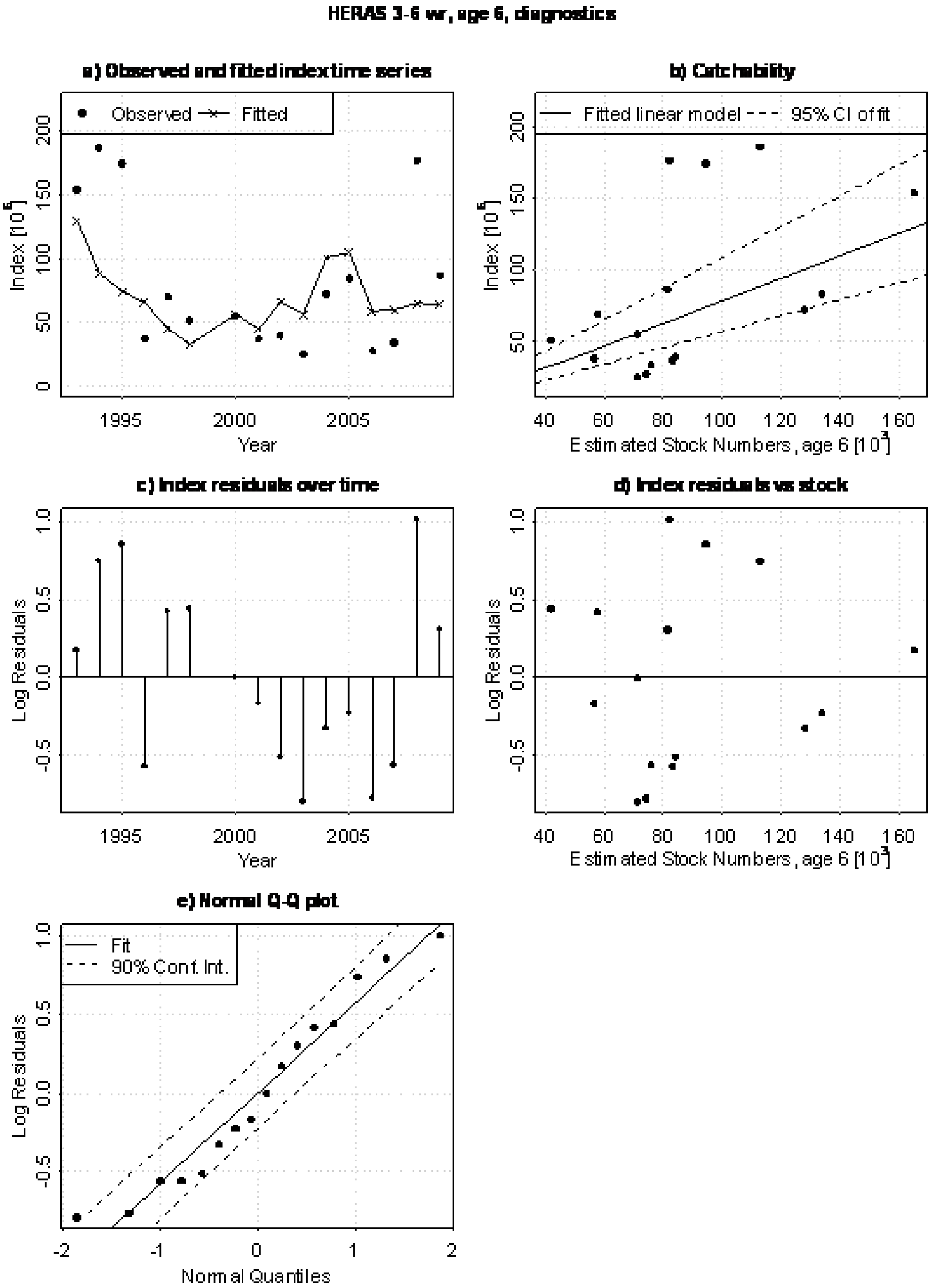


Figure 3.6.4.10 Western Baltic Spring Spawning Herring. Diagnostics of the Herring acoustic survey in the North Sea and division IIIa ("HerAS 3-6 wr") fit at 6 wr from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

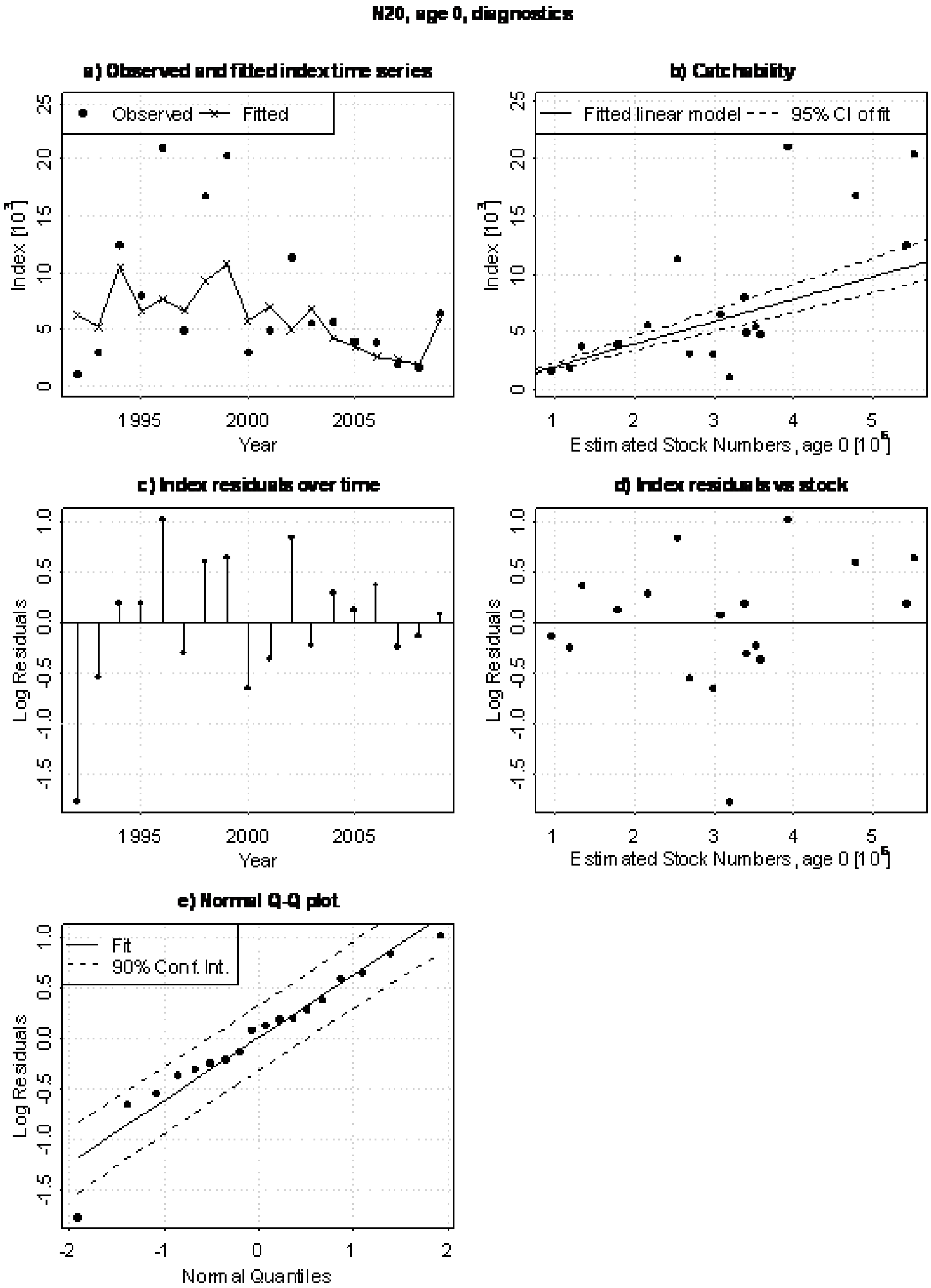


Figure 3.6.4.11 Western Baltic Spring Spawning Herring. Diagnostics of the N20 larval index from the assessment. a) Comparison of observed (points) and fitted (line) index value. b) Scatterplot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (linear model – solid line), with 95% confidence interval (dotted line). c) Log residuals of catchability model fitted by FLICA as a function of time. d). Log residuals from the catchability model against stock size at age estimated by the FLICA assessment method. e). Normal Q-Q plot of log residuals (points) with fitted linear regression (solid line) and 90% confidence interval for predication (dotted line).

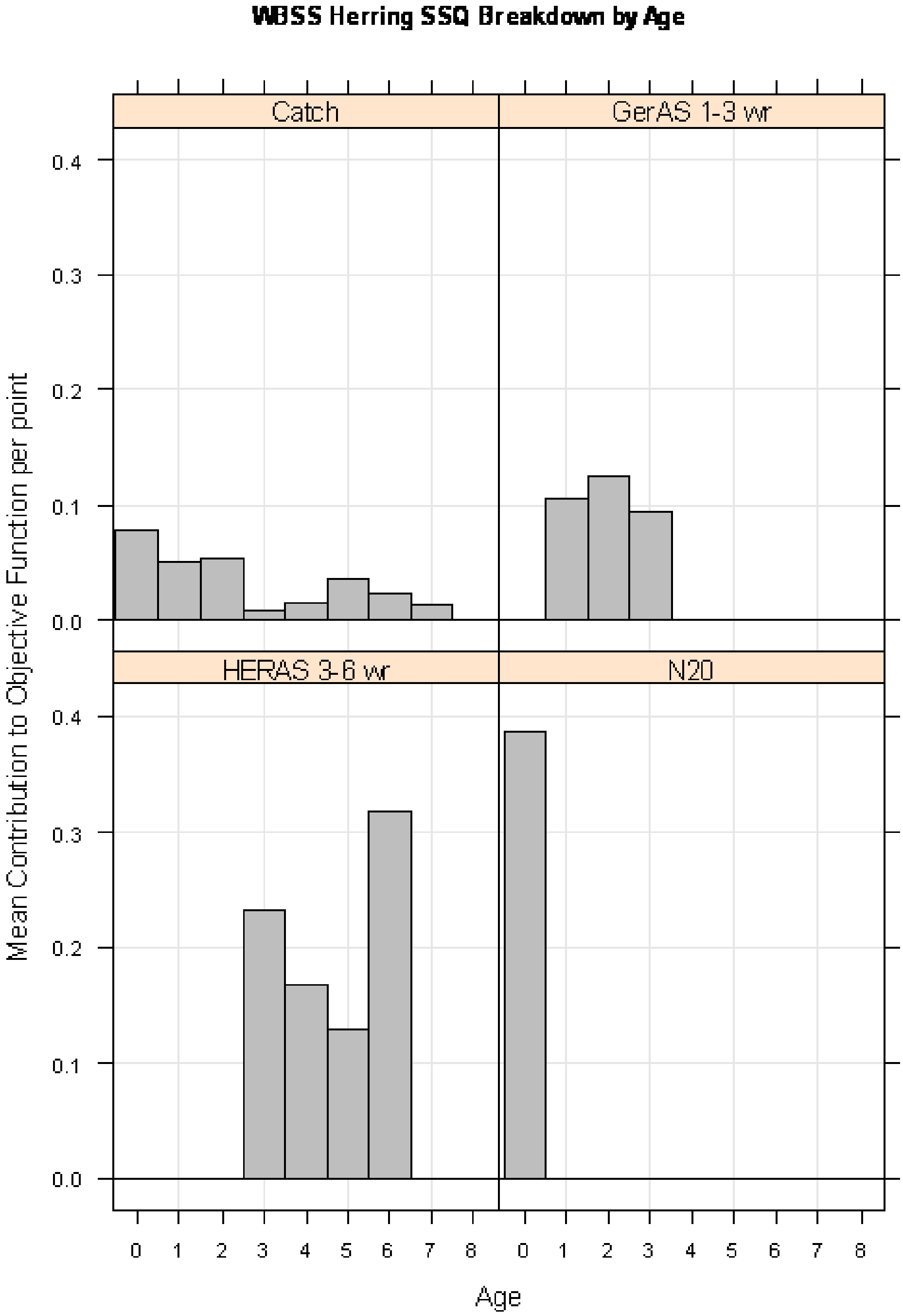


Figure 3.6.4.12 Western Baltic Spring Spawning Herring. Mean contribution of a data point individual information groups (ages in each survey) to the FLICA objective function. The contribution is calculated from the mean of the squared residuals in the corresponding class, and weighted according to the appropriate value employed by the optimiser.

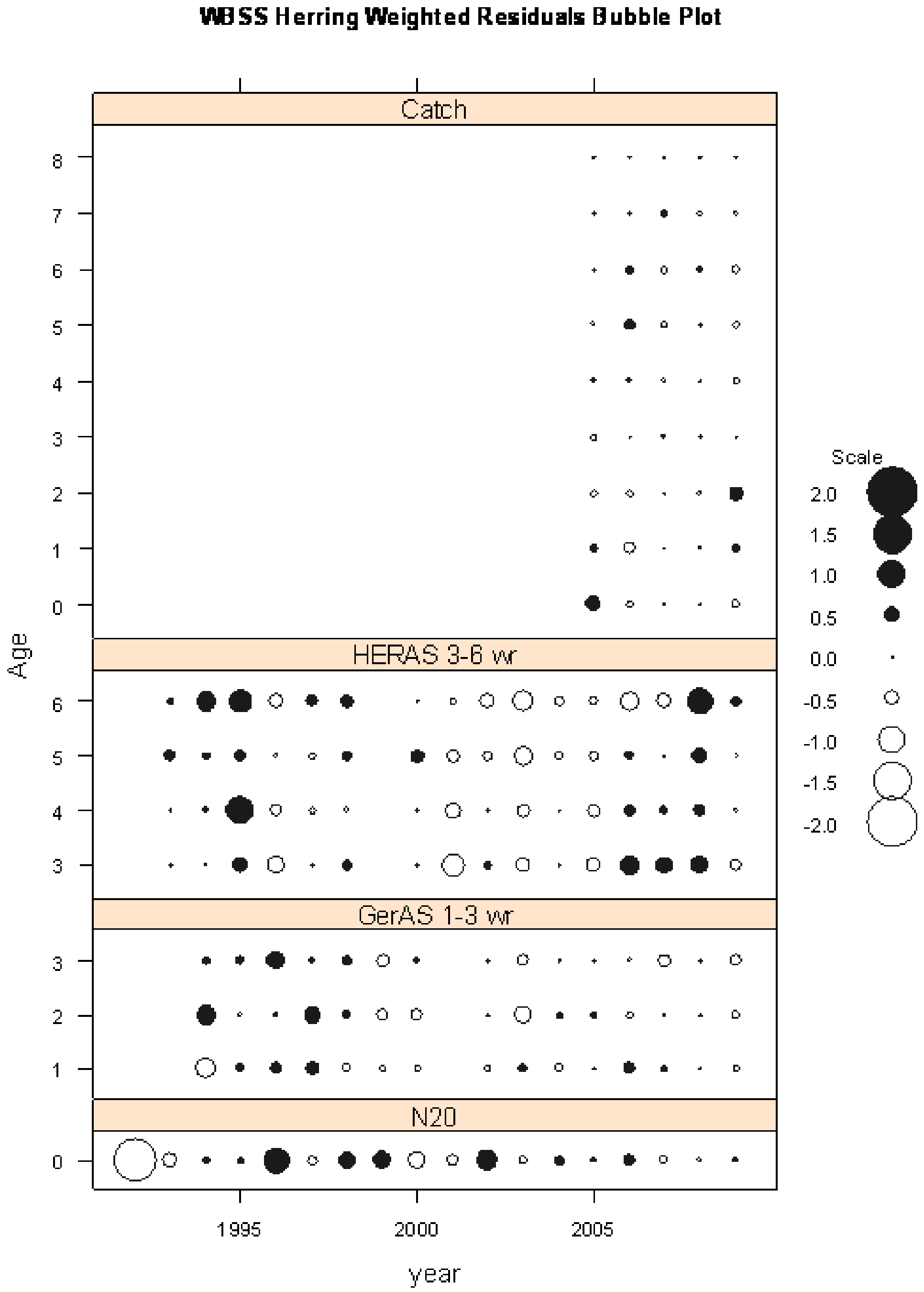


Figure 3.6.4.13 Western Baltic Spring Spawning Herring. Bubble plot showing the weighted residuals for each piece of fitted information. Individual values are weighted following the procedures employed internally with FLICA in calculating the objective function. The bubble scale is consistent between all panels.

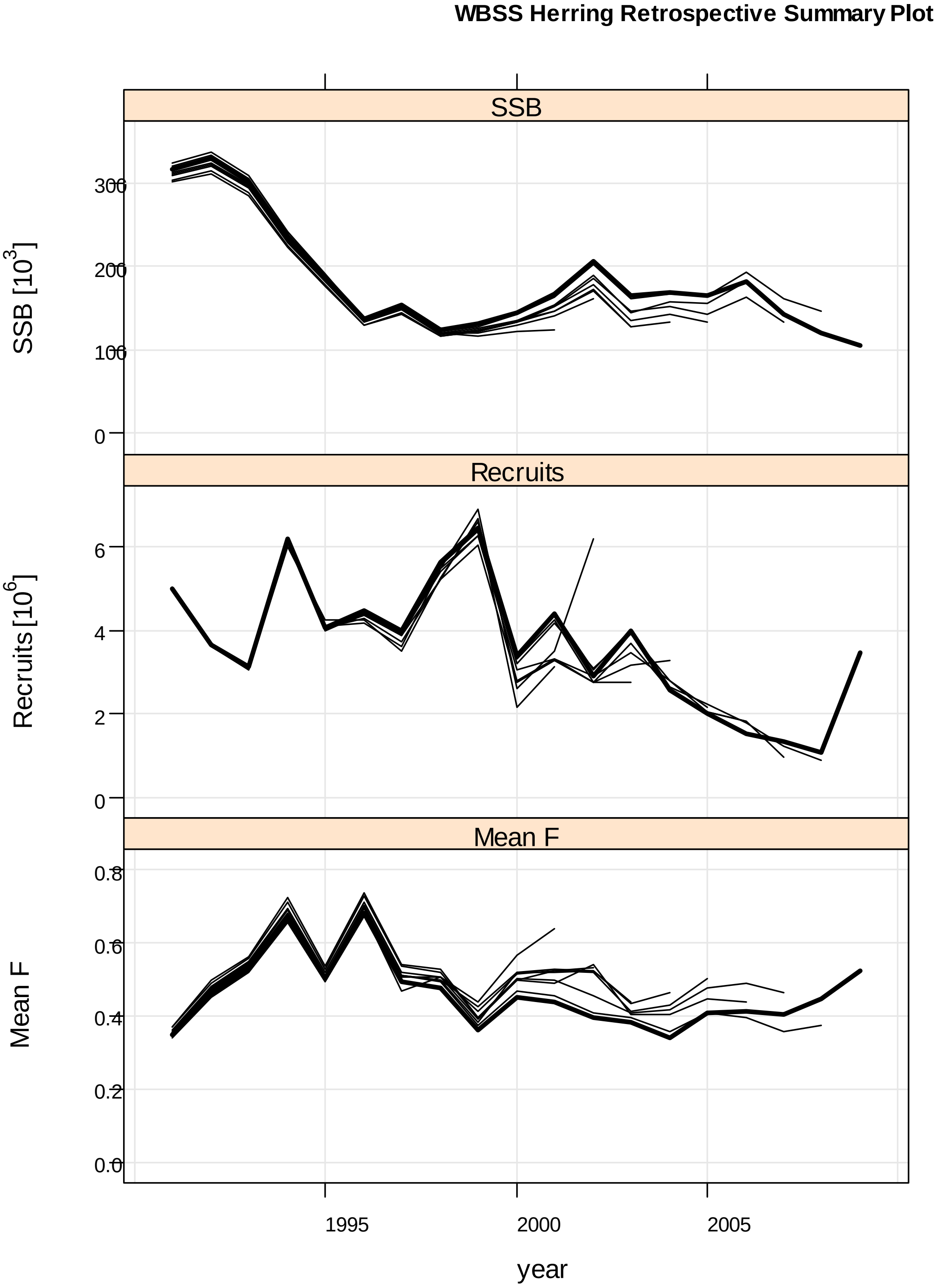


Figure 3.6.4.14 Western Baltic Spring Spawning Herring. Analytical retrospective pattern in the assessment. Top panel: Spawning stock biomass. Middle panel: Recruitment at age 0 wr. Bottom panel: Mean fishing mortality in the ages 3-6 ringer. The heavy black line shows the current assessment.

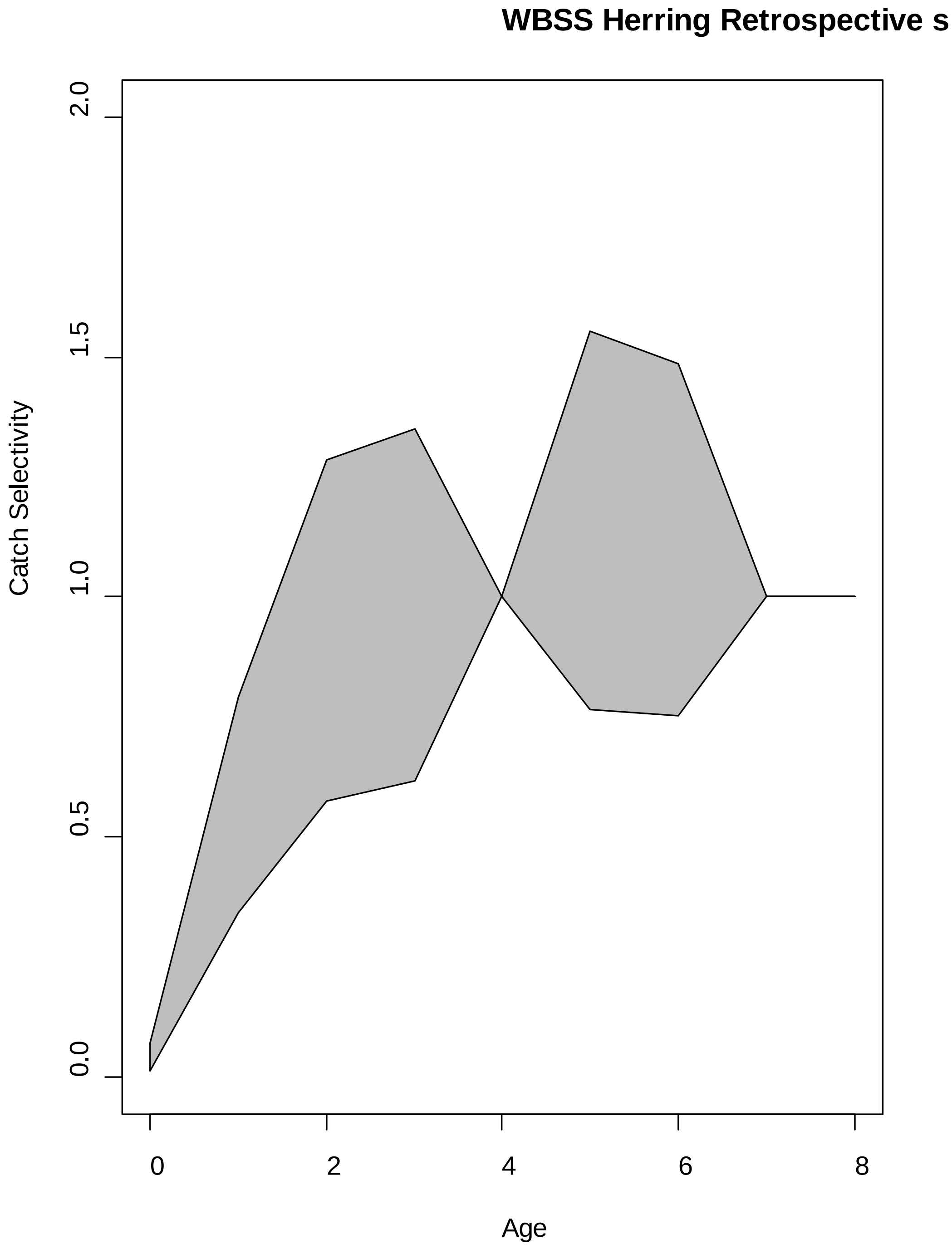


Figure 3.6.4.15 Western Baltic Spring Spawning Herring. Retrospective selection pattern by age. The selection pattern is estimated retrospectively using a truncated data series running from the start of the assessment period (1991) up to the final year indicated by the legend. The grey area shows the 95% confidence interval for the selectivity in the full assessment.

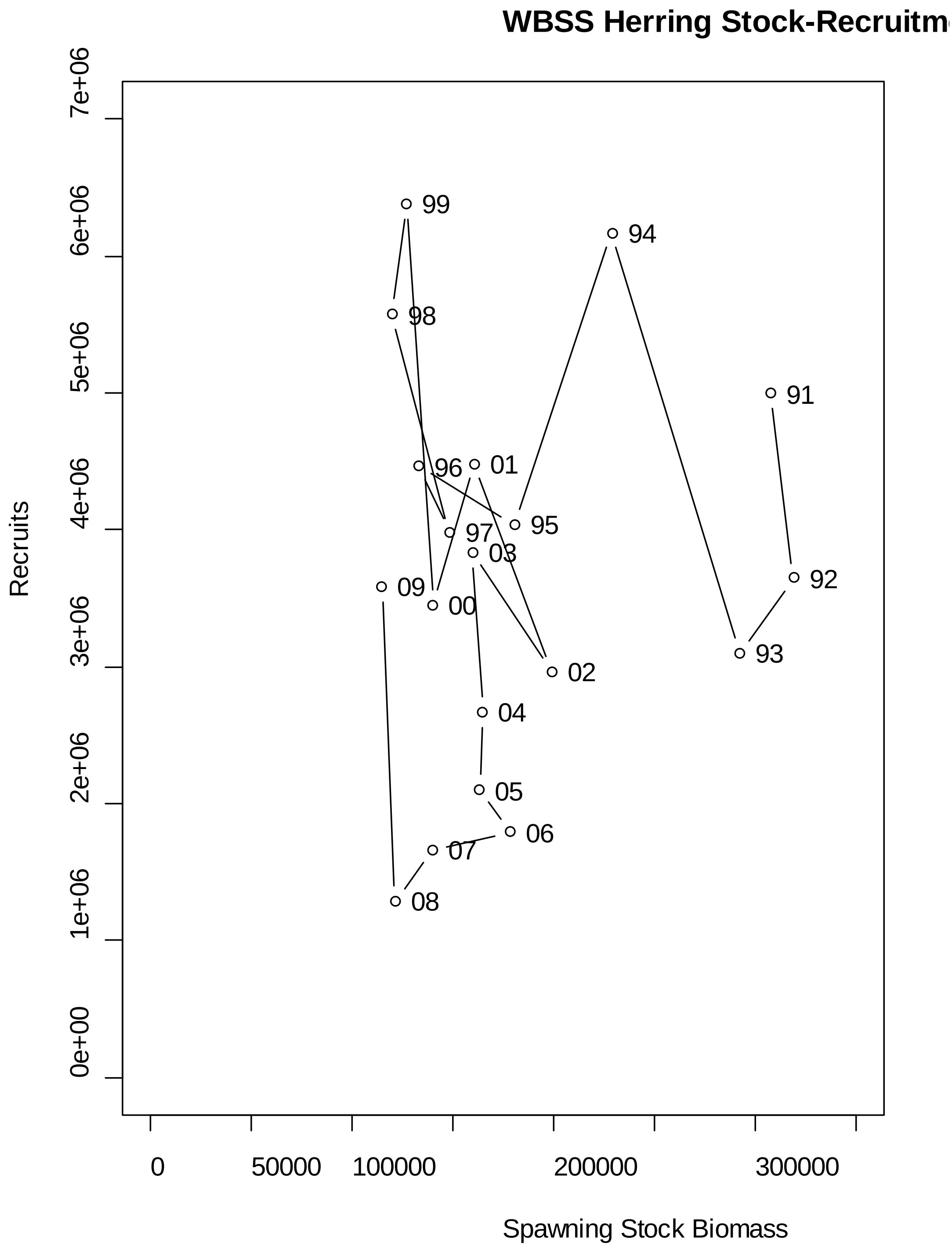


Figure 3.6.4.16 Western Baltic Spring Spawning Herring. Stock-recruitment relationship. Recruitment at age 0-wr (in thousands) is plotted as a function of spawning stock biomass (tonnes) estimated by the assessment. Successive years are joined by the line. Individual data points are labelled with the two-digit year.

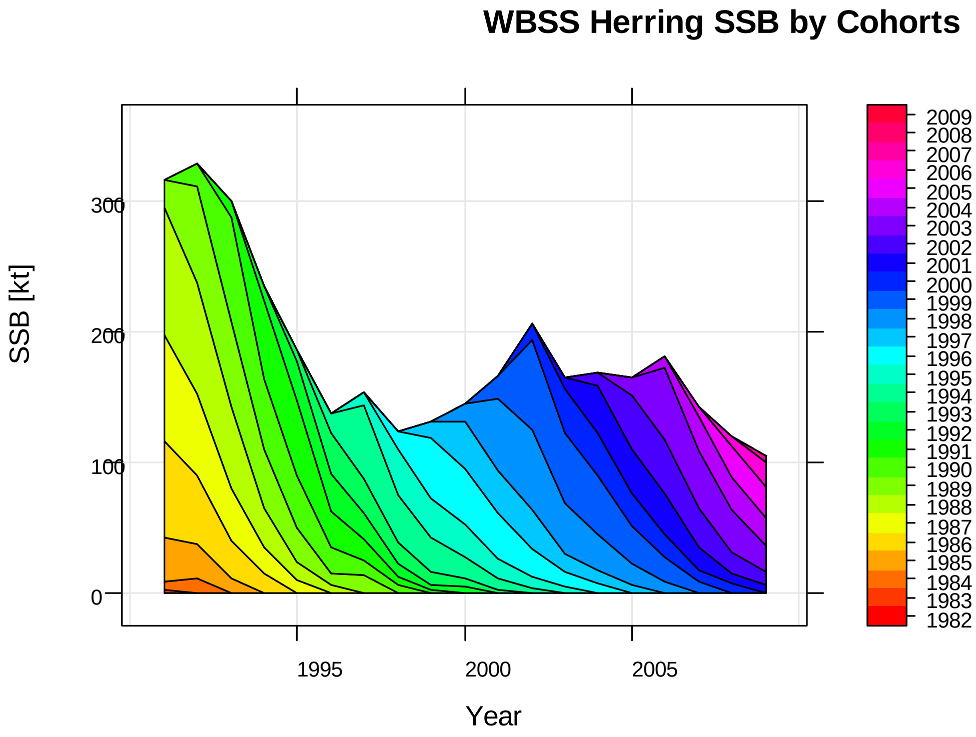


Figure 3.6.5.1 Western Baltic Spring Spawning Herring. Contribution of each cohort (indicated by the colouring scheme, and the key to the right) to the spawning stock biomass.

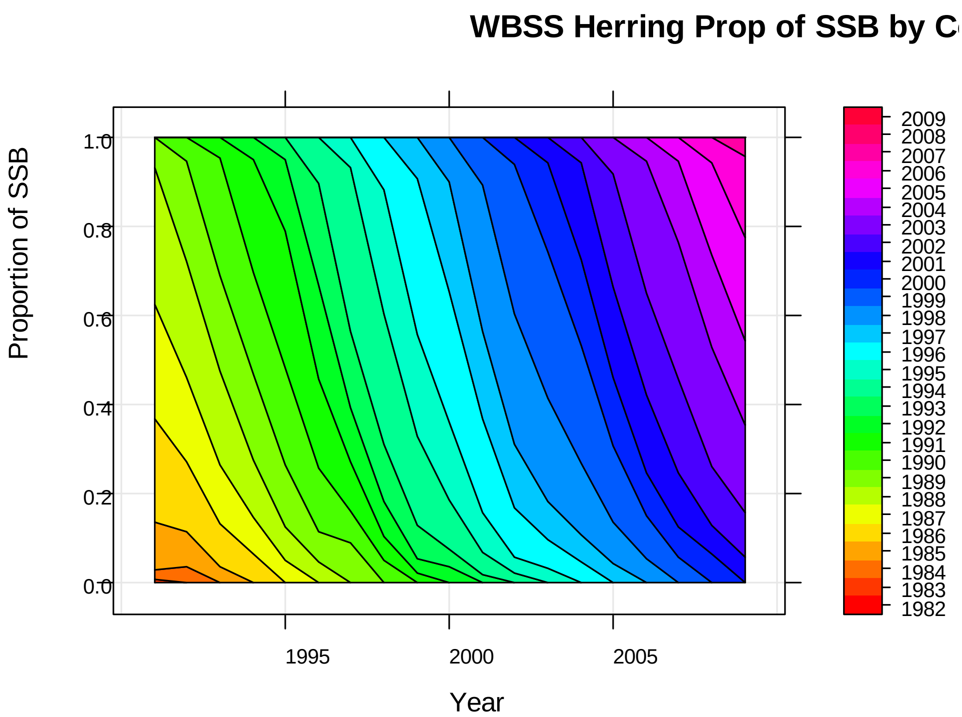


Figure 3.6.5.2 Western Baltic Spring Spawning Herring. Relative contribution by weight of each cohort (indicated by the colouring scheme, and the key to the right) to the spawning stock biomass.

4 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. 2009 refers to the 2009/2010 season.

4.1 The Fishery

4.1.1 Advice and management applicable to 2009 – 2010

The TAC is set by calendar year and in 2009 was 5 918 t, and in 2010 is 10 150 t. In 2009 ICES classified the stock as having full reproductive capacity, and being fished below $F_{0.1}$. The TAC for 2010 was based on the rebuilding plan.

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 TAC. In 2009, the plan was evaluated by ICES and found to be in accordance with the precautionary approach, within the estimated stock dynamics. If a sequence of low recruitments were to take place however, ICES considered that the harvest control rule may have to be re-evaluated.

4.1.2 The fishery in 2009/2010

In 2009/2010, 32 vessels took part in the Irish fishery. These are categorised as follows:

- 4 Pelagic refrigerated seawater (RSW) trawlers
- 4 Polyvalent bulk storage trawlers,
- 24 Polyvalent dry hold trawlers.

The fishery took place in the third and fourth quarter of 2009 and in the first quarter of 2010. In quarter 3 fishing only took place in VIIj and VIIg. In the fourth quarter the fishery was in VIIj, VIIg and VIIaS and in quarter 1 2010 was in VIIaS only. Most vessels under 20 m reported landings of about 100 t for the season while a number of RSW vessels reported combined landings of around 1000 t. The term "Polyvalent" refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species,

The third quarter fishery took place in VIIg and VIIj, landing a total of 776 t, from mid-September. The quarter 4 fishery took place in VIIj, off the south Irish coast, and further east in VIIg and between Cork and Capel Island and also further east in VIIaS. This fishery began around the 1st October, and lasted until the 2nd week of December.

Due to difficulties in agreeing Irish quota allocations, the fishery was closed in quarter 1, 2010, except for the sentinel fishery that took place in Division VIIaS, where 270 t were caught. The sentinel fishery took place in the second and third weeks of January.

The distribution of the total landings is presented in Figure 4.1.2.1.

4.1.3 The catches in 2009/2010

The estimated national catches from 1988–2009 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 2009 season has fallen to the lowest estimate in the series, being about 5 700 t (Figure 4.1.3.1.). The catch data include discards, until 1997. Catches considered to be area-misreported are subtracted as unallocated catches.

There are no recent estimates of discards for this fishery. Statements from fishermen suggest that discarding is not a feature of this fishery at present.

4.1.4 Regulations and their effects

The closure of VIIaS in 2009/2010, except for a sentinel fishery means that only small dry hold vessels, no more than 65 feet total length, can fish in that area. This closure has meant that the majority of the quota was taken by the larger bulk storage vessels further west, including VIIj.

There is evidence that closure of Division VIIaS, under the rebuilding plan, has helped to reduce fishing mortality substantially. This box has been the dominant spawning area, and before the closure a large proportion of the catch was taken from it. Closing the box seems to have had a positive effect of keeping fishing mortality down. There is no evidence that this closure has led to improved recruitment, however, this area, particularly the area off Dunmore East, is important for recruit spawners. It can be expected that the closure allows these fish to spawn at least once, and contribute to SSB through further growth and spawning potential.

The spawning box closures instituted under EU legislation (See Stock Annex) does not appear to have been beneficial to the stock in terms of either SSB, F or recruitment.

4.1.5 Changes in fishing technology and fishing patterns

The stock is exploited by three types of vessels, larger boats with RSW or bulk storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). These boats are excluded from VIIaS under the terms of the rebuilding plan, as they are over 65 feet. The fleet involved in the sentinel fishery is increasing, both in number of vessels and fishing efficiency.

In 2009/2010 the sentinel fishery in VIIaS was predominantly in the open sea off Tramore to the mouth of Waterford Harbour. There was very little fishing within the harbour.

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 2009. In 2009, there was a strong dominance of 3-ringers (2005 year class) and 5-ringers (2003 year class). These cohorts were also strong in the previous season as 2- and 4- ringers respectively. A strong cohort of 1-ringers (2007-year class) was also evident in the catch-numbers-at age. The weak 2001/2002 year class has now almost disappeared from the catches by now (Table 4.2.1.1). The poor 2001 year class and the attenuation of the age structure means there are not many fish represented in the plus group. The yearly mean standardised catch numbers-at-age for 9+ and 6+ are shown in Figure 4.2.1.1 and 4.2.1.2. Both plots show that 2-ringers have been the dominant age in catches in general throughout the series.

The overall proportions at age were similar in all sampled metiers (division*quarter). Vessels under and over 10m were raised separately. A slightly different age profile can be seen in quarter 4 from vessels that were under 10m. These boats picked up a high proportion of 1-ringers. These small vessels were only fishing close inshore. However, unusually the survey and the commercial fishery did not agree as well as in previous years in terms of proportions at age (Figure 4.2.1.3). The 3- and 5-ringers that were dominant in the commercial catch were less dominant in the survey. A high proportion of 0- and 1-ringers were found in the survey with smaller proportions picked up by the commercial fishery.

Table 4.2.1.2 shows the length frequency data by area and quarter. A similar length range was found in each area.

4.2.2 Quality of catch and biological data

Biological sampling of the catches throughout the region was comprehensive throughout the area exploited by the Irish fishery (Table 4.2.2.1). 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 2009/2010 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.

In 2010 a minor revision was made to the 2009 catch data where 79t of area misreported catch was added to VIIj quarter 1.

There is no information on discarding currently available from this fishery.

4.3 Fishery Independent Information

4.3.1 Acoustic Surveys

The Celtic Sea herring acoustic survey time series currently used in the assessment runs from 2002 -2009 and is presented in Table 4.3.1.1.

The acoustic survey of the 2009/2010 season was carried out in October 2009, on the *Celtic Explorer* (Saunders *et al* 2009). 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.

In 2009/2010 the SSB estimate was 90 000 t. This is the same as the 2008 SSB estimate. The current has a CV of 24 %, which is higher than the CV in 2008 which was 20%. The distribution of herring encountered on the 2009 survey was more concentrated than in 2008.

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.

4.3.2 Other surveys

In 2008 and 2009, trawl surveys were conducted to develop a recruitment index. The 2008 survey was a scoping exercise and the 2009 was intended to be the first in a series. However funding was not secured to continue this series and no survey was conducted in 2010. The two surveys do however give information on the distribution of young fish that could be used in planning future research.

4.4 Mean weights-at-age and maturity-at-age

The mean weights in the catch and mean weight in the stock at spawning time are presented in Figure 4.4.1.1 and 4.4.1.2 respectively. There has been an overall downward trend in mean weights at age since the mid-1980s. However, in recent years the main age groups 2-8 have shown an increase. For 2009/2010 the weights at age have increased for ages 2-5 with decreases evident for 1-ring and 6-9-rings.

Mean weights in the stock at spawning time were calculated from biological samples, for quarters 4 and 1 (Figure 4.4.1.2). A slight increase across the main ages 2-8 is evident in these data for the most recent season.

The 1-ringers that are resident in the Celtic Sea appear to have greater than 50% maturity. The Celtic Sea 1 ringers that are present in the Irish Sea have less than 50% maturity (Beggs WD, 2009).

4.5 Recruitment

At present there are no recruitment estimates for this stock.

4.6 Assessment

4.6.1 Stock Assessment

This update assessment was carried out using FLICA. The same settings as 2009 were used (Table 4.6.1.10) and the assessment, as in 2009, was tuned using the Celtic Sea Herring acoustic survey. The input and output data are presented in Table 4.6.1.1 to 4.6.1.21.

The survey diagnostics at age are presented in Figures 4.6.1.1 – 4.6.1.4 and are similar to last year. The fit between the observed and expected time series is relatively good with the fit improving as the age increases. High estimates of the 2003 and 2005 year classes can be seen in 2009.

The separable model diagnostics (Table 4.6.1.18 and Figure 4.6.1.5) show that the total residuals by age and year between the catch and separable model do not show any clear trends. A flat topped selection pattern is considered appropriate for this stock.

The catch and survey residual patterns are shown in Figure 4.6.1.6. Year effects can be seen in the earlier acoustic surveys in 2002, 2003 and 2005. In more recent years the survey is performing better in the assessment with smaller residuals and no clear age or year effects.

An "otolith" plot which depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality is presented in Figure 4.6.1.7. This figure shows that there is considerable uncertainty in the estimates of SSB with a wide range of values shown. This plot is produced by re-sampling from the variance co variance matrix. To investigate further, which values in this matrix may be influencing the form of the otolith plot, the random draws are presented as histograms in Figure

4.6.1.8. It can be seen that all parameters, with the exception of the terminal year population at 1 ring, have a quasi normal distribution. These estimates of 1 ringers in the terminal year show high uncertainty and a skewed distribution. The incoming recruitment of 1 ringers is poorly estimated in the assessment and leads to greater uncertainty the estimation of SSB.

The retrospective selection pattern is presented in Figure 4.6.1.9 and shows a stable selection pattern over time. Retrospective plots by cohort are shown in Figure 4.6.1.10. Over and under estimations can be seen across many cohorts. The lack of precision in terminal year recruitment estimation is clearly illustrated in this plot.

The analytical retrospective pattern is displayed in Figure 4.6.2.11. The retrospective pattern was investigated as far back as 2003 but excludes the 2004 estimates. A retrospective analysis cannot be extended into earlier years because of the lack of reliable survey data. There has been an alteration in perception of SSB in the current assessment, relative to recent ones. A historical retrospective is presented in Figure 4.6.2.12. This compares the final assessments in 2009 and 2010. SSB has been revised upwards and mean F revised downwards.

4.6.2 State of the stock

The stock appears to have increased in size and is well above B_{pa} (44,000 t). F has declined from the peak in 2003, and is estimated to be below $F_{0.1}$, and the lowest in the series. The stock continues to be in a state of recovery. However it is still dependent on strength of incoming year classes, that cannot be observed until fully recruited. There have been two confirmed strong cohorts recruited to this stock with the incoming one also appearing strong.

4.7 Short term projections

4.7.1 Deterministic Short Term Projections

A deterministic short term forecast was performed, using the MFDP software (Smith, 2000). The input data are presented in Table 4.7.1.1. Mean weights in the catch and in the stock were calculated as means over the last three years. Recruits (1-ring) are poorly represented in the catch and only one observation of their abundance is available. The population numbers at 1 ring are replaced by geometric mean from 1995-2007. 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 (2010) were calculated by the degradation of geometric mean recruitment (1995-2007) 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 2010/2011. This was calculated as the remaining Irish quota for 2010 + the likely Irish catch in quarter 1 of 2011.

The 2011 quarter 1 catch was estimated assuming that the quota would be increased by 25% and divided into 3 equal parts for quarters 1, 3 and 4. The use of Irish catch estimates in the interim year assumes that other countries' catches are unallocated.

The results of the short term projection are presented in Table 4.7.1.2 and Table 4.7.1.3. Fishing according to the proposed rebuilding plan implies catches of 13,200 t in 2011. Only very high catches are associated with SSB < B_{pa} in 2011.

4.7.2 Yield Per Recruit

A yield per recruit analysis was conducted using MFYPR in 2010 and $F_{0.1}$ was estimated to be 0.17. The yield per recruit is presented in Figure 4.7.2.1.

4.8 Precautionary and yield based reference points

Reference points are defined for this stock, $\mathbf{B_{pa}}$ is currently at 44 000t (low probability of low recruitment) and $\mathbf{B_{lim}}$ at 26 000 t ($\mathbf{B_{loss}}$) for this stock. $\mathbf{F_{pa}}$ and $\mathbf{F_{lim}}$ are not defined. Exploratory work was carried out to determine possible options for $\mathbf{B_{trigger}}$ and $\mathbf{F_{msy}}$. An F value of 0.25 is suggested as a possible option for $\mathbf{F_{msy}}$ with 50,000 t as a possible $\mathbf{B_{trigger}}$. More detail is presented in section 1.3.

4.9 Quality of the Assessment

This assessment is an update of the accepted assessment of last year and the assessment is broadly similar to last year. A retrospective upward revision of SSB perception is a feature of the 2010 assessment. Also precision of SSB and F is lower in 2010. This has been shown to be due to the poor estimation of the incoming year class at 1-ring. . 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.

2009 report					**This year**				
	Year	SSB	Catch	F 2-5		Year	SSB	Catch	F 2-5
Assess 2008	2007	40553	7636	0.23	**Assess 2009**	2007	53651	7636	0.17
	2008	55804	5793	0.13		2008	70958	5872**	0.09
	2009*	55948	6809	0.13		2009	74689	5745	0.07

* From Intermediate year in STF
** Revision due to area mis-reporting

4.10 Management Considerations

Fishing mortality on this stock was high for many years, well above a long term sustainable level of $F_{0.1} = 0.17$. In the past three years F has been substantially reduced and is now below $F_{0.1}$ and at its lowest rate in 45 years. The current estimate of F is 0.07.

The advice for 2010 was based on the rebuilding plan and led to a 71% increase in TAC. There is good evidence to show that the stock has increased substantially. The rebuilding plan should continue until 2011 and then if the stock can be shown to have rebuilt, the rebuilding plan will be replaced by a long term management plan.

The measures to protect first time spawners by closing the VIIaS Box should continue until 2011 as set out in the rebuilding plan. The measure has not been in place long enough to assess its benefits fully. Sampling of the sentinel fishery which takes place in this closed area will continue.

4.11 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.

4.12 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). 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 has had any effect on productivity of this stock.

Table 4.1.3.1. Celtic Sea and Division VIIj herring. Landings by quota year (t), 1988–2009. (Data provided by Working Group members.) These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988	-	-	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

Table 4.1.3.2. Celtic Sea & Division VIIj herring landings (t) by assessment year (1st April–31st March) 1988/1989-2009/2010. (Data provided by Working Group members.) These figures may not in all cases correspond to the official statistics and cannot be used for management purposes.

Year	France	Germany	Ireland	Netherlands	U.K.	Unallocated	Discards	Total
1988/1989	-	-	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

Table 4.2.1.1. Celtic Sea & Division VIIj herring. Comparison of age distributions (percentages) in the catches of Celtic Sea and VIIj herring from 1960-2009

	1	2	3	4	5	6	7	8	9
1960	2%	53%	18%	3%	10%	3%	4%	3%	3%
1961	3%	22%	44%	8%	3%	7%	4%	2%	7%
1962	1%	16%	17%	41%	7%	3%	7%	3%	5%
1963	0%	52%	13%	4%	21%	3%	1%	3%	3%
1964	12%	25%	28%	11%	3%	14%	2%	1%	4%
1965	0%	56%	8%	13%	3%	4%	10%	1%	6%
1966	5%	15%	46%	8%	10%	4%	3%	7%	3%
1967	5%	26%	13%	32%	6%	6%	3%	4%	4%
1968	8%	35%	25%	7%	14%	3%	3%	1%	3%
1969	4%	40%	24%	14%	5%	8%	2%	1%	1%
1970	1%	24%	33%	17%	12%	5%	4%	1%	2%
1971	8%	15%	24%	27%	12%	7%	3%	3%	1%
1972	4%	67%	9%	8%	7%	2%	1%	1%	0%
1973	16%	26%	38%	5%	7%	4%	2%	2%	1%
1974	5%	43%	17%	22%	4%	4%	3%	1%	1%
1975	18%	22%	25%	11%	13%	5%	2%	2%	2%
1976	26%	22%	14%	14%	6%	9%	4%	2%	3%
1977	20%	31%	22%	13%	4%	5%	3%	1%	1%
1978	7%	35%	31%	14%	4%	4%	1%	2%	1%
1979	21%	26%	23%	16%	5%	2%	2%	1%	1%
1980	11%	47%	18%	10%	4%	3%	2%	2%	1%
1981	40%	22%	22%	6%	5%	4%	1%	0%	1%
1982	20%	55%	11%	6%	2%	2%	2%	0%	1%
1983	9%	68%	18%	2%	1%	0%	0%	1%	0%
1984	11%	53%	24%	9%	1%	1%	0%	0%	0%
1985	14%	44%	28%	12%	2%	0%	0%	0%	0%
1986	3%	39%	29%	22%	6%	1%	0%	0%	0%
1987	4%	42%	27%	15%	9%	2%	1%	0%	0%
1988	2%	61%	23%	7%	4%	2%	1%	0%	0%
1989	5%	27%	44%	13%	5%	2%	2%	0%	0%
1990	2%	35%	21%	30%	7%	3%	1%	1%	0%
1991	1%	40%	24%	11%	18%	3%	2%	1%	0%
1992	8%	19%	25%	20%	7%	13%	2%	5%	0%
1993	1%	72%	7%	8%	3%	2%	5%	1%	0%
1994	10%	29%	50%	3%	2%	4%	1%	1%	0%
1995	6%	49%	14%	23%	2%	2%	2%	1%	1%
1996	3%	46%	29%	6%	12%	2%	1%	1%	1%
1997	3%	26%	37%	22%	6%	4%	1%	1%	0%
1998	5%	34%	22%	23%	11%	3%	2%	0%	0%
1999	11%	27%	28%	11%	12%	7%	1%	2%	0%
2000	7%	58%	14%	9%	4%	5%	2%	0%	0%
2001	12%	49%	28%	5%	3%	1%	1%	0%	0%
2002	6%	46%	32%	9%	2%	2%	1%	0%	0%
2003	3%	41%	27%	16%	6%	4%	3%	0%	1%
2004	5%	10%	50%	24%	9%	2%	1%	0%	0%
2005	19%	38%	7%	23%	9%	2%	1%	0%	0%
2006	3%	58%	19%	4%	11%	4%	1%	0%	0%
2007	12%	17%	56%	9%	2%	3%	1%	0%	0%
2008	3%	31%	20%	38%	6%	1%	1%	0%	0%
2009	24%	11%	30%	12%	20%	2%	1%	1%	0%

Table 4.2.1.2. Celtic Sea & Division VIIj herring. Length frequency distributions of the Irish catches (raised numbers in '000s) in the 2009/2010 season in the Celtic Sea and VIIj fishery.

	2009				2010		
	7j Q3	7j Q4	7g Q3	7g Q4	7aS Q4	7aS Q1	Total
14							
14.5			8				8
15							
15.5							
16					3		3
16.5					3		3
17							
17.5							
18				12			12
18.5		6		58	3		68
19				152	18		169
19.5		32	8	245	34	2	321
20		78	46	712	79	2	917
20.5		104	61	888	111		1163
21		175	61	1308	181	3	1728
21.5		149	91	1588	279	2	2109
22	8	246	46	1378	246	10	1934
22.5	16	136	53	923	179	11	1317
23	8	188	53	479	111	42	880
23.5	24	233	114	712	114	61	1259
24	67	246	168	1063	174	119	1837
24.5	119	356	396	1588	299	145	2904
25	222	764	610	2710	424	280	5010
25.5	242	958	785	3130	494	360	5969
26	242	1236	686	3411	492	355	6422
26.5	186	1152	313	2126	293	249	4319
27	59	770	198	1086	152	128	2394
27.5	36	375	99	502	65	73	1151
28		207	8	93	22	27	357
28.5	12	52		35	15	29	142
29		6	8		3	6	23
29.5		6			3	1.6	11
30							
30.5							
31							
31.5							

Table 4.2.2.1 Celtic Sea & Division VIIj (2009/2010). Sampling intensity of Irish commercial catches. Only Ireland provides samples of this stock.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIIg	2009	3	576	5	312	500	0.31
VIIg	2009	4	3073	9	667	2072	0.67
Sub-total			3649	14	979	2572	
VIIaS over 10	2009	4	321	7	519	791	0.52
VIIaS under 10	2009	4	135	3	223	497	0.22
VIIaS over 10	2010	1	195	8	592	878	0.59
VIIaS under 10	2010	1	66	1	75	114	0.08
VIIaS driftnet	2009	4	7	1	75	119	0.08
Sub-total			724	20	1484	2399	
VIIj	2009	2	200	2	148	313	0.15
VIIj	2009	4	1154	7	519	1155	0.52
Sub-total			1354	9	667	1468	
Total Celtic Sea			5728	43	3130	6439	

Table 4.3.1.1. Celtic Sea & Division VIIj herring. Revised acoustic index of abundance used in the assessment. Total stock numbers-at-age (10^6) estimated using combined acoustic surveys (age refers in winter rings, biomass and SSB in 000's tonnes). Only 2-5 ring abundance is used in tuning.

	2002	2003	2004	2005	2006	2007	2008	2009
	2003	2004	2005	2006	2007	2008	2009	2010
0	0	24	-	2	-	1	99	239
1	42	13	-	65	21	106	64	381
2	185	62	-	137	211	70	295	112
3	151	60	-	28	48	220	111	210
4	30	17	-	54	14	31	162	57
5	7	5	-	22	11	9	27	125
6	7	1	-	5	1	13	6	12
7	3	0	-	1	-	4	5	4
8	0	0	-	0	-	1		6
9	0	0	-	0	-	0		1
							-	
Abundance	423	183	-	312	305	454	769	1,147
SSB	41	20	-	33	36	46	90	91
CV (%)	49	34	-	48	35	25	20	24
Design *	AR	AR		R	R	R	R	R

*AR Adaptive random; R random

Table 4.6.1.1 Celtic Sea and Division VIIj Herring. CATCH IN NUMBER

Units : thousands

year

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

year

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

year

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

year

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	4276	15419
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	9470	30710
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	46243	5766
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21863	18666
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	7349
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

year

age	2006	2007	2008	2009
1	1460	8043	1306	10171
2	33894	11028	12638	4465
3	10914	36223	8255	12859
4	2469	5509	15777	4887
5	6261	1365	2360	8458
6	2997	2509	921	1578

Table 4.6.1.2 Celtic Sea and Division VIIj Herring. WEIGHTS AT AGE IN THE CATCH

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	0.214	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	0.089	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

year

age	2006	2007	2008	2009
1	0.093	0.074	0.091	0.078
2	0.105	0.106	0.120	0.122
3	0.127	0.123	0.144	0.146
4	0.151	0.141	0.156	0.160
5	0.155	0.166	0.172	0.169
6	0.168	0.164	0.193	0.188

Table 4.6.1.3 Celtic Sea and Division VIIj Herring. WEIGHTS AT AGE IN THE STOCK

Units : kg

age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	0.096	0.087	0.093	0.098	0.109	0.103	0.105	0.103	0.122	0.119	0.119	0.122
2	0.115	0.119	0.122	0.127	0.146	0.139	0.139	0.143	0.154	0.158	0.166	0.164
3	0.162	0.166	0.156	0.156	0.170	0.194	0.182	0.180	0.191	0.185	0.196	0.200
4	0.185	0.185	0.191	0.185	0.187	0.205	0.215	0.212	0.212	0.217	0.215	0.217
5	0.205	0.200	0.205	0.207	0.210	0.217	0.225	0.232	0.237	0.243	0.235	0.237
6	0.224	0.220	0.222	0.224	0.234	0.241	0.235	0.249	0.250	0.257	0.257	0.252

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.128	0.117	0.132	0.125	0.141	0.137	0.137	0.134	0.127	0.127	0.117	0.115
2	0.162	0.166	0.170	0.174	0.180	0.187	0.174	0.185	0.189	0.174	0.174	0.172
3	0.200	0.200	0.194	0.205	0.210	0.215	0.205	0.212	0.217	0.212	0.207	0.210
4	0.225	0.225	0.220	0.215	0.225	0.240	0.235	0.222	0.240	0.230	0.237	0.245
5	0.240	0.245	0.245	0.245	0.237	0.251	0.259	0.243	0.279	0.253	0.259	0.267
6	0.262	0.261	0.265	0.269	0.264	0.269	0.278	0.271	0.288	0.282	0.273	0.287

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.115	0.109	0.093	0.104	0.112	0.096	0.097	0.106	0.099	0.092	0.096	0.092
2	0.154	0.148	0.142	0.140	0.155	0.138	0.132	0.129	0.137	0.128	0.123	0.129
3	0.194	0.198	0.185	0.170	0.172	0.186	0.168	0.151	0.153	0.168	0.150	0.155
4	0.237	0.220	0.213	0.201	0.187	0.192	0.203	0.169	0.167	0.182	0.177	0.180
5	0.262	0.276	0.213	0.234	0.215	0.204	0.209	0.194	0.188	0.190	0.191	0.201
6	0.279	0.305	0.249	0.256	0.252	0.245	0.224	0.208	0.213	0.219	0.205	0.211

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.097	0.088	0.088	0.093	0.099	0.090	0.092	0.082	0.096	0.078	0.077	0.074
2	0.135	0.126	0.118	0.124	0.121	0.120	0.111	0.107	0.115	0.100	0.127	0.103
3	0.168	0.151	0.147	0.141	0.153	0.149	0.148	0.139	0.139	0.130	0.133	0.145
4	0.179	0.178	0.159	0.157	0.163	0.167	0.168	0.162	0.156	0.141	0.151	0.143
5	0.190	0.188	0.185	0.172	0.173	0.180	0.185	0.177	0.184	0.156	0.156	0.155
6	0.214	0.210	0.210	0.198	0.194	0.191	0.193	0.194	0.201	0.168	0.187	0.167

age	2006	2007	2008	2009
1	0.085	0.066	0.083	0.076
2	0.104	0.102	0.117	0.117
3	0.123	0.116	0.140	0.142
4	0.153	0.135	0.156	0.158
5	0.150	0.151	0.170	0.168
6	0.159	0.160	0.180	0.178

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
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1

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
1	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
3	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
5	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

Table 4.6.1.6 Celtic Sea and Division VIIj Herring. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age \ year	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 \ year	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 \ year	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 \ year	2003	2004	2005	2006	2007	2008	2009
1	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
3	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
5	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

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
1	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
3	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
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

Table 4.6.1.8 Celtic Sea and Division VIIj Herring. SURVEY INDICES

```
Celtic Sea Herring acoustic survey - Configuration

Celtic Sea   and   Division  VIIj herring . Imported from VPA file.
      min       max plusgroup   minyear   maxyear    startf      endf
        2         5        NA      2002      2009         1         1
Index type : number

Celtic Sea Herring acoustic survey - Index Values

Units  :  NA
   year
age  2002 2003 2004  2005  2006 2007 2008 2009
  2 185.2 61.7   -1 137.1 210.5   70  295  112
  3 150.6 60.4   -1  28.2  47.8  220  111  210
  4  29.7 17.2   -1  54.2  13.5   31  162   57
  5   6.6  5.4   -1  21.6  11.0    9   27  125

Celtic Sea Herring acoustic survey - Index Variance (Inverse Weights)

Units  :  NA
   year
age 2002 2003 2004 2005 2006 2007 2008 2009
  2    1    1    1    1    1    1    1    1
  3    1    1    1    1    1    1    1    1
  4    1    1    1    1    1    1    1    1
  5    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      2009         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	298897	114330	83122	0.3492	22978	1.1144
1959	888441	140462	78380	0.3000	15086	1.1238
1960	192863	88749	63985	0.4398	18283	1.1314
1961	224247	77750	55010	0.2750	15372	0.7759
1962	577013	118501	65198	0.5820	21552	1.0137
1963	290395	90811	59944	0.3890	17349	1.0017
1964	1097102	171440	83875	0.2385	10599	1.0234
1965	344774	154413	113318	0.2222	19126	1.1620
1966	706724	195879	120911	0.2685	27030	0.9617
1967	719201	202044	125520	0.3385	27658	1.1093
1968	843672	216333	128838	0.3175	30236	0.9937
1969	447356	177987	117572	0.4992	44389	1.0062
1970	216367	124985	89770	0.4418	31727	1.0041
1971	859891	168823	85230	0.6645	31396	1.0385
1972	265620	115558	72549	0.6998	38203	0.9936
1973	291921	89954	52559	0.7065	26936	1.0461
1974	130365	58318	36459	0.7820	19940	1.0226
1975	145745	47254	27431	0.7228	15588	0.9298
1976	176017	46584	25447	0.6192	9771	1.0604
1977	170640	44325	24432	0.5352	7833	0.9983
1978	135252	41602	25225	0.4990	7559	1.0882
1979	238696	52704	27073	0.6345	10321	0.9954
1980	148680	44263	26383	0.6715	13130	0.9302
1981	406081	69324	30663	0.9597	17103	0.9861
1982	674426	106320	46039	0.6752	13000	0.9865
1983	747245	132243	63463	0.6702	24981	0.9551
1984	575327	114838	63769	0.8395	26779	1.0089
1985	519292	111589	63256	0.4818	20426	0.9760
1986	541482	122679	67935	0.6280	25024	0.9992
1987	984753	153851	75273	0.7160	26200	1.0043
1988	395296	113644	73646	0.3980	20447	0.9962
1989	477359	114218	67377	0.5160	23254	0.9984
1990	431270	101558	62012	0.4385	18404	1.0102
1991	182282	73307	49970	0.6665	25562	0.9873
1992	968298	130020	56209	0.9600	21127	1.0467
1993	332834	90507	57614	0.5560	18618	0.9993
1994	706938	124238	66467	0.4150	19300	1.0049
1995	687783	123733	69726	0.5250	23305	0.9979
1996	344205	94572	62588	0.3850	18816	0.9981
1997	375724	85873	51756	0.5918	20496	1.0037
1998	245460	67728	42357	0.6123	18041	1.0016
1999	518995	80479	40139	0.8332	18485	1.0024
2000	459754	76441	38881	0.8282	17191	1.0001
2001	429310	67232	35395	0.7212	15269	1.0064
2002	538134	84867	43653	0.2860	7465	0.9994
2003	117634	52022	34703	0.3785	11536	0.9977
2004	300290	55448	29139	0.4995	12743	1.0080
2005	944957	97091	41065	0.3930	9494	0.9983
2006	341091	80792	50463	0.2050	6944	0.9976
2007	733787	95764	53651	0.1650	7636	0.9998
2008	313423	99143	70958	0.0925	5872	0.9995
2009	412638	360012	74689	0.0715	5745	0.9963

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	1968	1969
1	0.009	0.002	0.024	0.015	0.002	0.002	0.011	0.000	0.016	0.017	0.023	0.034
2	0.164	0.316	0.294	0.309	0.304	0.331	0.178	0.226	0.196	0.198	0.277	0.434
3	0.392	0.150	0.612	0.218	0.855	0.388	0.184	0.169	0.327	0.335	0.328	0.531
4	0.476	0.394	0.376	0.256	0.551	0.406	0.333	0.242	0.258	0.461	0.311	0.476
5	0.365	0.340	0.477	0.317	0.618	0.431	0.259	0.252	0.293	0.360	0.354	0.556
6	0.365	0.340	0.477	0.317	0.618	0.431	0.259	0.252	0.293	0.360	0.354	0.556

age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.010	0.024	0.051	0.135	0.069	0.147	0.126	0.078	0.033	0.078	0.079	0.164
2	0.313	0.414	0.707	0.631	0.731	0.501	0.323	0.290	0.308	0.402	0.550	0.653
3	0.473	0.646	0.702	0.774	0.718	0.863	0.505	0.477	0.533	0.560	0.767	1.144
4	0.501	0.888	0.595	0.631	0.802	0.743	1.000	0.810	0.621	0.898	0.626	1.003
5	0.480	0.710	0.795	0.790	0.877	0.784	0.649	0.564	0.534	0.678	0.743	1.039
6	0.480	0.710	0.795	0.790	0.877	0.784	0.649	0.564	0.534	0.678	0.743	1.039

age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	0.037	0.029	0.055	0.056	0.012	0.010	0.009	0.028	0.010	0.017	0.017	0.008
2	0.487	0.673	0.507	0.395	0.446	0.493	0.305	0.411	0.329	0.622	0.621	0.368
3	0.671	0.713	0.685	0.406	0.632	0.793	0.479	0.481	0.480	0.616	0.940	0.495
4	0.810	0.533	1.274	0.596	0.753	0.803	0.371	0.605	0.465	0.680	1.249	0.764
5	0.733	0.762	0.892	0.530	0.681	0.775	0.437	0.567	0.480	0.748	1.030	0.597
6	0.733	0.762	0.892	0.530	0.681	0.775	0.437	0.567	0.480	0.748	1.030	0.597

age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	0.027	0.022	0.016	0.016	0.038	0.044	0.035	0.059	0.010	0.037	0.030	0.023
2	0.411	0.443	0.338	0.422	0.430	0.593	0.659	0.570	0.229	0.245	0.336	0.264
3	0.472	0.535	0.428	0.586	0.670	0.913	0.865	0.814	0.352	0.365	0.539	0.424
4	0.305	0.540	0.344	0.717	0.685	0.922	0.878	0.707	0.247	0.498	0.584	0.460
5	0.472	0.582	0.430	0.642	0.664	0.905	0.911	0.794	0.316	0.406	0.539	0.424
6	0.472	0.582	0.430	0.642	0.664	0.905	0.911	0.794	0.316	0.406	0.539	0.424

age	2006	2007	2008	2009
1	0.012	0.010	0.006	0.004
2	0.138	0.111	0.062	0.048
3	0.221	0.178	0.100	0.077
4	0.240	0.193	0.108	0.084
5	0.221	0.178	0.100	0.077
6	0.221	0.178	0.100	0.077

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	298897	888441	192863	224247	577013	290395	1097102	344774	706724	719201
2	28518	109003	326139	69301	81258	211822	106658	399223	126802	255867
3	111954	17931	58872	180111	37675	44397	112752	66159	235854	77247
4	71151	61959	12632	26150	118620	13112	24651	76779	45730	139290
5	43021	39997	37808	7848	18319	61842	7904	15992	54520	31963
6	188558	126173	52599	55416	48329	27951	58808	120147	89867	92407

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
1	843672	447356	216367	859891	265620	291921	130365	145745	176017	170640
2	260163	303285	159076	78830	308984	92835	93838	44772	46275	57082
3	155428	146075	145550	86144	38612	112871	36581	33464	20101	24828
4	45223	91672	70312	74274	36957	15669	42638	14609	11560	9930
5	79515	29971	51557	38546	27651	18451	7546	17299	6289	3848
6	53991	69284	54258	45000	21029	23354	15082	14394	21410	9210

age \ year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	135252	238696	148680	406081	674426	747245	575327	519292	541482	984753
2	58057	48131	81257	50555	126786	239207	267035	200343	180658	196782
3	31632	31620	23845	34740	19492	57728	90449	119164	99972	85709
4	12611	15200	14791	9063	9058	8161	23165	37324	65030	43516
5	3998	6130	5603	7154	3009	3647	4332	5863	18604	27724
6	8492	8031	10390	8721	9029	3797	3310	1571	2679	9003

age \ year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
1	395296	477359	431270	182282	968298	332834	706938	687783	344205	375724
2	358795	144080	170814	157084	65947	350167	121507	253024	247531	124606
3	89025	195996	70738	91029	62452	26264	179488	59656	120310	130722
4	31765	45140	99171	35838	40243	19979	13106	91618	28614	64198
5	17637	19834	22300	56338	16434	10443	8421	8739	48310	18360
6	12715	19036	18234	17858	45474	23451	24120	20798	18573	19248

age \ year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
1	245460	518995	459754	429310	538134	117634	300290	944957	341091	733787
2	135984	86924	182651	163358	148828	195936	41702	107226	339573	123956
3	60540	65523	35604	70029	68468	87684	113614	22086	61002	219214
4	59575	25353	21531	12271	25411	39414	49842	54254	11832	40038
5	28369	27173	9123	8097	5476	17955	21684	25144	31002	8425
6	15941	23303	17072	7187	7970	20809	5400	7558	15848	16153

age \ year	2008	2009
1	313423	412638
2	267303	114667
3	82201	186097
4	150225	60909
5	29875	121998
6	10183	22238

Table 4.6.1.15 Celtic Sea and Division VIIj Herring. SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2010
1	NA
2	151152
3	80950
4	141009
5	50677
6	120785

Table 4.6.1.16 Celtic Sea and Division VIIj Herring. FITTED SELECTION PATTERN

Units : NA

age	2004	2005	2006	2007	2008	2009
1	0.055	0.055	0.055	0.055	0.055	0.055
2	0.623	0.623	0.623	0.623	0.623	0.623
3	1.000	1.000	1.000	1.000	1.000	1.000
4	1.084	1.084	1.084	1.084	1.084	1.084
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

year												
age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	1642	1203	2840	2129	772	297	7529	57	7093	7599	12197	9472
2	3742	25717	72246	16058	18567	51935	15058	70248	19559	39991	54790	93279
3	33094	2274	24658	32044	19909	13033	17250	9365	59893	20062	39604	55039
4	25746	19262	3779	5631	48061	4179	6658	15757	9924	49113	11544	33145
5	12551	11015	13698	2034	8075	20694	1719	3399	13211	9218	22599	12217
6	55010	34748	19057	14363	21304	9353	12790	25536	21776	26650	15345	28242

year												
age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1319	12658	8422	23547	5507	12768	13317	8159	2800	11335	7162	39361
2	37260	23313	137690	38133	42808	15429	11113	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12399	11726	21861
4	26481	41904	15842	7012	22530	7333	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	19746	21900	11051	12216	8445	7494	9777	3794	3356	3785	5215	5410

year												
age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	15339	13540	19517	17916	4159	5976	2307	8260	2702	1912	10410	1608
2	42725	102871	92892	57054	56747	67000	82027	42413	41756	63854	26752	94061
3	8728	26993	41121	36258	42881	43075	30962	68399	24634	38342	35019	9372
4	4817	3225	16043	16032	32930	23014	9398	19601	35258	16916	27591	10221
5	1497	1862	2450	2306	8790	14323	5963	8205	8116	28405	10139	4491
6	4492	1939	1872	618	1266	4651	4299	7875	6636	9004	28056	10085

year												
age	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
1	12130	9450	3476	3849	5818	14274	9953	15724	3495	2711	5589	13872
2	35768	79159	61923	37440	41510	34072	77378	62153	26472	37006	10358	21638
3	61737	22591	38244	53040	27102	36086	18952	35816	18532	24444	43298	6968
4	3289	36541	7943	31442	28274	14642	12060	5953	5309	14763	21089	19097
5	3025	3686	16114	8318	13178	15515	5230	4249	1416	5719	8638	8300
6	8665	8772	6195	8720	7405	13305	9787	3771	2061	6628	2151	2495

year				
age	2006	2007	2008	2009
1	2622	4544	1091	10171
2	37853	11259	13930	4668
3	11007	32479	7087	12585
4	2404	6692	14665	4669
5	5863	1309	2702	8657
6	2997	2509	921	1578

Table 4.6.1.18 Celtic Sea and Division VIIj Herring. CATCH RESIDUALS

Units : thousands NA

age	2004	2005	2006	2007	2008	2009
1	-0.268	0.106	-0.586	0.571	0.180	0.000
2	-0.090	0.350	-0.110	-0.021	-0.097	-0.045
3	0.066	-0.189	-0.009	0.109	0.153	0.022
4	0.036	-0.023	0.027	-0.195	0.073	0.046
5	0.000	-0.122	0.066	0.042	-0.135	-0.023
6	0.000	0.000	0.000	0.000	0.000	0.000

Table 4.6.1.19 Celtic Sea and Division VIIj Herring. PREDICTED INDEX VALUES

Celtic Sea Herring Acoustic

Units : NA NA

age	2002	2003	2004	2005	2006	2007	2008	2009
2	109	141	NA	76	273	102	232	101
3	69	88	NA	21	70	264	107	248
4	23	28	NA	40	11	38	156	65
5	4	11	NA	15	23	7	25	105

Table 4.6.1.20 Celtic Sea and Division VIIj Herring. INDEX RESIDUALS

Celtic Sea Herring Acoustic

Units : NA

age	2002	2003	2004	2005	2006	2007	2008	2009
2	0.529	-0.829	NA	0.591	-0.259	-0.379	0.242	0.106
3	0.775	-0.373	NA	0.303	-0.388	-0.184	0.035	-0.167
4	0.255	-0.480	NA	0.310	0.223	-0.212	0.035	-0.131
5	0.573	-0.725	NA	0.342	-0.745	0.314	0.069	0.172

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, 2004	0.54	0.16	0.39	0.74
F, 2005	0.42	0.17	0.30	0.60
F, 2006	0.22	0.19	0.15	0.32
F, 2007	0.18	0.20	0.12	0.27
F, 2008	0.10	0.22	0.07	0.15
F, 2009	0.08	0.24	0.05	0.12
Selectivity at age 1	0.06	0.33	0.03	0.10
Selectivity at age 2	0.62	0.13	0.48	0.81
Selectivity at age 4	1.08	0.11	0.88	1.34
Terminal year pop, age 1	3764366.45	0.79	793384.73	17860760.59
Terminal year pop, age 2	114666.37	0.29	64456.52	203988.33
Terminal year pop, age 3	186095.57	0.23	117554.28	294600.60
Terminal year pop, age 4	60908.37	0.22	39948.75	92864.75
Terminal year pop, age 5	121997.28	0.21	80696.64	184435.64
Last true age pop, 2004	21682.98	0.25	13394.06	35101.51
Last true age pop, 2005	25142.65	0.20	16981.98	37224.92
Last true age pop, 2006	31001.36	0.21	20601.04	46652.22
Last true age pop, 2007	8424.09	0.20	5685.41	12482.00
Last true age pop, 2008	29873.80	0.21	19941.39	44753.36
Index 1, age 2 numbers, Q	0.00	0.20	0.00	0.00
Index 1, age 3 numbers, Q	0.00	0.20	0.00	0.00
Index 1, age 4 numbers, Q	0.00	0.21	0.00	0.00
Index 1, age 5 numbers, Q	0.00	0.22	0.00	0.00

Table 4.7.1.1. Celtic Sea & Division VIIj Herring. Inputs to the Short Term Forecast

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	412638	1	0.5	0.551	0.5	0.075	0.0043	0.081
2	151152.3	0.3	1	0.551	0.5	0.112	0.0482	0.116
3	80949.53	0.2	1	0.551	0.5	0.132667	0.0774	0.137667
4	141009.2	0.1	1	0.551	0.5	0.149667	0.0839	0.152333
5	50676.64	0.1	1	0.551	0.5	0.163	0.0774	0.169
6	120785.1	0.1	1	0.551	0.5	0.172667	0.0774	0.181667

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	412638	1	0.5	0.551	0.5	0.075	0.0043	0.081
2	.	0.3	1	0.551	0.5	0.112	0.0482	0.116
3	.	0.2	1	0.551	0.5	0.132667	0.0774	0.137667
4	.	0.1	1	0.551	0.5	0.149667	0.0839	0.152333
5	.	0.1	1	0.551	0.5	0.163	0.0774	0.169
6	.	0.1	1	0.551	0.5	0.172667	0.0774	0.181667

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	412638	1	0.5	0.551	0.5	0.075	0.0043	0.081
2	.	0.3	1	0.551	0.5	0.112	0.0482	0.116
3	.	0.2	1	0.551	0.5	0.132667	0.0774	0.137667
4	.	0.1	1	0.551	0.5	0.149667	0.0839	0.152333
5	.	0.1	1	0.551	0.5	0.163	0.0774	0.169
6	.	0.1	1	0.551	0.5	0.172667	0.0774	0.181667

Table 4.7.1.2. Celtic Sea & Division VIIj Herring. Single catch option table from the Short Term Forecast

Year:	2010	F multiplier:	2.3762	Fbar:	0.1705				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0102	2643	214	412638	30948	206319	15474	124439	9333
2	0.1146	14175	1644	151152	16929	151152	16929	122140	13680
3	0.184	12369	1703	80950	10739	80950	10739	66184	8780
4	0.1994	24300	3702	141009	21104	141009	21104	120175	17986
5	0.184	8118	1372	50677	8260	50677	8260	43557	7100
6	0.184	19349	3515	120785	20856	120785	20856	103816	17926
Total		80955	12150	957211	108836	750892	93363	580310	74804

Year:	2011	F multiplier:	2	Fbar:	0.1435				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0086	2226	180	412638	30948	206319	15474	124550	9341
2	0.0964	11961	1388	150264	16830	150264	16830	122642	13736
3	0.1549	13019	1792	99856	13248	99856	13248	82963	11006
4	0.1678	8119	1237	55136	8252	55136	8252	47814	7156
5	0.1549	14290	2415	104523	17037	104523	17037	91292	14881
6	0.1549	17646	3206	129068	22286	129068	22286	112731	19465
Total		67261	10218	951486	108600	745167	93126	581992	75585

Year:	2012	F multiplier:	2	Fbar:	0.1435				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0086	2226	180	412638	30948	206319	15474	124550	9341
2	0.0964	11981	1390	150507	16857	150507	16857	122840	13758
3	0.1549	13180	1814	101086	13411	101086	13411	83985	11142
4	0.1678	10311	1571	70025	10480	70025	10480	60726	9089
5	0.1549	5767	975	42181	6875	42181	6875	36841	6005
6	0.1549	24751	4496	181035	31259	181035	31259	158120	27302
Total		68215	10426	957472	109830	751153	94356	587061	76637

Table 4.7.1.3. Celtic Sea & Division VIIj Herring. Single catch option table from the Short Term Forecast.

2010				
Biomass	**SSB**	**FMult**	**FBar**	**Landings**
108836	74804	2.3762	0.1705	12150

2011					2012	
Biomass	**SSB**	**FMult**	**FBar**	**Landings**	**Biomass**	**SSB**
108600	78293	1	0.072	5291	114527	83641
.	78017	1.1	0.079	5799	114042	82905
.	77742	1.2	0.086	6304	113560	82178
.	77469	1.3	0.093	6806	113082	81458
.	77197	1.4	0.101	7304	112607	80746
.	76925	1.5	0.108	7798	112136	80042
.	76655	1.6	0.115	8289	111668	79346
.	76386	1.7	0.122	8776	111203	78657
.	76118	1.8	0.129	9260	110742	77976
.	75851	1.9	0.136	9741	110284	77303
.	75585	2	0.144	10218	109830	76637
.	75320	2.1	0.151	10691	109379	75978
.	75057	2.2	0.158	11162	108931	75327
.	74794	2.3	0.165	11629	108486	74683
.	74533	2.4	0.172	12092	108045	74046
.	74272	2.5	0.179	12553	107607	73416
.	74013	2.6	0.187	13010	107172	72793
	73883	**2.65**	**0.190**	**13238**	**106955**	**72484**
.	73754	2.7	0.194	13464	106740	72176
.	73497	2.8	0.201	13915	106311	71567
.	73241	2.9	0.208	14363	105886	70964
.	72985	3	0.215	14807	105463	70368

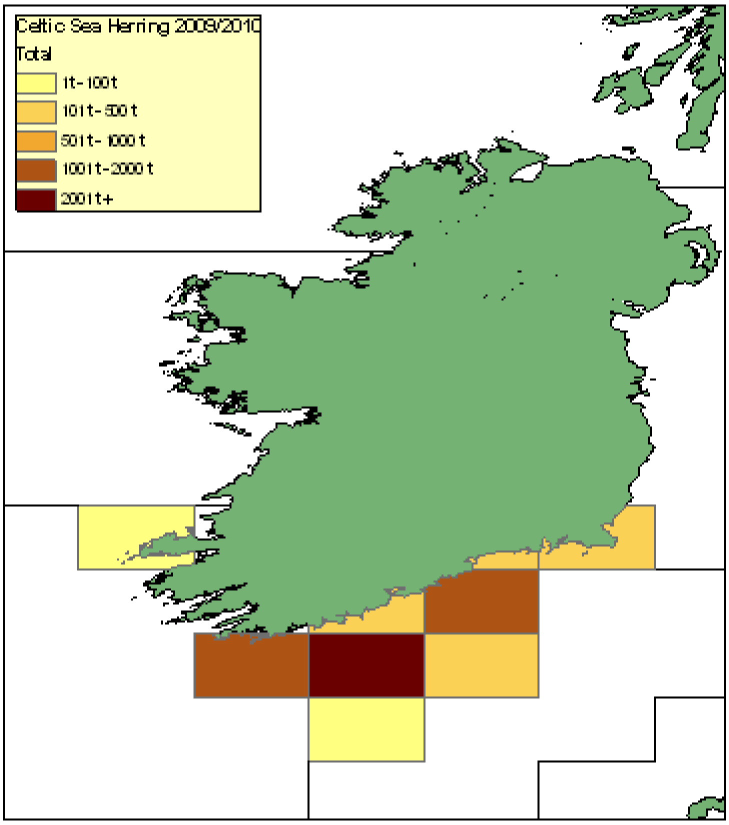


Figure 4.1.2.1. Celtic Sea and VIIj herring. Irish official herring catches by statistical rectangle in 2009/2010.

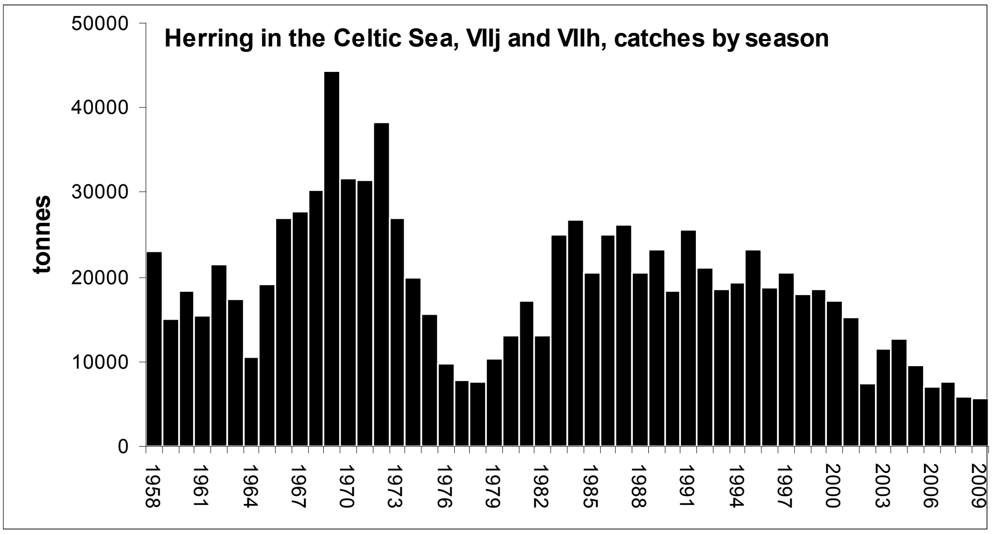


Figure 4.1.3.1 Celtic Sea and VIIj herring – working group estimates of herring landings per season.

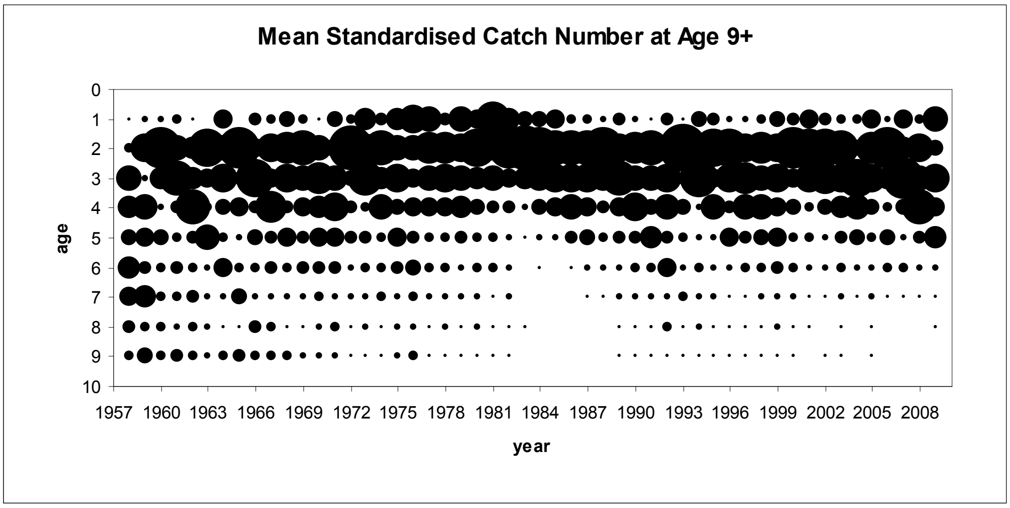


Figure 4.2.1.1. Celtic Sea and VIIj herring. Catch numbers at age standardised by yearly mean. 9-ringer is the plus group.

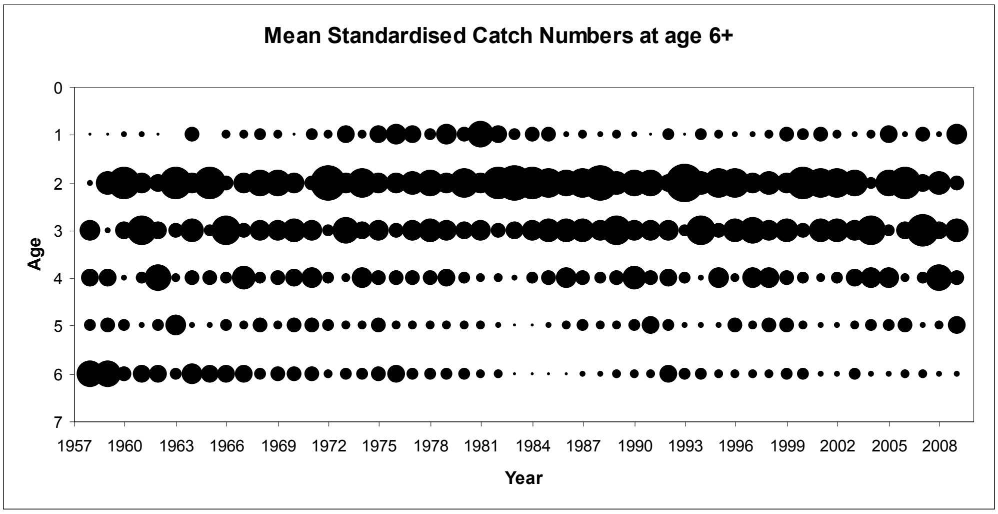


Figure 4.2.1.2. Celtic Sea and VIIj herring. Catch numbers at age standardised by yearly mean. 6-ringer is the plus group.

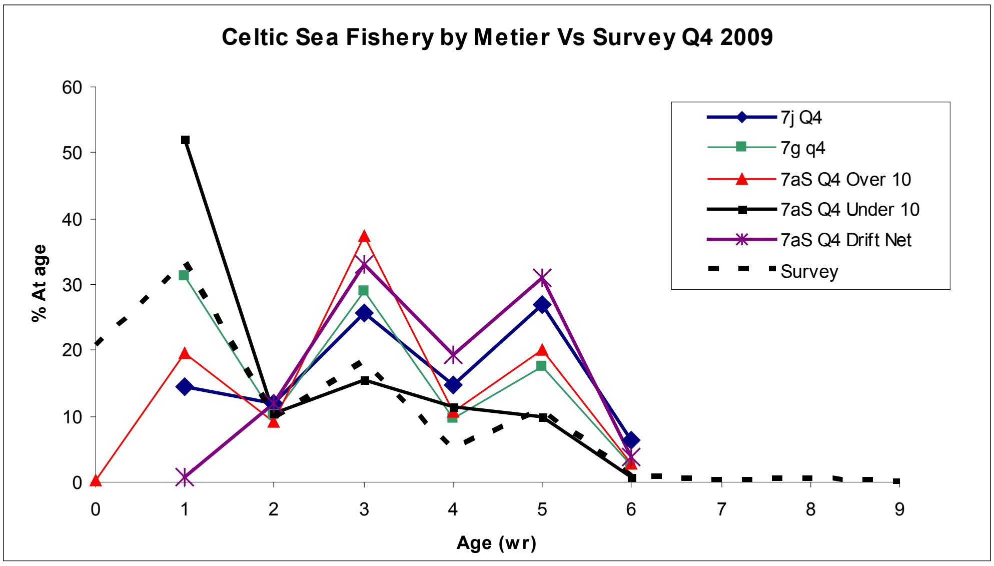


Figure 4.2.1.3. Celtic Sea and VIIj herring. The percentage age composition in the survey and the commercial fishery 2009/2010.

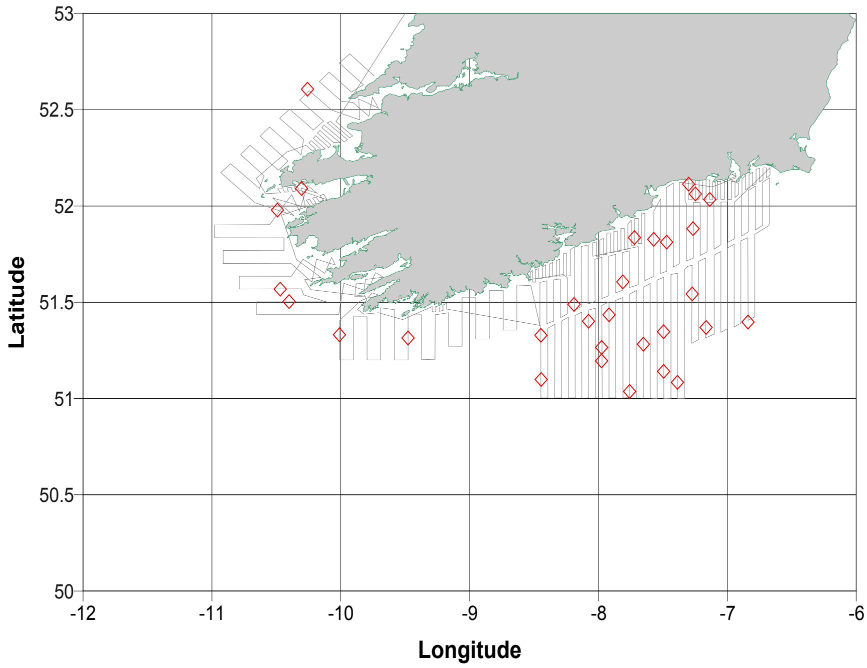


Figure 4.3.1.1a Celtic Sea and VIIj herring. Acoustic survey track and haul positions from acoustic survey, October 2009.

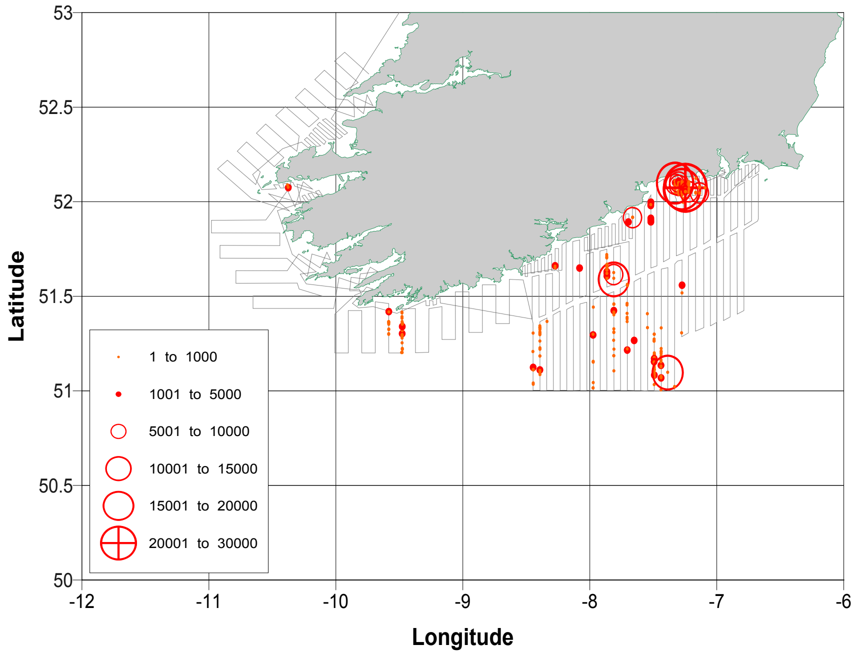


Figure 4.3.1.1b. Celtic Sea and VIIj herring. Acoustic survey 2008, total Sa values attributed to herring in the acoustic survey, October 2009.

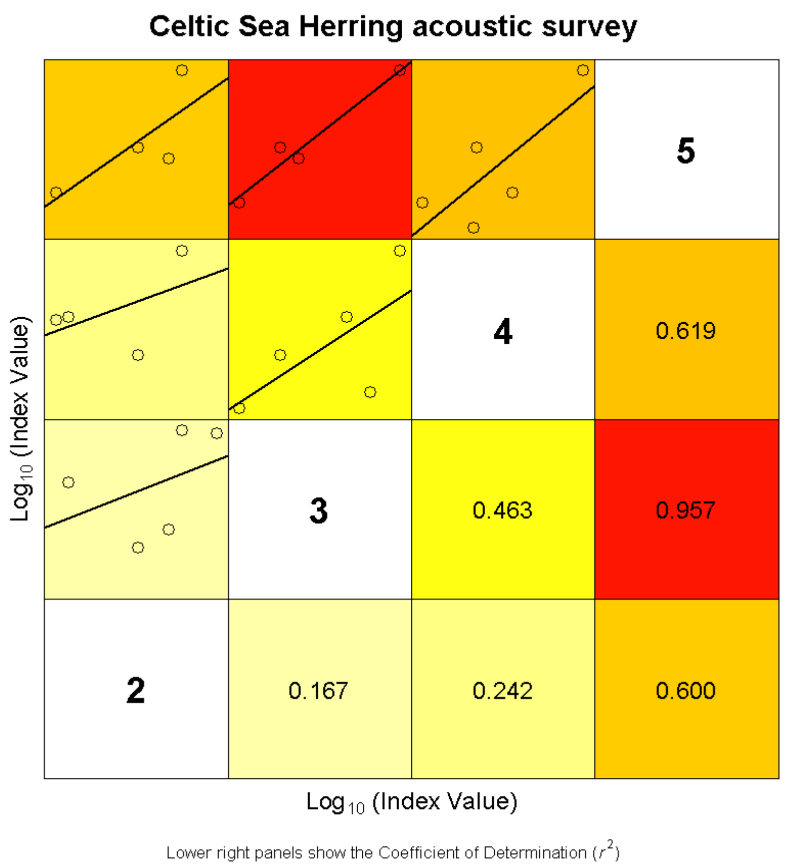


Figure 4.3.1.2. Celtic Sea and VIIj herring. Internal consistency between ages in the Celtic Sea Herring Acoustic survey time series.

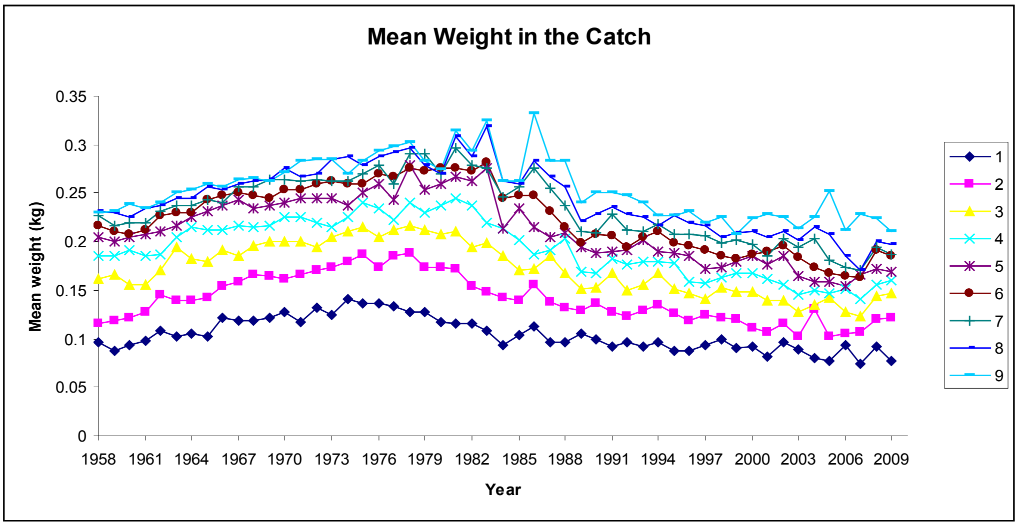


Figure 4.4.1.1. Celtic Sea and VIIj herring. Trends over time in mean weight at age in the catch from 1-9+

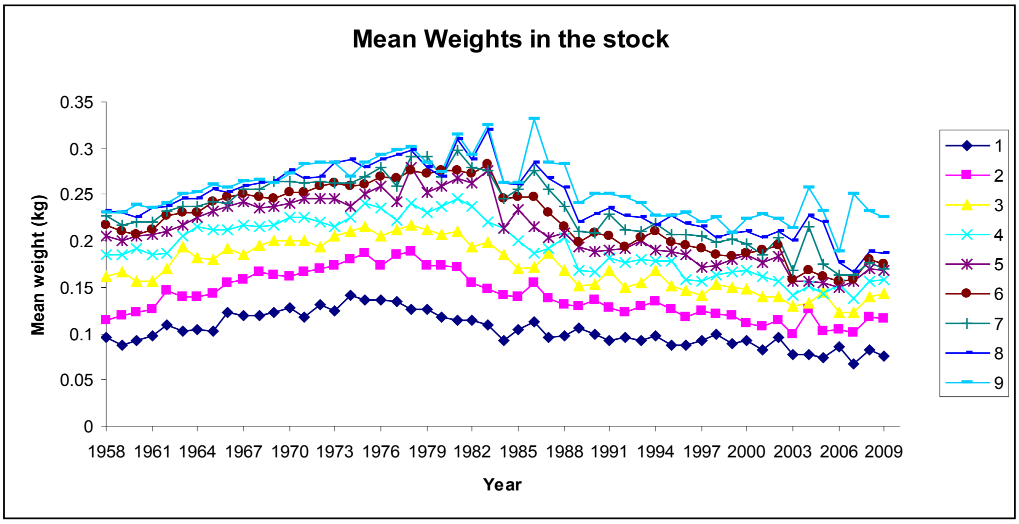


Figure 4.4.1.2. Celtic Sea and VIIj herring. Trends over time in mean weight at age in the stock at spawning time from 1-9+

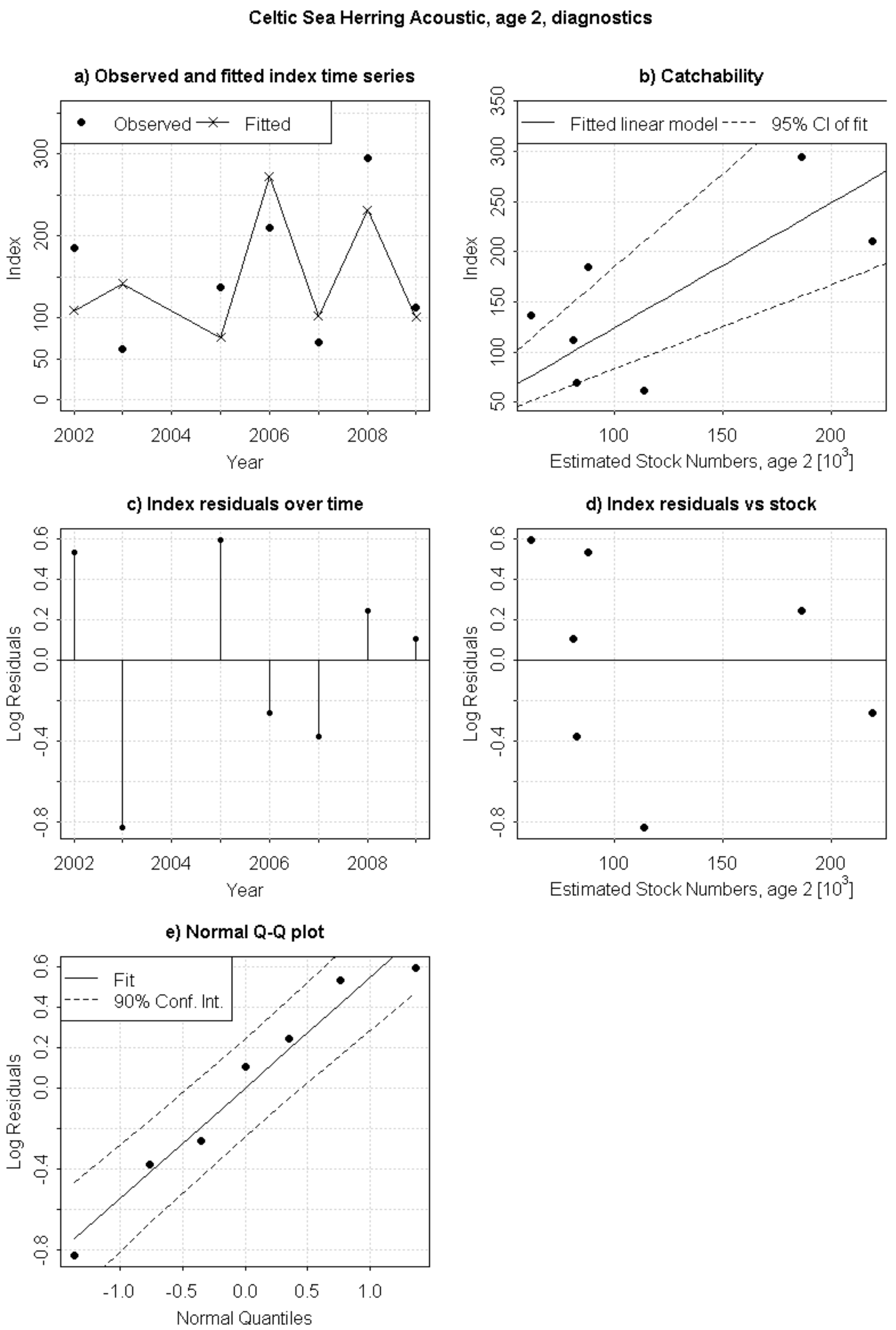


Figure 4.6.1.1. Celtic Sea and VIIj herring. Diagnostics from the Celtic Sea Herring Acoustic survey age 2.

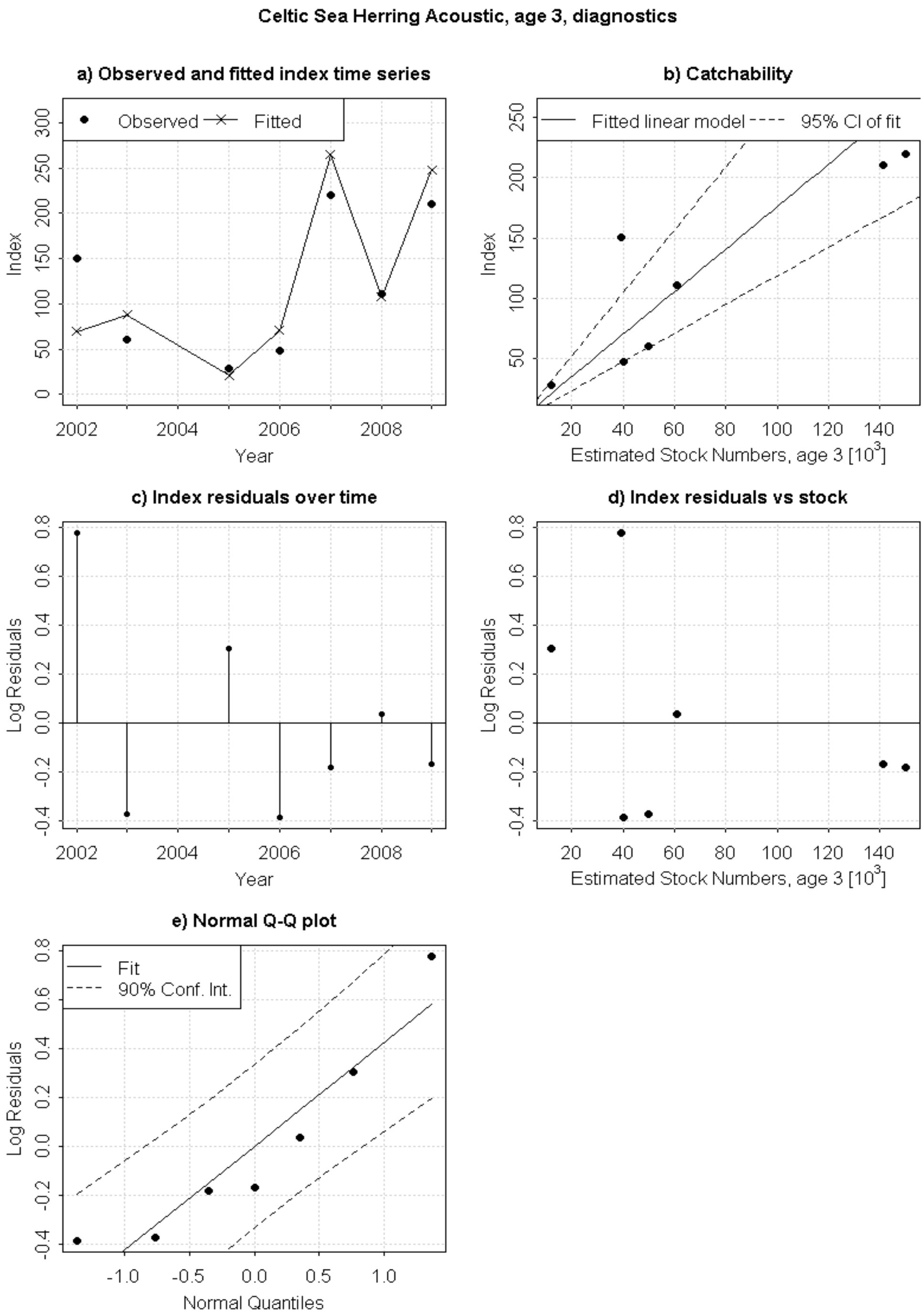


Figure 4.6.1.2. Celtic Sea and VIIj herring. Diagnostics from the Celtic Sea Herring Acoustic survey age 3.

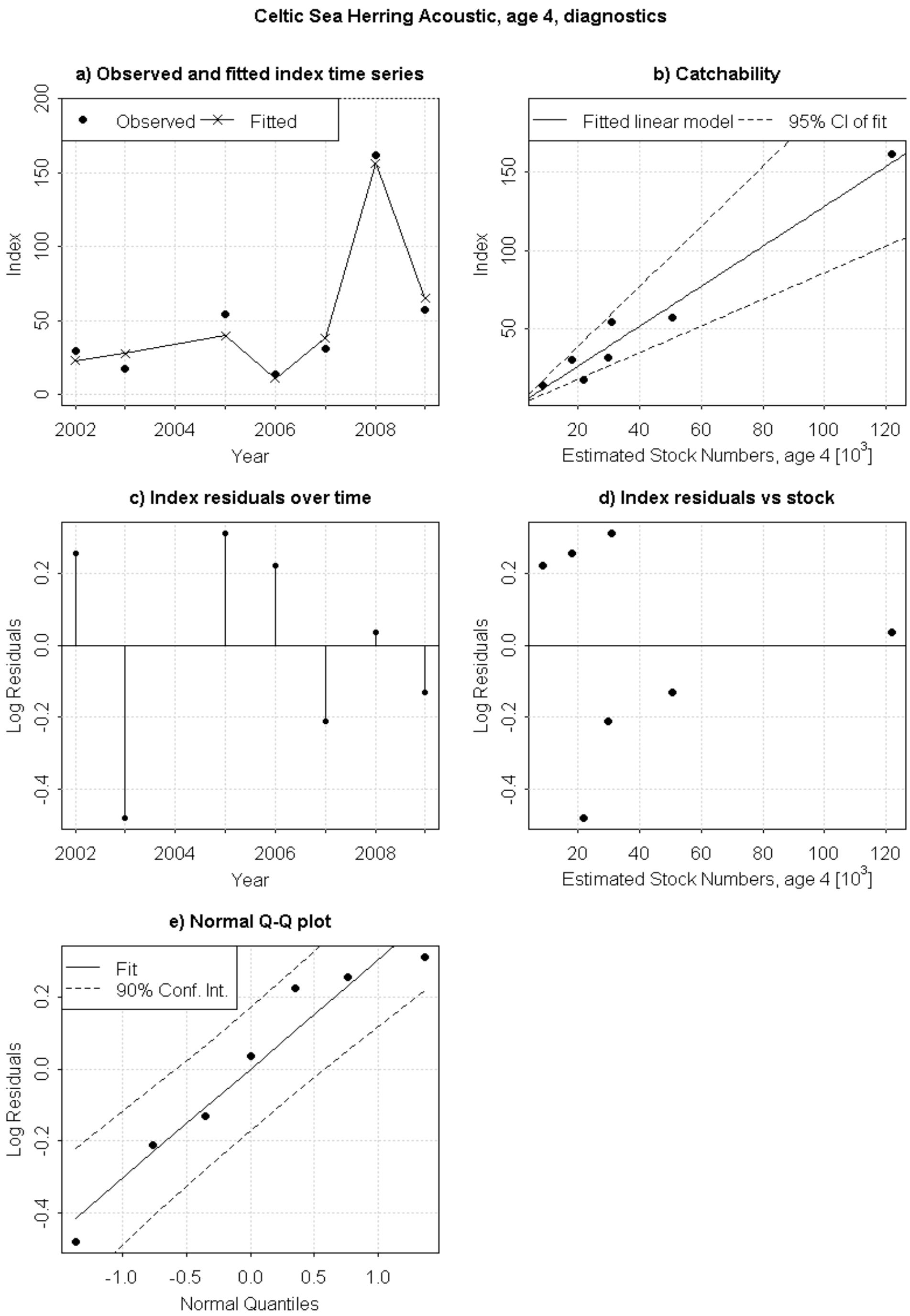


Figure 4.6.1.3. Celtic Sea and VIIj herring. Diagnostics from the Celtic Sea Herring Acoustic survey age 4.

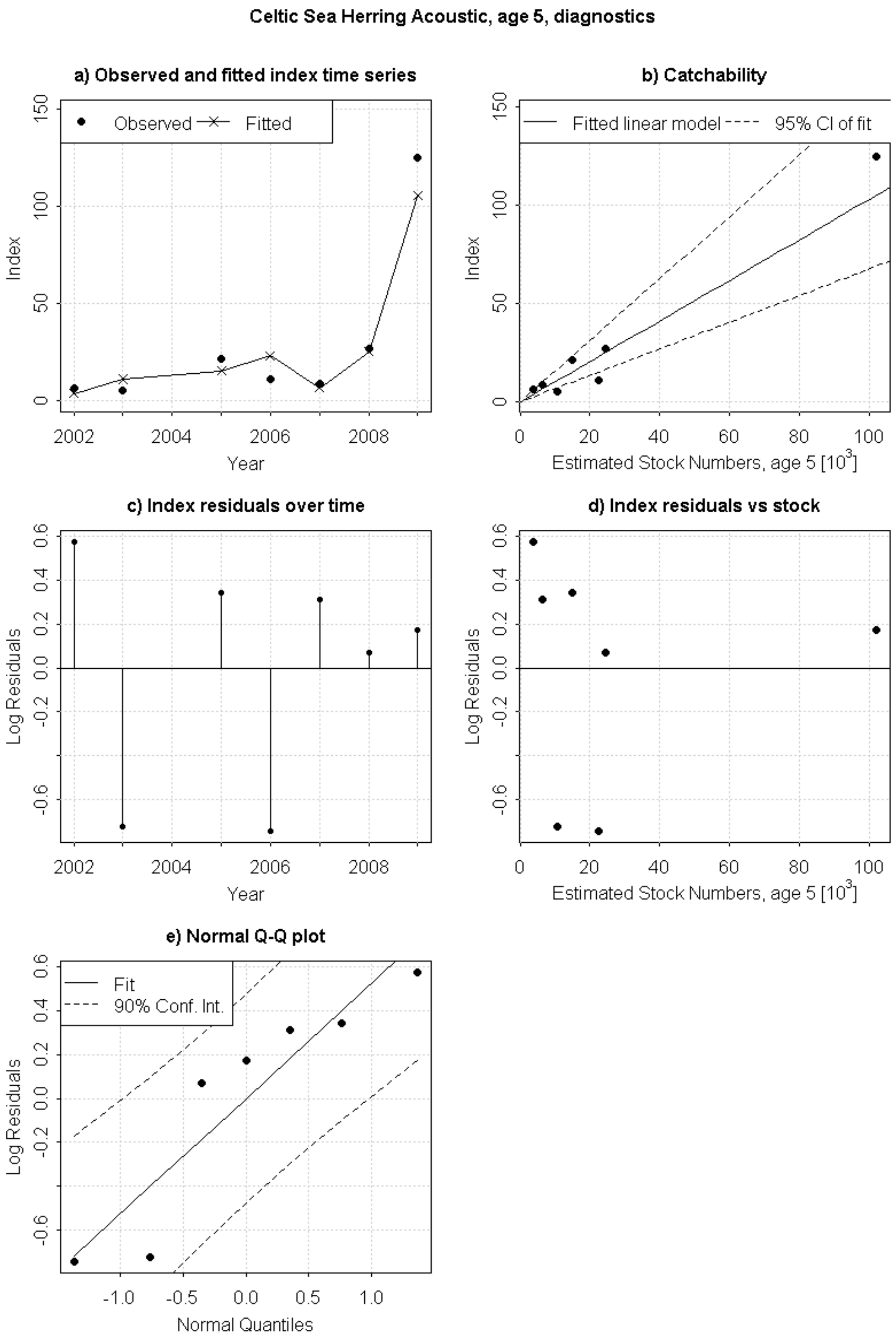


Figure 4.6.1.4. Celtic Sea and VIIj herring. Diagnostics from the Celtic Sea Herring Acoustic survey age 5.

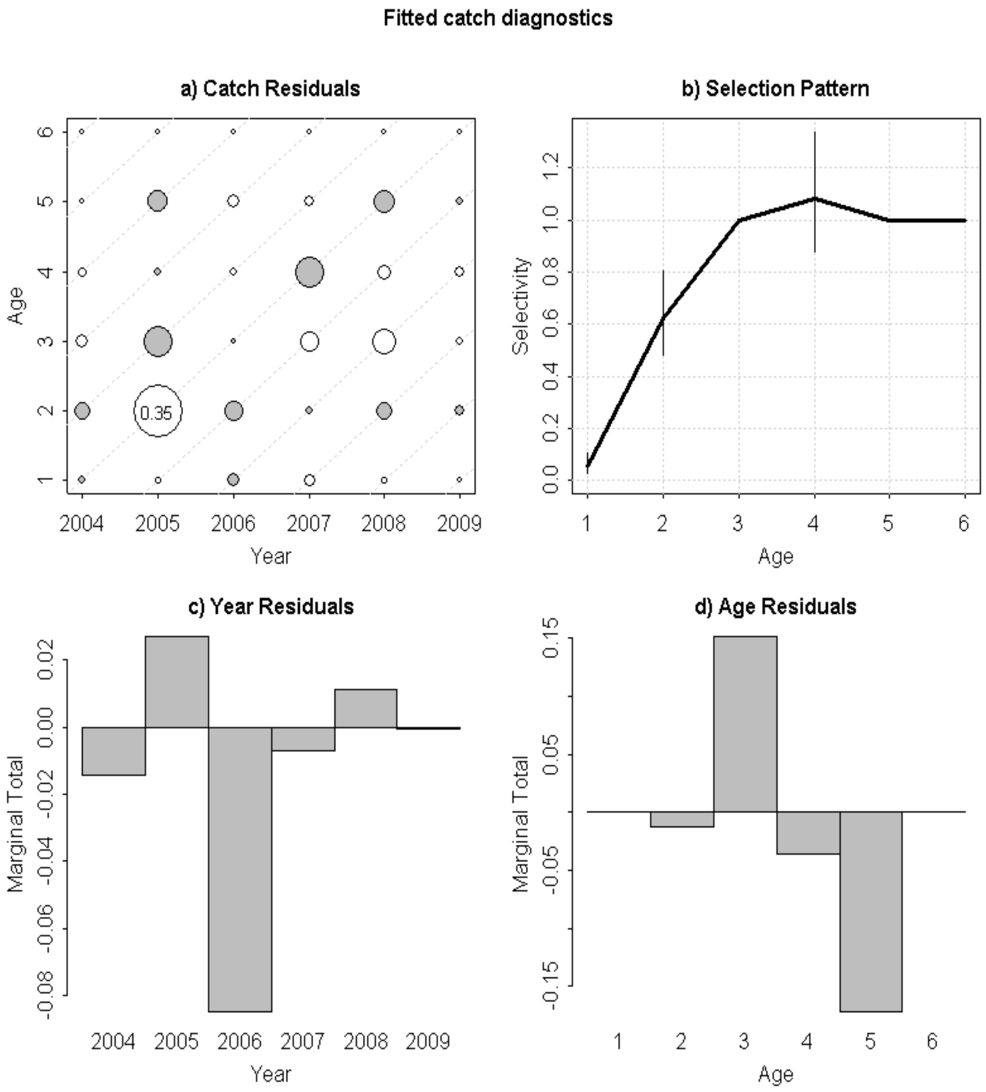


Figure 4.6.1.5. Celtic Sea and VIIj herring Illustration of selection patterns diagnostics, from deterministic calculation (6-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 3-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring.

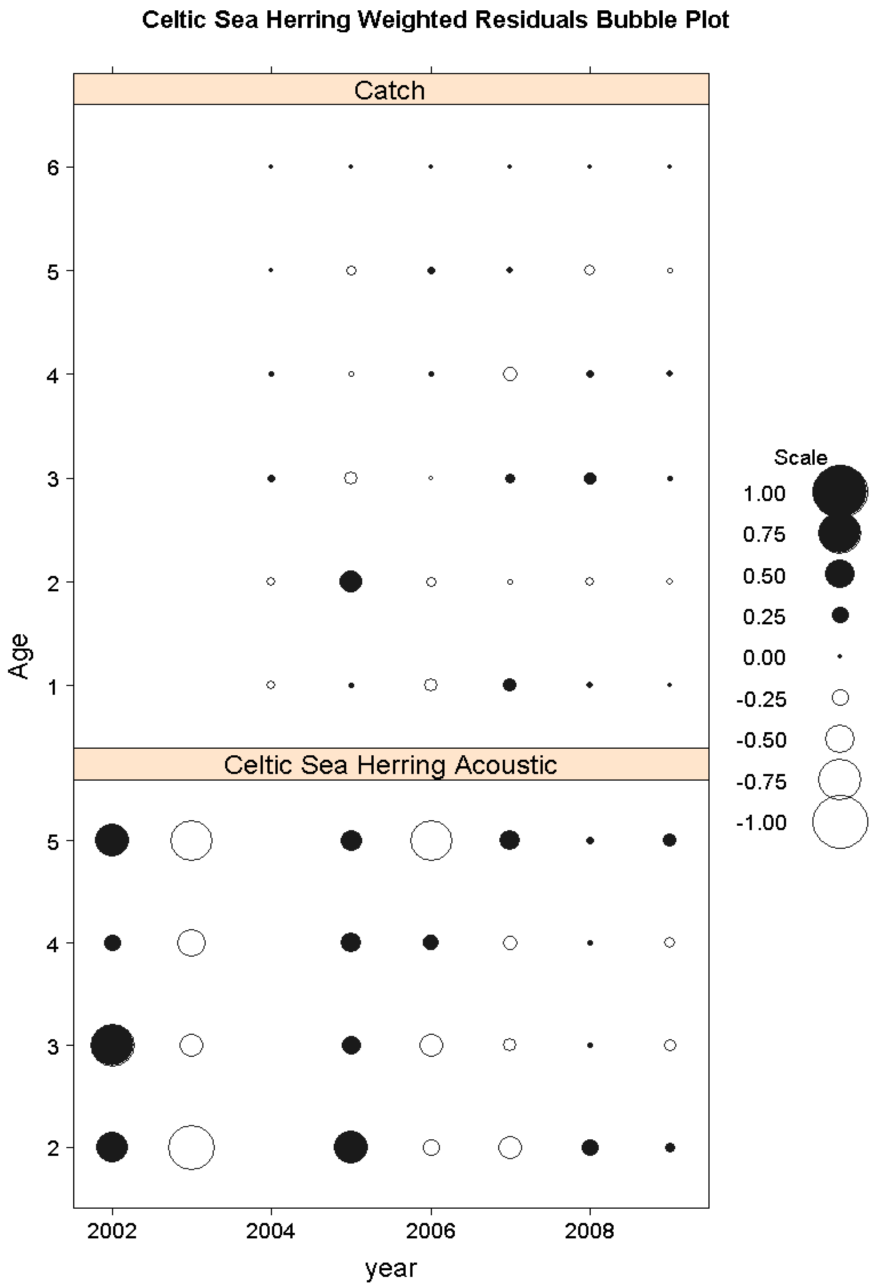


Figure 4.6.1.6. Celtic Sea and VIIj herring Weighted catch and survey residuals.

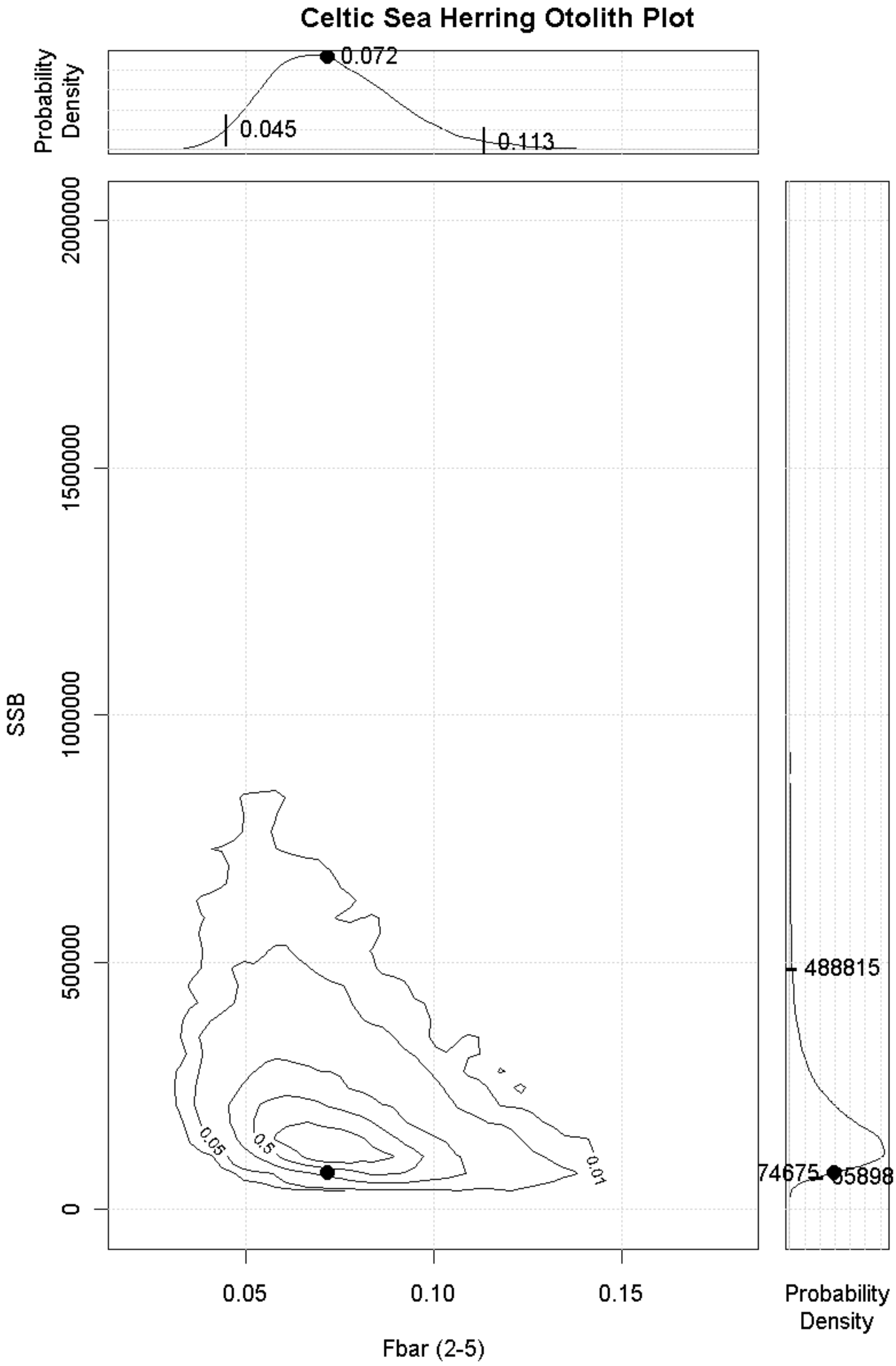


Figure 4.6.1.7. Celtic Sea and VIIj herring. Otolith plot showing the results of parametric bootstrapping from FLICA.

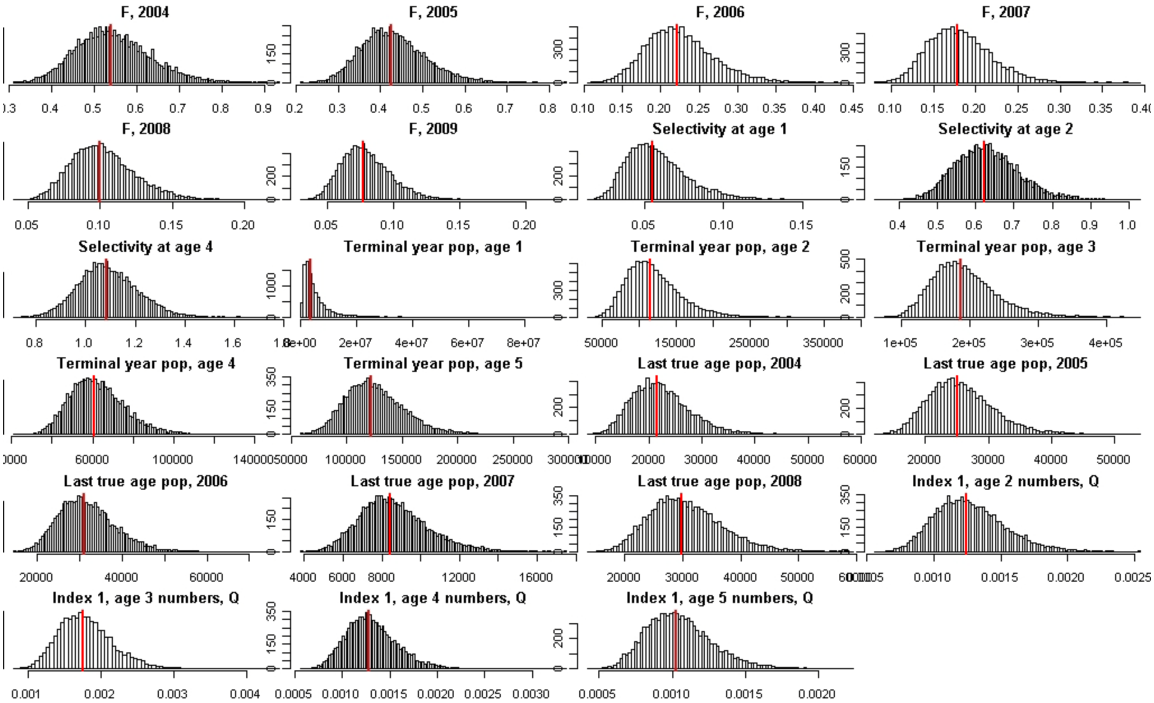


Figure 4.6.1.8. Celtic Sea and VIIj herring, Histograms showing the random draw of estimated parameters from FLICA.

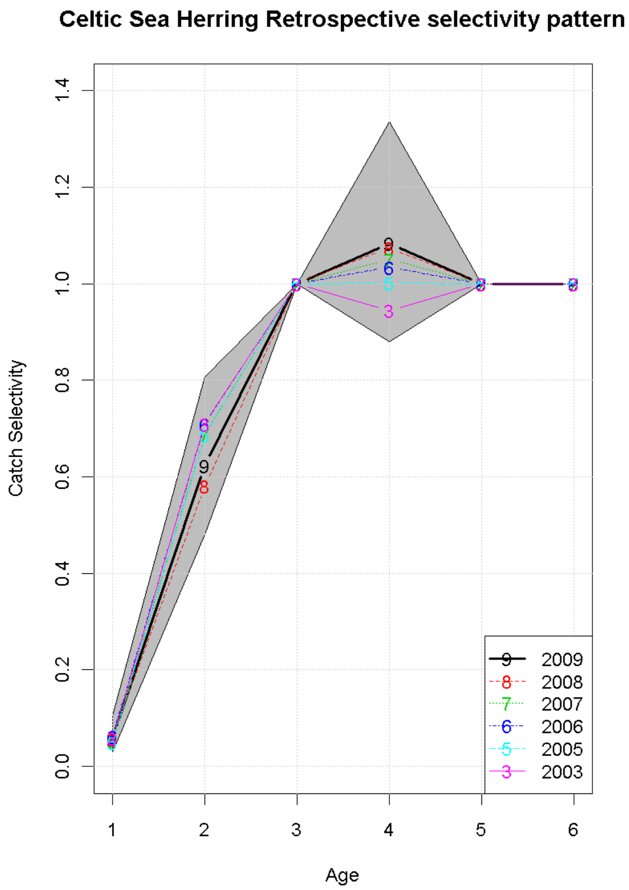


Figure 4.6.1.9. Celtic Sea and VIIj herring. Retrospective Selection pattern.

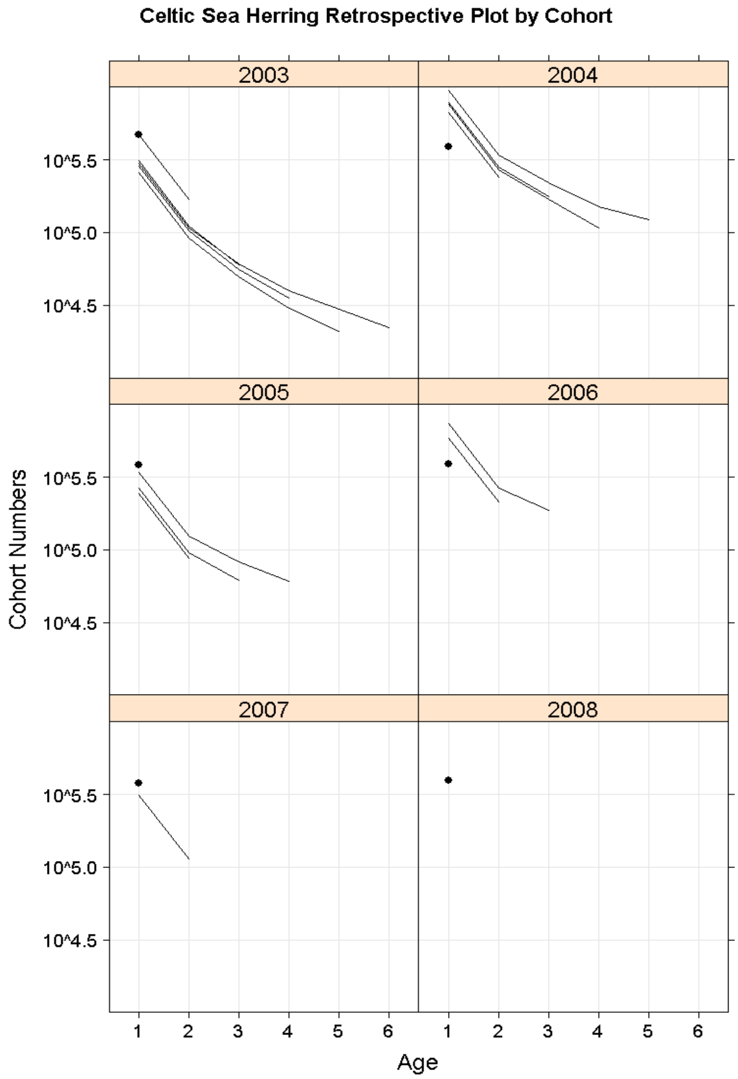


Figure 4.6.1.10. Celtic Sea and VIIj herring. Retrospectives by cohort.

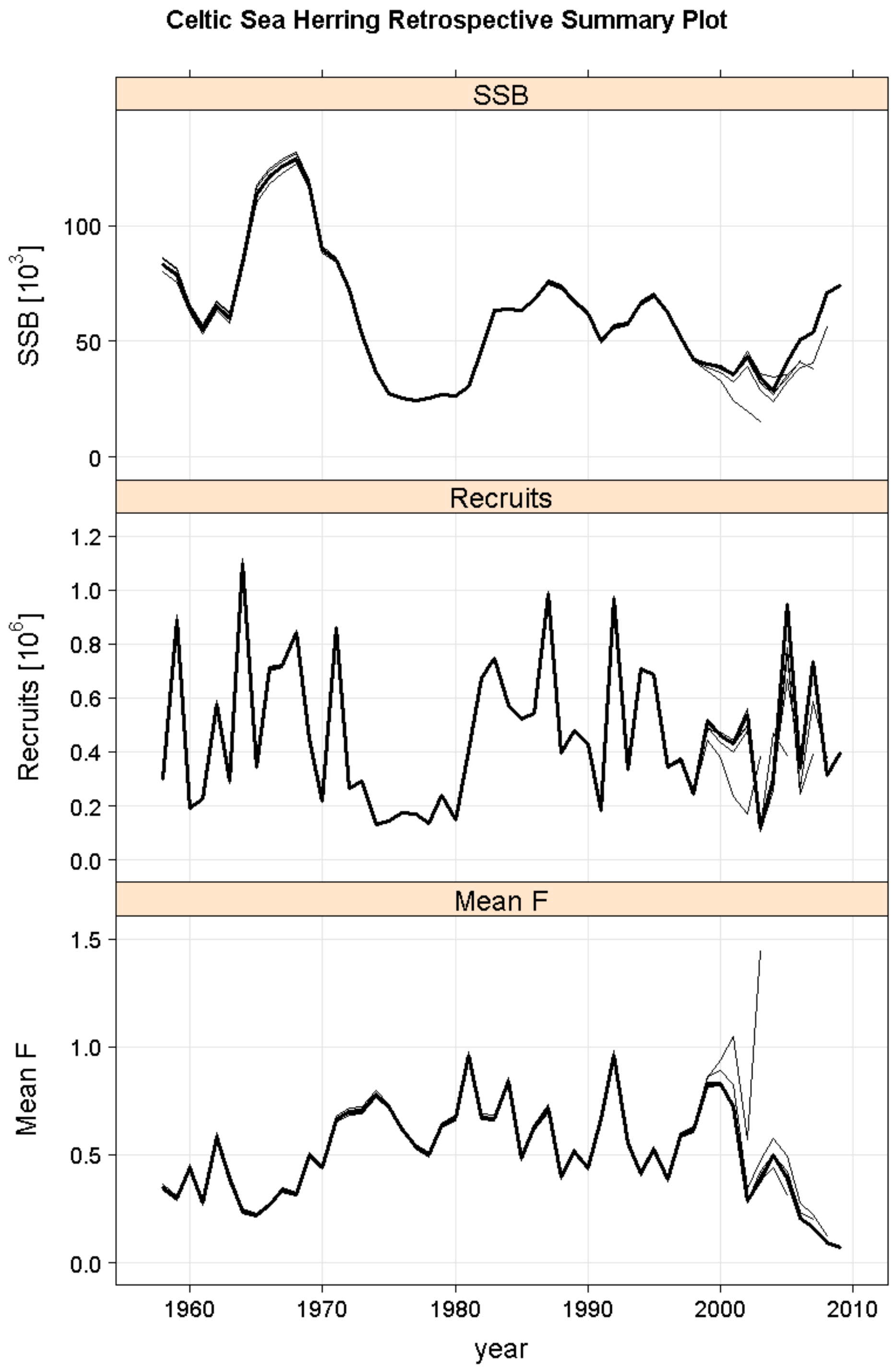
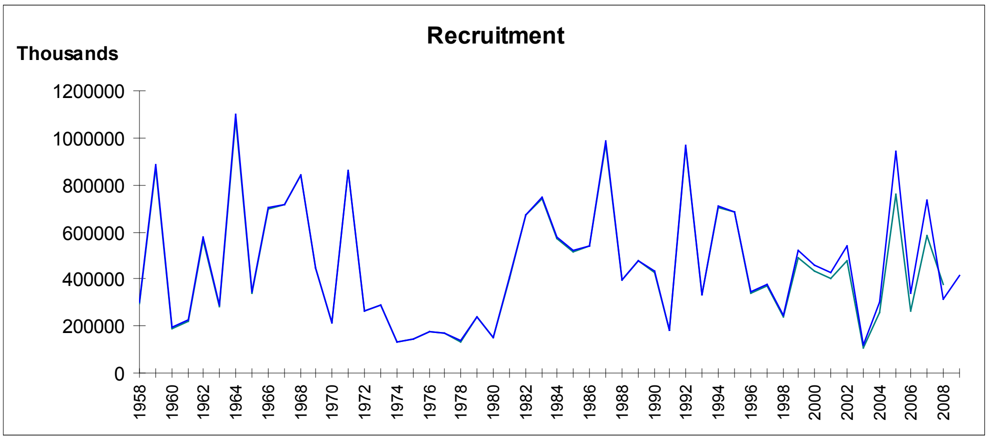
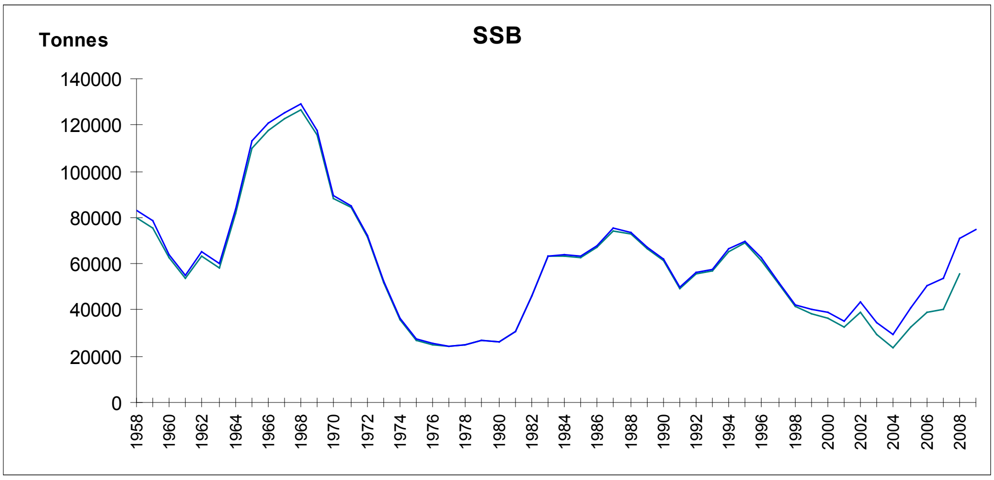


Figure 4.6.1.11. Celtic Sea and VIIj herring. Analytical retrospective pattern.





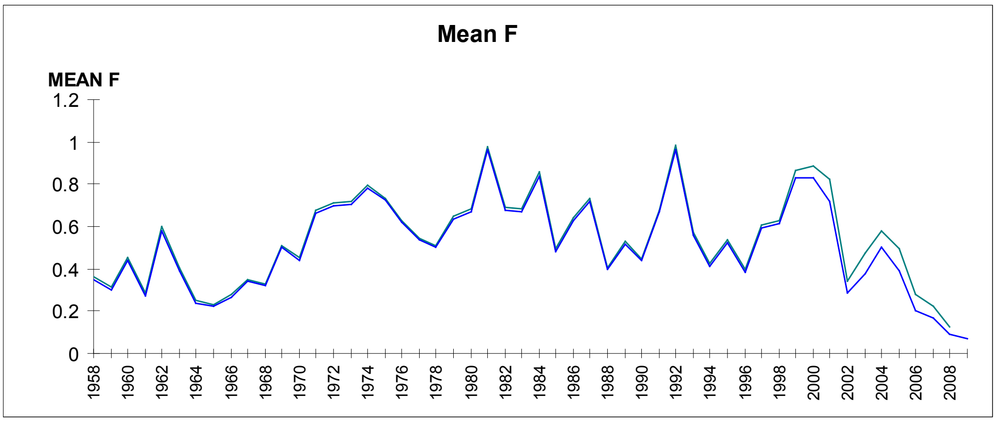
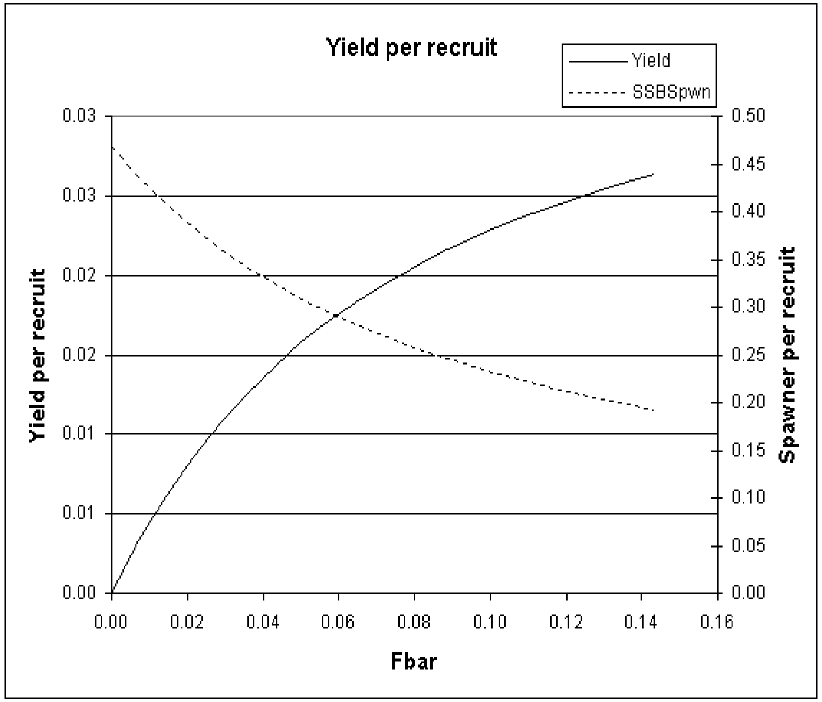
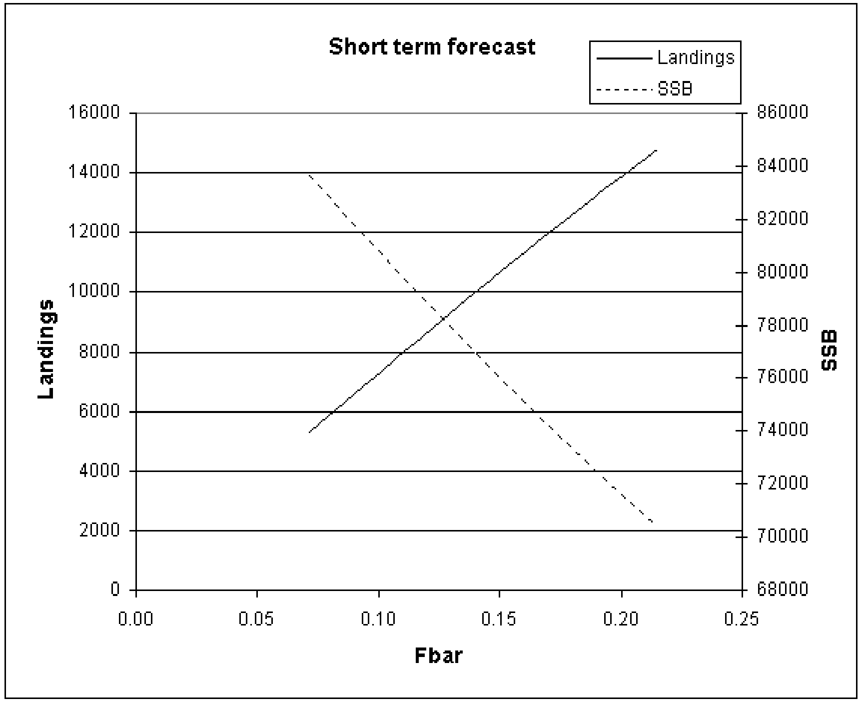


Figure 4.6.1.12. Celtic Sea and VIIj herring. Historical Retrospective based on the final assessments in 2008 and 2009.





Reference point F multiplier

Fbar(2-5)	1.0000	0.0718
FMax	>=1000000	
F0.1	2.3772	0.1706
F35%SPR	2.6314	0.1888
Flow	0.9124	0.0655
Fmed	3.0553	0.2192
Fhigh	6.7969	0.4877

Figure 4.7.2.1. Celtic Sea and VIIj herring. Yield per recruit curve.

5 Herring in Division VIa (North)

The location of the area occupied by the stock is shown in Figure 5.1. This is an update assessment.

Corrections were made to Section 5, after the working group had met, These relate to revised catch data. The revised catch data necessitated a rerun of the assessment and forecast. This section shows the results for the new assessment and forecast, and Appendix 14 gives details of the corrections. This new assessment and forecast follow the Stock Annex.

5.1 The Fishery

5.1.1 ACFM Advice Applicable to 2009 and 2010

ACFM reported in 2009 that the stock over recent years had been fluctuating at a low level and was being exploited close to F_{MSY}. Recruitment has been low since 1998, and the 2001 and 2002 year classes were very weak.

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 2010 is 24 420 t, which is in accordance with the agreed plan (see Section 5.1.3). The International TAC in 2009 was 21 760 t.

5.1.2 Changes in the VIa (North) Fishery.

Historically, catches have been taken from this area by three fisheries, (i) a Scottish domestic pair trawl fleet and the Northern Irish fleet; (ii) the Scottish single boat trawl and purse seine fleets and (iii) an international freezer-trawler fishery. The details of these fleets are described in the Stock Annex. In recent years the catch of the last two fleets has become more similar.

In 2009, the Scottish trawl fleet fished predominantly in areas similar to the freezer trawler fishery, and hardly in the coastal areas in the southern part of VIa (N). The Northern Irish fleet, unusually, did not fish in VIaN in 2009. Recently (since 2006) the majority of the fishery has been prosecuted in quarter 3. This pattern has continued in 2009, with 88% 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 2009, with 82% 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 2009 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 2009 and Allocation of Catches to Area for VIa (N)

For 2009 the preliminary report of official catches corresponding to the VIa (N) herring stock unit total 21 036 t, compared with the TAC of 21 760 t. The Working Group's estimates of area misreported and unallocated catches are 2 978 t. Various observer programs suggest that discarding is not perceived to be a problem.

The Working Group’s best estimate of removals from the stock in 2009 is 18 058 t (Table 5.1.1). These are revised catch figures from those available to the HAWG, with an increase of 3 879 t. The revisons are all within the UK catch data.

5.2 Biological composition of the catch

Catch and sample data, by country and by period (quarter), are detailed in Table 5.2.1. The number of samples used to allocate an age-distribution for the VIa (N) catches increased markedly from the low level seen over the last few years (except in 2006). There were 30 samples available in 2009, obtained from the Dutch (15), Scottish (13) and English (2) fleets. The Dutch and Scottish fleets each took a similar magnitude of catches in the area; the English fleet catch was slightly lower, at 26% of the UK catch. The English fleet catch was sampled by the Dutch. However, the samples were raised to the English reported catch. The available samples were used to allocate a mean age-structure (using the sample number weighting) to unsampled catches, in the same or adjacent quarters, as no sampling data were available for other quarters. The allocation of age structures to unsampled catches, and the calculation of total international catch-at-age and mean weight-at-age in the catches were made using the ‘sallocl’ programme (Patterson, 1998a). As 28 of the 30 samples obtained came from two of the major fisheries in one quarter (Netherlands and Scotland 3rd quarter) it is likely that they are reasonably representative of these catches, and reflect a large proportion of the fishery.

Catch number- and weight-at-age information is given in the ICA stock report section 5.6 (cf Table 5.6.2.1 and 5.6.2.2 respectively). Two larger year classes can be seen clearly in the catch-at-age table: 2000 and 2004 at 8- and 4-ringers respectively in 2009. The 2001, 2002 and 2003 year classes all appear relatively weak, with the 2002 year class the weakest. 1-ring herring in the catch are observed intermittently and are rarely representative of year class strength and are down-weighted in the assessment, (see Section 5.6).

5.3 Fishery Independent Information

5.3.1 Acoustic Survey – WoSHAS (MSHAS)

The survey values for number-, weight- and proportion mature-at-age in the stock were revised in 2009 (see Section 5.6.1).

The 2009 acoustic survey was carried out from the 29th June to the 18th July 2009 using a chartered commercial fishing vessel (MFV *Quantus*). Further details are available in the Report of the Working Group for International Pelagic Surveys (ICES 2010/ SSGESST:03). The commercial vessel changes through the time series, though year effects seen in the series are not linked to vessel effects. The spawning stock biomass estimate for VIa (North) from the acoustic survey (Table 5.3.1) has decreased by approximately 27% from 2008 (from 788 200 tonnes to 578 800 tonnes), to give the fourth highest estimate in the time series.

In 2009 quite similar year class proportions were seen in the catch and the survey. However, the catch showed slightly higher proportions of 2- to 4-ringers, whereas the survey showed higher proportions of 8-ring fish. There is no basis for concluding which of the sources of data are more reliable (ICES 2010/SSGESST:03) (cf. Figure 5.6.2.12 for residuals in the fitted model).

The survey shows quite good internal consistency (Figure 5.3.1.1) for the older ages (5- to 9-ringers), but not for the 1- to 4-ringers. The 1-ringers are downweighted in the assessment. The 2-, 3- and 4-ringers are not because there is no other fishery-independent information available for this stock.

5.4 Mean weights-at-age and maturity-at-age

5.4.1 Mean Weight-at-age

Weights-at-age in the stock from acoustic surveys are given in Tables 5.3.1 (for the current year) and 5.6.2.3 (for the time series); weights-at-age in the catches are given in Section 5.6.2 (cf. Table 5.6.2.2) and are used in the assessment. The weights-at-age in the catch are comparable to previous years for older ages, with slightly higher weights from 3- to 5-ring herring. The weights-at-age in the stock have continued the gradual increase seen since 2007 (cf. Table 5.6.2.3).

5.4.2 Maturity Ogive

The maturity ogive is obtained from the acoustic survey (Table 5.3.1). The survey provides estimated values for the period 1991 to 2009 (cf. Table 5.6.2.5). In 2009, 70% of the 2-ring fish were mature. This is a reduction from 2008 where 98% of the 2-ring fish caught were mature. The 2008 value was the second highest proportion mature at this age since 1992 when measurements began, with the highest value (virtually 100% mature) seen in 2007. The sensitivity of the assessed SSB to the estimated maturity was investigated in 2008 (ICES 2008/ACOM:02) where the assessment was re-run with fraction mature at 2-ring taken from average maturity for the years 2004-2006. This resulted in a 4% reduction of SSB in 2007. This was considered to be negligible in the context of the precision of the estimate of SSB.

5.5 Recruitment

There are no specific recruitment indices for this stock. Although both catch and acoustic survey generally have some catches at 1-ring both the fishery and survey encounter this age group only incidentally. The first reliable appearance of a cohort appears at 2-ring in both the catch and the stock. Thus in predictions, estimates of both 1- and 2-ring herring numbers from the assessment are replaced for prediction years.

5.6 Assessment of VIa (North) herring

5.6.1 Acoustic Input Data revision

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 (WD to HAWG 2010).

Several changes were calculated for 1987, 1991, 1993, 1994, 1995, 1997, 1999, 2000, 2001 and 2005. An assessment was then carried out in FLICA (Kell et al. 2007; Patterson 1998), using the same settings (SPALY) as in the 2009 HAWG, to determine any differences in the perception of the stock arising as a result of the changes to the input files. The survey time series in the 2009 HAWG was 1987, 1991-2008 and 1991-2008 in the assessment carried out with the revised data.

Both the revised and HAWG 2009 assessments have an 8 year separable period, from 2001 – 2008, tuned using the different survey time series above. Both use catch data from 1957 to 2008 giving an assessment of F from 1957 to 2008 and numbers-at-age from 1 Jan 1957 to 2009.

The HAWG 2009 assessment gave an SSB for 2008 of 91 884 t and a mean fishing mortality (3 to 6-ringers) of 0.155. The revised assessment gives an SSB for 2008 of 86 334 t and a mean fishing mortality (3 to 6-ringers) of 0.165, a change of around 6% in both SSB and F, downwards and upwards respectively.

The differences in SSB and F for the last ten years in the time series (1999 to 2008) between the Final HAWG 2009 assessment and the revised assessment are given in Table 5.6.1.1. The updated numbers-, weights-at-age in the stock, proportion mature and revised SSB time series are given in the Stock Annex.

The separable model residual patterns for the two runs (Final HAWG 2009 and revised survey input data) are virtually identical (Figure 5.6.1.1). The magnitude and location of residuals shown in the bubble plots are consistent and the year residuals follow the same pattern. The age residuals values are all small and there are no trends with age. However, the values are slightly larger when the revised survey data are used.

Figure 5.6.1.2 shows the values for SSB and F produced by the two assessment runs. There is a minimal difference between the two values for both SSB and F, with a marginally lower SSB, and therefore higher F, with the run using the revised survey data. These differences (Table 5.6.1.5) are well within the bounds of the confidence intervals of the assessment. There is no change to the perception of the stock, that it is above B_{lim}, and being fished below target and below F_{MSY}.

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).

5.6.2 Stock Assessment

This is an update assessment using FLICA (Kell 2007, Patterson 1998a) with the same settings as in 2009, using the revised catch data, post HAWG 2010, with the 8 year separable period moved forward one year to 2002 – 2009. However, it is tuned using the new recommended survey time series (1991-2009). The assessment uses catch data from 1957 to 2009 giving an assessment of F from 1957 to 2009 and numbers-at-age from 1 Jan 1957 to 2010. The input data are given in Tables 5.6.2.1-8, the run settings are presented in Tables 5.6.2.9-11.

The results of the assessment are given as stock summary in Table 5.6.2.12 and Figure 5.6.2.1. The output values are in Tables 5.6.2.13-17. Run diagnostics are given in Tables 5.6.2.18–20 and Figures 5.6.2.2-12. The parameter estimates are given in Table 5.6.2.21.

The separable model diagnostics (Table 5.6.2.18 and Figure 5.6.2.2) show that the total residuals by age and year between the catch and separable model are reasonably trend-free. The 2000 year class is still reasonably abundant in the catch and survey data in 2009 (8-ringers). A second year class (2004, 4-ringers in 2009) is also reasonably abundant in the catch and survey data in 2009. In 2009, the catch data suggested a better recruitment of the 2006 year class (2-ringers in 2009) but this was not apparent in the survey. The survey suggested that the 2007 year class (1-ringers in 2009) was stronger. 1-ringers are poorly represented in the catch. The fits between survey and assessment are illustrated in Figures 5.6.2.3-11 for ages 1 to 9+ winter rings. The poor fit at age 1 supports the downweighting of this index. The best fits are to middle ages 3-5.

The assessment shows continuing low levels of recruitment (the 2001, 2002 and 2003 year classes are all weak). The tuning diagnostics (Figures 5.6.2.3 to 5.6.2.12 and Table 5.6.2.17-21) show year effects in the survey that the assessment is sensitive to. The assessment fits between negative and positive residuals in the last two years of the assessment. The analytical retrospective (Figure 5.6.2.13) plots show that the assessment is noisy but now shows a reasonably stable but historically low stock level. Although the assessment is noisy, it gives a clear indication of the state of the stock in its historical context.

In conclusion, this assessment is driven by a noisy survey, giving the third lowest survey SSB estimate in 2007 to the second highest survey estimate in 2008. Point estimates of SSB and F from the survey are, therefore, not that informative and should be used to indicate medium term trends and used for guidance. The current management agreement that restricts large inter-annual changes in TACs is appropriate for such a noisy assessment.

5.6.2.1 State of the stock

The assessment gives an SSB for 2009 of 79 755 t and a mean fishing mortality (3 to 6-ringers) of 0.22. SSB has been stable in recent years. However, the outcome of the assessment this year suggests a slightly lower position to last year's assessment with SSB around 20% below the average of the last 20 years. F has increased to F=0.22 from last year (F=0.16). Catch in 2009 increased by 15% compared to 2008. Recruitment is low for the 2001, 2002 and 2003 year classes (Table 5.6.2.12). The 2004 recruitment currently appears to be around half the level of the last reasonable year class (2000); the 2005 and 2006 year classes appear to be around the same level as the poor 2001 – 2003 year classes. 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}.

Short-term projections were carried out using MFDP (Smith 2000), with the same settings as last year (TAC constraint). Input data are stock numbers on 1st January in 2010 from the 2009 ICA assessments (Section 5.6.2, Table 5.7.1.1), with geometric mean recruitment 1989-2007 replacing recruitment for 1-ringers in both 2009 and 2010 and survival of these recruits (as 2-ringers) in 2010. This period has been chosen as it represents the lower productivity regime experienced by the stock in this recent period. The retrospective assessment of recruitment estimates in the 2003 Working Group (ICES 2003/ACFM:17) showed the substantial revision of 1- and 2-ring herring abundance (1st January survivors) in subsequent assessments, justifying the use of geometric means for these ages. The selection pattern used is taken from the final year of the ICA assessment (Table 5.6.2.16, and Figure 5.6.2.2), and is therefore effectively the mean of last 8 years. For the projections, data for maturity, natural mortality, mean weights-at-age in the catch and in the stock are means of the three previous years (i.e., 2007 - 2009). A TAC constraint of 24 420 t in 2010 is used for the basis for the intermediate year in the projection, this implies an exploitation at F=0.28, above the target F. All the input values are summarised in Table 5.7.1.1.

The results of the short-term projection using the TAC 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), the F target in the accepted management plan is consistent with the MSY approach.

For F in accordance with the management plan using the TAC constraint (SSB2011 < 88 000 t, F =0.25 in 2011, TAC decrease of 13%) catches are projected to be 21 200 t, and SSB rises to approximately 93 000 t in 2012.

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 0.18.

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_{trig} at 75 000 t.

F_{MSY} target and trigger for new advisory framework

HAWG met before the new ICES framework had been developed. However HAWG was expected to comment on new F_{MSY} targets to inform the new advisory framework. The matter is discussed in detail in section 1.3 of this report.

At present HAWG considers that the parameters of the management plan do conform to the MSY approach.

5.9 Quality of the Assessment

This year's estimate of SSB for 2008 is around 99 000 t, compared with 92 000 t in last year's final assessment run, an increase of 4%.

The HAWG accepted this year's assessment. The quality of the assessment is the same as last year's. The precision of the assessment estimated through parametric bootstrap is shown in Figure 5.9.1. The influence of model settings was explored in 2009 (ICES 2009) and showed some differences but does not change the conclusions that F is below target F and SSB is above B_{trig}. The assessment outcomes were revised downwards from those made last year. SSB, catch and F estimated in last year's assessment and short term forecast are compared with this year's assessment in the text table below.

	2009 Assessment		2010 Assessment		Percentage change in estimate 2009-2010	
Year	SSB	F_{3-6}	SSB	F_{3-6}	SSB	F_{3-6}
2007	91848	0.288	98903	0.267	7.68	-7.29
2008	91884	0.16	99141	0.143	7.90	-10.63
2009*	94252	0.25	79755	0.224	-15.38	-10.40

***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 2009 to 2005 (Figure 5.6.2.13) support the perception of a noisy but fairly well balanced assessment.

5.10 Management Considerations

An analytical assessment shows that SSB (in 2010) is approx. 1.6 times B_{lim}. ICES considers that the stock is currently fluctuating at a low level and is being exploited close to F_{MSY}. Recruitment has been low since 1998, and the 2001, 2002 and 2003 year classes are weak.

There has been considerable uncertainty in the amount of landings from this stock in the past. Area misreporting is less of a problem than in the past, but almost all countries still take catches of herring in other areas and report it into VIa (N). Increased observer coverage and use of VMS and electronic log books is helping to reduce these problems.

The assessment is noisy, leading to annual revisions of SSB and F. The management plan has been designed to cope with this by applying a constraint on year-on-year change in TAC. Revisions in SSB can be upwards or downwards, so it is important to maintain the restrictions on change in TAC both when the stock is revised upwards or downwards. Asymmetrical changes in TAC have not been tested.

The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER. This identified Division VIa (N) as an area where catches comprise a mixture of fish from Divisions VIa (N), VIa (S), and VIIa (N). Concerning the management plan for Division VIa (N), ICES has advised that herring components should be managed separately to afford maximum protection. If there is an increasing catch on the mixed fishery in Division VIa (N), this should be considered in the management of the Division VIa (S) component which is in a depleted state. In 2008 ICES began to evaluate management for this Division VIa (S) and VIIa (N). It will be a number of years before ICES can provide a fully operational integrated strategy for these units. In this context HAWG recommends that the management plan for Division VIa (N) should be continued.

5.11 Ecosystem Considerations

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

Observers monitor the fisheries. Herring fisheries tend to be clean with little bycatch of other fish. Scottish discard observer programs since 1999 and more recently Dutch observers indicate that discarding of herring in these directed fisheries is at a low level. The Scottish discard observer programs have recorded occasional catches of seals and zero catches of cetaceans.

5.12 Changes in the environment

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES 2006/LRC:03). It is considered that this may have implications for herring. It is known that similar environmental changes have affected the North Sea herring. There is evidence that there have been recent changes of the productivity of this stock (ICES 2007/ACFM:11).

Herring are thought to be a source of food for seals. Grey seals (*Halichoerus grypus*) are common in many parts of the Celtic Seas area. The majority of individuals are found in the Hebrides and in Orkney (SCOS 2005). A recent study (Hammond & Harris 2006) of seal diets off western Scotland revealed that grey seals may be an important predator for cod, herring and sandeels in this area. Common seals (*Phoca vitulina*) are also widespread in the northern part of the ecoregion with around 15,000 animals estimated (SCOS 2005). The numbers of seals in VIa (N) is thought to have increased over the last decades. The seal consumption of herring is estimated with great uncertainty and the impact of increased predation is not known, but there is a possibility that seal predation could influence natural mortality.

Table 5.1.1. Herring in VIa (North). Catch in tonnes by country, 1986-2009. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1986	1987	1988	1989	1990	1991	1992	1993
Denmark								
Faroes	400				326	482		
France	18	136	44	1342	1287	1168	119	818
Germany	2188	1711	1860	4290	7096	6450	5640	4693
Ireland	6000	6800	6740	8000	10000	8000	7985	8236
Netherlands	5160	5212	6131	5860	7693	7979	8000	6132
Norway	4799	4300	456		1607	3318	2389	7447
UK	25294	26810	26894	29874	38253	32628	32730	32602
Unallocated	37840	18038	5229	2123	2397	-10597	-5485	-3753
Discards				1550	1300	1180	200	
Total	81699	63007	47354	53039	69959	50608	51578	56175
Area-Misreported	-10935	-18647	-11763	-19013	-25266	-22079	-22593	-24397
WG Estimate	70764	44360	35591	34026	44693	28529	28985	31778
Source (WG)	1988	1989	1990	1991	1993	1993	1994	1995

Country	1994	1995	1996	1997	1998	1999	2000	2001
Faroes								
France	274	3672	2297	3093	1903	463	870	760
Germany	5087	3733	7836	8873	8253	6752	4615	3944
Ireland	7938	3548	9721	1875	11199	7915	4841	4311
Netherlands	6093	7808	9396	9873	8483	7244	4647	4534
Norway	8183	4840	6223	4962	5317	2695		
UK	30676	42661	46639	44273	42302	36446	22816	21862
Unallocated	-4287	-4541	-17753	-8015	-11748	-8155		
Discards	700			62	90			
Total	54664	61271	64359	64995	65799	61514	37789	35411
Area-Misreported	-30234	-32146	-38254	-29766	-32446	-23623	-19467	-11132
WG Estimate	24430	29575	26105	35233*	33353	29736	18322$	24556$
Source (WG)	1996	1997	1997	1998	1999	2000	2001	2002

Country	2002	2003	2004	2005	2006	2007	2008	2009
Faroes	800	400	228	1810	570	484	927	1544
France	1340	1370	625	613	701	703	564	1049
Germany	3810	2935	1046	2691	3152	1749	2526	27
Ireland	4239	3581	1894	2880	4352	5129	3103	1935
Netherlands	4612	3609	8232	5132	7008	8052	4133	5675
Norway								
UK	20604	16947	17706	17494	18284	17618	13963	11076
Unallocated	878	-7						
Discards			123	772	163			
Total	36283	28835	29854	31392	34230	33735	25216	21306
Area-Misreported	-8735	-3581	-7218	-17263	-6884	-4119	-9162	-2798
WG Estimate	32914$	28081$	25021$	14129$	27346	29616	16054	18508
Source (WG)	2003	2004	2005	2006	2007	2008	2009	2010

$Revised at HAWG 2007

Table 5.2.1. Herring in VIa (North). Catch and sampling effort by nations participating in the fishery in 2009.

Summary of Sampling by Country

AREA : VIa(N)

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	3802.00	4351.00	2	222	50	100.16
Faroes	0.00	1544.00	0	0	0	0.00
France	0.00	1049.00	0	0	0	0.00
Germany	0.00	27.00	0	0	0	0.00
Ireland	0.00	1935.00	0	0	0	0.00
Netherlands	4812.00	5675.00	15	1889	375	100.23
Northern Ireland	0.00	251.00	0	0	0	0.00
Scotland	6385.00	6474.00	13	1772	568	106.09
Total VIa(N)	14999.00	21306.00	30	3883	993	102.71

Sum of Offical Catches : 21306.00
Unallocated Catch : -2798.00
Working Group Catch : 18508.00

PERIOD : 1

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	17.00	0	0	0	0.00
Faroes	0.00	1421.00	0	0	0	0.00
Ireland	0.00	667.00	0	0	0	0.00
Netherlands	0.00	4.00	0	0	0	0.00
Scotland	0.00	1.00	0	0	0	0.00
Period Total	0.00	2110.00	0	0	0	0.00

Sum of Offical Catches : 2110.00
Unallocated Catch : -671.00
Working Group Catch : 1439.00

PERIOD : 2

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
Faroes	0.00	113.00	0	0	0	0.00
Period Total	0.00	113.00	0	0	0	0.00

Sum of Offical Catches : 113.00
Unallocated Catch : 0.00
Working Group Catch : 113.00

PERIOD : 3

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	3802.00	3802.00	2	222	50	100.16
France	0.00	1049.00	0	0	0	0.00
Ireland	0.00	2.00	0	0	0	0.00
Netherlands	4812.00	5463.00	15	1889	375	100.23
Scotland	6385.00	6385.00	13	1772	568	106.09
Period Total	14999.00	16701.00	30	3883	993	102.71

Sum of Offical Catches : 16701.00
Unallocated Catch : -653.00
Working Group Catch : 16048.00

PERIOD : 4

Country	Sampled Catch	Official Catch	No. of samples	No. measured	No. aged	SOP %
England & Wales	0.00	532.00	0	0	0	0.00
Faroes	0.00	10.00	0	0	0	0.00
Germany	0.00	27.00	0	0	0	0.00
Ireland	0.00	1266.00	0	0	0	0.00
Netherlands	0.00	208.00	0	0	0	0.00
Northern Ireland	0.00	251.00	0	0	0	0.00
Scotland	0.00	88.00	0	0	0	0.00
Period Total	0.00	2382.00	0	0	0	0.00

Sum of Offical Catches : 2382.00
Unallocated Catch : -1474.00
Working Group Catch : 908.00

Table 5.3.1. Herring in VIa (North). Estimates of abundance, biomass, maturity, weight- and length-at-age from the 2009 Scottish acoustic survey. Thousands of fish at age and spawning biomass (SSB, thousand tonnes). N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Age (ring)	Numbers	Biomass	Maturity	weight(g)	Length (cm)
0					
1	346	20	0.00	59.0	18.5
2	187	28	0.70	151.5	24.8
3	264	55	1.00	206.4	27.5
4	430	96	1.00	223.3	28.3
5	374	87	1.00	233.1	28.6
6	219	51	1.00	231.2	28.6
7	187	43	1.00	231.8	28.6
8	500	116	1.00	232.3	28.6
9+	456	109	1.00	238.2	28.8
Immature	403	26		64.9	19.0
Mature	2,560	579		226.2	28.4
Total	2,962	605	0.86	204.2	27.1

Table 5.6.1.1. Herring in VIa (North). Comparison of the values of SSB and F3-6 derived from the assessment results from the 2009 HAWG and using the revised survey input values.

	2009 Final HAWG assessment SSB	2009 revised assessment SSB	% change in SSB	2009 Final HAWG assessment F3-6	2009 revised assessment F3-6	% change in F3-6
1999	81 928	80 369	-1.90	0.3025	0.309	2.15
2000	69 449	67 887	-2.25	0.2368	0.2422	2.28
2001	113 982	111 320	-2.34	0.241	0.2478	2.82
2002	134 943	131 471	-2.57	0.2668	0.2748	3.00
2003	133 947	129 803	-3.09	0.2315	0.2398	3.59
2004	119 690	115 318	-3.65	0.1948	0.2028	4.11
2005	98 238	94 359	-3.95	0.1202	0.1252	4.16
2006	93 270	88 985	-4.59	0.2272	0.2375	4.53
2007	91 848	86 907	-5.38	0.2875	0.3025	5.22
2008	91 884	86 334	-6.04	0.1555	0.165	6.11

Tables 5.6.2.1. – 5.6.2.21. 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 5.6.2.1 HERRING in VIa (N). CATCH IN NUMBER

Units : Thousands

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	6496	15616	53092	3561	13081	55048	11796	26546	299483	211675	207947
2	74622	30980	67972	102124	45195	92805	78247	82611	19767	500853	27416
3	58086	145394	35263	60290	61619	22278	53455	70076	62642	33456	218689
4	25762	39070	116390	22781	33125	67454	11859	26680	59375	60502	37069
5	33979	24908	24946	48881	22501	44357	40517	7283	22265	40908	39246
6	19890	27630	17332	11631	12412	19759	26170	24227	5120	19344	29793
7	8885	17405	16999	10347	5345	24139	8687	18637	22891	5563	11770
8	1427	9857	7372	6346	4814	6147	13662	8797	18925	17811	5533
9	4423	7159	8595	4617	2582	7082	6088	15103	19531	27083	25799

age \ year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	220255	37706	238226	207711	534963	51170	309016	172879	69053	34836	22525
2	94438	92561	99014	335083	621496	235627	124944	202087	319604	47739	46284
3	20998	71907	253719	412816	175137	808267	151025	89066	101548	95834	20587
4	159122	23314	111897	302208	54205	131484	519178	63701	35502	22117	40692
5	13988	211243	27741	101957	66714	63071	82466	188202	25195	10083	6879
6	23582	21011	142399	25557	25716	54642	49683	30601	76289	12211	3833
7	15677	42762	21609	154424	10342	18242	34629	12297	10918	20992	2100
8	6377	26031	27073	16818	55763	6506	22470	13121	3914	2758	6278
9	10814	26207	24082	31999	16631	32223	21042	13698	12014	1486	1544

age \ year	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	247	2692	36740	13304	81923	2207	40794	33768	19463	1708	6216
2	142	279	77961	250010	77810	188778	68845	154963	65954	119376	36763
3	77	95	105600	72179	92743	49828	148399	86072	45463	41735	109501
4	19	51	61341	93544	29262	35001	17214	118860	32025	28421	18923
5	13	13	21473	58452	42535	14948	15211	18836	50119	19761	18109
6	8	9	12623	23580	27318	11366	6631	18000	8429	28555	7589
7	4	8	11583	11516	14709	9300	6907	2578	7307	3252	15012
8	1	1	1309	13814	8437	4427	3323	1427	3508	2222	1622
9	0	0	1326	4027	8484	1959	2189	1971	5983	2360	3505

age \ year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
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
1	1521.37
2	9107.04
3	11139.77
4	16323.95
5	7900.09
6	6109.01
7	9119.31
8	11587.11
9	9094.07

TABLE 5.6.2.2 HERRING in VIa (N). WEIGHTS AT AGE IN THE CATCH

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079	0.079
2	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104	0.104
3	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130	0.130
4	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
5	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
6	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
7	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180	0.180
8	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183
9	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185	0.185

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.079	0.079	0.079	0.079	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.104	0.104	0.104	0.104	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.121
3	0.130	0.130	0.130	0.130	0.158	0.158	0.158	0.158	0.158	0.158	0.158	0.158
4	0.158	0.158	0.158	0.158	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.175
5	0.164	0.164	0.164	0.164	0.186	0.186	0.186	0.186	0.186	0.186	0.186	0.186
6	0.170	0.170	0.170	0.170	0.206	0.206	0.206	0.206	0.206	0.206	0.206	0.206
7	0.180	0.180	0.180	0.180	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218
8	0.183	0.183	0.183	0.183	0.224	0.224	0.224	0.224	0.224	0.224	0.224	0.224
9	0.185	0.185	0.185	0.185	0.224	0.224	0.224	0.224	0.224	0.224	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.080	0.080	0.080	0.069	0.113	0.073	0.080	0.082	0.079	0.084	0.091
2	0.121	0.140	0.140	0.140	0.103	0.145	0.143	0.112	0.142	0.129	0.118	0.119
3	0.158	0.175	0.175	0.175	0.134	0.173	0.183	0.157	0.145	0.173	0.160	0.183
4	0.175	0.205	0.205	0.205	0.161	0.196	0.211	0.177	0.191	0.182	0.203	0.196
5	0.186	0.231	0.231	0.231	0.182	0.215	0.220	0.203	0.190	0.209	0.211	0.227
6	0.206	0.253	0.253	0.253	0.199	0.230	0.238	0.194	0.213	0.224	0.229	0.219
7	0.218	0.270	0.270	0.270	0.213	0.242	0.241	0.240	0.216	0.228	0.236	0.244
8	0.224	0.284	0.284	0.284	0.223	0.251	0.253	0.213	0.204	0.237	0.261	0.256
9	0.224	0.295	0.295	0.295	0.231	0.258	0.256	0.228	0.243	0.247	0.271	0.256

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.089	0.083	0.106	0.081	0.089	0.097	0.076	0.0834	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
1	0.1084	0.0908	0.1152	NaN	0.1120
2	0.1327	0.1580	0.1667	0.1705	0.1727
3	0.1632	0.1676	0.1881	0.2060	0.2107
4	0.1845	0.1929	0.1968	0.2310	0.2351
5	0.2108	0.2076	0.2105	0.2309	0.2459
6	0.2258	0.2251	0.2214	0.2489	0.2505
7	0.2341	0.2443	0.2161	0.2529	0.2494
8	0.2556	0.2615	0.2618	0.2840	0.2525
9	0.2496	0.2750	0.3030	0.2877	0.2659

TABLE 5.6.2.3 HERRING in VIa (N). WEIGHTS AT AGE IN THE STOCK

Units : Kg

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

TABLE 5.6.2.3 HERRING in VIa (N) continued. WEIGHTS AT AGE IN THE STOCK

age \ year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.000	0.000

age \ year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.068
2	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.164	0.152
3	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.186
4	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.233	0.206
5	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.246	0.233
6	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.253
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.273
8	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.269	0.299
9	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.302

age \ year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1	0.073	0.052	0.042	0.045	0.054	0.066	0.054	0.062	0.062	0.062	0.064	0.059
2	0.164	0.150	0.144	0.140	0.142	0.138	0.137	0.141	0.132	0.153	0.138	0.138
3	0.196	0.192	0.191	0.180	0.180	0.176	0.166	0.173	0.170	0.177	0.176	0.159
4	0.206	0.220	0.202	0.209	0.199	0.194	0.188	0.183	0.190	0.198	0.190	0.180
5	0.225	0.221	0.225	0.219	0.213	0.214	0.203	0.194	0.198	0.212	0.204	0.189
6	0.234	0.233	0.227	0.222	0.222	0.226	0.219	0.204	0.212	0.215	0.213	0.202
7	0.253	0.241	0.247	0.229	0.231	0.234	0.225	0.211	0.220	0.225	0.217	0.213
8	0.259	0.270	0.260	0.242	0.242	0.225	0.235	0.222	0.236	0.243	0.223	0.214
9	0.276	0.296	0.293	0.263	0.263	0.249	0.245	0.230	0.254	0.259	0.228	0.206

age \ year	2005	2006	2007	2008	2009
1	0.0751	0.075	0.0750	0.0546	0.1013
2	0.1296	0.135	0.1675	0.1721	0.1734
3	0.1538	0.166	0.1830	0.1913	0.2064
4	0.1665	0.185	0.1914	0.2083	0.2233
5	0.1802	0.192	0.1951	0.2143	0.2331
6	0.1911	0.204	0.1951	0.2139	0.2313
7	0.2125	0.211	0.2021	0.2206	0.2318
8	0.2030	0.224	0.2034	0.2242	0.2323
9	0.2284	0.231	0.2138	0.2385	0.2382

TABLE 5.6.2.4 HERRING in VIa (N). NATURAL MORTALITY

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

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
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	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
9	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

TABLE 5.6.2.5 HERRING in VIa (N). PROPORTION MATURE

Units : NA

age \ year	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
3	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.57	0.57	0.57	0.57	0.57	0.47	0.93	0.59	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
1	0.00	0.00	0.00	0.00	0.00	0	0.00	0.0
2	0.92	0.76	0.83	0.84	0.81	1	0.98	0.7
3	1.00	1.00	0.97	1.00	0.97	1	1.00	1.0
4	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0
5	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0
6	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0
7	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0
8	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0
9	1.00	1.00	1.00	1.00	1.00	1	1.00	1.0

TABLE 5.6.2.6 HERRING in VIa (N) continued. FRACTION OF HARVEST BEFORE SPAWNING

Units : NA

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age	2002	2003	2004	2005	2006	2007	2008	2009
1	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
3	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
5	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
7	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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.2.7 HERRING in VIa (N). FRACTION OF NATURAL MORTALITY BEFORE SPAWNING

Units : NA

age	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
3	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
4	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
6	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
8	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

age	2002	2003	2004	2005	2006	2007	2008	2009
1	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
3	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
5	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
7	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
9	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67

TABLE 5.6.2.8 HERRING in VIa (N). SURVEY INDICES

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	2009.00	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
1	313100	424700	438800	564000	50200	112300	-1	47840	345821
2	1062000	436000	1039400	274500	243400	835200	126000	232570	186741
3	217700	1436900	932500	760200	230300	387900	294400	911950	264040
4	172800	199800	1471800	442300	423100	284500	202500	668870	430293
5	437500	161700	181300	577200	245100	582200	145300	339920	373499
6	132600	424300	129200	55700	152800	414700	346900	272230	219033
7	102800	152300	346700	61800	12600	227000	242900	720860	186558
8	52400	67500	114300	82200	39000	21700	163500	365890	499695
9	34700	59500	75200	76300	26800	59300	32100	263740	456039

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

West of Scotland Summer Acoustic Survey - Index Variance (Inverse Weights) continued

age \ year	2006	2007	2008	2009
1	10	10	10	10
2	1	1	1	1
3	1	1	1	1
4	1	1	1	1
5	1	1	1	1
6	1	1	1	1
7	1	1	1	1
8	1	1	1	1
9	1	1	1	1

TABLE 5.6.2.9 HERRING in VIa (N). STOCK OBJECT CONFIGURATION

min	max	plusgroup	minyear	maxyear	minfbar	maxfbar
1	9	9	1957	2009	3	6

TABLE 5.6.2.10 HERRING in VIa (N). FLICA CONFIGURATION SETTINGS

```
sep.2       : NA
sep.gradual : TRUE
sr          : FALSE
sr.age      : 1
lambda.age  : 0.1 1 1 1 1 1 1 1 0
lambda.yr   : 1 1 1 1 1 1 1 1
lambda.sr   : 0.01
index.model : linear
index.cor   : 1
sep.nyr     : 8
sep.age     : 4
sep.sel     : 1
```

TABLE 5.6.2.11 HERRING in VIa (N). FLR, R SOFTWARE VERSIONS

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

Package  : FLICA
Version  : 1.4-12
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 5.6.2.12 HERRING in VIa (N). STOCK SUMMARY

Year	Recruitment Age 1	TSB	SSB	Fbar (Ages 3-6) f	Landings Tonnes	Landings SOP
1957	1047904	392598	177547	0.2942	43438	0.7258
1958	2047073	479835	191909	0.3467	59669	0.7470
1959	2074569	514434	202977	0.3211	65221	0.7248
1960	612525	411328	235079	0.2069	63759	0.5679
1961	1259861	418694	235051	0.1362	46353	0.5846
1962	2268571	523813	224351	0.2164	58195	0.7727
1963	2089990	556368	247381	0.1915	49030	0.6970
1964	968450	507688	292588	0.1601	64234	0.5774
1965	7781033	1097971	301165	0.1641	68669	0.8586
1966	1060851	833333	414096	0.1987	100619	1.0136
1967	2490738	818116	447238	0.1934	90400	0.8072
1968	4094453	942849	426507	0.1457	84614	0.7964
1969	2997172	972592	465232	0.2455	107170	0.7573
1970	3438854	994250	436567	0.3626	165930	0.7343
1971	9566876	1509767	310678	0.7949	207167	1.0162
1972	2674985	1111025	439070	0.3674	164756	1.0239
1973	1073319	799553	383182	0.6081	210270	1.0438
1974	1670386	574829	202609	0.9605	178160	1.1255
1975	2092107	432684	106098	0.9134	114001	1.0108
1976	602202	261864	72355	1.0769	93642	0.9984
1977	617273	161194	50786	1.0122	41341	0.9154
1978	908462	168726	47207	0.7065	22156	1.0056
1979	1214835	214283	71157	0.0007	60	1.0011
1980	879639	250236	120851	0.0004	306	1.0007
1981	1655501	362253	130388	0.3661	51420	0.9698
1982	765451	303239	107856	0.6829	92360	1.0347
1983	2936347	421296	79482	0.7249	63523	1.0277
1984	1116817	348122	117577	0.5281	56012	0.9494
1985	1189740	343253	144193	0.3248	39142	1.0058
1986	878638	308827	129262	0.5426	70764	1.0479
1987	2064184	372188	118914	0.3573	44360	0.9725
1988	882683	326431	142877	0.2954	35591	1.0236
1989	816719	308740	158124	0.2559	34026	1.0199
1990	428373	261507	147818	0.3627	44693	0.9889
1991	377349	201637	120186	0.2722	28529	1.0693
1992	789891	187030	93017	0.2973	28985	1.0018
1993	576697	177903	94413	0.2567	31778	0.9912
1994	848600	172414	86801	0.2338	24430	0.9984
1995	611485	153802	68996	0.2705	29575	1.0001
1996	854265	186165	108390	0.1744	26105	1.0477
1997	1491696	203112	68332	0.5227	35233	1.0079
1998	484350	182133	97053	0.5139	33353	0.9992
1999	310691	140600	80904	0.3178	29736	1.0015
2000	1648013	199348	68858	0.2480	18322	0.9997
2001	1110060	222598	113181	0.2042	24556	1.0049
2002	1186712	258324	134667	0.2843	32914	1.0021
2003	470063	219164	136370	0.2280	28081	1.0074
2004	280812	175831	123254	0.1921	25021	1.0172
2005	320661	146886	102465	0.1166	14129	1.0021
2006	586576	171278	98428	0.2170	27346	0.9997
2007	312366	152508	98903	0.2672	29616	1.0004
2008	277081	135366	99141	0.1427	16054	1.0022
2009	616092	464867	79755	0.2236	18508	1.0276

TABLE 5.6.2.13 HERRING in VIa (N). ESTIMATED FISHING MORTALITY

Units : f

age	1957	1958	1959	1960	1961	1962
1	0.009847153	0.01212931	0.04118596	0.009232578	0.01653928	0.03901632
2	0.101692188	0.09839501	0.11144048	0.175181079	0.26496659	0.26667535
3	0.328866412	0.31149843	0.16416064	0.144555092	0.16121880	0.21444192
4	0.224386963	0.36445256	0.41690824	0.144192737	0.10486639	0.25219788
5	0.311646521	0.31279288	0.37145901	0.274920203	0.18543178	0.17855510
6	0.312073263	0.39806752	0.33180152	0.263972606	0.09313790	0.22023442
7	0.199842495	0.43670572	0.40412210	0.300662391	0.16670457	0.23516176
8	0.250192758	0.31602554	0.29656137	0.230362199	0.19906675	0.26186303
9	0.250192758	0.31602554	0.29656137	0.230362199	0.19906675	0.26186303

age	1963	1964	1965	1966	1967	1968	1969
1	0.008962237	0.04416793	0.06249031	0.3659034	0.1399238	0.08827168	0.02006945
2	0.119354413	0.13361058	0.06935515	0.2411764	0.1242895	0.14700694	0.08070723
3	0.257522830	0.15797809	0.15034186	0.1698739	0.1669146	0.13986431	0.16875413
4	0.160678121	0.18753709	0.18496637	0.2014127	0.2728356	0.16719993	0.21566446
5	0.211320749	0.12594885	0.21097761	0.1680979	0.1743488	0.14036821	0.31019375
6	0.136404334	0.16907479	0.11014775	0.2554712	0.1594031	0.13527836	0.28749472
7	0.127605401	0.12220947	0.21354537	0.1505637	0.2178958	0.10596138	0.34220637
8	0.181403652	0.16520008	0.15763567	0.2290152	0.1966740	0.15764983	0.22930523
9	0.181403652	0.16520008	0.15763567	0.2290152	0.1966740	0.15764983	0.22930523

age	1970	1971	1972	1973	1974	1975	1976
1	0.1149246	0.0348494	0.3668749	0.07789768	0.3352009	0.1384067	0.1966428
2	0.1117757	0.4161066	0.2362376	0.50259293	0.4961071	0.7394949	0.7798711
3	0.3500280	0.9836885	0.4279785	0.58737288	0.7730573	0.8863385	1.2267512
4	0.4043511	0.8673924	0.3000689	0.62993946	0.9126564	0.8569605	1.0937452
5	0.3799120	0.6944021	0.4126396	0.59587926	0.9333332	0.9096073	0.8977936
6	0.3159912	0.6340671	0.3289060	0.61913221	1.2230430	1.0008547	1.0893967
7	0.4748253	0.5876874	0.5047253	0.36416759	0.9138798	1.0688623	1.1324323
8	0.3362068	0.7373453	0.3852573	0.60891955	0.9049169	0.9815511	1.1158040
9	0.3362068	0.7373453	0.3852573	0.60891955	0.9049169	0.9815511	1.1158040

age	1977	1978	1979	1980	1981	1982
1	0.09277844	0.03988146	0.0003216905	0.0048512225	0.03563338	0.02781642
2	0.35801909	0.29699340	0.0005119396	0.0007230813	0.32566864	0.66245732
3	0.61590363	0.27431737	0.0007459931	0.0004409006	0.43044058	0.61188146
4	0.96226287	0.54969442	0.0003404713	0.0005751634	0.40069893	0.80877306
5	0.97753290	0.81350108	0.0002599177	0.0002575312	0.31064112	0.72910084
6	1.49314988	1.18866349	0.0016261660	0.0001989135	0.32249234	0.58184437
7	0.91791730	1.07304169	0.0026616878	0.0018002703	0.33153052	0.48320394
8	0.88746051	0.68923220	0.0010220983	0.0007366677	0.39272667	0.72659055
9	0.88746051	0.68923220	0.0010220983	0.0007366677	0.39272667	0.72659055

age	1983	1984	1985	1986	1987	1988
1	0.04497053	0.003130318	0.05550971	0.06239595	0.01501007	0.003065063
2	0.39401752	0.236159254	0.21508113	0.55735110	0.28714444	0.203073339
3	0.60029522	0.508274884	0.31418012	0.48610666	0.33401208	0.316536670
4	0.51137079	0.451609360	0.31165541	0.42239584	0.31801157	0.341321687
5	0.98047482	0.473213872	0.32084731	0.58203735	0.28133802	0.294859424
6	0.80738521	0.679455491	0.35236028	0.67980217	0.49564002	0.228995264
7	0.78367286	0.631055277	1.05378504	0.20056215	0.57468432	0.320128251
8	0.69744845	0.505101243	0.42759201	0.55919403	0.40560126	0.303226797
9	0.69744845	0.505101243	0.42759201	0.55919403	0.40560126	0.303226797

age	1989	1990	1991	1992	1993	1994
1	0.01210132	0.05398622	0.1161026	0.01056712	0.04962006	0.003225717
2	0.14039733	0.17277228	0.1954544	0.25834957	0.47656920	0.233652927
3	0.30888098	0.24209651	0.1625757	0.35735111	0.34284150	0.405048063
4	0.21949656	0.33721199	0.2495854	0.21488194	0.24968479	0.166518391
5	0.33753640	0.47700321	0.2536211	0.27737919	0.16038734	0.238574922
6	0.15749476	0.39430693	0.4229200	0.33942083	0.27401817	0.124899457
7	0.16204703	0.28119915	0.3630565	0.31918599	0.29183642	0.284335236
8	0.23335761	0.32503223	0.2881785	0.32236370	0.36834297	0.270987599
9	0.23335761	0.32503223	0.2881785	0.32236370	0.36834297	0.270987599

TABLE 5.6.2.13 HERRING in VIa (N) continued. ESTIMATED FISHING MORTALITY

age \ year	1995	1996	1997	1998	1999	2000
1	0.000688368	0.003620299	0.001265873	0.03007071	0.03952099	0.003430501
2	0.360887799	0.215507264	0.229571684	0.16957376	0.26713114	0.211137373
3	0.330901863	0.237399783	0.336549138	0.23076094	0.35748330	0.215108629
4	0.368995920	0.149619266	0.385053629	0.55359463	0.24771613	0.245076078
5	0.197427739	0.191570247	0.589969178	0.46965025	0.41962195	0.164911546
6	0.184564280	0.119113006	0.779364038	0.80163594	0.24651034	0.366960486
7	0.174041016	0.287905035	0.853357176	1.02916466	0.36871316	0.135397497
8	0.322195156	0.225310972	0.524530861	0.52478177	0.34360119	0.248836731
9	0.322195156	0.225310972	0.524530861	0.52478177	0.34360119	0.248836731

age \ year	2001	2002	2003	2004	2005
1	0.0002037820	0.0007615573	0.0006106124	0.0005145292	0.0003124155
2	0.1679294249	0.1345321649	0.1078671444	0.0908936461	0.0551894591
3	0.2863414872	0.2548583167	0.2043439861	0.1721893173	0.1045511506
4	0.1634912530	0.2710049260	0.2172902480	0.1830984125	0.1111750137
5	0.2043314907	0.3185394615	0.2554031751	0.2152140575	0.1306752224
6	0.1624533869	0.2928842638	0.2348329797	0.1978806974	0.1201506279
7	0.6068845578	0.3217666477	0.2579907151	0.2173944336	0.1319991189
8	0.2735925680	0.2710049260	0.2172902480	0.1830984125	0.1111750137
9	0.2735925680	0.2710049260	0.2172902480	0.1830984125	0.1111750137

age \ year	2006	2007	2008	2009
1	0.0005812514	0.0007155924	0.0003821222	0.0005987856
2	0.1026804027	0.1264122790	0.0675034180	0.1057778894
3	0.1945182002	0.2394759696	0.1278787677	0.2003860925
4	0.2068419471	0.2546480267	0.1359805575	0.2130816011
5	0.2431222318	0.2993135457	0.1598316835	0.2504563273
6	0.2235411447	0.2752068050	0.1469588249	0.2302845515
7	0.2455853511	0.3023459503	0.1614509699	0.2529937498
8	0.2068419471	0.2546480267	0.1359805575	0.2130816011
9	0.2068419471	0.2546480267	0.1359805575	0.2130816011

TABLE 5.6.2.14 HERRING in VIa (N). ESTIMATED POPULATION ABUNDANCE

Units : NA

age \ year	1957	1958	1959	1960	1961	1962
1	1047903.837	2047073.45	2074569.19	612524.90	1259860.55	2268570.68
2	891024.642	381724.81	743997.12	732397.09	223264.47	455874.27
3	227428.163	596261.84	256288.80	493043.14	455384.34	126898.87
4	134437.124	134017.18	357516.48	178064.22	349338.58	317323.88
5	133006.904	97194.06	84226.99	213209.07	139484.23	284625.76
6	77766.118	88124.85	64322.97	52565.31	146548.00	104848.85
7	51458.116	51502.61	53553.81	41767.36	36528.17	120809.52
8	6760.452	38127.11	30112.09	32348.41	27978.96	27976.90
9	20954.085	27691.19	35107.63	23534.92	15006.58	32232.38

age \ year	1963	1964	1965	1966	1967	1968	1969
1	2089989.52	968449.61	7781033.41	1060850.92	2490738.27	4094453.32	2997171.64
2	802626.06	762004.22	340879.32	2689079.25	270676.20	796646.21	1379004.03
3	258667.05	527703.47	493904.17	235608.94	1565213.82	177085.68	509486.70
4	83843.21	163697.28	368911.37	347929.42	162763.71	1084487.84	126061.44
5	223123.42	64603.62	122790.76	277435.94	257388.60	112108.14	830197.14
6	215426.57	163433.20	51538.11	89972.51	212192.13	195632.55	88154.92
7	76118.05	170070.96	124877.04	41769.81	63056.62	163708.77	154618.35
8	86405.68	60623.34	136183.92	91266.53	32512.03	45884.95	133236.76
9	38503.71	104080.29	140544.68	138777.81	151595.48	77810.86	134137.59

age \ year	1970	1971	1972	1973	1974	1975
1	3438853.57	9566876.13	2674984.70	1073318.59	1670386.38	2092106.62
2	1080689.87	1127737.68	3398918.63	681859.79	365261.28	439487.51
3	942380.93	715927.68	551070.21	1988180.08	305585.96	164762.63
4	352358.67	543691.25	219179.42	294089.38	904698.81	115488.83
5	91937.13	212788.45	206642.27	146910.23	141732.90	328634.34
6	550853.80	56894.17	96148.74	123760.66	73254.70	50431.25
7	59835.61	363390.57	27306.53	62614.10	60293.08	19509.46
8	99360.38	33675.67	182690.02	14915.49	39362.86	21874.85
9	88383.14	64073.49	54486.27	73873.64	36861.30	22836.80

age \ year	1976	1977	1978	1979	1980	1981
1	602202.310	617272.540	908462.018	1214834.699	879638.561	1655500.907
2	670162.409	181989.797	206961.380	321138.220	446768.966	322034.884
3	155417.397	227613.483	94248.181	113924.825	237783.283	330735.355
4	55599.114	37313.798	100659.679	58651.559	93204.202	194594.670
5	44354.462	16851.203	12898.362	52565.021	53052.060	84286.158
6	119741.874	16353.137	5736.729	5173.758	47550.437	47991.128
7	16772.764	36450.007	3324.336	1581.266	4673.803	43016.857
8	6061.984	4890.645	13171.091	1028.630	1426.985	4221.425
9	18607.225	2635.061	3239.274	7453.480	7667.090	4276.249

age \ year	1982	1983	1984	1985	1986	1987
1	765451.46	2936346.95	1116817.341	1189739.738	878637.612	2064183.52
2	587705.24	273868.86	1032719.639	409570.046	414047.270	303680.63
3	172257.64	224475.87	136815.302	604131.430	244698.492	175673.83
4	176069.35	76486.16	100833.737	67380.588	361264.963	123213.69
5	117945.17	70959.19	41501.891	58082.454	44643.180	214265.48
6	55900.68	51476.17	24085.983	23395.065	38130.570	22570.96
7	31453.93	28268.05	20774.656	11047.173	14882.185	17482.74
8	27940.06	17554.67	11682.118	10000.934	3484.726	11018.80
9	8144.97	17652.46	5169.476	6588.036	4813.171	18792.89

age \ year	1988	1989	1990	1991	1992	1993	1994
1	882683.09	816719.28	428372.69	377348.77	789891.46	576697.35	848600.06
2	748057.59	323727.20	296840.25	149307.42	123602.07	287530.35	201884.86
3	168819.85	452327.57	208409.28	185012.21	90972.11	70719.25	132258.62
4	102988.46	100715.07	271924.83	133942.06	128746.60	52101.92	41094.58
5	81118.30	66240.71	73170.98	175618.44	94426.52	93968.93	36727.18
6	146331.97	54655.46	42766.66	41091.27	123308.90	64744.11	72426.83
7	12441.33	105307.28	42247.89	26087.39	24358.37	79461.43	44541.64
8	8904.26	8173.49	81031.30	28857.08	16418.28	16017.63	53701.20
9	9457.27	17662.20	20854.53	18657.45	20959.27	12716.18	45079.32

age \ year	1995	1996	1997	1998	1999	2000
1	611485.30	854264.69	1491695.51	484350.239	310691.430	1648012.694
2	311177.13	224798.07	313130.73	548069.885	172904.181	109867.956
3	118397.15	160689.59	134248.87	184389.266	342690.958	98062.637
4	72219.58	69626.33	103759.39	78503.730	119855.657	196241.441
5	31480.17	45182.74	54245.69	63880.942	40835.488	84653.972

```
  6  26178.60  23381.15   33755.55  27209.177  36138.935   24286.717
  7  57839.82  19695.26   18780.46  14010.134  11044.343   25555.703
  8  30328.54  43975.66   13362.77   7238.833   4529.521    6911.628
  9  37238.17 161739.76   25333.65   8525.167   3924.144    2170.365
   year
age        2001        2002       2003      2004      2005      2006      2007
  1 1110060.037 1186711.911 470063.337 280811.98 320660.93 586575.90 312365.78
  2  604193.742  408285.057 436234.570 172821.08 103251.81 117927.71 215663.82
  3   65900.226  378405.165 264392.154 290125.32 116905.18  72383.72  78837.71
  4   64747.676   40520.191 240112.406 176459.16 199961.26  86212.23  48786.96
  5  138971.610   49749.805  27960.574 174830.50 132952.38 161895.11  63432.10
  6   64952.776  102507.726  32735.728  19597.31 127562.04 105563.83 114872.91
  7   15225.461   49959.221  69203.671  23421.02  14548.84 102355.52  76384.11
  8   20195.564    7508.866  32767.607  48378.87  17051.53  11536.46  72447.84
  9    4382.558    6283.546   7561.859  25134.43  14276.08  28570.67  19789.24
   year
age      2008      2009
  1 277081.12 616091.67
  2 114830.75 101893.51
  3 140795.51  79515.81
  4  50800.97 101436.17
  5  34220.17  40122.41
  6  42549.01  26389.95
  7  78934.59  33238.13
  8  51081.82  60774.40
  9  74042.85  49707.84
```

TABLE 5.6.2.15 HERRING in VIa (N). SURVIVORS AFTER TERMINAL YEAR

Units : NA

age	2010
1	NA
2	1303019.38
3	67907.76
4	53280.47
5	74169.14
6	28260.88
7	18966.97
8	23352.50
9	80783.53

TABLE 5.6.2.16 HERRING in VIa (N). FITTED SELECTION PATTERN

Units : NA

age	2002	2003	2004	2005	2006	2007
1	0.002810124	0.002810124	0.002810124	0.002810124	0.002810124	0.002810124
2	0.496419629	0.496419629	0.496419629	0.496419629	0.496419629	0.496419629
3	0.940419499	0.940419499	0.940419499	0.940419499	0.940419499	0.940419499
4	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000
5	1.175401002	1.175401002	1.175401002	1.175401002	1.175401002	1.175401002
6	1.080734096	1.080734096	1.080734096	1.080734096	1.080734096	1.080734096
7	1.187309221	1.187309221	1.187309221	1.187309221	1.187309221	1.187309221
8	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000
9	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000	1.000000000

age	2008	2009
1	0.002810124	0.002810124
2	0.496419629	0.496419629
3	0.940419499	0.940419499
4	1.000000000	1.000000000
5	1.175401002	1.175401002
6	1.080734096	1.080734096
7	1.187309221	1.187309221
8	1.000000000	1.000000000
9	1.000000000	1.000000000

TABLE 5.6.2.17 HERRING in VIa (N). PREDICTED CATCH IN NUMBERS

Units : NA

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
1	142.98	571.0966	181.3891	91.3129	63.31722	215.4679	141.2535
2	81030.48	44549.5759	38640.9841	13002.0017	4796.29578	9967.6501	22195.1260
3	14942.91	77485.7986	44438.8433	41713.4158	10536.76345	11634.4381	15277.5711
4	9305.89	9174.3199	44707.0843	28138.7007	20040.27395	15356.0675	10459.4023
5	24482.25	12948.9700	6010.0881	32272.7860	15515.34162	33317.9834	15653.3462
6	9280.71	24827.2446	6532.8081	3353.6706	13756.85264	20160.8634	26360.0478
7	6624.96	13115.5177	15007.6650	4362.6904	1713.93799	21253.4685	19013.5964
8	4610.61	1700.1091	6101.0766	7714.6385	1708.91724	2054.8669	15532.0410
9	1000.53	1422.6800	1407.9600	4008.0100	1430.76000	5088.9900	4242.6000

age \ year	2008	2009
1	66.9175	1341.121
2	6486.6853	8859.380
3	15350.8663	13130.321
4	6153.3771	18557.791
5	4816.6407	8476.930
6	5540.6632	5175.536
7	11214.2681	7085.120
8	6187.3958	11118.702
9	8968.6000	9094.070

TABLE 5.6.2.18 HERRING in VIa (N). CATCH RESIDUALS

Units : Thousands NA

age	2002	2003	2004	2005	2006
1	0.55236635541527390187	-1.17315197	-Inf	1.05859283	-0.48653136
2	-0.146422170040174770556	-0.14779648	-0.64174411	0.69732069	-0.39850829
3	0.1929347524581346284833	0.05316957	-0.62968601	0.79086293	-0.23628130
4	-0.0175838609652545635464	0.18452160	-0.01156217	0.02766314	-0.11814631
5	0.3356528615951930305528	0.21651673	0.34967606	-0.41572987	0.20912682
6	0.1208370085432240170764	-0.40791469	0.15504082	-0.34087249	0.32064002
7	-0.3721258519824962029965	-0.15768099	0.56053901	-0.52390798	-0.01328516
8	-0.0938190745476436271932	0.40939167	0.09470992	-0.35774727	0.39220876
9	0.00000000000000002220446	0.00000000	0.00000000	0.00000000	0.00000000

age	2007	2008	2009
1	-0.07726898	-Inf	0.12610537
2	0.43603037	0.1969123413067921102293	0.02757098
3	0.15027178	-0.1632209067032986404833	-0.16440257
4	-0.46725184	-0.1255058406048185914994	-0.12825637
5	-0.09287642	-0.4028444448748111916814	-0.07047415
6	0.14804399	0.0263429392529158402925	0.16582192
7	0.12369225	0.2796183083836765725927	0.25239732
8	-0.13390568	0.2745596389845708085176	0.04126470
9	0.00000000	0.00000000000000002220446	0.00000000

TABLE 5.6.2.19 HERRING in VIa (N). PREDICTED INDEX VALUES

WoS Summer Acoustic Survey

Units : NA NA

age	1991	1992	1993	1994	1995	1996	1997
1	107560.27	238482.00	170448.30	257234.3	185614.7	258895.73	452657.68
2	315648.18	252499.77	521516.93	418007.9	601136.5	470076.11	649789.03
3	700358.85	309689.87	242655.78	438685.5	408903.0	583979.79	462224.53
4	563437.79	551923.31	219158.96	180873.4	284656.2	309288.31	405408.06
5	700594.76	371849.70	394410.62	147722.2	129489.4	186447.35	180157.19
6	144734.83	454549.68	247324.65	300097.0	104999.3	97184.63	97904.31
7	95337.62	91172.90	301888.94	169915.3	234314.3	74986.49	52540.05
8	110461.64	61687.27	58692.57	207497.1	113961.8	174201.42	44969.02
9	78051.59	86062.56	50922.76	190360.1	152920.8	700207.01	93171.88

age	1998	1999	2000	2001	2002	2003
1	144687.63	92334.58	499502.785	337044.75	360208.85	142692.51
2	1175123.62	351529.85	230293.113	1296620.96	892288.13	967326.46
3	672538.37	1166514.38	360736.222	233191.62	1362181.15	978323.84
4	279809.97	504696.12	827536.256	285450.52	168473.14	1027986.82
5	226535.38	148813.97	354438.447	569494.12	191567.84	111434.86
6	77965.13	140137.16	88193.662	263676.35	387577.28	127750.88
7	35613.49	40237.85	105731.956	48718.33	186733.53	267812.55
8	24357.12	16822.61	27030.328	77923.33	29013.38	130371.44
9	31349.50	15927.82	9276.287	18480.32	26533.78	32880.37

age	2004	2005	2006	2007	2008	2009
1	85247.80	97355.71	178063.93	NA	84121.27	1075853.2
2	386782.81	235623.71	262238.54	473413.71	260294.44	226200.7
3	1092522.54	456759.77	269277.84	286188.83	543152.10	294865.8
4	769679.70	907058.46	371205.87	204660.73	227347.51	435273.2
5	712204.24	567143.58	649554.32	246826.01	143673.92	160336.7
6	78034.13	529916.67	414504.94	438534.15	174192.84	103242.2
7	92665.15	60304.72	398794.62	288540.21	321972.82	128979.6
8	196103.95	71881.55	46161.86	282436.58	212446.38	242356.4
9	111344.79	65770.86	124940.01	84313.06	336539.81	216635.2

TABLE 5.6.2.20 HERRING in VIa (N). INDEX RESIDUALS

WoS Summer Acoustic Survey

Units : NA

age \ year	1991	1992	1993	1994	1995	1996
1	1.14591718	-1.16604831	-4.28104242	0.6528517	0.8658251	-1.83750183
2	-0.06940358	0.69003435	0.10511327	0.2599134	0.6073296	0.20401134
3	-0.75887807	-0.38380805	1.04433729	0.3259314	0.1462516	0.31790286
4	-0.42643606	-0.76010075	1.14506655	0.4568299	0.4586320	0.06211815
5	-0.36102423	0.10918619	0.35916766	0.7307325	0.1668387	-0.67048971
6	0.19755599	-0.63821006	1.29214836	-0.1126337	0.5782239	-0.47231764
7	0.03507575	0.14756334	-0.02101820	0.8731198	-0.3255819	0.03142040
8	-0.20674928	-0.08412701	0.98945879	-0.1775574	0.7309302	-0.80107043
9	-0.29618588	-0.30497991	1.15388543	-0.3670249	0.2768616	-1.80809743

age \ year	1997	1998	1999	2000	2001	2002
1	0.55982919	2.133421483	1.75535162	-0.10971320	-0.07369307	0.16469904
2	-0.01227753	-0.391252034	-0.08650162	0.31702202	-0.19960770	-0.71614685
3	-0.47946474	-0.008599008	0.17384372	-0.06776738	-0.06874257	0.05340081
4	-0.88666081	0.520895992	-0.15553092	0.08338613	-0.50193385	0.17054053
5	-1.00266099	-0.235236053	0.72740277	0.10429221	-0.26367176	-0.16949923
6	-0.68161397	0.016598027	-0.01030836	1.03227944	-0.68738531	0.09052550
7	-1.17163842	-0.238735918	0.76533639	0.63490706	0.74673003	-0.20383035
8	-0.43902287	-0.564538947	0.49509182	1.25691740	-0.39681875	0.84437046
9	-1.33822482	0.159483944	0.79864441	1.94692594	0.63003312	0.80755762

age \ year	2003	2004	2005	2006	2007	2008
1	1.12335168	1.8894919	-0.6623564	-0.4609688057	NA	-0.5643973
2	0.07186287	-0.3429121	0.0324701	1.1584166604	-1.32368774	-0.1126222
3	-0.04797159	-0.3626630	-0.6847748	0.3650038687	0.02828757	0.5181958
4	0.35888380	-0.5539861	-0.7625983	-0.2660235619	-0.01061373	1.0791100
5	0.48671293	-0.2101759	-0.8389462	-0.1094724405	-0.52988310	0.8611640
6	0.01127948	-0.3371662	-1.2435899	0.0004704769	-0.23440114	0.4464843
7	0.25817255	-0.4050891	-1.5657136	-0.5634965341	-0.17218462	0.8059778
8	-0.13156100	-0.8694896	-0.6114579	-0.7548416486	-0.54664103	0.5436431
9	0.82727553	-0.3779587	-0.8977750	-0.7452244249	-0.96568076	-0.2437527

TABLE 5.6.2.20 HERRING in VIa (N) continued. INDEX RESIDUALS

age \ year	2009
1	-1.13494798
2	-0.19170015
3	-0.11041962
4	-0.01150756
5	0.84563965
6	0.75214504
7	0.36908773
8	0.72358846
9	0.74436336

TABLE 5.6.2.21 HERRING in VIa (N). FIT PARAMETERS

	Value	Std.dev	Lower.95.pct.CL
F, 2002	0.271003926	0.1472512	0.203063958
F, 2003	0.217289248	0.1491652	0.162205757
F, 2004	0.183097413	0.1512422	0.136126364
F, 2005	0.111174014	0.1523463	0.082475224
F, 2006	0.206840947	0.1556608	0.152452779
F, 2007	0.254647027	0.1708904	0.182168717
F, 2008	0.135979558	0.1924688	0.093248295
F, 2009	0.213080601	0.2226164	0.137736484
Selectivity at age 1	0.002809124	0.3812672	0.001330545
Selectivity at age 2	0.496418629	0.1420333	0.375791431
Selectivity at age 3	0.940418499	0.1292914	0.729904569
Selectivity at age 5	1.175400002	0.1162405	0.935922253
Selectivity at age 6	1.080733096	0.1122478	0.867303713
Selectivity at age 7	1.187308221	0.1134893	0.950515983
Terminal year pop, age 1	3544094.423528603	0.8738838	639205.273586716
Terminal year pop, age 2	101892.505359528	0.3327651	53074.621967973
Terminal year pop, age 3	79514.810223795	0.2550840	48229.880161234
Terminal year pop, age 4	101435.173485991	0.2230169	65516.816312619
Terminal year pop, age 5	40121.405580118	0.2076013	26709.291014371
Terminal year pop, age 6	26388.954820030	0.2022192	17753.735645443
Terminal year pop, age 7	33237.130264553	0.1989036	22506.778689984
Terminal year pop, age 8	60773.398461267	0.1998276	41078.717064841
Last true age pop, 2002	7507.866486844	0.2712506	4411.876755420
Last true age pop, 2003	32766.607492881	0.2175144	21393.381884501
Last true age pop, 2004	48377.872283790	0.1956888	32966.519785001
Last true age pop, 2005	17050.525526527	0.1828705	11914.485666958
Last true age pop, 2006	11535.460125367	0.1731578	8215.613967238
Last true age pop, 2007	72446.842268667	0.1746974	51441.549581727
Last true age pop, 2008	51080.822893322	0.1902786	35179.481776603
Index 1, age 1 numbers, Q	0.523696680	0.5787118	0.168449744
Index 1, age 2 numbers, Q	2.769435546	0.1842477	1.929996068
Index 1, age 3 numbers, Q	4.612521986	0.1830017	3.222287493
Index 1, age 4 numbers, Q	5.089469698	0.1826190	3.558148760
Index 1, age 5 numbers, Q	4.837216535	0.1829773	3.379419465
Index 1, age 6 numbers, Q	4.683749675	0.1838555	3.266575641
Index 1, age 7 numbers, Q	4.703647779	0.1855621	3.269498785
Index 1, age 8 numbers, Q	4.729740339	0.1876932	3.273931954
Index 1, age 9 numbers, Q	5.169013426	0.1851910	3.595587503

	Upper.95.pct.CL
F, 2002	0.361674857
F, 2003	0.291078554
F, 2004	0.246276044
F, 2005	0.149859081
F, 2006	0.280632323
F, 2007	0.355961822
F, 2008	0.198292528
F, 2009	0.329639186
Selectivity at age 1	0.005930783
Selectivity at age 2	0.655766564
Selectivity at age 3	1.211647372
Selectivity at age 5	1.476153772
Selectivity at age 6	1.346683990
Selectivity at age 7	1.483090067
Terminal year pop, age 1	19650346.769522578
Terminal year pop, age 2	195612.936342843
Terminal year pop, age 3	131093.111237047
Terminal year pop, age 4	157045.091614919
Terminal year pop, age 5	60268.435611348
Terminal year pop, age 6	39224.248372333
Terminal year pop, age 7	49083.293679627
Terminal year pop, age 8	89910.450579604
Last true age pop, 2002	12776.435587195
Last true age pop, 2003	50186.107665866
Last true age pop, 2004	70993.800436634
Last true age pop, 2005	24400.585040527
Last true age pop, 2006	16196.822396301
Last true age pop, 2007	102029.293389823
Last true age pop, 2008	74169.667535986
Index 1, age 1 numbers, Q	1.628130779
Index 1, age 2 numbers, Q	3.973983871
Index 1, age 3 numbers, Q	6.602563897
Index 1, age 4 numbers, Q	7.279825425
Index 1, age 5 numbers, Q	6.923870815
Index 1, age 6 numbers, Q	6.715751730

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Index 1, age 7 numbers, Q        6.766878926
Index 1, age 8 numbers, Q        6.832898177
Index 1, age 9 numbers, Q        7.430969147
```

Table 5.7.1.1. Herring in VIa (N). Input data for short-term predictions, numbers at age from the assessment with ages 1- and 2-ring in 2009 replaced by geometric mean values - natural mortality (M), proportion mature (Mat), proportion of fishing mortality prior to spawning (PF), proportion of natural mortality prior to spawning (PM), mean weights at age in the stock (SWt), selection pattern (Sel), mean weights at age in the catch (CWt). All biological data are taken as mean of the last 3 years. VIa (N) herring appears to have considerable annual variability in mean weights and in fraction mature. Last year's values are not applicable. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

2010

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	616091.7	1	0	0.67	0.67	7.70E-02	5.99E-04	7.57E-02
2	235259.1	0.3	0.893333	0.67	0.67	0.171	0.105778	0.169967
3	67908	0.2	1	0.67	0.67	0.193567	0.200386	0.2016
4	53280	0.1	1	0.67	0.67	0.207667	0.213082	0.220967
5	74169	0.1	1	0.67	0.67	0.214167	0.250456	0.2291
6	28261	0.1	1	0.67	0.67	0.213433	0.230285	0.240267
7	18967	0.1	1	0.67	0.67	0.218167	0.252994	0.239467
8	23352	0.1	1	0.67	0.67	0.219967	0.213082	0.2661
9	80784	0.1	1	0.67	0.67	0.230167	0.213082	0.285533

2011

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	616091.7	1	0	0.67	0.67	7.70E-02	5.99E-04	7.57E-02
2	.	0.3	0.893333	0.67	0.67	0.171	0.105778	0.169967
3	.	0.2	1	0.67	0.67	0.193567	0.200386	0.2016
4	.	0.1	1	0.67	0.67	0.207667	0.213082	0.220967
5	.	0.1	1	0.67	0.67	0.214167	0.250456	0.2291
6	.	0.1	1	0.67	0.67	0.213433	0.230285	0.240267
7	.	0.1	1	0.67	0.67	0.218167	0.252994	0.239467
8	.	0.1	1	0.67	0.67	0.219967	0.213082	0.2661
9	.	0.1	1	0.67	0.67	0.230167	0.213082	0.285533

2012

Age	N	M	Mat	PF	PM	SWt	Sel	CWt
1	616091.7	1	0	0.67	0.67	7.70E-02	5.99E-04	7.57E-02
2	.	0.3	0.893333	0.67	0.67	0.171	0.105778	0.169967
3	.	0.2	1	0.67	0.67	0.193567	0.200386	0.2016
4	.	0.1	1	0.67	0.67	0.207667	0.213082	0.220967
5	.	0.1	1	0.67	0.67	0.214167	0.250456	0.2291
6	.	0.1	1	0.67	0.67	0.213433	0.230285	0.240267
7	.	0.1	1	0.67	0.67	0.218167	0.252994	0.239467
8	.	0.1	1	0.67	0.67	0.219967	0.213082	0.2661
9	.	0.1	1	0.67	0.67	0.230167	0.213082	0.285533

Table 5.7.1.2. Herring in VIa (N). Short-term prediction single option table, with TAC constraint. N.B. In this table "age" refers to number of rings (winter rings in the otolith).

Year:	2010	F multiplier:	1.3131	Fbar:	0.2936				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0008	306	23	616092	47419	0	0	0	0
2	0.1389	26450	4496	235259	40229	210165	35938	156621	26782
3	0.2631	14302	2883	67908	13145	67908	13145	49792	9638
4	0.2798	12404	2741	53280	11064	53280	11064	41309	8579
5	0.3289	19836	4544	74169	15885	74169	15885	55645	11917
6	0.3024	7036	1690	28261	6032	28261	6032	21582	4606
7	0.3322	5116	1225	18967	4138	18967	4138	14198	3098
8	0.2798	5436	1447	23352	5137	23352	5137	18105	3983
9	0.2798	18807	5370	80784	18594	80784	18594	62634	14416
Total		109694	24420	1198072	161642	556886	109932	419887	83019

Year:	2011	F multiplier:	1	Fbar:	0.2236				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0006	233	18	616092	47419	0	0	0	0
2	0.1058	19691	3347	226469	38726	202313	34595	154153	26360
3	0.2004	25047	5049	151682	29361	151682	29361	115993	22452
4	0.2131	7818	1728	42735	8875	42735	8875	34648	7195
5	0.2505	7700	1764	36443	7805	36443	7805	28816	6172
6	0.2303	9473	2276	48301	10309	48301	10309	38713	8263
7	0.253	4028	965	18899	4123	18899	4123	14918	3255
8	0.2131	2252	599	12311	2708	12311	2708	9981	2196
9	0.2131	13031	3721	71228	16394	71228	16394	57750	13292
Total		89274	19466	1224160	165719	583912	114170	454972	89184

Year:	2012	F multiplier:	1	Fbar:	0.2236				
Age	F	CatchNos	Yield	StockNos	Biomass	SSNos(Jan)	SSB(Jan)	SSNos(ST)	SSB(ST)
1	0.0006	233	18	616092	47419	0	0	0	0
2	0.1058	19695	3347	226512	38734	202351	34602	154181	26365
3	0.2004	24923	5025	150932	29215	150932	29215	115419	22341
4	0.2131	18594	4109	101636	21106	101636	21106	82404	17113
5	0.2505	6602	1512	31247	6692	31247	6692	24708	5292
6	0.2303	5034	1210	25669	5479	25669	5479	20574	4391
7	0.253	7400	1772	34715	7574	34715	7574	27403	5979
8	0.2131	2429	646	13278	2921	13278	2921	10765	2368
9	0.2131	11175	3191	61083	14059	61083	14059	49525	11399
Total		96086	20830	1261165	173198	620912	121648	484980	95247

Table 5.7.1.3. Herring in VIa (N). Short-term prediction multiple option table, with TAC constraint.

2010				
Biomass	SSB	FMult	FBar	Landings
161642	83019	1.3131	0.2936	24420

2011					2012		
Biomass	SSB	FMult	FBar	Landings	Biomass	SSB	%TAC change
165719	100934	0	0	0	190454	123871	-100
.	99687	0.1	0.0224	2121	188572	120577	-91
.	98457	0.2	0.0447	4201	186726	117388	-83
.	97243	0.3	0.0671	6241	184917	114300	-74
.	96045	0.4	0.0894	8241	183143	111310	-66
.	94863	0.5	0.1118	10204	181403	108414	-58
.	93697	0.6	0.1341	12128	179697	105610	-50
.	92546	0.7	0.1565	14016	178024	102894	-43
.	91410	0.8	0.1788	15868	176384	100264	-35
.	90290	0.9	0.2012	17685	174776	97716	-28
.	89184	1	0.2236	19466	173198	95247	-20
.	88093	1.1	0.2459	21214	171652	92856	-13
.	87017	1.2	0.2683	22929	170135	90538	-6
.	85954	1.3	0.2906	24611	168647	88293	1
.	84906	1.4	0.313	26261	167188	86117	8
.	83871	1.5	0.3353	27880	165757	84008	14
.	82851	1.6	0.3577	29469	164353	81965	21
.	81843	1.7	0.38	31027	162977	79983	27
.	80849	1.8	0.4024	32557	161626	78063	33
.	79868	1.9	0.4247	34057	160302	76201	39
.	78900	2	0.4471	35529	159003	74395	45

Input units are thousands and kg - output in tonnes

165719	88093	1.1	0.2459	21214	171652	92856	-13
	100934	0	0	0	190454	123871	-100
	89184	1	0.2236	19466	173198	95247	-20
	86060	1.29	0.2884	24444	168794	88514	0
	82952	1.59	0.3554	29311	164492	82166	20

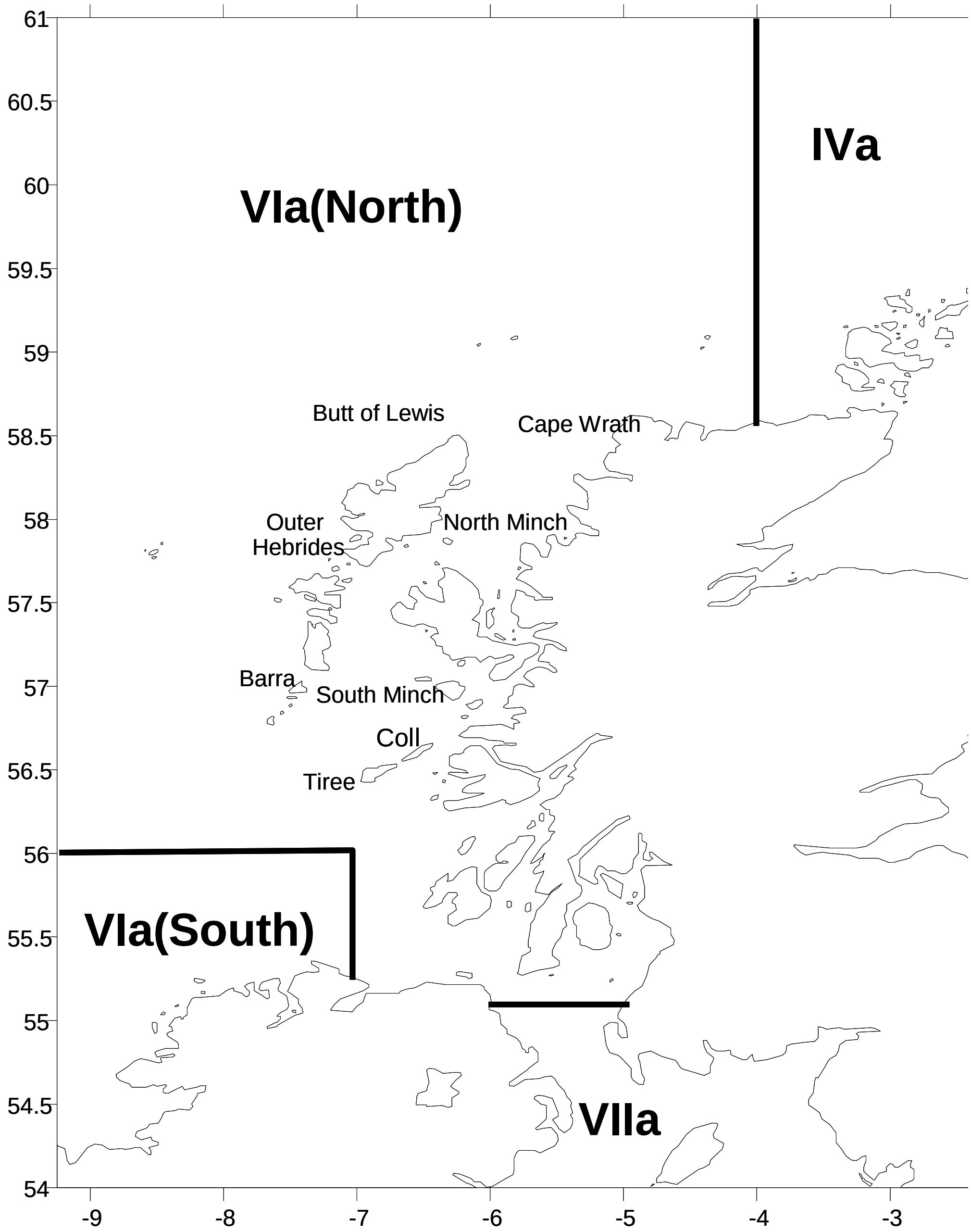


Figure 5.1. Location of ICES area VIa (North) and adjacent areas, with place names.

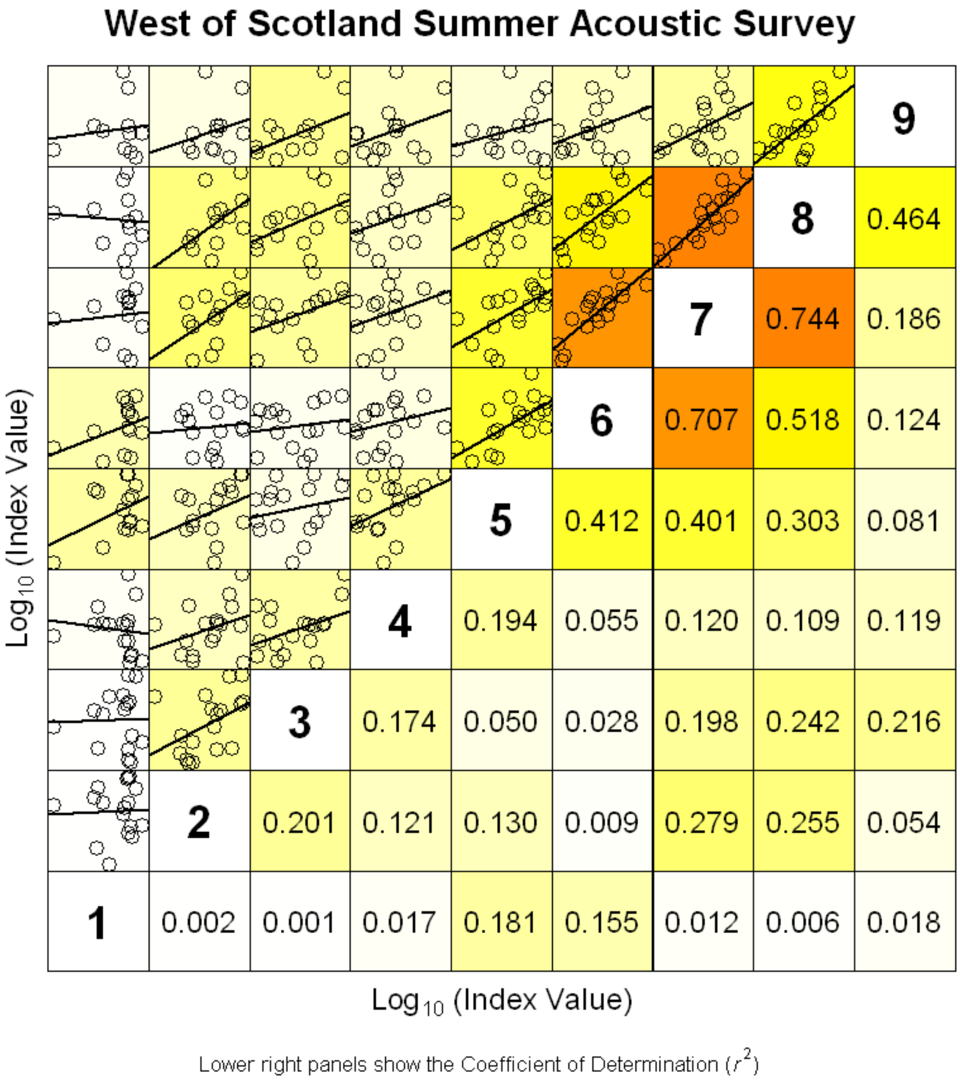


Figure 5.3.1.1. Herring in Via (North). Internal consistency between ages in the West of Scotland acoustic survey time series.

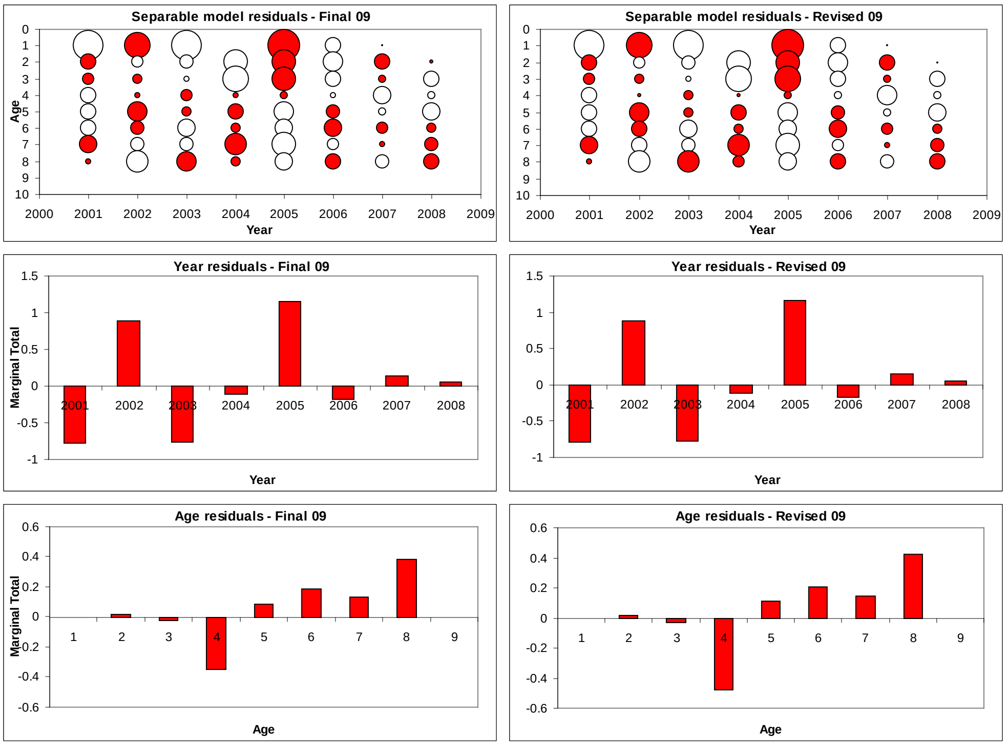
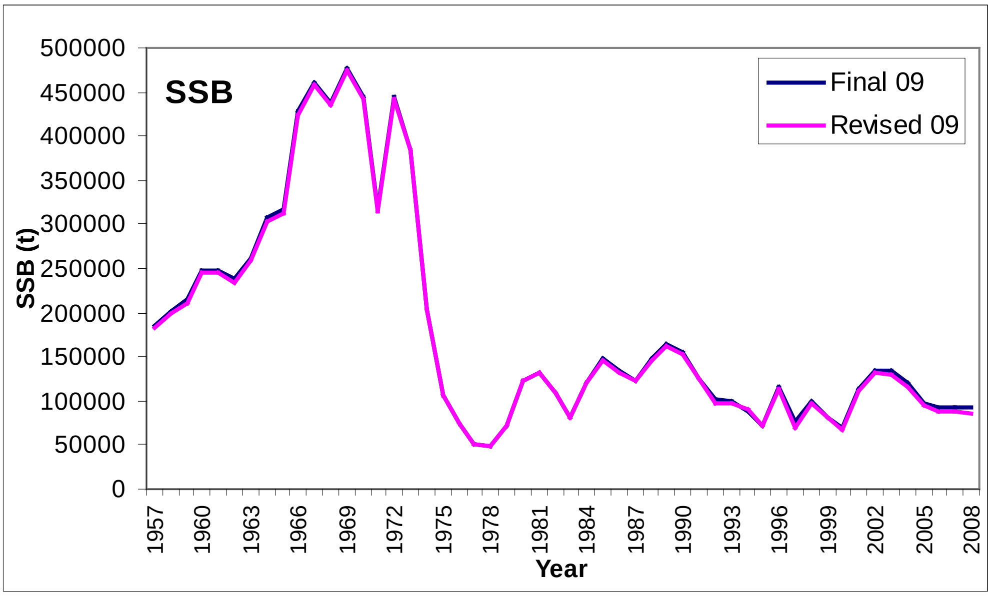


Figure 5.6.1.1. Herring in VIa (North). Illustration of selection pattern diagnostics, from deterministic calculation (8-year separable period) with data from 1957-2008. Left panels have the final assessment run at HAWG 2009 (Final 09); right panels the assessment with the revised input files of numbers-, weights- and proportion mature-at-age from the herring acoustic survey (Revised 09).



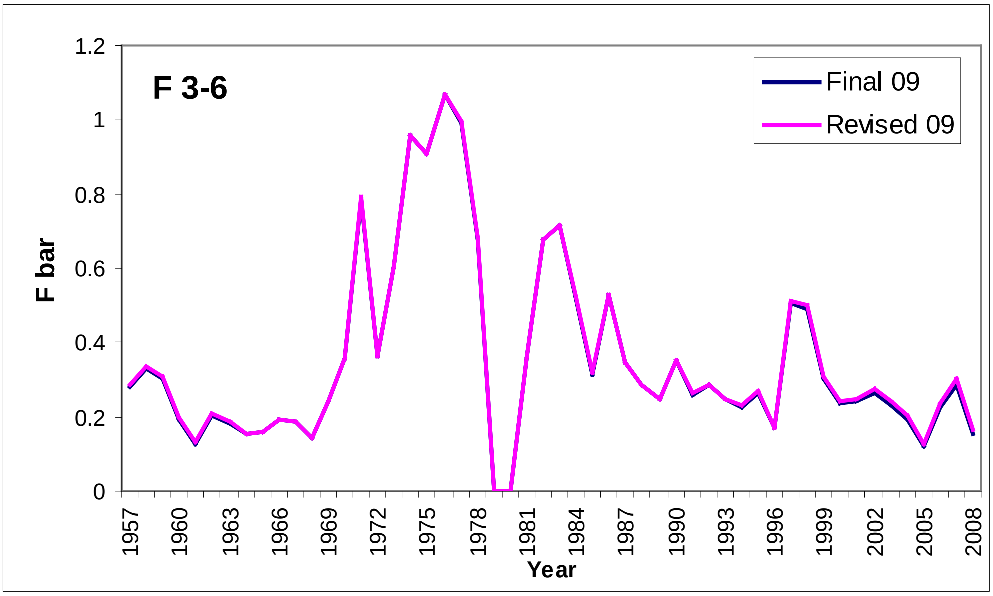


Figure 5.6.1.2. Herring in VIa (North). Illustration of spawning stock biomass at spawning time (upper panel) and fishing mortality at F3-6 (lower panel) from the assessment (8 year separable period) 1957-2008 to compare the outputs from the final assessment run at HAWG 2009 (Final 09) and the assessment with the revised input files of numbers-, weights- and proportion mature-at-age from the herring acoustic survey (Revised 09).

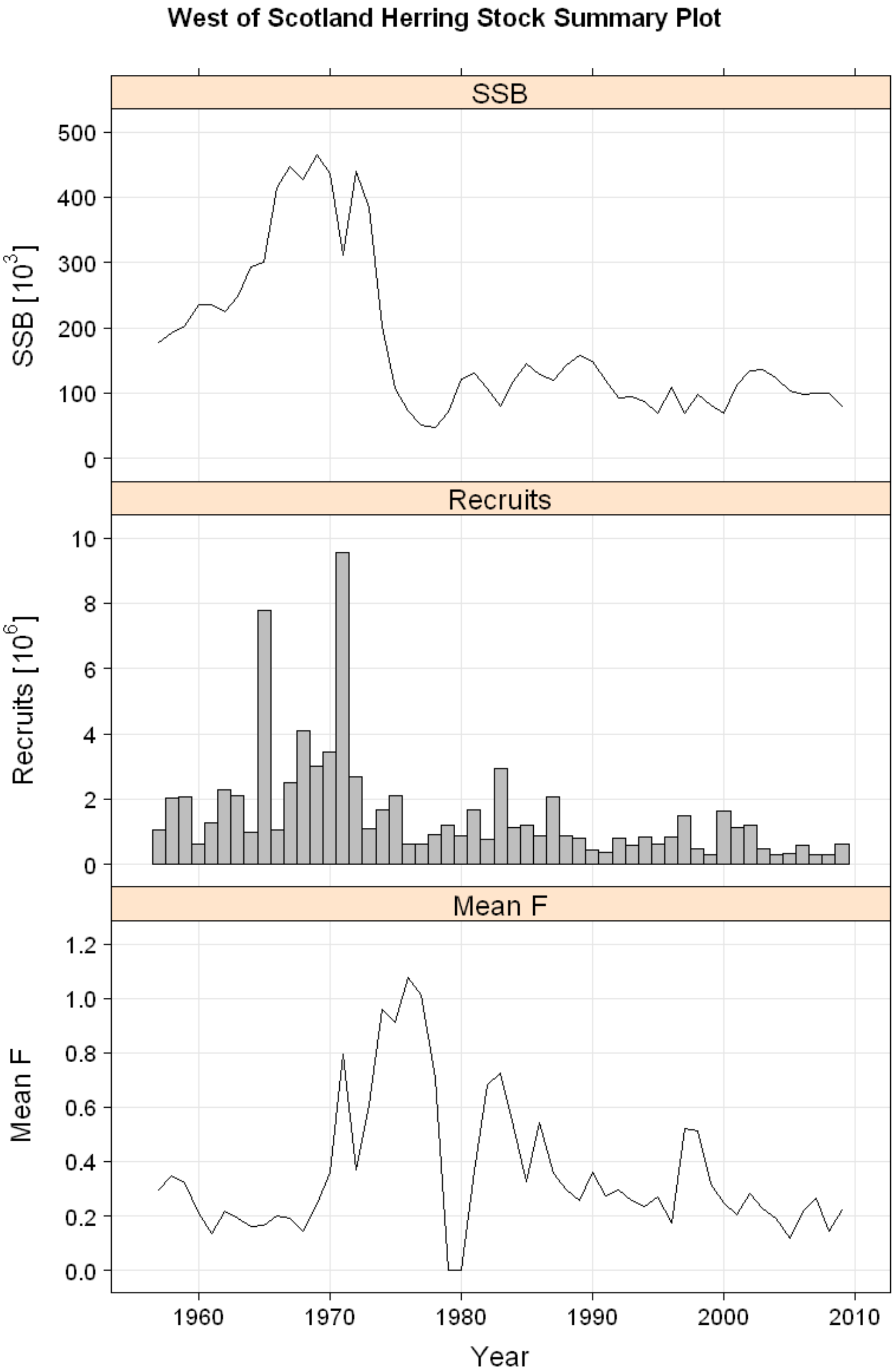


Figure 5.6.2.1. Herring in VIa (North). Illustration of stock trends from the assessment (8 year separable period) 1957-2009. Summary of estimates of landings, spawning stock biomass at spawning time, fishing mortality at F_{3-6}, recruitment at 1-ring, in the final assessment run. The 2009 estimate for recruitment is given as geometric mean (1989-2007) because there are no data to support its estimation.

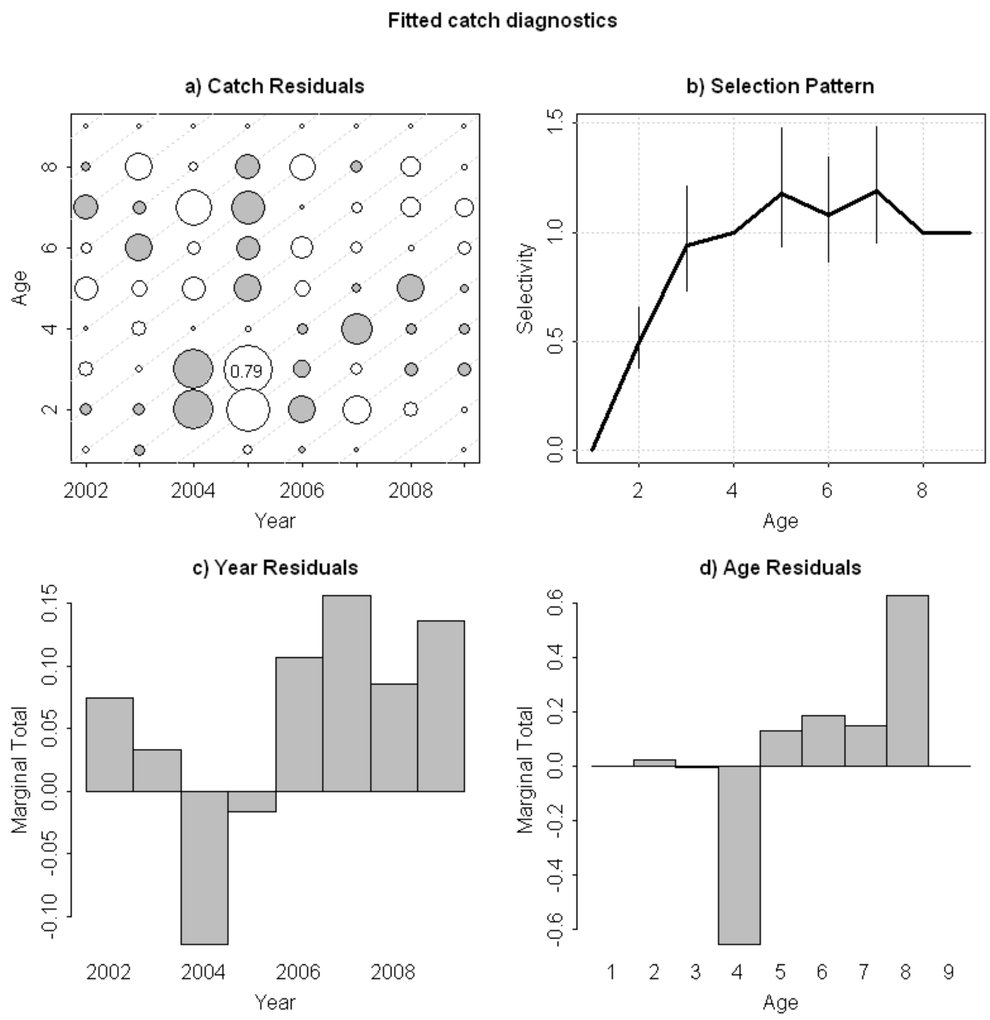


Figure 5.6.2.2. Herring in VIa (N). Illustration of selection patterns diagnostics, from deterministic calculation (8-year separable period). Top left, a bubble plot of selection pattern residuals. Top right, estimated selection (relative to 4-ringers) +/- standard deviation. Bottom, marginal totals of residuals by year and ring.

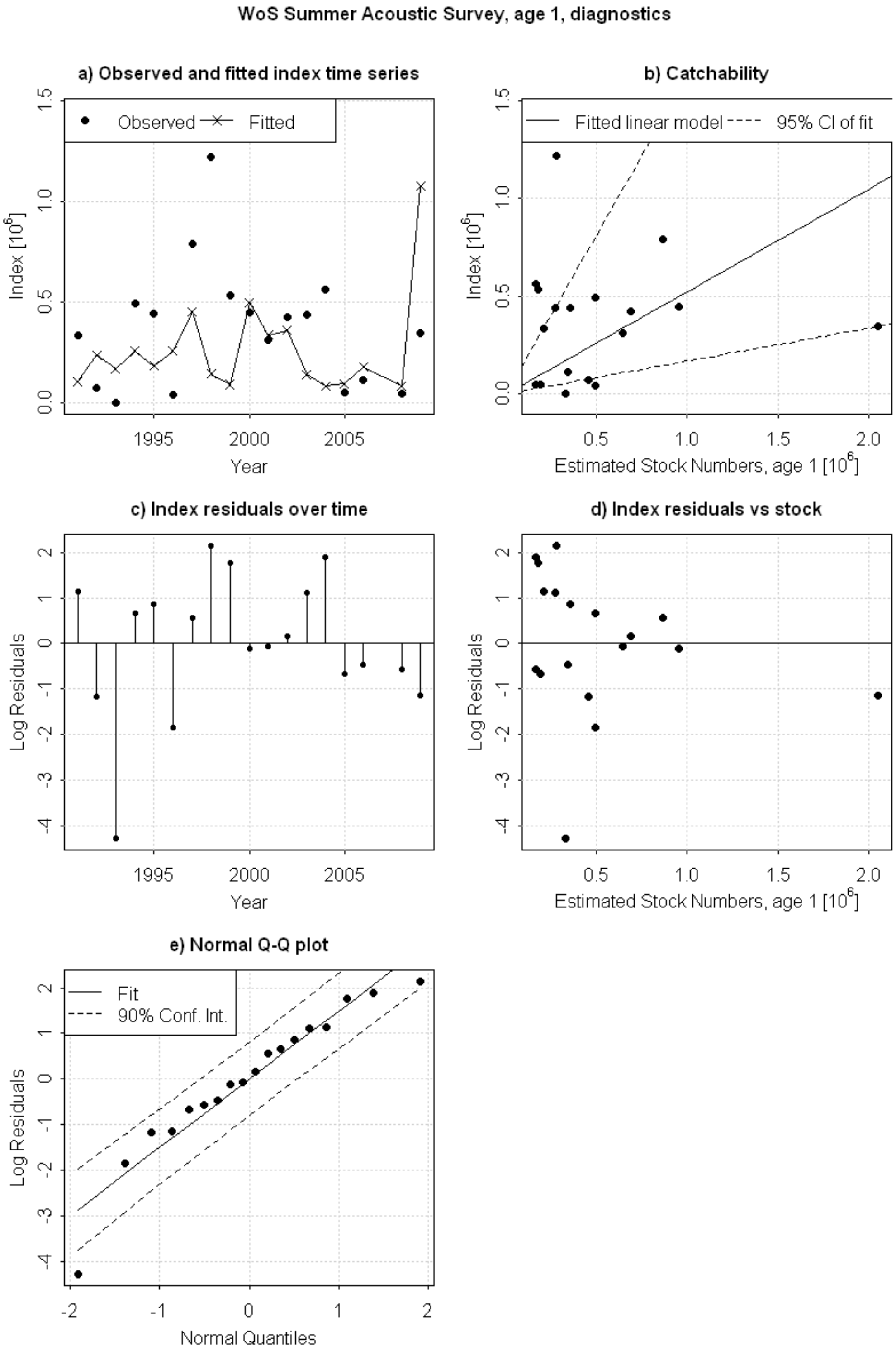


Figure 5.6.2.3. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 1 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

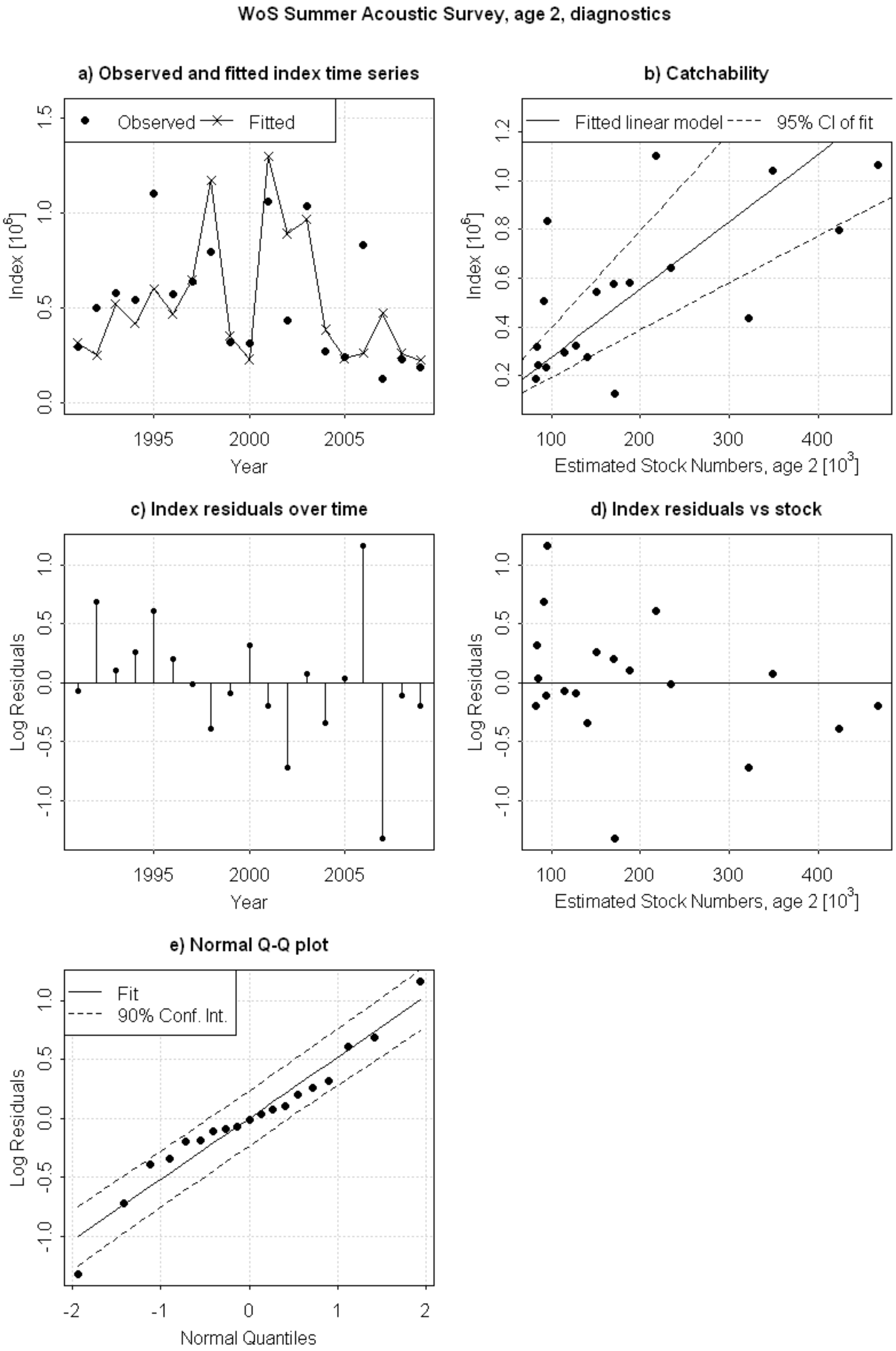


Figure 5.6.2.4. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 2 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

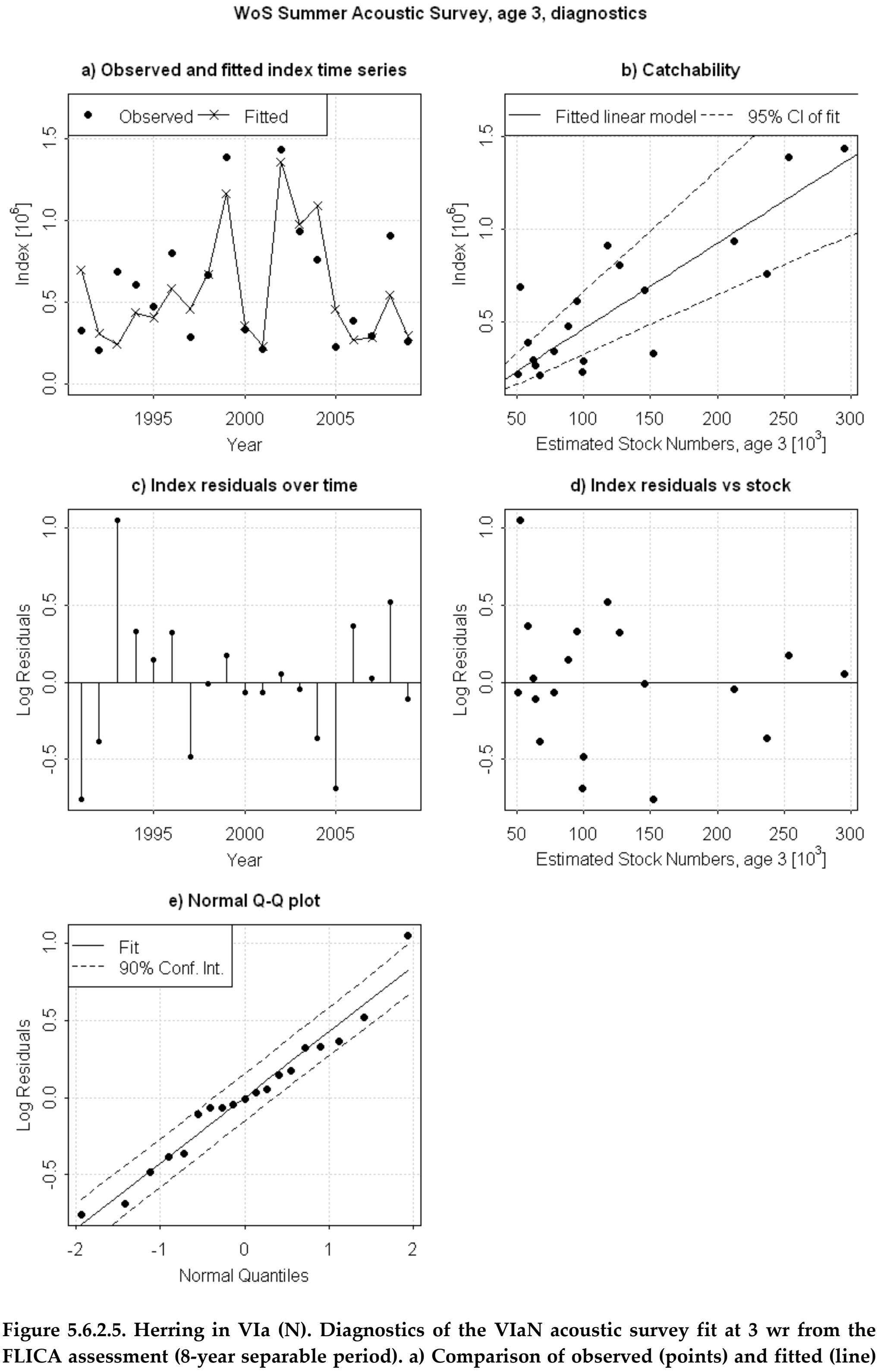


Figure 5.6.2.5. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 3 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

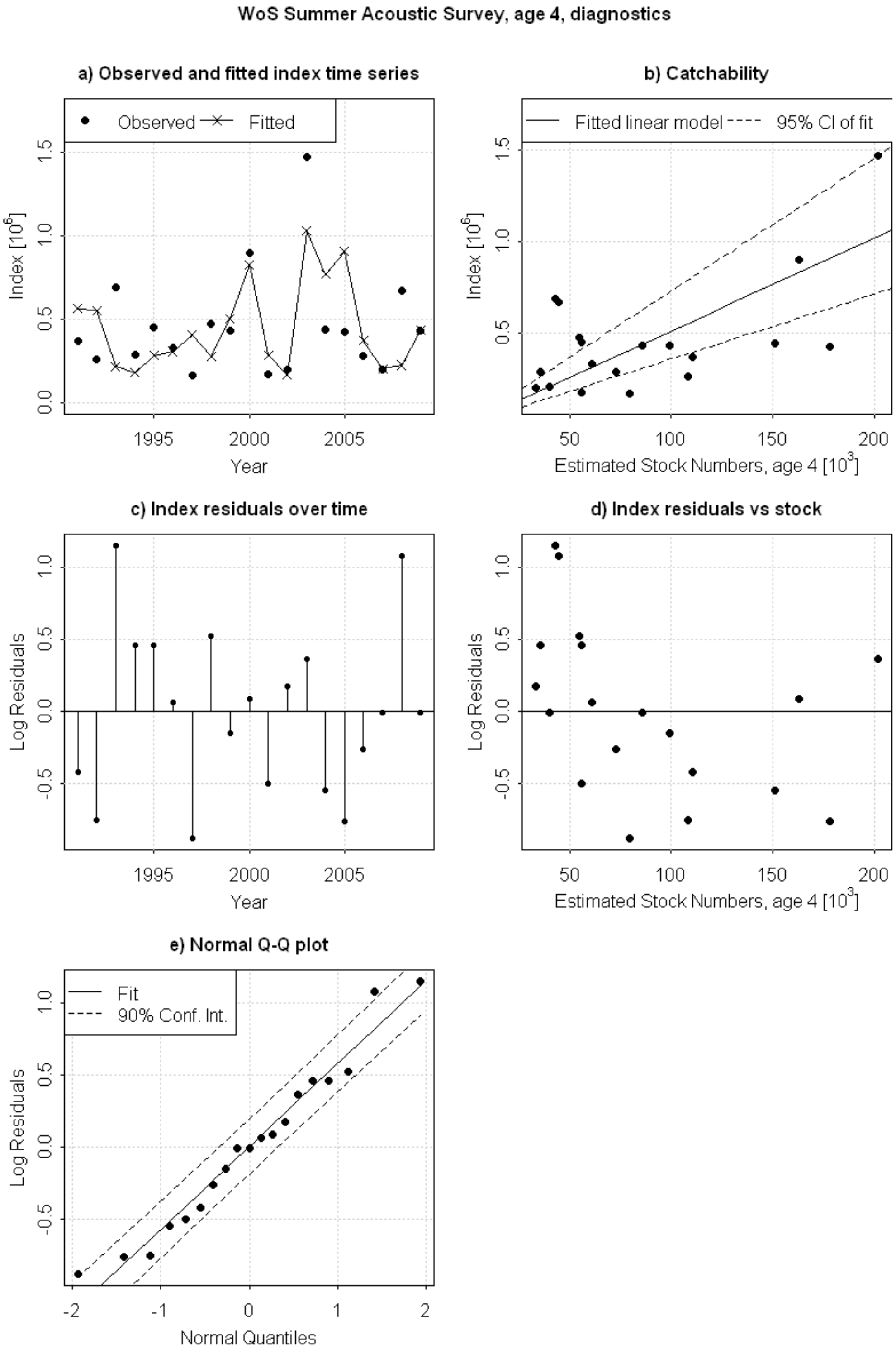


Figure 5.6.2.6. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 4 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

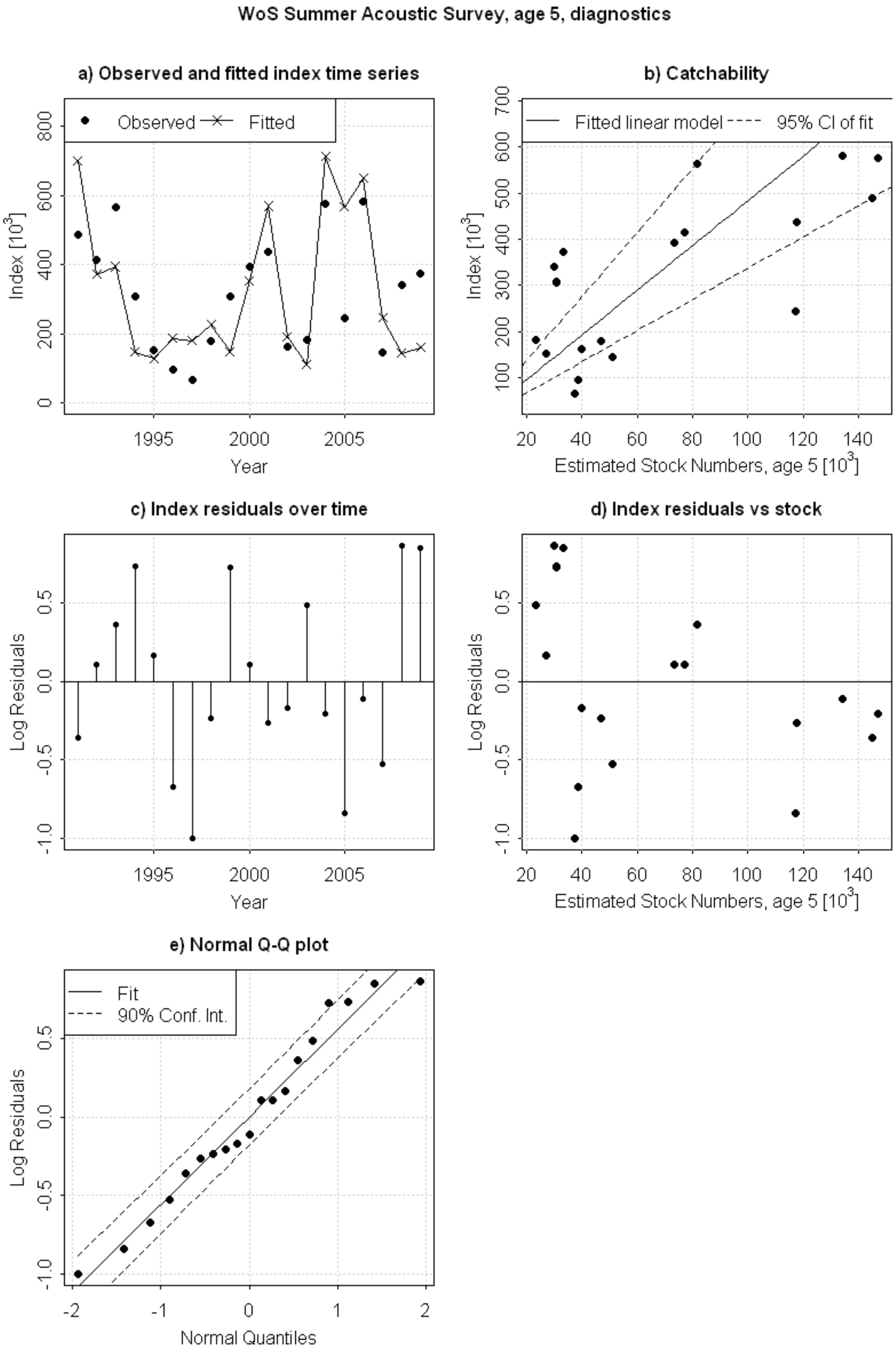


Figure 5.6.2.7. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 5 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

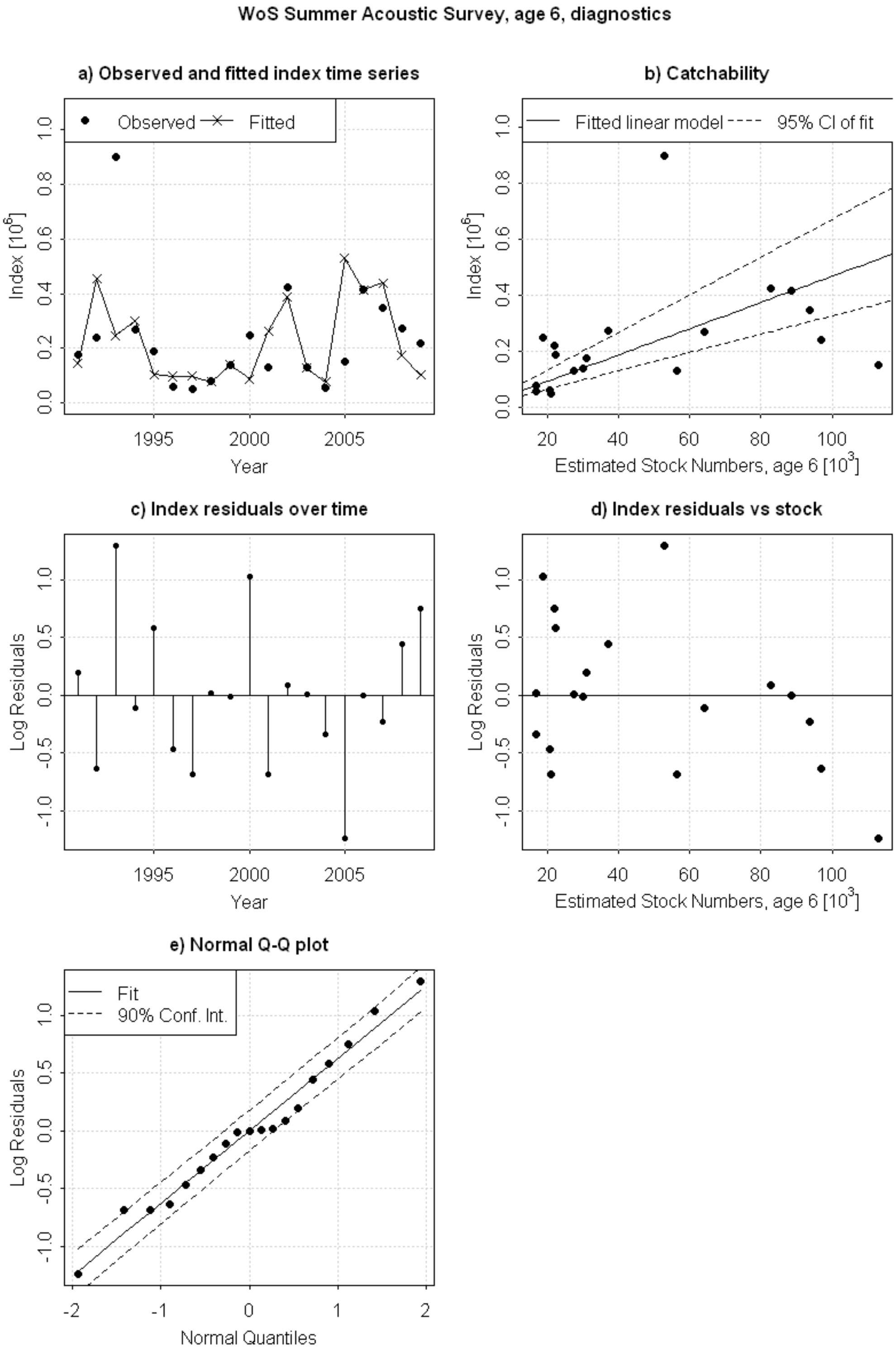


Figure 5.6.2.8. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 6 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

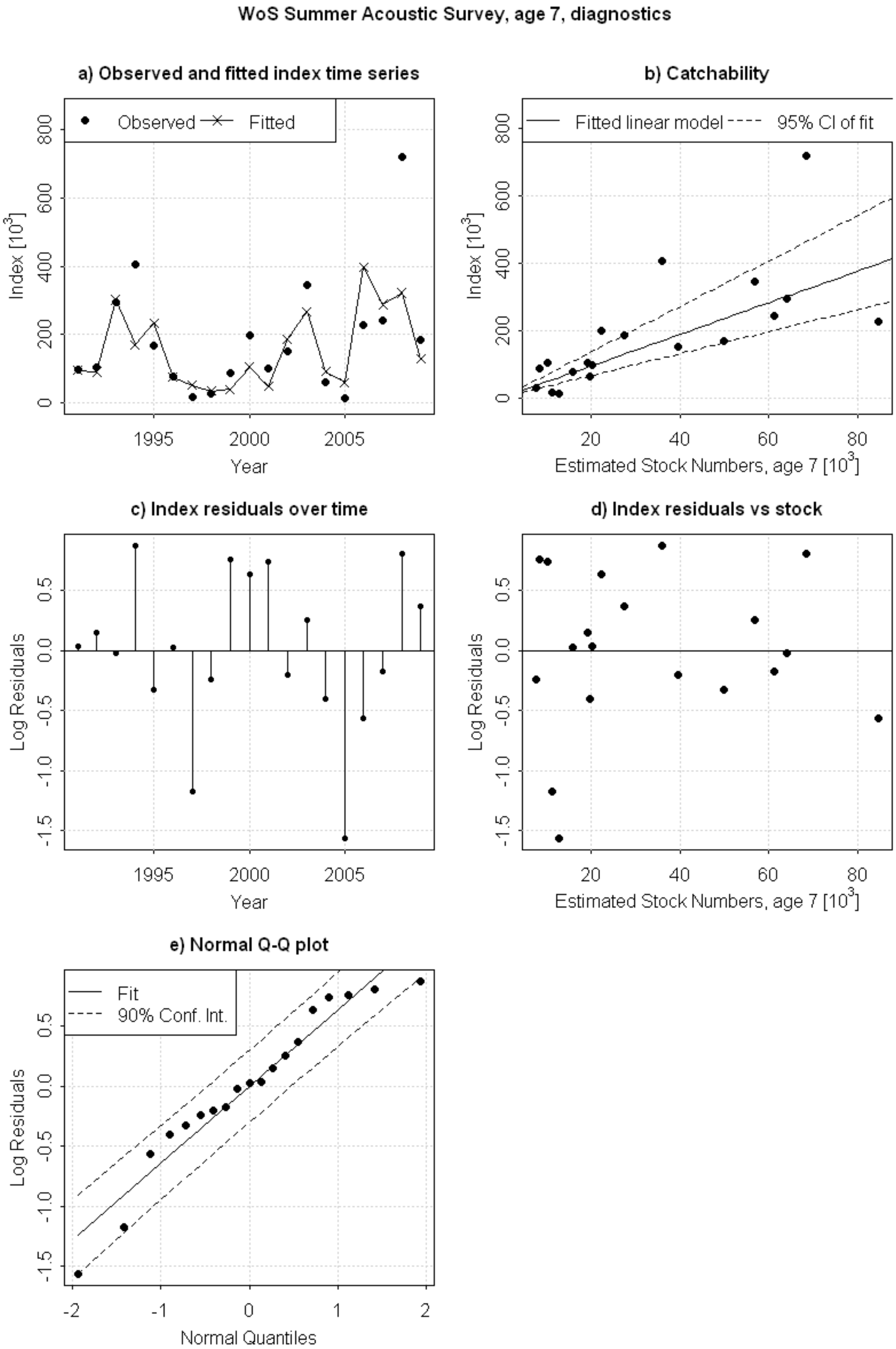


Figure 5.6.2.9. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 7 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted catchability (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).

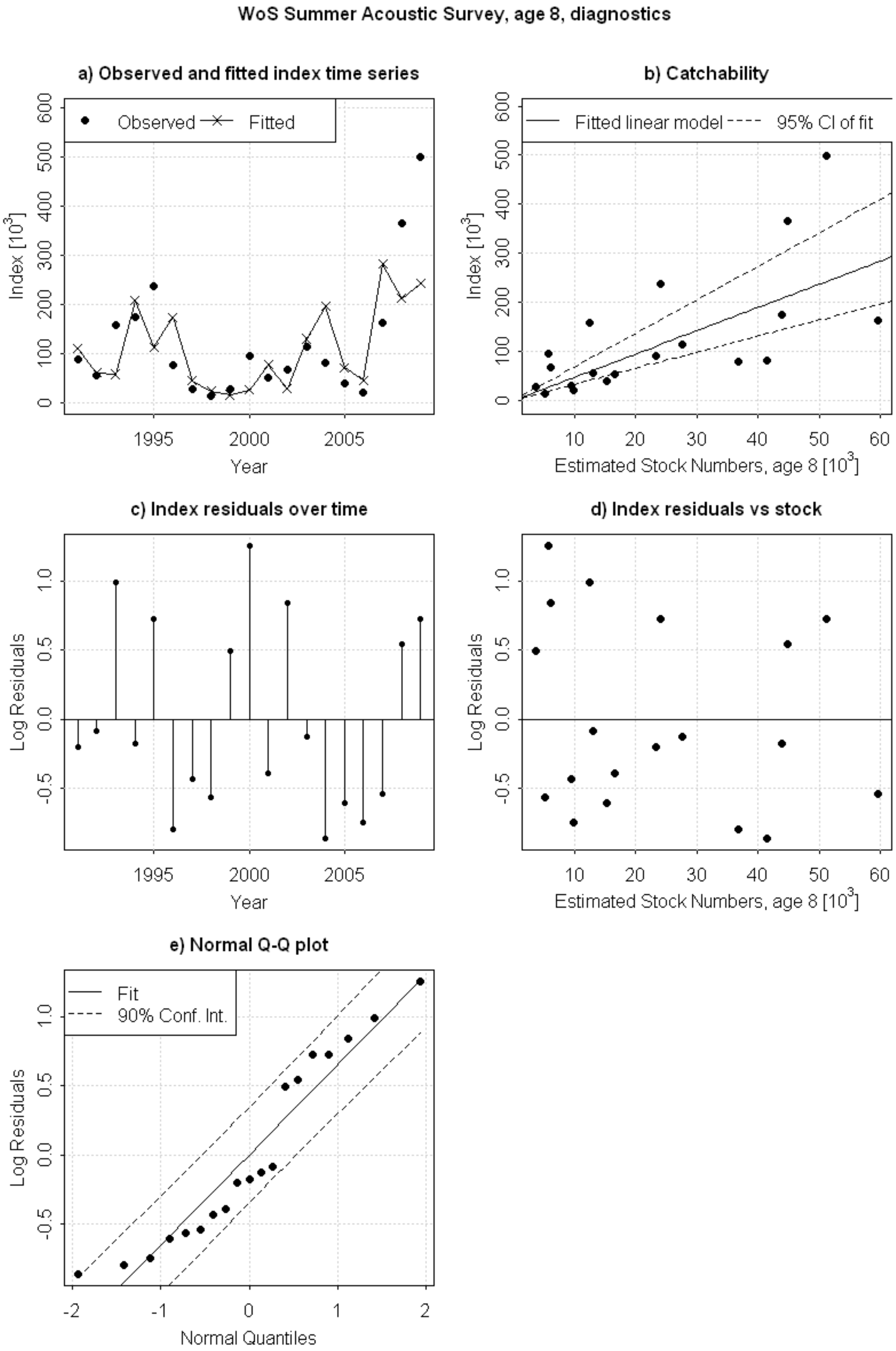


Figure 5.6.2.10. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 8 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

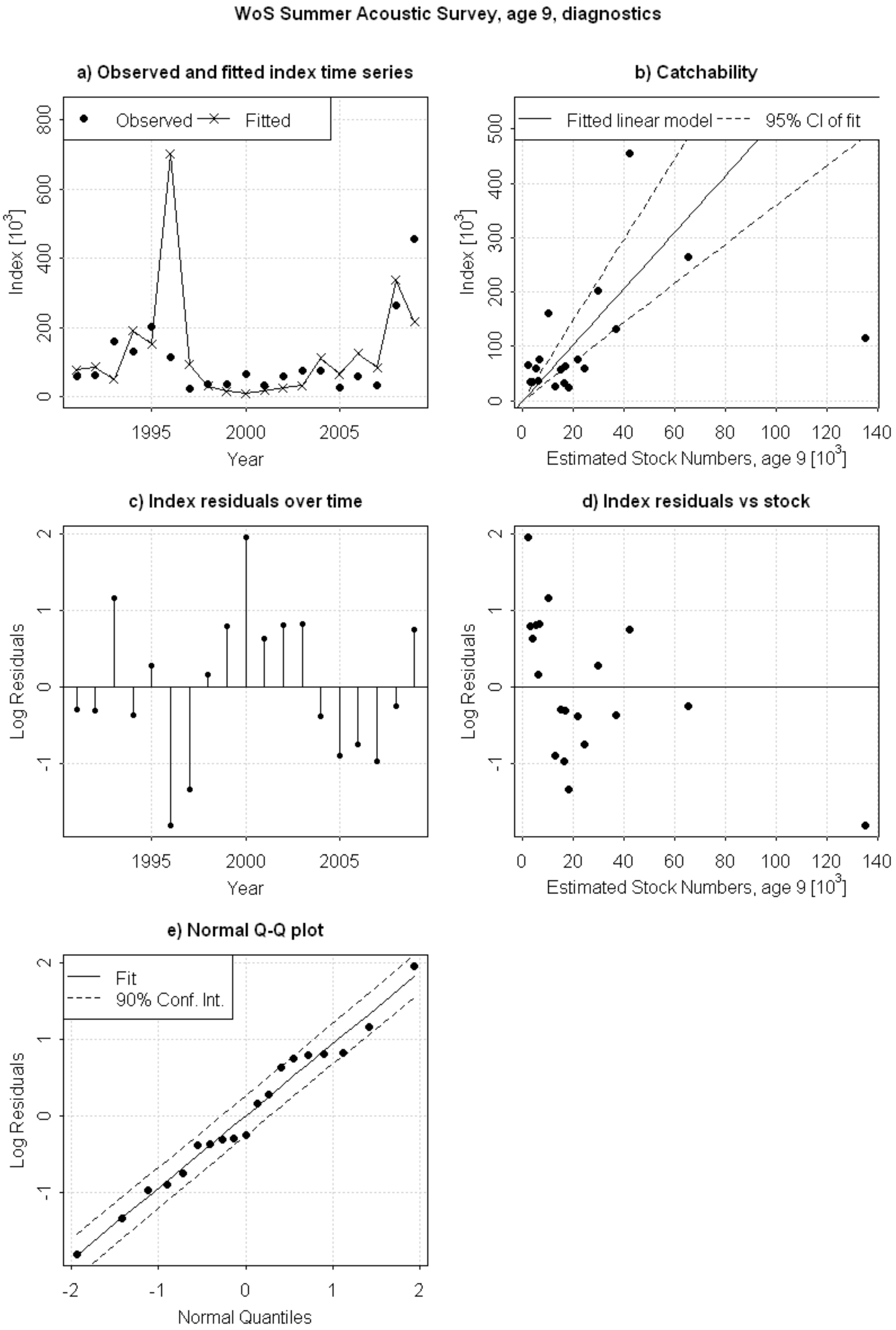


Figure 5.6.2.11. Herring in VIa (N). Diagnostics of the VIaN acoustic survey fit at 9 wr from the FLICA assessment (8-year separable period). a) Comparison of observed (points) and fitted (line) index value. b) Scatter plot of index observations versus FLICA estimates of stock numbers at age. Fitted 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).

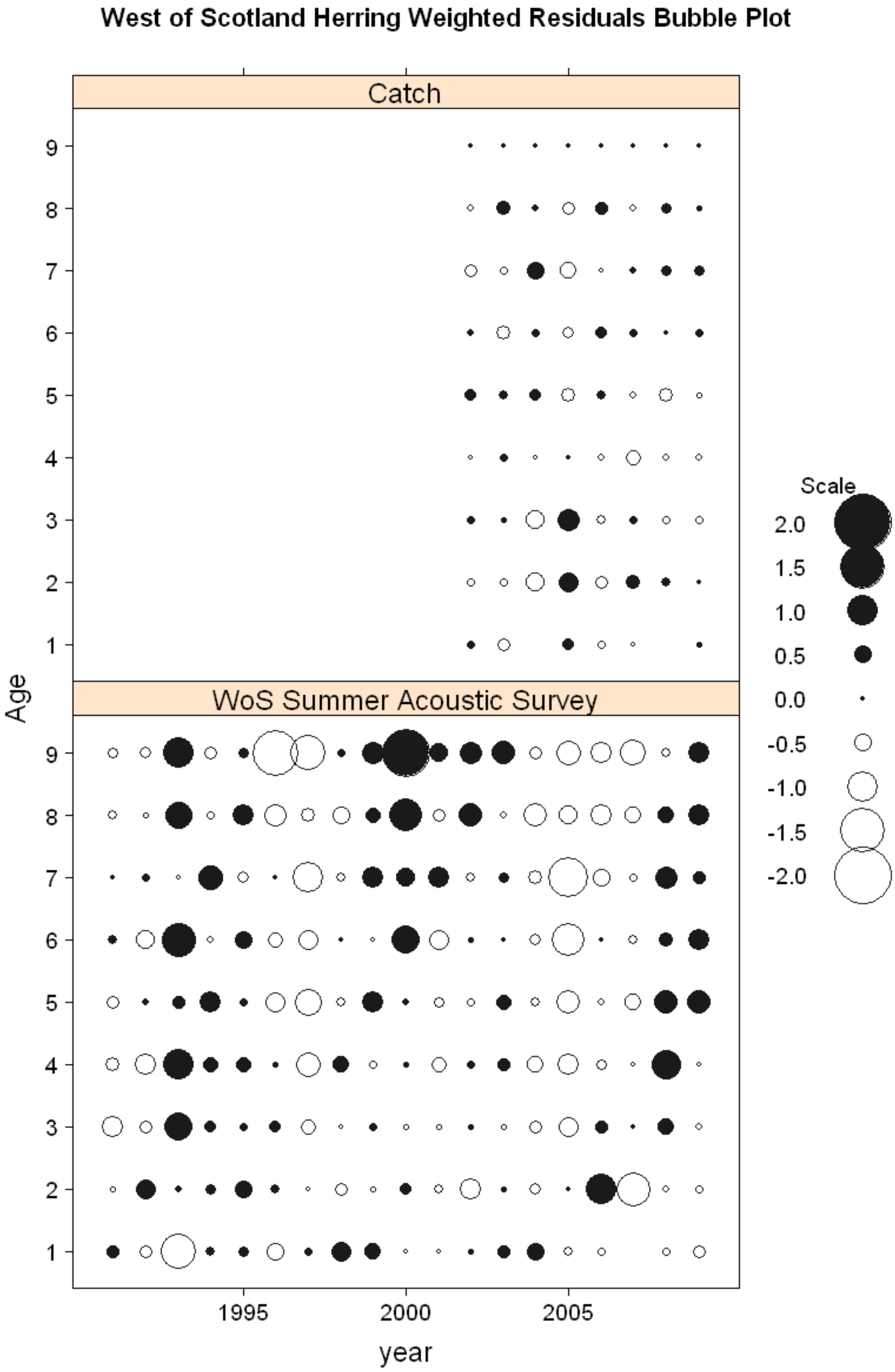


Figure 5.6.2.12. Herring in VIa (N). Comparison of residuals in the catch (top) and survey (bottom) Note the year effects in the survey, particularly in 2005 and 2008. The assessment effectively smoothes an otherwise noisy survey.

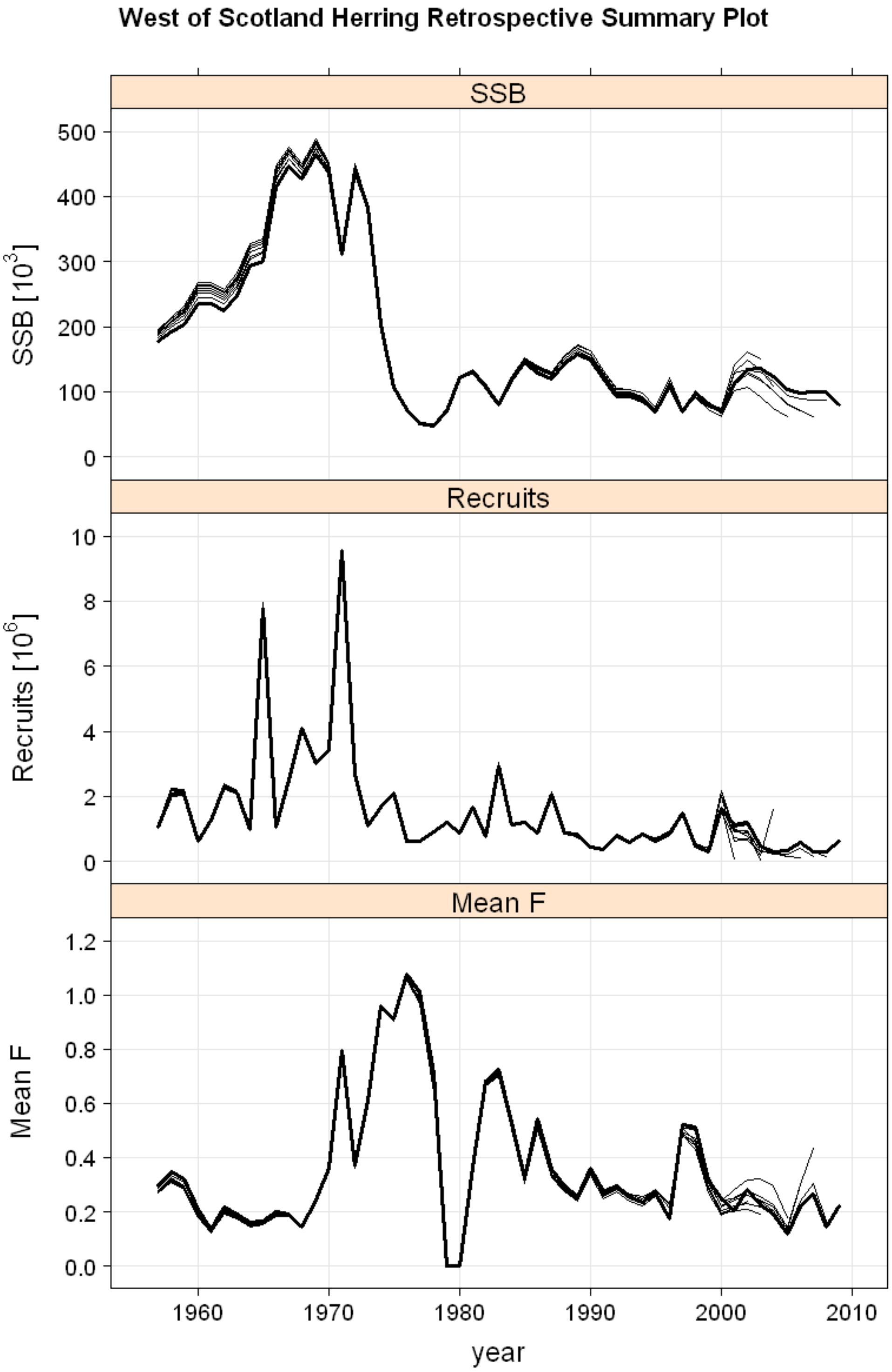
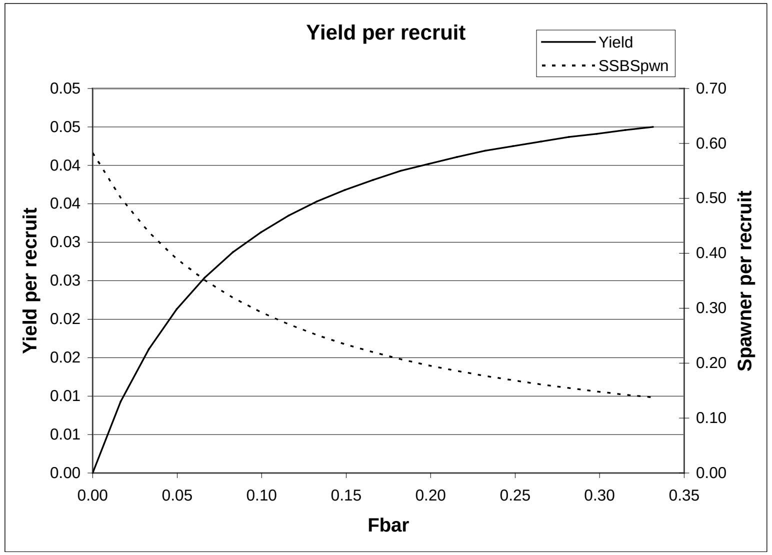
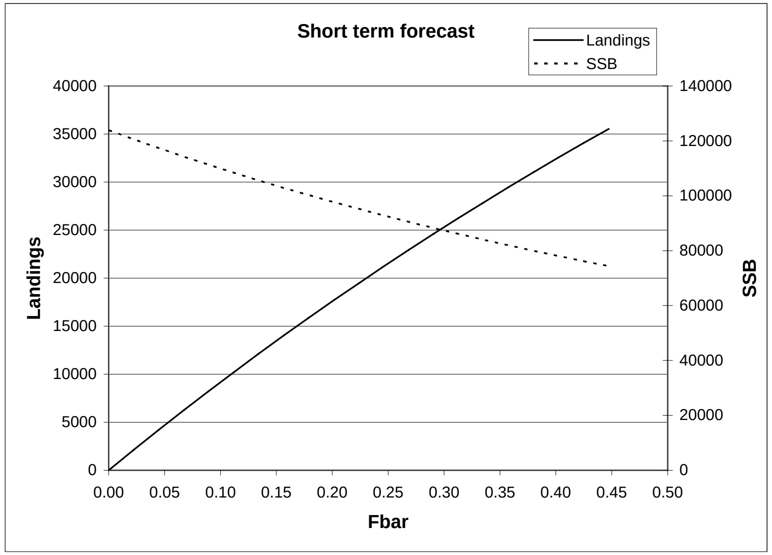


Figure 5.6.2.13. Herring in VIa (N). Analytical retrospective patterns (2009 to 2002) of SSB, mean F_{3-6} and recruitment from the final assessment. The 2009 estimate for recruitment is removed from the graph because there are no data to support its estimation.





MFYPR version 2a
Run: RevCatch1
Time and date: 13:59 09/06/2010

Reference point	F multiplier	Absolute F
Fbar(3-6)	1.0000	0.1658
FMax	200.4630	33.2311
F0.1	1.0710	0.1775
F35%SPR	1.1278	0.1870

Weights in kilograms

MFDP version 1a
Run: RevCatch2
Herring VIaN
Time and date: 14:04 04/06/2010
Fbar age range: 3-6

Input units are thousands and kg - output in tonnes

Figure 5.7.2.1. Herring in VIa (N). Yield-per-recruit and short-term forecast.

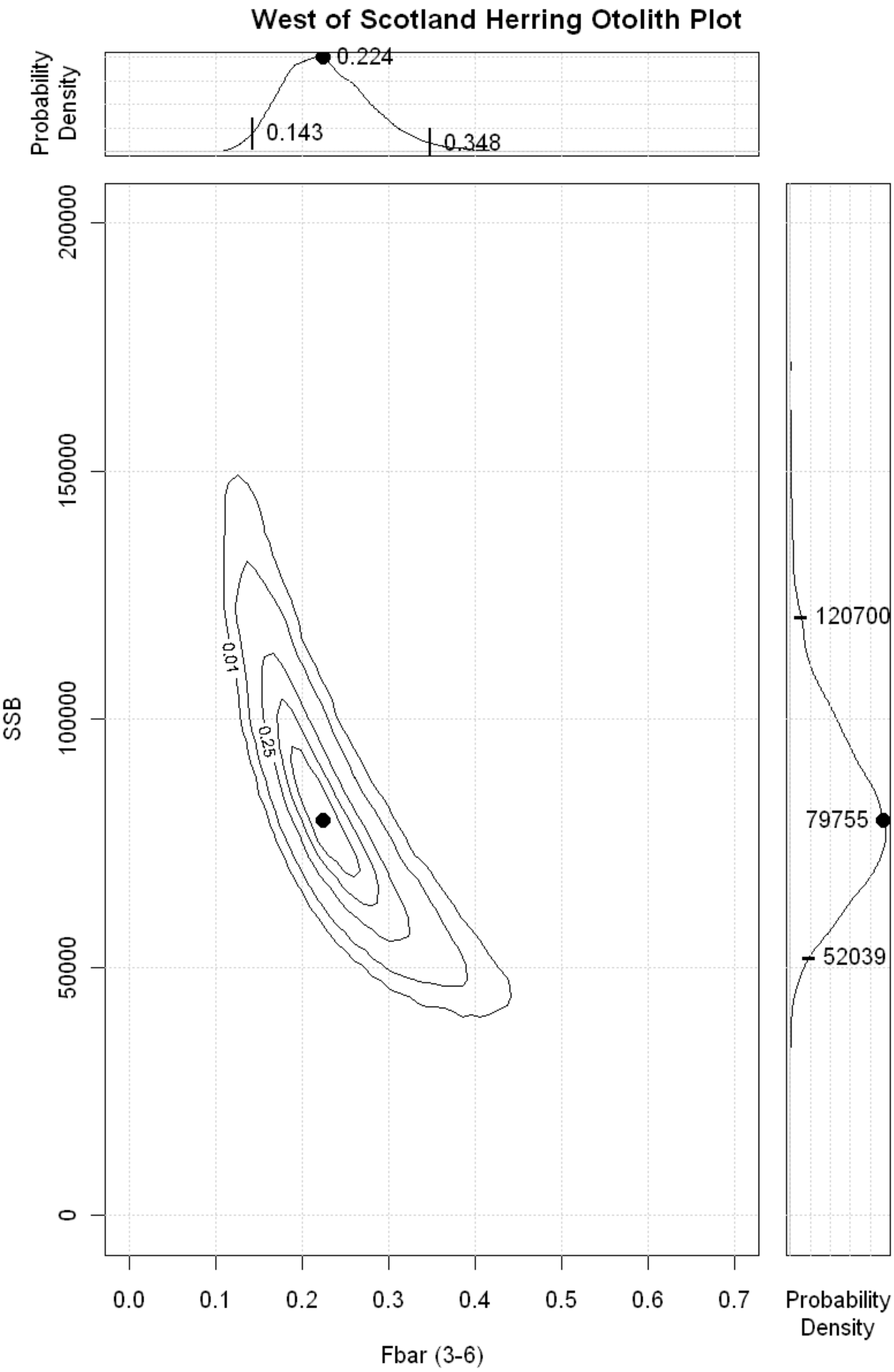


Figure 5.9.1. Herring in VIa (N). Results of parametric bootstrapping from FLICA. The main figure depicts the uncertainty in the estimated spawning stock biomass and average fishing mortality, and their correlation. Contour lines give the 1%, 5%, 25%, 50% and 75% confidence intervals for the two estimated 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.

6 Herring in Divisions VIa (South) and VIIb,c

This management unit has existed since 1982 when it was separated from VIa. Until that time, VIIb,c was a separate management unit. The stock comprises autumn and winter, and spring spawning components. This stock is classified as "SALY" in 2010.

6.1 The Fishery

6.1.1 Advice and management applicable to 2009–2010

The TAC for this area in 2009 was 9 314 t with a decrease of 20% to 7 451 t in 2010. For 2010, ICES advised that the exploratory assessment did not change the perception of the stock and did not give reason to change the advice. The advice for the fishery in 2010 is therefore the same as the advice given in recent years. ICES recommends a rebuilding plan be put in place that will reduce catches. If no rebuilding plan is established, there should be no fishing. ICES advised that the rebuilding plan should be evaluated with respect to the precautionary approach

Rebuilding plan

In 2009, the Federation of Irish Fishermens' Organisations and the Pelagic RAC developed a rebuilding plan for this stock. The plan was for *status quo* TAC in 2010, and, in subsequent years a TAC set at $F_{0.1}$.. This plan was not adopted, and instead the Commission proposed a 25% reduction in TAC, reduced to 20% by the Council of Ministers in December. Other provisions of the plan included allocation of quota for a sentinel fishery in areas not recently targeted, in the hope of finding older fish not currently represented in the age structure. STECF was asked to comment on the application of a survey based rule. STECF considered that this is a worthwhile approach. It was noted that a longer time series, and additional work, was required, before such a rule could be implemented. Additional recommended studies included the identification of spawning components in the Malin Shelf Survey. It was also noted that by the time a survey based rule was possible, there may be sufficient survey data to tune an analytical assessment also.

6.1.2 Catches in 2009

The working group estimates of landings recorded by each country from this fishery from 1988 – 2009 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 2009 was over 8 533 t, compared with 10 237 t in 2008. The total working group estimates of catches in these areas from 1970 –2009 are shown in Figure 6.1.2.1. The working group estimates of catch have declined from about 19 000 t in 2006 to 10 000 t in 2009. The Irish official catch was close to the quota.

There were no estimates of discards reported for 2009 and anecdotal reports from the industry are that there was some discarding in 2009. Some slippage took place but it is not possible to quantify exact amounts.

The assessment period runs concurrently with the annual quota. In recent years Ireland has been the dominant country participating in this fishery. In 2009 all of the catches were reported from quarters 1 and 4 in VIaS. Small landings were reported in VIIb in quarter 4. In the first quarter, fishing began in early January and continued until the end of February. Fishing reopened in the fourth quarter towards the end of October and closed in mid December when the quota was exhausted. The distribution of the landings from this area are presented in Figure 6.1.3.1. The main fishing took place throughout VIaS with a very small proportion in VIIb.

A total of 48 boats categorised as follows caught herring in 2009:

- 23 pelagic segment boats with refrigerated seawater (RSW) storage
- 4 polyvalent segment boats with refrigerated seawater storage
- 21 polyvalent segment vessels with bulk storage.

Polyvalent is a term used to define part of the Irish fleet allowed to catch both pelagic and demersal fish.

6.1.3 Regulations and their effects

The reduction in quotas in the recent past has meant that searching and fishing times have been reduced.

In effect, the boat-quotas were taken in one or two hauls in many cases. Quota is taken on an opportunistic basis, and only in two main areas (Federation of Irish Fishermens' Organisations, WD 2010).

Pelagic segment vessels are not allowed to fish with 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 the very recent past. The pattern of this fishery has changed over time. In the early part of the 20th century the main spawning components were the winter spawners off the north coast, and this was where the main fishery took place. In the 1970s and 1980s the west of Ireland autumn-spawning components were dominant and the fishery was mainly distributed along the coasts of VIIb,c and VIaS. More recently the northern grounds are more important again.

Since the 1980s, fishing has been focussed on spawning grounds or near to these grounds. This is because at that time, there was market for fish in spawning condition. Before that time, fishing was not focussed on spawning fish, but on post spawners or indeed feeding fish.

Mainly, only two main areas have been fished in the past two seasons. This is due to restrictive quotas, fuel prices and other factors that lead to decisions to avoid long distances from the main fishing port (Figure 6.1.4).

6.2 Biological composition of the catch

6.2.1 Catch in numbers-at-age

Catch-at-age data for this fishery are available since 1970 and are shown in Table 6.2.1.1 with percentages since 1994 shown in Table 6.2.1.2. In 2009 the fishery has been dominated by 2, 3, 4 and 5 ringers, accounting for 22%, 21%, 21% and 22% respectively. One ringers are never well represented in the catch and normally do not show up in the catch until quarter 3. In any case, the abundance of 1-ringer in the catches has been very low in the past five years of the time in the series. There is evidence for the progression of the 2003 year class in the past 3 seasons. The catch numbers at age have been mean standardised and are presented in Figure 6.2.1.1. The low numbers of 1 ringers and the attenuation of older ages can be clearly seen.

Five winter ring fish dominate the catch in quarter 1 while in quarter 4 a peak can be seen at 2-ring. Sampling data indicates that herring are fully recruited to the fishery at 3-ring and there is little evidence for 1-ringer fish being an important component of landings in fisheries in this area.

6.2.2 Quality of the catch and biological data

The management of the Irish fishery in recent years has tightened considerably and the accuracy of reported catches is believed to have improved. The numbers of samples and the associated biological data are shown in Table 6.2.2.1. As Ireland is the main participant in this fishery all of the sampling is carried out by Ireland. The length distributions of the catches taken per quarter by the Irish fleet are shown in Table 6.2.2.2. Only one sample was collected from VIIb, and overall landings in this area are very small.

6.3 Fishery Independent Information

6.3.1 Acoustic Surveys

The only survey that could be used to tune this assessment is the Northwest Ireland Acoustic Survey, a constituent survey of the Malin Shelf survey (MSHAS-NWIHAS). In 2009, the Irish survey of VIaS, VIIb, c was conducted in July with effort concentrating on summer feeding aggregations. This is the second acoustic survey that has been carried out at this time of year. The July 2009 survey track and NASC values attributed to herring are shown in Figures 6.3.2.1 and 6.3.2.2 respectively. The survey was carried out on the Celtic Explorer and commenced off the north coast of Ireland and worked in continuity southwards. Existing survey methods was followed with acoustic surveying undertaken between 04:00 and 23:00 (daylight hours).

The results of this acoustic survey are not directly comparable with the winter surveys conducted from 2004-2007 (Table 6.3.1.1). It is comparable in time and area with those conducted from 1994-1996 (Table 6.3.1.2) and the 2008 survey which had the same timing. The SSB estimate (20 906 t) was lower than surveys in 2008, 1994 and 1995 due to the large amount of juveniles encountered with over 55% of the total biomass immature. The total biomass estimate of 46 460 is similar to the 2008 estimate of 44 611 t. It remains unclear if the VIaS and VIIb, c stock is contained within the area of this survey as herring abundance increased moving towards the boundary with VIaN. For the 2010 survey it has been recommended that this survey extend northwards as far as the 57° line. This would allow overlap with the VIaN survey and improve coverage of the area where high abundance has been encountered. This survey is now conducted as part of the WGIPS survey programme.

6.4 Mean weights-at-age and maturity-at-age

6.4.1 Mean Weights at Age

The mean weights (kg) at age in the catches in 2009 are based on Irish catches (Figure 6.4.1.1). In 2009 there is a decrease in mean weights of 1 ringers. Two ringers have remained stable and increases can be seen in older ages. Generally the oldest and youngest ages are poorly represented in the catch data.

The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period that extends from October to February (Figure

6.4.1.2). There appears to be a slight decrease in 1 ringers, an increase in all other age classes.

6.4.2 Maturity Ogive

One ringers are considered to be immature. All older ages are assumed to be 100% mature.

6.5 Recruitment

There is little information on terminal year recruitment in the catch at age data and there are as yet no recruitment indices from the surveys. Numbers of 1-ringers in the catches vary widely but have been consistently low in the most recent years.

6.6 Stock Assessment

6.6.1 Data Exploration

A detailed analysis of basic data, including age composition of catches, log catch ratios and cohort catch curves was conducted in recent years and is presented in the Stock Annex (annex 7). There has been attenuation in older age groups in recent years, and in most recent years, 1-ringers also. However 1-ringers were never well represented in assessment. Log catch ratios show an upward trend in cohort total mortality on fully recruited year classes, since the mid 1990s. Catch curves show low mortality on the very large 1981, 1985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Low mortality was evident in the 1970s and increased mortality can be seen from 1990 on.

6.6.2 Assessment

Following the procedure of recent years, a separable VPA was used to screen over four terminal fishing mortalities, 0.2, 0.4, 0.5 and 0.6. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to 3 winter rings. This assessment is still exploratory, and no assessment has been accepted in recent years.

Four exploratory assessments using the separable VPA were performed, based on the four choices of terminal F. Recruitment, SSB and mean F from each run are plotted in Figure 6.6.2.1. This figure is more informative for the converged part of the VPA, but in most recent years has little information on the current stock dynamics. Outputs from separable VPAs with terminal Fs of 0.2, 0.4, 0.5 and 0.6 are presented in Tables 6.6.2.1, 6.6.2.2, 6.6.2.3 and 6.6.2.4 respectively. Residual plots for the four trial assessments are presented in Figure 6.6.2.2. Large residuals can be seen in 1 ringers, reflecting the poor estimation of this age group. A comparison with the previous year's separable VPA runs is shown in Figure 6.6.2.3.

Fishing mortality was the highest in estimated series in 1998. Subsequent Fs have been lower but still above the long term average in each case. There was a sharp rise in F in 2006, associated with an increased catch in that year.

Recruitment appears to have shown a declining trend over the last few years with all terminal F values used. A higher level of recruitment is estimated with terminal F=0.2.

All the F values greater than 0.2, show that SSB at lowest levels in the series and is considerably lower than the current levels of B_{pa} and B_{lim}. There is no evidence in the observed catch numbers at age to suggest that there are strong year classes recruiting to this fishery.

These explorations are only useful as indicators of historic trends. These results are consistent with the preliminary data screening that shows no stronger year classes in the fishery in recent years.

A retrospective assessment was conducted for each of the F scenarios. Using a terminal F = 0.2 and 0.4 (Figure 6.6.2.4 and 6.6.2.5) shows a bias towards overestimation of SSB and underestimation of F. Using a terminal F = 0.5 (Figure 6.6.2.6) displays a much more stable estimation of SSB and the underestimation of F is not as pronounced. The retrospective assessment using F=0.6 (Figure 6.6.2.7) shows a bias towards an underestimation of SSB and an overestimation of F.

The results of the retrospective analysis suggest that using a terminal F of 0.5 produces more stable estimates of SSB and F than smaller or larger values. This suggests that recent F has been in the range of 0 0.5, which is above $F_{0.1}$

A traditional user defined cohort VPA was applied. The same terminal F rates were used as inputs. Results were broadly similar in terms of SSB trajectories to the separable model. The separable VPA and this user defined VPA for F=0.5 are presented in Figure 6.6.2.8.

6.6.3 State of the Stock

The results of the exploratory assessment suggest that the decline in SSB may be continuing. The current level of SSB is uncertain but is likely to be below B_{pa} and B_{lim}. There is no evidence that large year classes have recruited to the stock in recent years. The perception of stock trends is consistent, even though the most recent estimates of SSB and F are uncertain.

6.7 Short term projections

In the absence of an agreed assessment, it was not considered informative to carry out any predictions.

6.8 Precautionary and yield based reference points

No revisions of the precautionary reference points have been proposed.

F_{MSY} target and trigger for new advisory framework

HAWG met before the new ICES framework had been developed. However HAWG produced a means to estimate the F_{MSY} targets to inform the new advisory framework. The matter is discussed in detail in section 1.3 of this report.

6.9 Quality of the Assessment

The assessment presented was based on the results from a separable VPA without a tuning index, therefore the estimates of SSB and F for recent years depend on the choice of terminal F. The VPA was run for a range of terminal F values and the current perception of the stock would be highly influenced by that choice. There is no information on recent recruitment levels both because the selectivity of the fishery appears to be low for the juveniles and also due to the lack of a recruitment index.

The attenuation of the age structure is also seen in recent surveys (Table 6.3.1.1). However in 2009, 1-ringer abundance in the survey was high. This was not picked up in the catch data for 2009, reflecting that the fishery poorly selects 1-ringers. It will be important to check if this year class appears strong in the 2010 catch.

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 a more stable retrospective pattern. The highest F of 0.6 used shows an overestimation of F. Based on this information we can infer that recent F may have been in the region of 0.5. Further work should be conducted to investigate the sensitivity of the exploratory stock trajectories to the separability assumption.

There are concerns about the underlying assumptions of the separable VPA. The assumption of a constant selection pattern throughout the series is invalid. However in the absence of a tuning index there is little alternative. Traditional VPA runs, using the same terminal Fs as inputs do not produce different stock trajectories, using the same terminal F values.

6.10 Management Considerations

Since 2000, reported landings have been much lower than previously, In the past three years landings have been reduced each year. There is no evidence available to alter stock perception. Evidence from the survey of a good incoming year class needs to be further corroborated in the next years. Recent F has been well above the range of potential estimates of F_{MSY}.

The catch target (20,000 - 25,000 t) of the local management plan is not likely to be achievable at current stock productivity. A rebuilding plan is urgently required and should include further substantial reductions in catches.

6.11 Environment

6.11.1 Ecosystem Considerations

No new information.

6.11.2 Changes in the Environment

No new information.

Table 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Estimated Herring catches in tonnes, 1988–2008. These data do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
France	-	-	+	-	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	250	-	-	11	-	-	-
Ireland	15000	18200	25000	22500	26000	27600	24400	25450	23800	24400	25200
Netherlands	300	2900	2533	600	900	2500	2500	1207	1800	3400	2500
UK (N.Ireland)	-	-	80	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	50	24	-	-	-
UK Scotland	-	+	-	+	-	200	-	-	-	-	-
Total landings	15300	21100	27613	23100	27150	30300	26950	26692	25600	27800	27700
Unallocated/ area misreported	13800	7100	13826	11200	4600	6250	6250	1100	6900	-700	11200
Discards	-	1000	2530	3400	100	250	700	-	-	50	
WG catch	29100	29200	43969	37700	31850	36800	33900	27792	32500	27150	38900

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
France	-	-	-	515	-	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	-	-	-	-	-	-
Ireland	16325	10164	11278	13072	12921	10950	13351	14840	12662	10237	8533
Netherlands	1868	1234	2088	366	-	64	-	353	13		
UK (N.Ireland)	-	-	-	-	-	-	-	-	-	-	-
UK (England + Wales)	-	-	-	-	-	-	-	-	-	-	-
UK Scotland	-	-	-	-	-	-	-	6	-	-	
Total landings	18193	11398	13366	13953	12921	11014	13351	15199	12675	10237	8533
Area misreported	7916	8448	1390	3873	3581	2813	2880	4353	5129	3103	1935
Unallocated								-353	-13		
Discards	-	-	-	-	-	-	-	-	-	-	
WG catch	26109	19846	14756	17826	16502	13827	16231	19193	17791	13340	10468

Table 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Catch in numbers-at-age (winter rings) from 1970 to 2009.

	1	2	3	4	5	6	7	8	9+
1970	135	35114	26007	13243	3895	40181	2982	1667	1911
1971	883	6177	7038	10856	8826	3938	40553	2286	2160
1972	1001	28786	20534	6191	11145	10057	4243	47182	4305
1973	6423	40390	47389	16863	7432	12383	9191	1969	50980
1974	3374	29406	41116	44579	17857	8882	10901	10272	30549
1975	7360	41308	25117	29192	23718	10703	5909	9378	32029
1976	16613	29011	37512	26544	25317	15000	5208	3596	15703
1977	4485	44512	13396	17176	12209	9924	5534	1360	4150
1978	10170	40320	27079	13308	10685	5356	4270	3638	3324
1979	5919	50071	19161	19969	9349	8422	5443	4423	4090
1980	2856	40058	64946	25140	22126	7748	6946	4344	5334
1981	1620	22265	41794	31460	12812	12746	3461	2735	5220
1982	748	18136	17004	28220	18280	8121	4089	3249	2875
1983	1517	43688	49534	25316	31782	18320	6695	3329	4251
1984	2794	81481	28660	17854	7190	12836	5974	2008	4020
1985	9606	15143	67355	12756	11241	7638	9185	7587	2168
1986	918	27110	24818	66383	14644	7988	5696	5422	2127
1987	12149	44160	80213	41504	99222	15226	12639	6082	10187
1988	0	29135	46300	41008	23381	45692	6946	2482	1964
1989	2241	6919	78842	26149	21481	15008	24917	4213	3036
1990	878	24977	19500	151978	24362	20164	16314	8184	1130
1991	675	34437	27810	12420	100444	17921	14865	11311	7660
1992	2592	15519	42532	26839	12565	73307	8535	8203	6286
1993	191	20562	22666	41967	23379	13547	67265	7671	6013
1994	11709	56156	31225	16877	21772	13644	8597	31729	10093
1995	284	34471	35414	18617	19133	16081	5749	8585	14215
1996	4776	24424	69307	31128	9842	15314	8158	12463	6472
1997	7458	56329	25946	38742	14583	5977	8351	3418	4264
1998	7437	72777	80612	38326	30165	9138	5282	3434	2942
1999	2392	51254	61329	34901	10092	5887	1880	1086	949
2000	4101	34564	38925	30706	13345	2735	1464	690	1602
2001	2316	21717	21780	17533	18450	9953	1741	1027	508
2002	4058	32640	37749	18882	11623	10215	2747	1605	644
2003	1731	32819	28714	24189	9432	5176	2525	923	303
2004	1401	15122	32992	19720	9006	4924	1547	975	323
2005	209	28123	30896	26887	10774	5452	1348	858	243
2006	598	22036	36700	30581	21956	9080	2418	832	369
2007	76	24577	43958	23399	13738	5474	1825	231	131
2008	483	12265	19661	28483	11110	5989	2738	745	267
2009	202	12574	12077	12096	12574	5239	2040	853	17

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

Table 6.2.2.1. Herring in Divisions VIa(S) and VIIb,c. Sampling intensity of catches in 2009.

ICES area	Year	Quarter	Landings (t)	No. Samples	No. aged	No. Measured	Aged/1000 t
VIaS official	2009	1	2275	10	655	2089	288
VIaS official	2009	4	6213	28	1559	5668	251
VIIb	2009	4	44	1	49	206	262
Total			8532	39	2263	7963	265

Table 6.2.2.2. Herring in Divisions VIa(S) and VIIb,c. Length distribution of Irish catches/quarter (thousands) 2009.

Length cm	Quarter 1 VIa South	Quarter 4 VIIbc	Quarter 4 VIa South
16.5	7.142		
17	14.283		
17.5	7.142		
18	14.283		
18.5	0		
19	7.142		
19.5	7.142		
20	21		6
20.5	29		
21	114		
21.5	150		6
22	414		6
22.5	343		6
23	371		62
23.5	279		56
24	357	4	173
24.5	243	4	313
25	357		660
25.5	464	13	1348
26	807	45	2405
26.5	1228	36	3110
27	1657	40	3093
27.5	1921	89	3401
28	2385	179	4374
28.5	1721	232	5146
29	1193	192	4323
29.5	450	67	2215
30	243	18	822
30.5	79		134
31	7		45
31.5	0		
32	14		
32.5	7		
33	0		
33.5	0		
34	7		
34.5			
35			
35.5			
36			
Nos./t	14919	919	31702

Table 6.3.1.1. Herring in Divisions VIa(S) and VIIb,c. Time series of acoustic surveys since 1999. The 2008 and 2009 surveys are part of a new summer survey of the Malin Shelf stock complex.

Winter rings	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0			5	0		0	1	0		12	416
1	19	11	23	36	10		8	2	0	83	81
2	105	61	52	14	26	4	57	7	4	65	11
3	33	49	6	24	30	62	94	87	60	38	15
4	11	26	6	14	11	55	110	58	22	22	8
5	2	9	3	6	3	80	101	28	12	29	7
6	1	2	2	6	1	47	57	16	6	9	7
7	0	1	0	5	1	14	21	5	2	5	0
8	0	0	0	3	0	12	25	5		2	1
9+	0	1	0	4	0		13	1		2	0
Abundance (millions)	170.8	160.36	97.9	111.33	82.6	274.06	485.29	202.9	105.41	266.85	547.59
Total Biomass (t)	23,762	21,048	11,062	8,867	10,300	41,700	71,253	27,770	14,222	44,611	46,460
SSB (t)	22,788	20,500	9,800	6,978	9,500	41,300	66,138	27,200	13,974	43,006	20,906
CV	-	-	-	-	-	-	-	49%	44%	34%	38%

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

Table 6.6.2.1. Herring in Divisions VIa(S) and VIIb,c. VPA run with a terminal F value of 0.2.

	Recruts 1 ring	SSB (t)	Landings (t)	Mean F 3-6
1970	402577	124139	20306	0.1843
1971	810604	108471	15044	0.1647
1972	728678	114481	23474	0.2063
1973	530236	145099	36719	0.2906
1974	584618	89534	36589	0.4567
1975	402812	95352	38764	0.4458
1976	679330	66120	32767	0.511
1977	569987	75103	20567	0.3263
1978	1032748	70514	19715	0.2686
1979	957687	102031	22608	0.279
1980	523609	97413	30124	0.4046
1981	666139	97890	24922	0.3252
1982	686349	108298	19209	0.2347
1983	2269525	103137	32988	0.3757
1984	944100	176381	27450	0.2132
1985	1210671	181015	23343	0.1778
1986	933622	215056	28785	0.1876
1987	3193682	187201	48600	0.3567
1988	475216	292646	29100	0.28
1989	710267	218396	29210	0.1872
1990	807208	188587	43969	0.2665
1991	502031	163316	37700	0.2496
1992	415383	130618	31856	0.2787
1993	615208	112224	36763	0.3592
1994	801495	93543	33908	0.3652
1995	457162	83061	27792	0.4702
1996	831479	62015	32534	0.5849
1997	821936	63701	27225	0.5385
1998	527648	52103	38895	1.043
1999	387166	44503	26109	0.7116
2000	441096	36981	19846	0.5313
2001	450541	34444	14756	0.6366
2002	557591	33194	17826	0.6987
2003	468241	38550	16502	0.6375
2004	498603	41169	13727	0.5727
2005	601366	42034	16231	0.5542
2006	403724	43254	19193	0.7619
2007	300432	39594	17791	0.53
2008	533027	36798	13340	0.449
2009	472943	50540	10468	0.301
Means	671367*	101463	26418	0.4104

Table 6.6.2.2. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.4.

	Recruits (1-ring)	SSB (t)	Landings (t)	Mean F 3-6
1970	404253	140636	20306	0.18
1971	814362	126636	15044	0.16
1972	732623	129647	23474	0.20
1973	533454	145843	36719	0.29
1974	588377	93259	36589	0.45
1975	406298	86401	38764	0.44
1976	685348	64404	32767	0.50
1977	575650	71064	20567	0.32
1978	1045296	70833	19715	0.26
1979	971497	97585	22608	0.27
1980	530860	103379	30124	0.40
1981	674194	97485	24922	0.32
1982	695468	107855	19209	0.23
1983	2298215	105856	32988	0.37
1984	955854	186424	27450	0.21
1985	1222782	187979	23343	0.17
1986	941515	223257	28785	0.18
1987	3216622	201891	48600	0.35
1988	477946	297891	29100	0.27
1989	713200	221967	29210	0.18
1990	809090	191822	43969	0.26
1991	502711	166325	37700	0.25
1992	415669	133305	31856	0.28
1993	615532	113246	36763	0.36
1994	801963	95077	33908	0.36
1995	457394	79428	27792	0.47
1996	831635	62616	32534	0.58
1997	821284	63823	27225	0.54
1998	526698	52238	38895	1.04
1999	385897	44420	26109	0.71
2000	439162	36893	19846	0.53
2001	445412	34342	14756	0.64
2002	545565	32869	17826	0.71
2003	448707	37634	16502	0.65
2004	459769	39549	13727	0.59
2005	511179	39116	16231	0.58
2006	298282	36980	19193	0.85
2007	185609	29623	17791	0.66
2008	265371	22533	13340	0.68
2009	201111	24113	10468	0.59
Means	632812*	102406	26418	0.43

*Geometric mean recruitment: 1970-2007

Table 6.6.2.3. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.5.

	Recruits (1-r)	SSB (t)	Landings (t)	Mean F 3-6
1970	404796	141336	20306	0.181
1971	815585	127291	15044	0.162
1972	733900	130313	23474	0.203
1973	534494	146820	36719	0.287
1974	589593	93754	36589	0.451
1975	407429	86898	38764	0.438
1976	687300	64813	32767	0.500
1977	577481	71512	20567	0.318
1978	1049353	71299	19715	0.262
1979	975936	98202	22608	0.271
1980	533184	104115	30124	0.393
1981	676772	98309	24922	0.313
1982	698390	108731	19209	0.226
1983	2307367	106870	32988	0.362
1984	959585	187825	27450	0.206
1985	1226623	189302	23343	0.172
1986	944011	224712	28785	0.182
1987	3223853	203352	48600	0.346
1988	478807	299487	29100	0.272
1989	714123	223168	29210	0.183
1990	809680	192884	43969	0.261
1991	502926	167128	37700	0.245
1992	415760	133950	31856	0.275
1993	615638	113779	36763	0.356
1994	802121	95501	33908	0.363
1995	457478	79589	27792	0.467
1996	831718	62717	32534	0.583
1997	821163	63896	27225	0.537
1998	526505	52266	38895	1.038
1999	385640	44430	26109	0.708
2000	438773	36894	19846	0.531
2001	444389	34319	14756	0.638
2002	543197	32802	17826	0.707
2003	445017	37470	16502	0.652
2004	452379	39240	13727	0.595
2005	493292	38544	16231	0.591
2006	276929	35759	19193	0.872
2007	162573	27635	17791	0.693
2008	214143	19665	13340	0.750
2009	153007	18864	10468	0.739
Means	629219*	102636	26418	0.433

*Geometric mean 1970-2007

Table 6.6.2.4. Herring in Divisions VIa(S) and VIIb,c. VPA run using a terminal F or 0.6..

	Recruits (1-r)	SSB (t)	Landings (t)	Mean F 3-6
1970	405236	141898	20306	0.181
1971	816576	127817	15044	0.161
1972	734936	130848	23474	0.203
1973	535337	147607	36719	0.286
1974	590578	94153	36589	0.449
1975	408346	87300	38764	0.436
1976	688882	65144	32767	0.498
1977	578962	71875	20567	0.316
1978	1052636	71677	19715	0.261
1979	979522	98701	22608	0.270
1980	535059	104711	30124	0.390
1981	678850	98976	24922	0.311
1982	700747	109439	19209	0.224
1983	2314734	107689	32988	0.360
1984	962582	188956	27450	0.204
1985	1229708	190369	23343	0.171
1986	946015	225884	28785	0.181
1987	3229645	204527	48600	0.344
1988	479496	300770	29100	0.270
1989	714862	224133	29210	0.182
1990	810152	193737	43969	0.260
1991	503099	167772	37700	0.244
1992	415834	134468	31856	0.275
1993	615725	114205	36763	0.355
1994	802249	95841	33908	0.362
1995	457547	79718	27792	0.467
1996	831793	62799	32534	0.582
1997	821088	63955	27225	0.536
1998	526377	52290	38895	1.037
1999	385470	44440	26109	0.707
2000	438515	36898	19846	0.531
2001	443710	34306	14756	0.638
2002	541632	32758	17826	0.708
2003	442650	37362	16502	0.653
2004	447649	39038	13727	0.598
2005	481562	38175	16231	0.595
2006	262717	34963	19193	0.885
2007	147200	26325	17791	0.716
2008	180552	17762	13340	0.808
2009	122507	15376	10468	0.882
Mean	626740*	102867	26418	0.438

***Geometric mean 1970-2007**

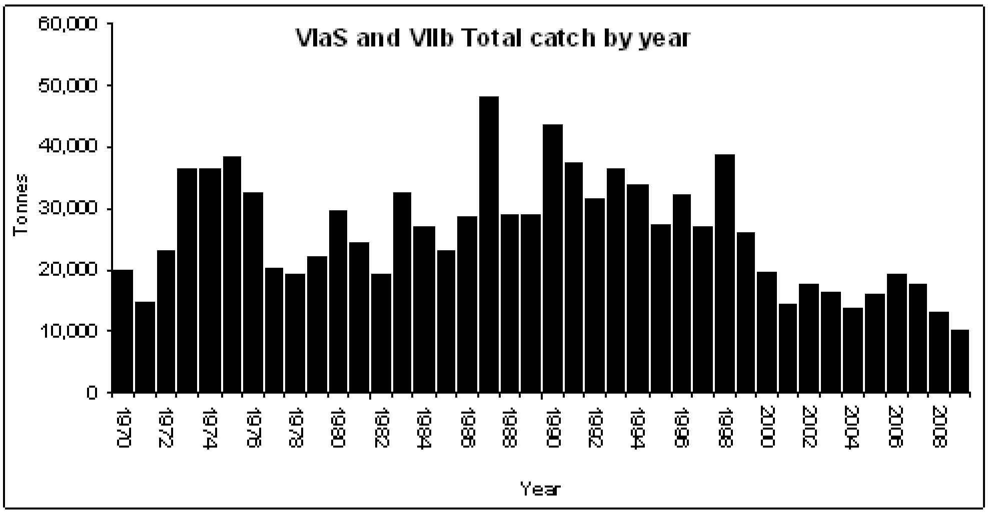


Figure 6.1.2.1. Herring in Divisions VIa(S) and VIIb,c. Working group estimate of catches from 1970-2009.

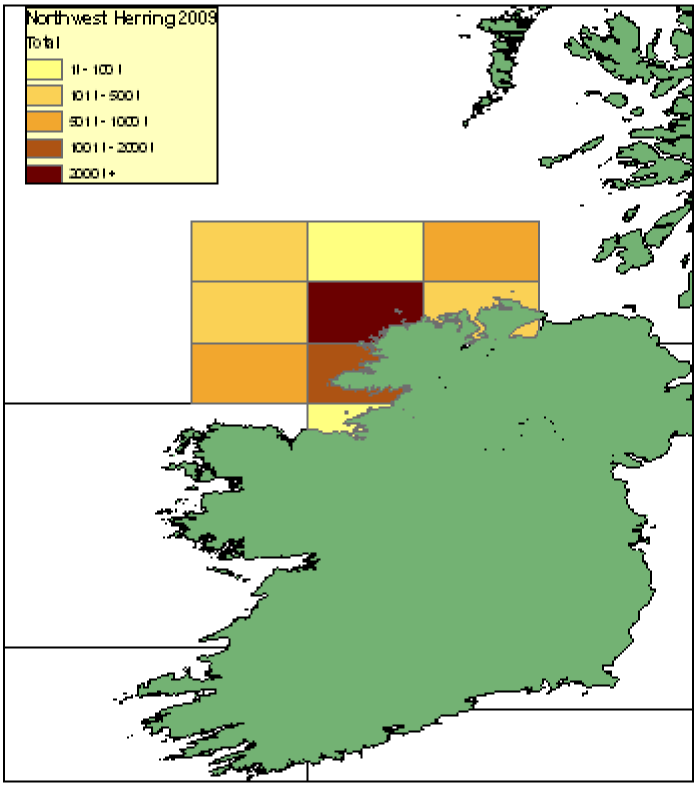


Figure 6.1.3.1. Herring in Divisions VIa(S) and VIIb,c. Herring landings by statistical rectangle in VIaS and VIIbc in 2009.

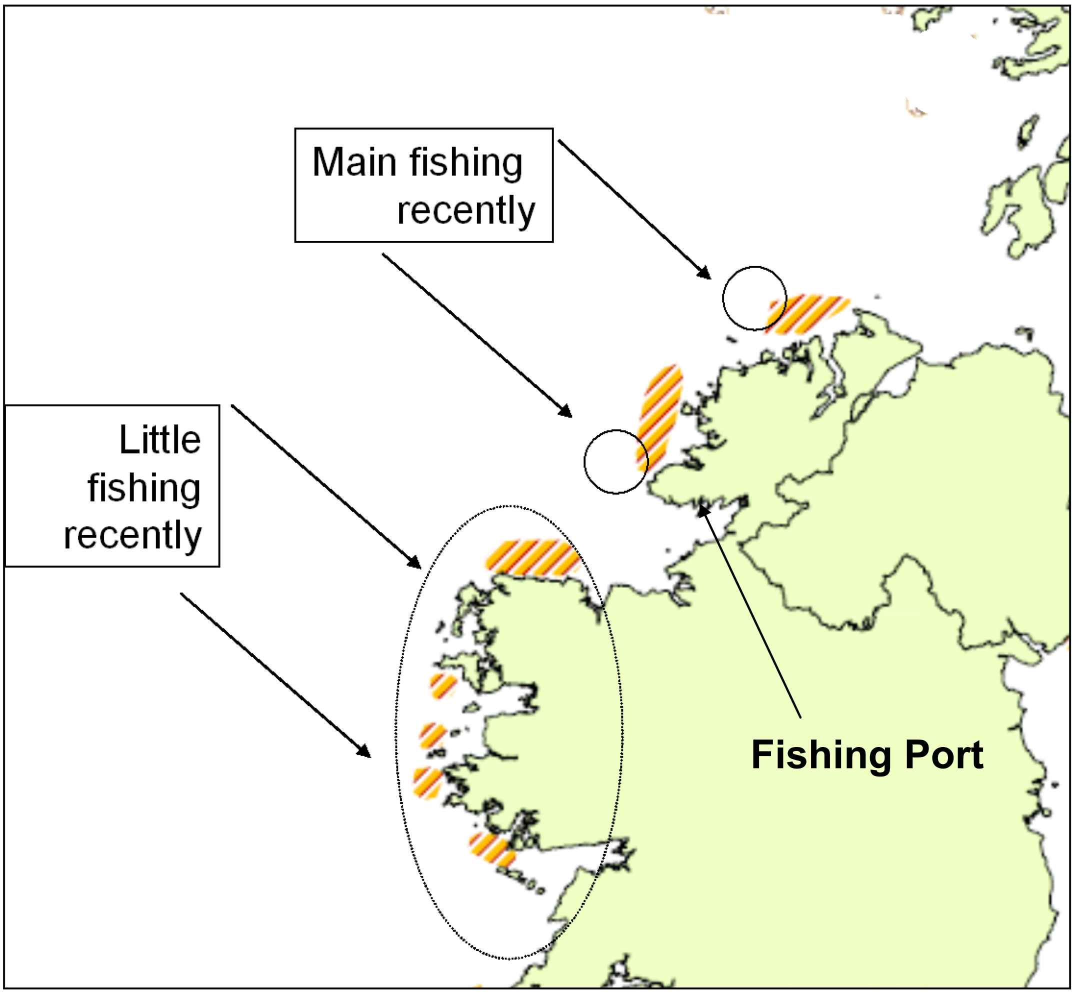


Figure 6.1.4. Herring in Divisions VIa(S) and VIIb,c. Main spawning grounds, and changes in recent fishing pattern. Fishing in recent years has been on or near the spawning grounds.

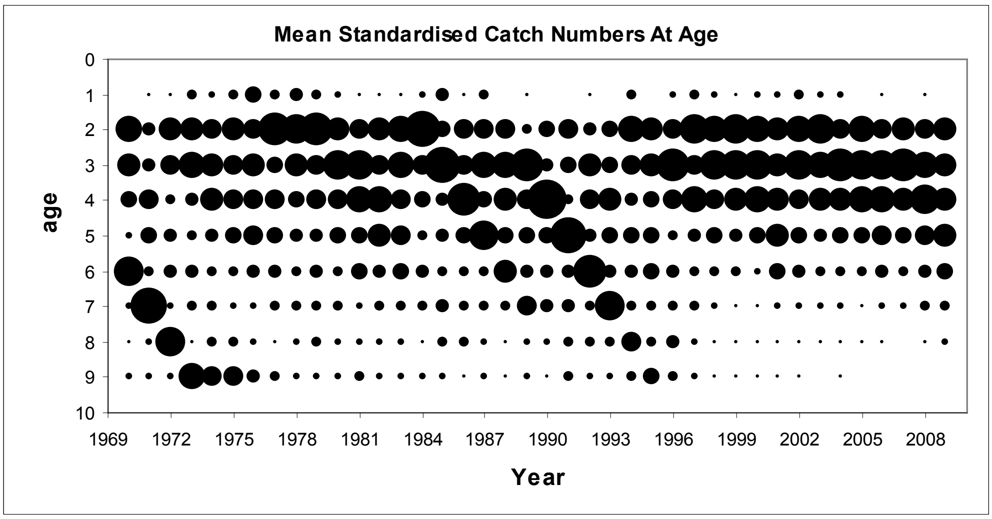


Figure 6.2.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean standardised catch numbers at age standardised by year for the fishery.

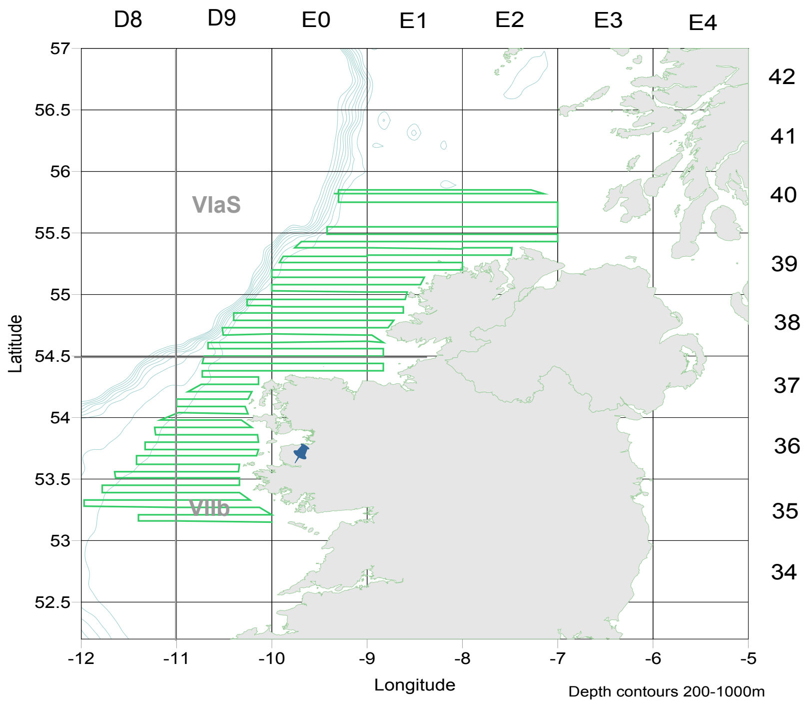


Figure 6.3.2.1. Herring in Divisions VIa(S) and VIIb,c. Survey track for acoustic survey conducted in July 2009 as part of the Malin Shelf stock survey.

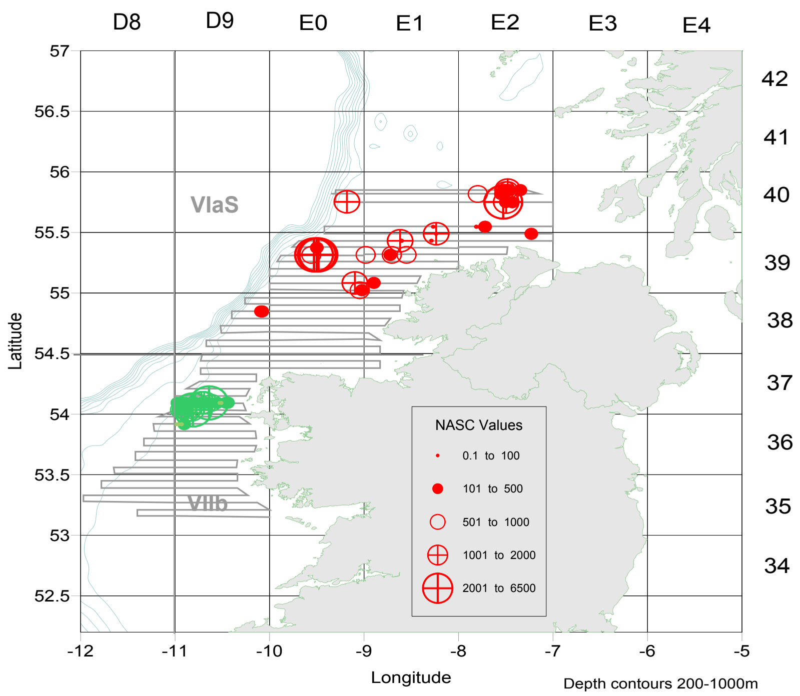


Figure 6.3.2.2. Herring in Divisions VIa(S) and VIIb,c. Total NASC (nautical area scattering coefficient) for herring in acoustic survey conducted in July 2009.

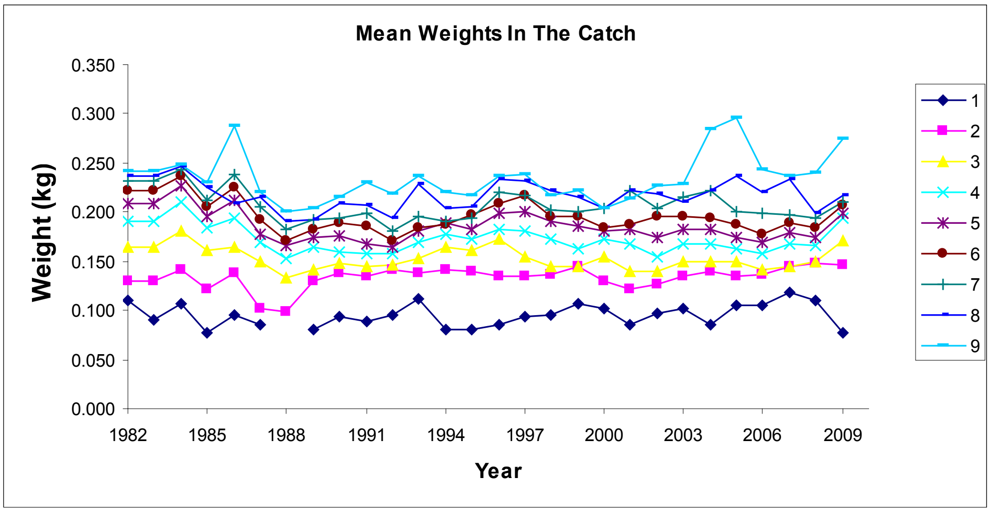


Figure 6.4.1.1. Herring in Divisions VIa(S) and VIIb,c. Mean Weights in the Catch (kg) by age in winter rings.

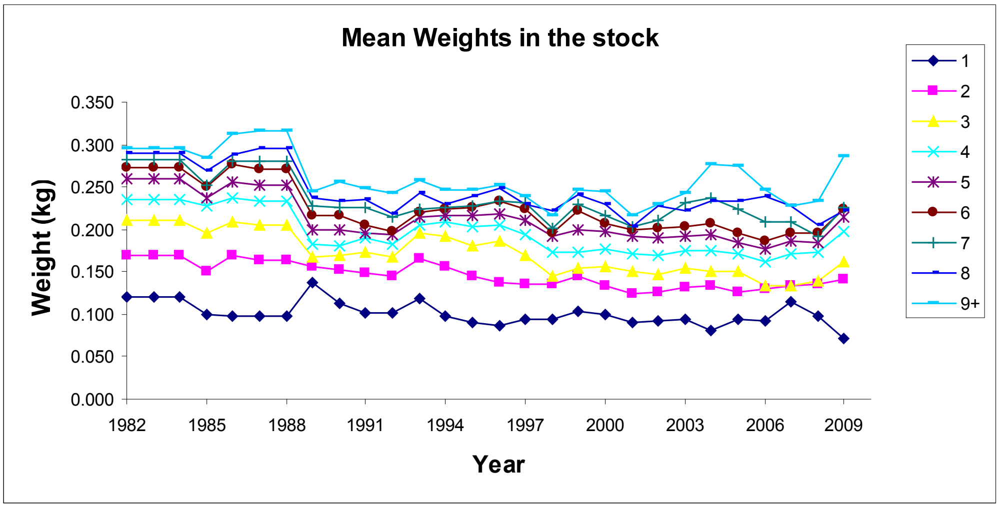
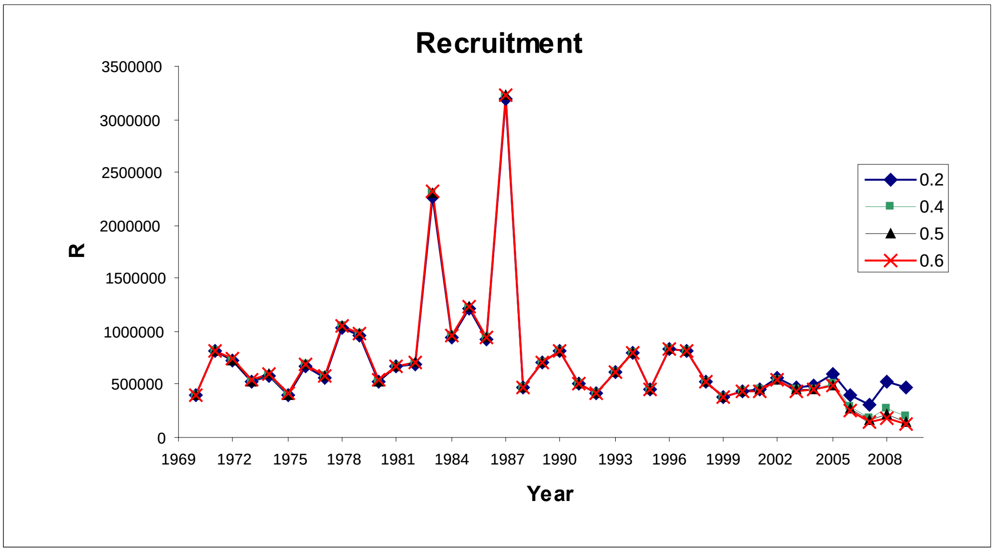
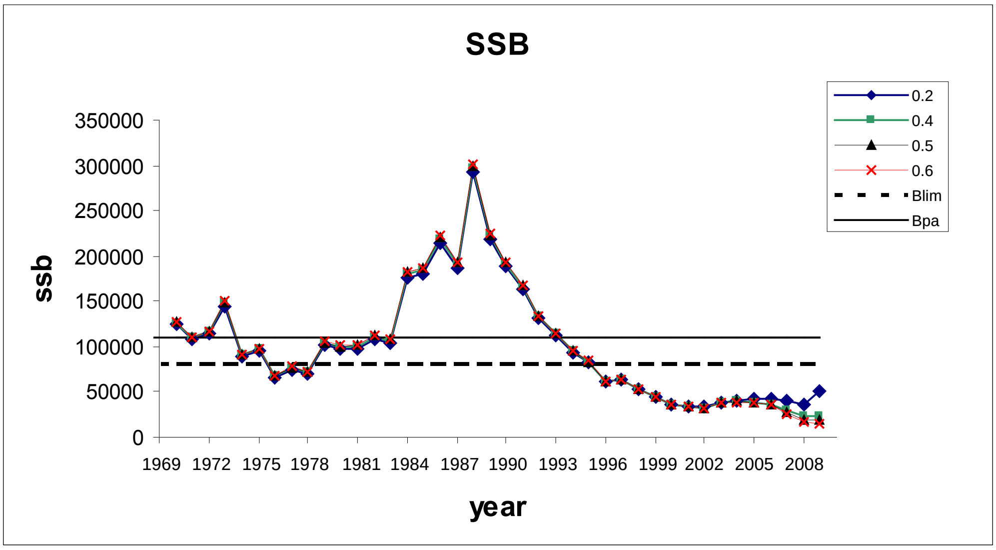


Figure 6.4.1.2. Herring in Divisions VIa(S) and VIIb,c. Mean weights in the stock (kg) by age in winter rings.





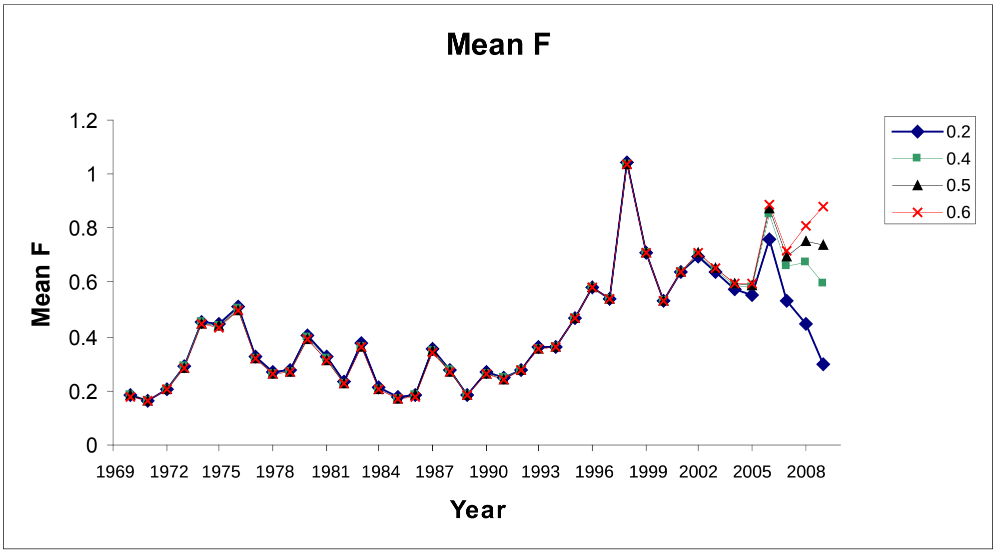


Figure 6.6.2.1. Herring in Divisions VIa(S) and VIIb,c. Four separable VPA runs using values of 0.2, 0.4, 0.5 and 0.6 for terminal F

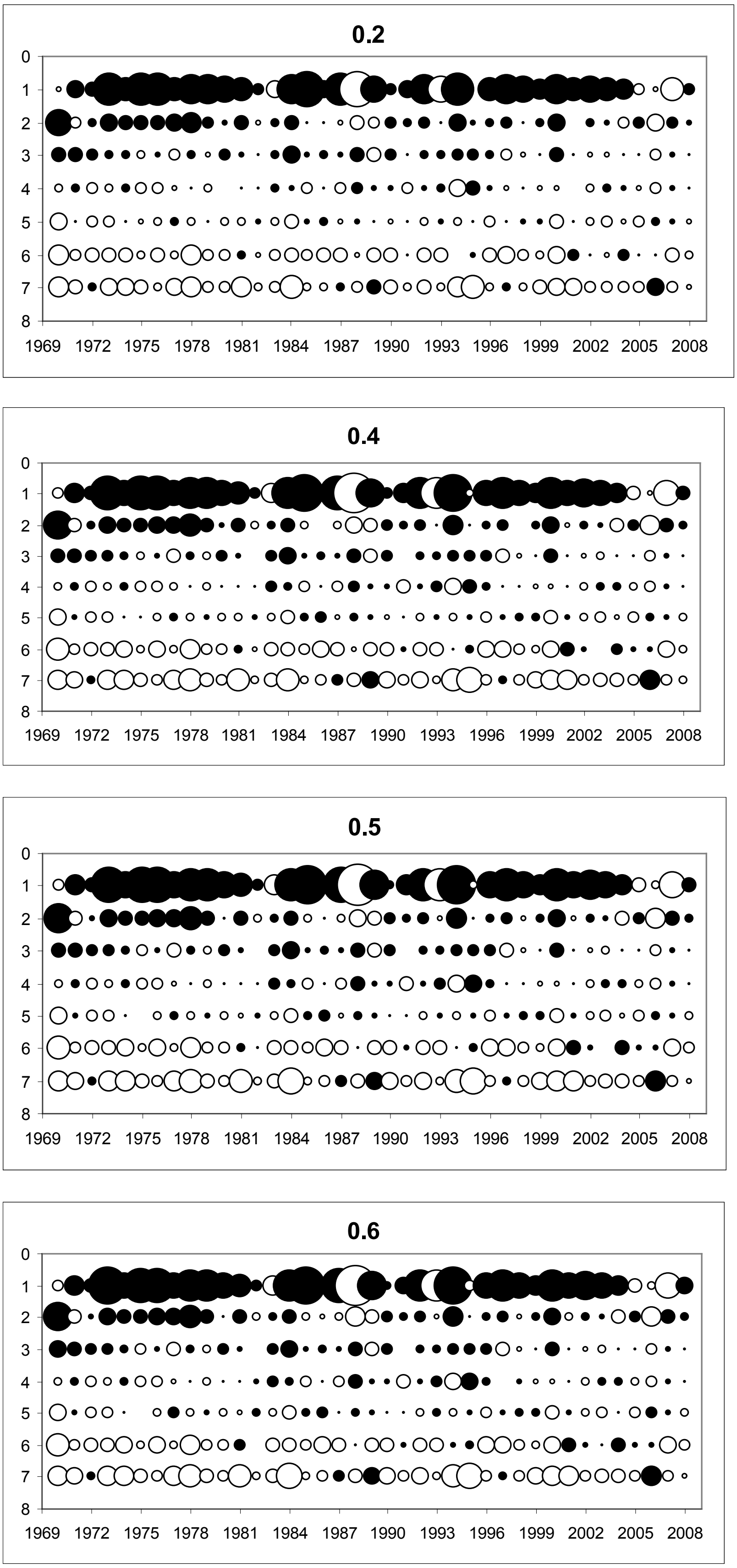
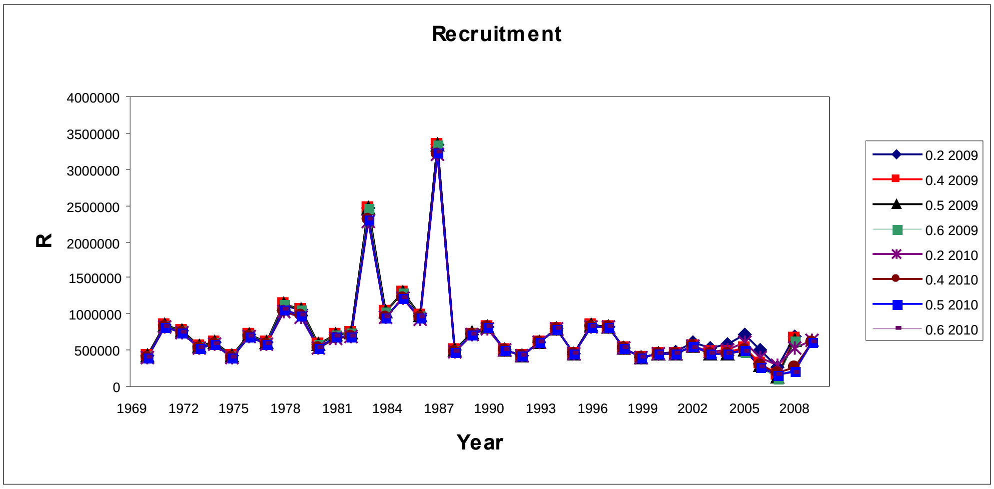
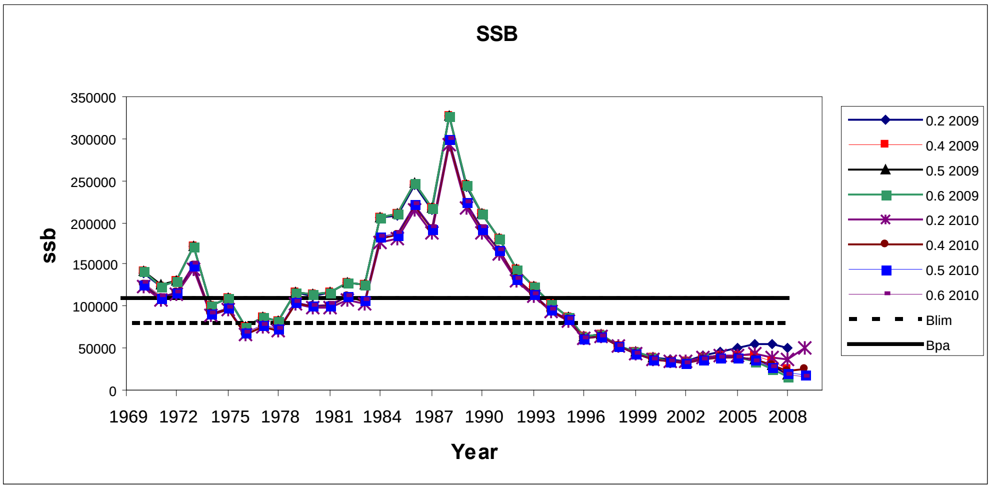


Figure 6.6.2.2. Herring in Divisions VIa(S) and VIIb,c. Residuals from three separable VPA runs using terminal F values of 0.2 , 0.4, 0.5 and 0.6 . Red indicates positive residuals and white indicates negative





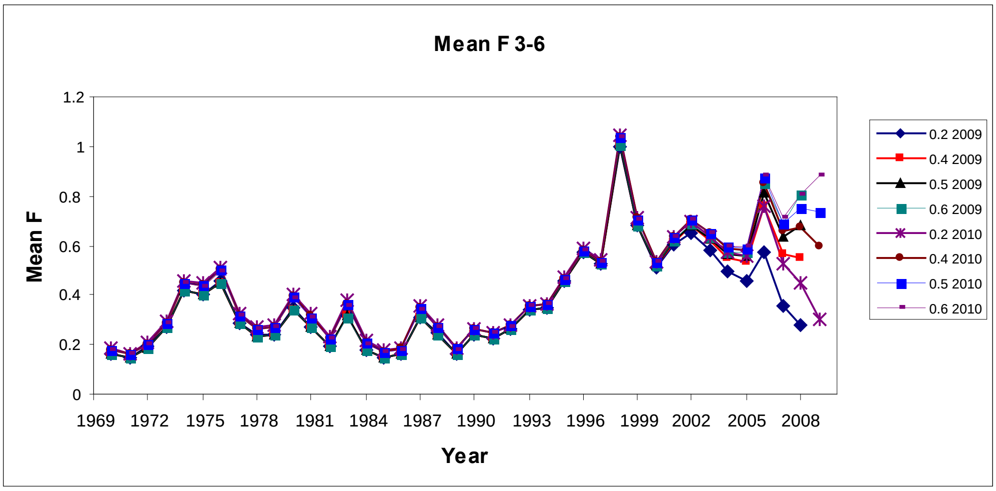


Figure 6.6.2.3. Herring in Divisions VIa(S) and VIIb,c. Comparison of four separable VPA runs of the current working group and the 2008 working group, using values of 0.2, 0.4 and 0.6 for terminal F.

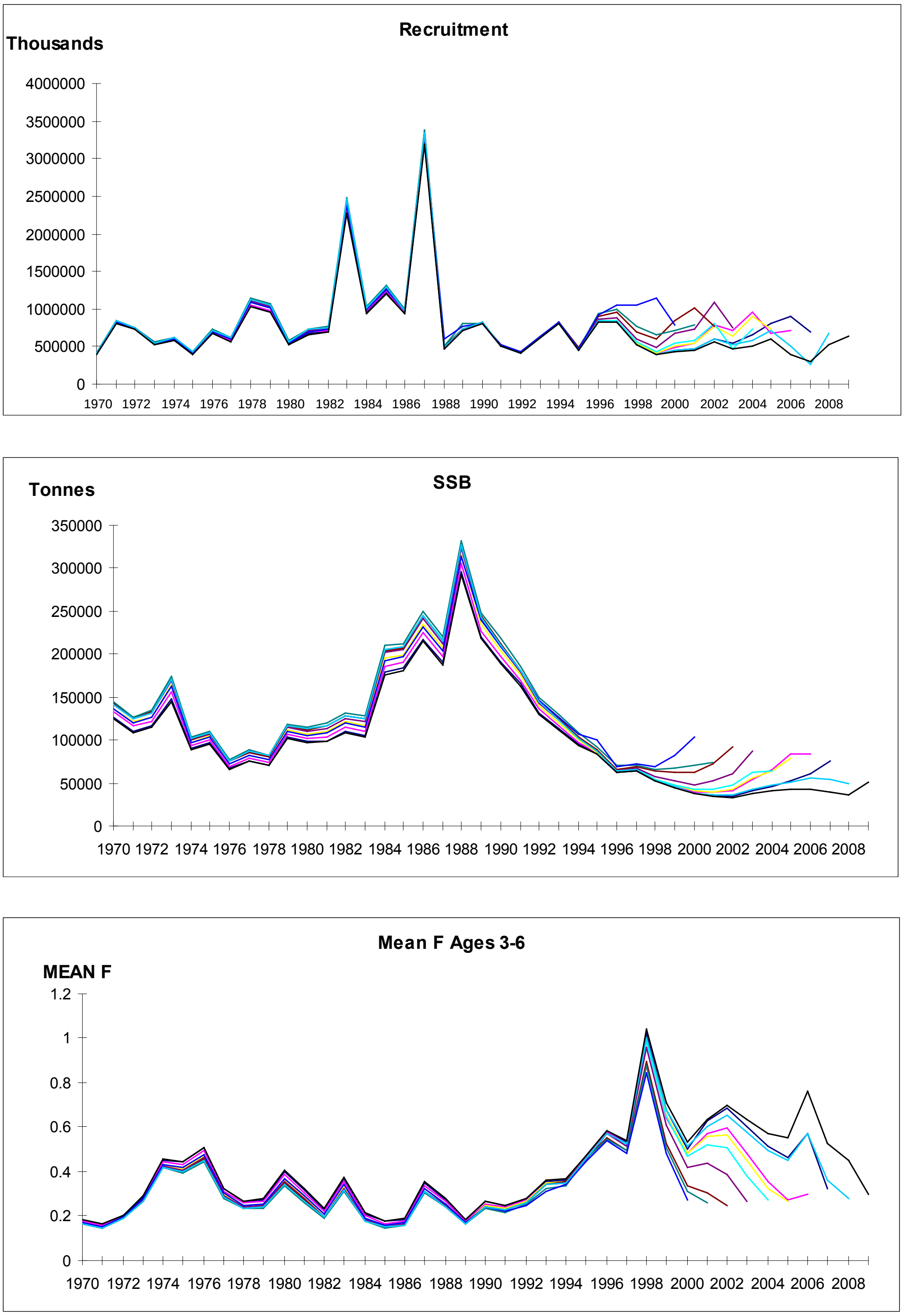


Figure 6.6.2.4. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.2.

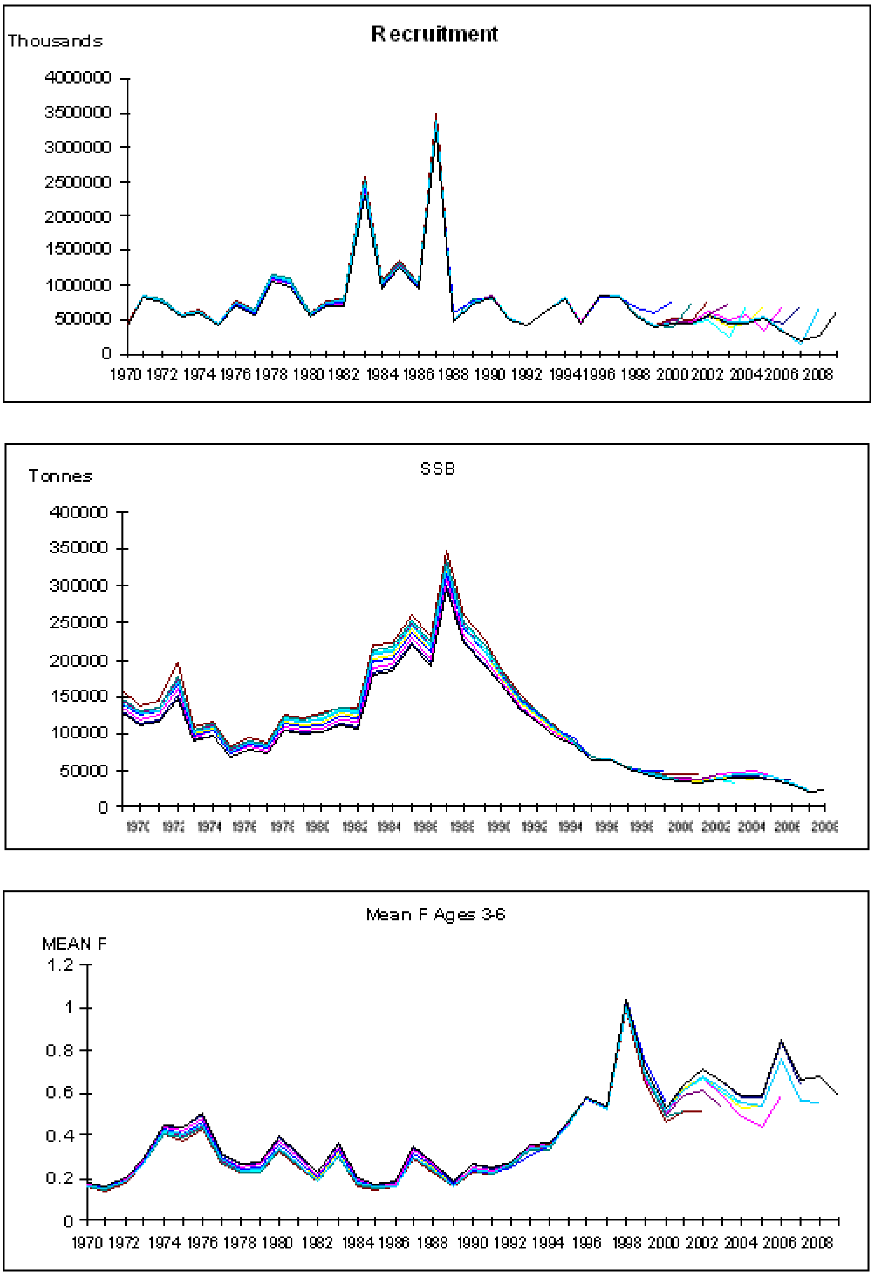


Figure 6.6.2.5. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.4.

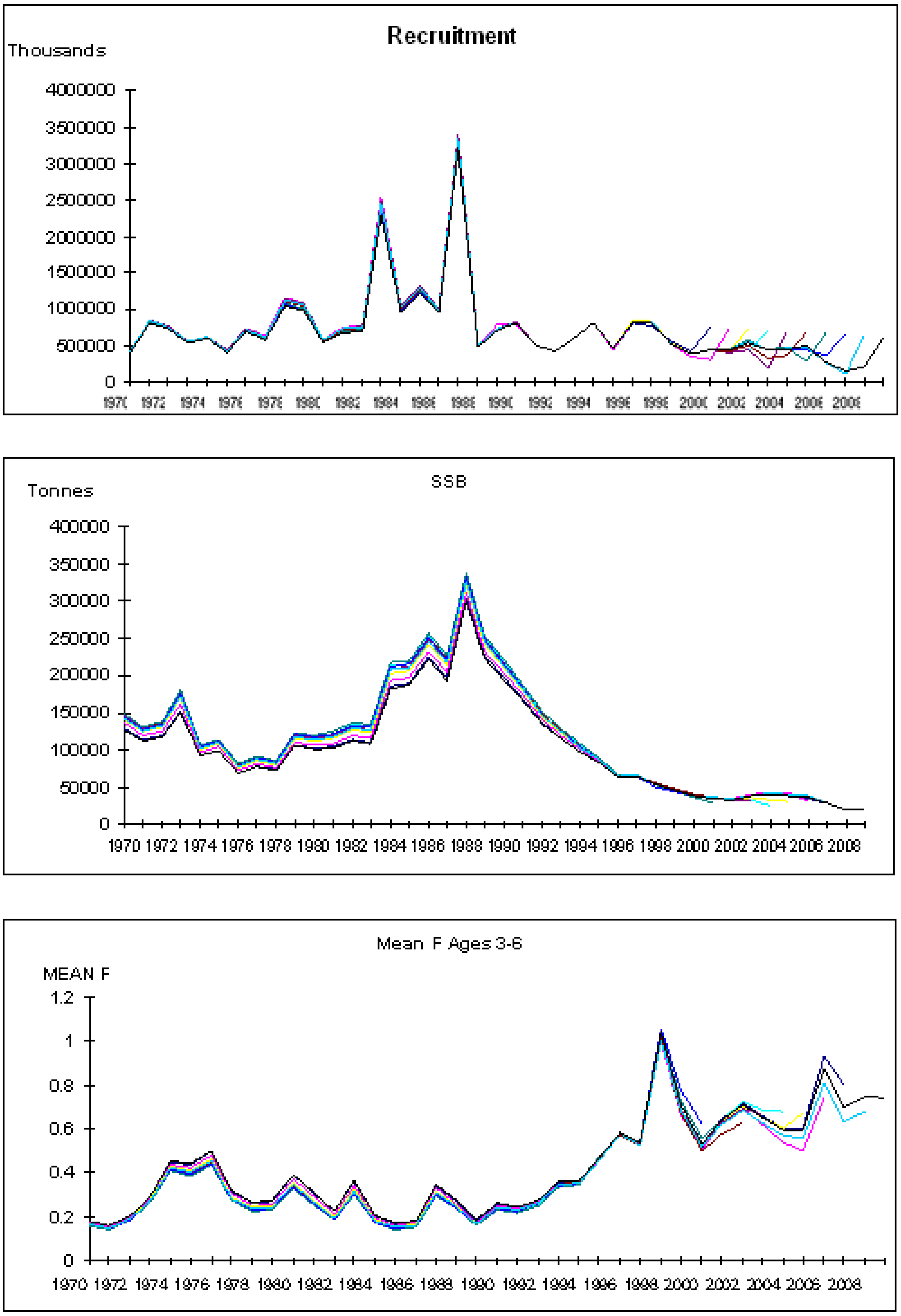


Figure 6.6.2.6. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0

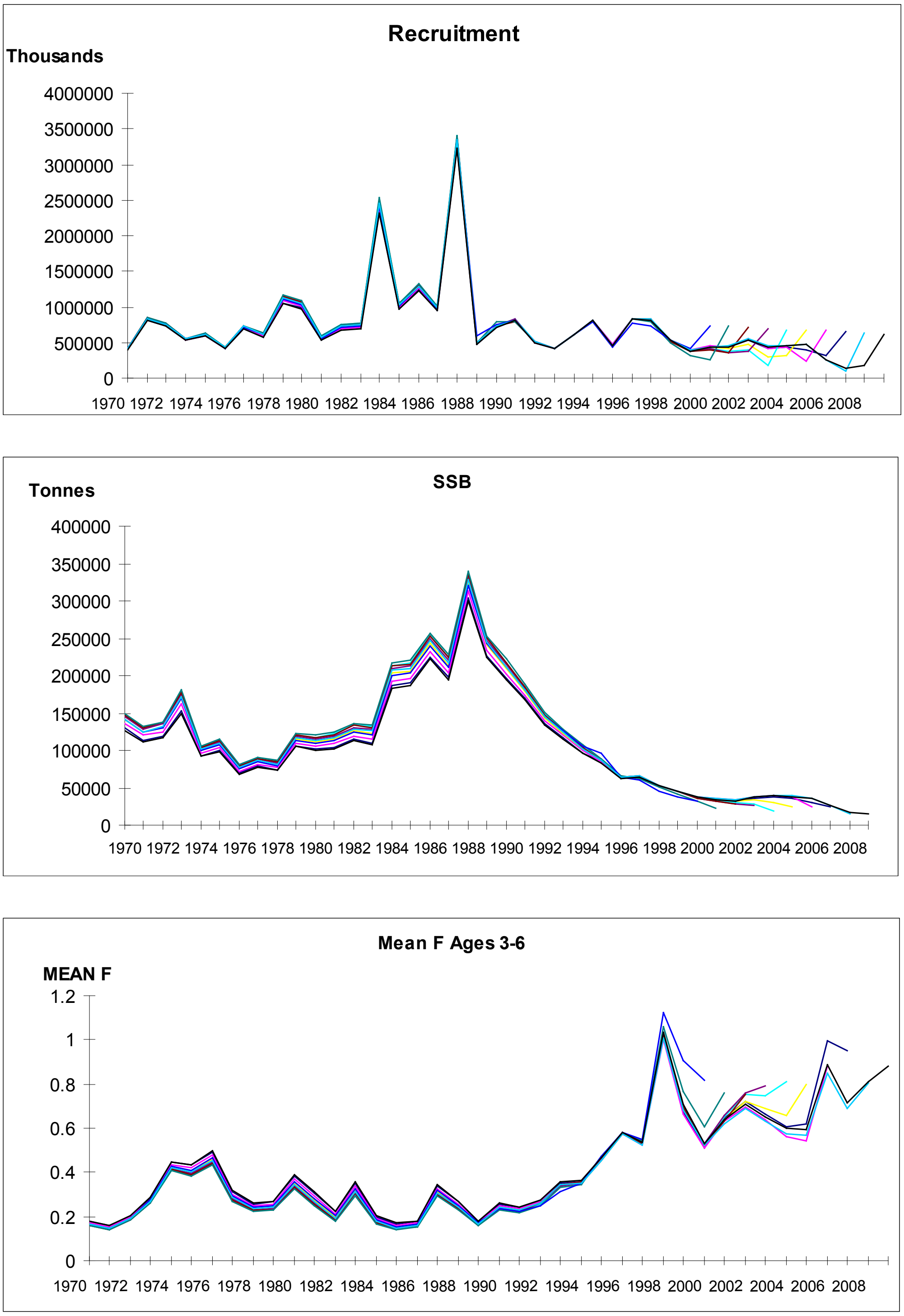


Figure 6.6.2.7. Herring in Divisions VIa(S) and VIIb,c. Retrospective assessment using F=0.6.

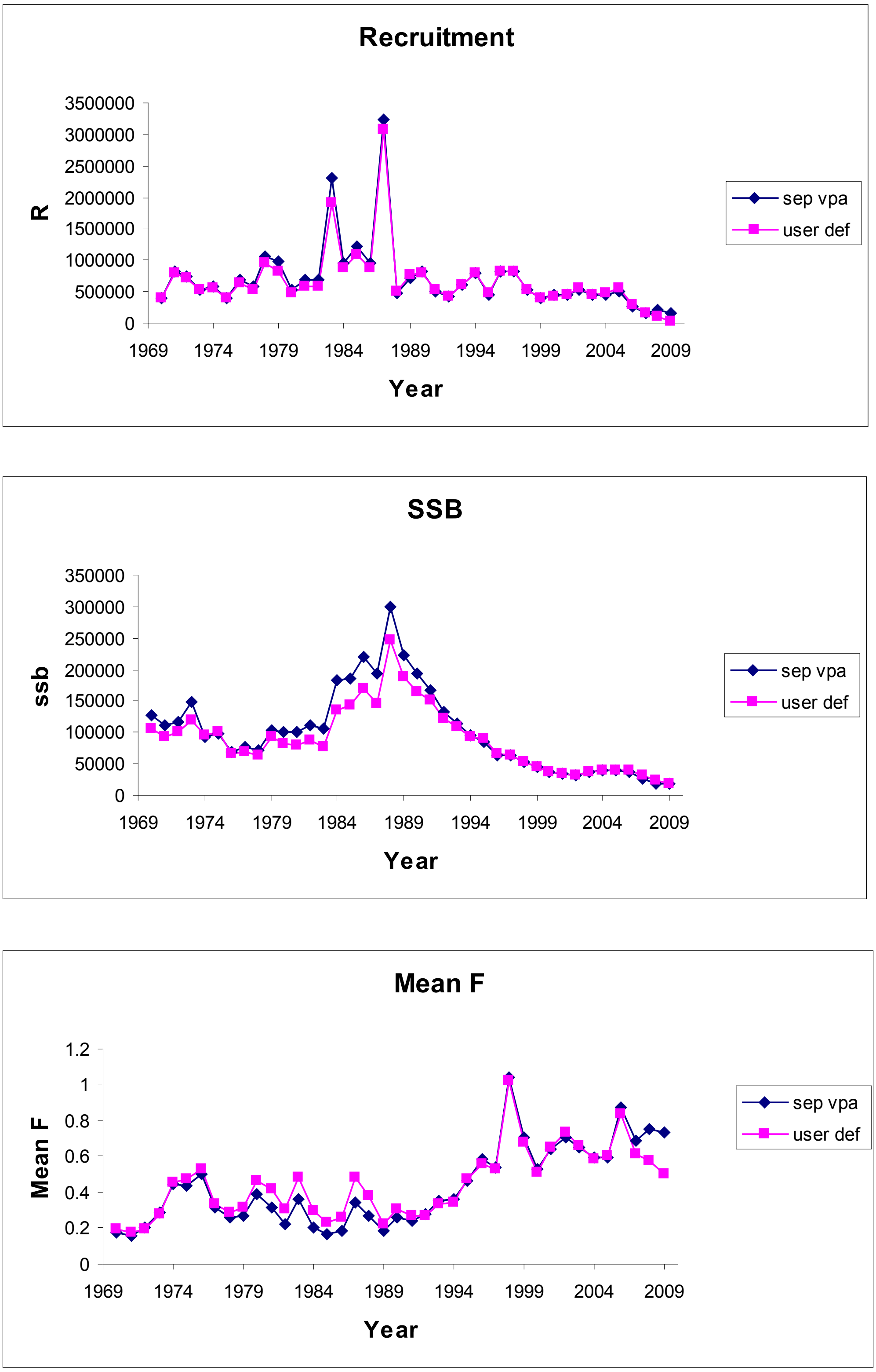


Figure 6.6.2.8. Herring in Divisions VIa(S) and VIIb,c. Results of a traditional user defined VPA and a the separable VPA using 0.5 as terminal F.

7 Herring in Division VIIa North of 52° 30' N (Irish Sea)

This is an exploratory assessment, SALY status.

7.1 The Fishery

7.1.1 Advice and management applicable to 2009 and 2010

In 2008 ACOM advised a TAC of 4 400 t in 2009. A *status quo* TAC of 4 800 t was subsequently adopted for 2009 and partitioned as 3 550 t to the UK and 1 250 t to the Republic of Ireland. In 2009 ACOM advised *status quo* TAC, which was adopted for 2010.

7.1.2 The fishery in 2009

The catches reported from each country for the period 1987 to 2009 are given in Table 7.1.1, and total catches from 1961 to 2009 in Figure 7.1.1. Reported international landings in 2009 for the Irish Sea amounted to 4 594 t with UK vessels acquiring extra quota through swaps with the Republic of Ireland. The majority of catches in 2009 were taken during the 3rd quarter to the northwest of the Isle of Man with very few landings from the Douglas Bank area.

The 2009 VIIa(N) herring fishery opened in August, with the majority of catches taken during August, September and October by a pair of UK pair trawlers. October saw activity of the Mourne fishery, limited to boats under 40ft. This was the 4th year of recorded landings for this fishery. In 2009 13 vessels recorded landings of ~171 t, all taken during 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 2009. The area to the east of the Isle of Man, encompassing the Douglas Bank spawning ground (described in ICES 2001, ACFM:10), was closed from 21st September to 15th November. Boats from the Republic of Ireland are not permitted to fish east of the Isle of Man.

The arrangement of closed areas in Division VIIa(N) prior to 1999 are discussed in detail in ICES (1996/ACFM:10) with a change to the closed area to the east of the Isle of Man being altered in 1999 (ICES 2001/ACFM:10). The closed areas consist of: all year juvenile closures along part of the east coast of Ireland, and the west coast of Scotland, England and Wales; spawning closures along the east coast of the Isle of Man from 21st September to 15th November, and along the east coast of Ireland all year round. Any alterations to the present closures be considered carefully, in the context of this report, to ensure protection for all components of this stock.

7.1.4 Changes in fishing technology and fishing patterns

The fishery in area VIIa(N) has not changed in recent years. A pair of UK pair trawlers takes the majority of catches during the 3rd and 4th quarters. A small local fishery continues to record landings on the traditional Mourne herring grounds during the 4th quarter. This fishery resumed in 2006 and has seen increasing catches of herring since, with 2006 landings of ~20 t, ~33.5 t in 2007, ~135 t in 2008 and 171 t in 2009.

7.2 Biological Composition of the Catch

7.2.1 Catch in numbers

There was no biological sampling of the main catch component (pair trawlers) in 2009 due to a failure to acquire samples from the landings. In lieu of biological sampling 2009 data were estimated (see section 7.6.1 for methods). Catches in numbers-at-age are given in Table 7.6.1 for the years 1972 to 2009 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 1993 to 2008. The catch in numbers-at-age (thousands) for the 2009 gillnet fishery are given below.

	Age (rings)							
Year	1	2	3	4	5	6	7	8+
2009	0	168	354	365	219	17	0	0

7.2.2 Quality of catch and biological data

There was no biological sampling of the main catch component in 2009 due to a failure to acquire samples from the landings. 4 biological samples were taken from the gillnet fishery operating on the Mourne ground. There are no estimates of discarding or slippage in the Irish Sea fisheries that target herring. Discarding however is not thought to be a feature of this fishery. Future monitoring in line with DCF requirements will take place. Details of sampling are given in Table 7.2.3.

7.3 Fishery Independent Information

7.3.1 Acoustic surveys

The information on the time-series of acoustic surveys in the Irish Sea is given in Table 7.3.1. As in the last year's assessment, the SSB estimates from the survey are calculated using the (annually varying) maturity ogives from the commercial catch data.

The acoustic survey in 2009 was carried out over the period 1st - 13th September. A survey design of stratified, systematic transects was employed, as in previous years (Figure 7.3.1.A). In previous years the bulk of the acoustic scatter attributed to pelagic fish was identified as sprat which are abundant around the periphery of the Irish Sea and to the north west of the Isle of Man (Figure 7.3.1.B). However in recent years the ratio of sprat to herring has been seen to increase in favour of the 0-group herring, a trend continued in 2009. 0-group herring were found to be most abundant to the west of the Isle of Man (Figure 7.3.2.B). The bulk of 1+ herring targets in 2009 were distributed to the east of the Isle of Man, in the region of the Douglas Bank spawning ground (Figure 7.3.2.A). Further 1+ herring targets were found to the west of the Isle of Man and the western Northern Irish coastline. The survey followed the methods described in Armstrong *et al.*, (ICES 2005 WD 23). Sampling intensity was high during the 2009 survey with 32 successful trawls completed. The length frequencies generated from these trawls highlights the spatial heterogeneous nature of herring age groups in the Irish Sea (Figure 7.3.3)

The estimate of herring SSB of 71 180 t for 2009 is the second highest estimate in the time series (Table 7.3.1). The biomass estimate of 95 989 t for 1+ ringers is the third highest in the time series and continues the trend observed in recent years. The age-disaggregated acoustic estimates of the herring abundance, excluding 0-ring fish, are given in Table 7.3.2.

Results of a microstructure analysis of 1-ringer+ fish were presented to the WG (Beggs *et al*., WD08). The study shows that "winter" spawners, of which the majority are thought to be of Celtic Sea origin, are present in the pre-spawning aggregations sampled in the Irish Sea during the acoustic survey. The presence of these "winter" spawners has implications for the estimates of 1-ringer+ biomass and SSB, as well as confounding traditional cohort type assessment methods, such as ICA. However, removal of the "winter" spawning component from the current acoustic biomass estimates does not change the perception of a significant increase in 1-ringer+ biomass and SSB estimates (Figures 7.3.7-7.3.8).

Extended acoustic surveys

A series of additional acoustic surveys was conducted since 2007 by Northern Ireland, following the annual pelagic acoustic survey (conducted during the beginning of September). The results of the first three years of the survey series were presented to the working group (Schön *et al*., WD11). The enhanced survey programme was initiated to investigate the temporal and spatial variability in the population estimates from the routine acoustic survey and only concentrate on the spawning grounds surrounding the Isle of Man and the Scottish coastal waters (strata 2 and 5-9, Figure 7.3.1.A). Herring found in this area represents on average 86% of the total Irish Sea SSB estimate since 2001 and 81% of 1-ringer + biomass.

The surveys were roughly timed every fortnight, except for the last survey. The density distributions from the surveys highlight the temporal and spatial complexity of the herring distributions. Problems with timing of the survey are further exacerbated by the significant interannual variation in the migration patterns, evident from the changes in density distributions. The results confirm the high estimate of abundance observed during the routine annual acoustic survey estimate in the last three years (Figure 7.3.4). Biomass estimates for the first three surveys in each year were above the previously observed maximum of the time series. The expected dissipation of herring off the spawning ground is evident from the marked decline in the survey estimates in late October/November. The results again highlight the complexity of the herring distributions in this area, and the importance of survey timing to annual population abundance estimates.

7.3.2 Larvae surveys

Northern Ireland undertook a herring larvae survey over the period 8th to 17th November 2009. The survey followed the methods and designs of previous surveys in the time-series (see stock annex 8). The production estimate for 2009 in the NE Irish Sea was similar to the previous year and below the time-series average (Table 7.3.3). As in previous years herring larvae were found to be most abundant to the south east and north east of the Isle of Man and less abundant in the western Irish Sea (Figure 7.3.5).

Of note was the continued low occurrence of larvae in the area of the traditional Mourne spawning ground, where in 2007 larvae had been caught. Signs of the expansion of a spawning component in this area in recent years are evident from the fishery operating here. As such larvae would be expected in the area. The low occurrence of larvae caught during the survey may therefore suggest a timing mis-match between larvae emergence and sampling.

7.3.3 Groundfish surveys of Area VIIa(N)

Groundfish surveys carried out by Northern Ireland since 1991 in the Irish Sea, were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring. These indices have performed poorly in the assessment and have not been used since. The time series was updated in 2009 and is shown in Figure 7.3.6. An increasing trend is evident for the 1-ring herring index from the spring groundfish survey over the time series. The indices of the groundfish do not take account of mixing between "winter" and "autumn" spawners.

7.4 Mean weight, maturity and natural mortality-at-age

No biological sampling of the 2009 catch meant mean weight and maturity data were estimated (see section 7.6.1). As in previous years, natural mortality per year was assumed to be 1.0 on 1-ringers, 0.3 for 2-ringers, 0.2 for 3-ringers and 0.1 for all older age classes (see stock annex 8). Mean weights-at-age have shown a general downward trend in the last 22 years.

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 survey. However, there is evidence that a proportion of these are of Celtic Sea origin (Brophy and Danilowicz, 2002). Separation of the trawl catches of 0-groups into autumn and winter spawning components, based on otolith microstructure and shape analysis was presented to the working group in 2008 by Beggs *et al*. (ICES 2008 WD4). It is hoped that repeating this procedure annually could result in a survey index of recruitment for the Irish Sea stock that could be used directly in the assessment. Such an index may also be of use in the Celtic Sea assessment, as it would provide an estimate of juveniles resident in the Irish Sea originating from this management area.

7.6 Assessment

7.6.1 Data exploration and preliminary modelling

No biological sampling of the landings in 2009 meant that catch-at-age data were estimated from 2008 population numbers adjusted by the mean F from the preceding 3 years (2006-2008) (Table 7.6.1). Catch in numbers at 1-ring was estimated as the geometric mean of the time series (1961 to 2008). 2009 catch weights and stock weights were calculated from the mean of the preceding 5 years for the stock (Table 7.6.2-7.6.3). Maturity at age for 2009 was taken as the mean 1994-2008 (excluding 2003 when a similar estimation procedure was followed) (Table 7.6.4).

Exploratory FLICA runs were conducted in 2010 with the updated survey indices; larval survey (SSB), acoustic survey and the estimated catch-at-age data. Catch-at-age data were downweighted (0.01) to eliminate the influence of this estimated data in the model fit. Results of the SPALY run are not considered reliable for absolute values of SSB and F during the separable period (Figure 7.6.1).

Residual patterns from the SPALY run highlighted a divergence in the signal from the acoustic and (larval survey) SSB indices (Figures 7.6.2-7.6.11). It has been observed that in recent years the abundance of larger herring larvae detected in the survey has declined. The abundance of these larger larvae has a significant influence on the SSB index. It is considered that the reduction in abundance of larger herring larvae is associated with a variation in the timing of spawning. The SSB index was therefore removed and FLICA run with the downweighted catch-at-age data and acoustic series. Removal of the SSB index improved the coherence between the observed and predicted abundance-at-age. Results of the run highlight the increasing trend in biomass detected by the acoustic survey in recent years (Figures 7.6.12-7.6.22). Considering knowledge of the larval surveys and improved residual patterns the WG considered the run with no SSB index more reliable as an indicator of stock trends.

The third exploratory FLICA run with no SSB index, included the adjusted acoustic numbers-at-age data (2006 to 2009) based on the microstructure work presented in Beggs *et al*., (WD08). The acoustic numbers-at-age data were adjusted by removal of the "winter" spawning component (Figures 7.3.7-7.3.8). A comparison of FLICA output between the adjusted acoustic data run (split) and unadjusted acoustic data (no split) does not change the perception of an increase in the recent SSB estimates (Figure 7.6.23). No attempt was made to adjust acoustic numbers-at-age estimates prior to 2006.

The acoustic survey series was screened using SURBA (ver. 3.0) to examine for year, age and cohort effects. Survey catchability and weighting factors by age were all entered as 1.0, with the exception of down weighing the 1-ring data to remove possible influence of the juvenile mixing problem. The reference age was set at 4, lambda smoothing to 1.0 and age 8 as a plus group. No adequate model fit was found. The diagnostic plots from the raw data (Figure 7.6.24.) show very poor internal consistency illustrated by the age scatter plots. The catch curves show some very steep profiles, with some shallower profiles for recent year classes. Obvious year effects are also evident and different interannual trends by age class.

7.6.2 Conclusion to explorations

The exploratory FLICA runs conducted in 2010 did not improve the perception of the suitability of ICA as an assessment method for the Irish Sea stock. The lack of sampling data in 2009 severely hampered the exploration of an age based assessment. However from the exploratory runs recent trends in SSB are thought to have increased while F has decreased. There is evidence that recent recruitment has been high.

2009 acoustic survey estimates suggest that SSB remains at higher levels than at any other period in the 17 year time-series, while 1-ringer+ biomass is also high. Numbers-at-age in the acoustic survey suggest the strong 2005 year class (1-ringers in 2007) is still present in the survey area as 3-ringers. The 2005 strong year-class has now been tracked successfully over 4 years of the survey. Recruitment estimates of 0-group herring from the acoustic survey also remain high.

The enhanced acoustic survey coverage in the Irish Sea provides additional information on the migration and distribution patterns of herring, which could provide some insight into the divergence of the mortality signal between the catch and survey information (HAWG 2008). Continuing otolith microstructure analyses also improves the knowledge of the degree of mixing of younger fish with different spawning season origins present in the Irish Sea.

The acoustic estimates of population size for the last three years indicate a significant increase in herring abundance in the Irish Sea. Although the survey data are noisy, consecutive surveys indicate similar high abundance. The lack of an accepted assessment to form the basis of scientific advice is unsatisfactory, especially if management measures cannot be changed to reflect dramatic changes in stock abundances. A benchmark assessment is required for this stock.

7.6.3 Final assessment

No final assessment presented.

7.6.4 State of the stock

Trends from the September and additional extended acoustic surveys indicate an increase in 1+ herring biomass in the Irish Sea since 2007. Recent catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data. Exploratory runs in ICA show trends in F has decreased while SSB has increased. There is evidence of recent high recruitment.

7.7 Short term projections

7.7.1 Deterministic short term projections

The Working Group decided that there was no basis for undertaking short-term predictions of stock size.

7.7.2 Yield per recruit

The Working Group decided that there was no basis for yield-per-recruit analysis.

7.8 Medium term projections

The Working Group decided that there was no basis for undertaking medium-term projections of stock size.

7.9 Precautionary and yield based reference points

The estimation of $\mathbf{B}_{pa}$ (9 500 t) and $\mathbf{B}_{lim}$ (6 000 t) were not revisited this year. There is no precautionary F value for this stock. Fmsy advice is being development for this stock.

7.10 Quality of the assessment

The exploratory FLICA runs conducted in 2010 did not improve the perception of the suitability of ICA as an assessment method for the Irish Sea stock. The lack of sampling data in 2009 severely hampered the exploration of an age based assessment.

In past years the assessment for this stock has not been accepted by the WG. Both the catches and survey data are seen to contain large year residuals. From the exploratory analysis in 2007 and 2008 it can be seen that the majority of this variation may arise from the inter-annual variation in herring migration patterns and their effect on the selectivity of both the fishery and acoustic survey (HAWG 2008).

7.11 Management considerations

Given the historical landings from this stock and the knowledge that fishing pressure is light and mostly confined to one pair of UK vessels it can be assumed that fishing pressure and activity has not varied considerably in recent years. The catches have been close to TAC levels and the main fishing activity has not varied considerably as shown from landing data (Figure 7.1.1).

In the absence of an accepted analytical assessment, the maintenance of catch levels at current TAC levels of 4 800 t, in the short-term, is considered precautionary.

In 2008 ICES began to evaluate management of Division VIa (N), VIa (S) and VIIa (N). It will, however, be a number of years before ICES can provide a fully operational integrated strategy for these units.

In lieu of a current age based assessment method the use of a survey based approach should be considered. The working group recommends that a management plan should be developed for this stock. Such a plan should be developed with stakeholders and forwarded to ICES for evaluation.

7.12 Ecosystem Considerations

No additional information presented (see stock annex 8).

Table 7.1.1 Irish Sea Herring Division VIIa(N). Working group catch estimates in tonnes by country, 1987-2009. 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**				
Ireland	1 153	581	0	0	0				
UK	3 234	3821	4 629	4895	4594				
Unallocated	-	-							
Total	4 387	4 402	4 629	4895	4594				

Table 7.2.2 Irish Sea Herring Division VIIa(N). Catch at length data 1993-2008. Numbers of fish in thousands. Table amended with 1990-1992 year-classes removed (see Annex 8).

Length (cm)	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
14																
14.5																
15																
15.5							10								16	
16			21	21	17		19	12	9					2		
16.5			55	51	94		53	49	27			13	1	44	33	1
17		84	139	127	281	26	97	67	53			25	39	140	69	3
17.5		59	148	200	525	30	82	97	105			84	117	211	286	11
18		69	300	173	1022	123	145	115	229			102	291	586	852	34
18.5		89	280	415	1066	206	135	134	240	36		114	521	726	2088	64
19	39	226	310	554	1720	317	234	164	385	18		203	758	895	2979	85
19.5	75	241	305	652	1263	277	82	97	439	0	29	269	933	1246	3527	108
20	75	253	326	749	1366	427	218	109	523	0	73	368	943	984	3516	100
20.5	57	270	404	867	1029	297	242	85	608	18	215	444	923	1443	2852	133
21	130	400	468	886	1510	522	449	115	1086	307	272	862	1256	1521	3451	192
21.5	263	308	782	1258	1192	549	362	138	1201	433	290	1007	1380	1621	2929	217
22	610	700	1509	1530	2607	1354	1261	289	1748	1750	463	1495	1361	2748	3821	271
22.5	1224	785	2541	2190	2482	1099	2305	418	1763	1949	600	2140	1448	3629	3503	229
23	2016	1035	4198	2362	3508	2493	4784	607	2670	2490	1158	2089	1035	4358	4196	322
23.5	2368	1473	4547	2917	3902	2041	4183	951	2254	1552	1380	2214	1256	2920	3697	264
24	2895	2126	4416	3649	4714	3695	4165	1436	3489	1029	1273	2054	1276	3679	3178	259
24.5	2616	2564	3391	4077	4138	2769	3397	1783	4098	758	1249	2269	1083	2431	2136	204
25	2207	3315	3100	4015	5031	2625	2620	2144	5566	776	1163	1749	1086	3438	1503	148
25.5	2198	3382	2358	3668	3971	2797	1817	1791	4785	1335	1211	1206	584	2198	952	114
26	2216	3480	2334	2480	3871	3115	1694	1349	3814	1570	1140	823	438	1714	643	78
26.5	2176	2617	1807	2177	2455	2641	1547	840	2243	1552	1573	587	203	605	330	42
27	2299	2391	1622	1949	1711	2992	1475	616	1489	776	1607	510	165	445	147	23
27.5	2047	1777	990	1267	1131	1747	867	479	644	433	1189	383	60	155	72	10
28	1538	1294	834	906	638	1235	276	212	496	162	726	198	45	104	33	12
28.5	944	900	123	564	440	170	169	58	179	108	569	51	18	9	26	1
29	473	417	248	210	280	111	61	42	10	36	163		12	46		
29.5	160	165	56	79	59	92		12	0	36	129				7	
30	83	9	40	32	8	84		6	9		43					
30.5	15	27	5	0	5	3					43					
31	4		1	2							43					
31.5																
32																
32.5																
33																
33.5																

Table 7.2.3 Irish Sea Herring Division VIIa(N). Sampling intensity of commercial landings in 2009.

Quarter	Country	Landings (t)	No. samples	No. fish measured	No. fish aged
1	Ireland	0	-	-	-
	UK (N. Ireland)	0.01	0	0	0
	UK (Isle of Man)	0	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
2	Ireland	0	-	-	-
	UK (N. Ireland)	0.12	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
3	Ireland	0	-	-	-
	UK (N. Ireland)	3938	4#	200	200
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-
4	Ireland	0	-	-	-
	UK (N. Ireland)	655	0	0	0
	UK (Isle of Man)	*	-	-	-
	UK (Scotland)	0	-	-	-
	UK (England & Wales)	0	-	-	-

*** no information, but catch is likely to be negligible**

 # samples of gillnet fishery

Table 7.3.1 Irish Sea Herring Division VIIa(N). Summary of acoustic survey information for the period 1989 - 2009. 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

[1] sprat only; [2]Data can be made available for the IoM waters only

Table 7.3.2 Irish Sea Herring Division VIIa(N). Age-disaggregated acoustic estimates (thousands) of herring abundance from the Northern Ireland surveys in September (ACAGE).

AGE (RINGS)	1	2	3	4	5	6	7	8+
1994	66.8	68.3	73.5	11.9	9.3	7.6	3.9	10.1
1995	319.1	82.3	11.9	29.2	4.6	3.5	4.9	6.9
1996	11.3	42.4	67.5	9	26.5	4.2	5.9	5.8
1997	134.1	50	14.8	11	7.8	4.6	0.6	1.9
1998	110.4	27.3	8.1	9.3	6.5	1.8	2.3	0.8
1999	157.8	77.7	34	5.1	10.3	13.5	1.6	6.3
2000	78.5	103.4	105.3	27.5	8.1	5.4	4.9	2.4
2001	387.6	93.4	10.1	17.5	7.7	1.4	0.6	2.2
2002	391	71.9	31.7	24.8	31.3	14.8	2.8	4.5
2003	349.2	220	32	4.7	3.9	4.1	1	0.9
2004	241	115.5	29.6	15.4	2.1	2.3	0.2	0.2
2005	94.3	109.9	97.1	17	8	0.8	0.6	5.8
2006	374.7	96.6	15.6	10.0	0.5	0.4	0.5	0.5
2007	1316.7	251.3	46.6	21.1	20.8	1.2	0.7	0.6
2008	475.7	452.4	114.2	39.1	26.4	17.1	4.3	0.6
2009	371.2	182.6	177.8	92.7	32.5	15.1	13.9	6.9

Table 7.3.3 Irish Sea Herring Division VIIa(N). Larval production (10^{11}) indices for the Manx component. Table amended with Douglas Bank time series removed (see Annex 8).

YEAR	NORTHEAST IRISH SEA					
		Isle of Man			Northern Ireland	
	Date	Production	SE	Date	Production	CV
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

SE = Standard Error *2005 Index value amended

TABLE 7.6.1 Irish Sea herring VIIa(N). catch-at-age (thousands) by year.

Units : Thousands

year

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

year

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

year

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

Units : Thousands

year

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	3905
2	21387	11879	16929	3743	11473	9021	4694	8833	13980	15253	18291	18974	41005
3	7562	3875	5936	5873	7151	1894	3345	5405	10555	8198	4980	7487	22704
4	7341	4450	1566	2065	13050	1866	2559	2161	3287	6318	1655	2696	9251
5	1641	6674	1477	558	3386	2395	882	623	1422	1325	1062	2082	3278
6	2281	1030	1989	347	936	953	2945	213	415	605	325	1761	1496
7	840	2049	444	251	650	474	872	673	292	262	122	328	892
8	1432	451	622	147	803	337	605	127	368	246	111	216	215

*** Estimated according to methods outlined in section 7.6.1**

TABLE 7.6.2 Irish Sea herring VIIa(N). Weights-at-age in the catch (Kg)

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.082	0.067	0.067	0.078	0.065	0.092	0.093	0.091	0.074	0.101	0.108	0.074
2	0.123	0.125	0.131	0.129	0.132	0.140	0.149	0.153	0.152	0.162	0.158	0.155
3	0.178	0.152	0.184	0.156	0.176	0.185	0.180	0.196	0.204	0.206	0.189	0.195
4	0.198	0.177	0.208	0.171	0.192	0.218	0.199	0.231	0.231	0.225	0.214	0.219
5	0.232	0.199	0.228	0.226	0.210	0.258	0.223	0.246	0.254	0.245	0.225	0.232
6	0.226	0.214	0.234	0.240	0.230	0.253	0.243	0.269	0.266	0.251	0.266	0.251
7	0.253	0.275	0.266	0.000	0.272	0.225	0.227	0.234	0.239	0.269	0.241	0.258
8	0.248	0.251	0.258	0.296	0.265	0.264	0.275	0.264	0.270	0.258	0.241	0.278

year

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

year

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

year

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

year

age	2009*
1	0.068
2	0.107
3	0.133
4	0.155
5	0.165
6	0.182
7	0.194
8	0.212

*** Average for the preceding five years**

TABLE 7.6.3 Irish Sea herring VIIa(N). Weights-at-age in the stock (Kg)

age	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.082	0.067	0.067	0.078	0.065	0.092	0.093	0.091	0.074	0.101	0.108	0.074
2	0.123	0.125	0.131	0.129	0.132	0.140	0.149	0.153	0.152	0.162	0.158	0.155
3	0.178	0.152	0.184	0.156	0.176	0.185	0.180	0.196	0.204	0.206	0.189	0.195
4	0.198	0.177	0.208	0.171	0.192	0.218	0.199	0.231	0.231	0.225	0.214	0.219
5	0.232	0.199	0.228	0.226	0.210	0.258	0.223	0.246	0.254	0.245	0.225	0.232
6	0.226	0.214	0.234	0.240	0.230	0.253	0.243	0.269	0.266	0.251	0.266	0.251
7	0.253	0.275	0.266	0.000	0.272	0.225	0.227	0.234	0.239	0.269	0.241	0.258
8	0.248	0.251	0.258	0.296	0.265	0.264	0.275	0.264	0.270	0.258	0.241	0.278

age	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.074	0.076
2	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.155	0.142
3	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.195	0.187
4	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.219	0.213
5	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.221
6	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.251	0.243
7	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.258	0.240
8	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.278	0.273

age	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	0.087	0.068	0.058	0.070	0.081	0.077	0.070	0.061	0.088	0.073	0.072	0.067
2	0.125	0.143	0.130	0.124	0.128	0.135	0.121	0.111	0.126	0.126	0.120	0.115
3	0.157	0.167	0.160	0.160	0.155	0.163	0.153	0.136	0.157	0.154	0.147	0.148
4	0.186	0.188	0.175	0.170	0.174	0.175	0.167	0.151	0.171	0.174	0.168	0.162
5	0.202	0.215	0.194	0.180	0.184	0.188	0.180	0.159	0.183	0.181	0.180	0.177
6	0.209	0.229	0.210	0.198	0.195	0.196	0.189	0.171	0.191	0.190	0.185	0.195
7	0.222	0.239	0.218	0.212	0.205	0.207	0.195	0.179	0.198	0.203	0.197	0.199
8	0.258	0.254	0.229	0.232	0.218	0.217	0.214	0.191	0.214	0.214	0.212	0.212

age	1997	1998	1999	2000	2001	2002	2003*	2004	2005	2006	2007	2008
1	0.063	0.073	0.068	0.063	0.066	0.085	0.081	0.067	0.067	0.064	0.073	0.071
2	0.119	0.121	0.121	0.120	0.105	0.113	0.116	0.114	0.103	0.105	0.114	0.110
3	0.148	0.150	0.145	0.149	0.139	0.144	0.136	0.144	0.136	0.131	0.137	0.135
4	0.167	0.166	0.168	0.171	0.156	0.167	0.160	0.161	0.156	0.149	0.158	0.153
5	0.178	0.179	0.178	0.188	0.167	0.180	0.167	0.170	0.166	0.164	0.174	0.156
6	0.189	0.190	0.189	0.204	0.183	0.184	0.172	0.192	0.180	0.177	0.183	0.182
7	0.206	0.200	0.199	0.205	0.199	0.191	0.186	0.202	0.191	0.184	0.199	0.196
8	0.214	0.230	0.214	0.215	0.205	0.217	0.199	0.214	0.209	0.211	0.227	0.206

age	2009*
1	0.068
2	0.109
3	0.137
4	0.155
5	0.166
6	0.183
7	0.194
8	0.213

*** Average for the preceding five years**

TABLE 7.6.4 Irish Sea herring VIIa(N). PROPORTION MATURE

Units : NA

age \ year	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.15	0.11	0.12	0.36	0.40
2	0.22	0.24	0.34	0.53	0.61	0.47	0.37	0.88	0.71	0.92	0.87	0.88	0.77	0.99	0.99
3	0.63	0.83	0.88	0.81	0.90	0.91	0.75	0.94	0.92	0.94	0.97	0.90	0.89	0.96	1.00
4	1.00	0.92	0.89	1.00	1.00	1.00	0.83	0.94	0.94	0.96	0.98	1.00	0.97	1.00	0.94
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	0.07	0.03	0.04	0.00	0.20	0.19	0.10	0.02	0.00	0.14	0.31	0.00	0.00	0.07	0.06
2	0.96	0.92	0.81	0.84	0.88	0.89	0.80	0.73	0.69	0.62	0.73	0.85	0.90	0.63	0.66
3	0.98	0.96	0.88	0.81	0.95	0.90	0.89	0.88	0.83	0.71	0.66	0.91	0.96	0.93	0.90
4	1.00	1.00	0.91	0.78	0.95	0.94	0.91	0.90	0.93	0.88	0.81	0.87	0.99	0.95	0.95
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003*	2004	2005
1	0.04	0.28	0.00	0.19	0.10	0.02	0.04	0.30	0.02	0.14	0.15	0.02	0.11	0.11	0.20
2	0.30	0.48	0.46	0.68	0.86	0.60	0.82	0.83	0.84	0.79	0.54	0.92	0.76	1.00	0.97
3	0.74	0.72	0.99	0.99	0.94	0.96	0.95	0.97	0.95	0.99	0.88	0.95	0.95	0.97	0.99
4	0.82	0.81	1.00	0.97	0.99	0.83	1.00	0.99	0.97	1.00	0.97	0.98	0.97	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

age \ year	2006	2007	2008	2009#
1	0.19	0.16	0.16	0.13
2	0.89	0.94	0.84	0.82
3	1.00	0.98	1.00	0.97
4	1.00	1.00	1.00	0.98
5	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00

***Average preceding nine years**
#Average preceding fourteen years, excluding 2003

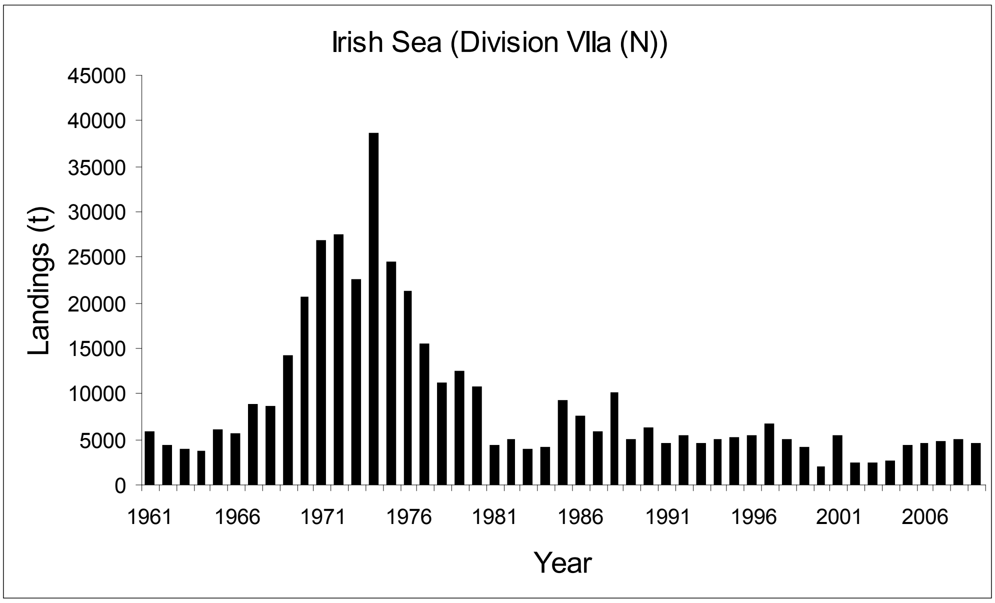


Figure 7.1.1 **Irish Sea herring VIIa(N). Landings of herring from VIIa(N) from 1961 to 2009.**

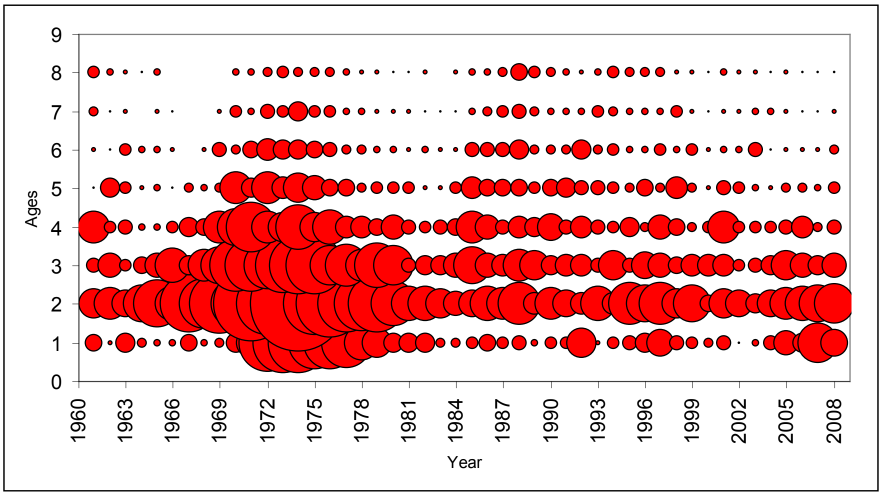


Figure 7.2.1 **Irish Sea herring VIIa(N). Landings (catch-at-age) of herring from VIIa(N) from 1961 to 2008. No 2009 commerical samples.**

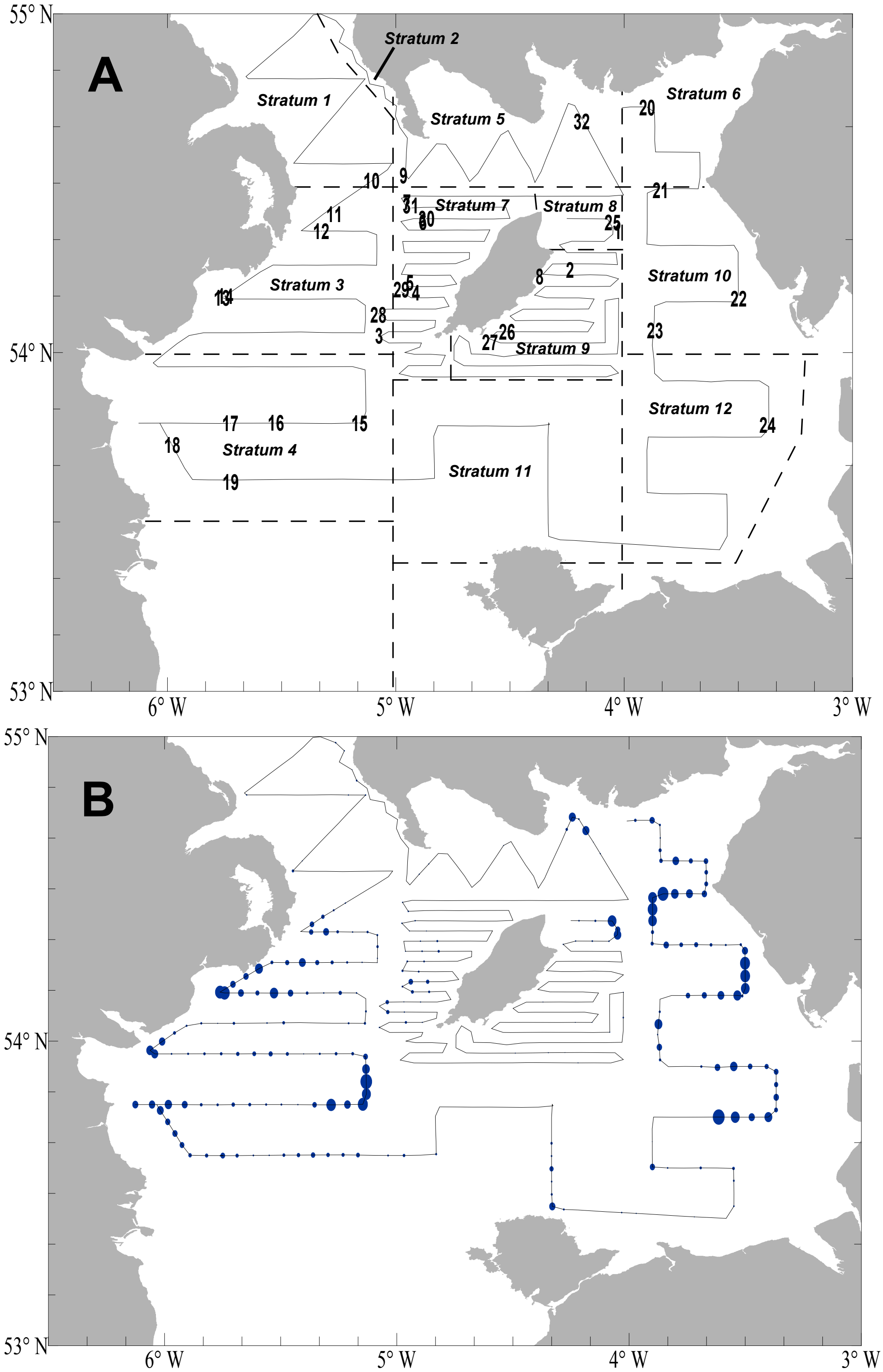
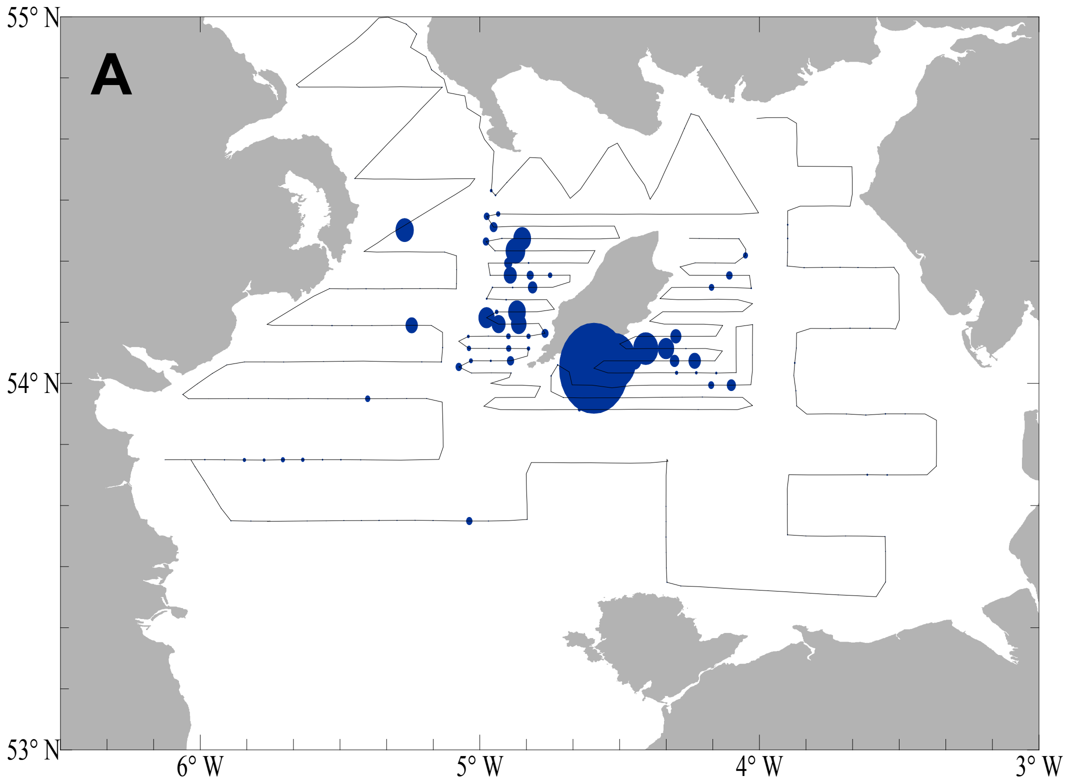


Figure 7.3.1 Irish Sea herring VIIa(N). (A) Transects, stratum boundaries and trawl positions for the 2009 acoustic survey; (B) Density distribution of sprats (size of ellipses is proportional to square root of the fish density (t n.mile-2) per 15-minute interval). Maximum density was 270 t n.mile^{-2}. Note: same scaling of ellipse sizes on above figures.



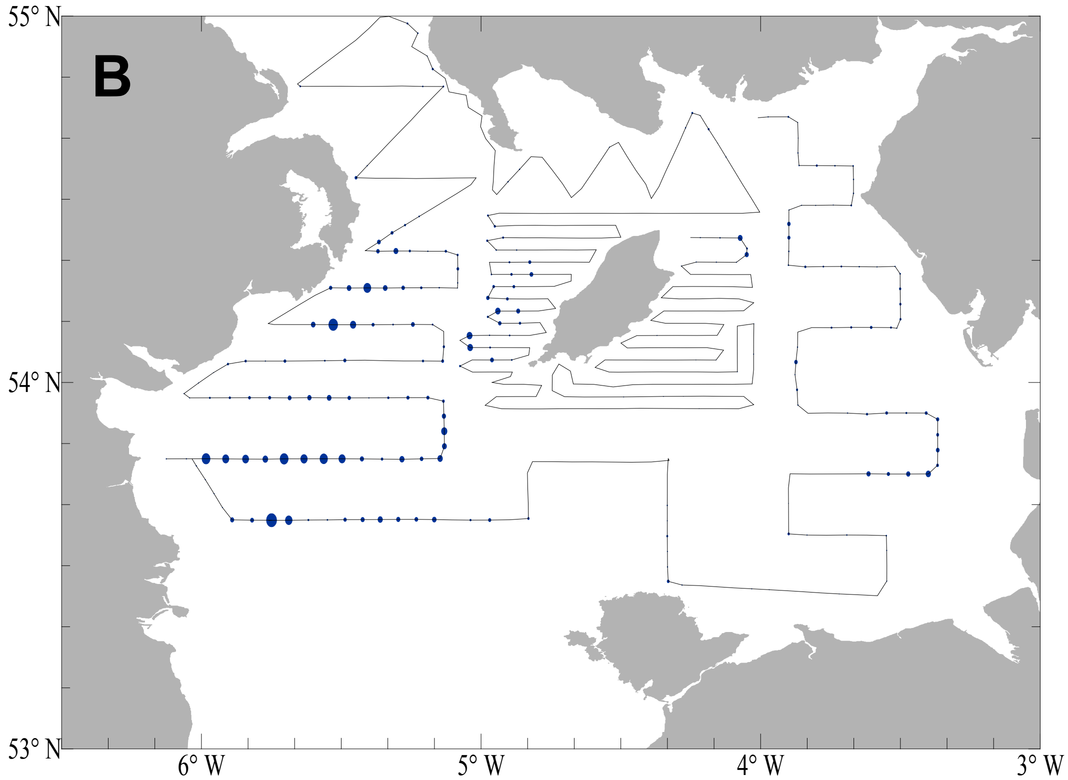


Figure 7.3.2 Irish Sea herring VIIa(N). (A) Density distribution of 1-ring and older herring (size of ellipses is proportional to square root of the fish density (t n.mile^{-2}) per 15-minute interval). Maximum density was 6 740 t n.mile^{-2}. (B) Density distribution of 0-ring herring. Maximum density was 150 t n.mile^{-2} . Note: same scaling of ellipse sizes on above figures.

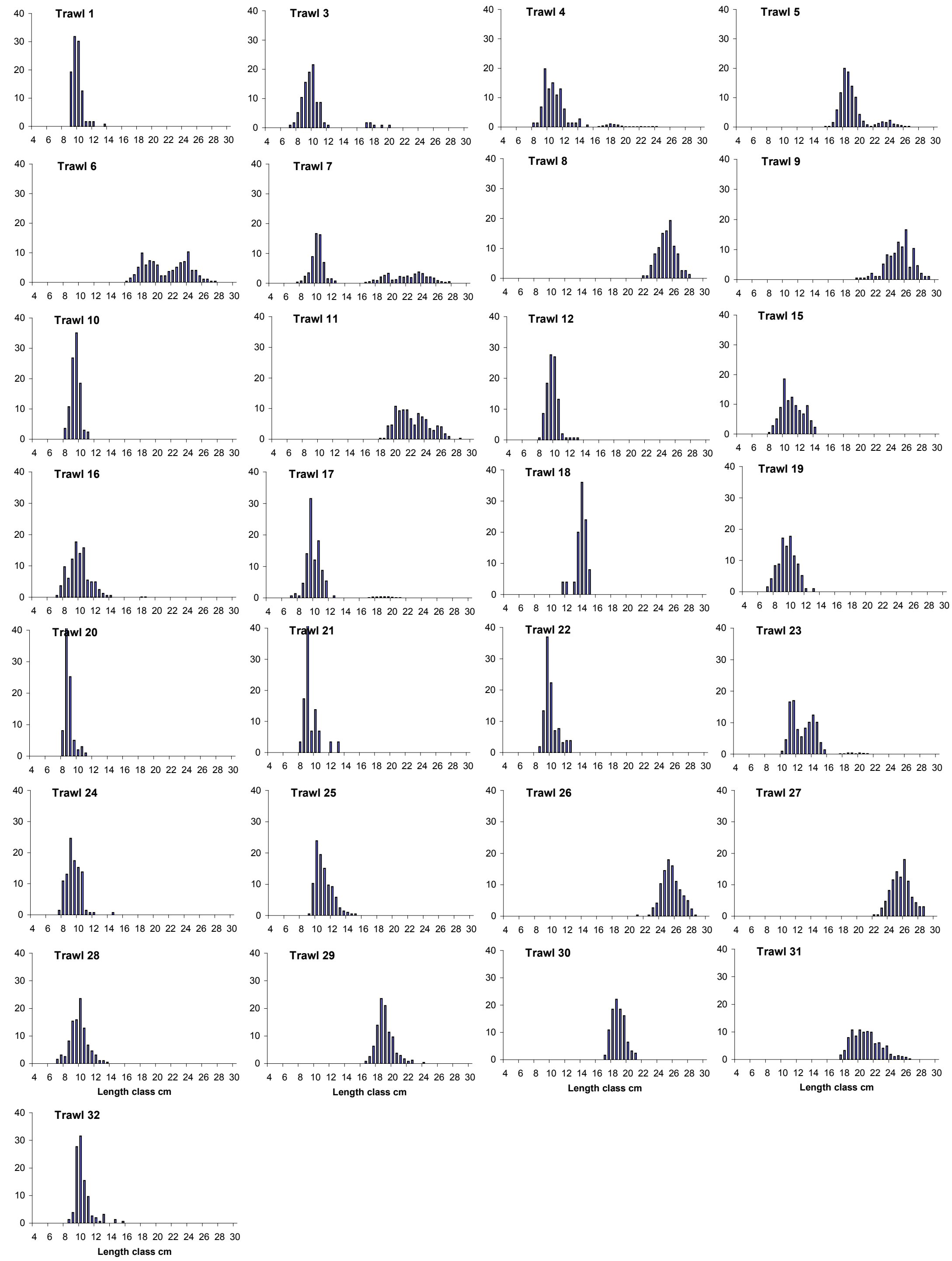


Figure 7.3.3 Irish Sea herring VIIa(N). Percentage length compositions of herring in each trawl sample in the September 2009 acoustic survey.

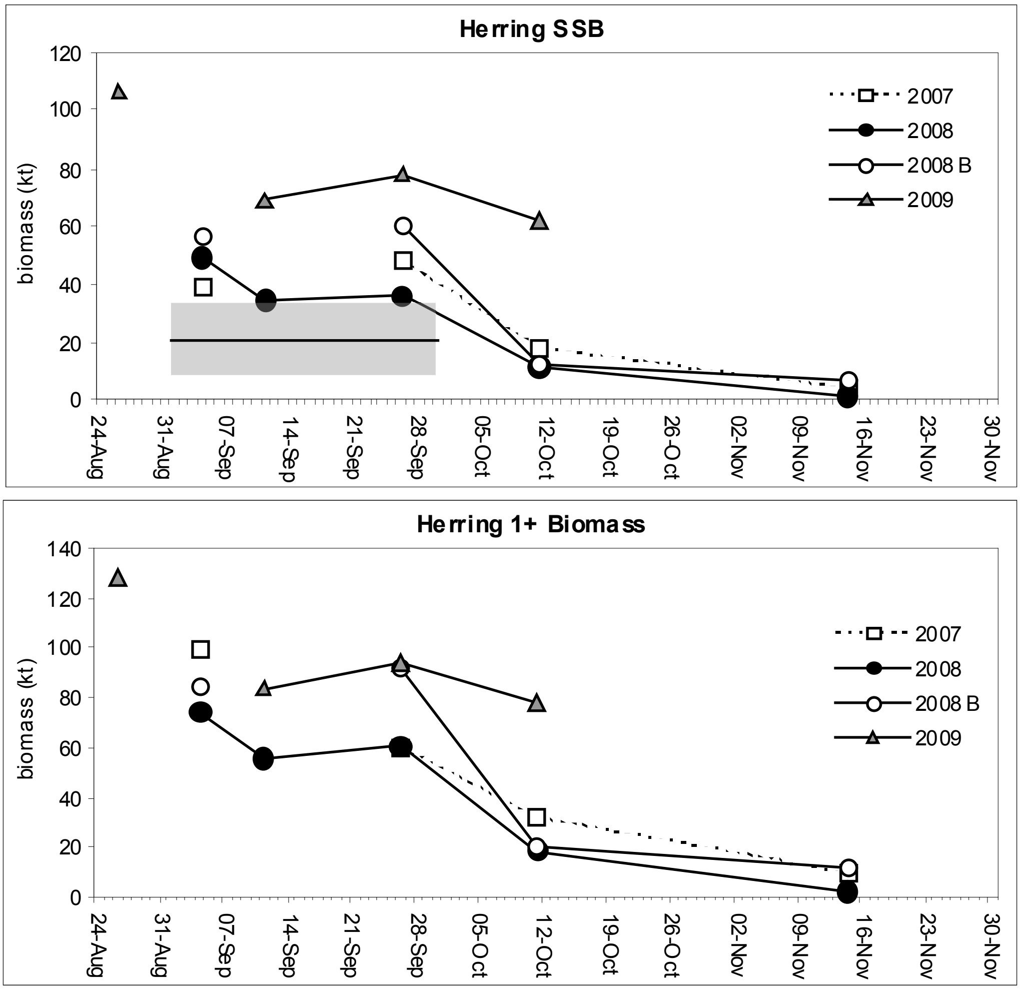


Figure 7.3.4 **Irish Sea herring VIIa(N). Comparison of SSB (top panel) and 1-ring and older herring biomass (bottom panel) from the enhanced acoustic survey programme, 2007-2009. Only information from surveys covering around Isle of Man and Scottish Coast are plotted. Additional data series for 2008 includes estimates of additional small strata to the west of the Isle of Man and additional survey transects. Shaded areas illustrate historic (1994-2006) average and range of estimates during routine survey in September.**

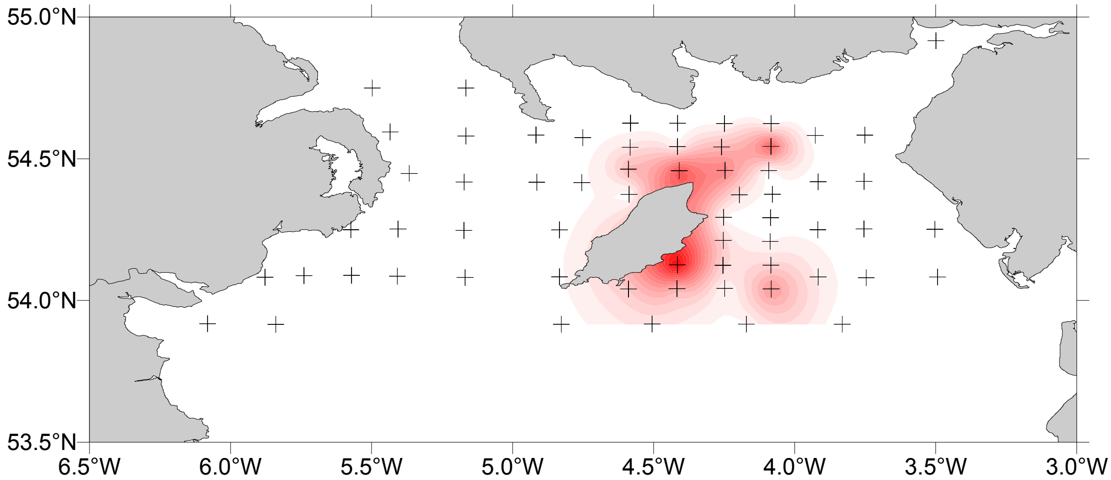


Figure 7.3.5 **Irish Sea herring VIIa(N). Estimates of larval herring abundance in the Northern Irish Sea, 8th to 17th November 2009. (maximum abundance = 182 per m²).**

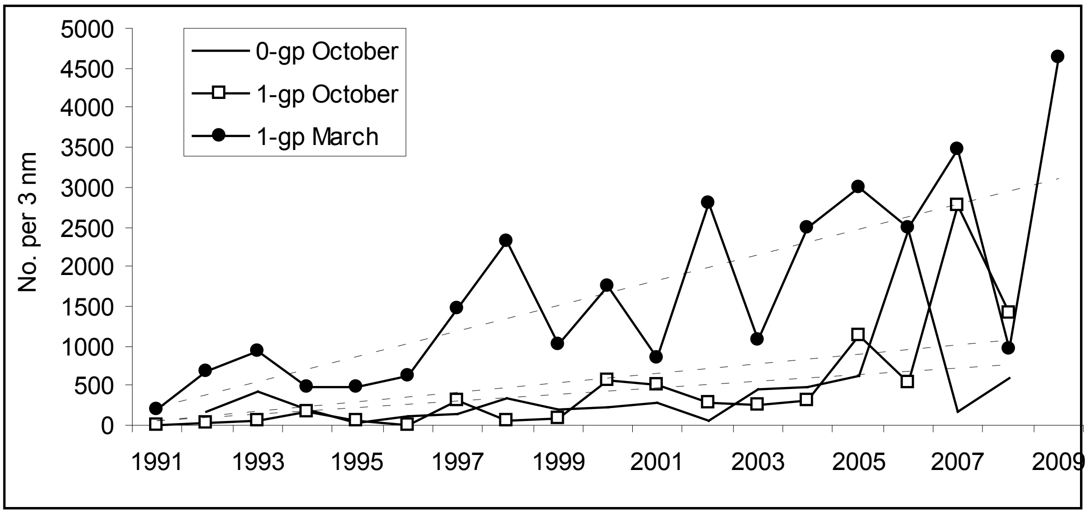


Figure 7.3.6 **Irish Sea herring VIIa(N). Trends in 0-gp and 1-gp herring indices from the Northern Irish March and October groundfish surveys in the northern Irish Sea. [Ages are length sliced]**

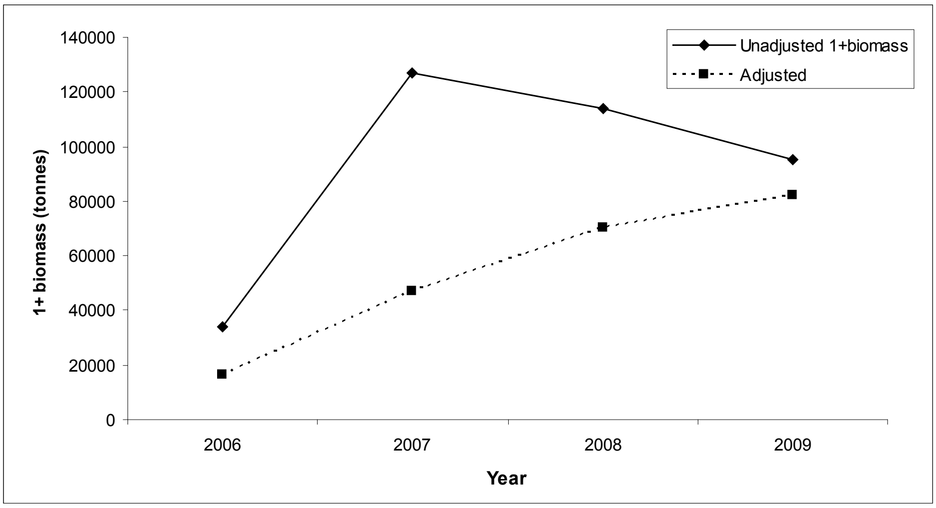


Figure 7.3.7 Irish Sea herring VIIa(N). Comparison of 1-ringer+ biomass estimates from acoustic survey with adjusted data ("winter spawers removed") and unadjusted data sets.

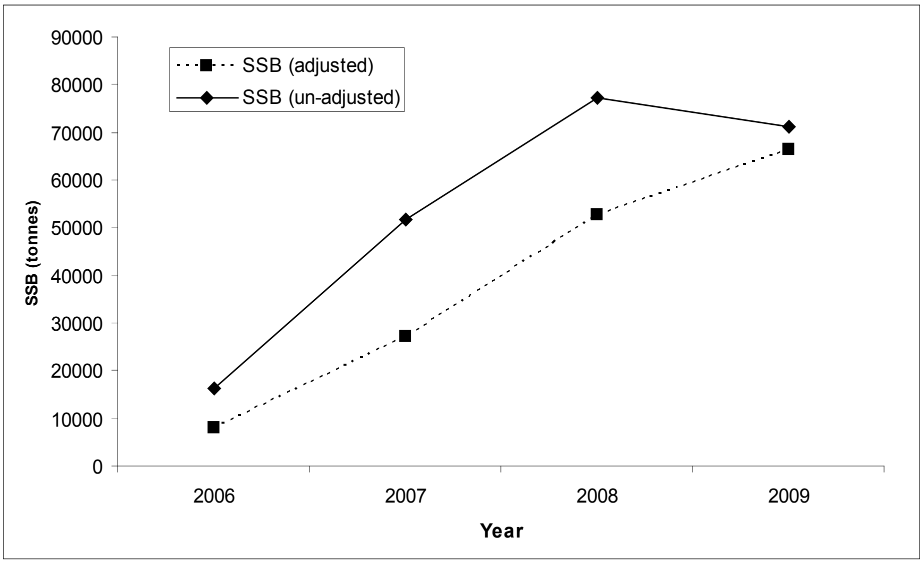


Figure 7.3.8 Irish Sea herring VIIa(N). Comparison of SSB biomass estimates from acoustic survey with adjusted data ("winter spawers removed") and unadjusted data sets.

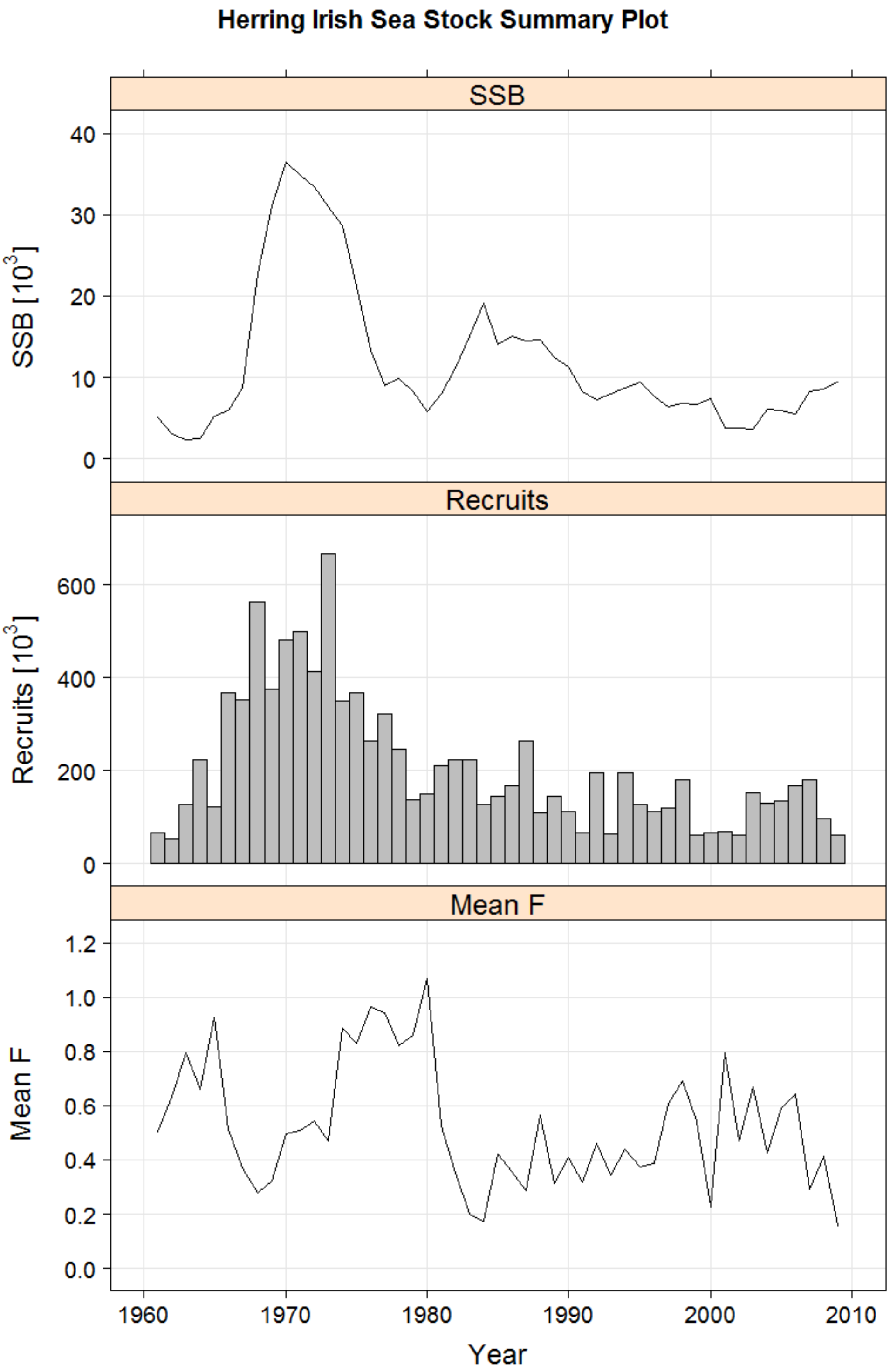


Figure 7.6.1 Irish Sea herring VIIa(N). SPALY FLICA run output illustrations of stock trends from deterministic calculation (6-year separable period) using downweighted catch at age data. Summary of estimates of spawning stock at spawning time, recruitment at 1-ring, mean F2-6.

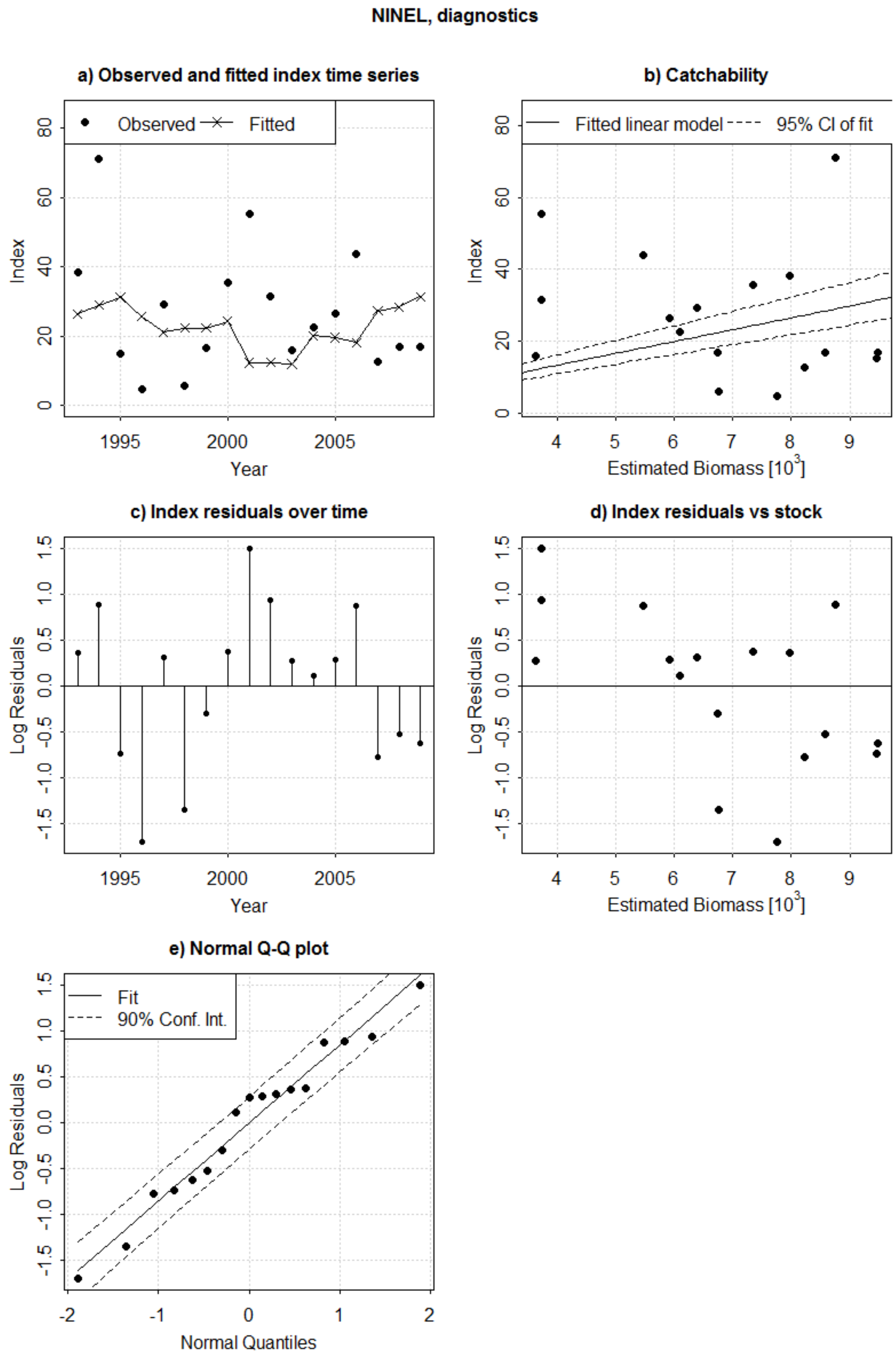


Figure 7.6.2 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of NINEL survey catchability at all ages. Top left: VPA estimates of biomass of all ages and biomass predicted from index abundance for all ages. Top right: scatterplot of index observations versus VPA estimates of all ages with the best-fit catchability model. Middle left: log residuals of catchability model by VPA estimate of numbers at 0 wr. Middle right: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

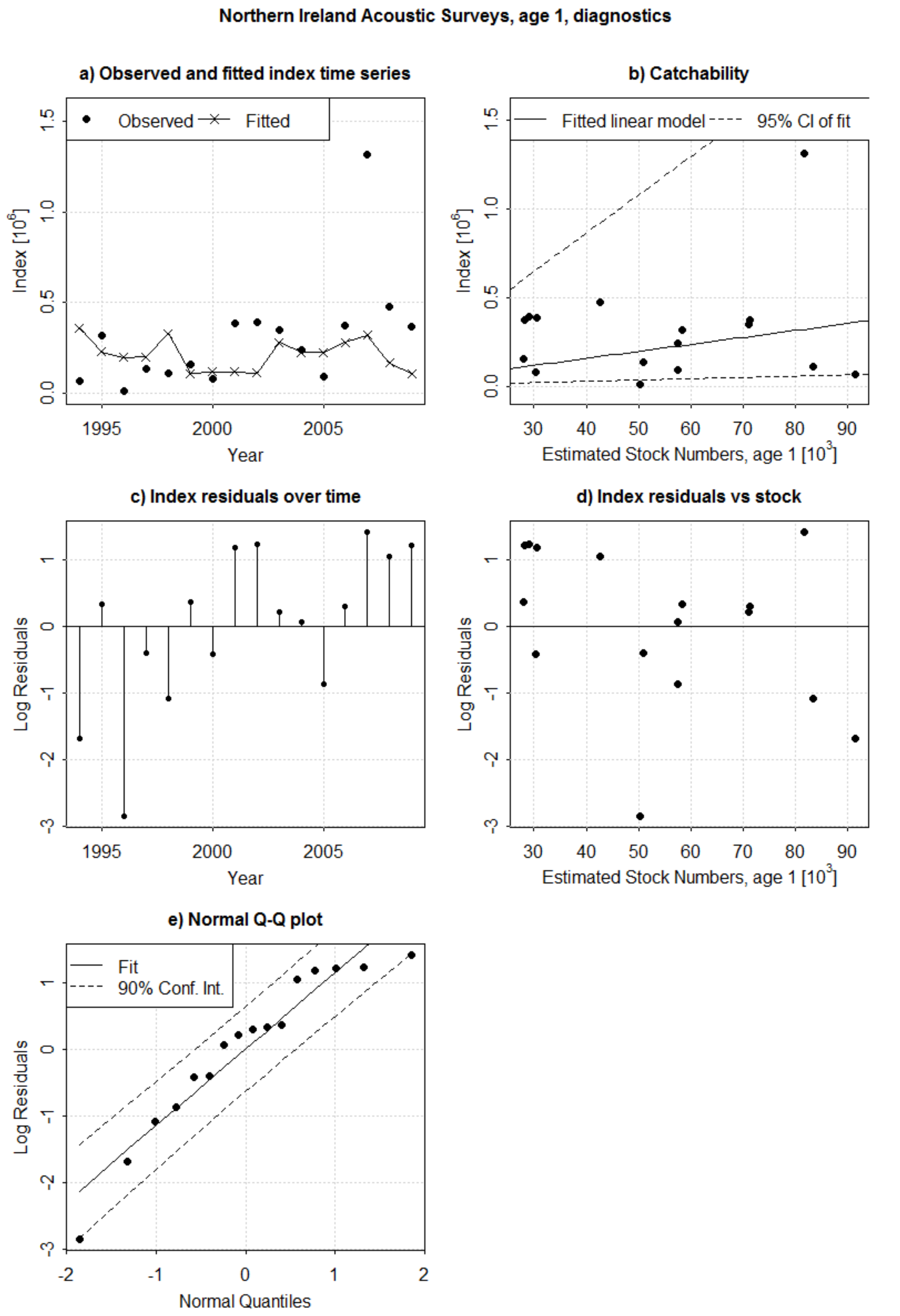


Figure 7.6.3 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

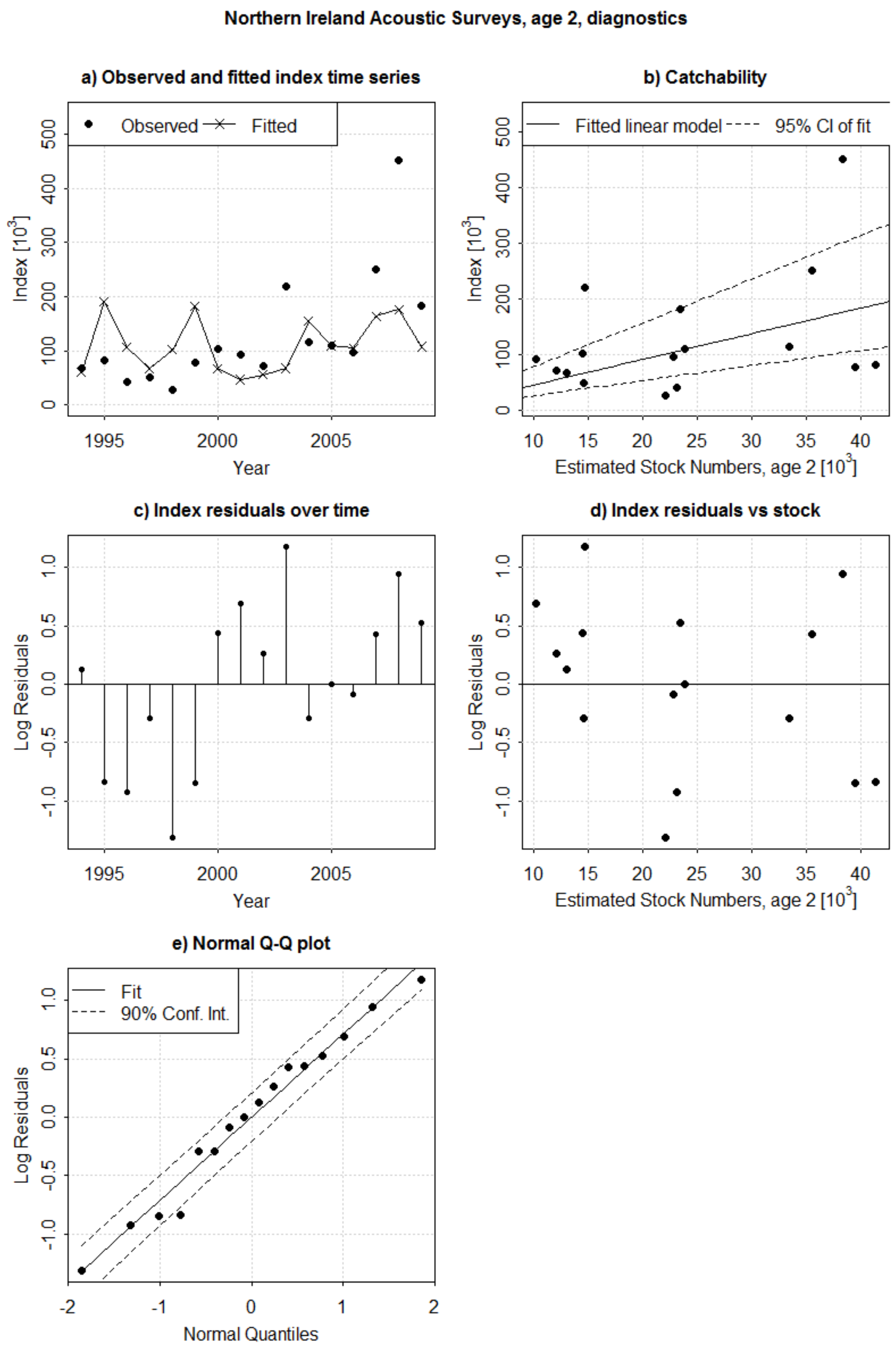


Figure 7.6.4 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

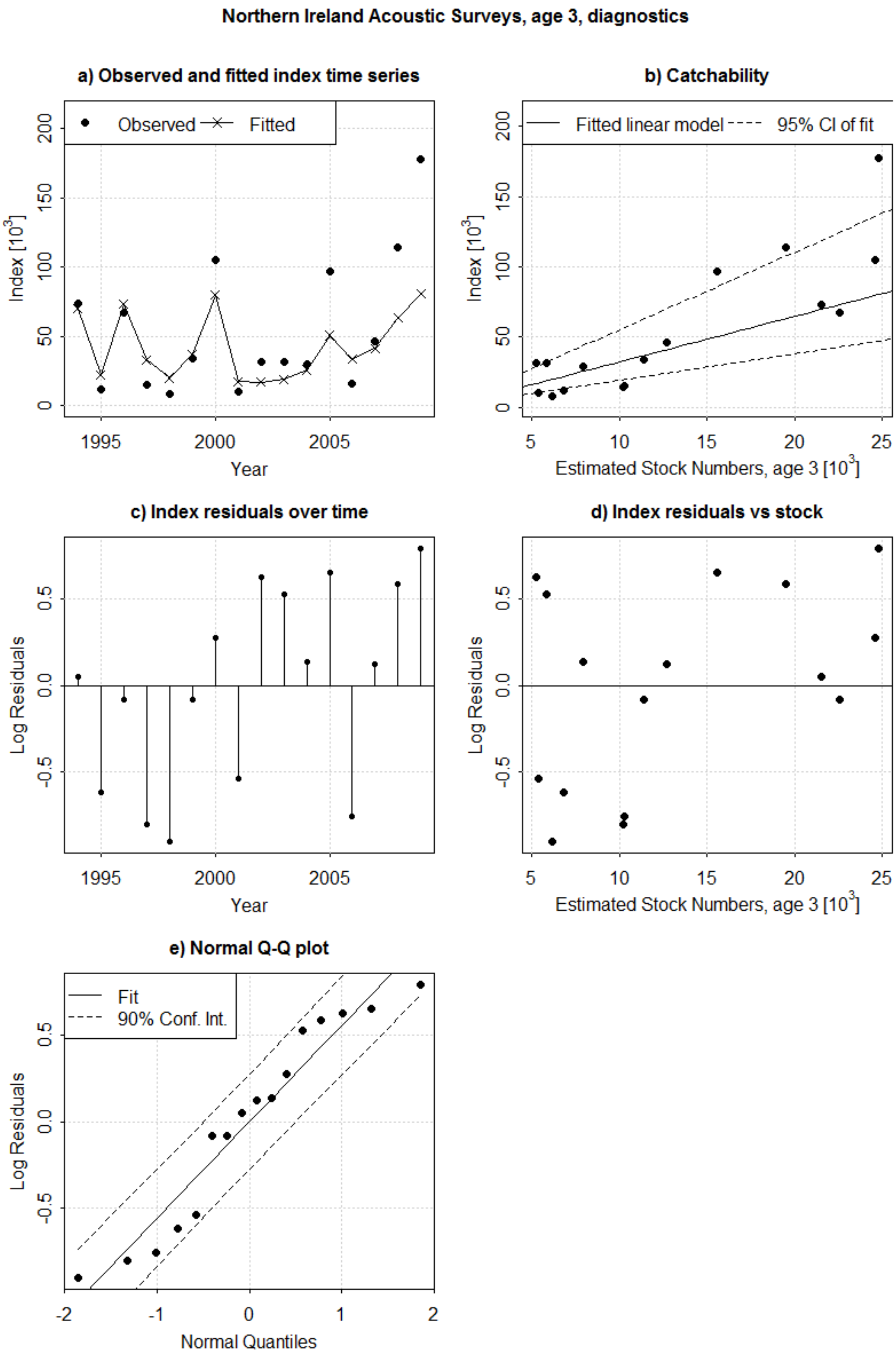


Figure 7.6.5 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

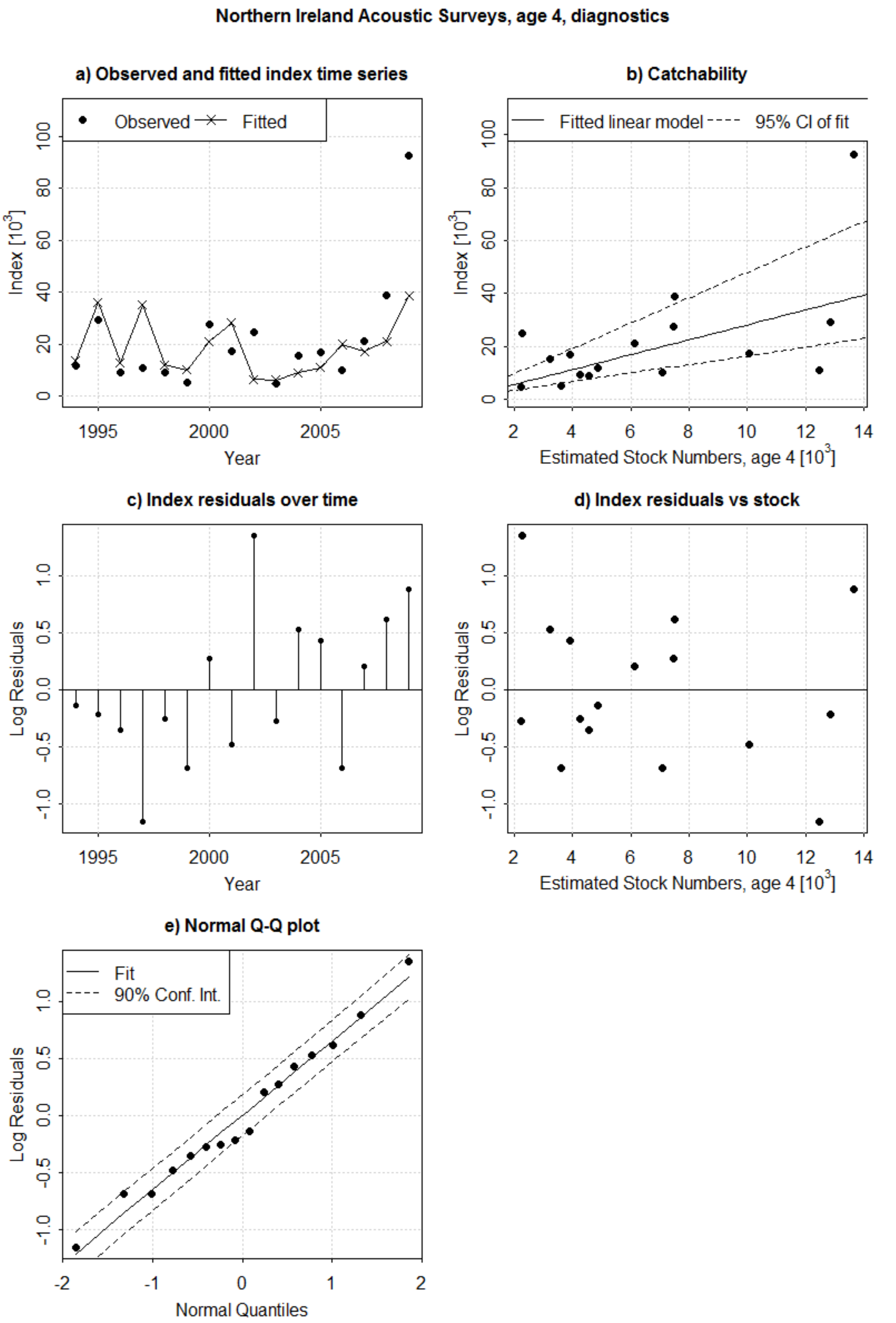


Figure 7.6.6 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

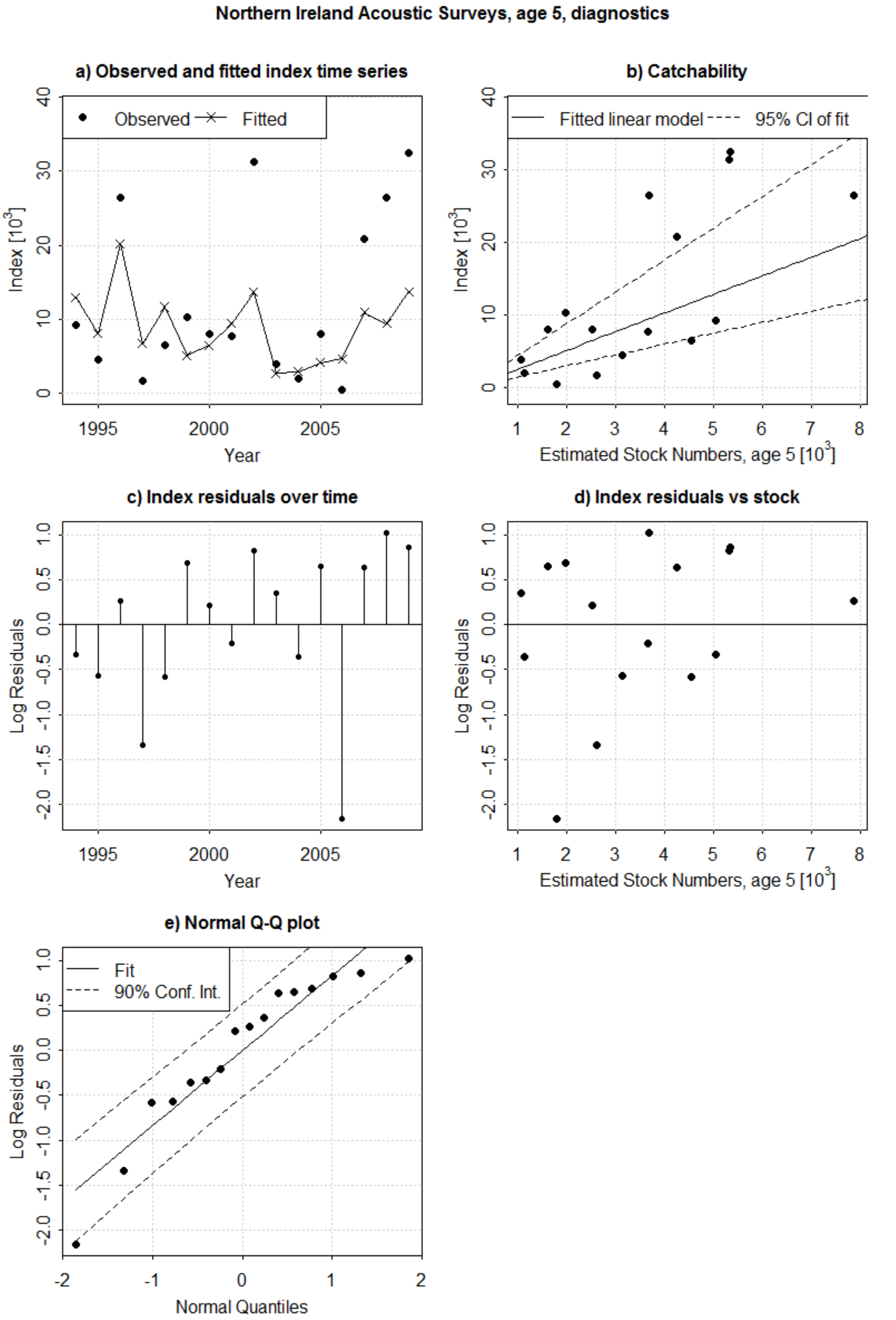


Figure 7.6.7 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

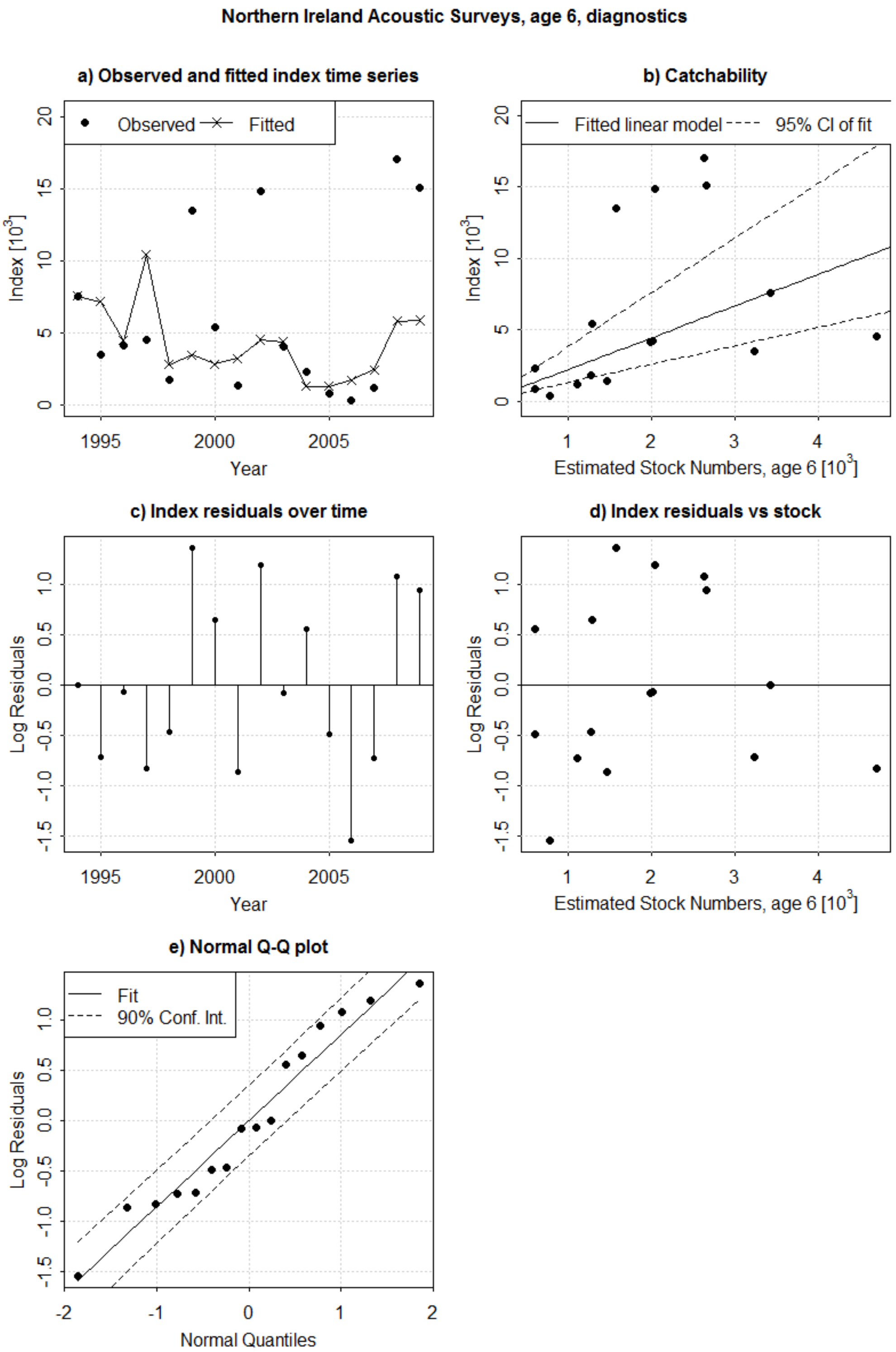


Figure 7.6.8 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

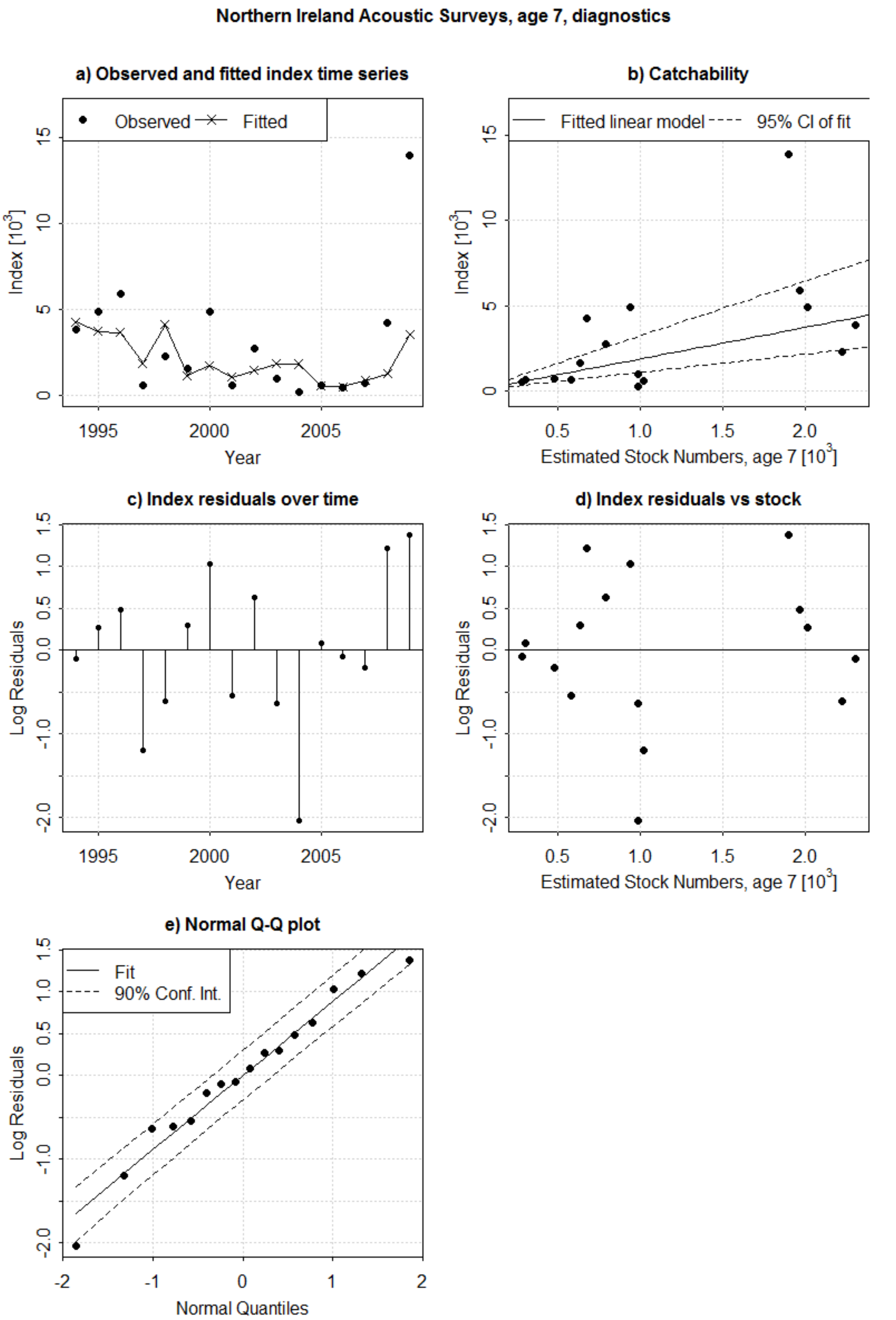


Figure 7.6.9 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

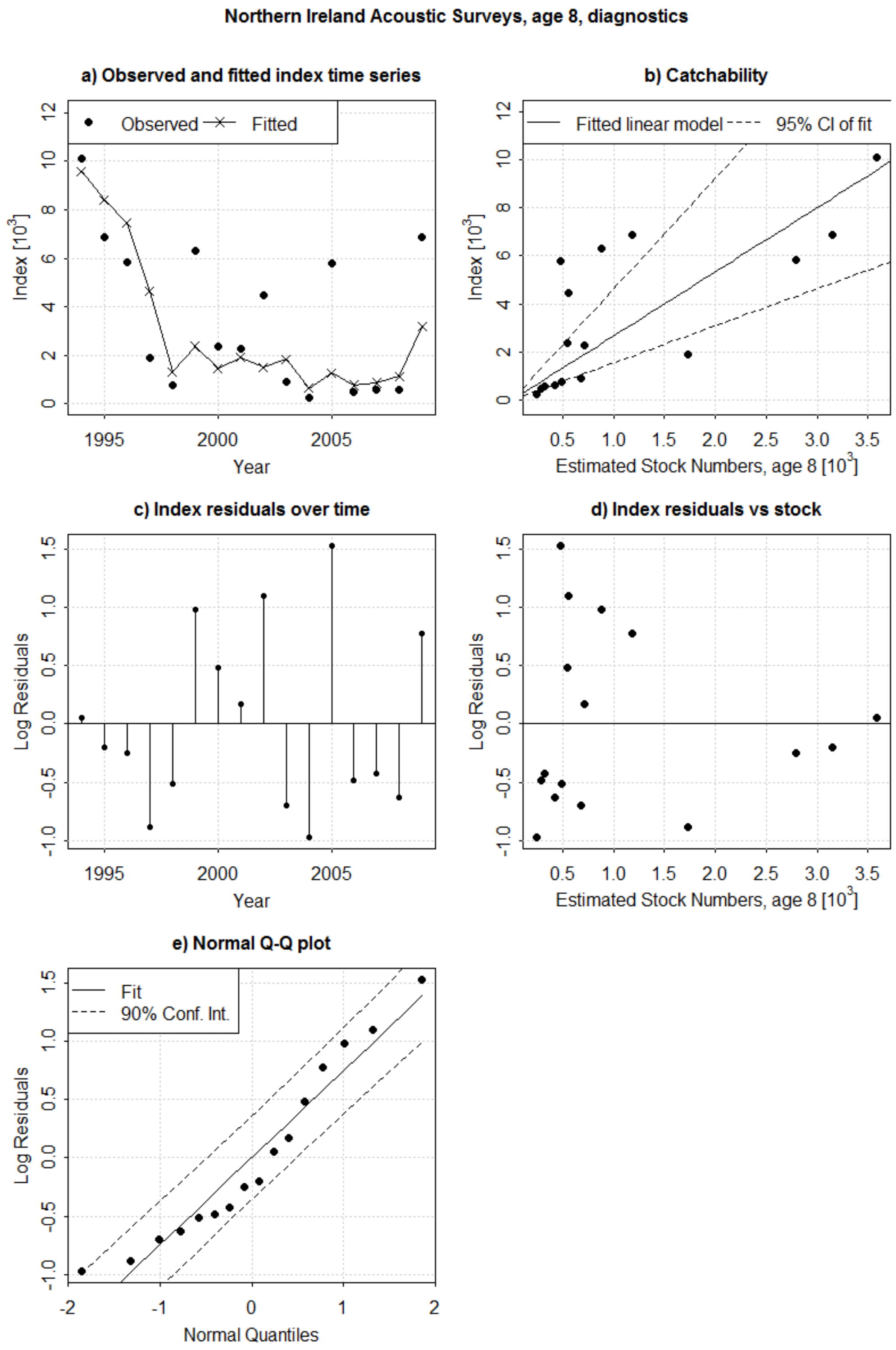


Figure 7.6.9 Irish Sea herring VIIa(N). SPALY FLICA run output. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

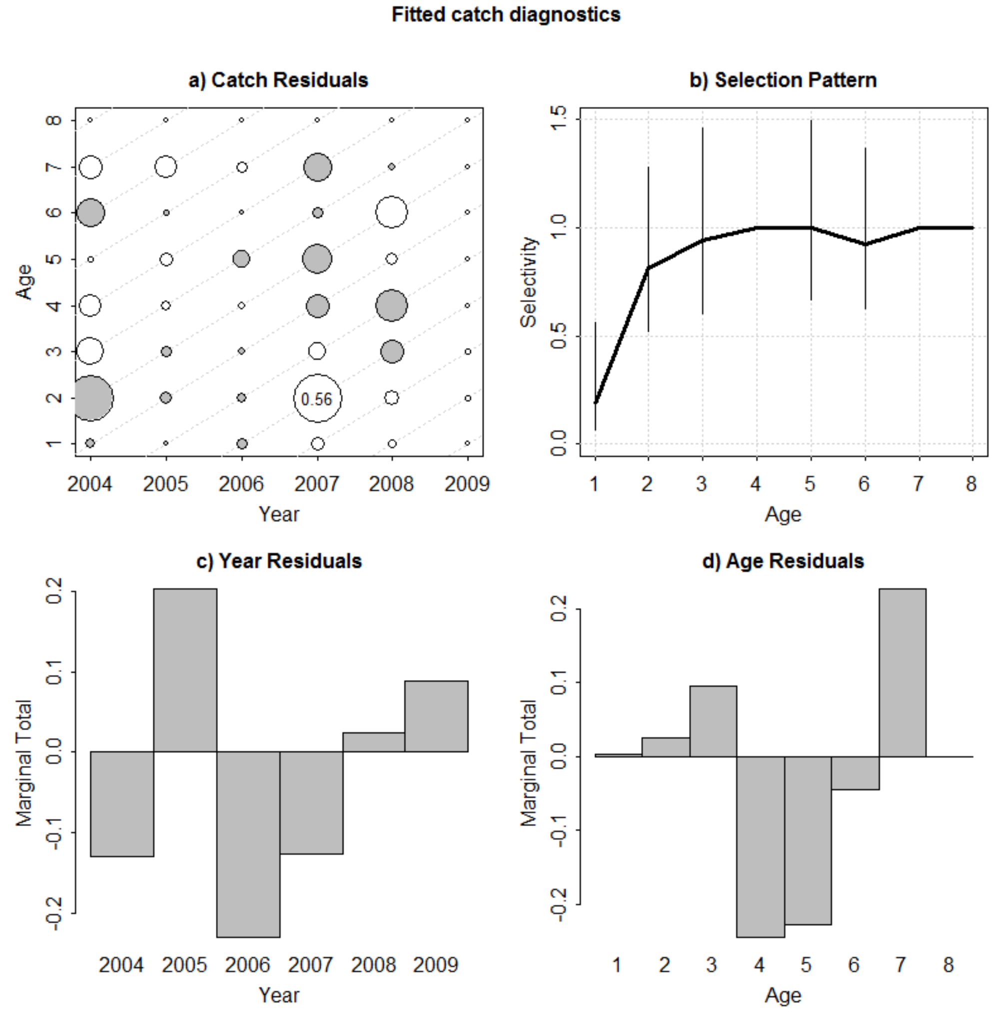


Figure 7.6.10 Irish Sea herring VIIa(N). SPALY FLICA run output Figure 7.3.1 Irish Sea herring VIIa(N). FLICA run output no SSB. Selection pattern diagnostics from deterministic calculations (6-year separable period). a) catch residuals. b) estimated selection (relative to 4-wr)+/- standard deviation. c) marginal totals of residuals by year and d) ring (ages 2-7 only).

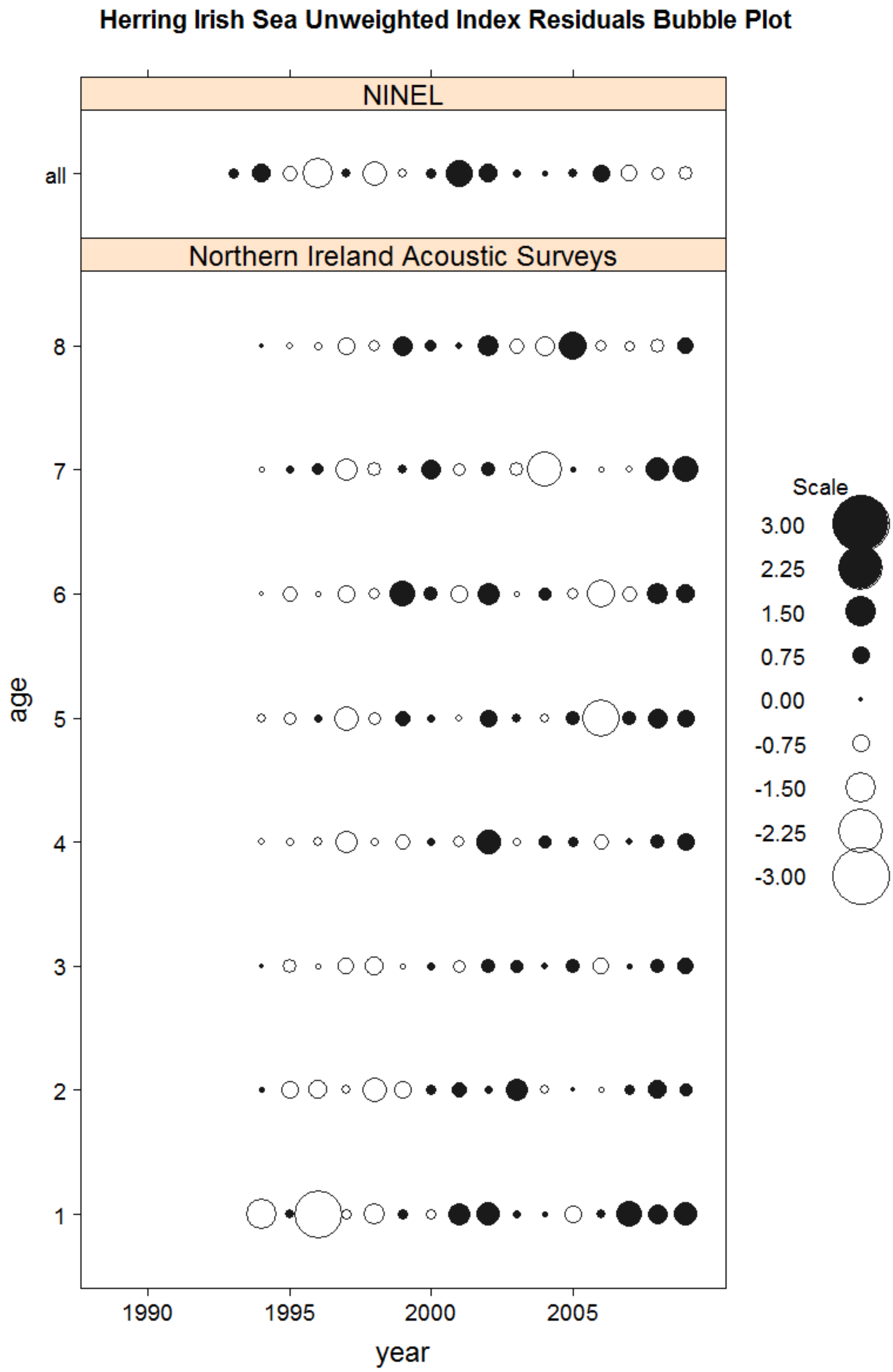


Figure 7.6.11 Irish Sea herring VIIa(N). SPALY FLICA run output unweighted residuals of larval survey (SSB index) and acoustic for the assessment up to 2009.

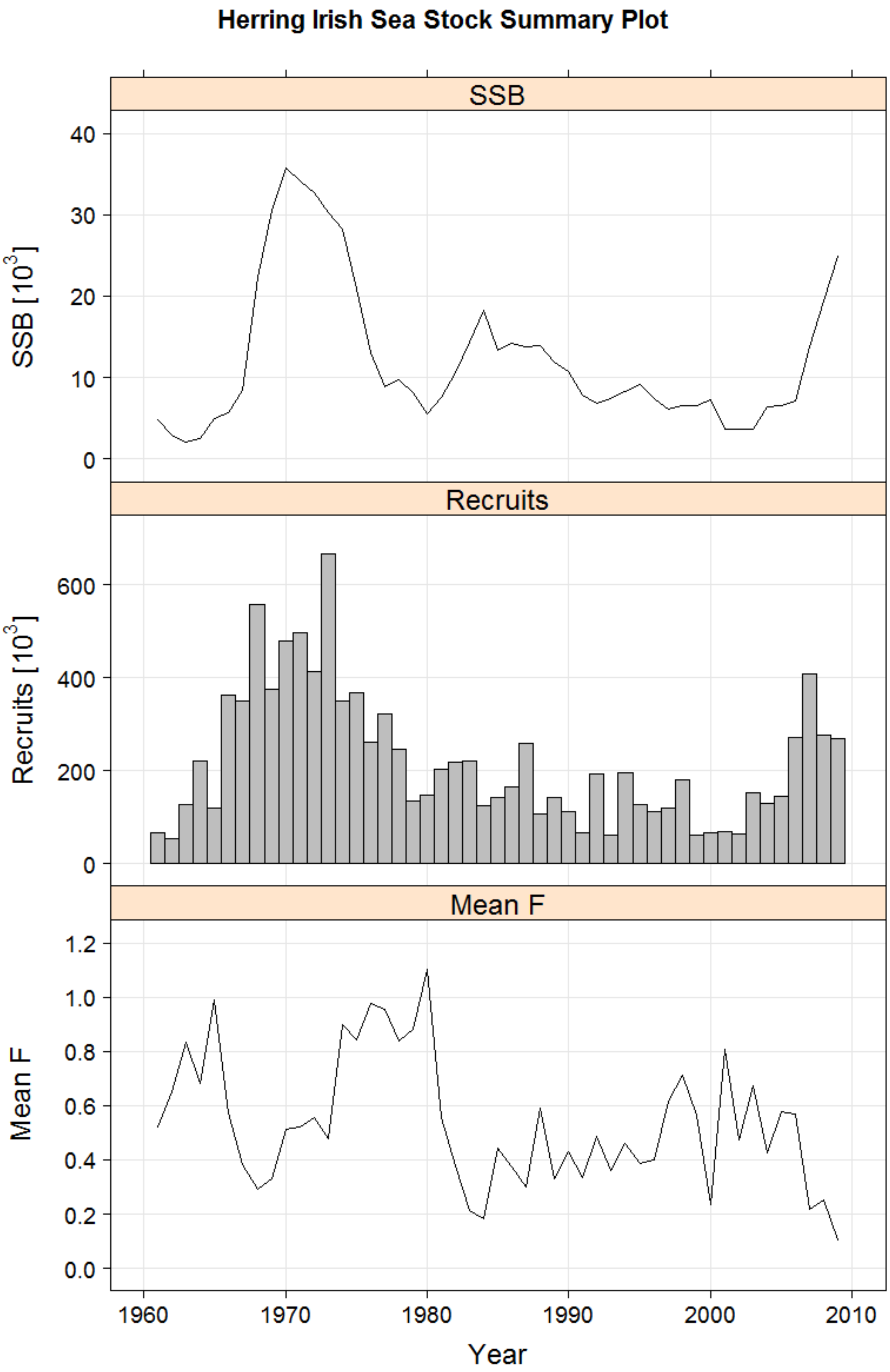


Figure 7.6.12 Irish Sea herring VIIa(N). FLICA outputs with no SSB index run output illustrations of stock trends from deterministic calculation (6-year separable period) using down-weighted catch at age data. Summary of estimates of spawning stock at spawning time, recruitment at 1-ring, mean F2-6.

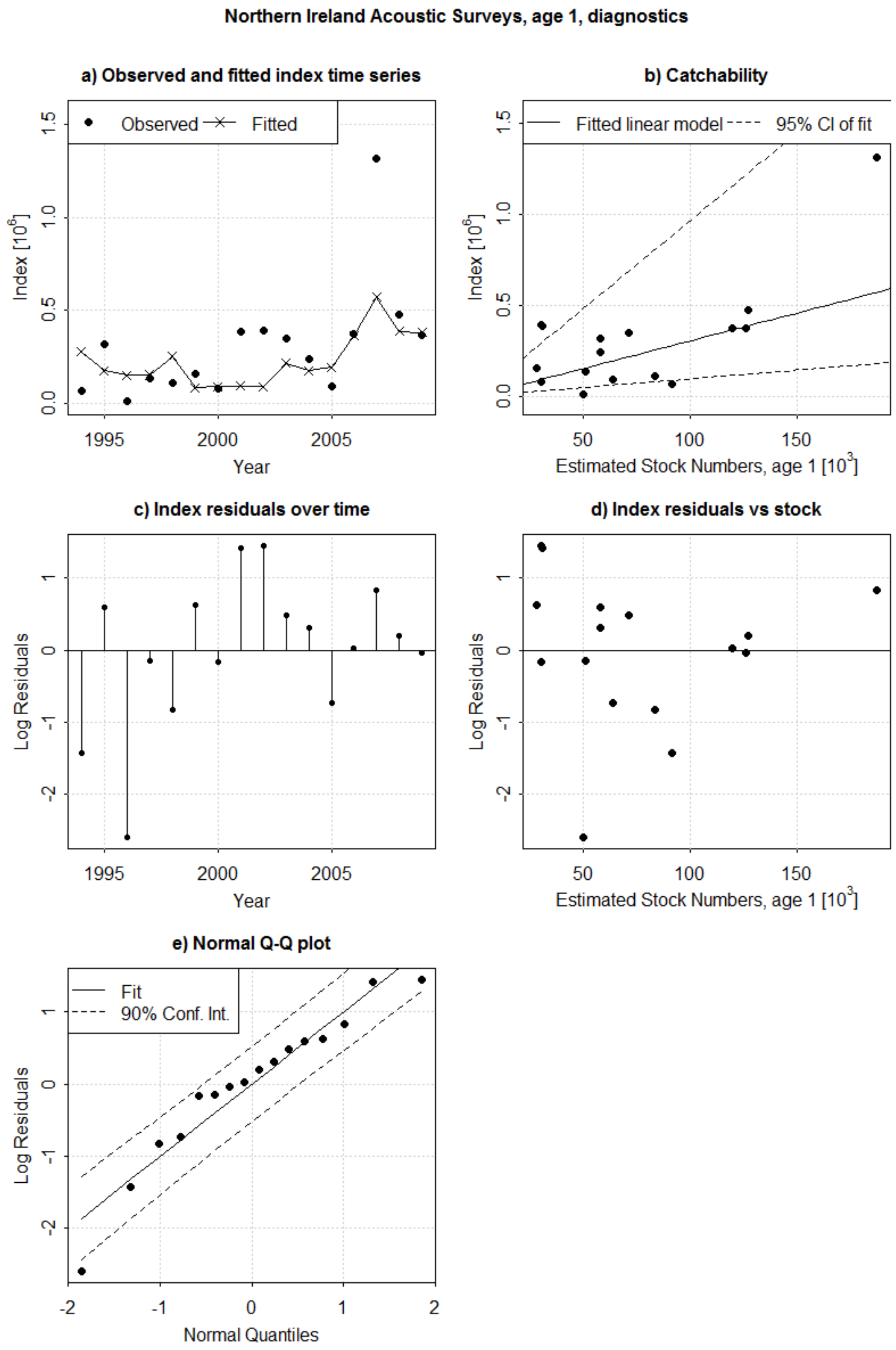


Figure 7.6.13 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

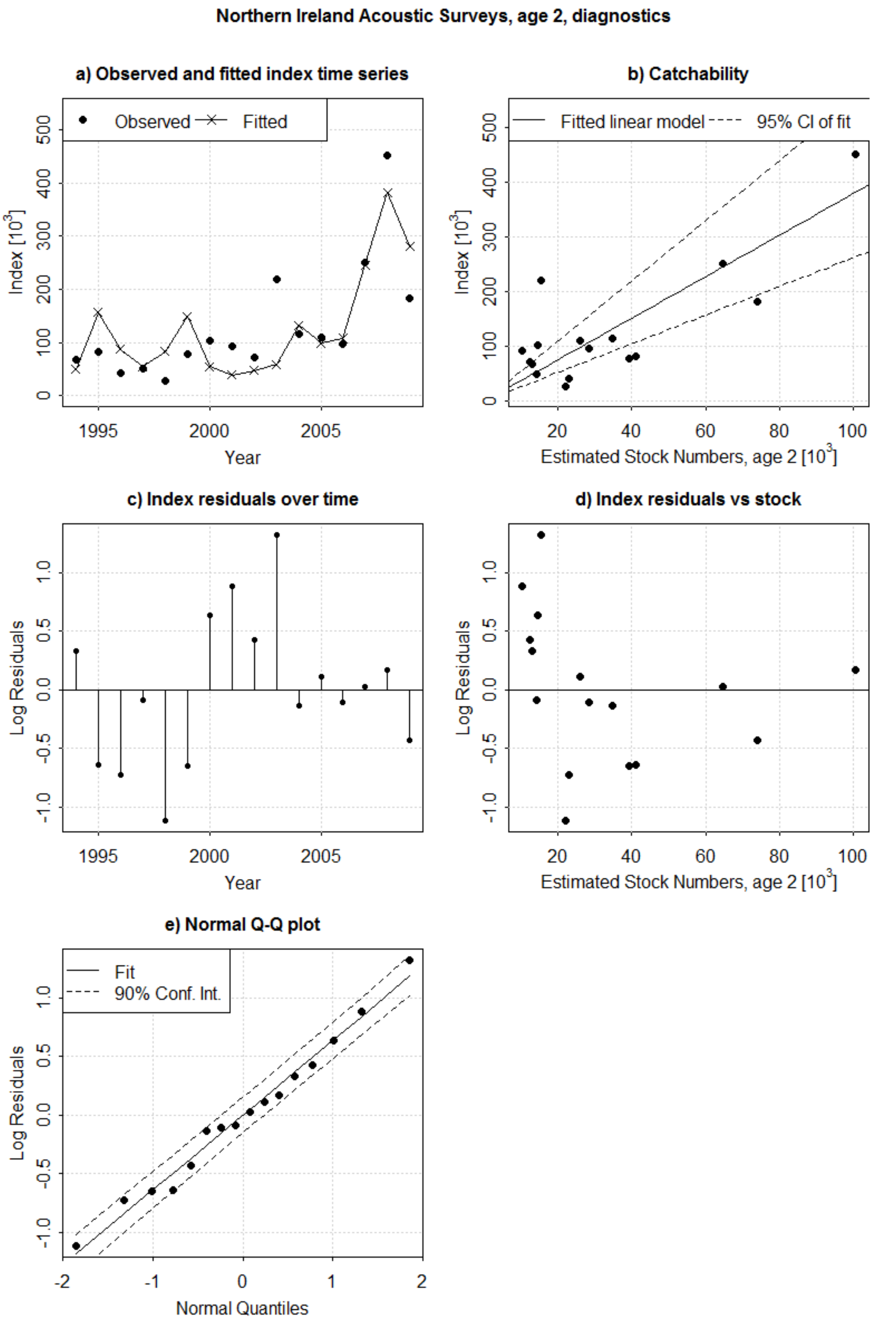


Figure 7.6.14 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.FLICA run output no SSB.

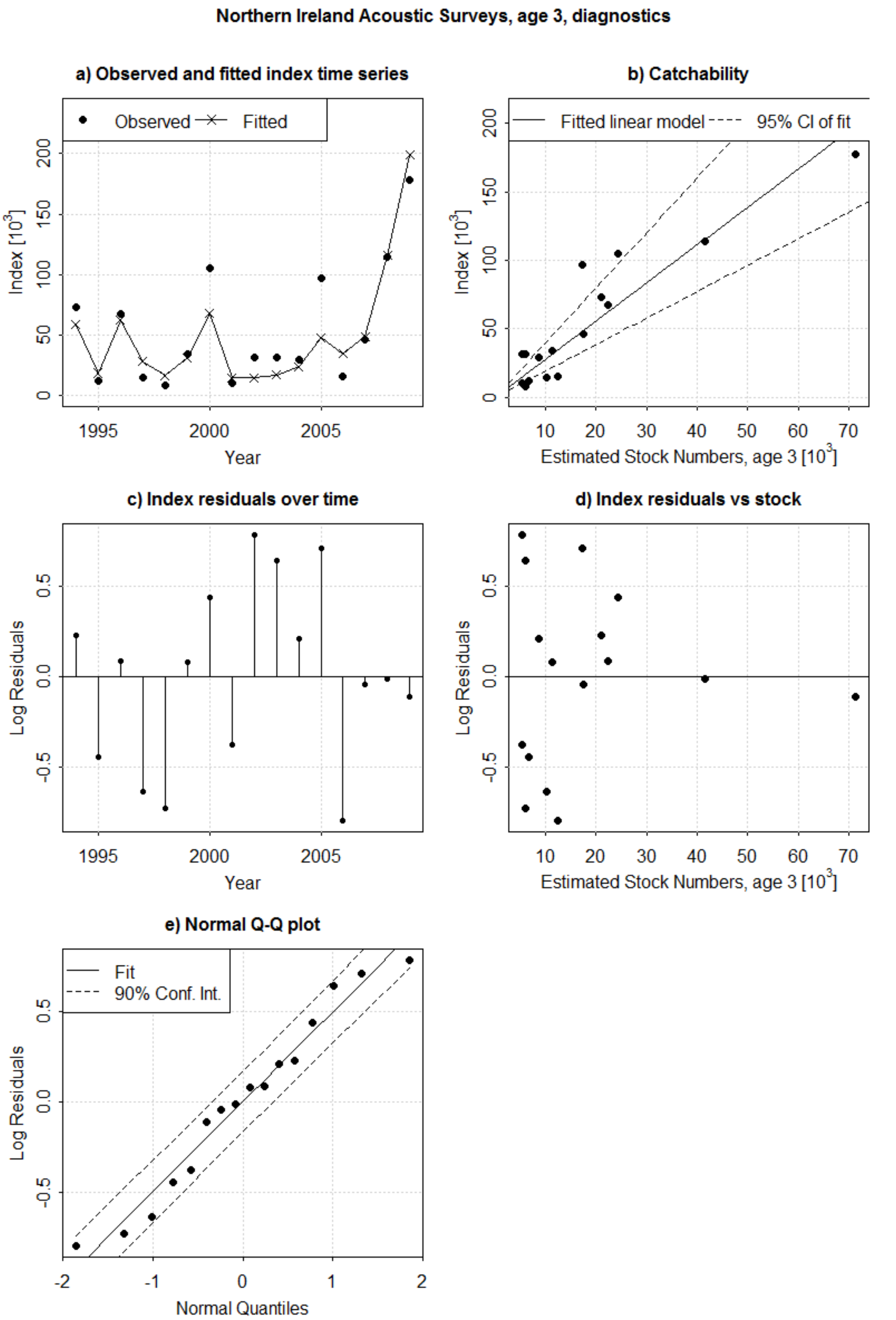


Figure 7.6.15 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

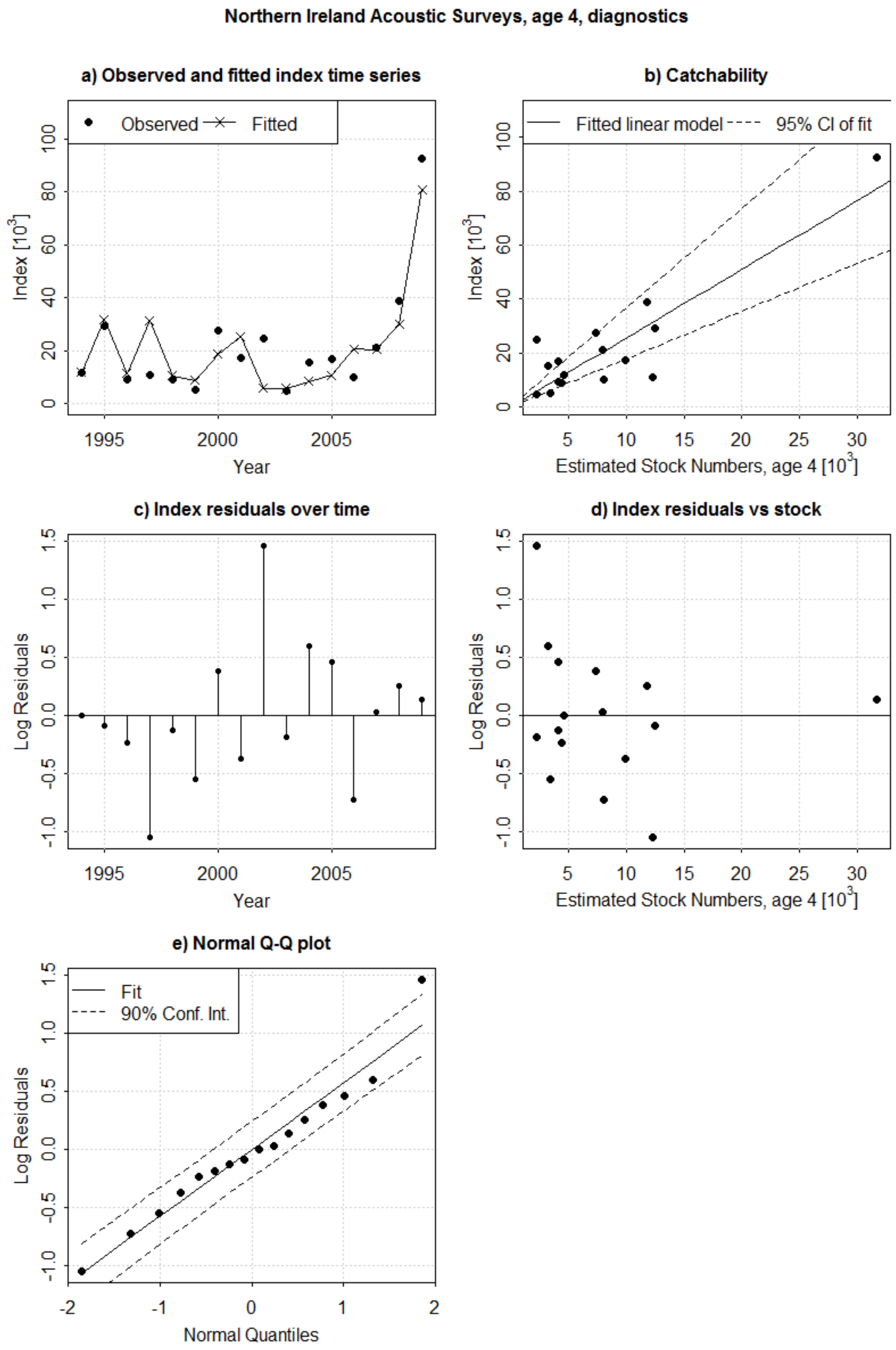


Figure 7.6.16 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

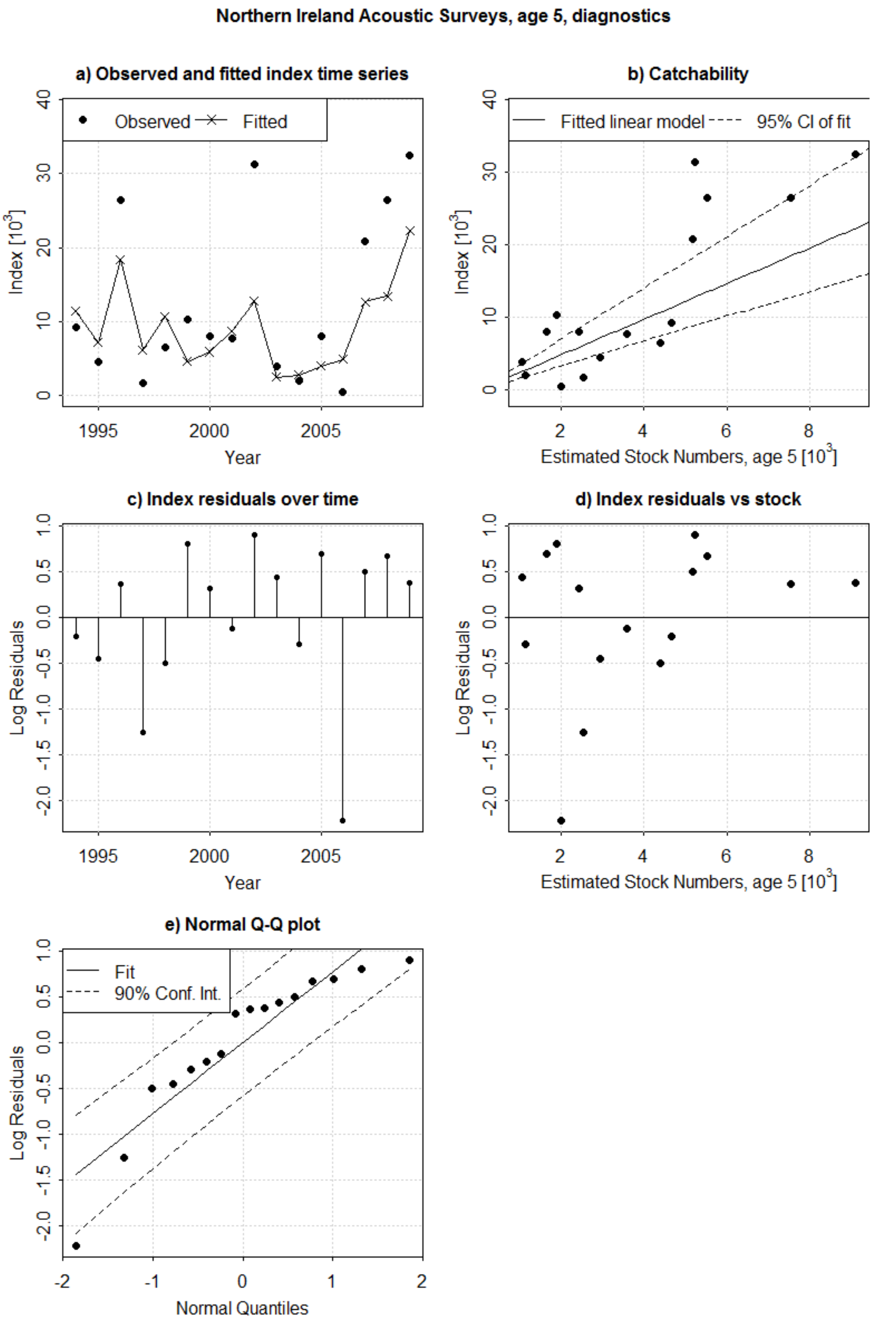


Figure 7.6.17 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

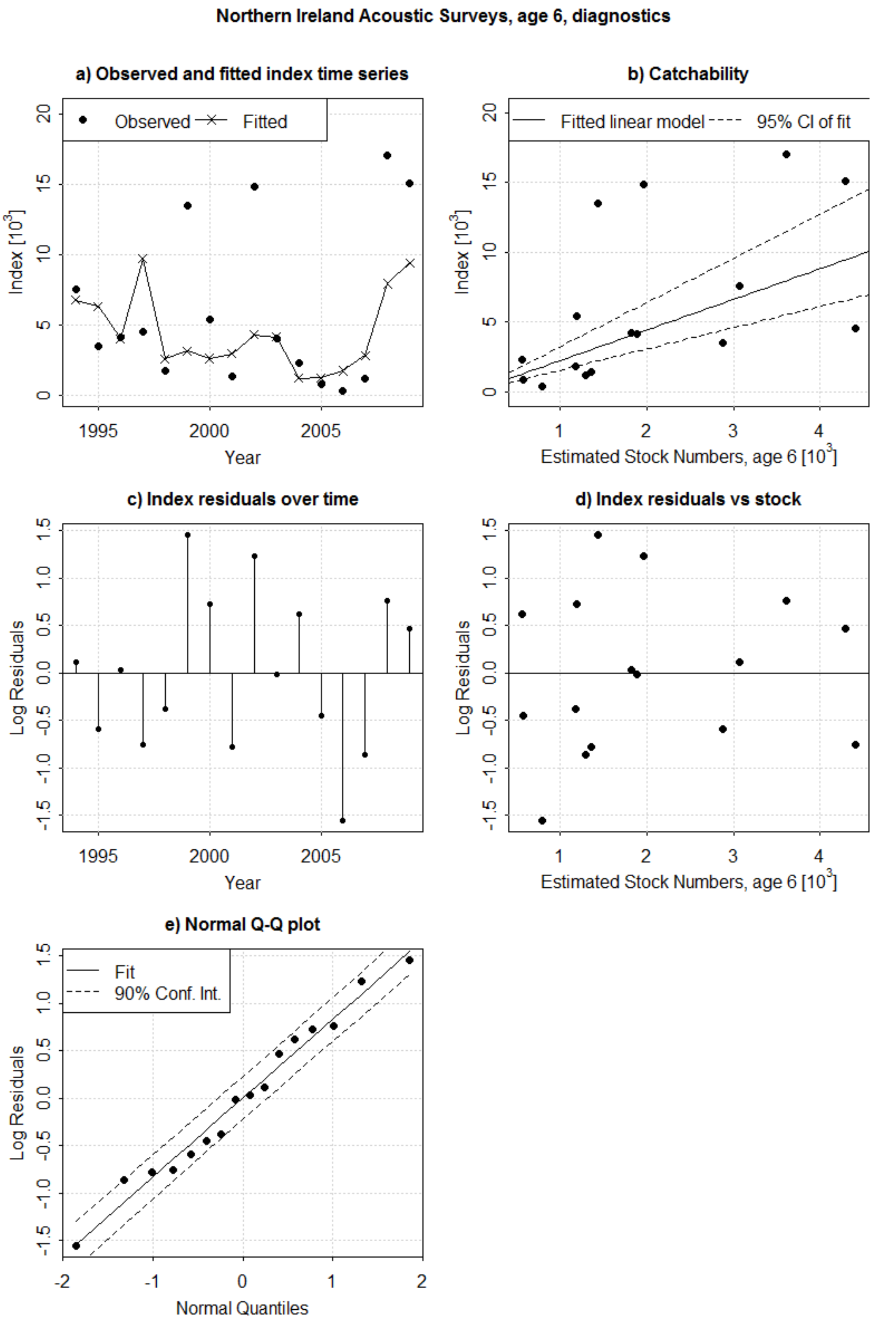


Figure 7.6.18 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residuals of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

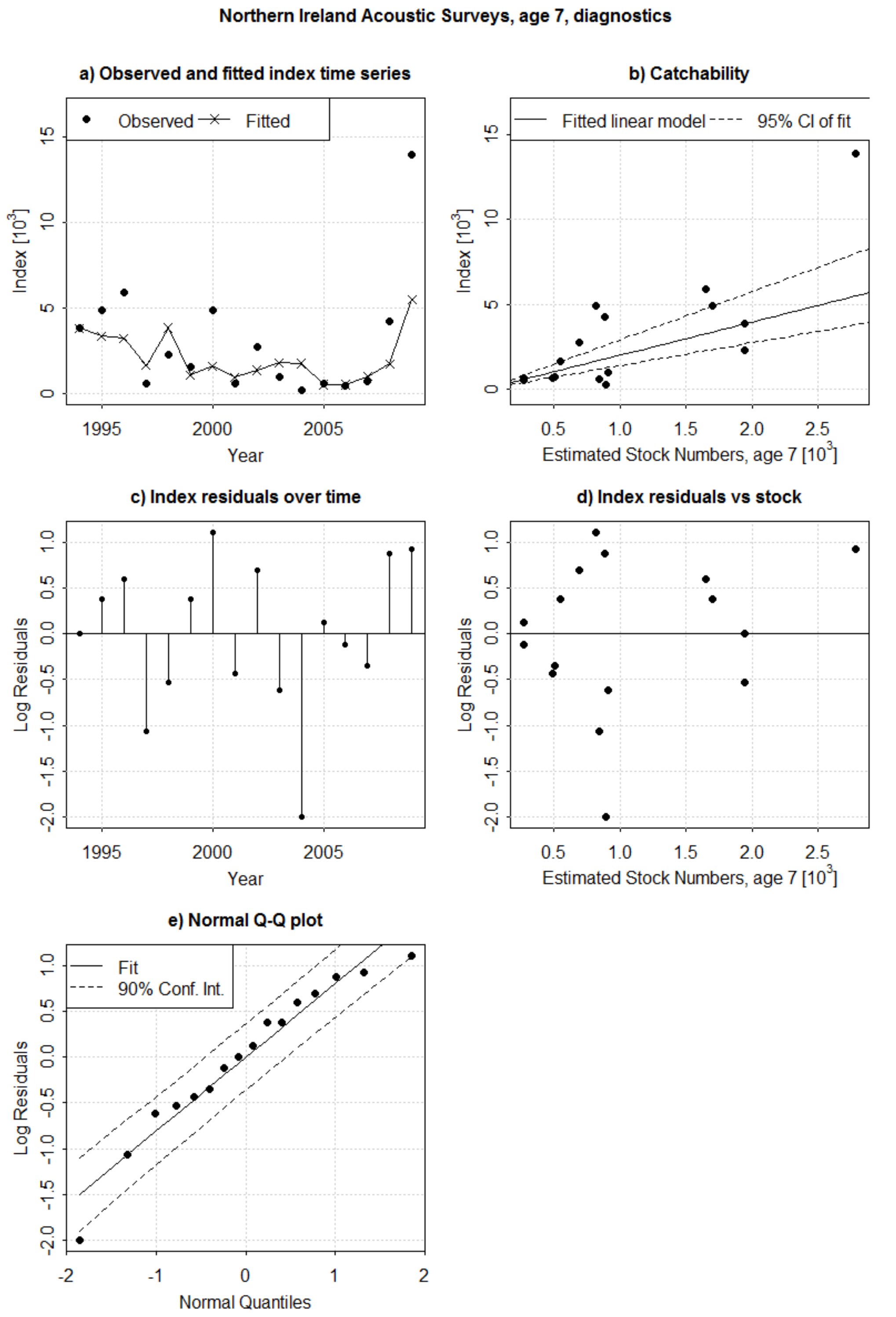


Figure 7.6.19 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residu-als of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

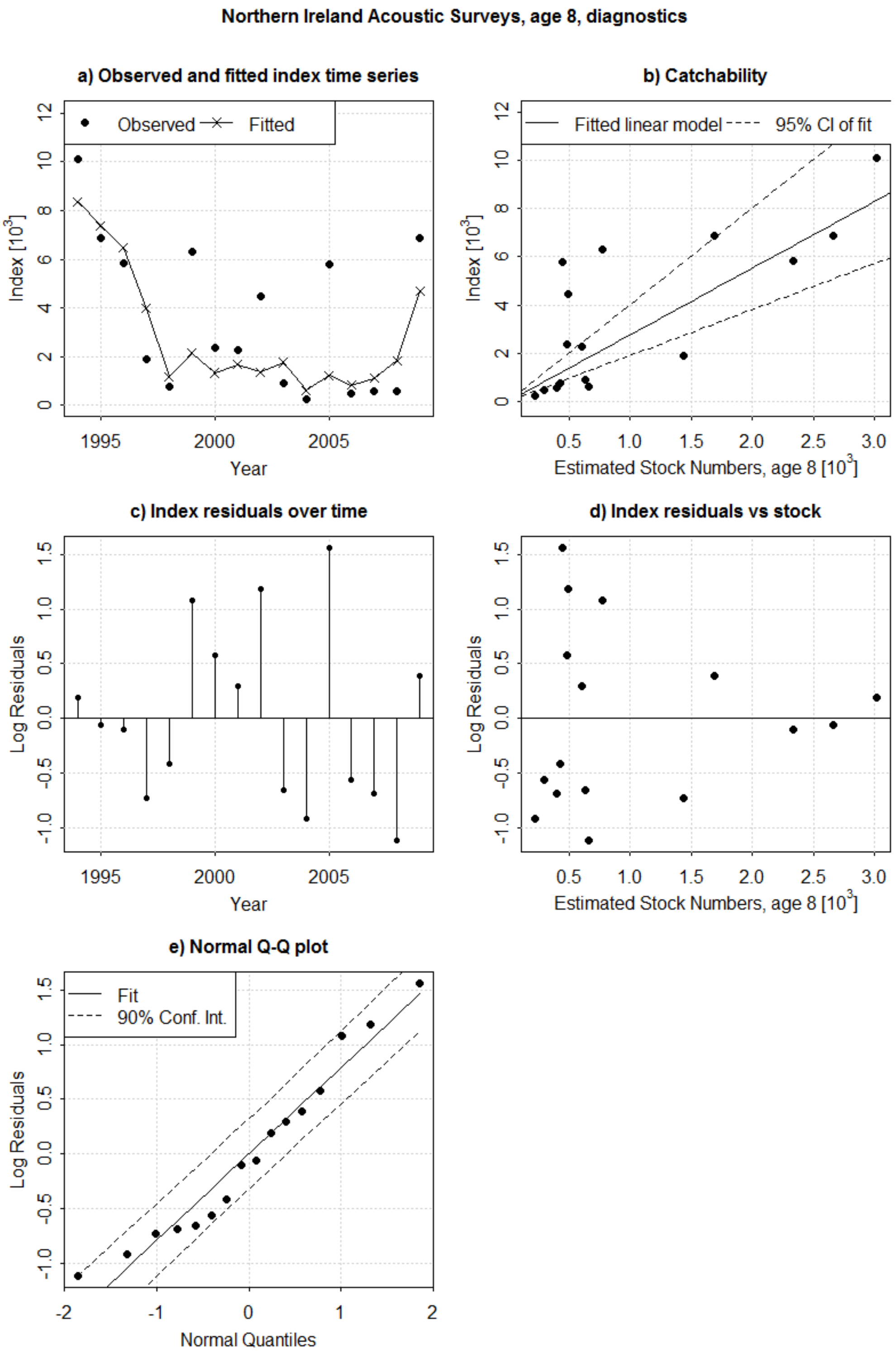


Figure 7.6.20 Irish Sea herring VIIa(N). FLICA run outputs no SSB. Diagnostics of Acoustic survey catchability at age (rings). Top left: VPA estimates of numbers at age (line) and numbers predicted from index abundance at age. Top right: scatterplot of index observations versus VPA estimates of numbers at age with the best-fit catchability model (linear function). Middle right: log residu-als of catchability model by VPA estimate of numbers at age. Middle left: log residuals of catchability model by year. Bottom left: normal Q-Q plot of log residuals.

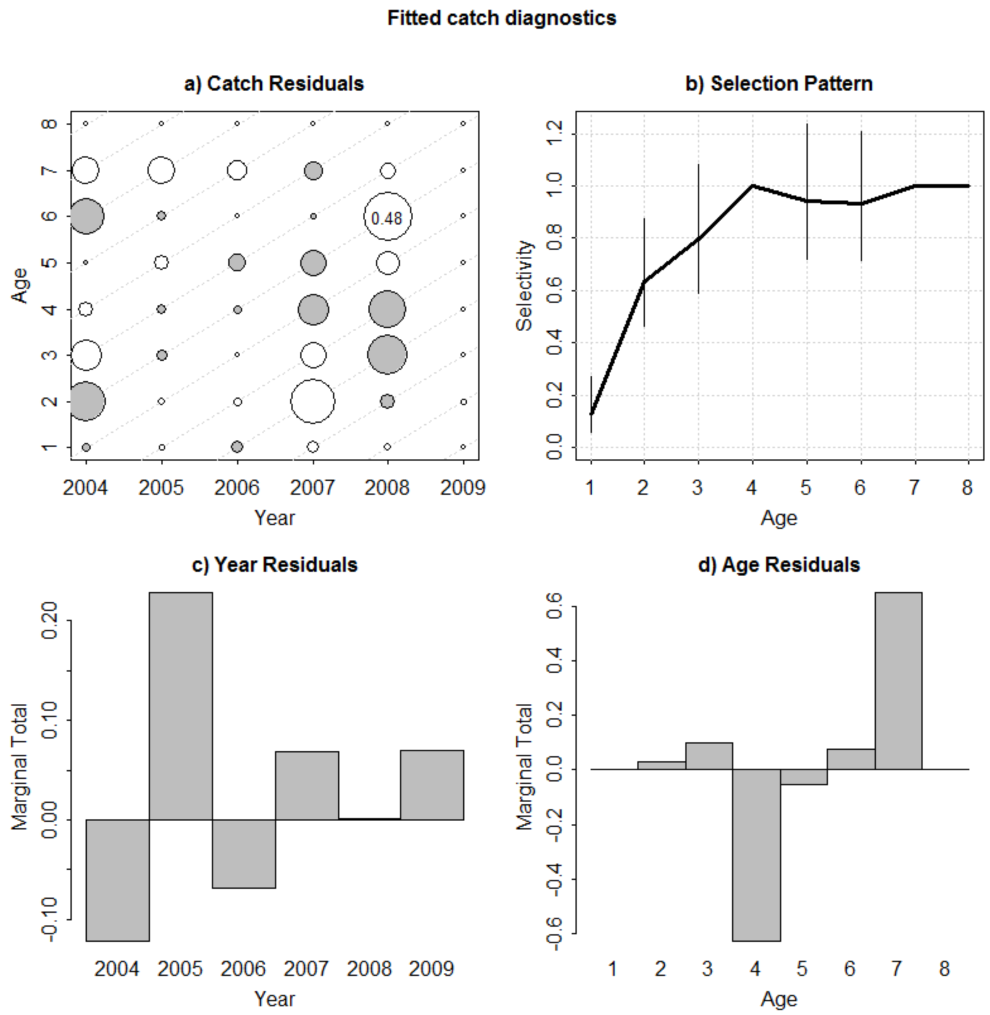


Figure 7.6.21 Irish Sea herring VIIa(N). FLICA run output no SSB. Selection pattern diagnostics from deterministic calculations(6-year separable period). a) catch residuals. b) estimated selection (relative to 4-wr)+/- standard deviation. c) marginal totals of residuals by year and d) ring (ages2-7 only).

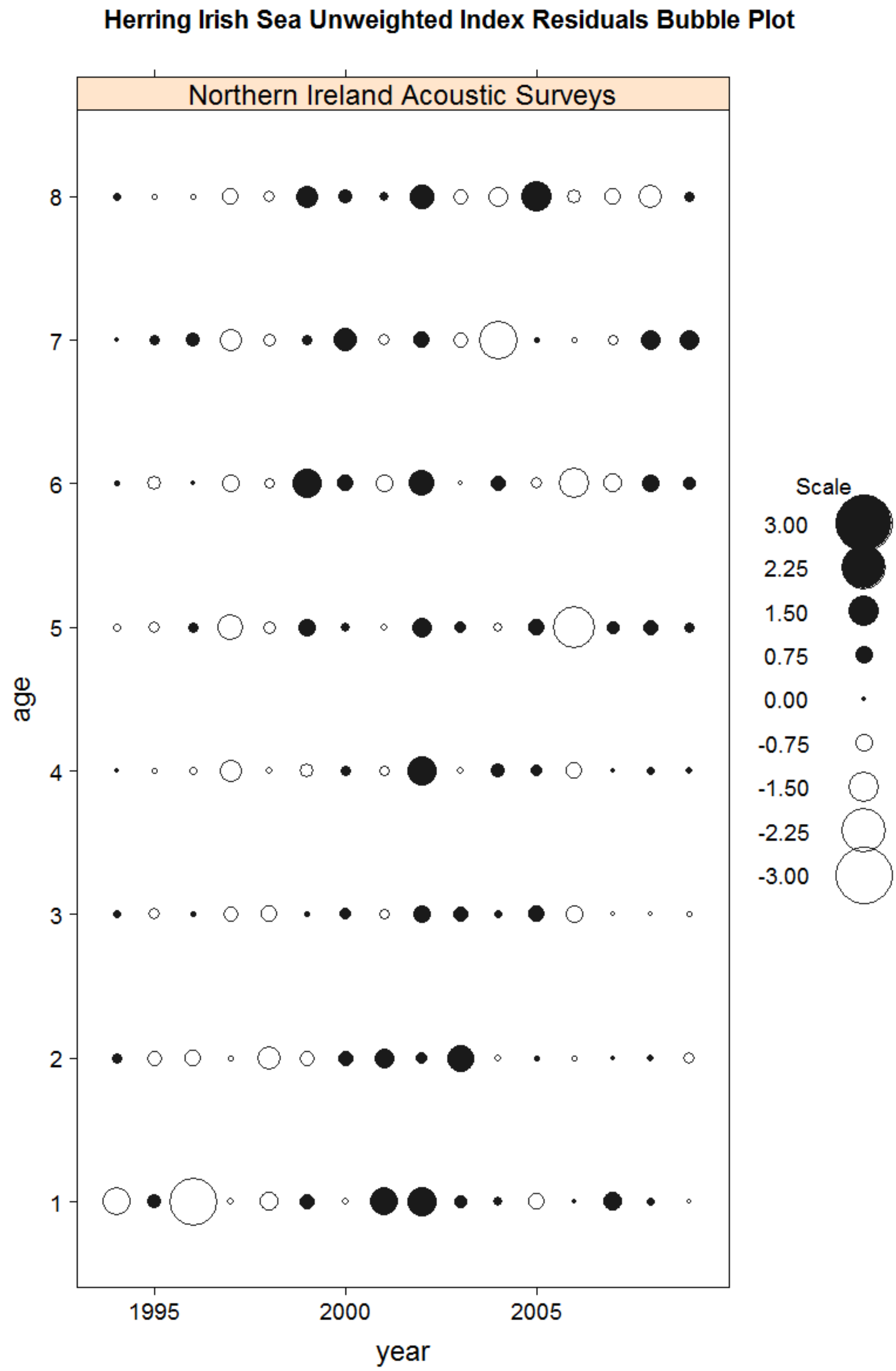


Figure 7.6.22 Irish Sea herring VIIa(N). FLICA run output no SSB. Unweighted residuals of acoustic for the assessment up to 2009.

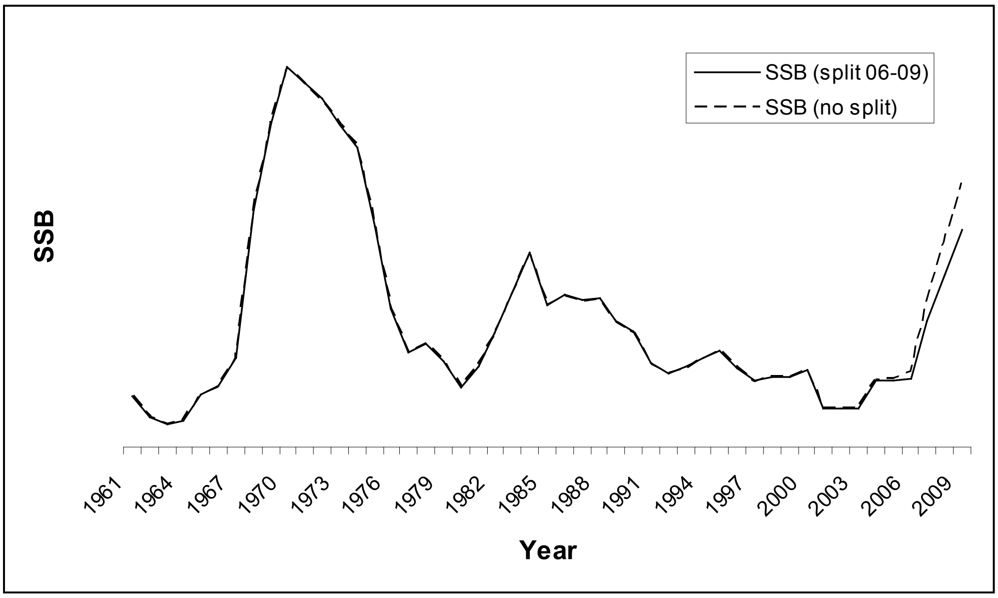


Figure 7.6.23 Irish Sea herring VIIa(N). Comparison plot of FLICA outputs of SSB estimates using split and unadjusted acoustic data.

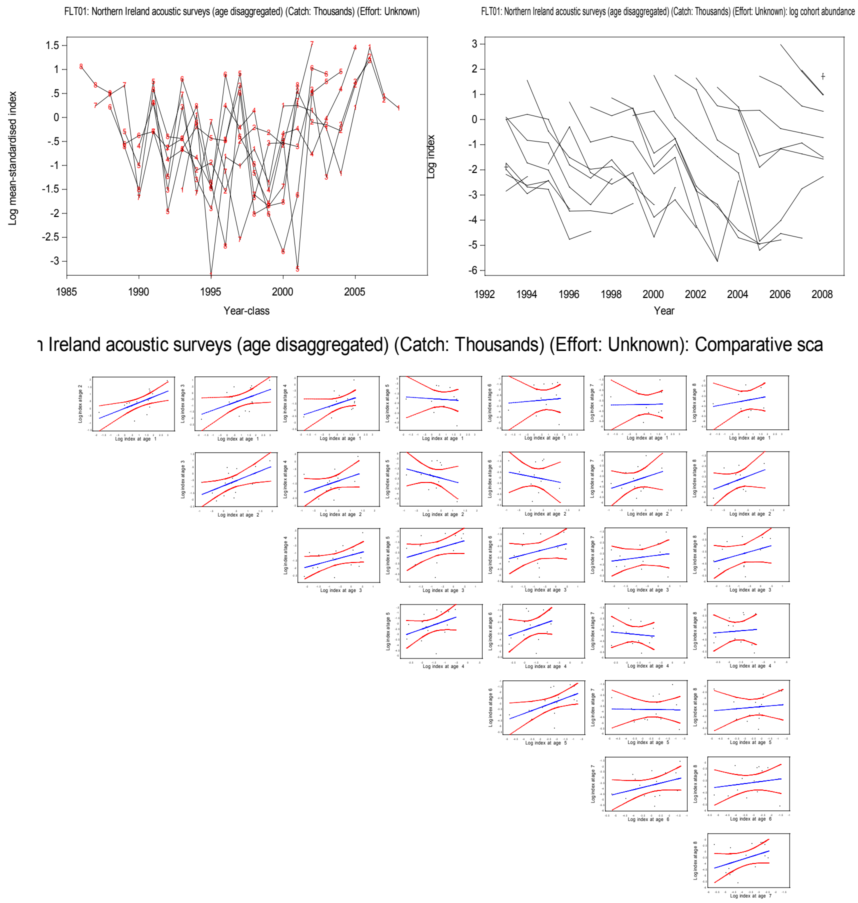


Figure 7.6.24. Irish Sea herring VIIa(N). Output from SURBA (ver. 3.0) plots for the Northern Ireland acoustic survey (ages 1-8+), showing log mean-standardised indices by year class, scatter plots and catch curves.

8 Sprat in the North Sea

8.1 The Fishery

8.1.1 ACFM Advice Applicable to 2009 and 2010

There have never been any explicit management objectives for this stock. The TAC set for 2009 was 170 000 t. For 2009, the by-catch quota of herring (EU fleet) was set at 15 985 t. For 2010 a preliminary TAC of 170 000 t is set and a revised mid-year advice is expected. For 2010, the by-catch quota of herring (EU fleet) was set at 13 587 t.

Catches in 2009

Catch statistics for 1996–2009 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). In 1996 total landings were 137 000 t and have since been in the range of 61 000 t (2008) to 208 000 t (2005). As in previous years sprat from the fjords of western Norway are not included in the catches for the North Sea, due to uncertainties in stock identity. Annual catches of Norwegian fjord sprat have ranged between 400 t (2004) and 3 300 t (1996, 1999) in this period. Total catches for the North Sea in 2009 were 133 000 t. This is more than twice as high as in 2008, but about average for the time series. The Danish catches represent 93% of the total catches. The Norwegian sprat fishery caught 5 800 t of sprat.

The catches by year, quarter, and area show the same picture as last year, with the largest amount taken in IVb and IVc. Only very small catches were landed in the first two quarters in 2009 (Table 8.1.2). Quarterly and annual distribution of catches per rectangle for Subarea IV show a fishery located in the southern North Sea in the first quarter, the central-eastern areas in the second and third quarter and the central North Sea in the last quarter (Figures 8.1.1a-d and Figure 8.1.2).

8.1.2 Regulations and their effects

The Norwegian vessels are not allowed to fish in the Norwegian zone until the quota in the EU-zone has been taken. They are not allowed to fish in the 2nd quarter or July in the EU and the Norwegian zone. There is also a maximum vessel quota of 1 200 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. Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. A decrease in recruitment for the North Sea herring autumn spawners and a probable high incoming sprat year class may potentially result in a fishery for sprat with less by-catch of herring.

8.1.3 Changes in fishing technology and fishing patterns

No major changes in fishing technology and fishing patterns for the sprat fisheries in the North Sea have been reported.

8.2 Biological composition of the catch

Only data on by-catch from the Danish fishery were available to the Working Group (Table 8.2.1). The Danish sprat fishery has recently been conducted with a low by-catch of herring. The total amount of herring caught as by-catch in the sprat fishery has mainly been less than 10% except in 2008 (11%).

The Danish biological sampling from 1996 and onwards is considered reliable due to the changes in the Danish sampling scheme. The estimated quarterly landings at age in numbers for the period are presented in Table 8.2.2. In 2009 the one-year old sprat contributed 92% of the total landings, which is the second highest value since 1996 (2005: 96%, all other years: 18-83%). 2-year olds contributed in 2009 with 4% of the total landings, leaving 3% of the contribution to 0- and 3- year olds.

Mean-weight-at-age (g) in the landings in 2009 was similar to earlier values (Table 8.2.3), except for the 2-year-olds and the 1-year-olds in the 1st quarter. The latter comes from one sample only.

Denmark, Norway and UK-Scotland provided age data of commercial landings in 2009 for quarters 1, 3 and 4 (Table 8.2.4). The small fishery in quarter 2 was unsampled. The sample data were used to raise the landings data from the North Sea. The landings by UK-England and Sweden were minor and unsampled. The sampling level (no. per 1000 t landed) in 2009 was similar to 2008 considering the number of samples (0.4 samples for 2007-2009), number aged (2009: 16, 2008: 16, 2007: 18), and number measured (2009: 41, 2008: 40, 2007: 57). The required sampling level is given in the Stock Annex.

8.3 Fishery Independent Information

8.3.1 IBTS (February)

Sprat of age 1 and 2 were found in the south-east, with the highest concentrations in the more central parts of the distribution area (Figure 8.3.1a-c) and Division IVc (age 2).

8.3.2 Acoustic Survey (HERAS)

The sprat in 2009 was 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). Total abundance was estimated by WGIPS (see section 1.4.2) to be 65 200 million individuals and total biomass 556 000 t, which is an increase by 105% in terms of biomass when compared to last year and the highest estimate of the time series (ICES CM 2010/SSGESST:03). In 2009, as in most recent years, the majority of the stock consists of mature sprat. The estimated strength of the 1-year-olds in 2009 (the 2008 year class) is the second highest in the time series after the 2005 estimate. The sprat stock is dominated by 1- and 2-year old fish representing more than 95% of the biomass.

	Abundance (million)					Biomass (1 000 tonnes)				
Year/Age	0	1	2	3+	sum	0	1	2	3+	sum
2009	0	47,520	16,488	1,183	65,191	0	346	189	21	556
2008	0	17,165	7,410	549	25,125	0	161	101	9	271
2007	0	37,250	5,513	1,869	44,631	0	258	66	29	353
2006*	0	21,862	19,916	760	42,537	0	159	265	12	436
2005*	0	69,798	2,526	350	72,674	0	475	33	6	513
2004*	17,401	28,940	5,312	367	52,019	19	267	73	6	366
2003*	0	25,294	3,983	338	29,615	0	198	61	6	266
2002	0	15,769	3,687	207	19,664	0	167	55	4	226
2001	0	12,639	1,812	110	14,561	0	97	24	2	122
2000	0	11,569	6,407	180	18,156	0	100	92	3	196

***Re-calculated by the means of FishFrame (ICES 2009/LRC:02)**

8.4 Mean weights-at-age and maturity-at-age

Data on maturity by age, mean weight- and length-at-age during the 2009 summer acoustic survey are presented in the WGIPS report (ICES CM 2010/SSGESST:03).

8.5 Recruitment

The IBTS (February) 1-group index (Table 8.3.1) is used as a recruitment index for this stock.

In 2009 the incoming 1-group (2008 year class) was estimated to be the highest for the whole time series, both in absolute and relative terms. This index was dominated by a few large hauls. However, the 2008 year-class also gives the highest estimate of the time series as 2-year-olds (2010 index). In 2010, the incoming 1-group (2009 year class) was estimated to be the 6th highest of the time series.

8.6 Stock Assessment

The last benchmark of this stock was in September 2009 (ICES CM 2009/ACOM:34). The main conclusion was that previously used assessment methods are inappropriate, and that there is no basis for performing a formal assessment of this stock (see section 1.4.6).

There is no analytical assessment of this stock.

However, earlier acoustic surveys have proven to be reliable at estimating sprat abundance (e.g. Irish Sea, Baltic Sea), and also the acoustic survey for the North Sea sprat stock seems promising.

8.6.1 Data Exploration

The time series indices of the IBTS Q1 and Q3 surveys was recalculated following the method described in the stock annex of last year's HAWG report (ICES CM 2009/ACOM:03). The HERAS abundance estimates by statistical rectangle, as provided in the PGHERS/PGIPS/WGIPS reports 2004-2010, was extrapolated to cover unsampled rectangles, and subsequently averaged over the whole area to provide a HERAS index. All three indices were standardised by dividing by the maximum observed value in each time series (see Figure 8.6.1). A presence/absence index based on the same methods, where the value 0 = no sprat and 1 = one or more sprat, was the basis of the calculation of the indices provided in Figure 8.6.2.

Even though the survey indices are highly variable and dominated by few large hauls; visual inspection of the time series does indicate some correlation between the three independent data sources. However this correlation was not significant at a 0.05 level. Further analysis of the survey data may increase the signal-to-noise ratio. Further work should be done e.g. in analysing catchability in IBTS hauls, spatial distribution, and comparisons taking fisheries and natural mortality for the intermediate period into account. Alternative ways of index calculation and accounting for extraordinary large hauls and zero catches in a rigorous statistical method should also be explored.

8.6.2 State of the Stock

No absolute estimates or reliable trends of the North Sea sprat stock can be calculated given the poor data sets.

8.7 Short-term projections

No projections are presented for this stock.

8.8 Reference points

Precautionary reference points have not been defined for this stock and the available information is inadequate to estimate the absolute stock size.

Uncertainties in the survey indices make the current understanding of the dynamics of this stock extremely poor.

8.9 Quality of the assessment

See above.

8.10 Management Considerations

There are no explicit management objectives for this stock.

The sprat stock in the North Sea is dominated by young fish. The stock size is mostly driven by the recruiting year class. Thus, the fishery in a given year will be dependent on that year's incoming year.

In the forecast table for North Sea herring, industrial fisheries are allocated a by-catch of approx 15 200 t of juvenile herring in 2011. It is important to continue monitoring of by-catch of juvenile herring to ensure compliance with this allocation.

Catches in recent years have been well below the advised and agreed TAC and have decreased because of economics and other reasons. 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 as an independent stock. This management approach was tested last year 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. herring, sandeel, Norway pout). The implications of the environmental change for sprat and the influence of the sprat fishery for other fish species and sea birds are at present unknown.

The zooplankton community structure that is sustaining the sprat stocks appears to be changing, and there has been a long-term decrease in total zooplankton abundance in the northern North Sea (Reid *et al*., 2003; Beaugrand, 2003; ICES, 2006). However, sprat is mainly distributed in the southern North Sea where these trends have not been observed (ICES, 2006).

8.12 Changes in the environment

Temperatures in this area have been increasing over the last few decades. It is considered that this may have implications for sprat, although it is not possible to quantify either the magnitude or direction of such changes.

Table 8.1.1. North Sea sprat. Catches (' 000 t) 1996-2009. 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
	Division IVa													
Denmark	0.3			0.7		0.1	1.1		*		*	0.8	*	*
Norway														*
Sweden						0.1								
Total				0.7		0.2	1.1		*		*	0.8	*	*
	Division Ivb													
Denmark	76.5	93.1	119.3	160.3	162.9	143.9	126.1	152.9	175.9	204.0	79.5	55.5	51.4	115.6
Norway	52.8	3.1	15.3	13.1	0.9	5.9	*		0.1		0.8	3.7	1.3	4.0
Sweden	0.5		1.7	2.1		1.4				*				0.3
UK(Engl.&Wales)														*
UK(Scotland)				1.4								0.1		2.5
Total		96.2	136.3	176.9	163.8	151.2	126.1	152.9	176.0	204.1	80.3	59.3	52.7	122.4
	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
Netherlands				0.2										
Norway		0.1	16.0	5.7	1.8	3.6					9.0	2.9		1.8
Sweden														0.6
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*
UK(Scotland)													0.2	
Total		7.2	28.0	10.8	32.0	18.7	16.4	23.6	18.3	3.6	33.4	23.8	8.4	10.6
	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
Netherlands				0.2										
Norway	52.8	3.2	31.3	18.8	2.7	9.5	*		0.1		9.8	6.7	1.3	5.8
Sweden	0.5		1.7	2.1		1.5				*				0.9
UK(Engl.&Wales)	2.6	1.4	0.2	1.6	2.0	2.0	1.6	1.3	1.5	1.6	0.5	0.3	*	*
UK(Scotland)				1.4								0.1	0.2	2.5
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

* < 50 t

Table 8.1.2. North Sea sprat. Catches (tonnes) by quarter. Catches in fjords of Western Norway excluded. Data for 1996-1999 in ICES CM 2007/ACFM:1' The IVb catches for 2000-2007 divided by IVbW and IVE can be found in ICES CM 2008/ACOM:02.

Year	Quarter	Area				Total
		IVaW	IVaE	IVb	IVc	
2000	1			18 126	28 063	46 189
	2			1 722	45	1 767
	3			131 306	1 216	132 522
	4			12 680	2 718	15 398
	Total			163 834	32 042	195 876
2001	1	115		40 903	9 716	50 734
	2			1 071		1 071
	3			44 174	481	44 655
	4	79		65 102	8 538	73 719
	Total	194		151 249	18 735	170 177
2002	1	1 136		2 182	2 790	6 108
	2			435	93	528
	3			70 504	647	71 151
	4			52 942	12 911	65 853
	Total	1 136		126 063	16 441	143 640
2003	1			11 458	7 727	19 185
	2			625	26	652
	3			56 207	165	56 372
	4			84 629	15 651	100 280
	Total			152 919	23 570	176 489
2004	1			827	1 831	2 657
	2	7		260	16	283
	3			54 161	496	54 657
	4			120 685	15 937	136 622
	Total	7		175 932	18 280	194 219
2005	1			11 538	2 457	13 995
	2			2 515	123	2 638
	3			107 530		107 530
	4			82 474	1 033	83 507
	Total			204 057	3 613	207 670
2006	1	25	22	13 713	33 534	47 294
	2			190	8	198
	3			40 051	8	40 059
	4	2		26 579	77	26 658
	Total	27	22	80 533	33 627	114 209
2007	1			582	247	829
	2			241	3	244
	3			16 603		16 603
	4	769		41 850	23 531	66 150
	Total	769		59 276	23 781	83 826
2008	1			2 872	43	2 915
	2			52	*	52
	3			21 787		21 787
	4			27 994	8 334	36 329
	Total			52 706	8 377	61 083
2009	1			36	1 268	1 304
	2			2 526	1	2 527
	3		22	41 513		41 535
	4			78 373	9 336	87 709
	Total		22	122 448	10 604	133 075

* < 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 1998-2009.

	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
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

Table 8.2.2 North Sea sprat. Catch in numbers (millions) by quarter and by age 1996-2009.

Year	Quarter	Age						
		0	1	2	3	4	5+	Total
1996	1		524.7	4 615.4	2 621.9	316.4	11.3	8 090
	2		1.9	241.5	32.7	15.5	0.3	292
	3		400.5	100.7	22.9	0.3		524
	4		1 190.7	1 069.0	339.6	5.6		2 605
	Total		2 117.8	6 026.6	3 017.1	337.8	11.6	11 511
1997	1		74.4	314.0	229.2	55.3	2.5	675
	2		11.3	47.8	34.9	8.4	0.4	103
	3		1 991.9					1 992
	4	127.6	3 597.2	996.2	117.8	58.1		4 897
	Total	127.6	5 674.8	1 358.1	381.9	121.8	2.8	7 667
1998	1		683.2	537.2	18.3	0.1		1 239
	2		70.9	55.3	1.8			128
	3	74.2	3 356.6	693.3				4 124
	4	772.4	4 822.4	2 295.1	483.5	39.5		8 413
	Total	846.6	8 933.1	3 580.9	503.6	39.6		13 904
1999	1		728.1	2 226.0	554.2	86.6	9.2	3 604
	2		38.6	58.4	18.1	2.6		118
	3		12 919.0	38.9				12 958
	4	105.0	2 143.2	211.5				2 460
	Total	105.0	15 828.9	2 534.8	572.3	89.2	9.2	19 139
2000	1		559.2	3 177.3	797.5	247.5	72.0	4 854
	2		6.8	107.4	60.1	12.8	0.5	188
	3		9 928.9	1 111.9	77.8			11 119
	4		1 153.7	129.2	9.0			1 292
	Total		11 648.7	4 525.8	944.4	260.3	72.6	17 452
2001	1		746.3	3 197.7	1 321.9	22.2		5 288
	2		15.9	66.2	26.1			108
	3	0.4	3 338.8	299.9				3 639
	4	1 205.0	4 178.7	1 224.6	261.9			6 870
	Total	1 205.4	8 279.8	4 788.4	1 609.9	22.2		15 906
2002	1		104.7	400.3	30.2	11.2		546
	2		13.7	27.9	2.4	0.6		45
	3	40.9	5 745.6	582.1	42.3	4.1		6 415
	4	415.0	4 578.0	626.2	119.8	3.1		5 742
	Total	455.9	10 441.9	1 636.5	194.8	19.0		12 748
2003	1		1 953.9	1 218.9	85.3	11.3		3 269
	2		41.8	46.3	4.7	0.6		93
	3	1.1	3 481.3	772.0	42.9			4 297
	4	539.3	7 051.8	1 115.1	93.8	36.5	21.9	8 858
	Total	540.4	12 528.7	3 152.3	226.6	48.4	21.9	16 518
2004	1		16.5	214.0	26.3	1.6	0.6	259
	2		22.1	14.9	3.0	0.1		40
	3	210.0	3 661.9	558.2	31.4			4 462
	4	15 674.4	5 582.8	632.1	59.2			21 949
	Total	15 884.4	9 283.2	1 419.2	119.8	1.8	0.6	26 709
2005	1		2 476.5	268.5	13.8	2.2		2 761
	2		499.6	23.4	4.3	4.9		532
	3		11 920.2	192.3	7.6			12 120
	4	302.5	7 467.9	191.1				7 962
	Total	302.5	22 364.3	675.3	25.7	7.0		23 375
2006	1		1 559.2	5 119.1	95.7	2.3		6 776
	2		5.8	21.5	0.2			27
	3		3 077.8	625.0	129.1			3 832
	4		2 048.5	416.0	85.9			2 550
	Total		6 691.2	6 181.6	310.8	2.3		13 186
2007	1		12.1	57.4	17.3			87
	2		3.9	18.5	5.6			28
	3		1 025.3	194.5	17.7	25.3		1 263
	4	858.6	4 047.6	1 066.0	150.9			6 123
	Total	858.6	5 088.8	1 336.5	191.4	25.3		7 501
2008	1		356.0	170.9	8.4	1.0		536
	2		7.8	2.7	0.1			11
	3	1.7	444.3	1 225.8	189.9	29.3		1 891
	4	486.3	1 812.5	1 032.8	147.5	13.9		3 493
	Total	488.0	2 620.5	2 432.2	345.9	44.2		5 931
2009	1		886.6					887
	2	0.5	252.8	12.7	1.3			267
	3	2.9	4 160.0	210.4	21.6			4 395
	4	415.5	8 259.0	413.0	44.8			9 132
	Total	418.9	13 558.4	636.1	67.6			14 681

Table 8.2.3 North Sea sprat. Mean w eight (g) by quarter and by age for 1996 - 2009.
** Any inconsistencies in total catches and SOP are due to rounding errors.
* These w eights come from allocation of quarter 3 samples

Year	Quarter	Age						SOP*
		0	1	2	3	4	5+	Tonnes
1996	1		3.9	9.3	14.9	15.3	16.1	88 807
	2		6.9	8.4	11.6	20.0	15.2	2 735
	3		11.6	14.2	18.2	21.5		6 501
	4		12.1	15.9	17.2	20.5		37 359
Weighted mean			10.0	10.5	15.1	15.6	16.0	135 401
1997	1		8.0	10.0	15.0	17.0	19.0	8 161
	2		8.0	10.0	15.0	17.0	19.0	1 243
	3		14.2					28 285
	4	3.7	11.9	16.4	19.1	19.6		63 083
Weighted mean		3.7	12.7	14.7	16.3	18.2	19.0	100 772
1998	1		5.6	6.0	8.7	15.0		7 232
	2		5.6	6.0	8.3			743
	3	3.7	14.7	15.3				60 149
	4	4.1	10.6	13.8	16.3	14.6		94 173
Weighted mean		4.0	11.7	12.8	16.0	14.7		162 297
1999	1		3.3	8.7	12.5	14.4	16.3	30 168
	2		3.1	10.1	13.6	15.4		993
	3		10.0	18.3				129 383
	4	4.4	11.0	14.4				27 126
Weighted mean		4.4	9.8	9.4	12.5	14.4	16.3	187 670
2000	1		4.2	10.1	10.7	10.2	10.5	46 192
	2		3.3	9.0	10.2	12.8	10.5	1 767
	3		11.9	11.9	11.0			132 563
	4		11.9	11.9	11.0			15 403
Weighted mean			11.6	10.6	10.7	10.3	10.5	195 925
2001	1		3.3	9.7	12.9	16.5		50 794
	2		3.3	10.3	12.9			1 071
	3	4.0	12.0	15.3				44 656
	4	3.8	11.6	12.6	19.1			73 444
Weighted mean		3.8	11.0	10.8	13.9	16.5		169 965
2002	1		7.0	12.0	14.0	13.0		6 106
	2		5.3	11.2	12.5	12.4		423
	3	2.0	10.9	15.0	15.0	24.0		72 173
	4	3.9	12.0	15.0	15.7	24.0		67 902
Weighted mean		3.7	11.2	13.4	14.9	14.8		146 604
2003	1		3.6	9.4	11.0	15.0		19 599
	2		3.1	9.9	11.0	15.0		648
	3	3.0	13.0	16.0	13.0			58 169
	4	4.6	10.8	14.8	16.9	15.0	18.0	97 670
Weighted mean		4.6	10.3	12.9	13.8	15.0	18.0	176 085
2004	1		3.6	10.3	13.8	16.6	16.1	2 663
	2		6.0	8.5	7.3	10.2		282
	3	4.5	11.9	17.0	20.0			54 639
	4	4.0	11.4	14.6	18.3			136 653
Weighted mean		4.0	11.0	10.9	14.5	16.8	16.1	194 238
2005	1		4.6	8.9	12.1	16.0		13 995
	2		4.8	6.5	9.8	10.0		2 641
	3		8.9	9.9	18.6			107 531
	4	4.1	10.7	12.0				83 515
Weighted mean		4.1	8.9	10.0	13.6	11.8		207 682
2006	1		4.3	7.7	9.6	13.0		47 293
	2		3.7	8.1	11.2			198
	3		9.8	12.5	16.1			40 053
	4		9.8	12.5	16.1			26 658
Weighted mean			8.5	8.5	14.1	13.0		114 202
2007	1		4.0	9.0	12.0			829
	2		4.0	9.0	12.0			244
	3		12.0	17.0	13.0	17.0		16 603
	4	5.1	10.9	13.5	16.3			66 150
Weighted mean		5.1	11.1	13.8	15.5	17.0		83 826
2008	1		4.2	7.8	10.3	10.0		2 930
	2		3.9	7.5	8.7			52
	3	2.0	11.1	11.4	12.9	14.6		21 759
	4	3.7	10.4	13.1	13.8	14.0		36 362
Weighted mean		3.7	9.6	11.9	13.2	14.3		61 102
2009	1		1.5					1 330
	2**	3.9	9.2	14.1	15.7			2 531
	3	3.9	9.2	14.1	15.7			41 628
	4	3.9	9.7	14.0	14.0			88 005
Weighted mean		3.9	9.0	14.0	14.5			133 494

Table 8.2.4. **North Sea sprat.** Sampling for biological parameters in 2009.

Country	Quarter	Landings ('000 tonnes)	No. samples	No. measured	No. aged
Denmark	1	1.257	1	136	50
	2	2.499			
	3	41.533	32	2922	1115
	4	78.485	17	1839	739
	Total	123.774	50	4897	1904
UK (England & Wales)	1	0.047			
	2	0.001			
	3				
	4	0.002			
	Total	0.049			
UK (Scotland)	1				
	2	*			
	3				
	4	2.549	1	142	34
	Total	2.549	1	142	34
Norway	1				
	2	0.026			
	3	0.001			
	4	5.803	3	400	150
	Total	5.830	3	400	150
Sweden	1				
	2				
	3				
	4	0.870			
	Total	0.870			
All countries	1	1.304	1	136	50
	2	2.526	0	0	0
	3	41.534	32	2922	1115
	4	87.709	21	2381	923
Total North Sea		133.072	54	5439	2088

* < 1 t

Table 8.3.1. North Sea sprat. Abundance indices by age from IBTS (February) from 1984-2010. * 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*	2 006.97	1 852.49	133.94	30.38	1.14	4 024.92

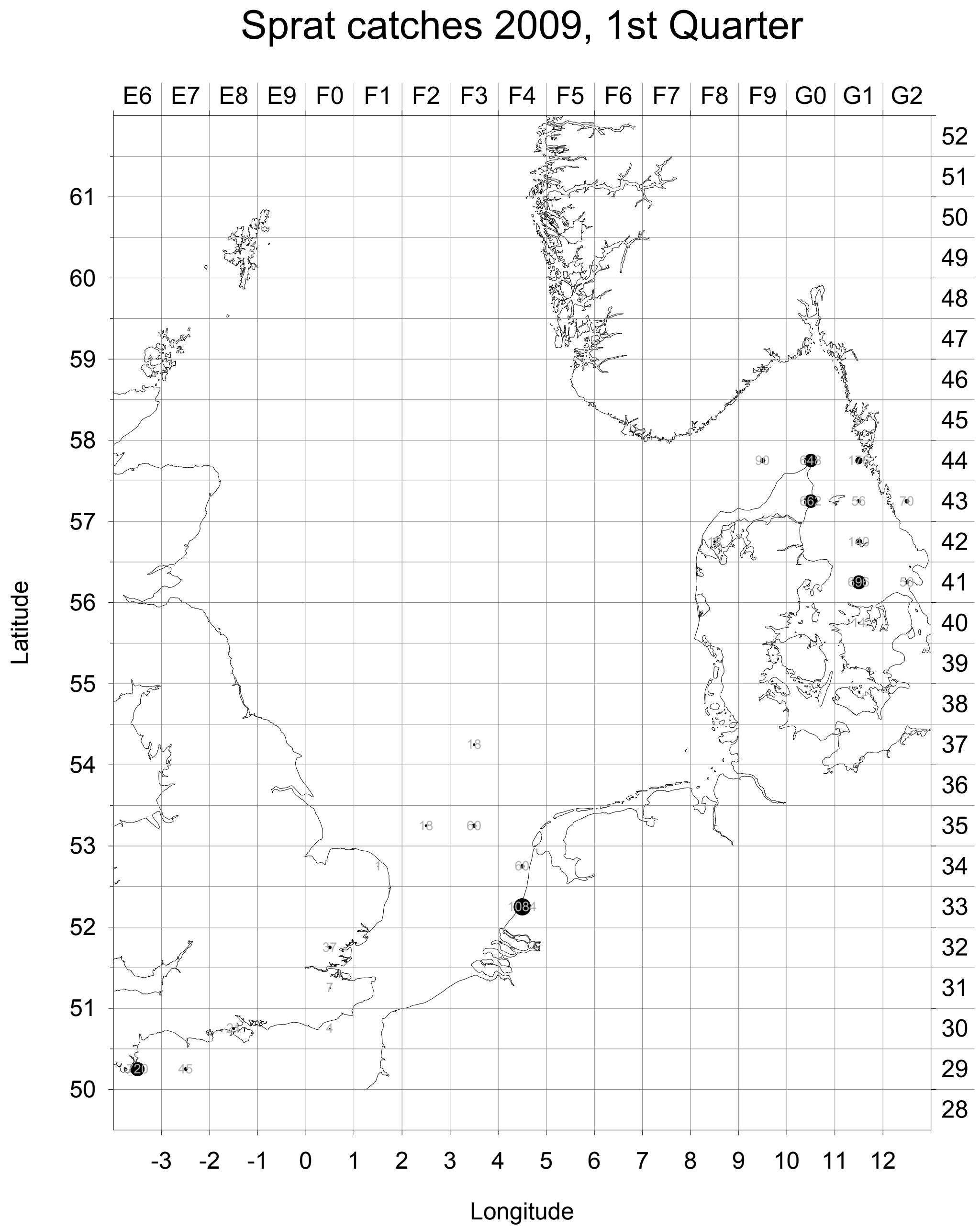


Figure 8.1.1a Sprat catches in the North Sea and Div. IIIa (in tonnes) in the first quarter of 2009 by statistical rectangle.

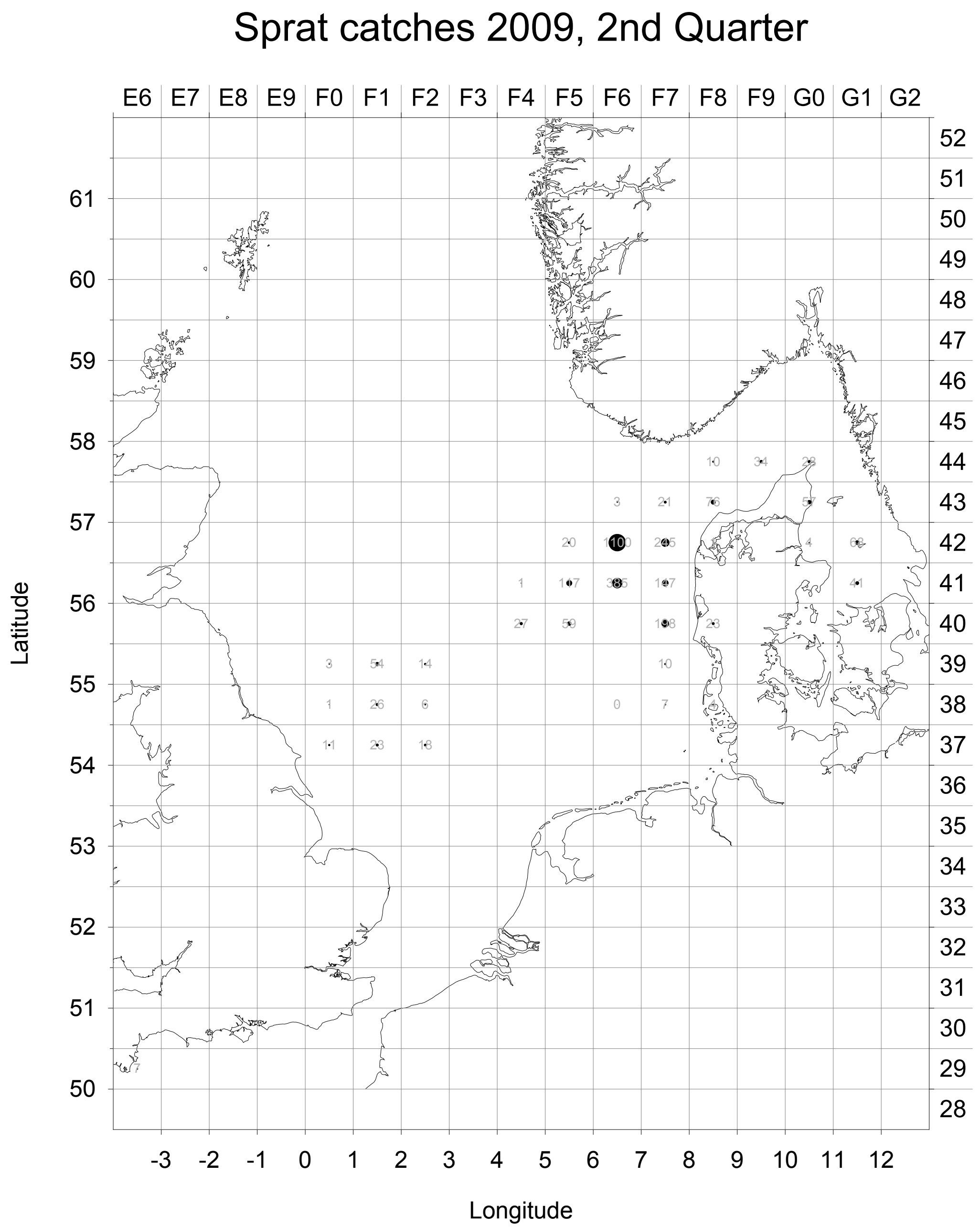


Figure 8.1.1b Sprat catches in the North Sea and Div. IIIa (in tonnes) in the second quarter of 2009 by statistical rectangle.

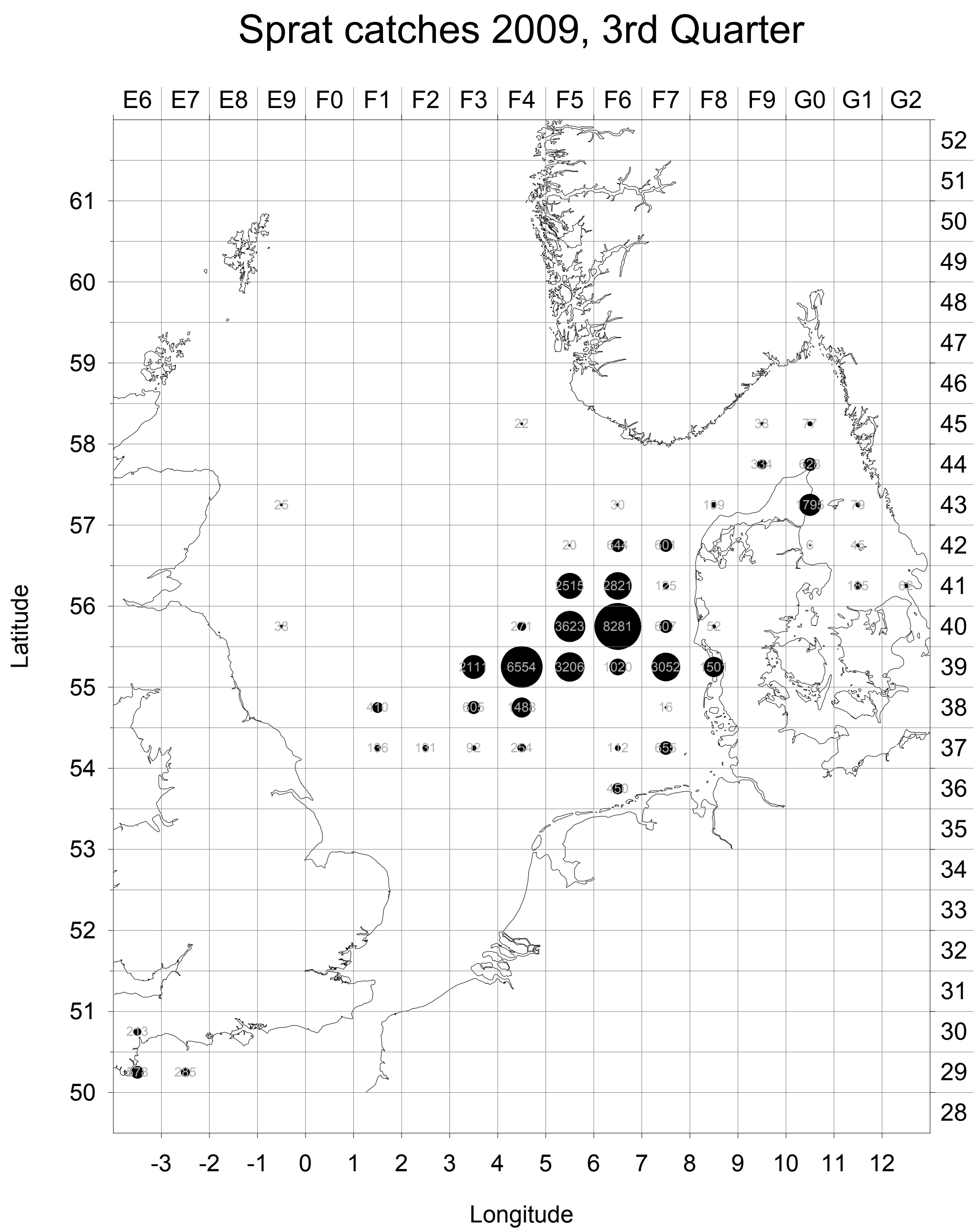


Figure 8.1.1c **Sprat catches in the North Sea and Div. IIIa (in tonnes) in the third quarter of 2009 by statistical rectangle.**

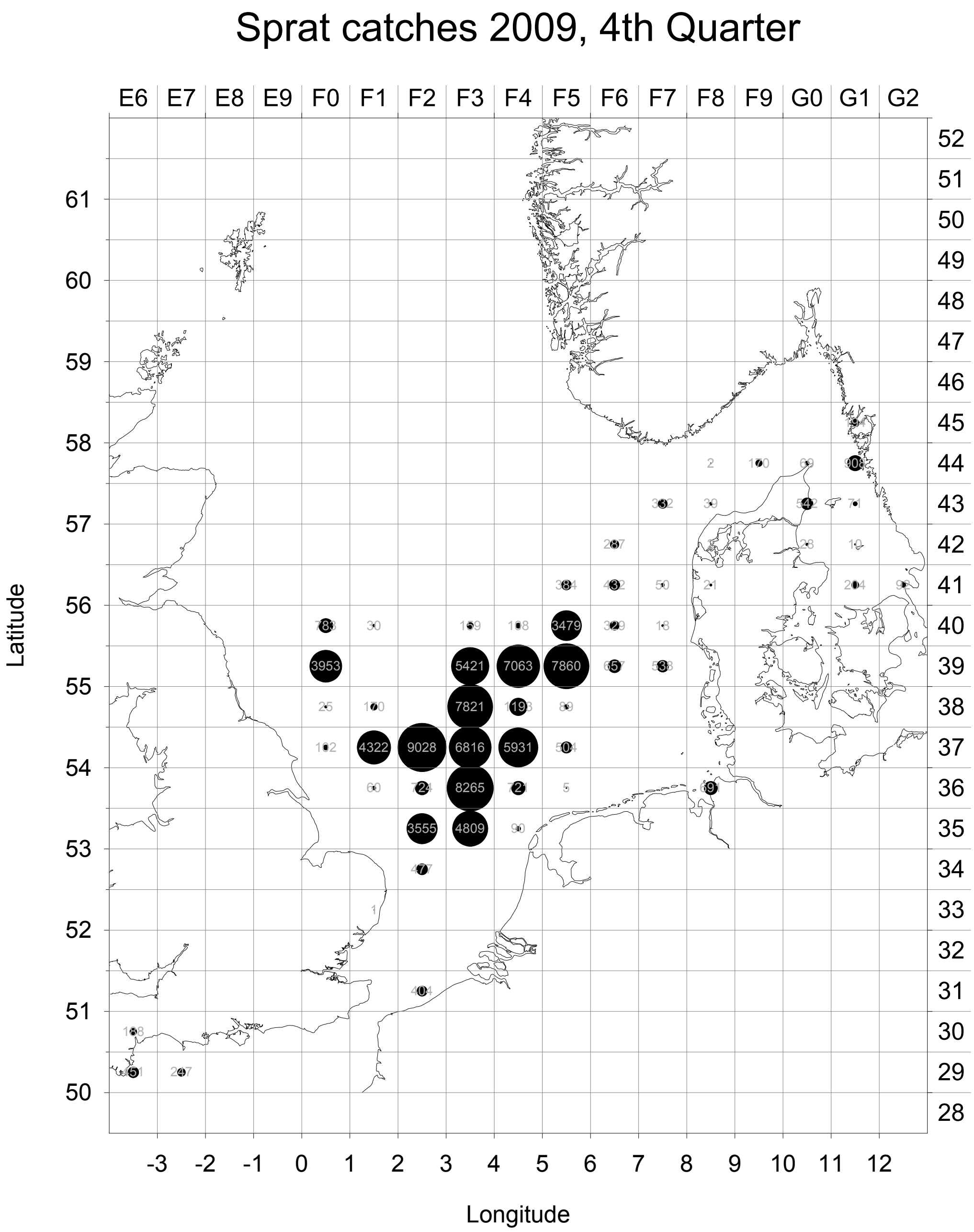


Figure 8.1.1d Sprat catches in the North Sea and Div. IIIa (in tonnes) in the fourth quarter of (in tonnes) in 2009 by statistical rectangle.

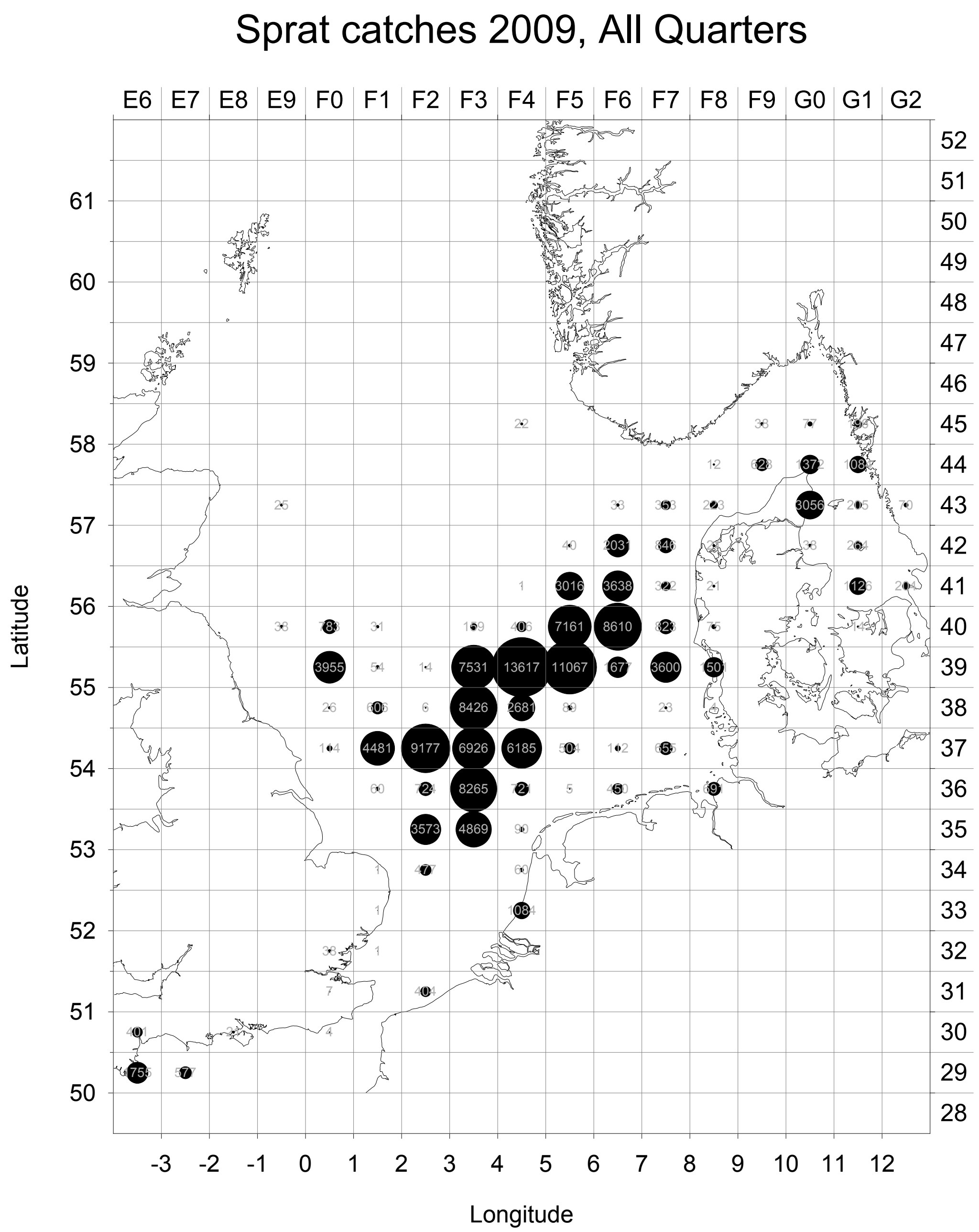


Figure 8.1.2 Sprat catches in the North Sea and Div. IIIa (in tonnes) in 2009 by statistical rectangle.

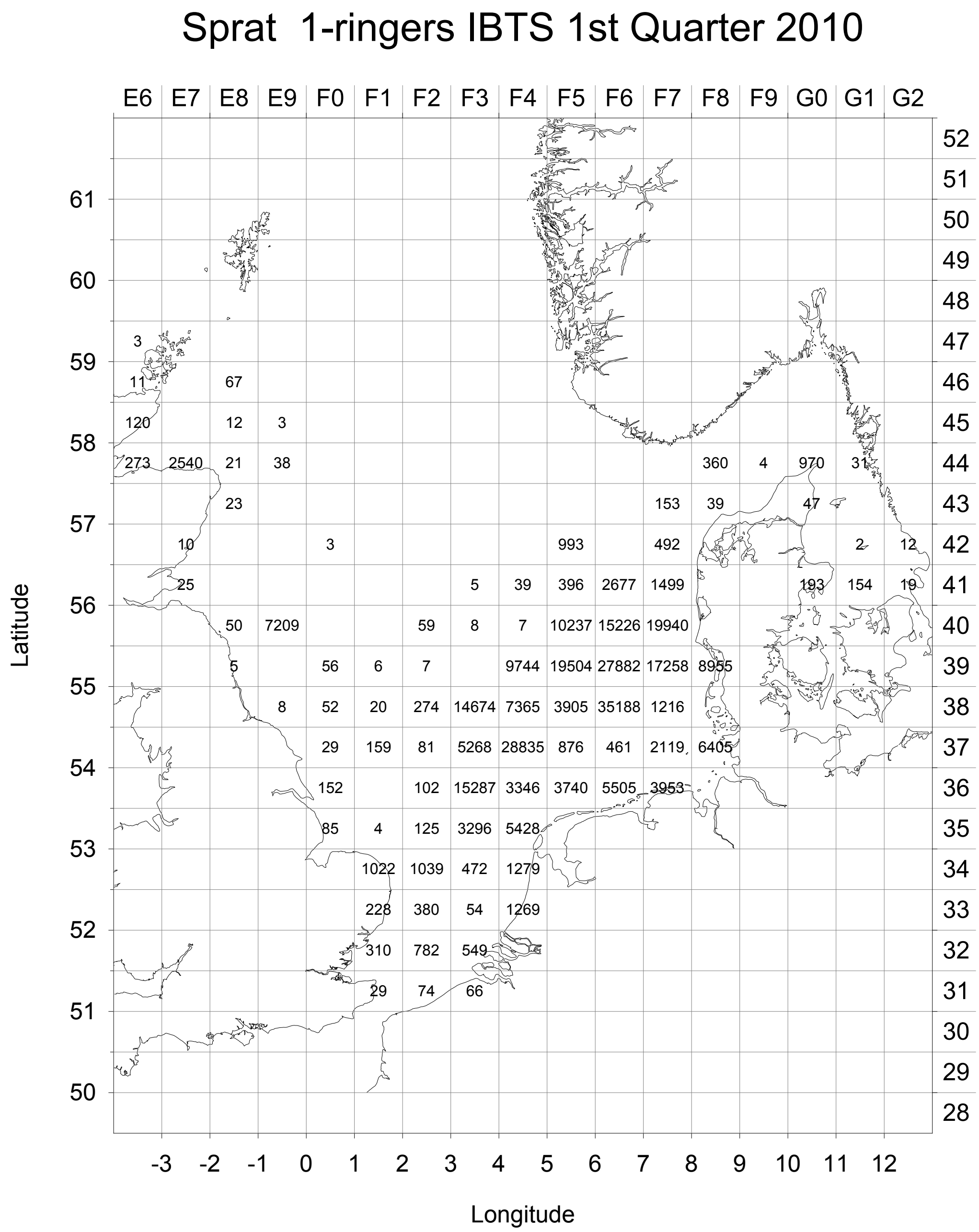


Figure 8.3.1a **Distribution of 1-ringers in the IBTS (February) 2010 in the North Sea and Division IIIa (Mean number per hour per rectangle).**

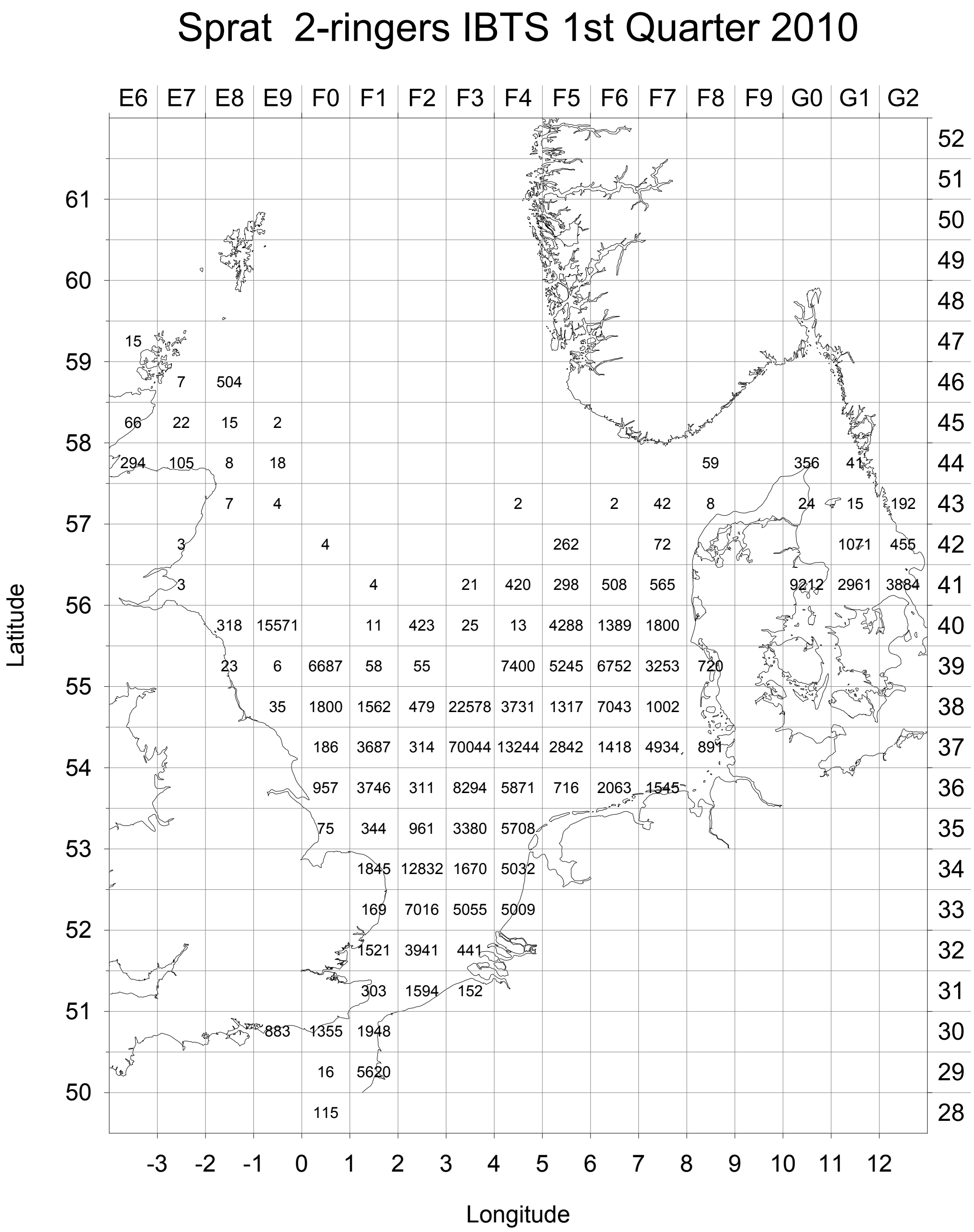


Figure 8.3.1b Distribution of 2-ringers in the IBTS (February) 2010 in the North Sea and Division IIIa (Mean number per hour per rectangle).

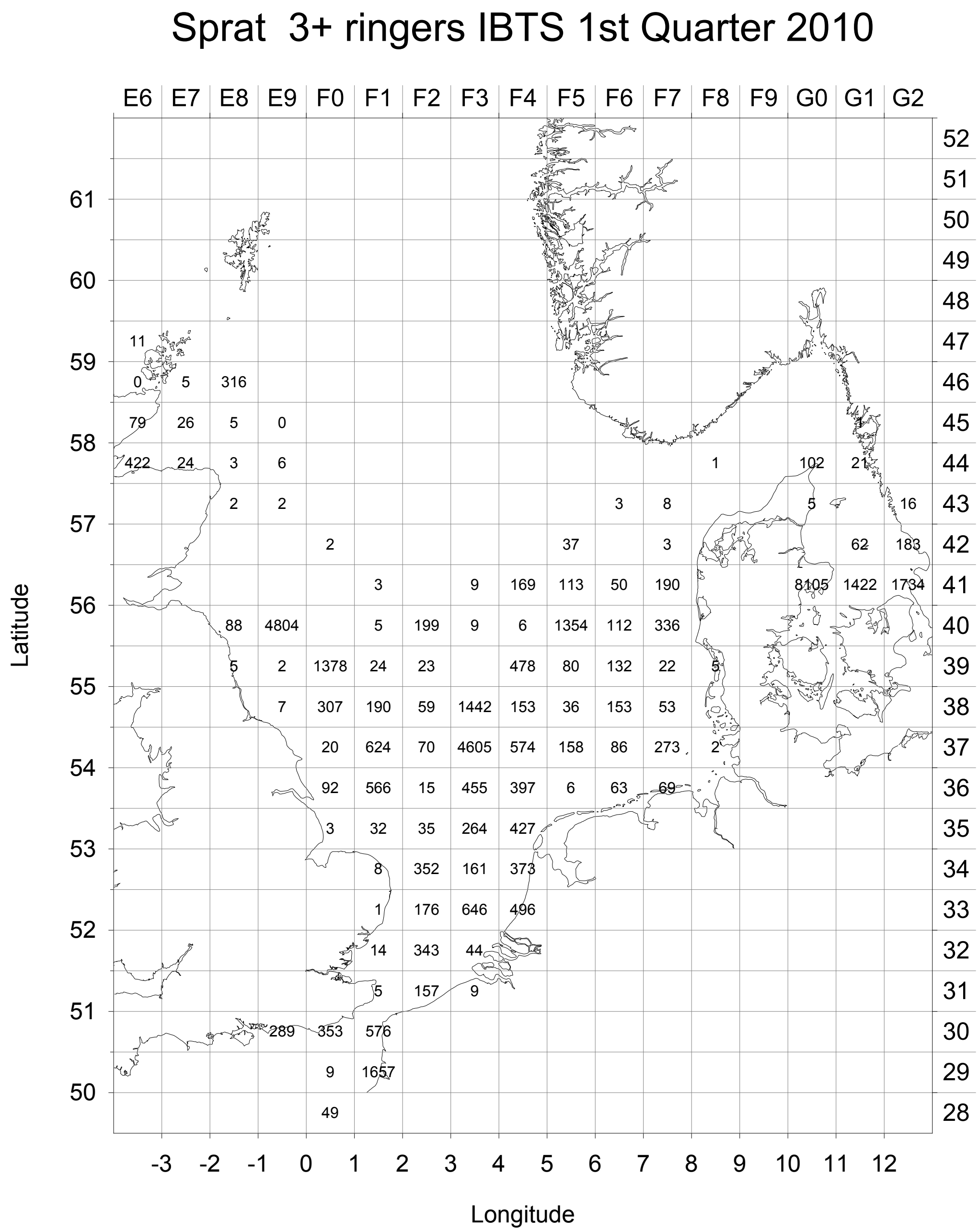


Figure 8.3.1c **Distribution of 3+-ringers in the IBTS (February) 2010 in the North Sea and Division IIIa (Mean number per hour per rectangle).**

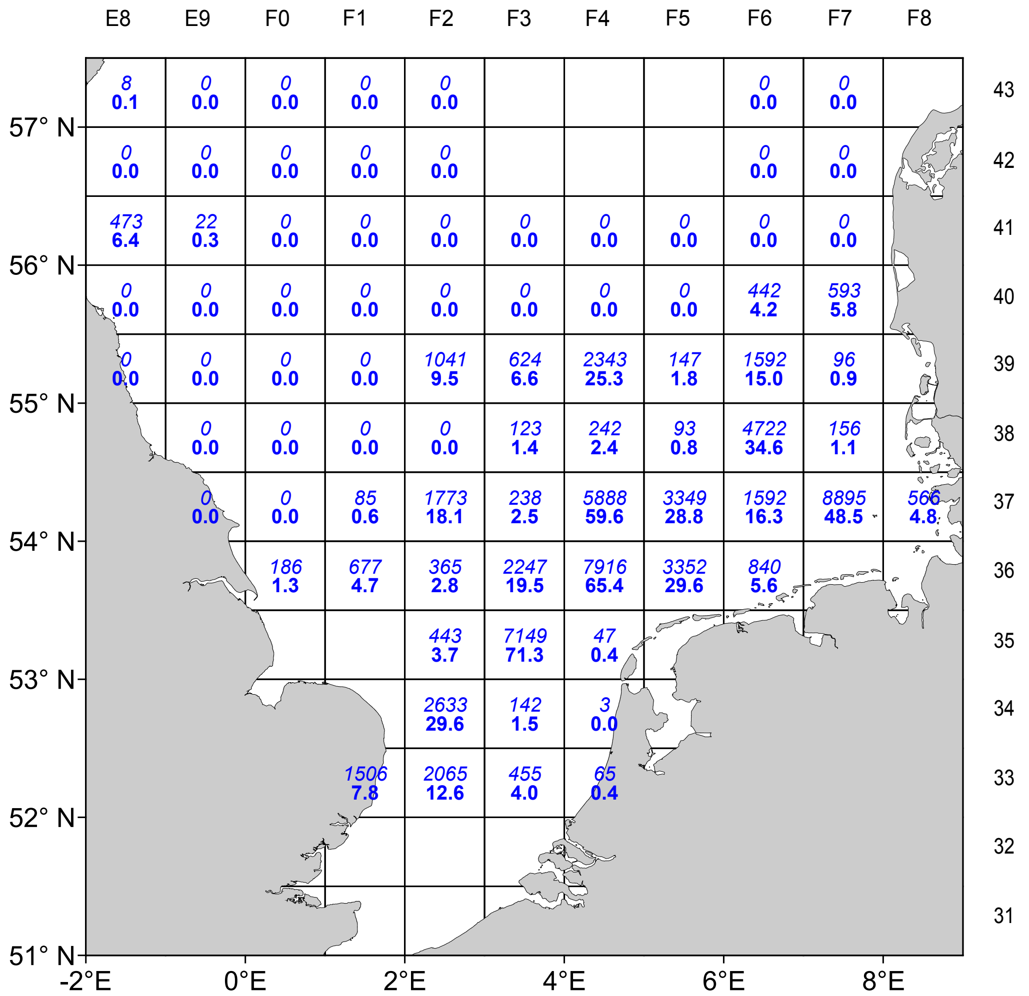


Figure 8.3.2 North Sea Sprat. Abundance (upper figure, in millions) and biomass (lower figure, in 1000 t) per statistical rectangle as obtained by the herring acoustic survey (HERAS) 2009. Blank rectangles were not covered.

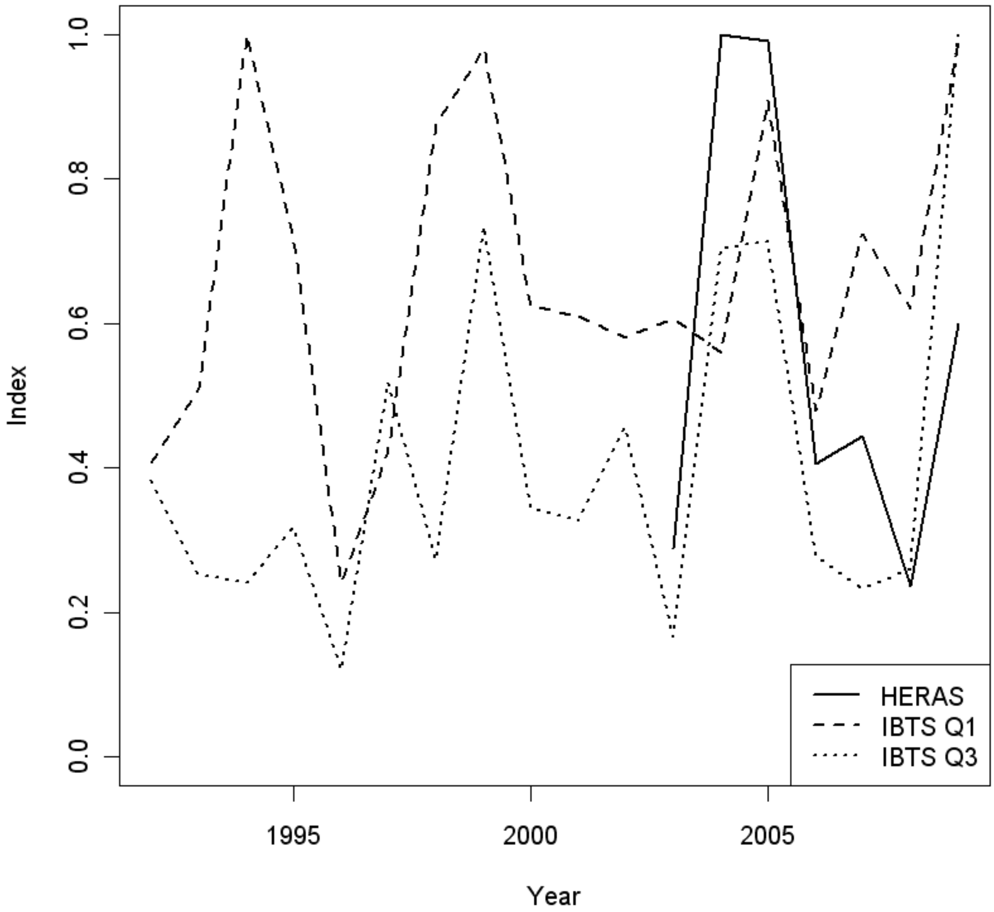


Figure 8.6.1 North Sea Sprat. Standardised survey indices.

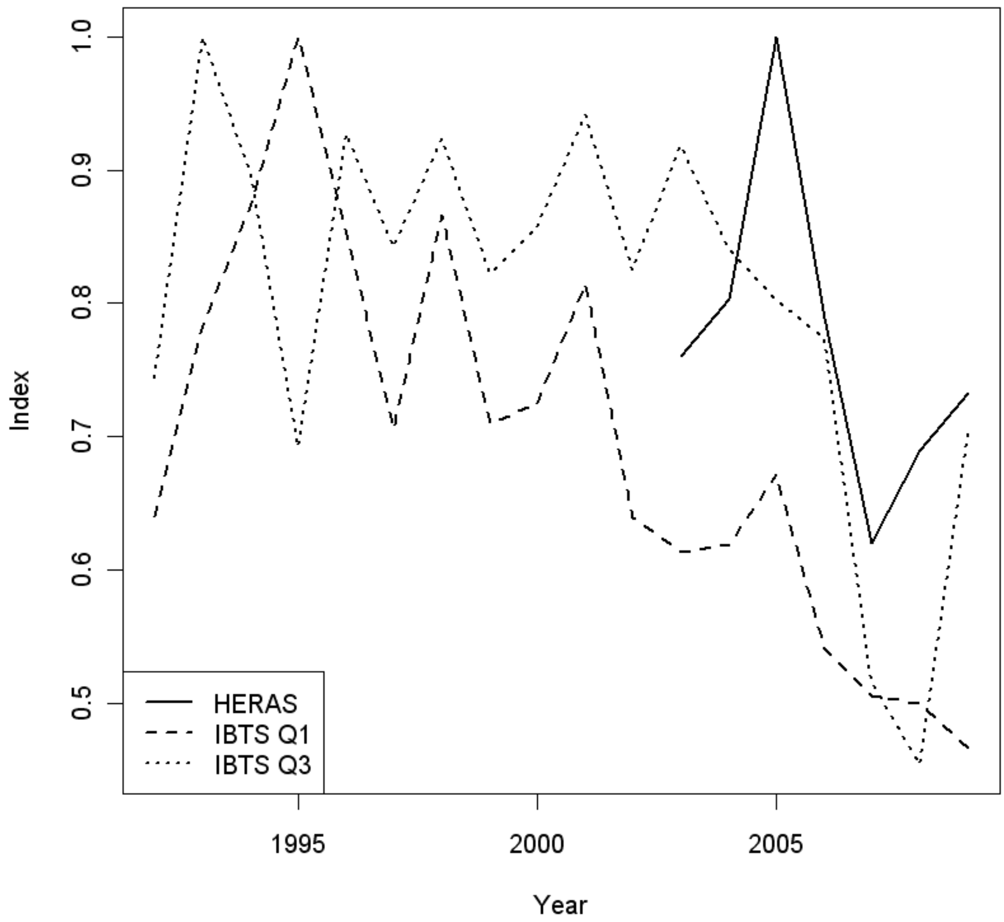


Figure 8.6.2 North Sea Sprat. Standardised presence-absence survey indices.

9 Sprat in Division IIIa

9.1 The Fishery

9.1.1 ICES advice applicable for 2009 and 2010

The ACOM advice on sprat management is that exploitation of sprat will be limited by the restrictions imposed on fisheries for juvenile herring. This is a result of sprat being fished mainly together with juvenile herring. The sprat fishery is controlled by a herring by-catch quota as well as by-catch percentage limits (Norway and Denmark: respectively max 10% and 20% by-catch of herring in weight). No advice on sprat TAC has been given in recent years. In 2009, the TAC for sprat was set at 52 000 t, and the by-catch quota of herring at 8 373 t. For 2010, the TAC for sprat is set at 52 000 t and the by-catch quota for herring for the EU fleet, is set at 7 515 t.

9.1.2 Landings

The total landings decreased from 15 700 t in 2007 to 9 200 t in 2009 (Table 9.1.1) which is the lowest landings reported for the period. The table presents the landings from 1996 onwards. The data from 1996 onwards are considered reliable in this context due to the implementation of the new Danish monitoring scheme. The data prior to 1996 can be found in the HAWG report from 2006 (ICES 2006/ACFM:20).

There were sprat landings in all quarters (Table 9.1.2, see Figures 8.1.1–8.1.2). In 2009 nearly 70% of the total landings were taken in the 1st quarter. In the Norwegian fishery sprat were taken in the 1st and 4th quarter, all as part of the fishery for "anchovy"-production (large sprat).

9.1.3 Fleets

Fleets from Denmark, Norway and Sweden carry out the sprat fishery in Division IIIa.

The Danish sprat fishery consists of trawlers using 16 mm mesh size codend, and all landings are used for fishmeal and oil production. Some of the sprat landings from Denmark and Sweden are by-catches from the herring fishery using 32 mm mesh size codends. There is a Swedish fishery (mainly pelagic trawlers, but also a few purse seiners) directed at herring for human consumption, with by-catches of sprat.

The Norwegian sprat fishery in Division IIIa is a coastal / fjord purse seine fishery for human consumption.

9.1.4 Regulations and their effects

Sprat cannot be fished without by-catches of herring except in years with high sprat abundance or low herring recruitment. Management of this stock should consider management advice given for herring in Subarea IV, Division VIId, and Division IIIa.

Most sprat catches are taken in a small-meshed industrial fishery where catches are limited by herring by-catch restrictions.

9.1.5 Changes in fishing technology and fishing patterns

No changes in fishing technology and fishing patterns for the sprat fisheries in IIIa have been reported for 2009.

9.2 Biological Composition of the Catch

9.2.1 Catches in number and weight-at-age

In 2009 the total numbers of sprat was at the same level as in the last four years (Table 9.2.1). In 2009 the majority of the landings (in numbers) of 1-year olds, contributed to about 80% of the total number.

Denmark and Sweden provided biological samples from all quarters. No Norwegian samples were collected. Landings in 2009, for which samples were collected, were raised using a combination of Swedish and Danish samples, without any differentiation in types of fleets. Details on the sampling for biological data per country, area and quarter are shown in Table 9.2.3. Mean weight-at-age (g) in the catches are presented by quarter in Table 9.2.2. Mean-weight-at-age for all ages is in the same order as the previous years, except for 2007 where the mean weight-at-age 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.

9.3 Fishery-independent information

Acoustic estimates of sprat have been available from the ICES co-ordinated Herring Acoustic Surveys in Division IIIa since 1996. At the time of the surveys, sprat has mainly been recorded in the Kattegat (ICES CM 2010/SSGESST:03).

In 2009 sprat was again only observed in the Kattegat (ICES squares 41G1-G2, 42G0-G2, 43G0-G1 and 44G1). The total abundance was estimated to be 2 233 million individuals, a significant increase compared to 775 million sprat in 2008. The Working Group considers the results on age and maturity distribution from the 2009 Acoustic survey (HERAS) in IIIa (Kattegat) as dubious and recommends that the data from the survey are revised.

The IBTS (February) sprat indices for 1984-2010 are presented in Table 9.3.1. The preliminary total IBTS index for 2010 reduced by more than 50% compared to the 2009 index. The abundance index for the 1-group was the lowest since 1998.

9.4 Mean weight-at-age and length-at-maturity

Data on maturity by age, mean weight- and length-at-age during the 2009 summer acoustic survey are presented in Table 4.2.3 in the WGIPS report (ICES CM 2010/SSGESST:03).

9.5 Recruitment

For this stock, the IBTS index for 1-group sprat in the first quarter is considered the most suitable recruitment index (Table 9.3.1). The 1-group index for 2010 is the second lowest for the period, making less than 10% of the total index. In 2008 the 1-group index contributed less than 10% of the total index. The procedure for the survey did not differ from previous years. However, the index does not fully reflect 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 2009) for sprat in the North Sea.

9.6 Stock Assessment

9.6.1 Data exploration

No data exploration of sprat from Div IIIa was made. The time available was too short to fully explore the data for IIIa as the data exploration of the North Sea sprat was given priority. The three time series of survey indices (IBTS-Q1, IBTS-Q3 and HERAS) should be analysed for suitability as indices in the assessment of the stock.

9.6.2 Stock Assessment

No assessment of IIIa sprat was made.

9.6.3 State of the Stock

No assessment of the sprat stock in Division IIIa has been presented since the mid-1980ies. Various methods have been explored without success (ICES CM 2007/ACFM:11).

9.7 Short term projections

No assessment is presented for this stock.

9.8 Reference Points

No precautionary reference points are defined for this stock.

9.9 Quality of the Assessment

See above.

9.10 Management Considerations

Sprat is a short-lived species with large inter-annual fluctuations in stock biomass. The natural inter-annual variability in stock abundance, mainly driven by recruitment variability, is high and does not appear to be strongly influenced by the observed levels of fishing effort.

The sprat has mainly been fished together with herring. The human consumption fishery only takes a minor proportion of the total catch. Within the current management regime, where there is a by-catch ceiling limitation of herring as well as by-catch percentage limits, the sprat fishery is controlled by these factors. In the last years the sprat fisheries has not been limited by the sprat quota, since this quota has not been taken.

9.11 Ecosystem Considerations

No information of the ecosystem and the accompanying considerations are known at present. In the adjacent North Sea Multispecies investigations have demonstrated that sprat is one of the important prey species in the North Sea ecosystem, for both fish and seabirds. At present, there are no data available on the total amount of sprat taken by seabirds in the IIIa area (Tycho Anker-Nilssen, pers. communication, ICES WGSE). Many of the plankton feeding fish have recruited poorly in recent years (e.g. herring, sandeel, Norway pout). The implications for sprat in IIIa are at present unknown.

9.12 Changes in the environment

Temperatures in the Skagerrak area have increased over the last few years. In the North Sea a shift in species composition and biomass of zooplankton have been observed. This has reduced the availability of food sources for some species (cod, sandeel). There are no indications of systematic changes in growth or age at maturity in sprat in the North Sea or in Div. IIIa.

Table 9.1.1 Division IIIa sprat. Landings in ('000 t) 1996-2009.
(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

* < 50 t

Table 9.1.2. Division IIIa sprat. Landings of sprat ('000 t) by quarter and by countries, 2000-2009. Data for 1996-1999 in ICES CM 2007/ACFM:11 (Data provided by the Working Group members)

	Quarter	Denmark	Norway	Sweden	Total
2000	1	4.1	0.1	2.3	6.5
	2			1.9	1.9
	3	4.8	0.1		4.9
	4	3.8	0.7	2.3	6.8
	Total	12.7	0.9	6.4	20.0
2001	1	2.5		2.6	5.2
	2	6.6		0.1	6.7
	3	10.2		0.1	10.2
	4	0.9	1.4	4.8	7.1
	Total	20.2	1.4	7.6	29.1
2002	1	3.8		1.4	5.2
	2	2.1		0.4	2.4
	3	5.9		0.1	6.0
	4	1.7		2.4	4.1
	Total	13.4		4.3	17.7
2003	1	3.5	0.1	1.7	5.3
	2	0.6		0.8	1.4
	3	1.0		0.7	1.7
	4	5.0	0.8	2.3	8.1
	Total	10.2	0.8	5.5	16.5
2004	1	3.1		1.4	4.5
	2	0.6		0.9	1.5
	3	3.7		0.4	4.1
	4	6.9	1.1	3.8	11.9
	Total	14.4	1.1	6.5	22.0
2005	1	6.5		1.7	8.1
	2	4.6		0.1	4.7
	3	18.6	0.7	0.8	20.1
	4	2.1		5.2	7.3
	Total	31.9	0.7	7.7	40.3
2006	1	5.4	0.2	2.7	8.3
	2	0.2		0.2	0.3
	3	1.3		0.1	1.4
	4	0.9	0.1	1.5	2.5
	Total	7.8	0.3	4.4	12.5
2007	1	2.3	0.4	0.4	3.1
	2	0.7		0.6	1.3
	3	5.1	*	0.2	5.4
	4	1.8	1.2	3.0	5.9
	Total	9.9	1.6	4.2	15.7
2008	1	2.3	0.2	0.6	3.1
	2	0.7		0.4	1.0
	3	0.4		0.2	0.6
	4	2.5	0.7	1.2	4.4
	Total	5.8	0.9	2.4	9.1
2009	1	2.2	0.4	0.4	3.0
	2	0.3			0.3
	3	3.2		0.1	3.3
	4	1.2	0.2	1.2	2.6
	Total	6.9	0.6	1.7	9.2

* < 50 t

Table 9.2.1 **Division IIIa sprat**. Landed numbers (millions) of sprat by age groups in 2004-2009. 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

Table 9.2.2. **Division IIIa sprat.** Quarterly mean weight-at-age (g) in the landings for the years 2004-2009. The equivalent data for 1996-2003 can be found in ICES CM 2007 /ACFM: 11. (Danish and Swedish data)

Year		Age					
	Quarter	0	1	2	3	4	5+
2004	1		4.6	14.6	17.8	17.3	17.3
	2		7.0	13.6	16.7	17.0	19.5
	3	3.0	14.1	16.7	20.0	21.4	
	4	3.5	16.8	19.9	22.2	20.9	28.0
Weighted mean		3.5	10.4	16.3	18.4	17.8	17.9
2005	1		3.0	14.6	16.3	20.3	21.1
	2		5.4	11.7	26.8		
	3	2.9	11.9	14.6	15.4	11.0	
	4	3.3	13.1	19.1	20.1	21.1	23.1
Weighted mean		5.0	7.6	15.4	17.1	17.2	21.5
2006	1		5.0	12.2	15.4	15.2	18.5
	2		7.0	13.3	16.3	22.0	
	3		11.2	17.4	20.3	18.6	22.8
	4	4.3	16.1	19.6	21.4	23.8	26.6
Weighted mean		4.3	6.8	13.6	16.8	16.1	19.4
2007	1		2.3	12.3	16.3	17.0	25.2
	2		6.1	17.1	20.6	21.9	20.4
	3		12.0	13.0	17.0	17.6	
	4	7.9	14.1	20.3	23.4	22.6	26.2
Weighted mean		7.9	11.5	15.9	18.4	19.3	25.2
2008	1		5.6	11.7	15.5	18.1	18.3
	2		8.0	12.5	17.1	19.3	22.2
	3	3.4	7.9	21.1	21.5	25.3	22.5
	4	3.4	9.2	20.7	21.4	25.2	22.8
Weighted mean		3.4	9.0	13.3	16.9	19.5	20.0
2009	1		3.9	11.5	14.7	17.4	21.4
	2		3.9	6.1	5.1	7.2	
	3		12.0	14.6	13.8	12.4	
	4	5.2	13.7	18.7	20.3	20.8	19.8
Weighted mean		5.2	8.0	14.3	15.5	16.7	21.1

Table 9.2.3 **Division IIIa sprat.** Sampling commercial landings for biological samples in 2009.

Country	Quarter	Landings (tonnes)	No. samples	No. meas.	No. aged
Denmark	1	2 245	24	2 844	620
	2	316	6	468	126
	3	3 157	24	1 889	430
	4	1 170	7	643	160
	Total	6 888	61	5 844	1 336
Norway	1	437	0	0	0
	2	0	0	0	0
	3	0	0	0	0
	4	233	0	0	0
	Total	670	0	0	0
Sweden	1	357	0	0	0
	2	0	0	0	0
	3	133	0	0	0
	4	1 157	11	539	539
	Total	1 647	11	539	539
Denmark		6 888	61	5 844	1 336
Norway		670	0	0	0
Sweden		1 647	11	539	539
	Total	9 205	72	6 383	1 875

Table 9.3.1. **Division IIIa sprat**. IBTS (February) indices of sprat per age group 1984-2010.

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	137.27	910.96	279.92	165.56	6.91	1 500.62

* Preliminary

10 Stocks with insufficient data

Two stocks with very low research intensity were poorly described in previous reports in devoted sections or chapters. These were Clyde herring (Section 5.11 in ICES 2005a) and sprat in VIId,e (Section 9 in ICES 2005). The advice on these stocks cannot be improved at present. In this section only the times series are maintained. For most recent advice refer to the appropriate sections in the HAWG report (ICES CM 2005/ACFM:18).

There was no sampling of the catch in 2009 for Clyde herring. The catch of Clyde herring in 2009 was the highest since 1998 and exceeded the quota (Table 10.1). However, comparison of Working Group estimates of landings and preliminary ICES FISHSTAT data, available after data compilation by the Stock Coordinator, for 2009, suggests that there may have been an overestimation of landings by the HAWG.

The catches of sprat in VIId and VIIe were nearly doubled in 2008 compared to the past years (Table 10.2). Landings had not been at the level of 2008 since 1999. In 2009 the landings declined by 18% but continued to be among the highest since 1999.

Table 10.1 Herring from the Firth of Clyde. Catch in tonnes by country, 1955–2009. Spring and autumn-spawners combined.

Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
All Catches														
Total	4 050	4 848	5 915	4 926	10 530	15 680	10 848	3 989	7 073	14 509	15 096	9 807	7 929	9 433

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	
All Catches														
Total	10 594	7 763	4 088	4 226	4 715	4 061	3 664	4 139	4 847	3 862	1 951	2 081	2 135	

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Scotland	2 506	2 530	2 991	3 001	3 395	2 895	1 568	2 135	2 184	713	929	852	608	392
Other UK	-	273	247	22	-	-	-	-	-	-	-	1	-	194
Unallocated[1]	262	293	224	433	576	278	110	208	75	18	-	-	-	-
Discards	1 253	1 265	2 308[3]	1 344[3]	679[3]	439[4]	245[4]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]	-[2]
Agreed TAC			3 000	3 000	3 100	3 500	3 200	3 200	2 600	2 900	2 300	1 000	1 000	1 000
Total	4 021	4 361	5 770	4 800	4 650	3 612	1 923	2 343	2 259	731	929	853	608	586

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Scotland	598	371	779	16	1	78	46	88	-	-	+	163	54	266
Other UK	127	475	310	240	0	392	335	240	-	318	512	458	622	739
Unallocated[1]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discards	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agreed TAC	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	1 000	800	800	800
Total	725	846	1089	256	1	480	381	328	0	318	512	621	676	1005

[1]Calculated from estimates of weight per box and in some years estimated by-catch in the sprat fishery

[2]Reported to be at a low level, assumed to be zero, for 1989-1995.

[3]Based on sampling.

[4]Estimated assuming the same discarding rate as in 1986

Table 10.2 Sprat VIId,e. Nominal catches in tonnes of sprat in VIId,e from 1985-2009.

Country	1985	1986	1987	1988	1989	1990	1991	1992
Denmark		15	250	2,529	2,092	608		
France	14		23	2	10			35
Netherlands								
UK (Engl.&Wales)	3,771	1,163	2,441	2,944	1,319	1,508	2,567	1,790
Total	3,785	1,178	2,714	5,475	3,421	2,116	2,567	1,825

Country	1993	1994	1995	1996	1997	1998	1999	2000
Denmark								
France	2	1	0					18
Netherlands							1	1
UK (Engl.&Wales)	1,798	3,177	1,515	1,789	1,621	2,024	3,559	1,692
Total	1,800	3,178	1,515	1,789	1,621	2,024	3,560	1,711

Country	2001	2002	2003	2004	2005	2006	2007	2008
Denmark								
France								
Netherlands								
UK (Engl.&Wales)	1,349	1,196	1,377	836	1,635	1,974	1,819	3,366
Total	1,349	1,196	1,377	836	1,635	1,974	1,819	3,366

Country	2009
Denmark	
France	
Netherlands	
UK (Engl.&Wales)	2,765
Total	2,765

11 Working Documents

WD01 Aloysius T.M. van Helmond and Harriët M.J. van Overzee. Can pelagic freezer trawlers reduce discarding? IMARES, Wageningen UR.

WD02 Aloysius T.M. van Helmond and Harriët M.J. van Overzee. Estimates of discarded herring by Dutch flagged vessels 2003-2009 and other PFA vessels in 2009. IMARES, Wageningen UR.

WD03 Harriët M.J. van Overzee, Mark Dickey-Collas, Ineke Pennock-Vos, Silja V. Tribuhl, Stijn M. Bierman, Cindy J.G. van Damme & M. Warmerdam. Norwegian Sea Herring Stock Discrimination – NORDIS. IMARES, Wageningen UR.

WD04 Payne, M. R. 2010. Mind the gaps: a model robust to missing observations gives insight into the dynamics of the North Sea herring spawning components. ICES Journal of Marine Science.

WD05 Emma M.C. Hatfield[1] and E. John Simmonds[2] Revisions to acoustic survey derived data for the west of Scotland – VIa (North) - herring stock. [1]Marine Scotland-Science, UK.[2] Joint Research Centre, Italy.

WD06 Tomas Gröhsler. Fisheries & Stock assessment data 2009 in the Western Baltic. Johann Heinrich von Thünen-Institut, Institut für Ostseefischerei (OSF), Rostock.

WD07 Federation of Irish Fishermens' Organisations. Problems with the assessment of herring in VIaS and VIIb,c.

WD08 Steven Beggs, Pieter-Jan Schön, Willie McCurdy, John Peel, Peter McCorriston, Ian McCausland and Enda O'Callaghan. Seasonal Origin of Irish Sea Herring. Agri-Food and Bioscience Institute, UK

WD09 Norbert Rohlf and Joachim Gröger. Report of the herring larvae surveys in the North Sea in 2009/2010. Johann Heinrich von Thünen-Institut, Institut für Seefischerei, Hamburg.

WD10 Joachim Gröger and Norbert Rohlf. Updating the Climate-Driven ARIMAX Recruitment Model (CDARM) to the Extended Period 1960 to 2009. Johann Heinrich von Thünen-Institut, Institut für Seefischerei, Hamburg.

WD11 P-J. Schön, S. Beggs, I. McCausland, P. McCorriston, W. McCurdy, E. O'Callaghan and J. Peel. Extended pelagic acoustic survey in the Irish Sea (Division VIIa (North)) – preliminary results 2007-2009. Agri-Food and Bioscience Institute, UK.

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ANNEX 1: List of Participants

Herring Assessment Working Group South of 62° N [HAWG]

15-23 March 2010

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Annex 2 - Recommendations

HAWG 2010 makes the following recommendations:

RECOMMENDATION	ACTION
HAWG expresses concern that the results on age and maturity distribution of sprat from the 2009 Acoustic survey (HERAS) in IIIa (Kattegat) are unusual and recommend that WGIPS revisit these results.	WGIPS, ICES Secretariat
HAWG recommends that the acoustic surveys used for tuning Celtic Sea and Irish Sea stocks be coordinated by WGIPS. These surveys are not otherwise dealt within ICES survey working groups.	WGIPS, ICES Secretariat
HAWG recommends that ICES consider the possibilities for separating between NSAS and WBSS caught in the area IIIa, in the standard index calculation of IBTS abundance indices.	WGIBTS, ICES Secretariat
HAWG recommends that ICES check DATRAS raising procedures for IBTS Q1 and Q3 actually follow the procedure described in the North Sea Sprat stock annex.	ICES Secretariat
HAWG recommends that two stocks are benchmarked in 2012, Herring in the North Sea and Herring in the Irish Sea (VIIa North). Depending on the outcome of SGHERWAY, the proposal to benchmark Herring in the Irish Sea may have to be reviewed.	ACOM, ICES Secretariat
HAWG recommends that routines should be implemented in InterCatch to report on CATON, WECA, WEST and CANUM for area IIIa, and for NSAS and WBSS spawners separately.	ICES Secretariat
HAWG recommends that all information in the exchange sheets should be also available in InterCatch (e.g., catch per rectangle, input mask for national data files, 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 2011 HAWG, until InterCatch provides the additional functionality.	ICES Secretariat
HAWG recommends that the Marine Scotland-Science Marine Laboratory Aberdeen should continue to to perform the west coast MIK surveys. Given that they cover the spawning period of herring of VIaS and VIIb, there probably will be utility in this survey as an index of larval abundance.	National scientists
Sampling of population components within the Malin Shelf survey should continue to be conducted.	PGCCDBS

Annex 3– Stock Annex North Sea Herring

Quality Handbook	ANNEX: hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	North Sea Autumn Spawning Herring (NSAS)
Working Group:	Herring Assessment WG for the Area south of 62°N
Date:	16 March 2010
Authors:	C. Zimmermann, J. Dalskov, M. Dickey-Collas, H. Mosegaard, P. Munk, J. Nichols, M. Pastoors, N. Rohlf, E.J. Simmonds, D. Skagen, M. Payne, N. Hintzen

A. General

A.1. Stock definition:

Autumn spawning herring distributed in ICES area IV, Division IIIa and VIId. Mixing with other stocks occurs especially in Division IIIa (with Western Baltic Spring Spawning herring). Genetic studies have failed to prove that the stock is not one unit (Mariani *et al*., 2005; Reiss *et al*., 2009).

A.2. Fishery

North Sea Autumn Spawners are exploited by a variety of fleets, ranging from small purse seiners to large freezer trawlers, of different nations (Norway, Denmark, Sweden, Germany, The Netherlands, Belgium, France, UK, Faroe Islands). The majority of the fishery takes place in the Shetland-Orkney area and northern North Sea in the 2nd and 3rd quarter, and in the English Channel (Division VIId) in the 4th quarter. Juveniles are caught in Division IIIa and as by-catch in the industrial fishery in the central North Sea. For management purposes, 4 fleets are currently defined: Fleet A is harvesting herring for human consumption in IV and VIId, but includes herring by-catches in the Norwegian industrial fishery; fleet B is the industrial (small mesh, <32 mm mesh size) fleet of EU nations operating in IV and VIId. North Sea Autumn spawners are also caught in IIIa in fleets C (human consumption) and D (small mesh).

A.3. Ecosystem aspects:

Herring is the key pelagic species in the North Sea and is thus considered to have major impact as prey and predator to most other fish stocks in that area (Dickey-Collas *et al*., 2010).

The North Sea is semi-enclosed and situated on the continental shelf of North-western Europe and is bounded by England, Scotland, Norway, Sweden, Denmark, Germany, the Netherlands, Belgium and France. It covers an area of ~750 000 km^2 of which the greater part is shallower than 200 m. It is a highly productive (>300 gC m^{-2} yr^{-1}) ecosystem but with primary productivity varying considerably across the sea. The highest values of primary productivity occur in the coastal regions, influenced by terrestrial inputs of nutrients, and in areas such as the Dogger Bank and tidal fronts. Changes observed in trophic structure are indicative of a trend towards a decreasing resilience of this ecosystem. This trend is partially a response to inter-annual changes in the physical oceanography of the North Atlantic.

Herring are an integral and important part of the pelagic ecosystem in the North Sea. As plankton feeders they form an important part of the food chain up to the higher trophic levels. Both as juveniles and as adults they are an important source of food for some demersal fish, birds and for sea mammals (see review Dickey-Collas *et al*., 2010). Over the past century the top predator, man, has exerted the greatest influence on the abundance and distribution of herring in the North Sea. Spawning stock biomass has fluctuated from estimated highs of around 4.5 million tonnes in the late 1940s to lows of less than 100 000 tonnes in the late 1970s (Mackinson, 2001; Mackinson and Daskalov, 2007; Simmonds 2007). The species has demonstrated robustness in relation to recovery from such low levels once fishing mortality is curtailed in spite of recruitment levels being adversely affected (Payne *et al*., 2009, Nash *et al*., 2009).

Their spawning and nursery areas, being near the coasts, are particularly sensitive and vulnerable to anthropogenic influences. The most serious of these is the ever increasing pressure for marine sand and gravel extraction and the development of wind farms. This has the potential to seriously damage and to destroy the spawning habitat and disturb spawning shoals and destroy spawn if carried out during the spawning season. It also has the potential to destroy traditional spawning grounds which are currently unused but likely to be recolonised (Schmidt *et al*., 2009). Similarly, trawling at or close to the bottom in known spawning areas can have the same detrimental effects. It is possible that the disappearance of spawning on the western edge of the Dogger Bank could well be attributable to such anthropogenic influences.

In more recent years the oil and gas exploration in the North Sea has represented a potential threat to herring spawning although great care has been taken by the industry to restrict their activities in areas and at times of known herring spawning activity.

By-catch and Discard

By-catch consists of the retained ‘incidental’ catch of non-target species and discard is a deliberately (or accidentally) abandoned part of the catch returned to the sea as a result of economic, legal, or personal considerations. This section therefore deals with these two elements of the fishery, looking specifically at fishery-related issues. Cetacean, seabird and other threatened, rare and charismatic species which may form part of a by-catch are considered separately in the next section. Discarding is illegal for Norwegian vessels and slippage and high grading is now illegal for EU vessels if quota is still available and the fish are above minimum landing size.

Incidental Catch: The incidental catch of non-target species in the North Sea pelagic herring fishery in general is considered to be low (Borges *et al*., 2008). A study by Pierce *et al.* (2002) investigated incidental catch from commercial pelagic trawlers over the period January to August 2001. The target species, herring, accounted for 98% by weight of the overall catch with an overall incidental catch of 2.3% made up of mackerel, haddock, horse mackerel and whiting. However, onboard sampling over 2002 by Scottish and German observers found substantial discards of herring, taken as by-catch in the mackerel fishery over the 3rd and 4th quarters, after herring quotas had been exhausted. This was not found in a study of the Dutch fleet (Borges *et al*., 2008) when the herring fishery was found to be relatively “clean”. Updates of the time series of Dutch discarding due to sorting suggest an approximate discard of <5% of the catch (Helmond and Overzee, 2010a).

Discards and slipping: The indications are that large-scale discarding is not widespread in the directed North Sea herring fishery. A number of direct-observer surveys have been conducted on Scottish, Dutch and Norwegian pelagic trawlers, (Napier *et al*, 1999; 2002; Borges *et al*., 2008). The overall discard rate was less than 5% of the landed catch. It is likely that there are different discard rates between the specific fishing types. There is disagreement about the amount of slippage compared to discarding by the differing fleets (**slippage**- fish released from the nets whilst still in the water but still resulting in the mortality of the majority of pelagic fish, **discarding**- fish dumped back into the sea after having been brought on board). In freezer trawlers discarding can occur through sorting the catch and through emptying of tanks via the processing belts without sorting. For both pursers and trawlers 'poor' fish quality was a significant cause of discarding. Another reason is the processing capacity of freezer trawlers when catches are abundant (Helmond and Overzee, 2010b). The strength of year classes influences discarding behaviour, particularly of undersized fish. The influence of strong herring year classes was apparent in the composition of discards with smaller, younger fish accounting for a high proportion of the fish discarded in 2001. In the mid 2000s the stronger recruitment of mackerel has probably lead to the increase in discarding of smaller mackerel.

Ecosystem Considerations. The incidental non-target fish catch by directed North Sea herring fisheries appears to be low (ca. 2%), mainly consisting of mackerel when fishing mixed shoals. Thus it is likely that the impact of incidental fish catches is negligible. The discard of unwanted herring, mostly in the form of high-grading to improve catch quality and grade sizes of fish between 2-4 years of age is low and now illegal in both the EU and Norway. Discarding is thought to be reducing.

Interactions with Rare, Protected or charismatic mega fauna: Interactions between the directed North Sea herring fishery with rare, protected or charismatic mega fauna species are, in general, considered to be low. Species which may interact with the fishery are considered below.

Cetacean by-catch: Since 2000, the Sea Mammal Research Unit (SMRU) of St. Andrew's University in Scotland, under contract to DEFRA, has carried out a number of surveys to estimate the level of by-catch in UK pelagic fisheries. SMRU, in collaboration with the Scottish Pelagic Fishermen's Association, placed observers on board thirteen UK vessels for a total of 190 days at sea, covering 206 trawling operations around the UK. No cetacean by-catch was observed in the herring pelagic fishery in the North Sea. Pierce (2002) also reports that no by-catches of marine mammals were observed over 69 studied hauls and considers that the underlying rate for marine mammals in the pelagic fisheries studies (pelagic trawls in IVa and VIa) is no more than 0.05 (i.e. five events per 100 hauls) and may well be considerably lower than this. Consequently, the cetacean by-catch by the pelagic trawl fishery can be regarded as negligible. This was also confirmed by an UK observer programme that ended in 2003 (Northridge, pers. Comm.) and Dutch observers (1 catch from 2007-2009: over 210 days observed; Couperus 2009).

Other than the above, there are no reliable estimates of by-catch for pelagic trawl fisheries, though observations have been made and by-catch rates have been established for several fisheries. Data are now collected routinely through the DRF and have yet to be analysed. Kuklik and Skóra (2003) refer to a single record of a harbour porpoise (*Phocoena phocoena*) by-catch in a herring trawl in the Baltic. Observations in several other pelagic trawl fisheries were reported by Morizur *et al*. (1999) and Couperus (1997). All appear to agree that incidental catches of cetaceans in the Dutch pelagic trawl fishery are largely restricted to late-winter/early-spring in an area along the continental slope southwest of Ireland, so outside the North Sea.

Seal by-catch: The by-catch of seals in directed pelagic herring fishery in the North Sea is reported to be "very rare" (Aad Jonker, pers. comm.). Independent verification also confirms this to be so, with perhaps one animal being caught by the whole North Sea fleet a year (Bram Couperus (IMARES, pers. comm.). Northridge (2003) observed 49 seals taken in 312 pelagic trawl tows throughout UK waters and reports that the fishery in North-western Scotland has the highest observed seal by-catch levels of UK pelagic trawl fisheries, possible amounting to dozens per year. Although not confirmed, it was assumed that the majority were grey seal *Halichoerus grypus*. This species is mainly distributed around the Orkneys and Outer Hebrides – out of a UK population of 129 000, only around 7 000 and 5 900 are distributed off the Scottish and English North Sea coasts respectively (SCOS, 2002), and so by-catch rates in the North Sea are likely to be substantially less than off the NW Scottish coast. The eastern Atlantic population of the Grey seal is not considered to be threatened.

Other by-catch: Sharks are occasionally caught by pelagic trawlers in the North Sea, although this is rare with a maximum of two fish per trip (Aad Jonker, pers. comm.). Survival rates are apparently high, sharks are released during or after the cod-end has been emptied. The species are unknown, although blue shark *Prionace glauca*, which preys primarily upon schooling fishes such as anchovies, sardines and herring, are known to have been caught by pelagic trawls off the SW English coast (Bram Couperus (IMARES), pers. comm.). Gannets (*Morus bassanus*), which frequently dive at and around nets, were observed by Napier *et al.* (2002) entangled in the nets but were not present in samples. Actual mortality rates of caught gannets have not been assessed in detail, and some have been observed alive after release from the gear. An extrapolation from observed mortalities corresponds to around 560 gannet deaths per year, although this is based on a relatively low sample frame. Seabird by-catch in the North Sea is considered to be comparatively rare. In the NW Scotland, 1-3 birds may be caught, especially in grounds off St. Kilda (Aad Jonker (former freezer trawler skipper), pers. comm.). IMARES observers in the North Sea only recorded one incident of seabird by-catch over 10 trips (Bram Couperus, pers. comm.).

B. Data

B.1. Commercial catch:

Commercial catch is obtained from national laboratories of nations exploiting herring in the North Sea. Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2007 catch data was v1.6.4. This method is now run in parallel with INTERCATCH, which is maintained by ICES. INTERCATCH is still in development and thus HAWG uses both. The data in the exchange spreadsheets are allocated samples to catch using the SALLOCL-application (Patterson, 1998). This programme gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing data and raising the catch information of one nation/quarter/area with information from another data set.

In addition, commercial catch and sampling data were stored and processed using the Intercatch-software for the first time during the WG in 2007. While at that time larger discrepancies up to 5 % between the SALLOCL routines and Intercatch did occur, INTERCATCH performed quite well in 2008. The estimates of CANON, CATON and WECA were highly comparable. However INTERCATCH is still not completely satisfactory in terms of flexibility and outputs. Thus both methods are still being used.

The "wonderful table". The following figure explains were the estimates in the wonderful table are derived from:

Year		2007	2008	
Sub-Area IV and Division VIId: TAC (IV and VIId)				
Recommended Divisions IVa, b [1]	22			
Recommended Divisions IVc, VIId	14			
Expected catch of spring spawners				
Agreed Divisions IVa,b [2]	TAC human consumption in IVa and b	303.5	174.6	Total TAC for human consumption in North Sea
Agreed Div. IVc, VIId	TAC human consumption in IVc and VIId	37.5	26.7	Total TAC for human consumption in North Sea
Bycatch ceiling in the small mesh fishery	TAC industrial fishery	31.9	18.8	
CATCH (IV and VIId)				
National landings Divisions IVa,b [3]		326.8		
Unallocated landings Divisions IVa,b		21.9		
Discard/slipping Divisions IVa,b [4]		0.1		
Total catch Divisions IVa,b [5]		348.8		
National landings Divisions IVc, VIId [3]		34.3		
Unallocated landings Divisions IVc,VIId		4.7		
Discard/slipping Divisions IVc, VIId [4]		-		
Total catch Divisions IVc, VIId		39.0		
Total catch IV and VIId as used by ACFM [5]		**387.8**		Herring caught in the North Sea
CATCH BY FLEET/STOCK (IV and VIId) [10]				
North Sea autumn spawners directed fisheries (Fleet A)		379.6		NS catch human consumption
North Sea autumn spawners industrial (Fleet B)		7.1		NS catch industrial fishery
North Sea autumn spawners in IV and VIId total		**386.7**		
Baltic-IIIa-type spring spawners in IV		1.1		Catch of WBSS in IV, estimated by splitting
Coastal-type spring spawners		0.0		e.g. spring spawner in river estuaries (Thames, Wash)
Norw. Spring Spawners caught under a separate quota in IV [20]		0.7		direct information from Norway
Division IIIa: TAC (IIIa)				
Predicted catch of autumn spawners	22			
Recommended spring spawners	22			
Recommended mixed clupeoids				
Agreed herring TAC		69.4	51.7	
Agreed mixed clupeoid TAC				
Bycatch ceiling in the small mesh fishery		15.4	11.5	
CATCH (IIIa)				
National landings		47.3		
Catch as used by ACFM		47.4		
CATCH BY FLEET/STOCK (IIIa) [10]				
Autumn spawners human consumption (Fleet C)		16.4		
Autumn spawners mixed clupeoid (Fleet D) [19]		3.4		
Autumn spawners other industrial landings (Fleet E)				
Autumn spawners in IIIa total		**19.8**		Catch of NSAS in IIIa, estimated by splitting
Spring spawners human consumption (Fleet C)		25.3		
Spring spawners mixed clupeoid (Fleet D) [19]		2.3		
Spring spawners other industrial landings (Fleet E)				
Spring spawners in IIIa total		**27.6**		
North Sea autumn spawners Total as used by ACFM		**406.5**		

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year. Since 2007, the corresponding datasets are also stored in Intercatch, where they are accessible to the stock coordinators only.

Current methods of compiling fisheries assessment data. The stock co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to un-sampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet), area and quarter. If an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an un-sampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

The Working Group acknowledges the effort some members have made to provide "corrected" data, which in some cases differ significantly from the officially reported catches. Most of this valuable information is gathered on the basis of personal knowledge of the fishery and good relations between the scientist responsible and the fishermen. In addition the Working Group recognises and would like to highlight the inherent conflict of interest in obtaining details of unallocated catches by country and increasing the transparency of data handling by the Working Group.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) is derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described above. For information on recent sampling levels and nations providing samples, see Sec. 2.2. of the most recent HAWG report.

Mean weights-at-age in the stock and proportions mature (maturity ogive) are derived from the June/July international acoustic survey (see next paragraph). All 1 ring fish are assumed to be immature, and all fish over five rings are assumed to be mature.

B.3. Surveys

B.3.1 Acoustic: ICES Co-ordinated Acoustic Surveys for herring in North Sea, Skagerrak and Kattegat

The ICES Coordinated acoustic surveys started in 1979 around Orkney and Shetland with first major coverage in 1984. An index derived from that survey has been used in assessments since 1994 with the time-series data extending back to 1989. The survey was extended to IIIa to include the overlapping Western Baltic spring spawning stock in 1989, and the index has been used with a number of other tuning indices since 1991. The early survey had occasionally covered VIa (North) during the 1980s and was extended westwards in 1991 to cover the whole of VIa (North). Since 1991, this survey provides the only tuning index for VIa (North) herring and from 2008 for the whole Malin Shelf, By carrying out the co-ordinated survey at the same time from the Kattegat to Donegall all herring in these areas are covered simultaneously, reducing uncertainly due to area boundaries as well as providing input indices to three distinct stocks. The surveys are co-ordinated under ICES Working Group for International Pelagic Surveys (WGIPS).

The acoustic recordings are carried out using Simrad EK60 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel or towed bodies. Prior to 2006, Simrad EK500 and EY500 were also used. Further data analysis is carried out using either BI500, Echoview or Echoann software. The survey track is selected to cover the area giving a basic sampling intensity over the whole area based on the limits of herring densities found in previous years. A transect spacing of 15 nautical miles is used in most parts of the area with the exception of some relatively high density sections, east and west of Shetland, north of Ireland in the Skagerrak where short additional transects were carried out at 7.5 nautical miles spacing, and in the southern area, where a 30 nautical miles transect spacing is used.

The following target strength to fish length relationships have been used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L -71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

Data are reported through standardised data exchange format and uploaded into the FishFrame database, currently held at DTU Aqua, Charlottenlund, Denmark. National estimates are aggregated through Fishframe during PGIPS to calculate global estimates for the North Sea, the Malin Shelf and the western Baltic Sea. The exchange format currently holds information on the ICES statistical rectangle level, with at least one entry for each rectangle covered, but more flexible strata are accommodated by allowing multiple entries for abundance belonging to different strata. Data submitted consists of the ICES rectangle definition, biological stratum, herring abundance by proportion of autumn spawners (North Sea and VIa North) and Spring spawners (Western Baltic, age and maturity, and survey weight (survey track length). Data are presented according to the following age/maturity classes: 1 immature (maturity stage 1 or 2), 1 mature (maturity stage 3+), 2 immature, 2 mature, 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+. In addition to proportions at age data on mean weights and mean length are reported at age/maturity by biological strata. Data are combined using an effort weighted mean based on survey effort reported as number of nautical miles of cruise track per statistical rectangle. A combined survey report is produced annually. Apart from the Biomass index for 1-9+-ringers, mean weights at age in the catch and proportions mature are derived from the survey to be used in the NSAS assessment.

B.3.2 International Bottom Trawl Survey:

The International Bottom Trawl Survey (IBTS) started out as a Young Herring Survey (IYHS) in 1966 with the objective of obtaining annual recruitment indices for the combined North Sea herring stocks (Heessen *et al.*, 1997). It has been carried out every year since, and it was realized that the survey could provide recruitment indices not only for herring, but for roundfish species as well. Examination of the catch data from the 1st quarter IBTS showed that these surveys also gave indications of the abundances of the adult stages of herring, and subsequently the catches have been used for estimating 2-5+ ringer abundances. The surveys are carried out in 1st quarter (February) and in 3rd quarter (August-September) using standardized procedures among all participants. The standard gear is a GOV trawl, and at least two hauls are made in each statistical rectangle. In 2007 the IBTS was extended into English Channel. In addition, historical IBTS indices have been updated from 2004 onwards (in 2007).

In 1977 sampling for late stage herring larvae was introduced at the IBTS 1st quarter, using Isaccs-Kidd Midwater trawls. These catches appeared as a good indicator of herring recruitment, however examination of IKMT performance showed deficiencies in its catchability for herring larvae, and a more applicable gear, a ring net (MIK) was suggested as an alternative gear. Hence, gear type was changed in the mid 90'ies, and the MIK has been the standard gear of the programme since. This ring net is of 2 meter in diameter, has a long two-legged bridle, and is equipped with a black netting of 1.5 mm mesh size. Two oblique hauls per ICES statistical rectangle are made during night.

Indices of 2-5+ ringer herring abundances in the North Sea (1st quarter). Fishing gear and survey practices were standardised from 1983, and herring abundance estimates of 2-5+ ringers from 1983 onwards has shown the most consistent results in assessments of these age groups. This series is used in North Sea herring assessment. Catches in Division IIIa are not included in this index. These estimates are determined by the standard IBTS methodology developed by the ICES IBTS working group.

Index of 1-ringer recruitment in the North Sea (1st quarter). The 1-ringer index of recruitment is based on trawl catches in the entire survey area, hence, all 1-ringer herring caught in Division IIIa is included in this index. Indices are calculated as an area weighted mean over means by ICES statistical rectangle, and are available for year classes 1977 to recent. The Downs herring hatch later than the other autumn spawned herring and generally appears as a smaller sized group during the 1st quarter IBTS. A recruitment index of smaller sized 1-ringers is calculated using the standard procedure, but solely based on abundance estimates of herring <13 cm (ICES CM 2000/ ACFM:10, and ICES CM 2001/ACFM:12).

MIK index of 0-ringer recruitment in the North Sea (1st quarter). The MIK catches of late stage herring larvae are used to calculate an 0-ringer index of autumn spawned herring in the North Sea, this represents recruitment strength (Nash & Dickey-Collas 2005). A flowmeter at the gear opening is used for estimation of volume filtered by the gear, and using this information together with information on bottom depth, the density of herring larvae per square meter is estimated. The mean herring density in statistical rectangles is raised to mean within subareas, and based on areas of these subareas an index of total abundance is estimated (see also ICES 1996/Asses:10). The series estimates for subareas as well as the total index.

B.3.3. Larvae:

Surveys of larval herring have a long tradition in the North Sea. Sporadic surveys started around 1880, and available scientific data goes back to the middle of the 20th century. The co-ordination of the International Herring Larvae Surveys in the North Sea and adjacent waters (IHLS) by ICES started in 1967, and from 1972 onwards all relevant data are achieved in a data base (ICES PGIPS). The surveys are carried out annually to map larval distribution and abundance (Schmidt *et al.*, 2009). Larval abundance estimates are of value as relative indicators of the herring spawning biomass in the assessment.

Nearly all countries surrounding the North Sea have participated in the history of the IHLS. Most effort was undertaken by the Netherlands, Germany, Scotland, England, Denmark and Norway. A number of other nations have contributed occasionally. A sharp reduction in ship time and number of participating nations occurred in the end of the 1980s. Since 1994 only the Netherlands and Germany contribute to the larvae surveys, with one exception in 2000 when also Norway participated.

Larvae Abundance Index (LAI): The total area covered by the surveys is divided into 4 sub areas corresponding to the main spawning grounds. These sub areas have to be sampled in different given time intervals. The sampling grid is standardized and stations are approximately 10 nautical miles apart. The standard gear is a GULF III or GULF VII sampler (Nash *et al.*, 1998). Newly hatched larvae less than 10 mm total length (11 mm for the Southern North Sea) are used in the index calculation. To estimate larval abundance, the mean number of larvae per square meter obtained from the Ichthyoplankton hauls is raised to rectangles of 30x30 nautical miles and the corresponding surface area. These values are summed up within the given unit and provide the larval abundance per unit and time interval.

Multiplicative Larval Abundance Index (MLAI): The traditional LAI and LPE (Larval Production Estimates) rely on a complete coverage of the survey area. Due to the substantial decline in ship time and sampling effort since the end of the 80s, these indices could not be calculated in their traditional form since 1994. Instead, a multiplicative model was introduced for calculating a Multiplicative Larvae Abundance Index (MLAI, Patterson & Beveridge, 1995). In this approach the larvae abundances are calculated for a series of sampling units. The total time series of data are used to estimate the year and sampling unit effects on the abundance values. The unit effects are used to fill un-sampled units so that an abundance index can be estimated for each year.

Calculation of the linearised multiplicative model was done using the equation:

ln(Indexyear,LAI unit) = MLAIyear + MLAI$_{LAI}$ unit + uyear, LAI unit

where MLAIyear is the relative spawning stock size in each year, MLAI$_{LAI}$ unit are the relative abundances of larvae in each sampling unit and year, LAI unit are the corresponding residuals (Gröger *et al.*, 1999, 2000). The unit effects are converted such that the first sampling unit is used as a reference (Orkney/Shetland 01-15.09.72) and the parameters for the other sampling units are redefined as differences from this reference unit. The model is fitted to abundances of larvae less than 10 mm in length (11 mm for SNS). The MLAI is updated annually and represent all larval data since 1972. The time series is used as a biomass index in the herring assessment.

Another larval abundance index (**SCAI- Spawning Component Abundance Index**) has been developed to reduce the problems of missing observations and a high sampling noise (Payne 2010). It is a simple state-space statistical model that is considered robust to these problems. The model gives a good fit to the data and is demonstrated to be capable of both handling and predicting missing observations well. Furthermore, the sum of the fitted abundance indices across all components is a proxy for the biomass of the total stock, even though they only model processes at the component level. The use of this index will be further explored in the future.

B.4. Commercial CPUE

Not used for pelagic stocks.

B.5. Other relevant data

B.5.1 Separation of North Sea Autumn Spawners and IIIa-type Spring Spawners

North Sea Autumn Spawners and IIIa-type Spring Spawners occur in mixtures in fisheries operating in Divisions IIIa and IVaE (ICES, 1991/Assess:15; Clausen *et al.*, 2007): mainly 2+ ringers of the Western Baltic spring-spawners and 0-2-ringers from the North Sea autumn-spawners, including winter-spawning Downs herring. In addition, several local spawning stocks have been identified with a minor importance for the herring fisheries (ICES, 2001/ACFM 12).

The method of separating herring in Norwegian samples, using vertebral counts as described in former reports of this Working Group (ICES 1990/ Assess:14) assumes that for autumn spawners, the mean vertebral count is 56.5 and for Spring spawners 55.80. The fractions of spring spawners (fsp) are estimated from the formula (56.50-v)/(56.5-55.8), where v is the mean vertebral count of the (mixed) sample with the restriction that the proportion should be one if fsp>=1 and zero if fsp<=0. The method is quite sensitive to within-stock variation (e.g. between year classes) in mean vertebral counts.

Experience within the Herring Assessment Working Group has shown that separation procedures based on size distributions often will fail. The introduction of otolith microstructure analysis in 1996-97 (Mosegaard & Popp-Madsen, 1996) enables an accurate and precise split between three groups, autumn, winter and spring-spawners. However, different populations with similar spawning periods are not resolved with the present level of analysis. Different stock components that are not easily distinguished by their otolith microstructure (OM), are considered to have different mean vertebral counts (vs) as, e.g., winter-spawning Downs herring: 56.6 (Hulme, 1995), and the small local stocks, the Skagerrak winter/spring-spawners: 57 (Rosenberg and Palmén, 1982). Further, the estimated stock specific mean vs count varies somewhat among different studies; North Sea: 56.5, Western Baltic Sea: 55.6 (Gröger & Gröhsler, 2001) and North Sea: 56.5, Western Baltic Sea: 55.8 (ICES 1992/H:5). Comparison between separation methods using frequency distributions of vertebral counts and otolith microstructure showed reasonable correspondence. Using this information the years from 1991 to 1996 was reworked in 2001, applying common splitting keys for all years by using a combination of the vertebral count and otolith microstructure methods (ICES, 2001/ACFM:12). From 2001 and onwards, the otolith-based method only has been used for the Division IIIa.

Different methods of identifying herring stocks in the Division IIIa and Subdivisions 22-24 were evaluated in EU CFP study project (EC study 98/026). The study involved several inter-calibration sessions between microstructure readers in the different laboratories involved with the WBSS herring. After the study was finished a close collaboration concerning reader interpretations has been kept between the Danish and Swedish laboratories. Sub-samples of the 2002 and 2003 Danish, Swedish, and German microstructure analyses were double-checked by the same Danish expert reader for consistency in interpretation. The overall impression is an increasingly good agreement among readers (Clausen *et al.*, 2007).

New molecular genetic approaches for stock separation are being developed within the EU-FP5 project HERGEN (EU project QLRT 200-01370). Sampling of spawning aggregations during spring, autumn and winter has been carried out in 2002 and in 2003 in Division IIIa and in the Western Baltic at more than 10 different locations. Preliminary results point at a substantial genetic variation between North Sea and Western Baltic herring (Bekkevold *et al*., 2005; 2007; Ruzzante *et al*., 2006).

After the introduction of otolith microstructure analysis in 1996 it was discovered that in the western Baltic a small percentage of the herring landings might consist of autumn-spawners individuals. Before molecular genetic methods became available for Atlantic herring the existence of varying proportions of autumn spawners in Subdivisions 22–24 in different years was considered a potential problem for the assessment.

B.5.2 Mixing of North Sea spawning components

The relative populations of the spawning components of herring in the North Sea vary over time and show different dynamics (see Dickey-Collas *et al*., 2010). These broad dynamics can be monitored through the surveys and of larvae (Schmidt *et al*. 2009; Payne, 2010) or investigated in the catch (Bierman *et al*, 2010). For conservation and biodiversity objectives it is important to monitor the dynamics and resilience of the different spawning components, especially when they experience differing exploitation rates or changes in productivity (Kell *et al*., 2009).

C. Historical Stock Development

C.1 Model used:

A benchmark assessment for North Sea herring was carried out in 2006. Following the benchmark investigation in 2006, the tool for the assessment of North Sea herring is ICA. However, the environment to execute the ICA has changed from the original ICA software into FLR (now called FLICA). Justification of the choice of assessment model, catch and survey weightings and the length of separable period are found in HAWG 2006 and Simmonds (2003; 2009). After extensive testing HAWG assumes there are no differences between the old ICA and FLICA. Thus FLICA was used to carry out the assessments after 2008.

The assessment has the same set-up and basic assumption as the assessment that was carried out last year. Input data are given in Tables 2.6.2.2. The ICA programme operates by minimising the following general objective function:

$$\sum \lambda_c \left(C - \hat{C}\right)^2 + \sum \lambda_i \left(I - \hat{I}\right)^2 + \sum \lambda_r \left(R - \hat{R}\right)^2$$

which is the sum of the squared differences for the catches (separable model), the indices (catchability model) and the stock-recruitment model.

The final objective function chosen for the stock assessment model was:

$$\sum_{a=0,y=1997}^{a=8,y=2002} \lambda_a (\ln(\hat{C}_{a,y}) - \ln(C_{a,y}))^2 +$$
$$\sum_{y=1979}^{y=2002} \lambda_{mlai} \cdot (\ln(q_{mlai}.\hat{SSB}_y^K) - \ln(MLAI_y))^2 +$$
$$\sum_{a=1,y=1983**}^{a=5+,y=2003} \lambda_{a,ibtsa} (\ln(q_{a,ibtsa} \cdot \hat{N}_{a,y}) - \ln(IBTS_{a,y}))^2 +$$
$$\sum_{a=1,y=1989}^{a=9+,y=2002} \lambda_{a,acoust} (\ln(q_{a,acoust} \cdot \hat{N}_{a,y}) - \ln(ACOUST_{a,y}))^2 +$$
$$\sum_{y=1977}^{y=2003} \lambda_{mik} (\ln(q_{mik} \cdot \hat{N}_{0,y}) - \ln(MIK_y))^2 +$$
$$\sum_{y=1960}^{y=2002} \lambda_{ssr} (\ln(\hat{N}_{0,y+1}) - \ln\left(\frac{\alpha \hat{SSB}_y}{\beta + \hat{SSB}_y}\right))^2$$

** except for 1 ring IBTS which runs from 1979 to 2002

with the following variables:

a,y	age (rings)and year
C	Catch at age (rings)
$\hat{C}$	Estimated catch at age (rings) in the separable model
$\hat{N}$	Estimated population numbers
$\hat{SSB}$	Estimated spawning stock size
MLAI	MLAI index (biomass index)
ACOUST	Acoustic index (age disaggregated)
IBTS	IBTS index (1-5+ ringers)
MIK	MIK index (0-ringers)
q	Catchability
k	power of catchability model
α, β	parameters to the Beverton stock-recruit model
λ	Weighting factor

Software used: FLICA, based on ICA (Patterson, 1998; Needle, 2000; Kell *et al*., 2007)

Model Options chosen:

The model settings should be as follows (as determined by the last benchmark, HAWG 2006)

FLICA control settings	Settings	Description
sr	TRUE	Stock and recruitment relationship
sr.age	1	age at recruitment
lambda.age	0.1 0.1 3.67 2.87 2.23 1.74 1.37 1.04 0.94 0.91	Weighting matrices for catch-at-age; for aged surveys; for SSB surveys
lambda.yr	1 1 1 1 1	Relative weights by year
lambda.sr	0.1	weight for the SRR term in the objective function
index.model	linear – IBTS Q1 linear – MIK linear – Acoustic power - MLIA	Catchability model for each survey
index.cor	False	Are the age-structured indices correlated across ages
sep.nyr	5	Number of years for separable model
sep.age	4	Reference age for fitting the separable model
sep.sel	1	Selection on last true reference age

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	*Catch in tonnes*	*1960-2009*		*Yes*
Canum	*Catch at age in numbers*	*1960-2009*	*0-9+*	*Yes*
Weca	*Weight at age in the commercial catch*	*1960-2009*	*0-9+*	*Yes*
West	*Weight at age of the spawning stock at spawning time.*	*1960-2009*	*1-9+*	*Yes (3 year running mean)*
Mprop	*Proportion of natural mortality before spawning*	*1960-2009*	*1-9+*	*No*
Fprop	*Proportion of fishing mortality before spawning*	*1960-2009*	*1-9+*	*No*
Matprop	*Proportion mature at age*	*1960-2009*	*1-9+*	*Yes*
Natmor	*Natural mortality*	*1960-2009*	*1-9+*	*No*

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE (WR)
Tuning fleet 1	*IBTS Q1*	*1984-2010*	*1-5*
Tuning fleet 2	*MIK*	*1992-2010*	*0*
Tuning fleet 3	*Acoustic*	*1989-2009*	*1-9+*
Tuning fleet 4	*MLAI*	*1973-2009*	*SSB*

C.2 Variance and weighting factors for ICA

In the ICA model a fixed set of inverse variance weights for surveys and catch at age have been used. In the benchmark assessment in 2006 (ICES 2006/ACFM:20) the weighting factors of the indices used in ICA were fixed and have been used with the same values since. This reflects a slight change from a major investigation in 2001 carried out by the Study Group on Evaluation of Current Assessment Procedures for North Sea herring (SGEHAP, ICES 2001/ACFM:22). The original weighting factors were derived from the survey and catch data by methods given in ICES 2001/ACFM:22 and Simmonds (2003). The variance used is the variance of the natural logarithm of the estimates of the index based on a 2 stage bootstrap procedure. The choice matches the use of a maximum log likelihood method with a lognormal error distribution used within the ICA model. All indices are treated in the same manner. The individual station estimates at all ages are bootstrapped using a simple resampling with replacement procedure. This provides a variance covariance estimate of estimates of indices at age for each index assuming identically independently distributed samples. (iid)

As the spatial distributions are correlated and the sampling on the surveys are non-random in space, the spatial autocorrelation was taken into account using geostatistics. The methodology is described in Rivoirard *et al*. (2000), who provide the formulae and methods required to estimate variograms and calculate the estimation variance. Petitgas and Lafont (1997) provide the free software (EVA2) that has been used here for calculating the estimation variance for all the surveys. The iid estimates are corrected to provide overall estimates of variance covariance estimates across ages for each survey. The mean variance covariance estimate for the survey time series was calculated to provide one average variance/covariance matrix per survey.

ICA does not explicitly deal with covariance (in common with many assessment models) but it does allow modification of weights at age to account for this in a general way. The concept is to reduce the inverse variance factor by an amount that accommodates the covariance. The limits are: for zero correlation a factor of unity; for 100% covariance over n ages weights of 1/n. In both surveys the 1 to 2 group estimates are effectively independent and can be given weighting due to the full inverse variance weight, for subsequent ages the weighting has been implemented here for intermediate values of covariance to give the *Wage* weighting factors at age:

$$W_{age} = \frac{1}{\mathrm{var}_{age}}\{n - \sum \mathrm{cov}_{age,age-1}\} / \{\mathrm{cov}_{age,age-1} / \sum 1/\mathrm{cov}_{age,age-1}\}$$

Where var_{age} is the variance of ln(estimate at age)

cov is covariance (age, age-1)

n is the number of ages in the correlated sequence

The resulting correlation correction factors are given in Table 2.6.7.3 in HAWG Report 2008.

The weighting factors used since 2006 (ICES 2006/ACFM:20) are given in Table 1 and can be compared with the old weighting factors derived under SGEHAP (ICES 2001/ACFM:22). The major difference is a slight general reduction in survey weights relative to the catch. Among the surveys the resulting spread of weights is generally similar to the earlier values, reducing with age, more steeply with the IBTS than the acoustic. The major difference is the MIK weighting which is reduced to about 1/3 of the previous value. The change is caused by the recent extended analysis. The difference between the previous analysis and this one was that in the earlier work the geostatistical analysis of spatial variance was limited to only a few recent years in each series. This resulted quite accidentally and unknowingly in selecting years from the MIK index that were very precise.

Table 1: North Sea herring. New weighting factors (ICES 2006 /ACFM:20) based on bootstrap of survey data (Simmonds 2009). Old weights are included for comparison

	Catch		*Acoustic*		*IBTS*		*MIK*		*MLAI*	
Age	*Old*	*New*	*Old*	*New*	*Old*	*New*	*Old*	*New*	*Old*	*New*
0	***0.10***	***0.10***					***2.05***	***0.63***		
1	***0.10***	***0.10***	***0.74***	***0.63***	***0.67***	***0.47***				
2	***3.17***	***3.67***	***0.75***	***0.62***	***0.24***	***0.28***				
3	***2.65***	***2.87***	***0.64***	***0.17***	***0.06***	***0.01***				
4	***1.94***	***2.23***	***0.27***	***0.10***	***0.03***	***0.01***				
5	***1.31***	***1.74***	***0.14***	***0.09***	***0.03***	***0.01***				
6	***0.97***	***1.37***	***0.13***	***0.08***						
7	***0.75***	***1.04***	***0.12***	***0.07***						
8	***0.55***	***0.94***	***0.07***	***0.07***						
9	***0.54***	***0.91***	***0.07***	***0.05***						
SSB									***0.65***	***0.60***

D. Short-Term Projection

The short-term prediction method was substantially modified in 2002. Following the review by SGEHAP (ICES 2001/ACFM:22), which recommended that a simple multi-fleet method would be preferable, the complex split-factor method used for a number of years prior to 2002 has not been used since. The multi-fleet, multi-option, deterministic short-term prediction programme (MFSP) was accepted by ACFM in 2002 and further refined in 2003. It has been used routinely to perform short term predictions for this stock since then. The good agreement between predicted biomass for the intermediate year and SSB taken from the assessment one year after demonstrates that the current prediction procedure for stock numbers is working well.

Method

The procedure and programme used changed considerably and is a copy of the (MFSP Skagen; WD to HAWG 2003) code but rewritten in R. Both the Short Term Forecast Module North Sea (STFMNS, Hintzen) and the MFSP program have extensively been tested in 2009. For the North Sea herring, managers have agreed to constrain the total outtake at levels of fishing mortalities for ages 0-1 and 2-6, and need options to show the trade-off between fleets within those limits.

Input data

Fleet Definitions

The current fleet definitions are:

North Sea

Fleet A: Directed herring fisheries with purse seiners and trawlers. By-catches in industrial fisheries by Norway are included.

Fleet B: Herring taken as by-catch under EU regulations.

Division IIIa

Fleet C: Directed herring fisheries with purse seiners and trawlers

Fleet D: By-catches of herring caught in the small-mesh fisheries

The fleet definitions are the same as last year.

In some years, it has been agreed that Norway can take parts of its IIIa quota in the North Sea. When estimating the expected catch in the intermediate year, it is assumed that this transfer takes place, hence the assumed catch by the C-fleet of both stocks combined is reduced and the catch by the A-fleet increased with the agreed amount.

Input Data for Short Term Projections: All the input data for the short term projections are shown in Table 2.7.1 – Table 2.7.11, which is the input file for the predictions.

Stock Numbers: For the start of the intermediate year the stock numbers at age by 1. Jan that year are taken from the prediction made by ICA.

Recruitment: For the prediction years, the recruitment has in recent years been set to the geometric mean of the recruitments of the year classes from 2001 onwards, as estimated in this year's assessment. The low recruitment was assumed because all the year classes from 2001 onwards have been poor except for 2008 year class. Analysis of the time series of SSB and recruitment data by the SGRECVAP (ICES CM 2006/LRC:03) clearly indicates a shift in the recruitment success in 2001. The underlying cause for the change in 2001 is not clear, but there is no evidence to justify an assumption of long term average recruitment in the near future. Consequently, the advice is adapted to the current low recruitment regime.

Fishing Mortalities: Selection by fleet at age is calculated by splitting the total fishing mortality in the last assessment year at each age (from the assessment output) proportional to the catches by fleets at that age. These selections at age were used for all years in the prediction.

Mean weights in the catch by fleet: The 3 year average mean weights at age for each fleet are used for all prediction years, unless there are indications that some year class has abnormal growth.

Mean Weights at age in the stock: The weights at age applied in the last assessment year were used for all predictions years. These are running averages of the raw data. In previous years, the procedure was different, to account for the special growth of the 2000 year class.

Maturity at age: The 3 years average maturity was used.

Natural Mortality: Equal to those assumed in the assessment.

Proportion of M and F before spawning: Standard values of 0.67 for both.

Prediction

Assumptions for the intermediate year.

A-fleet: The TAC for the A fleet has been over-fished every year since 2003 until 2008. In 2009 however the catches equalled the TAC and it is assumed that this will be the case in the intermediate year as well.

The catches by the B-fleet have been well below the by-catch quota for the B-fleet. The quota has been reduced recently, and the fraction used has increased. Therefore, the same fraction as last year is assumed. Also the C and D fleets have catches well below the quota, partly because the quota also includes WBSS herring. For 2010, the same fraction as in 2009 was assumed; previously a 3 year average has been used in some cases.

Points of interpretation:

In years when Norway is allowed to transfer some of its quota in IIIa to IV, this transfer is assumed in the predictions

Management Option Tables for the TAC year

The EU-Norway agreement on management of North Sea herring was updated in 2008, to adapt to the present reduced recruitment, accounting for the results by WKHMP. The revised rule specifies fishing mortalities for juveniles ($F_{0\text{-}1}$) and for adults ($F_{2\text{-}6}$) not to be exceeded, at 0.05 and 0.25 respectively, for the situation where the SSB is above 1.5 million tonnes. When the SSB is below 1.5 million tonnes F is reduced to give

$F_{2\text{-}6}$= 0.25-(0.15*(1500-SSB)/700),

with allowance for a stronger reduction in TAC if necessary. Below 0.8 million tonnes $F_{2\text{-}6}$= 0.1 and $F_{0\text{-}1}$ = 0.04.

Furthermore, there is a constraint at 15% change in the TAC from one year to the next. The $F_{0\text{-}1}$ and $F_{2\text{-}6}$ stated in the rule are assumed to apply to the total F summed over all fleets. The SSB referred to is taken to be the SSB in the prediction year, i.e. the fishing mortalities for 2010 should reflect its consequence for SSB in 2010.

Catches by the C and D fleet influence the fishing opportunities for the B-fleet in particular, since the NSAS herring caught by these fleets mostly are at age 0-2. The assumed catch of NSAS herring by the C and D fleets is derived according to a likely TAC for WBSS herring in a three step procedure:

1) The fraction of the total TAC for WBSS that is taken in Division IIIa is assumed to be the same as last year, giving an expected catch of WBSS in Division IIIa.
2) The WBSS caught in Division IIIa is allocated to the C and D fleets assuming the same share as last year. The total expected catch of WBSS in IIIa is split accordingly, which gives expected catch of WBSS by fleet.
3) Using the ratio between NSAS and WBSS in the catches by each fleet, the total catch by fleet and the catch of NSAS by fleet are derived from the catch of WBSS by fleet.

These expected catches of NSAS by the C and D fleets are used as catch constraints in the prediction.

The basis for deriving these catches is weak. The main purpose is to provide realistic assumptions on the impact of these fleets when predicting the catches for the North Sea fleets. The effect of other assumptions for the C and D fleet should be calculated if needed, but are not presented in the advice.

The catches for the A and B fleets are derived according to the harvest rule.

When the harvest rule leads to SSB below the trigger biomass (1.5 million tonnes), an iterative procedure is needed to find a fishing mortality and a corresponding SSB in accordance with the rule. At present, this is done manually by scanning over ranges of F for the A and B fleet.

E. Medium-Term Projections – *–are made as needed.*

Model used: 10 year stochastic prediction Software used: STPR3 has been used as a standard in the past, as it allows for independent regulations of two 'flles' (fisheries)

Initial stock size: As for the short term prediction, but with random variation according the variance-covariance matrix taken from the ICA assessment

Natural mortality: Constant as in the assessment

Maturity: As in the short term prediction

F and M before spawning: Constant values: 0.67 for both.

Weight at age in the stock: Obtained each projection year by drawing a historical year randomly and using the weights from that year.

Weight at age in the catch: As weight at age in the stock.

Exploitation pattern: As for short term forecast. Fleet A separately, fleets B-C-D merged.

Intermediate year assumptions: As for short term prediction

Stock recruitment model used: Beverton Holt or Hockey stick

Uncertainty models used:

Initial stock size: See above

Natural mortality: Constant

Maturity: Constant

F and M before spawning: Constant

Weight at age in the stock: See above

Weight at age in the catch: See above

Exploitation pattern: Constant

Intermediate year assumptions: Constant

Stock recruitment model used: Log-normal variation around a stock-recruit function with fixed parameters. Opportunity to truncate the distribution.

F. Long-Term Projections – *–not done since 1996*

G. Biological Reference Points

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

The Blim

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

Fpa and Bpa

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

Concept of a management plan (harvest control rule)

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

Concept of precautionary reference points

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

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

The consequences for the management plan and the reference points of the development of the MSY approach is currently unknown.

H. Other Issues

H.1 Biology of the species in the distribution area

The herring (*Clupea harengus*) is a pelagic species which is widespread in its distribution throughout the North Sea. Herring originated in the Pacific and colonised the Atlantic approximately 3 million years ago. The herring's unique habit is that it produces benthic eggs which are attached to a gravely substrate on the seabed (Geffen 2009). Herring evolved from fish that spawned in rivers and at some later date re-adapted to the marine environment (Geffen 2009). The spawning grounds in the southern North Sea are located in the beds of rivers which existed in geological times and some groups of spring spawning herring still spawn in very shallow inshore waters and estuaries. Spawning typically occurs on coarse gravel (0.5-5 cm) to stone (8-15 cm) substrates and often on the crest of a ridge rather than hollows. For example, in a spawning area in the English Channel, eggs were found attached to flints 2.5-25 cm in length, where these occurred in gravel, over a 3.5 km by 400m wide strip.

As a consequence of the requirement for a very specific substrate, spawning occurs in small discrete areas in the near coastal waters of the western North Sea (Schmidt *et al*., 2009). They extend from the Shetland Isles in the north through into the English Channel in the south. Within these specific areas actual patches of spawn can be extremely difficult to find.

The fecundity of herring is length related and varies between approximately 10 000 and 60 000 eggs per female (Damme *et al*., 2009). This is a relatively low fecundity for teleosts. The age of first maturity is 3 years old (2 ringers) but the proportion mature at age may vary from year to year dependent on growth. Over the past 15 years the proportion mature at age 3 years (2 ringers) has ranged from 47% to 86% and for 4 year old fish (3 winter ringers) from 63% to 100%. Above that age, all are considered to be mature.

The benthic eggs take about three weeks to hatch dependant on the temperature. The larvae on hatching are 6 mm to 9 mm long and rise due to buoyancy changes to become planktonic (Dickey-Collas *et al*, 2009). Their yolk sac lasts for a few days during which time they will begin to feed on phytoplankton and small zooplankton. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to various coastal nursery areas on both sides of the North Sea and into the Skagerrak and Kattegat (Heath *et al*., 1997).

Herring continue to be mainly planktonic feeders throughout their life history although there are numerous records of them taking small fish, such as sprat and sandeels, on an opportunistic basis. Calanoid copepods, such as *Calanus*, *Pseudocalanus* and *Temora* and the Euphausids, *Meganyctiphanes* and *Thysanoessa* still form the major part of their diet during the spring and summer (Hardy, 1924; Savage, 1937; Bainbridge and Forsyth, 1972; Last, 1989) and are responsible for the very high fat content of the fish at this time. They also consume fish eggs (Segers *et al*., 2007).

In the past, herring age has been determined by using the annual rings on the scales. In more recent years the growth rings on the otolith have proved more reliable for age determination. Herring age is expressed as number of winter rings on the otolith rather than age in years as for most other teleost species where a nominal 1 January birth date is applied. Autumn spawning herring do not lay down a winter ring during their first winter and therefore remain as '0' winter ringers until the following winter. When looking at year classes, or year of hatching, it must be remembered that they were spawned in the year prior to their classification as '0' winter ringers.

North Sea herring comprise both spring and autumn spawning groups, but the major fisheries are carried out on the offshore autumn/winter spawning fish. The spring spawners are found mainly as small discrete coastal groups in areas such as The Wash, the Thames estuary, Danish Fjords and the now extinct Zuiderzee herring. Juveniles of the spring spawning stocks are found in the Baltic, Skagerrak and Kattegat, and may also be found in the North Sea as well as Norwegian coastal spring spawners. There is thought to be an input of larvae from the west of Scotland (Heath et al., 1997).

The main autumn spawning begins in the northern North Sea in August and progresses steadily southwards through September and October in the central North Sea to November and as late as January in the southern North Sea and eastern English Channel. The widespread but discrete location of the herring spawning grounds throughout the western North Sea has been well known and described since the 19th century (Heincke, 1898; Bjerkan, 1917). This led to considerable scientific debate and eventually to investigation and research on stock identity. The controversy centred on whether or not the separate spawning grounds represented discrete stocks or 'races' within the North Sea autumn spawning herring complex (McQuinn, 1997). Resolution of this issue became more urgent as the need for the introduction of management measures increased during the 1950's. The International Council for the Exploration of the Sea (ICES) encouraged tagging and other racial studies and a review of all the historic evidence to resolve this problem and innovative approaches to assessing mixed and connective stocks (Secor *et al*., 2009; Kell *et al*., 2009). The conclusions were the basis for establishing the working hypothesis that the North Sea autumn spawning herring comprise a complex of at least four spawning components each with separate spawning grounds, migration routes and nursery areas. There is mixing between these components during the summer

The main four spawning components are:

- The Orkney/Shetland component which spawn from July to early September in the Orkney Shetland area. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.
- The Buchan component which spawn from August to early September off the Scottish east coast. Nursery areas for fish up to two years old are found along the east coast of Scotland and also across the North Sea and into the Skagerrak and Kattegat.
- The Banks or central North Sea component, which derive their name from their former spawning grounds around the western edge of the Dogger Bank. These spawning grounds have now all but disappeared and spawning is confined to small areas along the English east coast, from the Farne Islands to the Dowsing area, from August to October. The juveniles are found along the east coast of England, down to the Wash, and also off the west coast of Denmark.
- The Downs component which spawns in very late Autumn through to February in the southern Bight of the North Sea and in the eastern English Channel. The drift of their larvae takes them north-eastwards to nursery areas along the Dutch coast and into the German Bight (Burd 1985).

At certain times of the year, individuals from the three stock units may mix and are caught together as juveniles and adults but they cannot be readily separated in the commercial catches other than using otolith methods (Clausen *et al*, 2007; Bierman *et al*., 2009). However North Sea autumn spawning herring are managed as a single unit with the understanding that they comprise of many spawning components.

A further complication is that juveniles of the North Sea stocks are found, outside the North Sea, in the Skagerrak and Kattegat areas and are caught in various fisheries there. The proportions of juveniles of North Sea origin, found in these areas varies with the strength of the year class, with higher proportions in the Skagerrak and Kattegat when the year class is good.

Recruitment strength is determined during the larval phase (Nash & Dickey-Collas 2005) and this is likely to occur prior to the larvae being 20mm in length (Oeberst *et al.*, 2009).

H.2 Stock dynamics, regulation and catches through 20th century

Over many centuries the North Sea herring fishery has been a cause of international conflict sometimes resulting in war, but in more recent times in bitter political argument. The North Sea herring fishery has a long history and catches between 1600 and 1850 were usually between 40 000 and 100 000 tonnes per year (Poulsen 2006). Catching opportunities for the fishery were known to be variable. Since the 1900s the annual average catch was 450 Kt. Changes in fleet catching potential have been driven both by changes in catching power and in response to changes in market requirements, particularly the demand for fish meal and oil. Most of these changes have resulted in greater exploitation pressures that increasingly led to the urgent need to ensure a more sustainable exploitation of North Sea herring. Such pressures really began to exert themselves for the first time during the 1950's when the spawning stock biomass of North Sea autumn spawning herring fell from 5 million tonnes in 1947 to 1.4 million tonnes by 1957 (Simmonds 2007, 2009). That period also witnessed the decline and eventual disappearance of a traditional autumn drift net fishery in the southern North Sea (Burd, 1978).

At the time and with the exception of the 12-mile coastal zone, the North Sea was still a free fishing area and the stock was exploited by fleets from at least 14 different nations (ICES, 1977). Despite the conclusions of the ICES Herring Assessment Working Group becoming more alarming each year (ICES, 1977), the North East Atlantic Fisheries Convention (NEAFC) had no mandate to impose measures unless they were agreed by all member states (Ackefors, 1977). As a consequence, NEAFC could only agree on measures that constituted no real obstacle to any of the national fleets involved (Simmonds, 2007).

The annual landings from 1947 through to the early 1960's were high, but stable, averaging around 650 000t (Cushing and Bridger, 1966). Over the period 1952-62, the high fishing mortality (F 0.4 ages 2-6) resulted in a rapid decline in the spawning stock biomass from around 5 million tonnes to 1.5 million tonnes.

Fishing mortality on the herring in the central and northern North Sea began to increase rapidly in the late 1960's and had increased to F1.3 ages 2-6, or over 70% per year of those age classes, by 1968. Landings peaked at over 1 million tonnes in 1965, around 80% of which were juvenile fish. This was followed by a very rapid decline in the SSB and the total landings. By 1975 the SSB had fallen to 83 500 t, although the total landings were still over 300 000t (Simmonds 2007). At the same time, spawning in the central North Sea had contracted to the grounds off the east coast of England whilst spawning grounds around the edge of the Dogger Bank were no longer used. Recruitment collapsed. This heralded the serious decline and collapse of the North Sea autumn spawning herring stock which led to the moratorium on directed herring fishing in the North Sea from 1977 to 1981 (Cushing, 1992; Dickey-Collas *et al.*, 2010).

On the 1st of January 1977, all countries around the North Sea extended their exclusive economic zones (EEZ) to 200 miles (Coull, 1991). The North Sea was no longer a free fishing area and suddenly national governments could introduce conservation measures within their own areas. Using this opportunity, the British government was the first (March 1st, 1977) to declare a total ban on all directed herring fisheries in the British EEZ (Coull, 1991). Other governments were slow to follow. The scientific argument that a closure of the fishery was required finally persuaded all other countries to join in. By the end of June 1977, all directed herring fisheries in the North Sea ceased.

In general, the fishing ban was well respected, except in the Channel area where local trawlers continued to fish small quantities of spawning herring (ICES, 1982). Also, herring could still be landed as a by-catch taken in other fisheries, and limited directed fishing did occur on this basis. It was during this time that the European Union agreed on a Common Fisheries Policy and took responsibility for the management in all community waters. Some fleets moved to exploit herring stocks in adjacent areas. Following reports of a recovery of the Downs component, a small TAC for the southern North Sea and Channel area was set in 1981 and 1982. The ban on directed fishing in other areas of the North Sea was lifted in June 1983.

International larvae surveys and acoustic surveys were used to monitor the state of the stocks during the moratorium. By 1980 these surveys were indicating a modest recovery in the SSB from its 1977 low point of 52 000 t. By 1981 the SSB had increased to over 200 000 t. This was associated with an increase in the productivity of the stock, i.e. apparent compensatory recruitment (Nash *et al*., 2009). Once the fishery reopened in 1981 the North Sea autumn spawning herring stock was managed by a Total Allowable Catch (TAC) constraint through the EU Common Fisheries Policy and agreement with Norway. The TAC was only applied to the directed herring fishery in the North Sea which exploited mainly adult fish for human consumption. Targeted fishing for herring for industrial purposes was banned in the North Sea in 1976 but there was a 10% by-catch allowance in the fisheries for other species, including the small meshed fisheries for industrial purposes, mainly for sprat. Following the reopening of the now controlled fishery the SSB steadily increased, peaking at 1.3 million tonnes in 1989. Annual recruitment was well above the long-term average over this period. The 1985 year class was the biggest recorded since 1960 and the third highest in the records dating back to 1946 (Nash *et al*., 2009). Landings also steadily increased over this period reaching a peak of 876 000 tonnes in 1988. This resulted from a steady increase in fishing mortality to $F_{ages\ 2\text{-}6} = 0.6$ (ca. 45%) in 1985 and a high by-catch of juveniles in the industrial fisheries for sprat. Following a period of four years of below average recruitment (year classes 1987-91), SSB fell rapidly to below 500 000 tonnes in 1993. Fishing mortality further increased averaging $F_{ages\ 2\text{-}6}$=0.75 (ca. 52%) over the period 1992–95 and recorded landings regularly exceeded the TAC. The North Sea industrial fishery for sprat developed rapidly over this period with the annual catch increasing from 33 000 tonnes in 1987 to 357 000 tonnes by 1995. With the 10% by-catch limit as the only control on the catch of immature herring, there was a consequent high mortality on juvenile herring which averaged 76% of the total catch in numbers of North Sea autumn spawners over this period.

During the summer of 1991 the presence of the parasitic fungus *Ichthyophonus* spp was noted in the North Sea herring stock. All the evidence suggested that the parasite was lethal to herring and that its occurrence could have a significant effect on natural mortality in the stock and ultimately on spawning stock biomass. High levels of infection were recorded in the northern North Sea north of latitude 60°N whilst infection rates in the southern North Sea and English Channel were very low. Efforts were made to estimate the prevalence of the disease in the stock through a programme of research vessel and commercial catch sampling. This led to estimates of annual mortality up to 16% (Anon., 1993) which was of the same order as the estimate of fishing mortality at the time. It was recognised that the behavioural changes and catchability of infected fish affected the reliability of the estimate of prevalence of the disease in the population. The uncertainty about the effect on stock size varied between estimates of 5% to 10% and 20%. Continued monitoring of the progress of the disease showed that by 1994 the prevalence in the northern North Sea had fallen from 5% in 1992 to below 1% and confirmed that the infection did not appear to be spreading to younger fish. Ultimately it was concluded that the disease had caused high mortality in the northern North Sea during 1991 and subsequently declined to the point where by 1995 the disease induced increase in natural mortality was insignificant.

The increased fishing pressure during the first half of the 1990's and the disease induced increase in natural mortality led to serious concerns about the possibilities of a stock collapse similar to that in the late 1970's. Reported landings continued at around 650 000 tonnes per year whilst the spawning stock began to decline again from over 1 million tonnes in 1990. The assessments at that time were providing an over optimistic perception of the size of the spawning stock and, for example, it was not until 1995 that it was realised that the SSB in 1993 had already fallen below 500 000 tonnes. This was well below the minimum biologically accepted level of 800 000 tonnes (MBAL) which had been set for this stock at that time.

H.3 Management and ICES advice

In 1996, the total allowable catches (TACs) for Herring caught in the North Sea (ICES areas IV and Division VIId) were changed mid-year with the intention of reducing the fishing mortality by 50% for the adult part of the stock and by 75% for the juveniles. For 1997, the regulations were altered again to reduce the fishing mortality on the adult stock to 0.25 and for juveniles to less than 0.1 with the aim of rebuilding the SSB up to 1.1 million t in 1998 (Simmonds 2007).

According to the EU and Norway agreement adopted in December 1997, efforts should be made to maintain the SSB above the MBAL (Minimum Biologically Acceptable Level) of 800 000 tonnes. An SSB reference point of 1.3 million has been set above which the TACs will be based on an F= 0.25 for adult herring and F= 0.12 for juveniles. If the SSB falls below 1.3 million tonnes, other measures will be agreed and implemented taking account of scientific advice. The management agreement was revised in 2004 and now reads:

The stock is managed according to the EU-Norway Management agreement which was updated in November 2008, the relevant parts of the text are included here for reference:

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

0.25-(0.15*(1,500,000-SSB)/700,000) for 2 ringers and older, and no more than 0.05 for 0 - 1 ringers

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

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

H.4 Sampling of commercial catch

Sampling of commercial catch is conducted by the national institutes. HAWG has recommended for years that sampling of commercial catches should be improved for most of the stocks. In January 2008, a new directive for the collection of fisheries data was implemented for all EU member states (Commission Regulations 2008/949/EC, 2008/199 and 2008/665). The provisions in the "data directive" define specific sampling levels. As most of the nations participating in the fisheries on herring assessed here have to obey this data directive, the definitions applicable for herring and the area covered by HAWG are given below:

AREA	SAMPLING LEVEL PER 1 000 T CATCH		
Baltic area (IIIa (S) and IIIb-c)	*1 sample of which*	*100 fish measured and*	*50 aged*
Skagerrak (IIIa (N))	*1 sample*	*100 fish measured*	*100 aged*
North Sea (IV and VId):	*1 sample*	*50 fish measured*	*25 aged*
NE Atlantic and Western Channel ICES areas II, V, VI, VII (excluding d) VIII, IX, X, XII, XIV	*1 sample*	*50 fish measured*	*25 aged*

Exemptions to the above mentioned sampling rules are:

Concerning lengths:

(1) the national programme of a Member State can exclude the estimation of the length distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

(i) the relevant quotas must correspond to less than 5 % of the Community share of the TAC or

to less than 100 tonnes on average during the previous three years;

(ii) the sum of all quotas of Member States whose allocation is less than 5 %, must account for

less than 15 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programme to achieve for their overall landings the implementation of the sampling scheme described above, or another sampling scheme, leading to the same precision.

Concerning ages:

(1) the national programme of a Member State can exclude the estimation of the age distribution of the landings for stocks for which TACs and quotas have been defined under the following conditions:

i) the relevant quotas correspond to less than 10 % of the Community share of the TAC or to less than 200 tonnes on average during the previous three years;

ii) the sum of all quotas of Member States whose allocation is less than 10 %, accounts for less than 25 % of the Community share of the TAC.

If the condition set out in point (i) is fulfilled, but not the condition set out in point (ii), the relevant Member States may set up a coordinated programme as mentioned for length sampling.

If appropriate, the national programme may be adjusted until 31 January of every year to take into account the exchange of quotas between Member States;

H.5 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that:

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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References have not been thoroughly checked this year and are likely to be incomplete!

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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:	20.03.2010
Authors:	M. Cardinale, J. Dalskov, T. Gröhsler, H. Mosegaard, M. van Deurs, J. Gröger, T. Jansen, Worsøe Clausen, L.

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 in Kattegat, in the area east of Læsø, (ICES, 2005; ICES, 2006). In 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 an historical 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 previous mentioned local spring-spawners from the Norwegian Skagerrak fjords (it should be emphasised that this is not the Norwegian Spring Spawners alias Atlantic-Scandio Herring), is higher than for the NSAS (Rosenberg and Palmén, 1982; van Deurs, 2005), and will bias fsp estimates if present in the samples. The Norwegian samples used in the stock assessment are from the eastern North Sea. The local Norwegian spring spawners therefore only constitute a problem if they migrate to feeding areas in the eastern North Sea. Inconclusive results from a study 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 the photo treatment software Image Pro plus 5.0. However, so far the technique does not provide a way to efficiently split between spring spawning population in the mix occurring in division IIIa.

A.2. Fishery

Fleet definitions

The fleet definitions used since 1998 for the fishery in Division IIIa are:

- **Fleet C**: directed fishery for herring in which trawlers (with 32 mm minimum mesh size) and purse seiners participate.
- **Fleet D**: All fisheries in which trawlers (with mesh sizes less than 32 mm) and small purse seiners, fishing for sprat along the Swedish coast and in the Swedish fjords, participate. For most of the landings taken by this fleet, herring is landed as by-catch.

Danish and Swedish by-catches of herring from the sprat, 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.

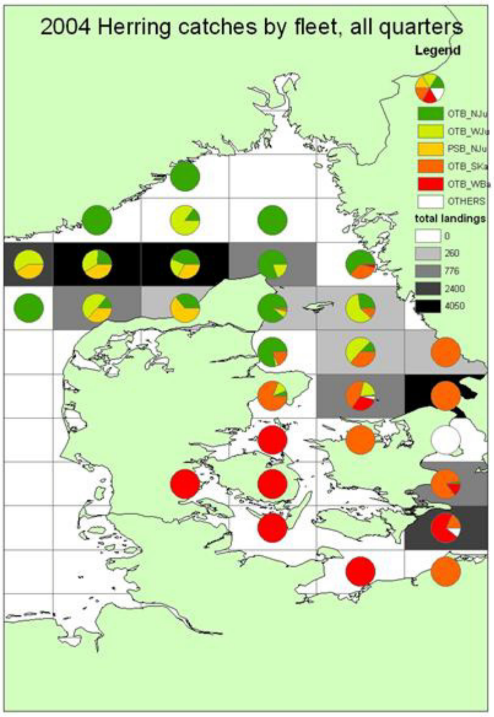

Figure A.2.1 Danish landings in IIIa by vessel and homeport.

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 1^{st} 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). **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 R/V 'Solea' in October. **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: "fwd()"-method of Flash package in FLR

Initial age structured stock at beginning of intermediate year: ICA estimates of survivors

Recruitment: Geometric mean of the recruitment over the 5 years previous to the assessment year

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:

$$\begin{aligned}\text{Risk} &= \text{P(harmful event)} \times \text{severity of harmful event} \\ &= \text{P(lower SSB limit undercut)} \times \text{EL}\end{aligned} \quad (1)$$

with expected loss (EL) being defined as

$$\text{EL} = \text{E}[\text{SSB}_{\text{lower limit}} - \text{SSB}_{\text{estimated}} \mid \text{SSB}_{\text{estimated}} < \text{SSB}_{\text{lower limit}}] \quad .(2)$$

While this definition of risk is not only implemented as part of many national constitutions (for instance, of the German constitution; Schuldt 1997, Schulte 1999, Schulz *et al.* 2001) but is also commonly used in engineering, in natural or environmental sciences or in medicine (see, for instance, Burgmann 2004), in mathematical sciences however P (harmful event) is often solely used as a definition for risk. As we aim at specifying costs or loss from a political and economic perspective, Eq. (1) turns out to be the appropriate risk measure, as it contains a probability term specifying the chance or likelihood of a harmful event and a severity term quantifying the magnitude of the loss. Further information on the theory underlying risk assessment and risk management can be found in Burgmann (2004), Francis and Shotton (1997) and Lane and Stephenson (1997). For a formal treatment of quantitative risk assessment and management see McNeil (2005).

H. Other Issues

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 2010

Authors: Afra Egan, Maurice Clarke and Deirdre Lynch

A. General

The herring (*Clupea harengus*) to the south of Ireland in the Celtic Sea and in Division VIIj comprise both autumn and winter spawning components. For the purpose of stock assessment and management, these areas have been combined since 1982. The inclusion of VIIj was to deal with misreporting of catches from VIIg. The same fleet exploited these stocks and it was considered more realistic to assess and manage the two areas together. This decision was backed up by the work of the ICES Herring Assessment Working Group (HAWG) in 1982 that showed similarities in age profiles between the two areas. In addition, larvae from the spawning grounds in the western part of the Celtic Sea were considered to be transported into VIIj (ICES, 1982). Also it was concluded that Bantry Bay which is in VIIj, was a nursery ground for fish of south coast (VIIg) origin (Molloy, 1968).

A study group examined stock boundaries in 1994 and recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb,c be moved southwards from latitude 52°30'N to 52°00'N (ICES, 1994). However, a recent study (Hatfield, *et al* 2007) examined the stock identity of this and other stocks around Ireland. It concluded that the Celtic Sea stock area should remain unchanged.

Some juveniles of this stock are present in the Irish Sea for the first year or two of their life. Juveniles, which are believed to have originated in the Celtic Sea move to nursery areas in the Irish Sea before returning to spawn in the Celtic Sea. This has been verified through herring tagging studies, conducted in the early 1990s, (Molloy, *et al* 1993) and studies examining otolith microstructure (Brophy and Danilowicz, 2002). Recent work carried out also used microstructure techniques and found that mixing at 1 winter ring is extensive but also suggests mixing at older ages such as 2 and 3 ring fish. The majority of winter spawning fish found in adult aggregations in the Irish Sea are considered to be fish that were spawned in the Celtic sea (Beggs et al, 2008).

Age distribution of the stock suggests that recruitment in the Celtic Sea occurs first in the eastern area and follows a westward movement. After spawning herring move to the feeding grounds offshore (ICES, 1994). In VIIj herring congregate for spawning in autumn but little is known about where they reside in winter (ICES, 1994). A schematic representation of the movements and migrations is presented in Figure 1. Figure 2 shows the oceanographic conditions that will influence these migrations.

The management area for this stock comprises VIIaS, VIIg, VIIj, VIIk and VIIh. Catches in VIIk and VIIh have been negligible in recent years. The linkages between this stock and herring populations in VIIe and VIIf are unknown. The latter are managed by a separate precautionary TAC. A small herring spawning component exists in VIIIa, though its linkage with the Celtic Sea herring stock area is also unknown.

A.2. Fishery

Historical fishery development

Coastal herring fisheries off the south coast of Ireland have been in existence since at least the seventeenth century (Burd and Bracken, 1965). These fisheries have been an important source of income for many coastal communities in Ireland. There have been considerable fluctuations in herring landings since the early 1900s.

In the Celtic Sea, historically, the main fishery was the early summer drift net fishery and the Smalls fishery which also took place in the summer. In 1933 several British vessels, mainly from Milford Haven, began to fish off the coast of Dunmore East and the winter fishery gained importance. The occurrence of the world war changed the pattern of the herring fishery further with little effort spent exploiting herring in the immediate post war years (Burd and Bracken, 1965). Landings of herring off the south west coast increased during the 1950s.

In 1956 Dunmore East was considered as the top herring port in Ireland with over 3,000 t landed. This herring was mainly sold to the UK or cured and sent to the Netherlands (Molloy, 2006). During this time many boats from other European countries began to exploit herring in this area during the spawning period. This continued until the 1960s when catches began to fall. In 1961 the Irish fishery limits changed whereby non-Irish vessels were prohibited from fishing in the inshore spawning grounds (Molloy, 1980). Consequently, continental fleets could no longer exploit herring on the Irish spawning grounds. They had to purchase herring from Irish vessels in order to meet requirements (Molloy, 2006).

During the period from 1950-1968 the fleet exploiting the stock changed from mainly drift and ring nets to trawls. Further fluctuations in the landings were evident during this time with high quantities of herring landed from 1966 – 1971 (Molloy, 1972). In the mid-sixties, the introduction of mid-water pair trawling led to greater efficiency in catching herring and this method is still employed today. Overall the 1960s saw a rise in herring landings with 1969 seeing a rise to 48,000t. The North Sea herring fisheries were becoming depleted and several countries were turning to Ireland to supply their markets. Prices also increased and additional vessels entered the fleet (Molloy, 1995). Increases in effort led to increased catches initially but this did not continue and this combined with poor recruitment began the decline of the fishery. It was eventually closed in April 1977 and remained closed until November 1982 (Molloy, 2006). When the fishery reopened the management area now included VIIj also. In 1983 a new management committee was formed.

Fishery in recent years

In the past, fleets from the UK, Belgium, The Netherlands and Germany as well as Ireland exploited Celtic Sea herring. In recent years however this fishery has been prosecuted entirely by Ireland. This fishery is managed by the Irish “Celtic Sea Herring Management Advisory Committee”, established in 2000 and constituted in law in 2005.

The Irish quota is managed by allocating individual quotas to vessels on a weekly basis. Participation in the fishery is restricted to licensed vessels and these licensing requirements have been changed. Previously, vessels had to participate in the fishery each year to maintain their licence. Since 2004 this requirement has been lifted. This has been one of the contributing factors to the reduction in number of vessels participating in the fishery in recent seasons (ICES, 2005b). Fishing is restricted to the period Monday to Friday each week, and vessels must apply a week in advance before they are allowed to fish in the following week. Triennial spawning box closures are enshrined in EU legislation (Figure 3).

The stock is exploited by two types of vessels, larger boats with RSW storage and smaller dry hold vessels. The smaller vessels are confined to the spawning grounds (VIIaS and VIIg) during the winter period. The refrigerated seawater (RSW) tank vessels target the stock inshore in winter and offshore during the summer feeding phase (VIIg). There has been less fishing in VIIj in recent seasons.

The fleet can be classified into four categories of vessels:

Category 1: "Pelagic Segment".	Refrigerated seawater trawlers
Category 2: "Polyvalent RSW Segment".	Refrigerated seawater or slush ice trawlers
Category 3: "Polyvalent Segment".	Varying number of dry hold pair trawlers,
Category 4: Drift netters.	A negligible component in recent years, very small vessels

The term "Polyvalent" refers to a segment of the Irish fleet, entitled to fish for any species to catch a variety of species, under Irish law. Since 2002 fishing has taken place in quarter 3, targeting fish during the feeding phase on the offshore grounds around the Kinsale Gas Fields. These fish tend to be fatter and in better condition than winter-caught fish. In 2003 the fishery opened in July on the Labadie Bank and caught large fish. In 2004-2006 it opened in August and in 2007 and in 2008 began in September. Only RSW and bulk storage vessels can prosecute this fishery. Traditional dry-hold boats are unable to participate.

In recent years, the targeting fleet has changed. The fleet size has reduced but an increasing proportion of the catch is taken by RSW and bulk storage vessels and less by dry-hold vessels. There has been considerable efficiency creep in the fishery since the 1980s with greater ability to locate fish.

A.3. Ecosystem aspects

The ecosystem of the Celtic Sea is described in ICES WGRED (2007b). The main hydrographic features of this area as they pertain to herring are presented in Figure 2.

Temperatures in this area have been increasing over the last number of decades. There are indications that salinity is also increasing (ICES, 2006a). Herring are found to be more abundant when the water is cooler while pilchards favour warmer water and tend to extend further east under these conditions (Pinnegar, *et al* 2002). However, studies have been unable to demonstrate that changes in the environmental regime in the Celtic Sea have had any effect on productivity of this stock.

Herring larval drift occurs between the Celtic Sea and the Irish Sea. The larvae remain in the Irish Sea for a period as juveniles before returning to the Celtic Sea. Catches of herring in the Irish Sea may therefore impact on recruitment into the Celtic Sea stock (Molloy, 1989). Distinct patterns were evident in the microstructure and it is thought that this is caused by environmental variations. Variations in growth rates between the two areas were found with Celtic Sea fish displaying fastest growth in the first year of life. These variations in growth rates between nursery areas are likely to impact recruitment (Brophy and Danilowicz, 2002). Larval dispersal can further influence maturity at age. In the Celtic Sea faster growing individuals mature in their second year (1 w. ring) while slower growing individuals spawn for the first time in their third year (2 winter ring). The dispersal into the Irish Sea which occurs before recruitment and subsequent decrease in growth rates could thus determine whether juveniles are recruited to the adult population in the second or third year (Brophy and Danilowicz, 2003).

The spawning grounds for herring in the Celtic Sea are well known and are located inshore close to the coast. These spawning grounds may contain one or more spawning beds on which herring deposit their eggs. Individual spawning beds within the spawning grounds have been mapped and consist of either gravel or flat stone (Breslin, 1998). Spawning grounds tend to be vulnerable to anthropogenic influences such as dredging and sand and gravel extraction. The main spawning grounds are displayed in Figure 4, whilst the distributions of spawning and non-spawning fish are presented in Figure 5.

Herring are an important component of the Celtic sea ecosystem. There is little information on the specific diet of this stock. Farran (1927) highlighted the importance of *Calanus* spp. copepods and noted that they peaked in abundance in April/May. Fat reserves peak in June to August (Molloy and Cullen, 1981). Herring form part of the food source for larger gadoids such as hake. A study was carried out which looked at the diet of hake in the Celtic Sea. This study found that the main species consumed by hake are blue whiting, poor cod and Norway Pout. Quantities of herring and sprat were also found in fish caught in the northern part of the Celtic sea close to the Irish coast. Large hake, >50cm tended to have more herring in their stomachs than smaller hake (Du Buit, 1996).

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, 2009).

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, 2009)

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 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 1998-2009. 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.

Cohort catch curves across all ages were constructed using the catch at age data and 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 2007-2010

In 2007, a benchmark assessment used a variety of models including ICA (Patterson, 1998), separable VPA, XSA, CSA and Bayesian catch at age methods. In addition an analysis of long term dynamics of recruitment was conducted. Simulations of various fishing mortalities were conducted based on stock productivity. Though no final model formulation was settled upon, the assessment provided information on trends. ICA was preferred to XSA because it is more influenced by younger ages that dominate the stock and fishery, and because of consistency. The settings that had been used before 2007 were found to produce the most reasonable diagnostics.

In 2007 it was considered that the assumption that a constant separable pattern could be used may not have been valid and it was recommended that future benchmark work should consider models that allow for changes in selection pattern.

Also in 2007 a reduction of the plus group to 7+ was recommended. This change did not achieve better diagnostics in 2007, but exploratory assessments in 2008 did find that this change improved the diagnostics.

In 2008 and 2009, the working group continued to explore different assessment settings in ICA. The working group treated these explorations as extensions of the benchmark of 2007. In 2008 ICA was replaced by FLICA and the same stock trajectories were found in each.

In 2009 a final analytical assessment was proposed and was conducted using FLICA (flr-project.org). This assessment was based on exploratory work done in 2008 and 2009. The refinements to the benchmark assessment of 2007 were as follows:

- Further reduction of plus group to 6+
- Exclusion of acoustic surveys before 2002, because a sufficient series of comparable surveys was now available.

The assessment showed improved precision and coherence between the catch at age and the survey data. The survey residuals were lower since 2002 which is reflected in better tuning diagnostics. The stock trajectories, based on this assessment are presented in Figure 17.

The model formulation used for ICA in the 2007 benchmark and the final assessment carried out in 2009 and 2010 are presented in the table below.

ICA Settings	**2007 Benchmark**	**Final Assessment 2009 and 2010**
Separable period	6 years (weighting = 1.0 for each year)	6 years (weighting = 1.0 for each year)
Reference ages for separable constraint	3	3
Selectivity on oldest age	1.0	1.0
First age for calculation of mean F	2	2
Last age for calculation of mean F	6	5
Weighting on 1 ringers	0.1	0.1
Weighting on other age classes	1.0	1.0
Ages for acoustic abundance estimates	2-5	2-5
Plus group	7	6

Update Assessment 2010.

In 2010 the same procedure as in 2009 was carried out.

Estimation of terminal year Recruitment and SSB

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
Acoustic Survey	CSHAS	2002-2009	2-5

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1958-2009	1-6 +	Yes
Canum	Catch at age in numbers	1958-2009	1-6 +	Yes
Weca	Weight at age in the commercial catch	1958-2009	1-6+	Yes
West *	Weight at age of the spawning stock at spawning time.	1958-2009	1-6+	Yes
Mprop	Proportion of natural mortality before spawning	1958-2009	1-6 +	No
Fprop	Proportion of fishing mortality before spawning	1958-2009	1-6 +	No
Matprop	Proportion mature at age	1958-2009	1-6 +	No
Natmor	Natural mortality	1958-2009	1-6 +	No

* mean weights in the stock in the new plus group were re-weighted using catch numbers at age.

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 HAWG, 2006, Table 1.8.3.1).

Calculation of the surplus production

$$Ps = Br + Bg - M$$

where Br is the biomass of the recruits, Bg the gain of biomass due to growth of all fish excluding the recruits and M the natural mortality. The net production equals the surplus production minus the fishing mortality (F).

The Celtic Sea herring stock had a low productivity throughout the whole time series, compared to other stocks (ICES, 2007). The net and surplus production is very noisy displaying 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 and 2010. The method used was the "Multi fleet Deterministic Projection" software (Smith, 2000). A short-term projection is carried out under the following assumptions. Recruitment was set at geometric mean, either for the entire time series, minus the most recent two years. This value is considered a good proxy for recruitment strength in recent years. This is because the recent recruitments have fluctuated about this value. Mean weights in the catch and in the stock were calculated as means over the last three years. Selection is taken from the most recent assessment. Population number of 2 ringers in the intermediate season was calculated by the degradation of geometric mean recruitment using the equation below, following the same procedure as in previous years.

$$N_{t+1} = N_t * e^{-Ft+Mt}$$

E. Medium-Term Projections

Yield per recruit analyses have been conducted for this stock since the mid 1960s, though not necessarily every year. Recent analyses have used the "Multi Fleet Yield Per Recruit" software. 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.

F. Long-Term Projections

In 2007, a number of possible management scenarios were tested using the stochastic simulation tool FPRESS (Codling and Kelly,2005). This tool is used to test the robustness of harvest control rules.

G. Biological Reference Points

B_{pa} is 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 estimated. However $F_{0.1}$ can be assumed to be a proxy for F_{msy} and was estimated in 2009 to be = 0.17.

The reference points for this stock have not been revised in recent years. There is some evidence that B_{lim} should be revised upwards, to the point of recruitment impairment estimated by Clarke and Egan (2008). These authors showed a changepoint in a segmented regression at 47 000 t.

H.1. Biology of the species in the distribution area

Herring shoals migrate to inshore 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

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[1] http://www.gma.org/herring/biology/life_cycle/default.asp

Molloy (1979), found that there were two spawning populations with the autumn one being most important.

The relationship between fecundity and length has been calculated for both spawning components of Celtic Sea herring. The regression equations are as shown in Hay *et al* 2001, are as follows:

Autumn spawning component: Fecundity = 5.1173 L – 56.69 (n=53)

Winter spawning component: Fecundity = 3.485 L – 35.90 (n=37)

The larval phase is an important period in the herring life cycle. Larvae use their oil globule for food and to provide buoyancy. Currents transport the newly hatched larvae to areas in the Celtic Sea or to the Irish Sea (Molloy, 2006). The conditions experienced during the larval phase as well as during juvenile phase are likely to have some influence on the maturation of Celtic Sea herring. Fast growing juveniles can recruit to the population a year earlier than slow growing juveniles. Faster growth may also lead to increased fecundity (Brophy and Danilowich, 2003). Fluctuating environmental conditions play an important role in the growth and survival of herring in this area.

The juveniles tend to remain close inshore, in shallow waters for the first two years of their lives, in nursery areas. There are many of these nursery areas around the coast. The minimum landing size for herring is 20cm and therefore these juvenile herring are not caught by the fishery in the early stages of their life cycle (Molloy, 2006).

Celtic Sea herring have undergone changes in growth patterns and a declining trend in mean weights and lengths can be seen over time. It is important to detect these changes from a management perspective because changes can have an impact on the estimation of stock size. Growth has an impact on factors such as maturity and recruitment (Molloy, 2006). Trends in mean weights and lengths are currently being examined over the time series and possible links to environmental factors investigated (Lynch, 2009).

The locations of spawning and non spawning fish in the Celtic Sea are shown in Figure 5. This is based on the knowledge of fishermen and shows spawning herring are found close inshore and non spawning fish are found in areas further off shore.

H.2. Management and ICES Advice

The assessment year is from 1st April to 31st March. However for management purposes, the TAC year is from 1st January to 31st December.

The first time that management measures were applied to this fishery was during the late 1960s. This was in response to the increasing catches particularly off Dunmore East. The industry became concerned and certain restrictions were put in place in order to prevent a glut of herring in the market and a reduction in prices. Boat quotas were introduced restricting the nightly catches and the number of boats fishing. Fishing times were specified with no weekend fishing and herring could not be landed for the production of fishmeal. A minimum landing size was also introduced (Molloy, 1995).

The TAC (total allowable catch) system was introduced in 1972, which meant that yearly quotas were allocated. This continued until 1977 when the fishery was closed. During the closure a precautionary TAC was set for Division VIIj. This division was not assessed analytically (ICES, 1994). After the closure of this fishery a new management structure was implemented with catches controlled on a seasonal basis and individual boat quotas were put in place (Molloy 1995).

Table 8 shows the history of the ICES advice, implemented TACs and ICES' estimates of removals from the stock. It can be seen that the implemented TAC has been set higher than the advice in about 50% of years since the re-opening of the fishery in 1983. The tendency for the TAC to be set higher than the advice has also increased in recent years. It can also be seen that ICES catch estimates have been lower than the agreed TAC in most years.

This fishery is still managed by a TAC system with quotas allocated to boats on a weekly basis. Participation in the fishery is restricted to licensed vessels. A series of closed areas have been implemented to protect the spawning grounds, when herring are particularly vulnerable. These spawning box closures were implemented under EU legislation.

The committee set up to manage the stock has the following objectives.

- To build the stock to a level whereby it can sustain annual catches of around 20,000 t.
- In the event of the stock falling below the level at which these catches can be sustained the Committee will take appropriate rebuilding measures.
- To introduce measures to prevent landings of small and juvenile herring, including closed areas and/or appropriate time closures.
- To ensure that all landings of herring should contain at least 50% of individual fish above 23 cm.
- To maintain, and if necessary expand the spawning box closures in time and area.
- To ensure that adequate scientific resources are available to assess the state of the stock.
- To participate in the collection of data and to play an active part in the stock assessment procedure.

The Irish Celtic Sea Herring Management Advisory Committee has developed a rebuilding plan for this stock. This Committee proposes that this plan be put forward for Council Regulation for 2009 and subsequent years. The plan incorporates scientific advice with the main elements of the EU policy statement on fishing opportunities for 2009, local stakeholder initiatives and Irish legislation.

Proposed Rebuilding plan

1. For 2009, the TAC shall be reduced by 25% relative to the current year (2008).
2. In 2010 and subsequent years, the TAC shall be set equal to a fishing mortality of $F_{0.1}$.
3. If, in the opinion of ICES and STECF, the catch should be reduced to the lowest possible level, the TAC for the following year will be reduced by 25%.
4. Division VIIaS will be closed to herring fishing for 2009, 2010 and 2011.
5. A small-scale sentinel fishery will be permitted in the closed area, Division VIIaS. This fishery shall be confined to vessels, of no more than 65 feet 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.

H.4. Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusion for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being."

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

YEAR CLASS (AUTUMN SPAWNERS)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

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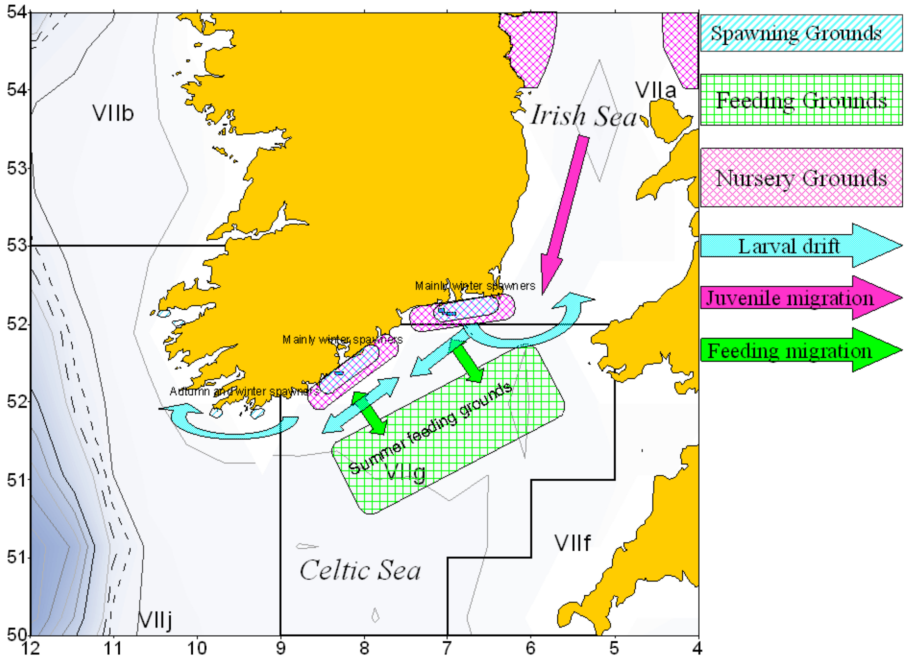


Figure 1. Herring in the Celtic Sea and VIIj. Schematic presentation of the life cycle of Celtic Sea and VIIj Herring (ICES, 2005c, SGRESP).

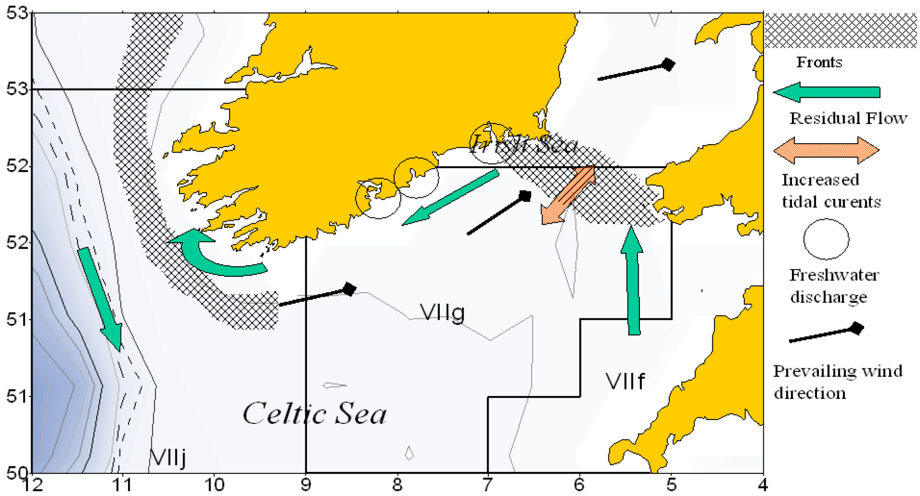


Figure 2. Herring in the Celtic Sea and VIIj. Schematic presentation of prevailing oceanographic conditions in the Celtic Sea and VIIj (ICES, 2005c, SGRESP).

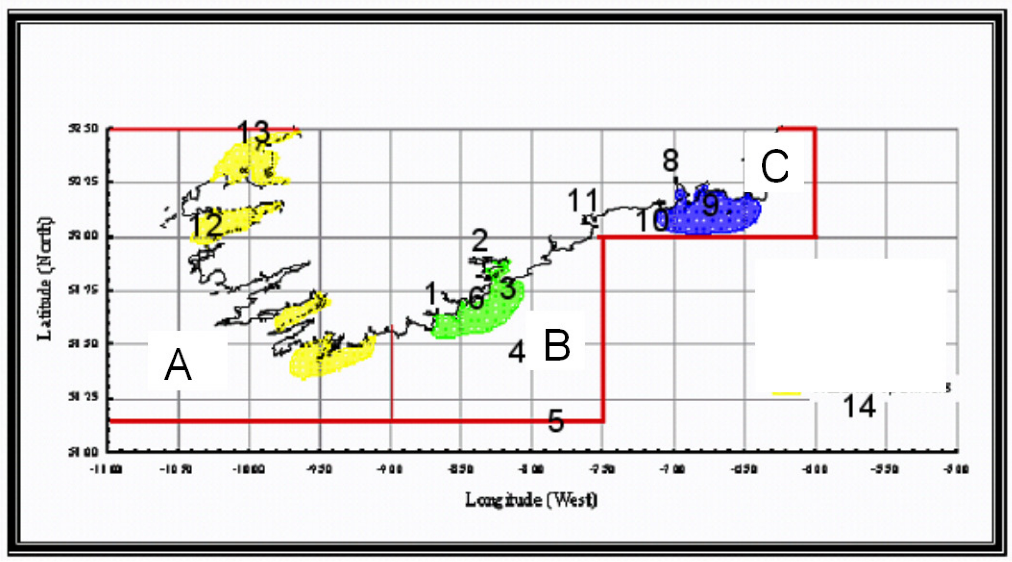


Figure 3. Herring in the Celtic Sea and VIIj. Areas mentioned in the text and spawning boxes A, B and C, south of Ireland. One of these boxes is closed each season, under EU legislation. 1 Courtmacsherry, 2 Cork Harbour, 3 Daunt Rock, 4 Kinsale Gas Field (Rigs), 5 Labadie Bank, 6 Kinsale, 8 Waterford Harbour, 9, Baginbun Bay, 10, Tramore Bay/ Dunmore East, 11, Ballycotton Bay, 12, Valentia Island, 13 Kerry Head to Loop Head, 14, The Smalls. The spawning boxes A-C correspond to ICES Divisions VIIj, VIIg and VIIaS respectively.

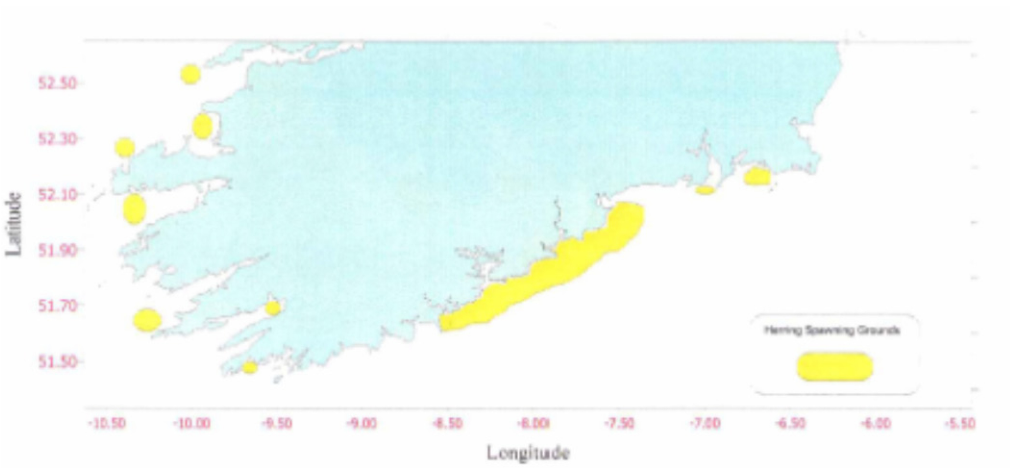


Figure 4. Herring in the Celtic Sea and VIIj. Spawning ground of herring along the south coast of Ireland, inferred from information on the Irish herring fishery (Breslin, 1998).

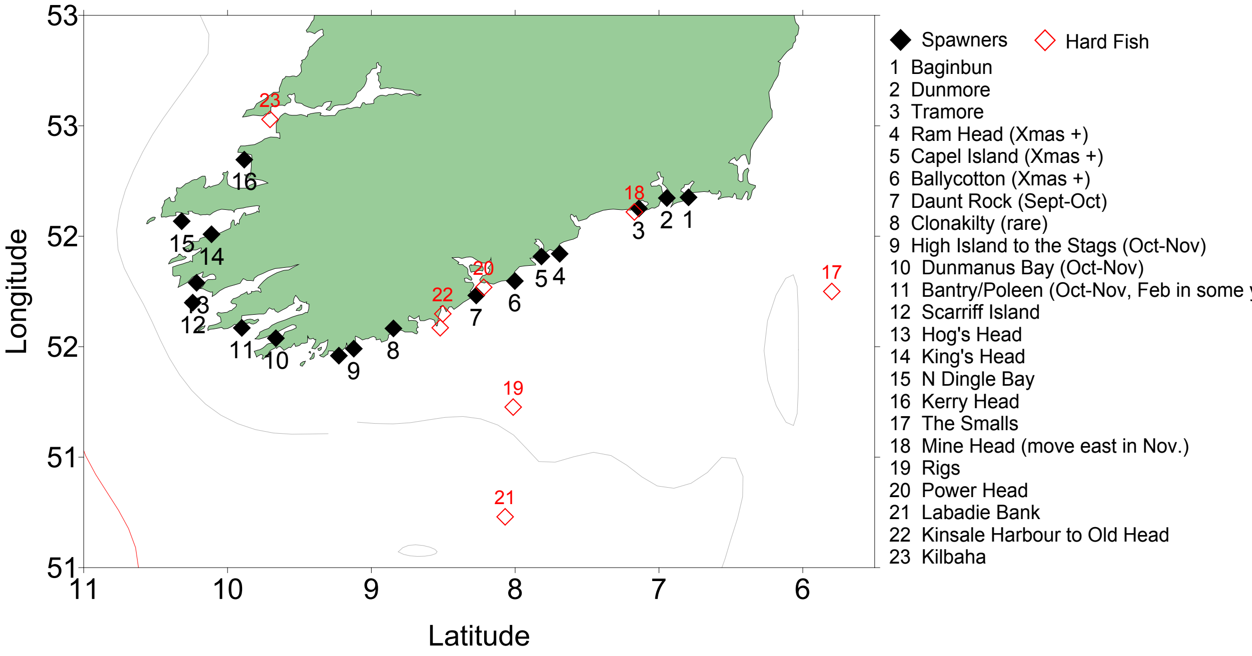


Figure 5. Herring in the Celtic Sea and VIIj. Location of spawning (closed symbol) and non spawning (open symbol) herring in the Celtic Sea and SW of Ireland, based on expert fishemens' knowledge.

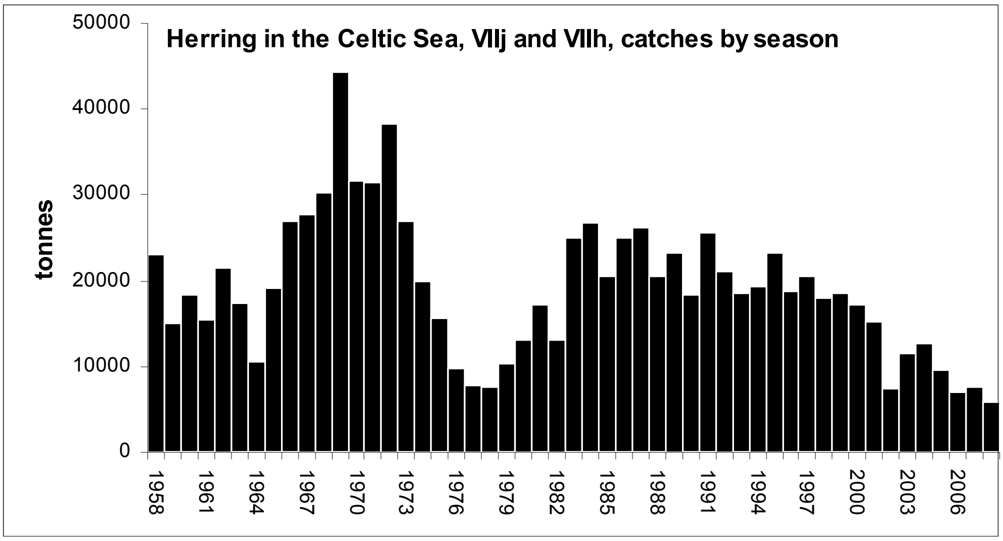


Figure .6. Herring in the Celtic Sea and VIIj. ICES estimates of herring catches (tonnes) per season 1958/1959 to 2008/2009.

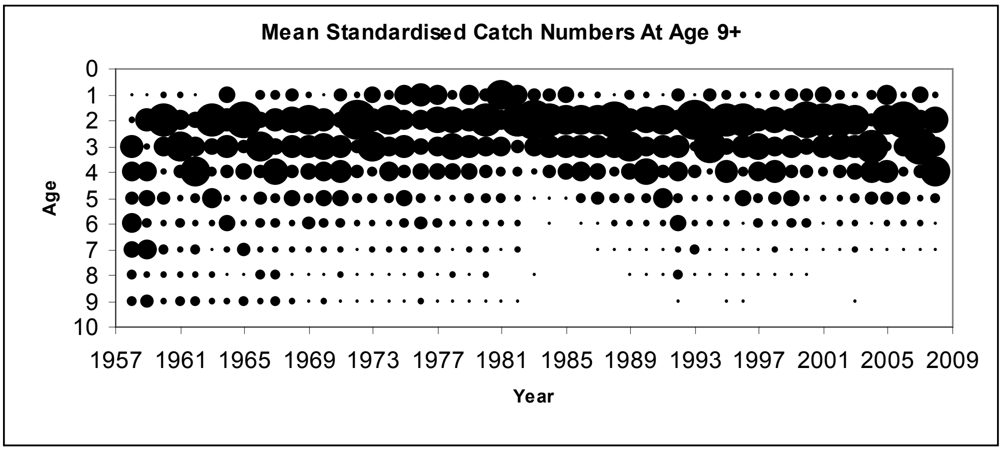


Figure 7. Herring in the Celtic Sea and VIIj. Catch numbers at age standardised by yearly mean.

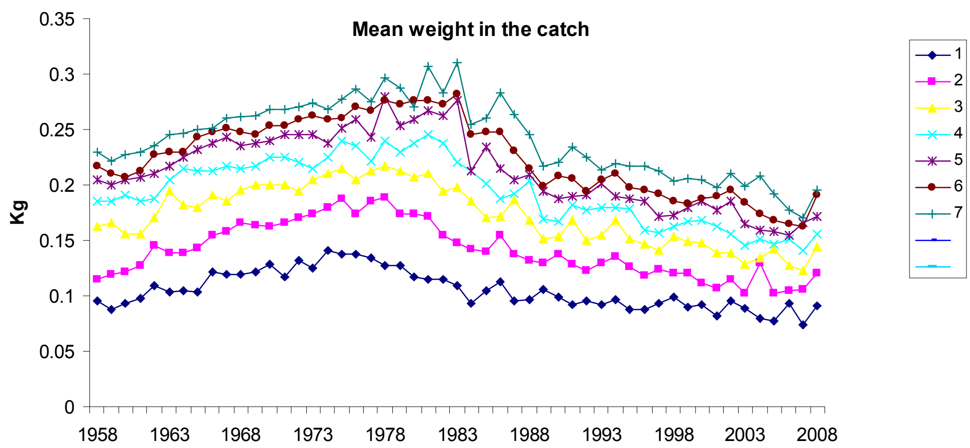


Figure 8. Herring in the Celtic Sea and VIIj. Trends over time in mean weights in the catch.

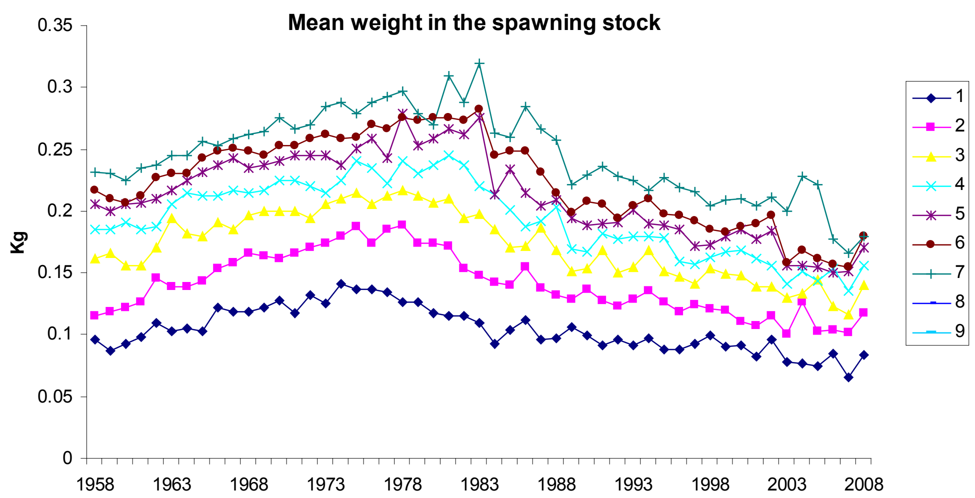


Figure 9. Herring in the Celtic Sea and VIIj. Trends over time in mean weights in the stock at spawning time.

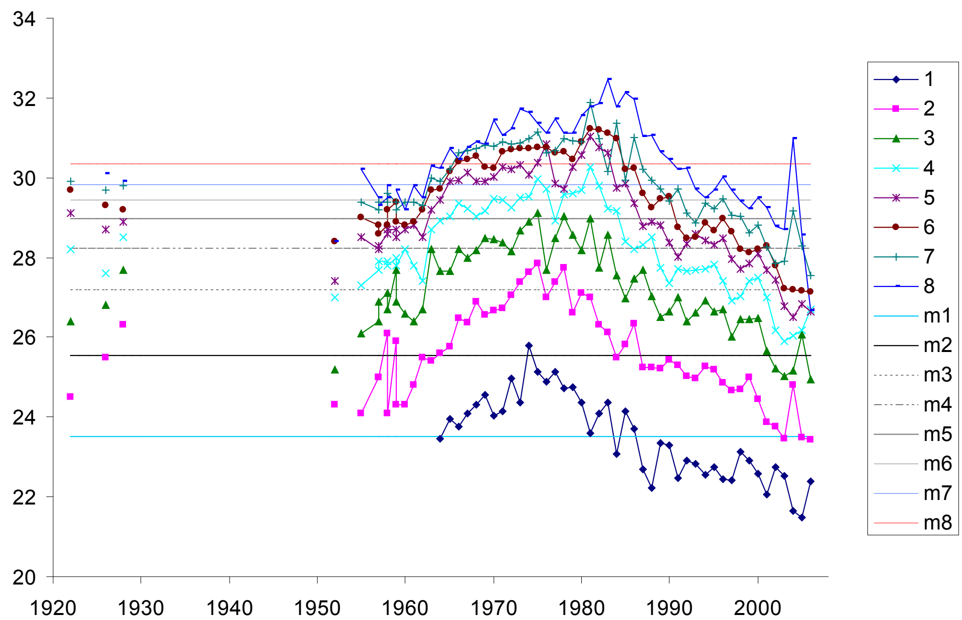


Figure 10 Mean length at age from historic sources (Burd et al, 1965) and references therein. Data from 1964 onwards are Irish data. Long term means are shown for each age and are labelled m1-m8. The data from the 1920s are depicted as single years though they represent a group of years (Lynch, 2009).

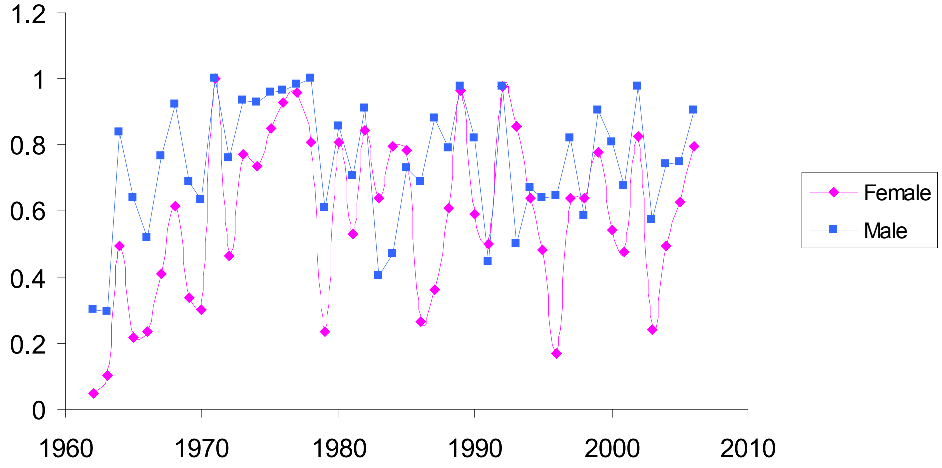
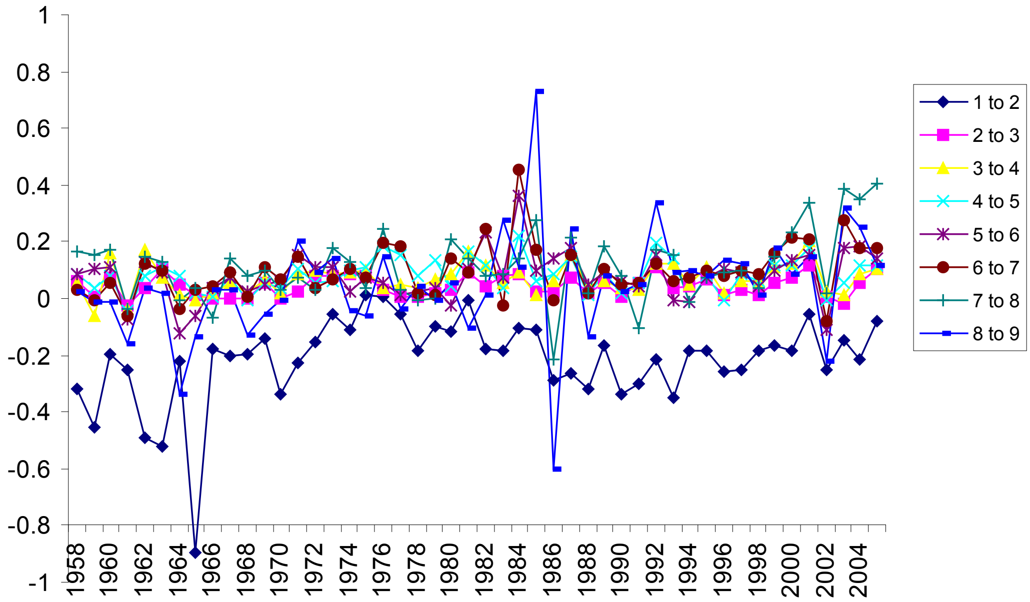


Figure 11: Percentage maturity in males and females at 1 winter ring (Lynch, 2009).



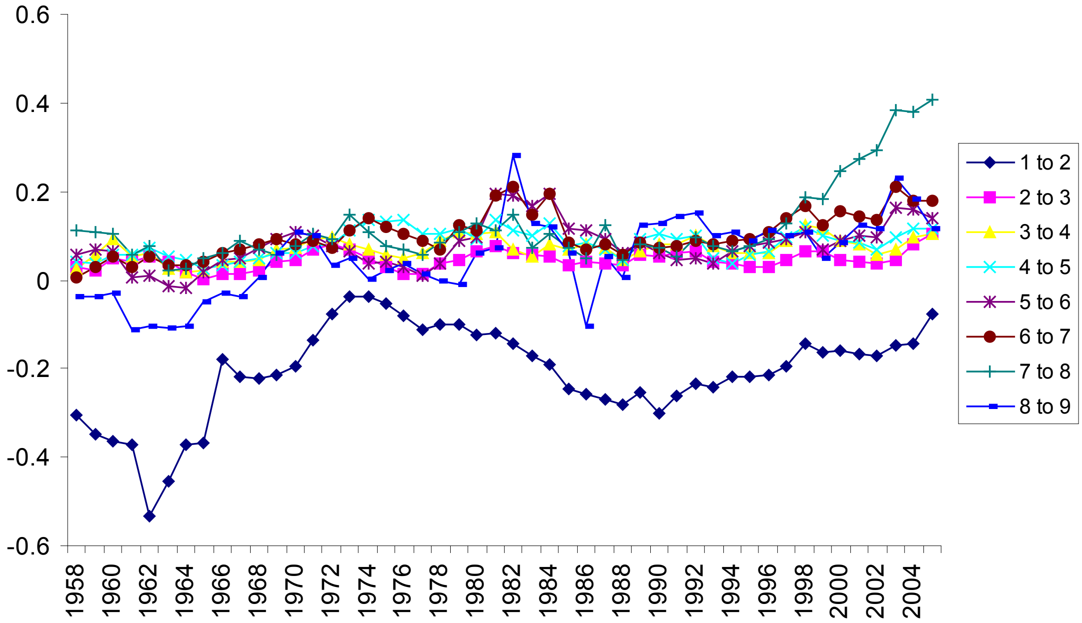


Figure 12. Herring in the Celtic Sea and VIIj. Log catch ratios (above) and log catch ratios smoothed with a 4 year moving average for each age group for the time series 1958-2006. Evidence of a change in selection pattern visible in upper panel in 2003.

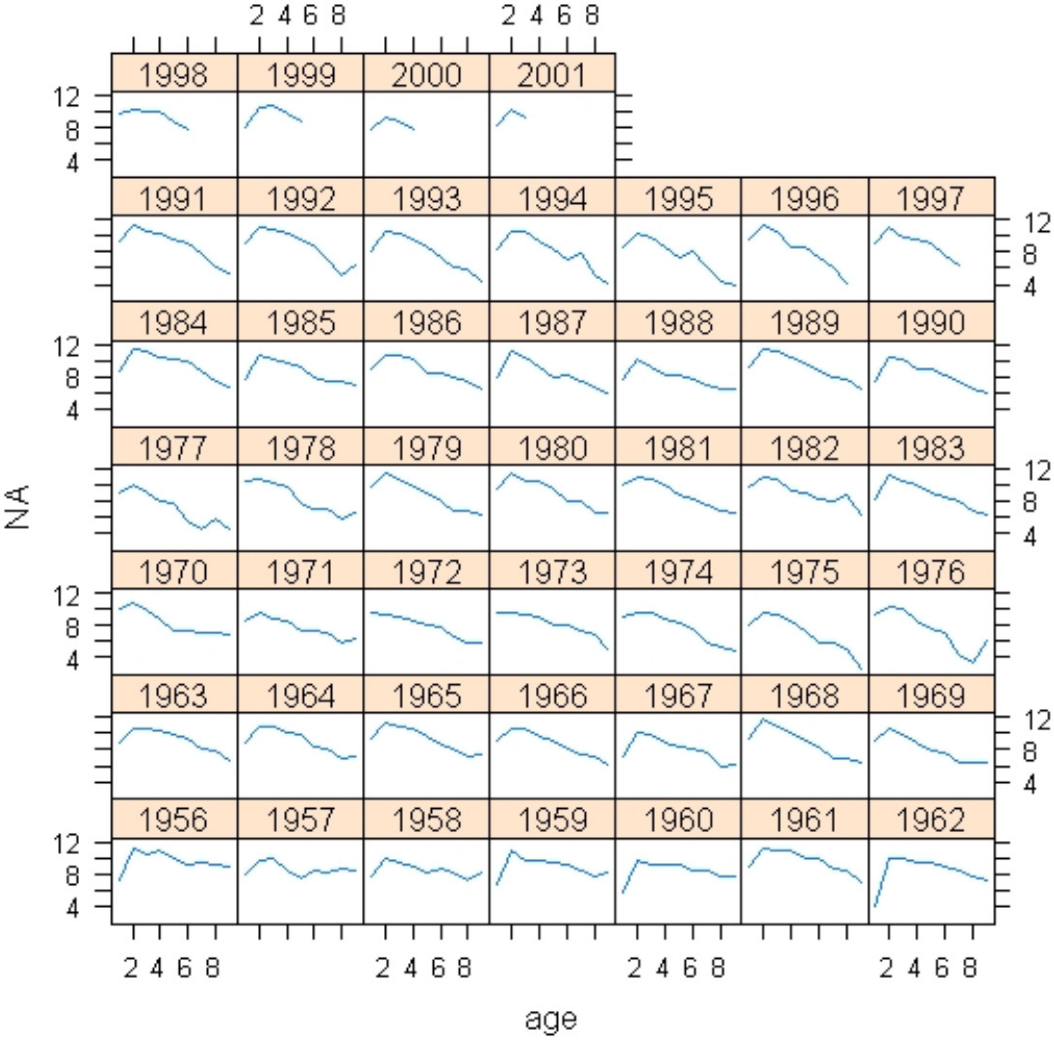


Figure 13. Herring in the Celtic Sea and VIIj. Cohort catch curves for the time series of catch at age data. Age in winter rings on the horizontal axis and log transformed catch numbers at age on the vertical axis.

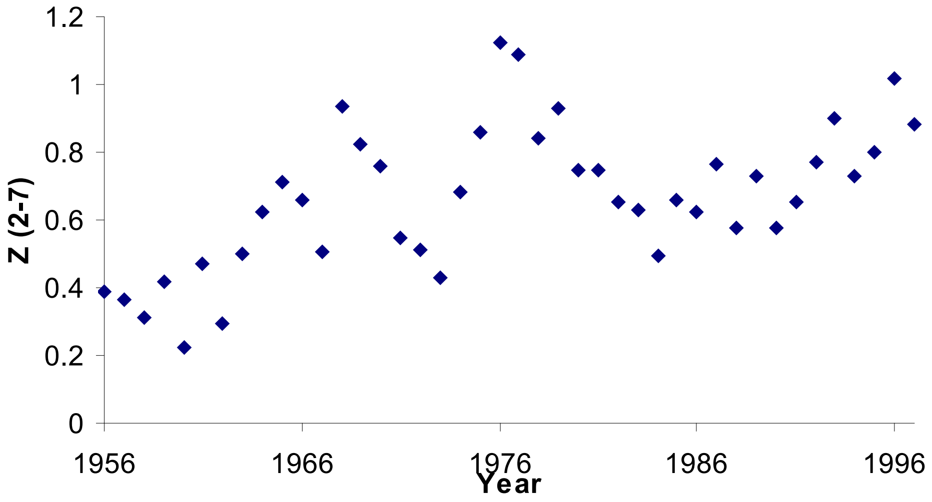


Figure 14: Herring in the Celtic Sea and VIIj. Total mortality (Z) estimated from cohort catch curves (2-7 ringer) for cohorts 1958 to 1997.

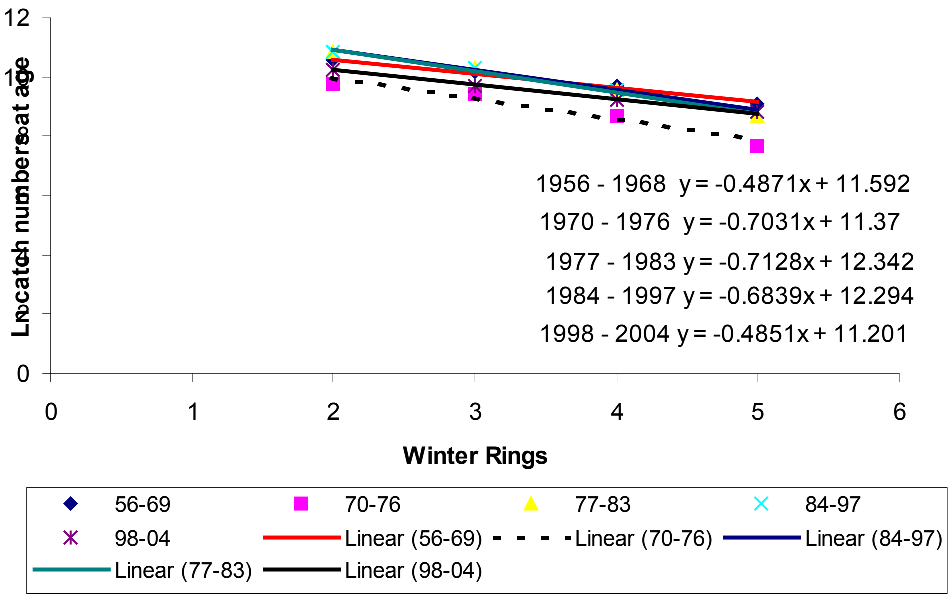


Figure 15. Herring in the Celtic Sea and VIIj. Cohort catch curves (2-5 ringer), averaged over several year classes, from catch at age data.

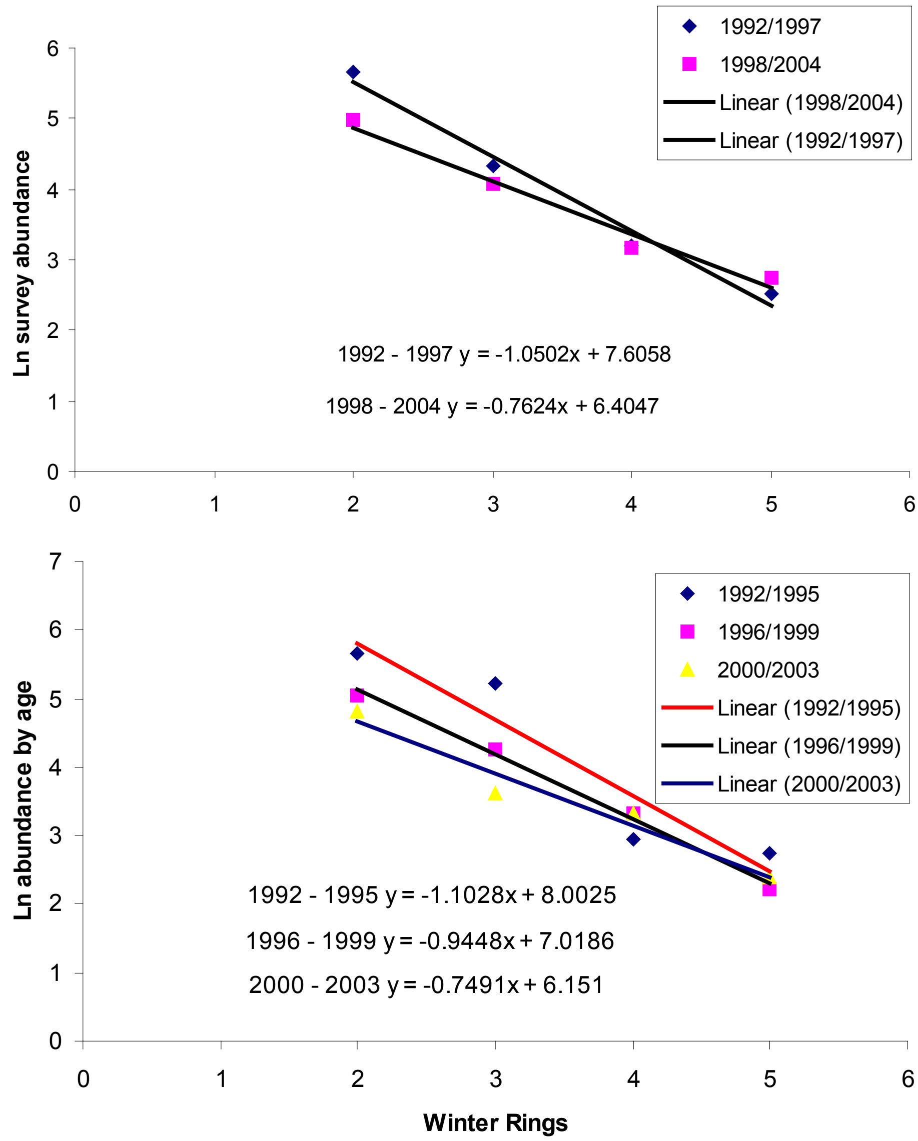


Figure 16. Herring in the Celtic Sea and VIIj. Cohort catch curves (2-5 ring) based on acoustic survey abundance. Upper panel shows means for two periods, and below for three time periods, over the same series of surveys

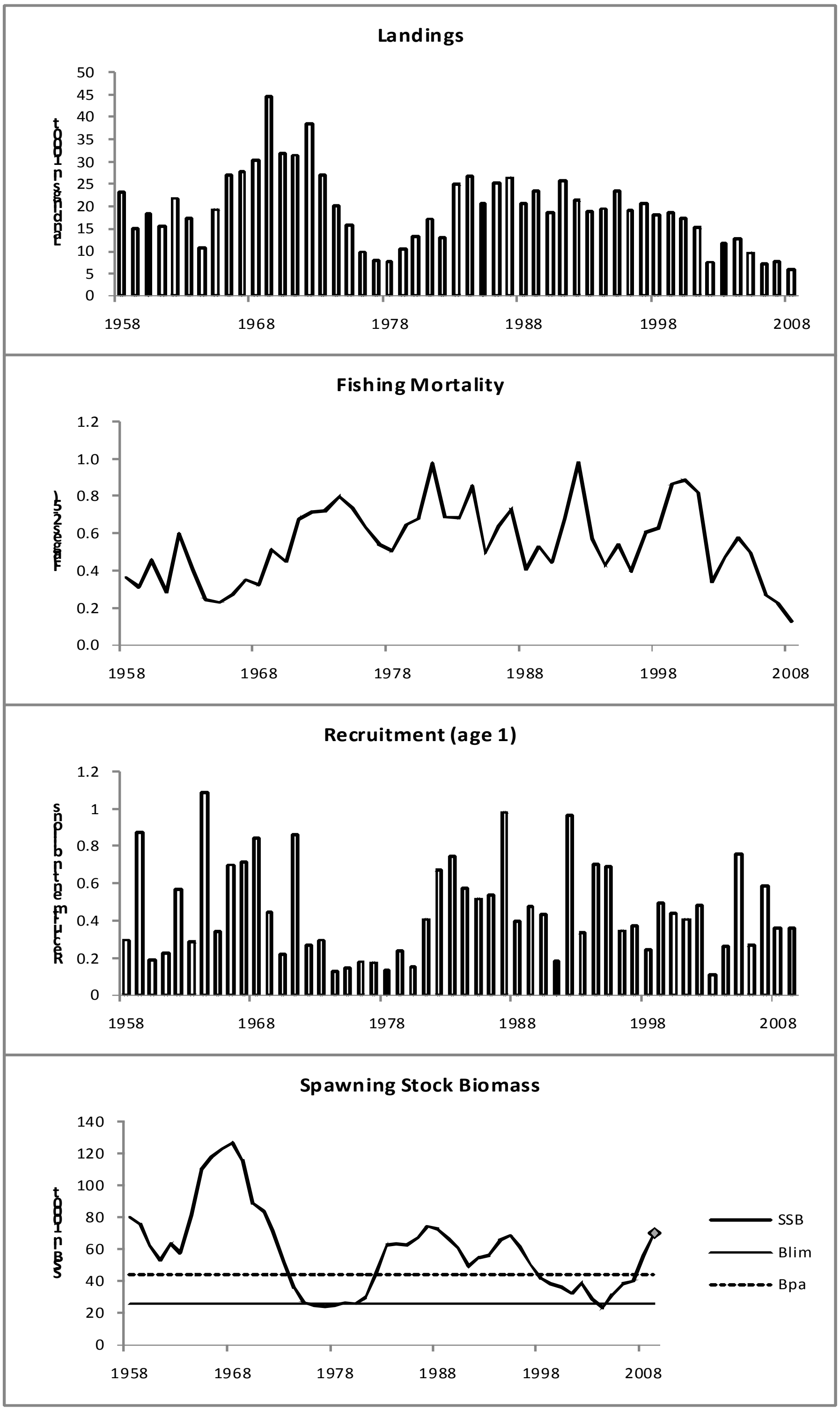


Figure 17. Herring in the Celtic Sea and VIIj. SSB, F and recruitment (1-ringer) from proposed final run. Note SSB in the terminal year is adjusted according to the protocol for this stock.

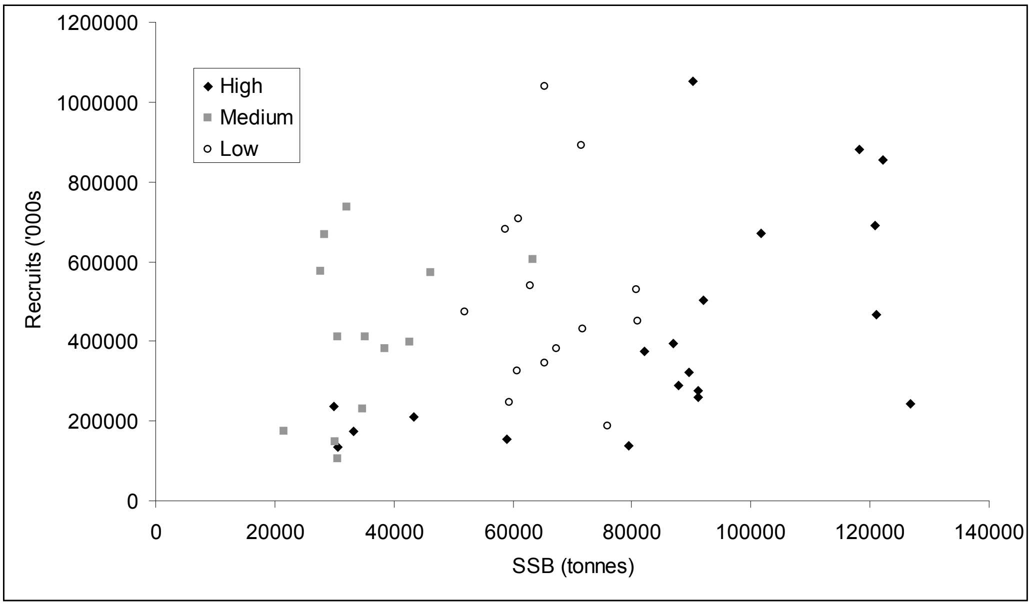


Figure 18. Herring in the Celtic Sea and VIIj. Stock recruit relationship from ICA base case runs. Data classified according to quality of input data, see Table 4.

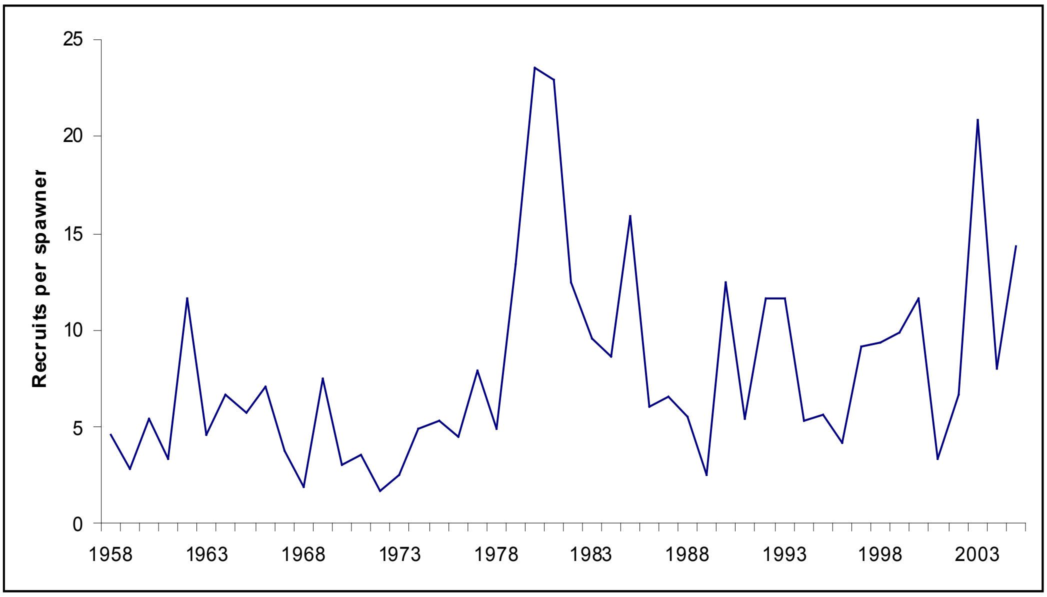


Figure 19. Herring in the Celtic Sea and VIIj. Recruits per spawner, in '000s/tonnes

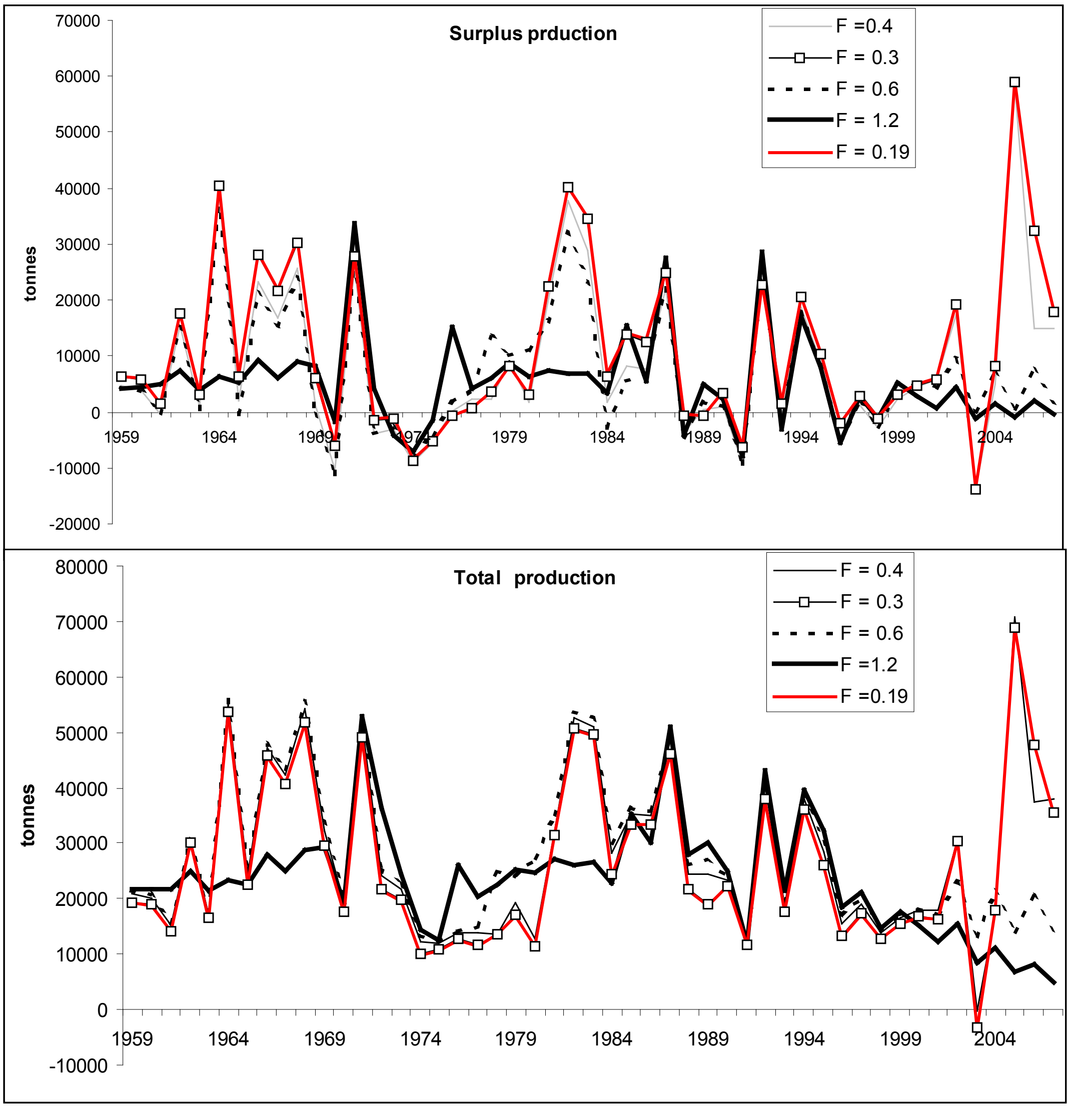


Figure 20. Herring in the Celtic Sea and VIIj. Total and surplus production in the time series over a range of fishing mortalities.

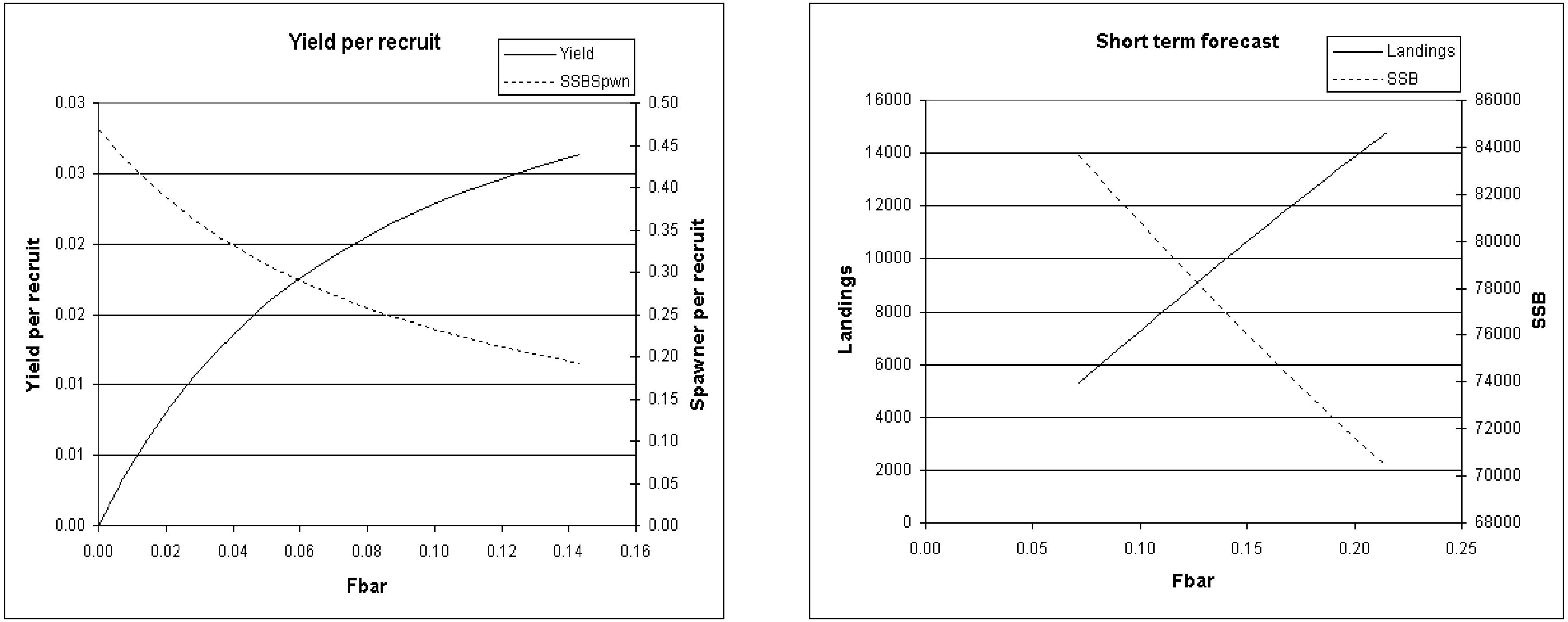


Figure 20. Herring in the Celtic Sea and VIIj. Yield per recruit carried out in 2010

Reference point	F multiplier	
Fbar(2-5)	1.0000	0.0718
FMax	>=1000000	
F0.1	2.3772	0.1706
F35%SPR	2.6314	0.1888
Flow	0.9124	0.0655
Fmed	3.0553	0.2192
Fhigh	6.7969	0.4877

Table 1. Herring in the Celtic Sea & Division VIIj. Acoustic surveys of Celtic Sea and VIIj herring, by season. Number of surveys per season and type indicated along with biomass and SSB estimates. Shaded sections show surveys not used in tuning, in most recent assessment.

Season	No.	Type	Survey Timing	SSB
1990/1991	2	Autumn and winter spawners	Oct and Jan/Feb	-
1991/1992	2	Autumn and winter spawners	Nov/Dec and Jan	-
1992/1993	2	Autumn and winter spawners	Nov and Jan	-
1993/1994	2	Autumn and winter spawners	Nov and Jan	-
1994/1995	2	Autumn and winter spawners	Nov and Jan	-
1995/1996	2	Autumn and winter spawners	Nov and Jan	36
1996/1997	1	Autumn and winter spawners	Oct/Nov and Jan	151
1997/1998	-	No survey		-
1998/1999	1	Autumn spawners	Nov and Jan	100
1999/2000	1	Feeding phase	July	-
1999/2000	1	Winter-spawners	Nov and Jan	-
2000/2001	2	Autumn and winter spawners	Oct and Jan	20
2001/2002	2	Pre-spawning	Sept and Oct	95
2002/2003	1	Pre-spawning	Sept/Oct	41
2003/2004	1	Pre-spawning	Oct/Nov	20
2004/2005	1	Pre-spawning	Nov/Dec	-
2005/2006	1	Pre-spawning	Oct	33
2006/2007	1	Pre-spawning	Oct	36
2007/2008	1	Pre-spawning	Oct	46
2008/2009	1	Pre-spawning	Oct	90

Table 2. Herring in the Celtic Sea & Division VIIj. Original acoustic survey abundance at age as used by ICES until HAWG 2006.

	1990 1991	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 & Division VIIj. Revised acoustic series as used by HAWG since 2006. Shaded colums show surveys excluded from tuning in 2009, where timing and design of earlier surveys were not considered comparable with the sufficiently long series of subsequent surveys.

1995 1996	1996 1997	1997 1998	1998 1999	1999 2000	2000 2001	2001 2002	2002 2003	2003 2004	2004 2005	2005 2006	2006 2007	2007 2008	2008 2009
202	3	-	0	-	25	40	0	24	-	2	-	1	99
25	164	-	30	-	102	28	42	13	-	65	21	106	64
157	795	-	186	-	112	187	185	62	-	137	211	70	295
38	262	-	133	-	13	213	151	60	-	28	48	220	111
34	53	-	165	-	2	42	30	17	-	54	14	31	162
5	43	-	87	-	1	47	7	5	-	22	11	9	27
3	1	-	25	-	0	33	7	1	-	5	1	13	6
1	15	-	24	-	0	24	3	0	-	1	-	4	5
2	0	-	4	-	0	15	0	0	-	0	-	1	
2	2	-	2	-	0	52	0	0	-	0	-	0	
													-
469	1338	-	656		256	681	423	183	-	312	305	454	769
36	151		100		20	95	41	20	-	33	36	46	90
53	26		36		100		49	34	-	48	35	25	20
AR	AR		AR		AR	AR	AR	AR		R	R	R	R

Table 4. Herring in the Celtic Sea & Division VIIj. Rudimentary history of the Irish fishery since 1958.

Time period	1958-1977	1977-1983	1983-1997	1998-2004	2004-2007
Type of fishery	Cured fish	Closure	Herring roe	Fillet/whole fish	Fillet/whole fish
Quality of catch data	High	Medium	Low	Medium/low	High
Source of catch data	Auction data	Auction data	Skipper logbook estimate	Skipper logbook estimate	Weighbridge landings
Discard Levels	Low	Low	High	Medium	Medium
Incentive to discard	None	None	Maturity stage	Size grade, market vs. quota	
Alloowance for water*	na	na	na	20%*	2%*

* RSW only. These vessels are more dominant in recent years.

Table 5. Celtic Sea and VIIj herring. Biological history of the stock.

	1958-1972	1973-1977	1978-1980	1981-1983	1984-1995	1996-2008
MW 2-ring (kg) median	0.146	0.181	0.179	0.158	0.135	0.115
ML 2-ring (cm) median	26.4	27.5	27.1	26.3	25.2	24.4
Z (cohort catch curve)	0.22 - 0.93	0.42 - 1.12	0.74 - 0.93	0.62 - 0.74	0.49 - 0.89	0.48 - 1.01
GM recruitment 10^6	448	167	168	587	514	340
Recruitment anomaly	positive	negative	negative	positive	positive	both
SSB (000 t)	53 - 126	27 to 52	25 - 26	30 - 63	49 - 68	24 - 70
F (2-5 r)	0.23 - 0.71	0.55 - 0.80	0.50 - 0.68	0.68 - 0.87	0.40 - 0.98	0.12 - 0.88

Table 6. Celtic Sea and VIIj herring. Total mortality Z estimated from cohort catch curves.

Cohort	Z (2-7 ring)	Cohort	Z (2-7 ring)
1956	0.39	1977	1.09
1957	0.37	1978	0.84
1958	0.31	1979	0.93
1959	0.42	1980	0.75
1960	0.22	1981	0.75
1961	0.47	1982	0.65
1962	0.30	1983	0.63
1963	0.50	1984	0.50
1964	0.62	1985	0.66
1965	0.71	1986	0.62
1966	0.66	1987	0.76
1967	0.51	1988	0.58
1968	0.93	1989	0.73
1969	0.82	1990	0.57
1970	0.76	1991	0.65
1971	0.55	1992	0.77
1972	0.51	1993	0.90
1973	0.43	1994	0.73
1974	0.68	1995	0.80
1975	0.86	1996	1.02
1976	1.12	1997	0.88

Table 7. Celtic Sea and VIIj herring. Estimates of estimates of $F_{0.1}$ and F_{max} from the literature and HAWG work.

	$F_{0.1}$	F_{max}	MSY	Comments	Reference
1965	-	>0.5	12 – 15 000 t	Years for calculation had lower recruitment	Burd and Bracken, 1965
1969	-	~0.45	22 000 t	Years for calculation had higher recruitment	Molloy, 1969
1974	-	>0.5	14 000 *	Fmsy calculated for periods of high and low recruitment	Corten, 1974
1983	0.16			Yield/Biomass ratio	HAWG, 1983
1990	0.16				HAWG, 1990
1994	0.16				HAWG, 1994
1995	0.16				HAWG, 1995
1996	0.16				HAWG, 1996
1997	0.1				HAWG, 1997
1999	<0.2				HAWG, 1999
2000	<0.2				HAWG, 2000
2002	0.17			MFYPR software	HAWG, 2002
2003	0.17			MFYPR software	HAWG, 2003
2004	0.17			MFYPR software	HAWG, 2004
2007	0.19			MFYPR software	HAWG, 2007
2009	0.17			MFYPR software	HAWG 2009

*endorses Molloy (1969) provided that recruitment is at level 1966 – 1969

Table 8 Celtic Sea and VIIj herring. Advice history.

ICES Advice	Predicted catch corresp. to advice	Agreed TAC	Official Landings	Discards	Estimated Catch[1]
NEAFC TAC		32	20	-	19.74
Reduce F, TAC ? 25,000		25	16	-	15.13
TAC between 10,000 and 12,000		10.8	10	-	8.2
No Fishing	0	0	8	-	3.0
No Fishing	0	0	8	-	7.1
TAC set for VIIj only, No fishing in Celtic Sea	0	6	10	-	12.1
TAC set for VIIj only, No fishing in Celtic Sea		6	9	-	9.2
TAC set for VIIj only, No fishing in Celtic Sea		6	17	-	16.8
TAC		8*	10	-	9.5
TAC		8*	22	4.0	22.18
TAC	13	13	20	3.6	19.7
TAC	13	13	16	3.1	16.23
No specific TAC, preferred overall catch 17,000t		17	13	3.9	23.3
Precautionary TAC	18	18	18	4.2	27.3
TAC	13	18	17	2.4	19.2
TAC	20	20	18	3.5	22.7
TAC	15	17.5	17	2.5	20.2
TAC (TAC excluding discards)	15 (12.5)	21	21	1.9	23.6
TAC	27	21	19	2.1	23
Precautionary TAC (including discards)	20–24	21	20	1.9	21.1
Precautionary TAC (including discards)	20–24	21	19	1.7	19.1
No specific advice	-	21	18	0.7	19
TAC	9.8	16.5–21	21	3	21.8
If required, precautionary TAC	< 25	22	20.7	0.7	18.8
Catches below 25	< 25	22	20.5	0	20.3
F = 0.4	19	21	19.4	0	18.1
F < 0.3	20	21	18.8	0	18.3
F < 0.34	17.9	20	19	0	17.7
F<0.35	11	11	11.5	0	10.5
Substantially less than recent catches	-	13	12	0	10.8
60% of average catch 1997–2000	11	13	12	-	11
60% of average catch 1997–2000	11	13	10	-	8
Further reduction 60% avg catch 2002–2004	6.7	11	9	-	8.5
No fishing without rebuilding plan	--	9.3	9.6	-	8.2
No targeted fishing without rebuilding plan	--	7.9	7.8		6.7
No targeted fishing without rebuilding plan	--	5.9			

*** TAC from 1st Oct – 31st Mar**

1) Calendar year

Annex 6 – Stock Annex Herring in VIaN

Quality Handbook ANNEX: Hawg-her47d3

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Herring in VIa (North)

Working Group: Herring Assessment WG for the Area south of 62°N

Date: 22 March 2010

Authors: E.M.C. Hatfield, E.J. Simmonds and A. Edridge

A. General

A.1. Stock definition

The stock is distributed over ICES Division VIa (N). Some of the larger adults typically found close to the shelf break may be caught in division Vb.

A.2. Fishery

The dominant fleet fishing in VIa (N) since 1957 has been the Scottish fleet. In the early years the Scottish fishery was prosecuted using a mixture of vessel size and gear, including gill nets, ring-nets and trawls. The boats were small, and targeted the coastal stock, primarily fishing in the winter. Until 1970 the only other nations fishing in this area on a regular basis were the former German Federal Republic, and to a much lesser extend the Netherlands. These fleets operated in deeper water near the shelf edge.

In 1970 a large increase in exploitation occurred with the entry of fleets from Norway and the Faroes, and an increased Netherlands catch. In addition, considerably smaller catches were taken by France and Iceland.

Throughout this period juvenile herring catches from the Moray Firth, in the 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.

B. Data

B.1. Commercial catch

Commercial catch is obtained from national laboratories of nations exploiting herring in VIa (N). Since 1999 (catch data 1998), these labs have used a spreadsheet to provide all necessary landing and sampling data, which was developed originally for the Mackerel Working Group (WGMHSA) and further adapted to the special needs of the Herring Assessment Working Group. The current version used for reporting the 2002 catch data was v1.6.4. The majority of commercial catch data of multinational fleets was provided on these spreadsheets and further processed with the SALLOCL-application (Patterson, 1998a). This program gives the needed standard outputs on sampling status and biological parameters. It also clearly documents any decisions made by the species co-ordinators for filling in missing sampling data and raising the catch information of one nation/quarter/area with information from another data set.

Transparency of data handling by the Working Group. The current practice of data handling by the Working Group is that the data received by the co-ordinators is available in a folder called "archive". These high-resolution data are not reproduced in the report. The archived data contains the disaggregated dataset (disfad), the allocations of samples to unsampled catches (alloc), the aggregated dataset (sam.out) and (in some cases) a document describing any problems with the data in that year.

Current methods of compiling fisheries assessment data. The species co-ordinator is responsible for compiling the national data to produce the input data for the assessments. In addition to checking the major task involved is to allocate samples of catch numbers, mean length and mean weight-at-age to unsampled catches. There are at present no defined criteria on how this should be done, but the following general process is implemented by the species co-ordinators. Searches are made for appropriate samples by gear (fleet) area quarter, if an exact match is not available the search will move to a neighbouring area if the fishery extends to this area in the same quarter. More than one sample may be allocated to an unsampled catch, in this case a straight mean or weighted mean of the observations may be used. If there are no samples available the search will move to the closest non-adjacent area by gear (fleet) and quarter, but not in all cases.

Until 2003 the VIa(N) catch data extended back to the early 1970s; since 1986 the series has run from 1976 to present. In 2004 the data set was extended back to 1957. Details are given below.

Historic Catches from 1957 to 1975

The working group has obtained preliminary estimates of catch and catch-at-age for the period 1957 to 1975. These have been estimated from records of catch presented in HAWG reports from 1973, 1974, 1981 and 1982. Intervening reports were also consulted to check for changes or updates during the period. Catch-at-age data were available from 1970 to 1975 from the 1982 Working Group report, and catches-at-age for the period 1957 to 1972 were estimated from paper records of catch-at-age by national fleets for 1957 to 1972, held at FRS Marine Laboratory Aberdeen. The fishing practices of national fleets were established for the period 1970 to 1980 from catches in VIa and VIa (N) recorded in the 1981 and 1982 Working Group reports respectively. This procedure suggested that, on average, more than 90% of catch by national fleet could be fully assigned to either VIa (N) or VIa (S). The remaining catch was assigned assuming historic proportions. During this period catches were split into autumn and spring spawning components; anecdotal information on trials to verify this separation suggests it was not a robust procedure. Currently about 5% of herring in VIa (N) is found to be spent at the time of the acoustic surveys in July, and thought to be spring spawning herring. However, at present the Working Group assesses VIa (N) herring as one stock, regardless of spawning stock affiliation. In the earlier period higher proportions were allocated as spring spawners. Currently the designated ‘spring spawning’ component is not included in the catch at age matrix, but the catch tones express the full amount giving rise to SoP differences in the early years. Similarly, a small Moray Firth juvenile fishery was also included in VIa (N) catch in earlier years because it was thought that these juveniles were part of the VIa (N) stock. Separating this component in the historic data was difficult, and as the fishery ceased in the very early 70s this has no implications for current allocation of these fish. The Moray Firth is, geographically, part of IVa (ICES stat. rectangles 44E6, 44E7, 45E6) and is now managed as part of that area. Currently there are no juvenile herring catches from the Moray Firth. Full details of the analysis carried out is provided as an appendix (Appendix 11) to the 2004 Working Group report. Further investigations are required before determining the correct actions concerning the ‘spring spawners’ in early period. The consequence of this is to slightly reduce the apparent stock size in the early years, when is already at an all time high. It has no implications for fitting of any survey data, or influence on the Blim reference point, however, it might further increase the high R seen at high SSB in a S/R relationship.

Allocation of catch and misreporting

This fishery has had a strong tradition of misreporting before 2000, though this has reduced in recent years. It is believed that the shortfall between the TAC and the catch was used to misreport catches from other areas (from IVa to the east and from VIa (S) to the south). In the past, fishery-independent information confirmed that large catches were being reported from areas with low abundances of fish, and informal information from the fishery and from other sources confirmed that most catches of fish recorded between 4°W and 5°W were most probably misreported North Sea catches. The problem was detailed in the Working Group report in 2002 (ICES 2002/ACFM:12). Improved information from the fishery in 1998 - 2002 allowed for re-allocation of many catches due to area misreporting (principally from VIa (N) to IVa (W)). This information was obtained from only some of the fleets

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

The Butt of Lewis box, (a seasonal closure to pelagic fishing of the spawning ground in the north west of the continental shelf in area VIa(North) since the late 1970s was opened to fishing in 2008 following a STECF review in 2007. It has not been possible to show either beneficial or deleterious effects from this closure.

Catches are included in the assessment. Biases and sampling designs are not documented. Discards are not included, though data from some fleets suggest these are very minor. Slippage and high grading are not recorded.

B.2. Biological

Catch-at-age data (catch numbers-at-age, mean weights-at-age in the catch, mean length-at-age) are derived from the raised national figures received from the national laboratories. The data are obtained either by market sampling or by onboard observers, and processed as described in Section B.1 above. For information on recent sampling levels and nations providing samples, see Section 2.2. in the most recent HAWG report.

Proportions mature (maturity ogive) and mean weights-at-age in the stock derived from the acoustic survey (see next section) have been used since 1992 and 1993, respectively. Prior to these years, time-invariant values derived from ??? were used.

Biological sampling of the catches was extremely poor in recent history (particularly in 1999). This was particularly the case for the freezer trawler fishery that takes the larger component of the stock based around the shelf break. The lack of samples was due in part to the fact that national vessels tend to land in foreign ports, avoiding national sampling programs. The same fleet is thought to high grade. The long length of fishing trips makes observer programs difficult. Even when samples are taken, age determination is limited for most nations.

Sampling has improved over the last few years. The number of age readings per 1,000 t of catch increased from the low in 1999 of 52 to a high in 2001 of 93. Numbers have decreased again since then to 57 per 1,000 t in 2003. From 1999 to 2003 the sampling has been dominated by Scotland (ranging between 70 and 98% of the age readings), except in 2001, when only 43% of the age determination was on Scottish landings in VIa (N).

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1957 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a) that were applied to adjacent areas (Anon. 1987b).

B.3. Surveys

B.3.1 Acoustic survey – WoSHAS (MSHAS)

An acoustic survey has been carried out for VIa (N) herring in the years 1987, 1991-2003

Biomass estimated from the acoustic survey tends to be variable. Herring are found in similar area each year, namely south of the Hebrides off Barra Head, west of the Hebrides and along the shelf edge.

The stock is highly contagious in its spatial distribution, which explains some of the high variability in the time series. Effort stratification has improved with knowledge of the distribution and this may be less of a problem in more recent years. The survey uses the same target strength as for the North Sea surveys and there is no reason to suppose why this should be any different. Species identification is generally not a great problem.

Review of acoustic survey time-series

In 2009, an examination of the time series of the spawning stock biomass (SSB) data derived from the annual acoustic survey for the west of Scotland herring stock, in preparation for a publication on the survey time-series, showed a number of discrepancies between the values given in the original survey reports, the PGHERS (or combined survey) reports, the HAWG reports and the combined acoustic survey data archive held in the Marine Lab. Aberdeen. The discrepancies could not be easily explained by simple means, e.g., the original survey report included data east of 4°W that was then subtracted for the SSB estimate later.

A simple calculation of the values in the survey assessment input files was performed:

Catch numbers-at-age in the survey * weights-at-age in the stock * proportion mature

to derive an estimate of the SSB. This showed up further discrepancies that warranted closer examination. Initially it was not certain from where the discrepancies may have arisen, and they were only in certain years.

The aim of this exercise was to produce a new set of survey input files of catch numbers-at-age in the survey (*fleet)*, weights-at-age in the stock (*west*) and proportion mature (*matprop*), with the correct values within and the reasons for those choices documented. The details are given in full in Hatfield and Simmonds (WD05 HAWG

2010). Several changes were calculated for 1987, 1991, 1993, 1994, 1995, 1997, 1999, 2000, 2001 and 2005. The updated numbers-, weights-at-age in the stock, proportion mature and revised SSB time series are given in the Stock Annex

The 1987 acoustic survey was carried out in November, and not in July like all but one of the subsequent surveys. Consequently, neither the actual proportions mature in July nor the mortalities between July and November were known and the historical values of weights-at-age and proportions mature were used. The survey was, initially, retained to lengthen the time series. This is no longer an issue. It is, therefore, recommended that the 1987 survey value be removed from the time series, to give a modified time-series (1991 onwards) of 19 years (to 2009).

B.3.2 Larvae survey

Larvae surveys for this stock were carried out from 1973 to 1993. Larval production estimates (LPE) and a larval abundance index (LAI) were produced for the time series. These values were used in the assessment, the LPE until 2001. However, in 2002 it was decided that the LAI had no influence on the assessment and has not been used since. Documentation of this survey time-series is given in ICES CM 1990/H:40.

B.4. Commercial CPUE

Not used for pelagic stocks

B.5. Other relevant data

C. Historical Stock Development

An experimental survey-data-at-age model was formulated at the 2000 HAWG. In 1999 and 1998 a Bayesian modification to ICA was used to account for the uncertainty in misreporting.

The ICA assessment (Patterson 1998a), implemented in FLR (Kell 2007) as FLICA, has exhibited substantial revision both up and down over the last few years, largely due to the noisy survey used for tuning the assessment. The model settings were last explored in detail in 2009 (ICES 2009/ACOM:03). The conclusion was that continuing with the current weighting and model settings is an acceptable solution, until more data, possibly as a result of the extended surveys from SGHERWAY, are available.

Model used: FLICA Software R / ICA (Patterson 1998b)

Model Options chosen:

Separable constraint over last 8 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 3

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.02 and 0.5

All survey weights equal i.e., 1.0 with the exception of 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

Type	Name	Year range	Age range	Variable from year to year Yes/No
Caton	Catch in tones	1957 - last data year	NA	Yes
Canum	Catch at age in Numbers	1957 - last data year	1-9+	Yes
Weca	Weight at age in the commercial catch	1957-1972 1973-1981 1982-1984 1985-last data year	1-9+ 1-9+ 1-9+ 1-9+	No No No Yes
West	Weight at age of the spawning stock at spawning time.	1957 - 1992 1993-last data year	1-9+ 1-9+	No Yes
Mprop	Proportion of natural mortality before spawning	1957-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	1957-last data year	NA	No
Matprop	Proportion mature at age	1957 - 1991 1992-last data year	1-9+ 1-9+	No Yes
Natmor	Natural mortality	1957 - last year	1-9+	No

Tuning data:

Type	Name	Year Range	Age Range
Tuning fleet 1	VIa (N) Acoustic Survey	1987,	1-9+
		1991- last data year	1-9+

D. Short-Term Projection

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. 1- and 2-ring recruits taken from a geometric mean for the years 1986 to one year prior to the last year.

Maturity: Mean of the last three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: Mean of the last three years in the assessment.

Weight at age in the catch: Mean of the last three years in the assessment.

Exploitation pattern: Mean of the previous eight years, scaled by the Fbar (3-6) to the level of the last year (eight because this is the assessment model assumption of 8 years separable period).

Intermediate year assumptions: **TAC** constraint. Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections (done intermittently)

Model used: STPR as described in Skagen (2003)

Initial stock size: Population parameters Terminal year survivors from ICA assessment with recruits replaced as in short term projections (D above). Drawn from a multivariate lognormal distribution with mean equal to the values estimated in the stock assessment model, and with covariance as estimated in the same model fit. Geometric mean recruitment for 1- and 2-ringers is used to replace the values in the assessment for the first projected year, covariance at age 2 retained and used for age 1 and 2.

Natural mortality: Mean of the last three years in the assessment.

Maturity: drawn randomly by year from 1990 to present.

F and M before spawning: Set to 0.67 for all years.

Weight at age in the stock: drawn randomly by year from 1990 to present.

Weight at age in the catch: drawn randomly by year from 1990 to present.

Exploitation pattern: from the eight year separable model

Intermediate year assumptions: TAC constraint

Stock recruitment model used: Variable Hockey-Stick or Beverton Holt fitted to recent data (1989 on) , but other options tested for robustness max year three years prior to the assessment.

G. Biological Reference Points

The report of SGPRP (ICES 2003/ACFM:15) proposed a B_{lim} of 50,000 t for VIa (N) herring. This is calculated from the values in the converged part of the VPA (1976-1999) and the Working Group endorsed this value in 2003 (ICES 2003/ACFM:17).

Suggested Precautionary Approach reference points:

B_{LIM} is 50,000 t	B_{PA} be set at 75,000 t

Technical basis:

B_{LIM}: B_{LOSS} Estimated SSB for sustained recruitment	Bpa: 1.5 * Blim

H. Other Issues

H.1 Biology of the species in the distribution area

The Atlantic herring, *Clupea harengus*, is numerically one of the most important pelagic species in North Atlantic ecosystems with widespread distribution around the Scottish coast. Within the Northeast Atlantic they are encountered from the north of Biscay to Greenland, and east into the Barents Sea. It is thought that herring stocks comprise many reproductively isolated subpopulations through specific spawning grounds and seasons (e.g. autumn and spring spawners), but the taxonomic status of these subpopulations remains unclear.

Herring are demersal spawners and produce dense beds of benthic eggs deposited on gravelly substrates. This behaviour is considered to be an evolutionary remnant of herrings' river spawning past. Each female produces a single batch of eggs per year, releasing a ribbon of eggs that adheres to the benthos; the male sheds milt while swimming a few centimetres above the female. This particular behaviour renders herring vulnerable to anthropogenic activity such as offshore oil and gas industries and gravel extraction.

The eggs take about three weeks to hatch, dependant on the temperature. The larvae on hatching are 6-9mm long and are immediately planktonic. Their yolk sac lasts for about a week during which time they will begin to feed on phytoplankton and crustacean larvae. Their planktonic development lasts around three to four months during which time they are passively subjected to the residual drift which takes them to coastal nurseries. The habitats of juveniles are primarily pelagic, and hydrographical features such as temperature and the depth of thermocline, as well as abundance of zooplankton affect their distribution. Adult fish are pelagic and found mostly in continental shelf seas to depths up to 200m. They form large shoals with diurnal migration patterns through the water column which can be associated with the availability of prey and stage of maturity. In the winter the feeding activity and growth are very slow. Herring can reach 40cm in length and have a maximum lifespan of 10 years although most herring range between 20-30cm and are less than 7 years.

Assessing age and year class for herring can be problematic due to the extended spawning season of autumn spawners from September to January. Using the convention of January 1st as the birthday, 0-group refer to fish born between 3 and 18 months ago but 0-group autumn spawners belong to a different class from 0-group spring spawners. Time series of a stock's age structure helps its management and it is vital that they are extended for all the '*West of Scotland*' herring components in the VIaN (North), VIaS (South) and VIb areas. The stock identity of herring west of the British Isles was reviewed by the EU-funded project WESTHER, which identified VIaN as an area where catches comprise a mixture of fish from Areas VIaN, VIaS, and VIIaN. ICES current advice is that herring components should be managed separately to afford maximum protection, but a study group will be convened in 2008 (SGHERWAY) to evaluate the WESTHER recommendations.

There are many hypotheses as to the cause of the irregular cycles shown in the productivity of herring stocks (weights-at-age and recruitment), but in most cases it is thought that the environment plays a key role (through prey, predation and transport). The VIaN herring stock has shown a marked decline in productivity during the late 1970s and has remained at a low level since then. ICES identifies that the VIaN stock is currently fluctuating at low levels and is being exploited above F_{msy}.

Historically, the stock in this area has been affected by three fisheries:

A Scottish domestic pair trawl fleet and the North Irish fleet operated in shallower, coastal areas, principally fishing in the Minches and around the Island of Barra in the South where younger herring are encountered. This fleet has reduced in the last years.

The Scottish single-boat trawl and purse-seine fleets, with refrigerated seawater tanks, targeting herring mostly in the northern North Sea, but also operating in the northern part of VIaN. This fleet now operates mostly with trawls but many vessels can deploy either gear.

An international freezer-trawler fishery has historically operated in deeper water near the shelf edge where older fish are distributed. These vessels are mainly registered in the Netherlands, Germany, France, and England but most are Dutch owned.

In recent years the age structure of the catch of these last two fleets has become more similar.

In addition to being a valuable protein resource for humans, herring represent an important prey item for many predators including cod and other large gadoids, dogfish and sharks, marine mammals and sea birds. Because the trophic importance of herring puts its stocks under immense pressure from constant exploitation, it is important that management takes into account all anthropogenic, environmental and biological variables.

H.2 Terminology

The WG uses "rings" rather than "age" or "winter rings" throughout the report to denominate the age of herring, with the intention to avoid confusion. It should be observed that, for autumn spawning stocks, there is a difference of one year between "age" and "rings". HAWG in 1992 (ICES 1992/Assess:11) stated that:

"The convention of defining herring age rings instead of years was introduced in various ICES working groups around 1970. The main argument to do so was the uncertainty about the racial identity of the herring in some areas. A herring with one winter ring is classified as 2-years-old if it is an autumn spawner, and one-year-old if it is a spring spawner. Recording the age of the herring in rings instead of in years allowed scientists to postpone the decision on year of birth until a later date when they might have obtained more information on the racial identity of the herring.

The use of winter rings in ICES working groups has introduced a certain amount of confusion and errors. In specifying the age of the herring, people always have to state explicitly whether they are talking about rings or years, and whether the herring are autumn- or spring spawners. These details tend to get lost in working group reports, which can make these reports confusing for outsiders, and even for herring experts themselves. As the age of all other fish species (and of herring in other parts of the world) is expressed in years, one could question the justification of treating West-European herring in a special way. Especially with the present trend towards multispecies assessment and integration of ICES working groups, there might be a case for a uniform system of age definition throughout all ICES working groups.

However, the change from rings to years would create a number of practical problems. Data files in national laboratories and at ICES would have to be adapted, which would involve extra costs and manpower. People that had not been aware of the change might be confused when comparing new data with data from old working group reports. Finally, in some areas (notably Division IIIa), the distinction between spring- and autumn spawners is still hard to make, and scientists preferred to continue using rings instead of years.

The Working Group discussed at length the various consequences of a change from rings to years. The majority of the Group felt that the advantages of such a change did not outweigh the disadvantages, and it was decided to stick to the present system for the time being. "

The text table below gives an example for the correlation between age, rings and year class for the different spawning types in late 2002:

Year class (autumn spawners)	2001/2002	2000/2001	1999/2000	1998/1999
Rings	0	1	2	3
Age (autumn spawners)	1	2	3	4
Year class (spring spawners)	2002	2001	2000	1999
Rings	0	1	2	3
Age (spring spawners)	0	1	2	3

I.1. Management and ICES Advice

COUNCIL REGULATION (EC) No 1300/2008 of 18 December 2008 established a multi-annual management agreement for the stock of herring distributed to the west of Scotland and the fisheries exploiting that stock.

F = 0.25 if SSB > 75 000 t 20% TAC constraint.

F = 0.20 if SSB < 75 000 t but > 62 500 t 20% constraint on TAC change.

F = 0.20 if SSB <62 500 t but > 50 000 t 25% constraint on TAC change

F = 0 if SSB < 50 000 t.

There is derogation from the above constraints. If STECF considers that the herring stock in the area west of Scotland is failing properly to recover, the TAC constraints may differ from those in the management agreement. This plan is similar but not identical to the proposed plan.

I. References

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Skagen, D.W. 2003. Programs for stochastic prediction and management simulation (STPR3 and LTEQ). Program description and instruction for use. WD to HAWG 2003.

Table Annex 6-1. Revised values of numbers-at-age in the VIa (North) acoustic survey, to be used in the stock's assessment.

Year/Age	1	2	3	4	5	6	7	8	9
1991	338312	294484	327902	367830	488288	176348	98741	89830	58043
1992	74310	503430	210980	258090	414750	240110	105670	56710	63440
1993	2357	579320	689510	688740	564850	900410	295610	157870	161450
1994	494150	542080	607720	285610	306760	268130	406840	173740	131880
1995	441200	1103400	473300	450300	153000	187200	169200	236700	201700
1996	41220	576460	802530	329110	95360	60600	77380	78190	114810
1997	792320	641860	286170	167040	66100	49520	16280	28990	24440
1998	1221700	794630	666780	471070	179050	79270	28050	13850	36770
1999	534200	322400	1388000	432000	308000	138700	86500	27600	35400
2000	447600	316200	337100	899500	393400	247600	199500	95000	65000
2001	313100	1062000	217700	172800	437500	132600	102800	52400	34700
2002	424700	436000	1436900	199800	161700	424300	152300	67500	59500
2003	438800	1039400	932500	1471800	181300	129200	346700	114300	75200
2004	564000	274500	760200	442300	577200	55700	61800	82200	76300
2005	50200	243400	230300	423100	245100	152800	12600	39000	26800
2006	112300	835200	387900	284500	582200	414700	227000	21700	59300
2007	-1	126000	294400	202500	145300	346900	242900	163500	32100
2008	47840	232570	911950	668870	339920	272230	720860	365890	263740

Table Annex 6-2. Revised values of weights-at-age in the stock from the VIa (North) acoustic survey, to be used in the stock's assessment.

Year/Age	1	2	3	4	5	6	7	8	9
1991	0.09	0.164	0.208	0.233	0.246	0.252	0.258	0.269	0.292
1992	0.068	0.152	0.186	0.206	0.233	0.253	0.273	0.299	0.302
1993	0.073	0.164	0.196	0.206	0.225	0.234	0.253	0.259	0.276
1994	0.052	0.15	0.192	0.22	0.221	0.233	0.241	0.27	0.296
1995	0.042	0.144	0.191	0.202	0.225	0.227	0.247	0.26	0.293
1996	0.045	0.14	0.18	0.209	0.219	0.222	0.229	0.242	0.263
1997	0.054	0.142	0.180	0.199	0.213	0.222	0.231	0.242	0.263
1998	0.066	0.138	0.176	0.194	0.214	0.226	0.234	0.225	0.249
1999	0.054	0.137	0.166	0.188	0.203	0.219	0.225	0.235	0.245
2000	0.062	0.141	0.173	0.183	0.194	0.204	0.211	0.222	0.23
2001	0.062	0.132	0.17	0.19	0.198	0.212	0.22	0.236	0.254
2002	0.062	0.153	0.177	0.198	0.212	0.215	0.225	0.243	0.259
2003	0.064	0.138	0.176	0.19	0.204	0.213	0.217	0.223	0.228
2004	0.059	0.138	0.159	0.18	0.189	0.202	0.213	0.214	0.206
2005	0.0751	0.1296	0.1538	0.1665	0.1802	0.1911	0.2125	0.203	0.2284
2006	0.075	0.135	0.166	0.185	0.192	0.204	0.211	0.224	0.231
2007	0.075	0.1675	0.183	0.1914	0.1951	0.1951	0.2021	0.2034	0.2138
2008	0.0546	0.1721	0.1913	0.2083	0.2143	0.2139	0.2206	0.2242	0.2385

Table Annex 6-3. Revised values of proportions mature from the VIa (North) acoustic survey, to be used in the stock's assessment.

Year/Age	1	2	3	4	5	6	7	8	9
1991	0	0.57	0.96	1	1	1	1	1	1
1992	0	0.47	1	1	1	1	1	1	1
1993	0	0.93	0.96	1	1	1	1	1	1
1994	0	0.48	0.92	1	1	1	1	1	1
1995	0	0.19	0.98	1	1	1	1	1	1
1996	0	0.76	0.94	1	1	1	1	1	1
1997	0	0.55	0.95	1	1	1	1	1	1
1998	0	0.85	0.97	1	1	1	1	1	1
1999	0	0.57	0.98	1	1	1	1	1	1
2000	0	0.45	0.92	1	1	1	1	1	1
2001	0	0.93	0.99	1	1	1	1	1	1
2002	0	0.92	1	1	1	1	1	1	1
2003	0	0.76	1	1	1	1	1	1	1
2004	0	0.83	0.97	1	1	1	1	1	1
2005	0	0.84	1	1	1	1	1	1	1
2006	0	0.81	0.97	1	1	1	1	1	1
2007	0	1	1	1	1	1	1	1	1
2008	0	0.98	1	1	1	1	1	1	1

Table Annex 6-4. Revised values of the spawning stock biomass (SSB) from the VIa (North) acoustic survey.

Year	SSB (t)
1991	410,000
1992	351,460
1993	845,452
1994	533,740
1995	452,300
1996	370,300
1997	175,000
1998	375,890
1999	460,200
2000	444,900
2001	359,200
2002	548,800
2003	739,200
2004	395,900
2005	222,960
2006	471,700
2007	298,860
2008	788,200
2009	578,757

Annex 7 – Stock Annex Herring in Division VIa South and VIIb,c

Quality Handbook	ANNEX: Herring VIaS and VIIb, c
Stock specific documentation of standard assessment procedures used by ICES	
Stock:	Herring in VIaS and VIIb, c
Working Group:	Herring Assessment Working Group for the area south of 62^0N
Date:	March 2010
Authors:	Afra Egan and Maurice Clarke

A. 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, later in the autumn and in the winter.

For the purpose of stock assessment and management, these areas have been separated from VIaN since 1982 and are split at 56° N. This split is based on work carried out by working groups in the late 1970s and early 1980s which found that the stocks exploited off the west coast of Scotland were biologically different from those off the north coast of Ireland. A second new assessment area was also recommended by the 1981 Working Group (ICES CM 1981). The Irish landings were taken mainly in the southern part of VIa and in VIIb, c. These catches were found to be biologically very similar with respect to age composition and spawning. It was decided at the 1981 working group to combine the areas and conduct a joint assessment (Molloy, 2006).

A herring tagging experiment was carried out in 1992 in order to investigate the movements and annual migrations of herring around the Irish Coast. 20,000 herring were tagged in total with 10,000 of these off the west coast. Some fish moved northwards and were recaptured along the north coast between July and February, in the main fishing areas. 90% of the fish tagged along the west coast were recovered from the Donegal Bay area. The maturity stages of the recaptured fish, suggests that the fish were migrating inshore towards spawning grounds (Molloy, *et al* 1993). There were no returns from north of Donegal although it is possible that there may not have been much fishing activity in the area at this time (Molloy and Kelly, 2000).

Assessment and biology

A study group on herring assessment and biology in the Irish Sea and adjacent areas met in 1994 (ICES, 1994). This meeting highlighted the problems associated with the assessment of herring stocks around Ireland. This group recommended that the boundary line separating this stock from the herring stock of VIaS and VIIb be moved southwards from latitude 52°30′N to 52°00′N (ICES, 1994). A Schematic presentation of the life cycle of herring to the west and northwest of Ireland is shown in Figure 1.

The spawning, nursery and feeding grounds are shown as well as the direction of larval drift and migration.

WESTHER

WESTHER was an EU-funded project, to review, the stock identity of herring west of the British Isles. A number of factors were examined including.

Morphometrics and meristic characteristics

Internal parasites

Otolith microstructure and microchemistry

Genetics

Results from this project identified distinct spawning grounds and spawning components. It was recommended that the stocks to the west of the British Isles should be managed as two stocks, the Malin Shelf stock and the Celtic Sea stock. Management plans should be fleet and area based in order to prevent the local depletion of any population unit in the areas (WESTHER, Q5RS-2002-01056). Further work on the management of these stocks will be conducted by SGHERWAY which met for the first time in late 2008. A meeting also took place in 2009 with further meetings planned for 2010. This group has three main terms of reference:

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;

explore a combined assessment of the three stocks and investigate its utility for advisory purposes;

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.

The final results from this group will be available for the deliberation of ACOM in July 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 was important in supplying the German markets. Herring fisheries, which took place every spring and summer off the coast of Donegal, have been under scientific observation since 1921, with very little scientific work carried out prior to this. The fishing grounds were well known and were located between ten and forty miles offshore. Fishing during this time was split into three well defined time periods.

1) December/January
2) May (main fishing took place)
3) September/October

During the 1930s many of the major herring markets disappeared (Molloy, 1995). In contrast to the rapid expansion experienced in the Celtic Sea the revival of the northwest fishery occurred at a slower pace (Molloy, 2006). The revival first became evident in the 1950s when many Scottish ring netters took part in this fishery with many of the Irish boats also using this gear. Then several boats changed to pelagic midwater trawls. The herring fleet continued to expand throughout the 1960s with many skippers becoming experts in pelagic pair trawling (Molloy, 2006).

In the 1970s and 1980s the autumn spawners became more significant and accounted for the majority of the landings. Galway and Rossaveal gained increasing importance as herring ports in the 1970s. In the 1974/75 season landings decreased dramatically and it was the first indication that the stock might have started to decline. The North Sea stock was already in decline and many Dutch boats were fishing off the Irish west coast. TACs were reduced and the stock continued to decline. In 1978 it was advised that the fishery be closed (Molloy, 2006). This closure lasted until 1981 and was reopened with new management units. VIaS and VIIb, c were joined and were assessed separately from VIaN.

In recent years the northern grounds have regained importance with catch also coming from the west coast close to the VIa boundary line (ICES, 2005). Very little fishing now takes place on previously important grounds in Galway Bay and along the Mayo coast (Molloy and Kelly, 2000).

Since the late 1970s considerable changes have taken place in the type of pelagic fishing carried out by Irish boats off the North West Coast, with directed herring fishing having been largely replaced by mackerel fishing (Breslin, 1998).

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 10,400 in 2009. Total catch over the complete time series are shown in the Figure 3. The number of boats participating in this fishery remained constant for a number of years at around 30 vessels. Increases were seen in recent years with 48 vessels landing northwest herring in 2009. 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 4), (Nolan and Lyons, 2006).

Environmental conditions can cause significant fluctuations in abundance in a variety of marine species including fish. A study conducted in 1980 found that west coast herring catches showed strong correlations with temperature and salinity at a constant lag of three or four years. Oceanographic variation associated with temperature and salinity fluctuations appears to affect herring in the first year of life, probably during the winter larval drift (Grainger 1980a).

Productivity in this region is reasonably high on the shelf but drops rapidly west of the shelf break. This area is important for many pelagic fish species. The shelf edge is a spawning area for mackerel *Scomber scombrus* and blue whiting *Micromesistius potassou*. Historically, there were important commercial fisheries for many demersals species also. On the shelf, the main resident pelagic species is herring *Clupea harengus* (ICES, 2007b). Preliminary examination of productivity shows that overall productivity in this area is currently lower than it was in the 1980s. Further information on this can be found in the HAWG report 2007 (ICES CM 2007).

Larvae that were spawned on the west and northwest coast follow a northwards drift. Larvae spawned further north off the Donegal coast were found to drift towards the Scottish west coast (Grainger and McArdle, 1985; Molloy and Barnwall, 1988) Studies have shown that the maximum larval depth is below the surface between 5-15m and there has been no evidence of diel migration, or variation in the distribution of different larval size categories (Grainger 1980b). 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

B.1. Commercial Catch

The commercial catch data are provided by national laboratories belonging to the nations that have quota for this stock. In recent years, only Ireland has been catching herring in this area, and the data are derived entirely from Irish sampling. Sampling is performed as part of commitments under the EU Council Regulation 1639/2001.

Commercial catch at age data are submitted in Exchange sheet v 1.6.4. These data are usually processed using SALLOCL (Patterson, 1998b). However, since only one country participates in this fishery this system is not required. Ireland acts as stock coordinator for this stock.

InterCatch

Since 2007, InterCatch, which is a web-based system for handling fish stock assessment data was used. National fish stock catches are imported into InterCatch. Stock coordinators then allocate sampled catches to unsampled catches, aggregate them to stock level and download the output. The InterCatch stock output can then be used as input for the assessment models. It is envisaged that this system will replace SALLOCL and other previously used systems.

Reallocation of Catches

Since 2007, landings data were revised with respect to reallocation of catches between area VIaS and VIaN, for the years 2000-2005. Before 2000, a comprehensive reallocation was used. For 2000-2005, various procedures were used. These attempted to deal with the increasing Irish catches along the 56° line and opportunistic Irish catches of herring in VIaN during the 4th and 1st quarter mackerel fishery. In some years some catches were reallocated, while in others no reallocations were made. In 2007, it was considered that the most correct procedure was that used before 2000. Therefore a retrospective reallocation has been conducted. It does not adequately consider the Irish herring catches in VIaN, nor does the reallocation consider fishing along the 56°line. However, in the absence of better information on Irish directed herring fishing in VIaN, this procedure provides the best possible method.

B.2. Biological

Sampling Protocol

Landings data are available for this area from 1970. Data on catch numbers at age, mean weights at age and mean lengths at age are derived from Irish data. Sampling is conducted by area and by quarter. Landings from this fishery, at present, are mainly into the port of Killybegs with lesser amounts landed into Rossaveal. Irish samples are collected from these commercial landings. Length frequency and age data is collected by ICES division by quarter. The length frequency data is added together for each division and quarter and raised to the landings for that area and quarter. The sample weight is divided into the catch weight to get the raising factor. The sum of the length frequencies per quarter is multiplied by the raising factor. An age length key is applied to this data and catch numbers at age calculated.

Age Reading Protocol

Northwest herring are currently aged using otoliths and are read using a stereoscopic microscope, with reflected light. The minimum level of magnification (15x) is used initially. It is then increased to resolve the features of the otolith. Herring otoliths are generally read in the magnification range of 20x – 25x. The patterns of opaque (summer) and translucent (winter) zones are viewed. The winter (translucent) ring at the otolith edge is counted only in otoliths from fish caught after the 1st January. The first winter ring that is counted is that which corresponds to the second "birth date" of the fish. Therefore a fish of 2 winter rings is a 3 year old. This convention applies to all ICES herring stocks with autumn spawning (Lynch, 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). Currently the catch is mainly composed of ages 2 ,3, 4 and 5 ringers. In recent years there have been decreasing proportions of older fish in the catch. This stock is different from the Celtic Sea in that there is no recruitment failure and the Northwest stock is less reliant on incoming recruitment. The decrease in the proportions of older ages can be seen in Figure 5.

Precision Estimates

The precision estimates on 2006 ageing data were worked up using a bootstrap technique. The results of the method found that the relative error is below 20% over the age range 2-6wr. At older ages, estimates of NW herring show higher CVs which is likely to be due to the relative paucity in the catch.

Mean Weights

Mean weights in the stock (West) are calculated using samples taken from Q1 and Q4. A mean weight at age is then calculated. Mean weights in the catch (Weca) are calculated using samples from all quarters of the fishery and a mean weight per age derived.

Trends in mean weights over time

The mean weights in the catch display quite a stable pattern over the time series, although variable weights are only available from the early 1980s. Younger ages (1-6 ring) show an overall downward trend with more fluctuations evident in older ages (7-9 ring). The mean weights in the stock at spawning time have been calculated from Irish samples taken during the main spawning period and show similar patterns to the mean weight in the catch.

Maturity ogive

A maturity ogive has been produced from the 2007 acoustic survey shows that 58% are mature at 1-ring, 99% at 2-ring and 100% mature at 3-ring. The maturity ogive used in the assessment considers 1-ringers to be all immature and all subsequent age groups as fully mature.

Log Catch Ratios

The log catch ratios ($\ln C_{a,y}/ C_{a+1,y+1}$) are presented below and are smoothed with a 4-year running average to show the main trends (Figure 6). 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 7). These catch curves show signals in total mortality over the time series.

Low mortality seems evident on the very large 1981,985 and 1988 year classes. These represent three of the biggest year classes recruited to this fishery. Increasing mortality can be seen from 1990 on, whilst the 1970s cohorts show lower Z.

B.3. Surveys

Acoustic Surveys

Acoustic surveys have been carried out in this area since 1994. The timing of these surveys has changed over this period. Initially the surveys were undertaken in the summer in order to coincide with international herring surveys and with the summer feeding period of this stock. In 1997, a research vessel was not available and the survey was not carried out. From 1998 -2001 surveys were undertaken in October in order to survey the autumn spawning component. This was changed in 2002 with surveys carried out in January targeting the winter spawning components of this stock.

Since 2004 the surveys have been carried out on the *R.V. Celtic Explorer*. A parallel transect design was adopted with transects running perpendicular to the coastline and extending up to 54 nmi (nautical miles) offshore. Transect spacing was set at 2 nmi throughout the survey. In bays a single zigzag transect approach was used to optimise coverage. The survey area was divided into strata based on the timing of spawning in each area. The first strata to be covered, was chosen in order to contain the earliest spawning components of the stock. The second strata is characterised as containing a mixture of early and mid spawning stock components. The third strata covered the area where the latest spawning is known to occur. Strata were subdivided in order to concentrate on known spawning grounds.

The acoustic data were collected using the Simrad ER60 scientific echosounder. The Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface.

Acoustic data analysis was carried out using Sonar data's Echoview® (V 3.2) post processing software and was backed up every 24 hrs. Partitioning of data was viewed and agreed upon by 2 scientists experienced in viewing echograms. Where no directed trawling had taken place, biological data from the nearest neighbour was used to determine the size classification of the echotrace.

The following TS/length relationships were used to analyse the data.

Herring	TS = 20logL – 71.2 dB per individual (L = length in cm)
Sprat	TS = 20logL – 71.2 dB per individual (L = length in cm)
Mackerel	TS = 20logL – 84.9 dB per individual (L = length in cm)
Horse mackerel	TS = 20logL – 67.5 dB per individual (L = length in cm)

The winter acoustic survey time series was split and ran from 1999-2003 and 2004-2007 because of the timing. Earlier survey series were carried out in Q4 and the more recent surveys were in Q1. The acoustic survey time series is shown in the text table below. A problem with the winter acoustic survey series has been synchronising the survey with the peak spawning event to ensure containment of the stock. The winter surveys that were carried out from 2004 – 2007 varied sharply in age profile and biomass estimates, and was not considered reliable. Bad weather often affected the survey as it took place in January. Also it was recognised that synoptic coverage of a stock that spawns over a period from October to February in an area spanning all of Divisions VIaS and VIIb cannot be achieved with a winter survey. Thus the series was discontinued in 2007. The review group of the 2007 assessment highlighted that although there is an acoustic abundance estimate, the historical series is too short to consider it as a tuning survey in an analytical assessment.

Acoustic surveys have been conducted in this area since 1999. In the mid 1990s, surveys were undertaken in summer. The timing changed in 1999 with the surveys being carried out in the winter (Table 6.3.1). Table 6.3.2 shows acoustic abundance at age and biomass estimates from all surveys conducted in this area, since 1994. The WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf.

The WESTHER project recommended that the survey effort along the Malin shelf area (including VIaN, VIaS, VIIb,c, Clyde and Irish Sea) should be increased or diverted to a combined survey on non-spawning herring. In 2008 PGHERS (CM 2008/LRC:01) discussed the possibility of conducting synoptic summer surveys on the Malin shelf. In 2008 and 2009, the Irish survey of VIaS, VIIb, c was conducted in July with effort concentrating on summer feeding aggregations.

Larval Surveys

Assessment of this stock was largely based on the results of larval surveys in the 1980s. Herring Larval surveys were first carried out on this stock, by Ireland, in 1981 and continued until 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).

B.4. Commercial CPUE

Research surveys were not started in Ireland until the mid 1960s and in the absence of this information commercial catch per unit effort (CPUE) data was used as an index of stock size. It is known that CPUE data may not give an accurate index of stock size due to the shoaling nature of pelagic stocks. Fish can aggregate in dense shoals in a small area and CPUE may remain high even though the stock size is low. However the CPUE data collected in the 1960s and 1970s did provide an index of changes that were occurring in the fisheries around Ireland. F was calculated for the Northwest herring stock using this data during this time and showed an increasing trend in F. This CPUE data was used to show the dramatic decline that took place in this stock in the 1970s (Molloy, 2006).

C. Historical Stock Development

Time periods in the fishery

This fishery peaked in the late 1980s, largely as a result of two strong year classes in 1981 and 1985. This corresponded to the highest SSB and a medium level of F. In the late 1980s changes also took place with regard to the location and timing of the fishery. The North and West coast fisheries in December and January were now the most important with smaller amounts taken during the autumn fishery (Molloy, 2006). Since then there has been a downward trend in SSB and recruitment with no evidence of strong year classes entering the fishery. Mean F has been fluctuating but is thought to be at a high level.

Spawning stock size peaked in 1988 and has followed a steady decline since then. Landings have drastically fallen since 1999 (ICES, 2004). Long term changes in the spawning component have occurred in the area and time of spawning. In 1920-1930s there was a north coast fishery that spawned in the North in spring and an autumn fishery that spawned in the west of Donegal. Sligo and Galway had no important fishery. In the '40-50 herring all over Ireland declined and the recovery in the 1960s occurred mainly in Mayo, Sligo and Galway as autumn spawners. Recently there has been a shift to the northern fishery, while little fishing occurs on the west coast of Ireland. The northwest herring fishery was based on hard (stage V) herring but towards the late 1980s the focus shifted to spawning herring.

Assessment

In 1930, Farran made his first attempt to quantify the abundance of the herring stock in this area. In the 1930s many of the previous herring markets disappeared and there was widescale discarding of herring along the Donegal coast. It is thought that during this time that the herring population was at a very low level (Molloy, 1995).

Recent Assessments

In recent years the model used for this stock was a separable VPA. This was used to screen over three terminal fishing mortalities, 0.2, 0.4 and 0.6. In 2009 terminal F of 0.5 was also examined. This was achieved using the Lowestoft VPA software (Darby and Flatman, 1994). Reference age for calculation of fishing mortality was 3-6 and terminal selection was fixed at 1, relative to age 3 winter rings. ICA was used in exploratory assessments with the acoustic surveys as a tuning fleet.

Model used: ICA and VPA

No final assessment has been accepted for this stock by the working group. However several scenarios are run, screening over a range of terminal F's (0.2, 0.4, 0.5 and 0.6). In 2006 and 2007 exploratory runs using the ICA model (Patterson, 1998) were performed. In the absence of a sufficient time series in this area the use of the ICA model has discontinued. Exploratory runs are carried out annually using a separable VPA with the settings below.

VPA

A separable VPA is used to track the historic development of this stock.

Software used: Lowestoft VPA Package (Darby and Flatman, 1994).

VPA Settingd

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	1970-2009	1-9 +	Yes
Canum	Catch at age in numbers	1970-2009	1-9 +	Yes
Weca	Weight at age in the commercial catch	1970-2009	1-9 +	Yes
West	Weight at age of the spawning stock at spawning time.	1970-2009	1-9 +	Yes
Mprop	Proportion of natural mortality before spawning	1970-2009	1-9 +	No
Fprop	Proportion of fishing mortality before spawning	1970-2009	1-9 +	No
Matprop	Proportion mature at age	1970-2009	1-9 +	No
Natmor	Natural mortality	1970-2009	1-9 +	No

Tuning data: Only used in ICA runs 2006 and 2007

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NWHAS	1999-2003	3-4
Tuning fleet 2	NWHAS	2004-2007	3-4

D. Short-Term Projection

Due to the absence of information on recruitment and the uncertainty about the current stock size short term predictions have not been routinely carried out for this stock.

E. Medium-Term Projections

Model Used: Multi Fleet Yield Per Recruit

Software Used: MFYPR Software

Yield-per-recruit analysis was carried out using MFYPR to provide yield-per-recruit plots for the data produced in the assessment. The values for $\mathbf{F}_{0.1}$ and $\mathbf{F}_{med}$ are 0.17 and 0.31. F_{max} is undefined and this is consistent with many other pelagic species (ICES, 2006).

F. Long-Term Projections

Not performed

G. Biological Reference Points

In 2007 the technical basis for the selection of the precautionary reference points was examined based on methods used by SGPRP (ICES CM 2001). No alternative biomass and fishing mortality reference points are available. It is clear that recruitment does not show any clear dependence on the SSB and that apart from the very high year classes in the 1980s is showing a decline.

The SGPRP (ICES CM 2003) has reviewed the methodology for the calculation of biological reference points, and applying a segmented regression to the stock and recruit data from the 2002 HAWG assessments. This showed that the fit to the stock and recruit data for this stock was not significant. There was no well defined change point and there was no reason to refine the reference points at that time.

Current reference points

B_{pa} = 81,000 t = the lowest reliable estimate of SSB

B_{llim} = 110,000 t = 1.4 x B_{pa}

F_{pa} = 0.22 = F_{med} (1998)

F_{lim} = 0.33 = lowest observed F

H: Other Issues

H.1 Biology of the species in the distribution area

The herring (*Clupea harengus*) is a widely distributed pelagic species in this area. This stock is comprised of different spawning components. Off the west coast the majority of the stock, are autumn spawners. Off the northwest coast distinct spawning units have also been identified. Autumn spawners, that spawn in the Donegal Bay area and winter/spring spawners, that spawn further north off the Donegal coast (Breslin, 1998). Autumn and winter spawners were distinguished by vertebral counts and timing of maturity. Peak spawning times from the autumn component have been inferred by larval surveys and occur late September and October in water temperatures ranging between 10-12ºC (Molloy and Barnwall, 1988).

Herring are benthic spawners and deposit their eggs on the sea bed usually on gravel or course sediments. The yolk sac larvae hatch and adopt a pelagic mode of life.

When referring to spawning locations the following terminology is used (Molloy, 2006)

- A <u>spawning bed</u> is the area over which the eggs are deposited
- A <u>spawning ground</u> consists of one or more spawning beds located in a small area.
- A <u>spawning area</u> is comprised of a number of spawning grounds in a larger area

Spawning grounds are typically located in high energy environments such as the mouth of large rivers and areas where the tidal currents are strong. Herring shoals return to the same spawning grounds each year (Molloy, 2006). 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 year 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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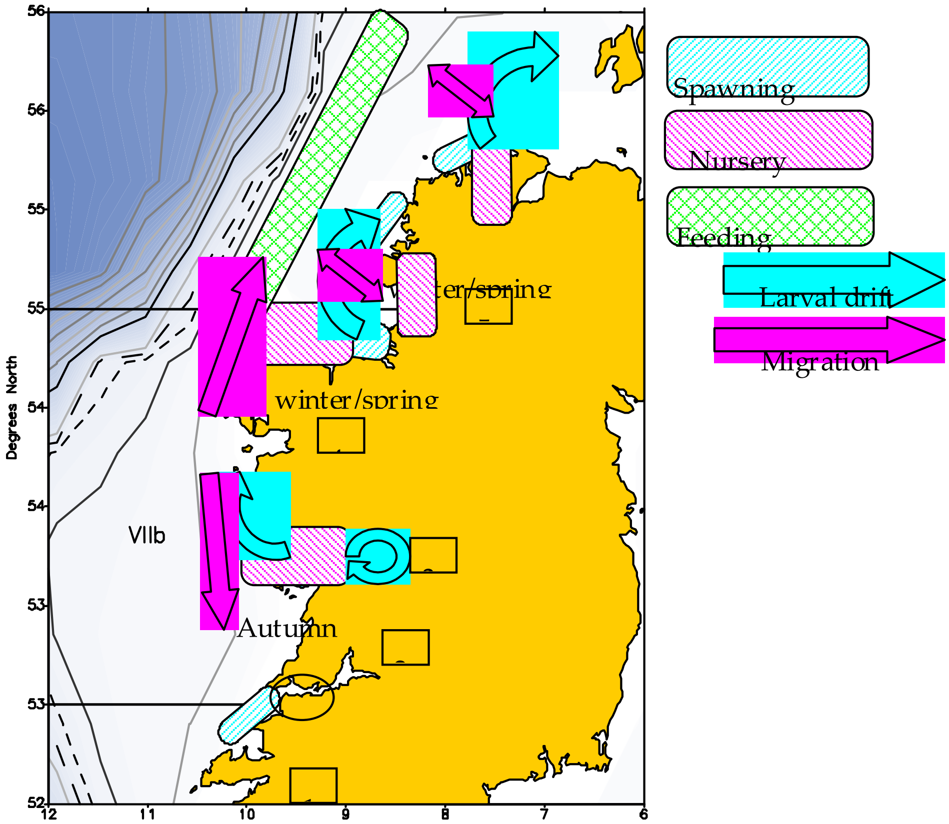

Figure 1 Schematic presentation of the life cycle of Herring west and northwest of Ireland. Numbers represent locations mentioned in the text:1 – Dingle Peninsula, 2 – Shannon River, 3 – Galway Bay, 4 – Mayo, 5 – Donegal Bay (ICES, 2005b, SGRESP)

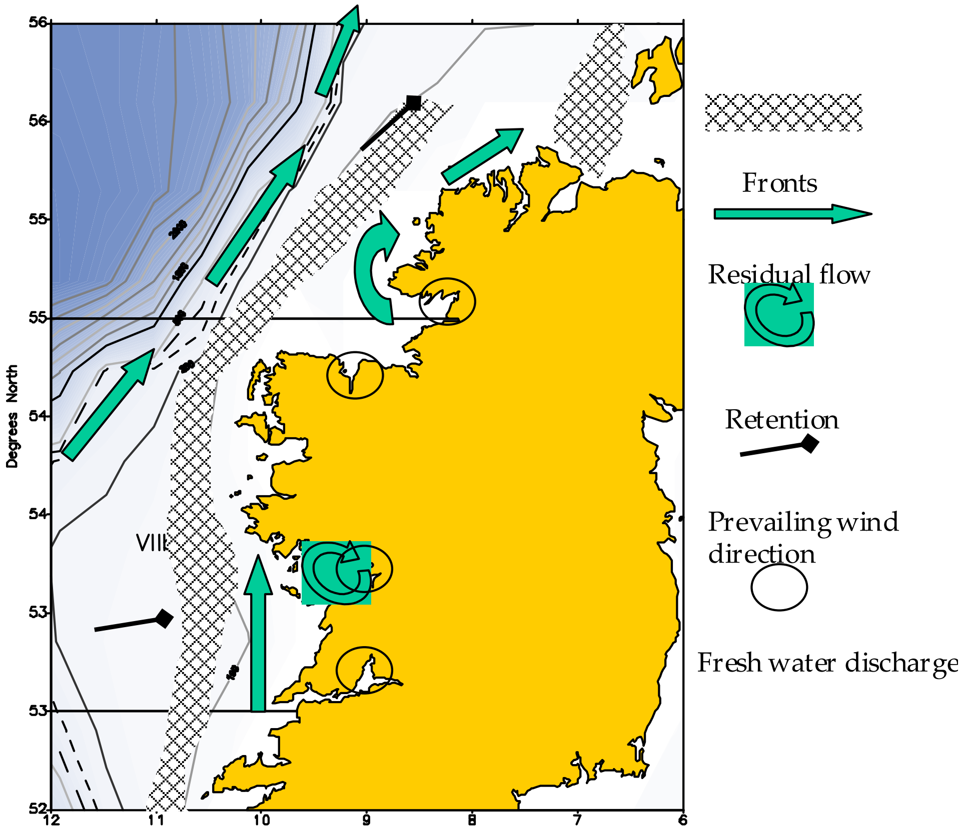

Figure 2 Schematic presentation of prevailing oceanographic conditions in the west and northwest of Ireland. Fronts are 1.) the Islay front northeast of Ireland and 2.) the Irish shelf front to the west of the Celtic Sea, both fronts are a thermohaline fronts persisting throughout the year with an additional tidal mixing front developing near Islay during summer stratification. Residual currents are the Irish coastal current, a clockwise density current and the Atlantic shelf edge current. Circulation is mainly wind driven with prevailing south-easterly winds from October to May and density driven from May to October (ICES, 2005b, SGRESP).

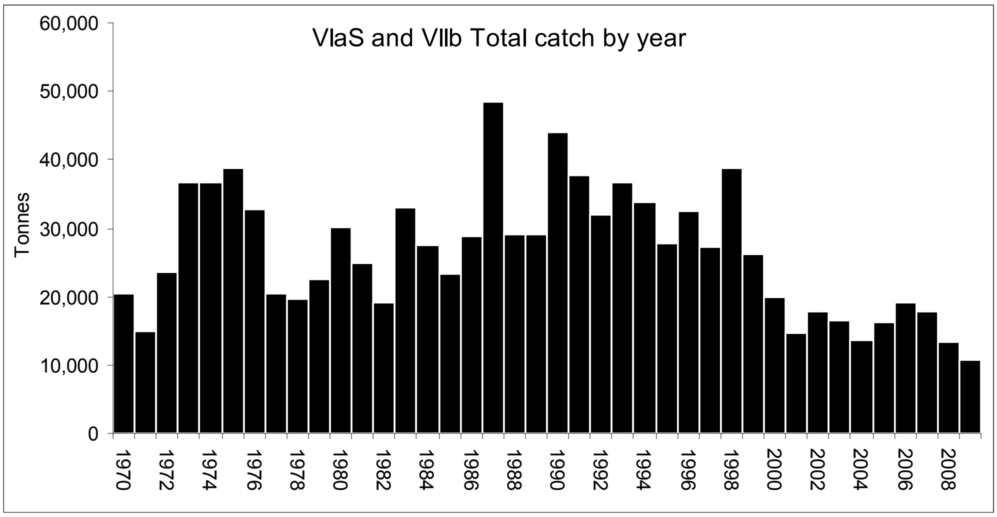

Figure 3: Total landings from VIaS, VIIb,c

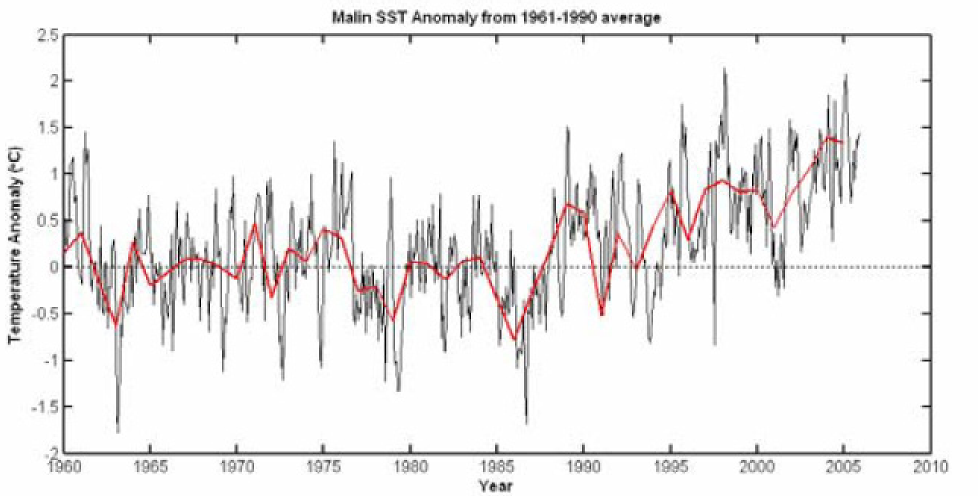

Figure 4: Sea surface temperature anomaly at Malin Head (1960-2005) (Nolan and Lyons, 2006)

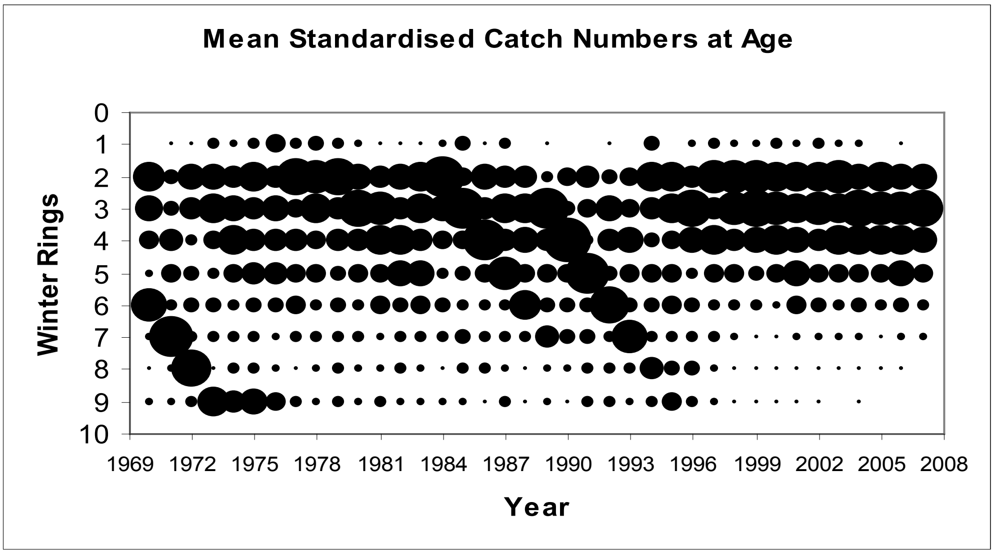

Figure 5: Mean Standardised Catch Numbers at Age

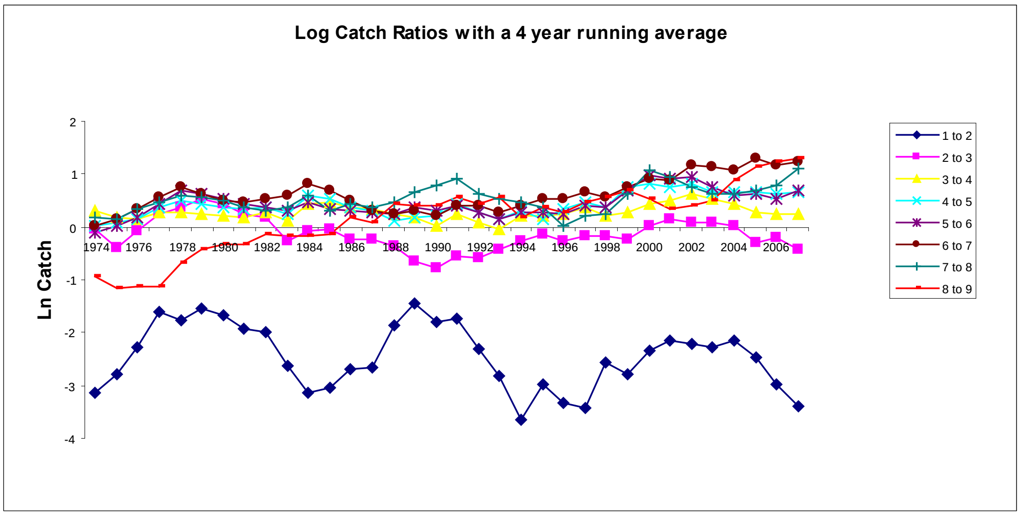

Figure 6: Log Catch Ratios with a four year running average

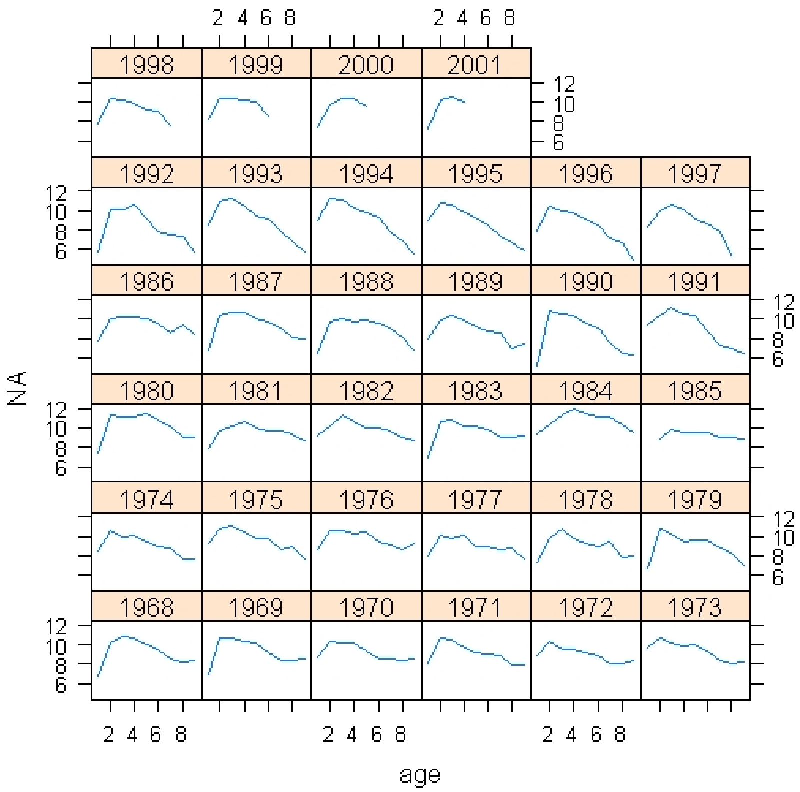

Figure 7: Catch Curves by cohort

Annex 8 - Stock Annex Irish Sea Herring VIIa (N)

Quality Handbook	ANNEX:_hawg-nirs

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Irish Sea herring (VIIa(N)
Working Group	Herring Assessment Working Group (HAWG)
Date:	23 March 2010
Revised by	Steven Beggs

A. General

A.1. Stock definition

Herring spawning grounds in the Irish Sea are found in coastal waters to the west and north of the Isle of Man and on the Irish Coast at around 54°N (ICES, 1994; Dickey-Collas *et al*., 2001). Spawning takes place from September to November in both areas, occurring slightly later on average on the Irish Coast than off the Isle of Man. ICES Herring Assessment Working Groups from 19XX to 1983 used vertebral counts to separate catches into Manx and Mourne stocks associated with these spawning grounds. However, taking account of inaccuracies in this method and the results of biochemical analyses, the 1984 WG combined the data from the two components to provide a "more meaningful and accurate estimate of the total stock biomass in the N. Irish Sea." All subsequent assessments have treated the VIIa(N) data as coming from a single stock. During the 1970s, catches from the Manx component were about three times larger than those from the Mourne component. By the early 1980s, following the collapse of the stock, the catches were of similar magnitude. The fishery off the Mourne coast declined substantially in the 1990s then ceased, whilst acoustic and larva surveys in this period indicate that the spawning population in this area has been very small compared to the biomass off the Isle of Man.

The occurrence in the Irish Sea of juvenile herring from a winter-spring spawning stock has been recognized since the 1960s based on vertebral counts (ICES, 1994). More recently, Brophy and Danilowicz (2002) used otolith microstructure to show that nursery grounds in the western Irish Sea were generally dominated by winter-spawned fish. Samples from the eastern Irish Sea were mainly autumn-spawned fish. Recaptures from 10,000 herring tagged off the SW of the Isle of Man in July 1991 occurred both on the Manx spawning grounds and along the Irish Coast with increasing proportions from the Celtic Sea in subsequent years (Molloy *et al*., 1993). The pattern of recaptures indicated a movement towards spawning grounds in the Celtic Sea as the fish matured.

A proportion of the Irish Sea herring stocks may occur to the north of the Irish Sea outside of the spawning period. This was indicated by the recapture on the Manx spawning grounds of 3-6 ring herring tagged during summer in the Firth of Clyde (Morrison and Bruce, 1981). Aggregations of post-spawning adult herring were detected along the west coast of England during an acoustic survey in December 1996 (Department of Agriculture and Rural Development for Northern Ireland, unpublished data), showing that a component of the stock may remain within the Irish Sea.

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

A.2. Fishery

There have been three types of fishery on herring in the Irish Sea in the last 40 years:

i) Isle of Man- aimed at adult fish that spawn around the Isle of Man.

ii) Mourne- aimed at adult fish that spawn off the Northern Irish eastern coast.

iii) Mornington- a mixed industrial fishery that caught juveniles in the western Irish Sea.

The Mornington fishery started in 1969 and at its peak it caught 10,000 tonnes per year. It took place throughout the year. The fishery was closed due to management concerns in 1978 (ICES, 1994). In the 1970s the catch of fish from the Mourne fishery made up over a third of the total Irish Sea catch. The fishery was carried out by UK and Republic of Ireland vessels using trawls, seines and drift nets in the autumn. However the fishery declined and ceased in the early 1990s (ICES, 1994). The biomass of Mourne herring, determined from larval production estimates is now 2-4% of the total Irish Sea stock (Dickey-Collas *et al.*, 2001).

The main herring fishery in the Irish Sea has been on the fish that spawn in the vicinity of the Isle of Man. The fish are caught as they enter the North Channel, down the Scottish coast, and around the Isle of Man. Traditionally this fishery supplied the Manx Kipper Industry, which requires fish in June and July. However the fish appeared to spawn slightly later in the year in the 1990s and this lead to problems of supply for the Manx Kipper Industry. In 1998 the Kipper companies decided to buy in fish from other areas. Generally the fishery has occurred from June to November, but is highly dependent on the migratory behaviour of the herring.

The fishery has been prosecuted mainly by UK and Irish vessels. TACs were first introduced in 1972, and vessels from France, Netherlands and the USSR also reported catches from the Irish Sea during the 1970s before the closure of the fisheries from 1978 to 1981. By the 1990s only the fishery on the Manx fish remained, and by the late 1990s this was dominated by Northern Irish boats. The number of Northern Irish vessels landing herring declined from 24 in 1995-96 to 6-10 in 1997-99 and to 4 in 2000. Only two vessels operated in 2002 and 2003. However, total landings have remained relatively stable since the 1980s whilst the mean amount of fish landed per fishing trip has increased, reflecting the increase in average vessel size

A.3. Ecosystem aspects

The main fish predators on herring in the Irish Sea include whiting (*Merlangius merlangus*), hake (*Merluccius merluccius*) and spurdog (*Squalus acanthias*). The size composition of herring in the stomach contents indicates that predation by whiting is mainly on 0-ring and 1-ring herring whilst adult hake and spurdogfish also eat older herring (Armstrong, 1979; Newton, 2000; Patterson, 1983). Sampling since the 1980s has shown cod (*Gadus morhua*), taken by both pelagic and demersal trawls in the Irish Sea, to be minor predators on herring. Small clupeids are an important source of food for piscivorous seabirds including gannets, guillemots and razorbills (ref…) which nest at several locations in and around the Irish Sea. Marine mammal predators include grey and harbour seals (ref.) and possibly pilot whales, which occur seasonally in areas where herring aggregate.

Whilst small juvenile herring occur throughout the coastal waters of the western and eastern Irish Sea, their distribution overlaps extensively with sprats (*Sprattus sprattus*). The biomass of small herring has typically been less than 5% of the combined biomass of small clupeids estimated by acoustics (ICES, 2008 ACOM:02). However in recent years the proportions have increased in favour of small herring (ICES, 2009 ACOM:??).

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

Changes in Environment

There has been an increase in water temperatures in this area (ICES, 2006) which is likely to affect the distribution area of some fish species, and some changes of distribution have already been noted. Temperature increase is likely to affect stock recruitment of some species. In addition, the combined effects of over exploitation and environmental variability might lead to a higher risk of recruitment failure and decrease in productivity (ICES, 2007).

B. Data

B.1. Commercial catch

National landings estimates

The current ICES assessment of Irish Sea herring extends back to 1961, and is based on landings only. ICES WG reports (ICES 1981, 1986 and 1991) highlight the occurrence of discarding and slippage of catches, which can occur in areas where adult and juvenile herring co-occur. Discarding has been practised on an increasing scale since 1980 (ICES, 1986). This increase is primarily related to the onset of slippage of catches that coincided with the cessation of the industrial fishery in early 1979 (ICES, 1980). As a result of sorting practices, slippage has led to marked changes in the age composition of the catch since 1979 and considerable change in the mean weights at age in the catch of the three youngest age groups (ICES 1981). Estimates of discarding were sporadically performed in the 1980s (ICES, 1981, 1982, 1985 and 1986), but there are no estimates of discarding or slippage of herring in the Irish Sea fisheries since 1986. Highly variable annual discard rates are evident from the 1980s surveys. For example, discards estimates of juvenile herring (0-group) for the Mourne stock taken in the 1981 *Nephrops* fishery was estimated at $1.9x10^6$ of vessels landing in Northern Ireland, which amounts to approximately 20% of the Mourne fishery (ICES 1982). In 1982, at least 50% of 1-group herring caught were discarded at sea by vessels participating in the Isle of Man fishery (ICES, 1983). A more comprehensive survey programme to determine the rate of discarding in 1985 revealed discard estimates of 82% by numbers of 1-ring fish, 30% of 2-ring and 6% of 3-ring fish, with the dominant age group in the landed catch being 3 ring (ICES, 1986). A similar survey in 1986, however, found the discarding of young fish fell to a very low level (ICES, 1987). The 1991 WG discussed the discard problem in herring fisheries in general and suggested possible measures to reduce discarding. No quantitative estimates were given, but reports of fishermen suggesting discards of up to 50% of catch as a result of sorting practices by using sorting machines (ICES, 1991). The variation in discard rates since 1980, as a result of changes in discard practices, can probably be attributed to several changes in the management of the fishery. These include the availability of different fishing areas, the change to fortnightly catch quotas per boat (ICES, 1987) and level of TAC, where lower discard rates are observed with a higher TAC (ICES, 1989). The level of slippage is also related to the fishing season, since slippage is often at a high level in the early months (ICES, 1987). Due to the variable nature of discard estimates and the lack of a continuous data series, it has not been included in the annual catch at age estimates (with the exception of the 1983 assessment when the catch in numbers of 1-ringers was doubled based on a 50% discard estimate of this age group).

Landings data for herring in Division VIIa(N) are generally collated from all participating countries providing official statistics to ICES, namely UK (England & Wales, Northern Ireland, Scotland and the Isle of Man), Ireland, France, the Netherlands and what was formally the USSR. The data for the period 1971 to 2002 are reported in the various Herring Assessment Working Group Reports and are reproduced in Table 1. The official Statistics for Irish landings from VIIa have been processed to remove data from the Dunmore East fishery in area VIIa(S), and represent landings from VIIa(N) only.

Over the past three decades, the WG highlighted the under- or misreporting of catches as the major problem with regards to the accuracy of the landing data. Related to this are the problems of illegal landings during closed periods and paper landings. Area misreporting was also recognised (ICES, 1999), although a less prominent problem that is mostly corrected for.

The 1980 WG first identified the problem of misreporting of landings based on the results of a 3-year sampling programme, which was initiated after 1975 when herring were being landed in metric units at ports bordering the Irish Sea (1 unit = 100 kg nominal weight). The study showed the weight of a unit to be very variable, but was usually well in excess of 100 kg. An initial attempt to allow for misreporting using adjusted catches made very little difference to any of the values of fishing mortality (ICES, 1980). Subsequently, despite serious concerns about considerable under-reporting being raised (ICES 1990, 1994, 2000 and 2001), the WG made no attempts to examination the extent of the problem. This uncertainty signifies no estimates of under-reporting and consequently no allowance for under-reporting of landings has been made. Considerable doubt was raised as to the accuracy of landing data over the period 1981-87 (ICES, 1994). However, after apparent re-examination all WG landing statistics are assumed to be accurate up to 1997 (ICES, 2000), but with no reliable estimates of landings from 1998-2000 (ICES, 2001). The WG acknowledged that poor quality landing data bring the catch in numbers at age data into question and hence the accuracy of any assessment using data from such periods (ICES, 1994).

In 2002 the ICES assessment was extended back to include data for 1961-1970 with the intention of showing the stock development prior to the large expansion in fishing effort and stock size in the early 1970s. This has now been extended further back to 1955. Landings data for this period were extracted from the UK fisheries data bases (England & Wales, Scotland and Northern Ireland: Table 1, columns 8-10) and publications by Bowers and Brand (1973) for Isle of Man landings (column 11). Landings data for Ireland and France were not available.

To estimate the VIIa(N) herring landings for Ireland and France during 1955-1970, the NE Atlantic herring catches for each country were obtained from the FAO database (column 16). Using the ICES landings data for each country (column 17) the mean proportion of the VIIa(N) catch to the NE Atlantic catch during 1971 to 1981 was estimated (column 18). This was applied to the NE Atlantic catches from each country, for the period 1955 to 1970, to give an estimated landing for both France and Ireland (column 19). These landings were added to the known catches from the CEFAS database to give the total landings. The landings data (tonnes) used in the assessment are given in Table 1, column 14. It is anticipated that landings data for VIIa(N) for years prior to 1971 can be extracted from the Irish databases. However, the French landings will remain as estimates. As yet there has been no analysis of magnitude of errors in the old data. Need discussion on errors due to misreporting

Catch at age data

Age classes in the ICES Canum file refer to numbers of winter rings in otoliths. As the Irish Sea stock comprises autumn spawners, *i*-ring fish taken in year *y* will comprise fish in their i_{th} year of life if caught prior to the spawning season and $(i+1)_{th}$ year if caught after the spawning period. An *i*-ring fish will belong to year-class *y*-2. As spawning stock is estimated at spawning time (autumn), spawning stock and recruitment relationships require estimates of recruitment of *i*-ring fish in year *y* and estimates of SSB in year *i*-2. The current assessment estimates recruitment as numbers of 1-ring fish.

The most recent description of sampling and raising methods for estimating catch at age of herring stocks is in ICES (1996). This includes sampling by UK(E&W) and Ireland, but not UK(NI) and Isle of Man

UK(NI):A random sample of 10-20kg of herring is taken from each landing into the main landing port (Ardglass) by the NI Department of Agriculture and Rural Development. Samples are also collected from any catches landed into Londonderry. Prior to the 1990s, the samples were mostly processed fresh. During the 1990s, there was an increasing tendency for samples to be frozen for a period of weeks before processing. No corrections have been applied to weight measurements to allow for changes due to freezing and defrosting. The length frequency (total length) of each sample is recorded to the nearest 0.5cm below. A sample of herring is then taken for biological analysis as follows: one fish per 0.5 cm length class, followed by a random sample to make the sample up to 50 fish.

Otoliths are removed from each fish, mounted in resin on a black slide and read by reflected light. Ages are assigned according to number of winter rings.

Length frequencies (LFDs) for VIIa(N) catches are aggregated by quarter. The weight of the aggregate LFD is calculated using a length-weight relationship derived from the biological samples. The LFD is then raised to the total quarterly landings of herring by the NI fleets. A quarterly age-length key, derived from commercial catch samples only, is applied to the raised LFD to give numbers at age and mean weight at age.

IOM: IOM sampling covers the period 1923 – 1997. Samples are collected from any landings into Peel, by staff of the Port Erin Marine Laboratory (Liverpool University). The sampling and raising procedures are the same as described for UK(NI) with the following exceptions: i) the weight of the aggregate quarterly LFD is obtained from the original sample weights rather than using a length-weight relationship, and ii) the biological samples are random rather than stratified by length. The 1993 ICES herring assessment WGs noted a potential under-estimation by one ring, of herring sampled in the IOM. This was caused by a change in materials used for mounting otoliths and appears to have been a problem for ageing older herring in 1990-92. This was since rectified. However, the bias for the 1990-92 period has not yet been quantified and will be examined in the near future.

Ireland:Irish sampling of VIIa(N) herring covers the period 19xx – 2001. Some samples are from landings into NI but transported to factories in southern Ireland. Irish sampling schemes for herring in Div. VIa(S), VIIb, Celtic Sea and VIIj are described in ICES (1996). Methods for sampling catches in VIIa(N) are similar. The procedure is the same as described above for UK(NI) except that the biological samples are random rather than length stratified. ICES (1996) notes that a length-stratified scheme should be adopted to ensure proper coverage at the extremes of the LFDs.

Quality control of herring ageing has fallen under the remit of EU funded programmes EFAN and TACADAR, to which the laboratories sampling VIIa(N) herring contribute. An otolith exchange exercise was initiated in 2002 and is currently being completed.

B.2. Biological

Natural Mortality

Natural mortality (M) varies with age (expressed in number of winter rings) according to the following:

Rings	M
1	1
2	0.3
3	0.2
4+	0.1

Those values have been held constant from 1972 to date. Those values correspond to estimates for North Sea herring based on recommendations by the Multi-species WG (Anon. 1987a). which were applied to adjacent areas (Anon. 1987b).

Maturity at age

Combined, year-specific maturity ogives were used in the 2003 Assessment (ICES 2003). The way those values were derived is documented on Dickey-Collas *et al.* (2003). Prior to 2003 annually invariant estimates of the proportion of fish mature by age were used. Those were based on estimates from the 1970s (ICES, 1994). The use of the variable maturity ogive in 2003 did not change greatly the perception of the stock state (Dickey-Collas *et al., op cit*). Due to inconsistencies in the maturity data collected in 2003, the WG used a mean maturity ogive for the preceding nine years for 2003. The rationale for the 9 years was that there appeared to be a shift in the maturity ogive around 1993. After 2003 all weights and maturity-at-age data were based on corresponding annual biological samples.

SSB in September is estimated in the assessment. The survey larvae estimate is used as a relative index of SSB. The proportions of M and F before spawning are held constant over time in the assessment.

Stock weights

Stock weights at age have been derived from the age samples of the 3rd quarter landings since 1984 (R. Nash *pers comm.*). The stock mean weights for 1975-83 are time invariant and were re-examined in 1985 (Anon. 1985). They result from combining Manx and Mourne data sets. The weights at age of those stocks were considered relatively stable over time.

Mean weights

Mean weights-at-age in the catch (1985 to 2007) are given in Table 3. Mean weights-at-age of all ages remained low. There has been a change in mean weight over the time period 1961 to the present (ICES, 2003 ACFM:17). Mean weights-at-age increased between the early 1960s and the late 1970s whereupon there has been a steady decline to the early 1990s, where they remained low. In the assessment, mean weights-at-age for the period 1972 to 1984 are taken as unchanging. In extending the data series back from 1971 to 1961, mean weights-at-age in the catch were taken from samples recorded by the Port Erin Marine Laboratory (ICES, 2003 ACFM:17).

There was some uncertainty in the mean weights-at-age for 2003 presented to the WG, and consequently the WG replaced these with the average mean stock weights-at-age for the preceding five years (1998 to 2002).

Mean Lengths

Mean lengths-at-age are calculated using the catch data and are given for the years 1985 to 2006 in Table 4. In general, mean lengths have been relatively stable over the last few years and this trend has continued in 2006.

Catch at length

Catch at length are listed for the years 1990-2004 (Table 5)

B.3. Surveys

The following surveys have provided data for the VIIa(N) assessment:

Survey Acronym	Type	Abundance data	Area and Month	Period
AC(VIIaN)	Acoustic survey	Numbers at age (1-ring and older); SSB	VIIa(N) from 53°20'N – 55°N; September	1994 – present
NINEL	Larva survey	Production of larvae at 6mm TL	VIIa(N) from 53° 50'N – 54° 50'N; November	1993 – present
DBL	Larva survey	Production of larvae at 6mm TL	East coast of Isle of Man; October	1989 – 1999 (1996 missing)
GFS-oct	Groundfish survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53°20'N – 54°50'N (stratified); October	1993 - 1999
GFS-mar	Groundfish survey	Mean nos. caught per 3 n.miles (1&2 ringers), by region	VIIa(N) from 53°20'N – 54°50'N (stratified); March	1993 - 1999

Data from a number of earlier surveys have been documented in the ICES WG reports. These include:

NW Irish Sea young herring surveys (Irish otter trawl survey using commercial trawler; 1980 – 1988)

Douglas Bank (East Isle of Man) larva surveys (ring net surveys; 1974 – 1988) (Port Erin Marine Lab)

Douglas Bank spawning aggregation acoustic surveys (1989, 1990, 1994, 1995) (Port Erin Marine Lab)

Western Irish Sea acoustic survey (July 1991, 1992) (UK(NI))

Eastern Irish Sea acoustic survey (December 1996)

Surveys used in recent assessments are described below.

AC(VIIaN) acoustic survey

This survey uses a stratified design with systematic transects, during the first two weeks of September. Vessel currently used is the R.V. Corystes (UK(NI)) replacing the R.V. *Lough Foyle* (UK(NI)). Starting positions are randomized each year (see recent HAWG reports for transect design and survey results). The survey is most intense around the Isle of Man (2 to 4 n.mile transect spacing) where highest densities of adult herring are expected based on previous surveys and fishery data. Transect spacing of 6 to 10 n.miles are used elsewhere. A sphere-calibrated EK-500 38kHz sounder is employed, and data are archived and analysed using Echoview (SonarData, Tasmania). Targets are identified by midwater trawling. Acoustic records are manually partitioned to species by scrutinising the echograms and using trawl compositions where appropriate. ICES-recommended target strengths are used for herring, sprat, mackerel, horse mackerel and gadoids. The survey design and implementation follows, where possible, the guidelines for ICES herring acoustic surveys in the North Sea and West of Scotland. The survey data are analysed in 15-minute elementary distance sampling units (approx. 2.5 n.miles). An estimate of density by age class, and spawning stock biomass, is obtained for each EDSU and a distance-weighted average calculated for each stratum. These are raised by stratum area to give population numbers and SSB by stratum.

NINEL larva survey

The DARD herring larva survey has been carried out in November each year since 1993. Sampling is carried out on a systematic grid of stations covering the spawning grounds and surrounding regions in the NE and NW Irish Sea (Figure 1). Larvae are sampled using a Gulf-VII high-speed plankton sampler with 280 μm net. Double-oblique tows are made to within 2m of the seabed at each station. Internal and external flow rates, and temperature and salinity profiles, were recorded during each tow. Lengths of all herring larva captured are recorded.

Mean catch-rates (nos.m^{-2}) are calculated over stations to give separate indices of abundance for the NE and NW Irish Sea. Larval production rates (standardised to a larva of 6mm), and birth-date distributions, are computed based on the mean density of larvae by length class. A growth rate of 0.35mm day^{-1} and instantaneous mortality of 0.14 day^{-1} are assumed based on estimates made in 1993 - 1997. More recent studies have indicated a mortality rate of 0.09, and this value is also applied to examine the effect on trends in estimates of larval production

DBL larva survey

Herring larvae were sampled on the east side of the Isle of Man in September or October each year. Double oblique tows with a 60 cm Gulf VII/PRO-NET high-speed plankton sampler with a 40cm aperture nose cone were undertaken on a 5 Nm square grid. The tow profile was followed with a FURUNO net sonde attached to the top of the equipment. The volume of water filtered was calculated from the nose cone mouth flow meter. The samples were preserved in 4% seawater buffered formalin and stored in 70% alcohol.

All herring larvae were sorted from the samples. The numbers of larvae per m^3 were calculated from the volume of water filtered and the number of larvae per tow. Up to 100 larvae from each tow were measured with an ocular graticule in a stereo microscope. Each sample was assigned to a sampling square and the total number of larvae per 0.5mm size class calculated from the average depth of the square and the surface area.

The total production and time of larvae hatch was calculated using an instantaneous mortality coefficient (k) of 0.14 and a growth rate of 0.35 mm d^{-1} in the formula:

$$N_t = N_o e^{-(kt)}$$

Production was calculated as the sum of all size classes/hatching dates. Spawning dates were taken as 10 days prior to the hatching date (Bowers 1952).

The Douglas Bank Larva survey has not been updated since 1999. Examination of the sum of squares surface from SPALY in 2005 indicated that the Douglas Bank larvae index (DBL) was having no influence in the assessment estimates for the current year. Therefore, the WG agreed on removing DBL from the analysis (ICES, 2005). The DBL time series is listed in Table 6

GFS-oct and –mar groundfish surveys

The DARD groundfish survey of ICES Division VIIaN are carried out in March and October at standard stations between 53° 20'N and 54° 45'N (Figure 2). Data from additional stations fished in the St George's Channel since October 2001 have not been used in calculating herring indices of abundance. As in previous surveys, the area was divided into strata according to depth contour and sediment type, with fixed station positions (note that the strata in Fig. 2 differ from those in the September acoustic survey shown in Fig. 1). The sampling gear was a Rockhopper otter trawl fitted with non-rotating rubber discs of approximately 15 cm diameter on the footrope. The trawl fishes with an average headline height of 3.0 m and door spread of 30 - 40 m depending on depth and tide. A 20mm stretched-mesh codend liner was fitted. During March, trawling was carried out at an average speed of 3 knots across the ground, over a standard distance of 3 nautical miles at standard stations and 1 nautical mile in the St. George's Channel. Since 2002, all survey stations in the October survey have been of 1-mile distance. Comparative trawling exercises during the October surveys and during an independent exercise in February 2003 indicate roughly similar catch-rates per mile between 1-mile and 3-mile tows. It is planned to continue with some comparative trawling experiments during future surveys to improve the statistical power of significance tests between the 1-mile and 3-mile tows.

As the surveys are targeted at gadoids, ages were not recorded for herring. The length frequencies in each survey were sliced into length ranges corresponding to 0-ring and 1-ring herring according to the appearance of modes in the overall weighted mean length frequency for each survey. Some imprecision will have resulted because of the overlap in length-at-age distributions of 1-ring and 2-ring herring. The error is considered to be comparatively small for most of the surveys where clear modes are apparent. There was no clear division between 1-ring and 2-ring herring in the March 2003 groundfish survey, and the estimate for 1-ringers may include a significant component of small 2-ringers. The arithmetic mean catch-rate and approximate variance of the mean was computed for each age-class in each survey stratum, and averaged over strata using the areas of the strata as weighting factors.

Groundfish surveys were used by the 1996 to 1999 HAWG to obtain indices for 0- and 1-ring herring in the Irish Sea. These indices have performed poorly in the assessment and have not been used since 1999. The time-series is listed in Table 7.

B.4. Commercial CPUE

Commercial CPUE's are not used for this stock.

B.5. Other relevant data

C. Historical Stock Development

Model used: ICA

Software used: ICA (Patterson 1998)

Model Options chosen:

Separable constraint over last 6 years (weighting = 1.0 for each year)

Reference age = 4

Constant selection pattern model

Selectivity on oldest age = 1.0

First age for calculation of mean F = 2

Last age for calculation of mean F = 6

Weighting on 1-rings = 0.1; all other age classes = 1.0

Weighting for all years = 1.0

All indices treated as linear

No S/R relationship fitted

Lowest and highest feasible F = 0.05 and 2.0

All survey weights fitted by hand i.e., 1.0 with the 1 ringers in the acoustic survey weighted to 0.1.

Correlated errors assumed i.e., = 1.0

No shrinkage applied

Input data types and characteristics:

TYPE	NAME	YEAR RANGE	AGE RANGE	VARIABLE FROM YEAR TO YEAR YES/NO
Caton	Catch in tonnes	1961-last data year	NA	Yes
Canum	Catch at age in numbers	1961-last data year	1-8+	Yes
Weca	Weight at age in the commercial catch	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
West	Weight at age of the spawning stock at spawning time.	1961-1971 1972-1983 1984-last data year	1-8+ 1-8+ 1-8+	Yes No Yes
Mprop	Proportion of natural mortality before spawning	1961-last data year	NA	No
Fprop	Proportion of fishing mortality before spawning	11961-last data year	NA	No
Matprop	Proportion mature at age	1961-last data year	1-8+	Yes
Natmor	Natural mortality	1961-last data year	1-8+	No

Tuning data:

TYPE	NAME	YEAR RANGE	AGE RANGE
Tuning fleet 1	NINEL	1993-2003	SSB
Tuning fleet 2	DBL	1989-1999	SSB
Tuning fleet 3	GFS-octtot	1993-2005	1 & 2
Tuning fleet 4	GFS-martot	1992-2003	1
Tuning fleet 5	ACAGE	1994-2003	1-8+
Tuning fleet 6	AC_VIIa(N)	1994-2003	SSB
Tuning fleet 7	AC_1+	1994-2003	SSB/Total biomass

Two-stage biomass model

In 2005 a Two-Stage Biomass model for the assessment of Irish Sea VIIa(N) herring given additional variance in the recruitment index was presented by Roel and De Oliveira (ICES 2005 WD10).

The model addresses the problem of the high uncertainty in the assessment of Irish Sea herring, which to some extent may be related to the presence of juvenile Celtic Sea herring in both the fishery and the survey area. In the absence of a Celtic Sea herring recruitment index, the biomass model presented addressed the problem by limiting recruitment variability in Irish Sea herring on the basis of information available for other herring stocks. The total variability in the recruitment data was divided into two components: the one related to Irish Sea herring recruitment variability and the rest which was likely to represent variability related to the presence of Celtic Sea juveniles.

The model is fitted to biomass indices of 1-ringer fish and to aggregated biomass indices for the 2-rings+ from Northern Ireland acoustic surveys. The survey age composition data and the weights-at-age from the catch are used to calculate the proportion of 1-ring fish in the survey. The proportion is then applied to the total acoustic biomass to compute the 1-ring biomass index while the 2-ring+ index is obtained by subtraction. The catch in weight was split in a similar manner but based on commercial catch samples.

The model

The dynamics take into account only two stages in the population: the recruits, 1-ringer fish, and the fully recruited that comprise 2-ringer and older fish. The biomass dynamics is represented by the following:

[1] $$B_{y+1} = B_{1,y+1} + \left[(B_{2+,y} + B_{1,y})\,e^{-3g/4} - C_y\right]e^{-g/4}$$

where

$B_{1,y}$ is the biomass of recruitment (tons) at the start of year y;

$B_{2+,y}$ is the biomass of 2+ aged fish (tons) at the start of year y;

C_y is the biomass of fish caught (tons) during year y, assumed to be taken in a pulse fishery 3/4 of the way into year y; and

g is a composite parameter, treated as an annual rate, which accounts for natural mortality and growth.

Maximum likelihood estimation is used, assuming survey indices are log-normally distributed about their expected values. Standard errors of the log-distributions are approximated by the sampling CVs of the untransformed distributions.

The estimable parameters are g, $B_{2+,1994}$, $B_{1,1994}$,...,$B_{1,2004}$, λ^2 and q

where q corresponds to the catchability associated with the survey indices $I_{1,y}$ and $I_{2+,y}$ and λ^2 is the additional variance.

The data were explored for values of recruitment variability (σ_R) = 0.4 and 0.8. The value 0.4 corresponds to the variability in recruitment age 1 as estimated by ICA for the period used in this analysis, but excluding the most recent estimate (1994 – 2006). The two parameters, g and q, may be confounded in the model indicating that fixing g was appropriate. This parameter was fixed to 0.2 following a similar approach as in Roel and De Oliveira (ICES 2005 WD10).

D. Short-Term Projection

NOT USED IN 2004
Model used: Age structured

Software used: MFDP ver 1a

Initial stock size: Taken from the last year of the assessment. 1-ring recruits taken from a geometric mean for the years 1983 to two years prior to the current year. Where 1-ringers are absurdly estimated in the assessment 2-ringers are estimated as a geometric mean of the previous 10 year period.

Maturity: Mean of the previous three years of the maturity ogive used in the assessment.

F and M before spawning: Set to 0.9 and 0.75 respectively for all years.

Weight at age in the stock: Mean of the previous three years in the assessment.

Weight at age in the catch: Mean of the previous three years in the assessment.

Exploitation pattern: Mean of the previous three years, scaled by the Fbar (2-6) to the level of the last year.

Intermediate year assumptions: TAC constraint.

Stock recruitment model used: None used

Procedures used for splitting projected catches: Not relevant

E. Medium-Term Projections

F. Long-Term Projections

Not done

G. Biological Reference Points

Until there is confidence in the assessment the Working Group decided not to revisit the estimation of $\mathbf{B}_{pa}$ (9,500 t) and $\mathbf{B}_{lim}$ (6,000 t). There were no new points to add to the discussions and deliberations presented in 2000 (ICES 2000/ACFM:10).

H. Other Issues

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Table 1. Biological sampling of Irish Sea (VIIa(N)) landings. Country denotes sampling nation.

	Coverage	% of landings sampled	No of samples	Total landings	landings by Q?	IRELAND				NORTHERN IRELAND				ISLE OF MAN				OTHERr UK/UK OFFSHORE				TOTAL			
Year						Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages	Landings	Samples	Lengths	Ages
1988	(4)					**2579																	0	0	0
1989	(3) temp spread good		88	4962	NO	1430	21	1843	555		45	11464	2249		21	5173	1057		1	96	0	4962	88	18576	3861
1990	p(1,2)	68%	100	6312	YES	1699	44	5176	1022	2322	38	9310	1900	542	18	5276	897	179/1570	0	0	0	6312	100	19762	3819
1991	g	90%	138	4398	YES	80	5	1255	247	3298	105	16724	2484	629	28	8280	1392	0/391	0	0	0	4398	138	26259	4123
1992	g	98%	32	5270	YES	406	3	593	99	4120	16	1588	770	741	13	3488	680	3	0	0	0	5270	32	5669	1549
1993	p (1)	65%	48	4408	YES	0	5	1378	245	3632	34	3744	832	776	9	1560	448	0	0	0	0	4408	48	6682	1525
1994	v.g	95%	59	4828	YES	0	21	569	100	3956	43	3691	1175	716	14	3724	614	156	0	0	0	4828	59	7984	1889
1995	g (1)	87%	85	5076	YES	0	21	569	100	3860	75	8282	2545	615	8	2182	400	601	0	0	0	5076	85	11033	3045
1996	g (1,5)	70%	51	5301	YES	100	1	537	55	4335	45	4813	1050	537	5	997	228	329	0	0	0	5301	51	6347	1333
1997	g (1,2)	91%	34	6649	YES	0	2	473	50	5679	25	2900	1199	765	7	2246	340	205	0	234	76	6649	34	5853	1665
1998	g (2)	84%	31	4904	YES	0	2	150	50	4131	29	2979	1450	0	0	0	0	7732	0	0	0	4904	31	3129	1500
1999	g (2)	72%	32	4127	YES	0	4	0	200	2967	28	2518	1400	0	0	0	0	11602	0	0	0	4127	32	2518	1600
2000	v.g	97%	28	2002	YES	0	5	932	0	2002	23	1915	1150	0	0	0	0	0	0	0	0	2002	28	2847	1150
2001	p (2)	70%	31	5461	YES	862	8	1031	222	3786	23	2915	1149	86	0	0	0	7272	0	0	0	5461	31	3946	1371
2002	p (1)	62%	9	2392	YES	286	0	0	0	2051	9	949	450	4	0	0	0	51	0	0	0	2392	9	949	450
2003			9	2399	YES	0				2399	9	1132	445												
2004			9	2531	YES	749	2	190	133	1782	7	991	350												
2005			26	4387	YES	1153	5	1312	372	3234	21	4135	1018												
2006			22	4402	YES	581	8	2248	549	3821	14	1982	686												
2007			29	4629	YES	0				4629	29														
2008			19	4895	YES	0				4895	19														
2009				4594	YES					4594												4594			

COVERAGE: Sum of the landings (by Q and Nation(UK disaggregated))/total landings. From 1993 (possibly from 1990) to date landings and sampling levels are presented by quarter so coverage is related to this level of detail:

VERY GOOD (v.g) : all landings which individually are >10% of the total were sampled, all Q for which there were landings were sampled

GOOD (g) : landings that constitute the majority of the catch (adding to approx 70% or more of total) were sampled

POOR (p) : some of the large landings not sampled

(1): unsampled quarters

(2): large landings with few samples or unsampled. High level of sampling corresponds to 1 sample per 100t landed (WG rep 1997)

(3): Comment from WG rep. From 1990 going back, Report landings and sampling levels are shown aggregated for the whole year. UK landings lumped in one figure.

(4): no information in the WGrep of level of sampling prior to 1988. Sampling levels believed to be good. Actual figures to be provided by R. Nash, M Armstrong and CEFAS after going back to their labs.

(5): NO samples for NI landings in 4th Q, there is a suspicion that the figures correspond to 'paper landings'.

[1]Samples applied to NI landings: [2]Large unsampled landings.

Table 2: Data and method used to estimate landings from Division VIIa(N) herring.

																ESTIMATES OF MAXIMUM LIKELY CATCH FOR VIIA(N) INCL. OF FRENCH AND ROI CATCHES							
Column No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		17		18		19	
	ICES table							British Isles catches						CATCH IN ASSESS-MENT		NE Atlantic catch		ICES 7a catch		% of NE atlantic		max likely catch	
	Ireland	UK	France	Netherlands	USSR/ Russia	Unallocated	Total	England	Northern Ireland	Wales	Manx	Irish	Total			France	Ireland	France	Ireland	France	Ireland	France	Ireland
1955								0	0	72	3815		3887	**8056**		60500	4900					3630	539
1956								5	0	20	4762		4787	**8743**		52000	7600					3120	836
1957								21	0	1638	2832		4491	**7966**		36100	11900					2166	1309
1958								31	0	12	2482		2525	**6261**		38800	12800					2328	1408
1959								20	0	96	3577		3693	**7833**		40400	15600					2424	1716
1960								1	0	9	2093		2103	**6607**		36200	21200					2172	2332
1961								32	0	144	1941		2117	**5710**		36600	12700					2196	1397
1962								4	0	21	1528		1552	**4343**		29100	9500					1746	1045
1963								5	0	34	974		1013	**3947**		33500	8400					2010	924
1964								2	0	0	556		558	**3593**		35000	8500					2100	935
1965								1629	0	398	1135		3162	**5923**		26400	10700					1584	1177
1966								2041	0	46	596		2683	**5666**		22400	14900					1344	1639
1967								2911	0	8	1959		4878	**8721**		20600	23700					1236	2607
1968								1504	0	5	3253		4762	**8660**		22800	23000					1368	2530
1969								3591	0	63	5044		8698	**14141**		27100	34700					1626	3817
1970								4662	0	16	9782		14461	**20622**		24400	42700					1464	4697
1971	3131	21861	1815				26807							**26807**		23500	31200	1815	3131	0.08	0.10		
1972	2529	23337	1224	260			27350							**27350**		29900	47800	1224	2529	0.04	0.05		
1973	3614	18587	254	143			22598							**22598**		30800	38900	254	3614	0.01	0.09		
1974	5894	27489	3194	1116	945		38638							**38638**		21199	39608	3194	5894	0.15	0.15		
1975	4790	18244	813	630	26		24503							**24503**		25645	29752	813	4790	0.03	0.16		
1976	3205	16401	651	989			21246							**21246**		20466	22227	651	3205	0.03	0.14		
1977	3331	11498	85	500			15414							**15414**		4164	23436	85	3331	0.02	0.14		
1978	2371	8432	174	98			11075							**11075**		4201	27717	174	2371	0.04	0.09		
1979	1805	10078	455				12338							**12338**		3596	27454	455	1805	0.13	0.07		
1980	1340	9272	1				10613							**10613**		6126	36917	1	1340	0.00	0.04		
1981	283	4094					4377							**4377**		6952	29926			0.00	0.00		
1982	300	3375				1180	4855							**4855**									
1983	860	3025	48				3933							**3933**						0.06	0.11		
1984	1084	2982					4066							**4066**									

1985	1000	4077				4110	9187							**9187**									
1986	1640	4376				1424	7440							**7440**									
1987	1200	3290				1333	5823							**5823**									
1988	2579	7593					10172							**10172**									
1989	1430	3532					4962							**4962**									
1990	1699	4613					6312							**6312**									
1991	80	4318					4398							**4398**									
1992	406	4864					5270							**5270**									
1993	0	4408					4408							**4408**									
1994	0	4828					4828							**4828**									
1995	0	5076					5076							**5076**									
1996	100	5180				22	5302							**5302**									
1997	0	6651					6651							**6651**									
1998	0	4905					4905							**4905**									
1999	0	4127					4127							**4127**									
2000	0	2002					2002							**2002**									
2001	862	4599					5461							**5461**									
2002	286	2107					2393							**2393**									
2003	0	2399					2399							**2399**									
2004	749	1782					2531							**2531**									
2005	1153	3234					4387							**4387**									
2006	581	3821					4402							**4402**									
2007	0	4629					4629							**4629**									
2008	0	4895					4895							**4895**									
2009	0	4594					4594							**4594**									

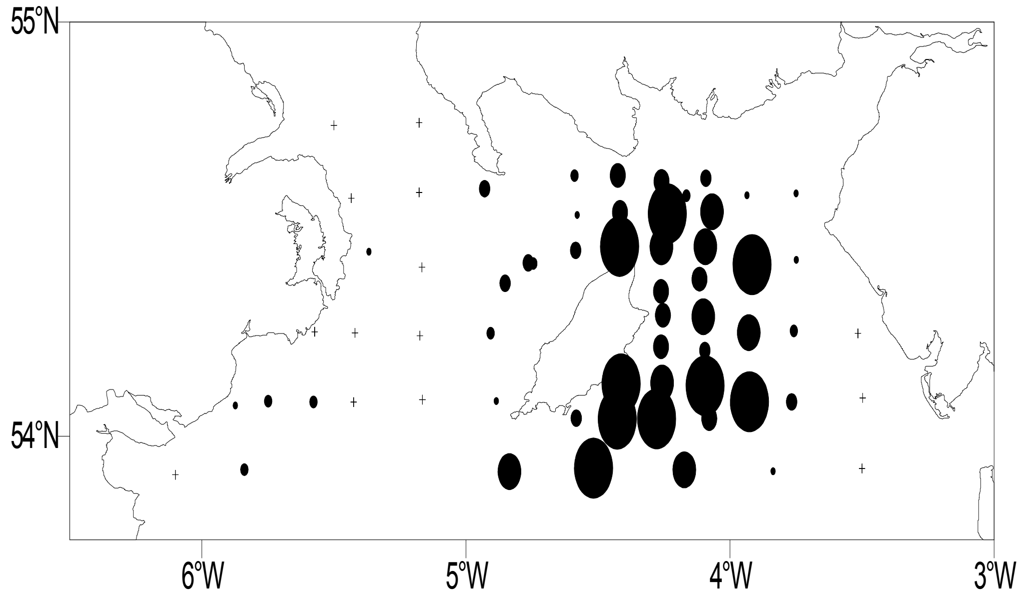
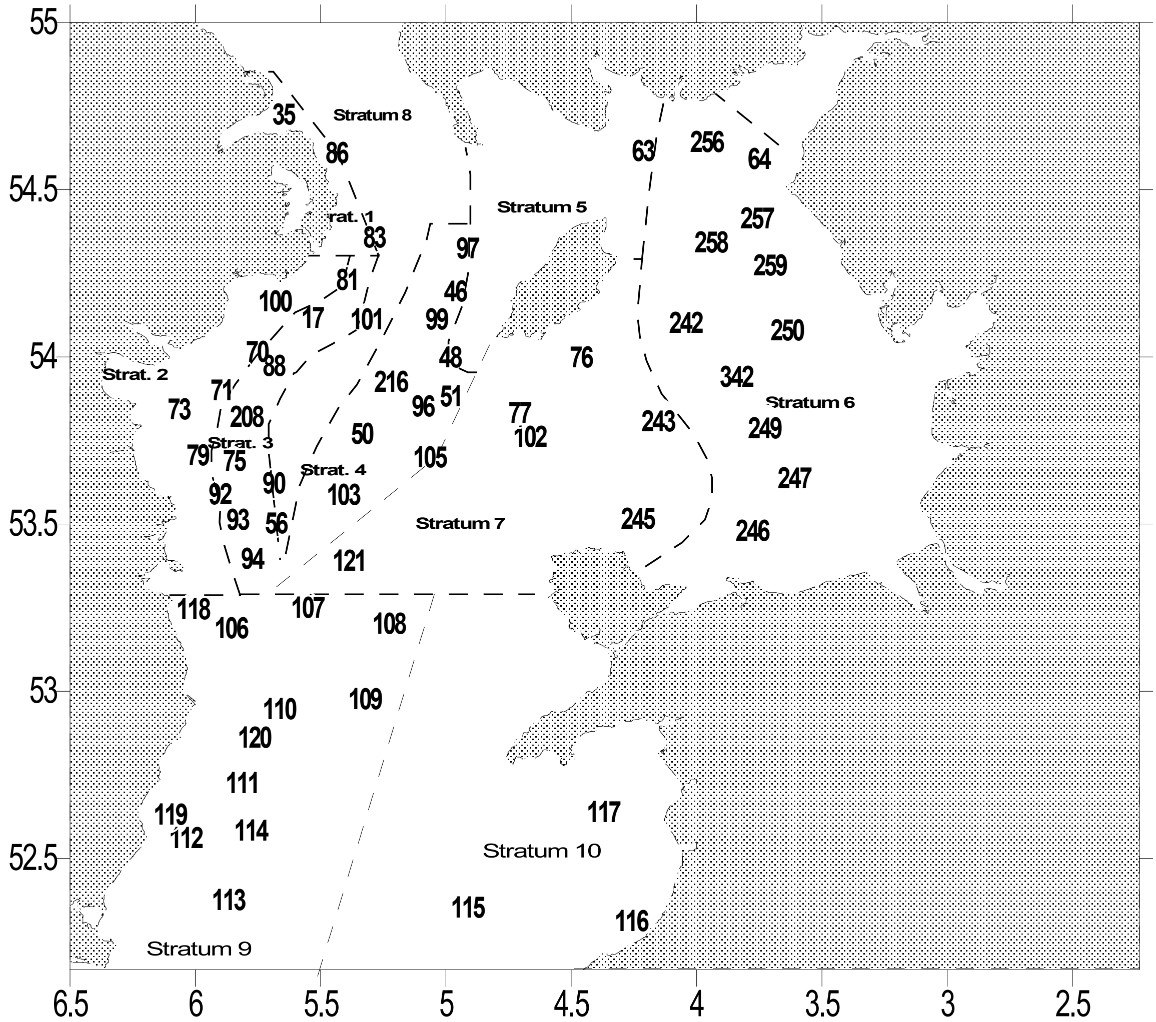


Figure 1. Sampling stations for larvae in the North Irish Sea (NINEL). Sampling is undertaken in November each year.



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	109	137	155	166	183	194	213

*** Average for the preceding five years**

Table 4. Irish Sea Herring Division VIIa(N). Mean length-at-age in the catch.

Year	Lengths-at-age (cm) Age (rings)						
	1	2	3	4	5	6	7	8+
1985	22.1	24.3	26.1	27.6	28.3	28.6	29.5	30.1
1986	19.7	24.3	25.8	26.9	28.0	28.8	28.8	29.8
1987	20.0	24.1	26.3	27.3	28.0	29.2	29.4	30.1
1988	20.2	23.5	25.7	26.3	27.2	27.7	28.7	29.6
1989	20.9	23.8	25.8	26.8	27.8	28.2	28.0	29.5
1990	20.1	24.2	25.6	26.2	27.7	28.3	28.3	29.0
1991	20.5	23.8	25.4	26.1	26.8	27.3	27.7	28.7
1992	19.0	23.7	25.3	26.2	26.7	27.2	27.9	29.4
1993	21.6	24.1	25.9	26.7	27.2	27.6	28.0	28.7
1994	20.1	23.9	25.5	26.5	27.0	27.4	27.9	28.4
1995	20.4	23.6	25.2	26.3	26.8	27.0	27.6	28.3
1996	19.8	23.5	25.3	26.0	26.6	27.6	27.6	28.2
1997	19.6	23.6	25.1	26.0	26.5	27.1	27.7	28.2
1998	20.8	23.8	25.2	26.1	27.0	26.8	27.2	28.7
1999	19.8	23.6	25.0	26.1	26.5	27.1	27.2	28.0
2000	19.7	23.8	25.3	26.3	27.1	27.7	27.7	28.1
2001	20.0	22.9	24.8	25.7	26.2	26.9	27.5	27.8
2002	21.1	23.1	24.8	26.0	26.6	26.7	27.0	28.1
2003	21.1	23.7	25.0	26.5	26.9	27.1	27.8	28.5
2004	20.7	23.1	24.6	25.8	26.1	27.1	27.6	28.3
2005	20.0	22.6	24.5	25.5	26.0	26.6	27.1	27.8
2006	19.5	22.7	24.3	25.3	26.0	26.6	26.9	28.0
2007	20.1	23.0	24.1	25.1	25.8	26.2	26.7	27.8
2008	20.0	22.7	24.1	25.0	25.2	26.3	26.9	27.4

Table 5. Irish Sea Herring Division VIIa (N). Catch-at-length for 1990-2008. 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 1990-2008. Numbers of fish in thousands.

Length	2005	2006	2007	2008
14				
14.5				
15				
15.5			16	
16		2		
16.5	1	44	33	1
17	39	140	69	3
17.5	117	211	286	11
18	291	586	852	34
18.5	521	726	2088	64
19	758	895	2979	85
19.5	933	1246	3527	108
20	943	984	3516	100
20.5	923	1443	2852	133
21	1256	1521	3451	192
21.5	1380	1621	2929	217
22	1361	2748	3821	271
22.5	1448	3629	3503	229
23	1035	4358	4196	322
23.5	1256	2920	3697	264
24	1276	3679	3178	259
24.5	1083	2431	2136	204
25	1086	3438	1503	148
25.5	584	2198	952	114
26	438	1714	643	78
26.5	203	605	330	42
27	165	445	147	23
27.5	60	155	72	10
28	45	104	33	12
28.5	18	9	26	1
29	12	46		
29.5			7	
30				
30.5				
31				
31.5				
32				
32.5				
33				
33.5				
34				

Table 6. Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles).

(a) 0-ring herring: October survey

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N. obs	SE
1991	54	34	22						
1992	210	31	99	240	8	149	177	46	68
1993	633	26	331	498	10	270	412	44	155
1994	548	26	159	8	7	5	194	41	55
1995	67	22	23	35	9	18	37	35	11
1996	90	26	58	131	9	79	117	42	50
1997	281	26	192	68	9	42	138	43	70
1998	980	26	417	12	9	10	347	43	144
1999	389	26	271	90	9	29	186	43	96
2000	202	24	144	367	9	190	212	38	89
2001	553	26	244	236	11	104	284	45	93
2002	132	26	84	18	11	10	63	45	31
2003	1203	26	855	75	11	47	446	45	296
2004	838	26	292	447	11	191	469	45	125
2005	1516	26	1036	256	11	152	627	45	363
2006	4677	26	2190	2140	11	829	2468	45	822

(b) 1-ring herring: March Surveys.

	Western Irish Sea			Eastern Irish Sea			Total Irish Sea		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1992	392	20	198	115	10	73	190	34	77
1993	1755	27	620	175	10	66	681	45	216
1994	2472	25	1852	106	9	51	923	39	641
1995	1299	26	679	73	8	32	480	42	235
1996	1055	22	638	285	9	164	487	39	230
1997	1473	26	382	260	9	96	612	43	137
1998	3953	26	1331	250	9	184	1472	43	466
1999	5845	26	1860	736	9	321	2308	42	655
2000	2303	26	853	546	10	217	1009	44	306
2001	3518	26	916	1265	11	531	1763	45	381
2002[a]	2255	25	845	185	11	84	852	44	294
2002[b]	7870	26	5667	185	11	84	2794	45	1960
2003	2103	26	876	896	11	604	1079	45	382
2004	6611	25	2726	491	11	163	2486	44	945
2005	7274	26	3097	1240	8	375	3001	42	1121
2006	4249	26	1687	2630	11	813	2496	45	662

a. Unusually large catch removed, b. unusually large catch retained.

Table 6. (Continued) Irish Sea herring Division VIIa(N). Northern Ireland groundfish survey indices for herring (Nos. per 3 miles.).

(c) 1-ring herring: October Surveys

	WESTERN IRISH SEA			EASTERN IRISH SEA			TOTAL IRISH SEA		
Survey	Mean	N.obs	SE	Mean	N.obs.	SE	Mean	N.obs	SE
1991	102	34	34	n/a	n/a	n/a	n/a	n/a	n/a
1992	36	31	18	20	8	11	21	46	8
1993	122	26	66	4	10	2	44	44	23
1994	490	26	137	17	6	10	176	40	47
1995	153	22	61	3	9	1	55	35	21
1996	30	26	13	2	9	1	11	42	5
1997	612	26	369	0.2	9	0.2	302	43	156
1998	39	26	15	13	9	10	53	43	35
1999	81	26	41	104	9	95	74	43	40
2000	455	24	250	74	9	52	579	38	403
2001	1412	26	641	5	11	3	513	45	223
2002	370	26	111	4	11	2	291	45	158
2003	314	26	143	410	11	350	267	45	144
2004	710	26	298	103	11	74	299	45	108
2005	3217	25	1467	18	11	12	1121	44	507
2006	1458	26	669	40	11	18	523	45	231

Table 7. Irish Sea Herring Division VIIa (N). Larval production (10^{11}) indices for the Manx component.

YEAR	DOUGLAS BANK		
		Isle of Man	
	Date	Production	SE
1989	26 Oct	3.39	1.54
1990	19 Oct	1.92	0.78
1991	15 Oct	1.56	0.73
1992	16 Oct	15.64	2.32
1993	19 Oct	4.81	0.77
1994	13 Oct	7.26	2.26
1995	19 Oct	1.58	1.68
1996			
1997	15 Oct	5.59	1.25
1998	6 Nov	2.27	1.43
1999	25 Oct	3.87	0.88

Annex 09 – Stock Annex – Sprat in the North Sea

Quality Handbook	ANNEX: Sprat in the North Sea
Stock specific documentation of standard assessment procedures used by ICES.	
Stock:	Sprat in the North Sea
Working Group	Herring Assessment Working Group (HAWG)
Date:	21 March 2010
Authors	E. Torstensen, L. W. Clausen, C. Frisk, C. Kvamme, M. Payne

A. General

A.1. Stock definition

Sprat (*Sprattus sprattus* Linnaeus 1758) in ICES area IV (North Sea).

Sprat in the North Sea is treated as a single management unit. However, questions have recently been raised about the geographic distribution of this stock and its interaction with neighbouring stocks: in particular, large abundances have been observed close to the southern boundaries of the stock (ICES HAWG 2009). The apparent overlap between North Sea sprat and English Channel sprat is very strong, whereas the overlap between North Sea sprat and Kattegat sprat is not as strong and varies between years.

A detailed genetic study has been performed to analyze the population structure of sprat over large ranges, from scales of seas to regions (Limborg *et al*., 2009). The study was performed with individuals from the Baltic Sea, Danish waters, Kattegat, North Sea, Celtic Sea and Adriatic Sea (Figure 2). The analysis partitioned the samples into groups based upon their genetic similarity (Figure 3). The Adriatic Sea population exhibited a large divergence from all other samples. The samples from the North Sea, Celtic Sea and Kattegat were separated from the Baltic Sea samples, with the Belt Sea (Kattegat) sample in between. The authors concluded that there exists a barrier to gene flow from the North Sea to the Baltic Sea, with the Belt Sea being a transition zone. This analysis does not support the separation of sprat into three stocks that is currently employed by ICES (i.e. subdivision VIId (English Channel), subdivision IIIa (Skagerrak/Kattegat) and division IV (North Sea). However, it is also important to note that this work is based on neutral markers, which are relatively insensitive. Further research on this issue is required.

A.2. Fishery

The majority of the sprat landings are taken in the Danish industrial small-meshed trawl fishery. The Norwegian sprat fishery is mainly carried out by purse seiners. Both landings are used for reduction to fish meal and fish oil. In the last decade, also the UK occasionally lands small amounts of sprat.

The commercial catches are sampled for biological parameters. In the most recent years Denmark, Norway and Scotland have sampled their sprat catches. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001, requiring 1 sample per 2000 tonnes.

In 2007 a new quota regulation (IOK) for the Danish vessels was implemented and realized from 2008 and onwards. The regulation gives quotas to the vessel, but these can be traded or sold. A large number of small vessels have been taken out of the fishery and their quotas sold to larger vessels. Today the Danish fleet is therefore dominated by large vessels.

There exists no information about discards and unallocated catches, but it is not expected to be a problem for this fishery.

Historically, the by-catch of juvenile herring in the industrial sprat fisheries has been problematically high (Figure 4). To reduce this by-catch, an area closed to the sprat fishery (the "sprat box") was established off the western coast of Denmark (from Vadehavet to Hanstholm) in October 1984 (Hoffman et al 2004). It was estimated that about 90% of the by-catches of juvenile herring in the industrial fisheries was taken within this box, and the intention of the sprat box was thus to reduce this juvenile herring by-catch.

Despite the establishment of this sprat box, the juvenile herring by-catches increased in the early 1990's, partly because of larger incoming year classes having a wider distribution (Hoffman et al 2004). It was concluded that there was no clear connection between the sprat box and the decrease in herring by-catches in the period 1984-1996. The sprat box is still in operation (Fiskeridirektoratet 2007).

After 1996, the by-catch mortality of juvenile herring was reduced (ICES HAWG 2009). This coincided with the introduction of a by-catch limit on herring in the industrial fisheries and improvements in the catch sampling.

Evaluation of the quality of the catch data

Due to large but unknown by-catches of juvenile North Sea herring in the industrial sprat fisheries prior to 1996 (Figure 4), sprat landings are only considered reliable from 1996 onwards. The reduction in by-catches of juvenile herring in 1996 coincides with the introduction of a by-catch limit on herring in the industrial fisheries, and improvements in catch-sampling.

The by-catches in the Danish industrial small-meshed trawl fishery for sprat (1998-2009) have been estimated from samples of the commercial catches. The major by-catches are herring (4.2-11.1% in weight), horse mackerel (0.0-1.6%), whiting (0.2-1.5%), haddock (0.0-0.1%), mackerel (0.2-2.2%), cod (<0.0%), sandeel (0.0-10.0%) and other (0.3-2.4%). Although these catches are relatively small by weight, they are often juveniles, and therefore can represent a significant number of individuals.

There exists no information about the by-catches of the other fleets.

A.3. Ecosystem aspects

Many predators in the North Sea feed extensively on sprat, including predatory fish, marine mammals and seabirds. Its role in the ecosystem has been evaluated in the 1981 and 1991 stomach sampling programs (ICES 1989, ICES 1997). Predation was strongest from whiting and mackerel (ICES SGMSNS 2006, ICES 1997). Predation from cod on sprat have been suggested to increase after the last sampling campaign in 1991 as sandeel and Norway pout stocks have decreased (ICES 1997).

Sprat can be very important for breeding seabirds in southern areas of the North Sea (Durinck et al 1991, Wilson et al. 2004). Estimates from 1985 have shown that the total seabird consumption in the North Sea could be on the same level as the fisheries

(Hunt and Furness (ed.) 1996). In winter, when sandeel are not available to most seabirds (because they are buried in the sand) many of the seabirds that overwinter in the North Sea take sprat as part of their diet. However, it is uncertain whether sprat abundance in the North Sea will affect seabird breeding success or overwinter survival.

Attempts have previously been made to include sprat in the MSVPA in the North Sea (ICES SGMSNS 2005). Recently, as no single species assessment on North Sea sprat has been performed, sprat was not included explicitly in the MSVPA. Sprat was therefore treated in the recent model as 'other food', and is thus included in the model indirectly as a prey organism. Unfortunately this method does not allow for an estimate on the predation mortality on sprat (ICES WGSAM 2008). Historically, MSVPA runs have included sprat by which it was found that the predation mortality on the species exceeds the fishing mortality (ICES SGMSNS 2005).

B. Data

B.1. Commercial catch

The majority of the sprat landings are taken in the Danish industrial small-meshed trawl fishery. The Norwegian sprat fishery is mainly carried out by purse seiners. Both landings are used for reduction to fish meal and fish oil. In the last decade, also the UK occasionally lands small amounts of sprat.

The commercial catches are sampled for biological parameters. In the most recent years Denmark, Norway and Scotland have sampled their sprat catches. The sampling intensity for biological samples, i.e., age and weight-at-age is mainly performed following the EU regulation 1639/2001, requiring 1 sample per 2000 tonnes.

There exists no information about discards and unallocated catches, but it is not expected to be a problem for this fishery.

Due to large but unknown by-catches of juvenile North Sea herring in the industrial sprat fisheries prior to 1996 (Figure 4), sprat landings are only considered reliable from 1996 onwards. The reduction in by-catches of juvenile herring in 1996 coincides with the introduction of a by-catch limit on herring in the industrial fisheries, and improvements in catch-sampling.

B.2. Biological

Sprat in the North Sea has a prolonged spawning season ranging from early spring to the late autumn, and is triggered by the water temperature (Alheit *et al*., 1987; Alshulth 1988a; Wahl and Alheit 1988). Sprat is a batch spawner, producing up to 10 batches in one spawning season and 100-400 eggs per gram of body weight (Alheit 1987; George 1987). The majority of the sprat in age groups 1+ in the summer acoustic surveys in June-July are shown to be spawners (ICES WGIPS 2010).

Disagreements in the age reading in North Sea sprat have been reported (*e.g*. Torstensen et al. 2004). The problems arise due to interpretation of winter rings. False winter rings can be set in periods of bad feeding conditions/starvation and due to rapid changes in temperature (E. Torstensen, personal communication 2009). False winter rings also occur in other species and areas, e.g. Baltic sprat (Kornilovs (edi.) 2006), herring (ICES WKARGH 2008) and sandeel (Clausen *et al*. 2006). Furthermore, the interpretation of the first winter ring can be difficult, as sprat can spawn until late autumn and larvae from these late spawning will likely not set down a winter ring during their first winter (Torstensen et al 2004). The absence of such rings can lead to errors in age determination, as these individuals cannot be distinguished from the individuals born the following year. Age readings in North Sea sprat were estimated to have a high coefficient of variance (CV) of 28% (Torstensen et al. 2004).

Mean weight-at-age in the North Sea sprat is variable over time (ICES HAWG 2009). This may be ascribed due to both the aging problems previously described, and also the prolonged spawning period, by which the individuals can have very different birthdates and thus also different growth conditions, i.e temperature and nutrition available. The mean weight-at-age in the catches for age 1 is approximately 4 g, at age 2 app. 10 g, at age 3 app. 11 g, and at age 4+ app. 14 g (se Sec 8-North Sea sprat in ICES HAWG 2010).

B.3. Surveys

Three surveys cover this stock. Two International Bottom Trawl Surveys (IBTS) cover the stock in the first and third quarters of the year, respectively. Additionally, the herring acoustic survey covers the same area during June-July.

The appropriateness and suitability of these surveys for use in the assessment of the North Sea sprat stock, was examined by the WKSHORT (2009).

B.3.1 International Bottom Trawl Surveys (IBTS)

Background

The North-Sea International Bottom Trawl Surveys started as a coordinated international survey in the mid-1960s as a survey directed towards juvenile herring. The gear used was standardised in 1977 to use the GOV trawl, but took time to be phased in. By 1983 all participating nations were using this gear, and the index can be considered consistent from this point onwards. A third-quarter North Sea IBTS survey using the same methodology was started in 1991 and can be considered consistent from its initiation. IBTS Surveys were also performed in the North Sea in the second and fourth quarters in the period 1991-1996, but are not considered further here (ICES 2006). More details on the survey are available from the manual (ICES 2004).

Suitability

The appropriateness of the IBTS survey for use as an estimate of the abundance of North Sea sprat was examined in a working document to the WKSHORT (Jansen et al 2009). Acoustic data collected during trawls performed as part of the IBTS were analysed, with focus on the vertical distribution. The relationship between the amount of sprat available in the water column (from acoustics) and the amount of sprat captured by the gear was found to be weak and highly variable in nature. The proportion of sprat in the water column that were in the bottom five metres was found to range widely between 0 and 100%, and also found to be a function of the time of day. The work therefore suggests that the IBTS survey, as it exists, may not be appropriate for use with sprat in the North Sea. However, further investigation, including the addition of further data points and comparison with results from other species (*e.g.* herring) are required before firm conclusions can be drawn.

Internal Consistency

Internal consistency analysis (Payne et al 2009 and references therein) was used to examine the ability of the IBTS survey to track the abundance of individual cohorts. This method involves plotting the log-abundance estimated by the survey at one age against the log-abundance of the same cohort in the following year: in cases where the total mortality is constant and the relative survey noise is low, this relationship should be linear. However, deviations from linearity may arise due to either high noise levels in the survey or variations in the total mortality experienced by the stock. The test is therefore asymmetric, in that a linear relationship is a strongly positive result, whilst the absence of a relationship does not automatically mean that the survey is of poor quality. Examination of the internal consistency can therefore be used as a measure (albeit biased) of the survey quality.

We find that the relationship between the abundance of successive ages in a cohort from the first quarter (Figure 5) and third quarter (Figure 6) surveys is extremely poor, and is dominated by noise. This noise may arise due to either the nature of the survey (e.g. survey design, variability in catchability) or variations in total mortality. In the absence of information regarding either fishing mortality (e.g. from a stock assessment) or natural mortality (e.g. from a multispecies model), it is not possible to separate these two sources of variability.

Confidence Intervals

Distribution of the IBTS indices are available from the ICES DATRAS database, following a bootstrapping procedure agreed upon in 2006 (ICES 2006). This data was analysed to extract key values characterising the distribution, including the confidence intervals for both IBTS Q1 (Figure 7) and Q3. Generally, the confidence intervals for the indices were found to be extremely broad. The median upper confidence limit is 250% greater than the value of the index estimated (although in some cases this can be as much as 4600% greater) and the median lower confidence limit is 40% less than the estimated index. The uncertainties are therefore much larger than the estimated dynamics of the stock and it is thus not possible to say, statistically, that the index value in one year is statistically different from another.

Composition of the Index

Catches of North Sea sprat in hauls in the IBTS survey can occasionally be extremely large; this phenomenon has previously been suggested as being important to the dynamics and uncertainty of IBTS survey indices (ICES HAWG 2007, ICES HAWG 2009). In order to examine this phenomenon more closely, the importance of each haul to the index was assessed by calculating the individual contribution of each haul to the total. These hauls were then ranked according to size and aggregated to produce an estimate of the cumulative contribution ranked by sized: in this manner, it is therefore possible to assess, for example, the proportional contribution of the largest 20 hauls in a given year. For all years in the both the IBTS Q1 (Figure 8) and Q3 (Figure 9), the 10 largest hauls contribute at least 35% of the survey index, and in some cases up to 85% of the index. The IBTS Q3 index appears to have more severe problems with large hauls than the Q1 index: in every year, the five largest hauls make up more than 50% of the index.

Alternative Analysis Methods

The method used by the ICES DATRAS database to calculate the IBTS indices is relatively simplistic, essentially comprising a set of stratified means (i.e. the mean CPUE per statistical rectangle is averaged over the entire North Sea). As an attempt to resolve problems caused by the presence of large hauls in the calculation of the index, a Log-Gaussian Cox Process (LGCP) was fitted to the individual haul data (Kristensen et al 2006, Kristensen 2009a, Kristensen and Lewy 2009). The LGCP model is a statistical model that can be used to account for the statistical nature of the catch process, including correlations between size classes, spatial correlation and between years. The model was fitted in a simplified form, where only spatial correlations were included. Total CPUE of sprat, CPUE by age and CPUE by length class were all used as classification schemes and each fitted individually using the model.

Unfortunately, the LGCP model failed to fit the IBTS survey data adequately. Goodness of fit tests on the fitted model showed that a number of key assumptions in the model were frequently violated. Furthermore, the confidence intervals on the estimated abundances were extremely broad, in some cases spanning more than six orders of magnitude. It was therefore concluded that the model, as fitted, was in appropriate for the data set.

It is currently unclear as to why the LGCP model fails to fit the IBTS sprat data. A number of candidate explanations have been considered, including the high number of zero hauls and the extreme "boom-bust" nature of the catches. It is currently unclear whether this modelling framework is capable of dealing with the nature of the sprat catches in the IBTS survey: the ultimate appropriateness of this method should be considered carefully before further work is performed.

Conclusions

The IBTS Q1 and Q3 surveys are the best time series of data available for use in characterising the abundance of sprat in the North Sea, covering the years from 1984 and 1991 onwards respectively: for comparison, the time series of catches begins in 1996 and the acoustic survey (see below) in 2004. However, the survey is greatly impacted by the presence of extremely large individual hauls that can make up 85% or more of the index in some years. The problem is compounded by the manner in which the ICES DATRAS database calculates the indices – the use of simple arithmetic means here does not account for the extremely high variability of sprat catches in the IBTS survey and propagates these problems through to the index value. The extremely broad confidence intervals and the lack of internal consistency can also be understood as consequences of this problem. Variability in the catchability of sprat in the IBTS's GOV gear caused by the time of day and the pelagic nature of sprat may contribute to this problem to a degree but seem unlikely to explain the order-of-magnitude variability observed. Instead, the highly schooling nature of sprat is likely to be the most important underlying cause: if the gear encounters and captures a high-density school of sprat, an extremely large haul could be produced.

Given the potential importance of the IBTS indices for the assessment of this stock, further investigations are warranted. The current analysis method is extremely simplistic and appears to be the main source of the problem. Future investigations should focus on attempting to analyse this large and valuable source of information in a manner that can account for both the large number of zero hauls and also the extremely large individual hauls. Qualitative indicators, such as distribution area, presence/absence metrics, and the frequency of large hauls may also be of use in an advice context.

B.3.2. Herring Acoustic Survey (HERAS)

Background

The Herring Acoustic Survey is a summer acoustic survey that has been performed by an international consortium since the 1980s. Sprat has been reported as a separate species in this survey from 1996 onwards. However, as the survey is targeted towards herring, which are generally in the northern half of the North Sea during summer, coverage in the southern-half has received less attention. The area covered was expanded progressively over time, and by 2004 covered the majority of the stock, reaching 52°N (the eastern entrance to the English Channel) and all of the way into the German Bight (ICES PGHERS 2005). The coverage of this survey has remained relatively unchanged since 2004 (*e.g.* ICES PGIPS 2009) and we consider the survey from this point and onwards.

Suitability

In theory, the herring acoustic survey should be better suited for the estimation of sprat abundance than the bottom trawl IBTS survey, given that it integrates over the entire water column and is thus less susceptible to changes in vertical distribution and the presence of large schools.

However, there are a number of difficulties with the acoustic estimation of sprat that must be considered. Each survey report since 2004 has noted that the survey does not appear to reach the southern boundary of the stock, with there being significant concentrations of sprat at or close to this limit. Failing to reach the southern boundary line would lead to an underestimation of the stock size and may increase the 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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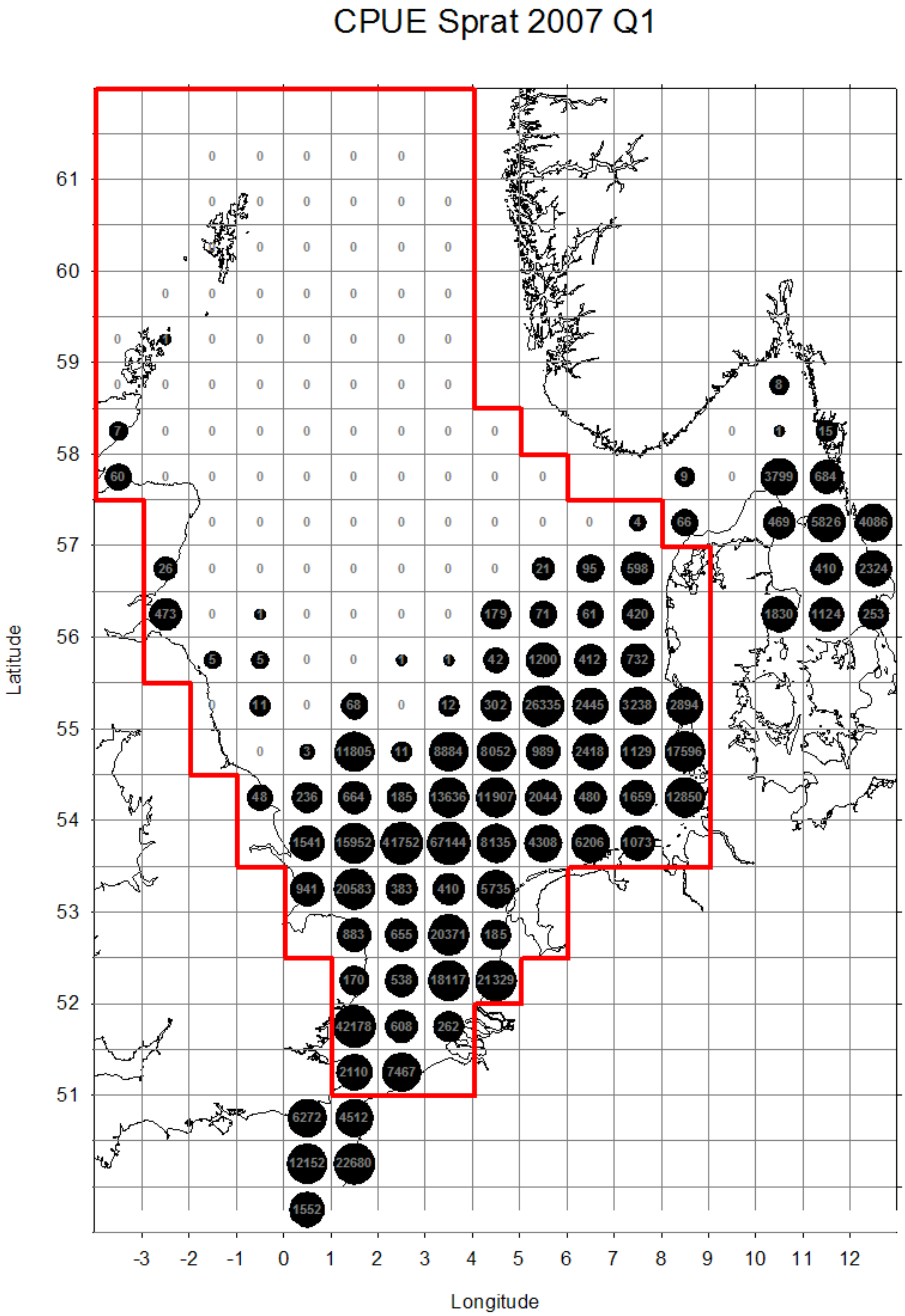

Figure 1. North Sea sprat. IBTS logCPUE from subareas; IV, IIIa, VII. The red area encircles the management area used for North Sea sprat. After ICES HAWG 2009.

Figure 2. North Sea sprat. Sampling stations (Limborg et al. 2009).

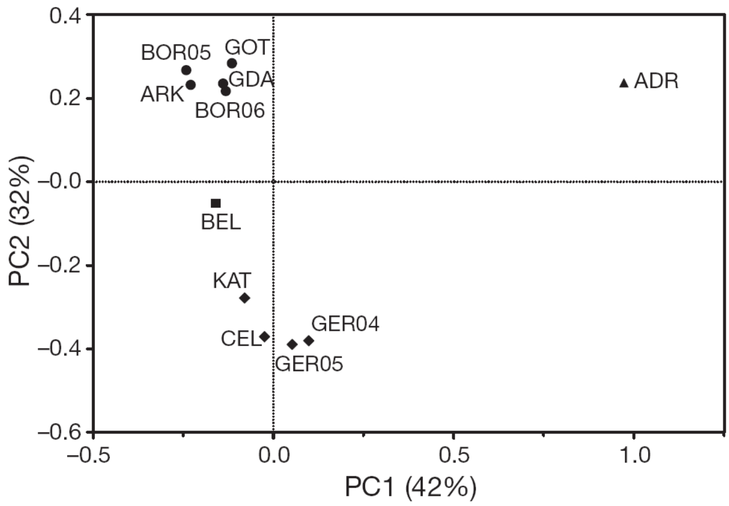

Figure 3. North Sea sprat. Plot of the generic variance in the samples. ADR = Adriatic Sea, ARK = Arkona Basin, BEL = Danish Belt, BOR = Bornholm Basin, CEL = Celtic Sea, GDA = Gdansk Deep, GER = German Bight (North Sea), GOT = Gotland Basin (Limborg et al. 2009).

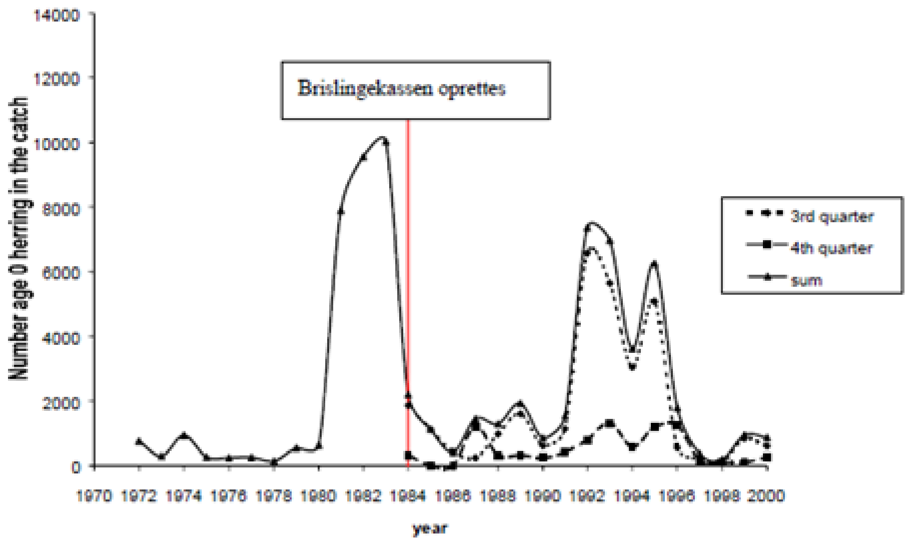

Figure 4: Catches of 0-group herring in the industrial fisheries in the central North Sea (IVb) in the 3rd and 4th quarter 1972-2000. The red line shows the time for establishing the sprat box. From Hoffman et al 2004.

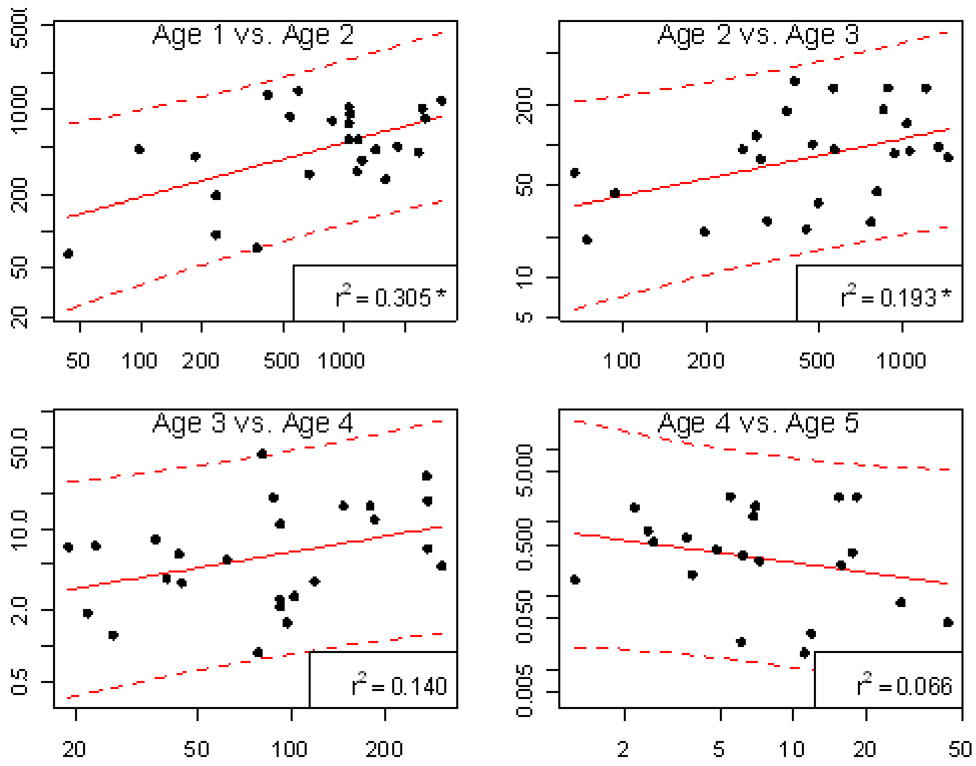

Figure 5 North Sea sprat. Internal consistency analysis from the IBTS Q1 survey. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (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.

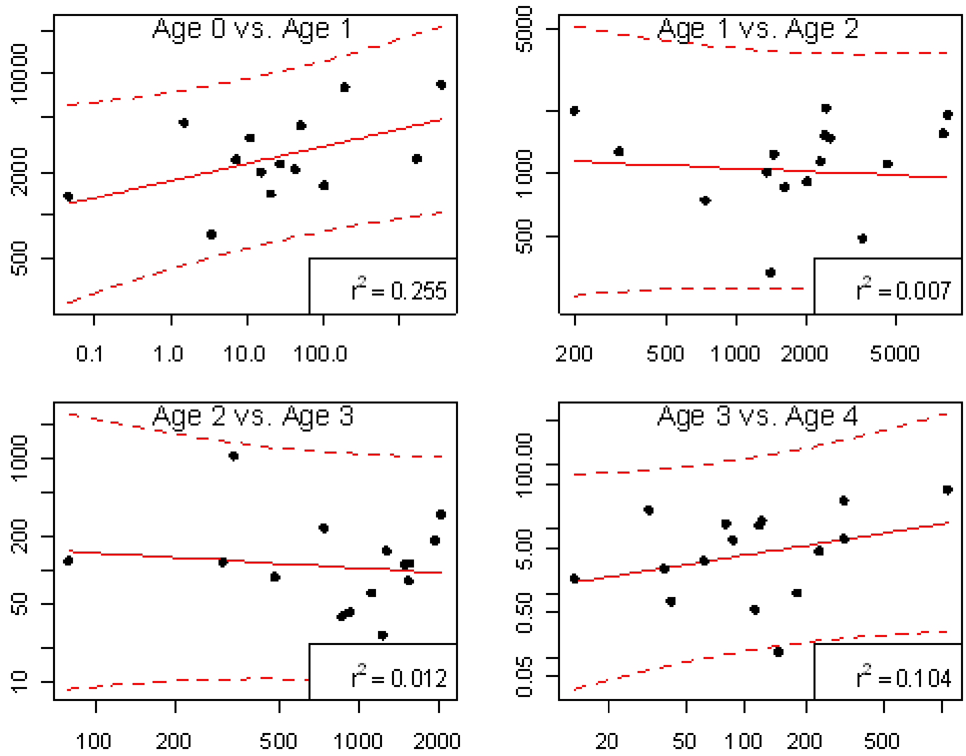

Figure 6. North Sea sprat. Internal consistency analysis from the IBTS Q3 survey. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient of determination (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.

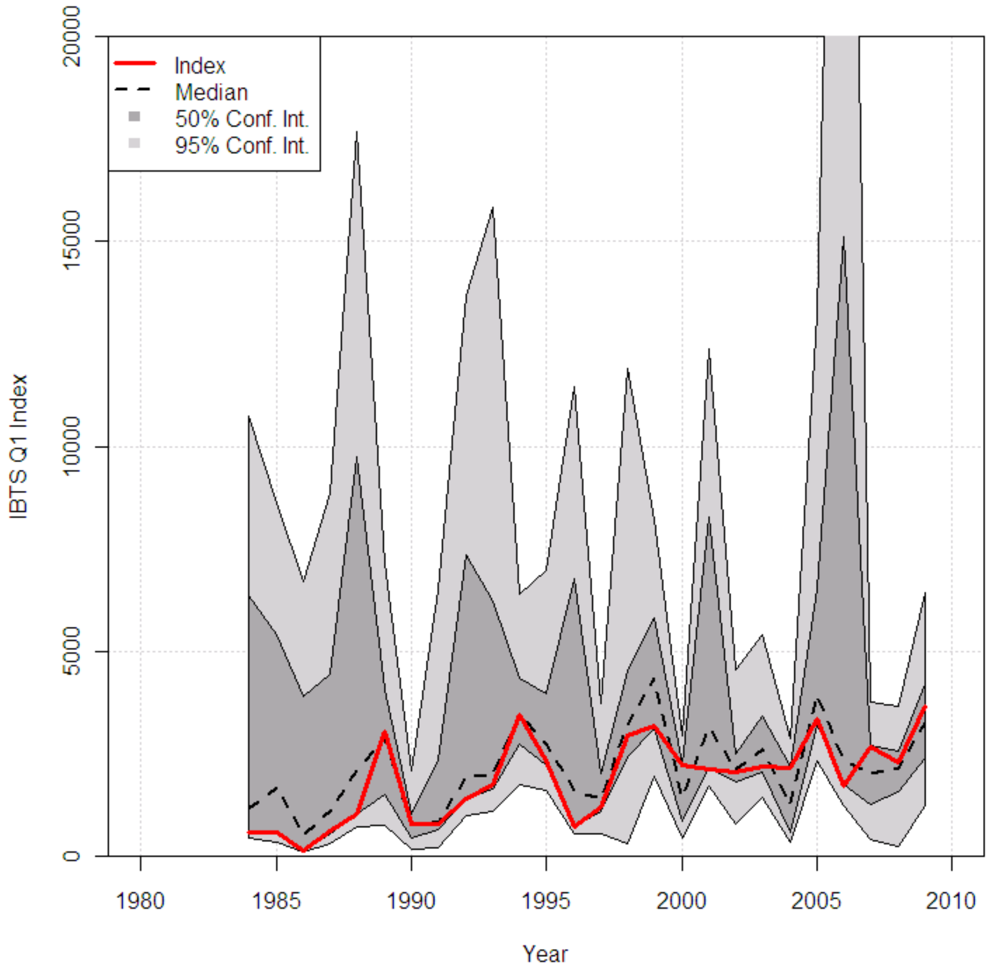

Figure 7. North Sea sprat. Distribution of index values for the IBTS Q1 index, as estimated by the DATRAS database. Values of both the mean index and median value are plotted, in addition to the 50% and 95% confidence bands.

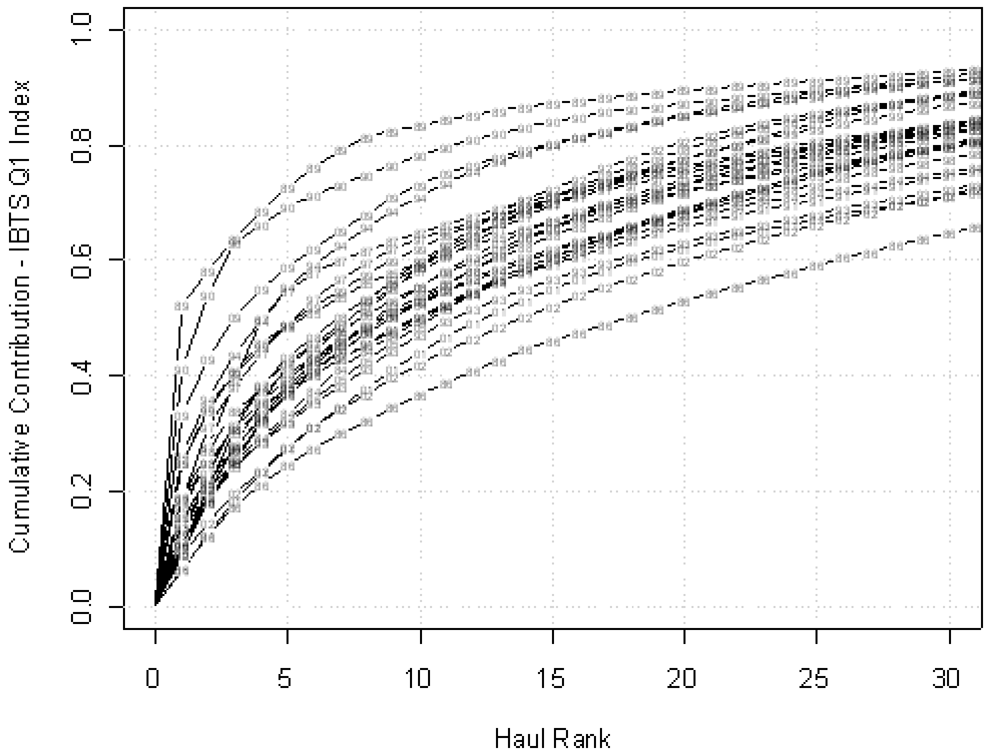

Figure 8. North Sea sprat. Cumulative distribution of the per-haul contribution to the total IBTS Q1 index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 30 largest hauls. Numbers on each line indicate the year for the survey.

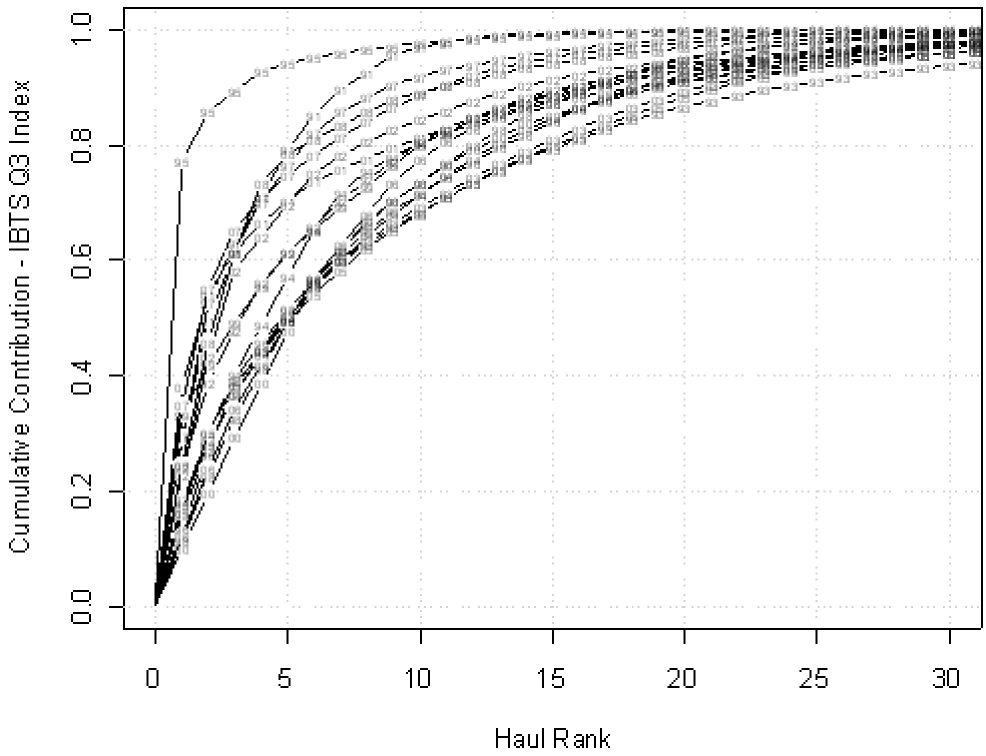

Figure 9. North Sea sprat. Cumulative distribution of the per-haul contribution to the total IBTS Q3 index. The 300-450 individual-haul contributions to the IBTS index in each year are sorted by size and then aggregated to calculate a cumulative-distribution. The plot shows only the contributions for the 30 largest hauls. Numbers on each line indicate the year for the survey.

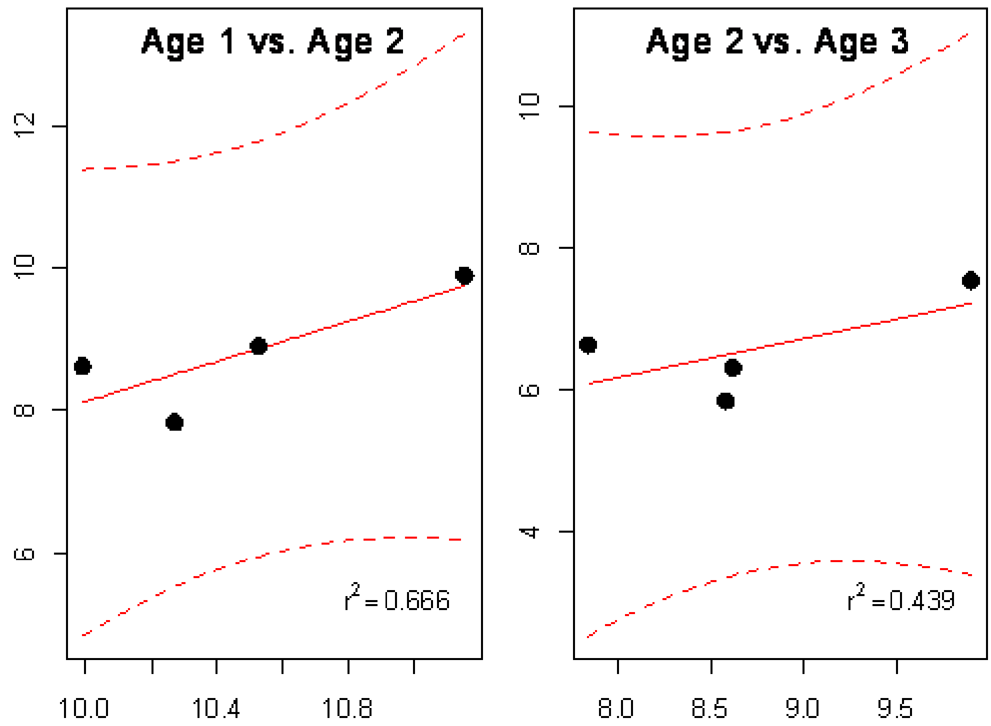

Figure 10. North Sea sprat. Internal consistency analysis from the herring acoustic survey, HERAS. Each panel plots, on a log scale, the abundance of a cohort perceived at a given age (horizontal axis) against the abundance of the same cohort as perceived one year later (vertical axis). The coefficient 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

ICES 1995. Report of the Herring Assessment Working Group for the Area South of 62ºN. ICES 1995/Assess:13

ICES 1999. International Bottom Trawl Survey in the North Sea, Skagerrak and Kattegat in 1998. ICES 1999/D:2

ICES 2001. Report of the Study Group on the Herring Assessment Units in the Baltic Sea. ICES CM 2001/ACFM:10.

ICES 2002. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2002/ACFM:12.

ICES 2005. Herring Assessment Working Group for the Area South of 62ºN (HAWG). ICES CM 2005/ACFM:16.

ICES 2006. Report of the Herring Assessment Working Group. ICES 2006 CM /ACFM:20

ICES 2009. Report of the Benchmark Workshop on Short-lived Species (WKSHORT). ICES CM/ACOM:34

Limborg, M.T., Pedersen, J.S., Hemmer-Hamsen,J., Tomkiewicz,J., Bekkevold, D. 2009. Genetic population structure of European sprat (Sprattus sprattus): differentiation across a steep environmental gradient in a small pelagic fish. Marine ecology progress series 379: 213–224.

Patterson, K.R. 1998: A programme for calculating total international catch-at-age and weight-at-age. Working Document to Herring Assessment Working Group South of 62°N. ICES CM 1998/ACFM:14.

Annex 11 Stock Annex – Sprat in Division VIIde

Quality Handbook	ANNEX:_Sprat VIIde

Stock specific documentation of standard assessment procedures used by ICES.

Stock:	Sprat in Division VIId,e
Working Group:	Herring Assessment Working Group (HAWG)
Date:	22 March 2010
Author:	Torstensen, E; Clausen, L.W., Kvamme, C.

A. General

A.1. Stock definition

Sprat in ICES area VIId, VIIe

A.2. Fishery

Vessels from UK (England and Wales) are currently responsible for the catches. The landings in this area are small and have never been above 6,000 t since 1985. Since 2000 the landings have been in the range of 840 t (2004) and 3 370 t (2008)

A.3. Ecosystem aspects

None

B. Data

B.1. Commercial catch

The commercial catch is provided by the national laboratories belonging to nations exploiting the sprat in the Division VIId and VIIe.

B.2. Biological

Sampling for biological samples, i.e. age and weight-at-age has not been performed since 1999, but as the fishery is so small, this is not considered to be a problem.

B.3. Surveys

There are no surveys targeting sprat in this area.

B.4. Commercial CPUE

Not used for this stock.

B.5. Other relevant data

None

C. Historical Stock Development

Not performed

D. Short-Term Projection

Not performed

E. Medium-Term Projections

Not performed

F. Long-Term Projections

Not performed

G. Biological Reference Points

Not set

H. Other Issues

None

I. References

Annex 12 Technical Minutes of the North Sea Review Group (RGNS) 2010

14-27 May 2010, Fairhaven Massachusetts, USA

Reviewers: Steve Cadrin (co-chair), Tony Wood (co-chair), Adam Barkley, Greg DeCelles, Dan Goethel, Fiona Hogan, Nikki Jacobson, Dave Martins, Owen Nichols, Yuying Zhang

Expert Groups:

- Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK; Clara Ulrich and Ewen Bell, chairs)
- Baltic Fisheries Assessment Working Group (WGBFAS; Michele Casini, chair)
- Herring Assessment Working Group (HAWG; Tomas Gröhsler and Maurice Clarke, chairs)
- Workshop on the Application of Advisory Framework to Data Poor stocks (WKFRAME; Ciaran Kelly, chair)

Secretariat: Barbara Schoute

Process: The ICES advisory service quality assurance program requested that a team of graduate and post-doctoral students and their professor serve as a student review group, as specified in Guidelines for Review Groups (ACOM 2009). The group initially met on 14 May to review the ICES advisory process, RG guidelines and to assign several WG report sections to each reviewer. A second meeting was held on 17 May to review standard ICES assessment models (XSA, ICA, B-ADAPT, and SAM). Members reviewed WG report sections independently, then presented their summaries and reviews to the group in a series of meetings from 19 to 24 May discuss reviewers' draft technical minutes and form RG conclusions.

General Comments: - Stock assessment reports for 23 stocks were reviewed (Table1). The EG reports were informative and generally complete. EG decisions about data, model choice and specification and interpretations were clearly explained and justified. The RG concludes that the reports are technically correct, and the RG agrees with EG recommendations, with few exceptions. In nearly all cases, the assessments appropriately applied the procedures specified in the stock annexes.

Some general issues were raised for many stocks.

- Documentation of SAM: Expert group suggests a transition to SAM as the assessment model for several stocks. However, the review group suggests that better documentation of SAM will be needed. The current reference for SAM is the ICES WGBFAS Report 2008 Working Paper 7. The working paper is not a complete source document, should be peer reviewed, and made available to reviewers.
- Discarded catch remains a major source of uncertainty in many assessments. Guidance on estimating discards in recent years and historically would be beneficial.
- MSY - ICES is developing new reference points to use in a Maximum Sustainable Yield framework. The Expert Groups have been asked to provide new reference points for stocks with an analytical assessment. The RG audited calculations of these reference points where these are presented. In

many assessments, MSY $B_{trigger}$ was not estimated. In other, MSY $B_{trigger}$ was not clearly defined.

- Retrospective analysis results would be more quantitative if retrospective metrics were used to describe the degree of retrospectivity, e.g. rho (Mohn, R. 1999. The retrospective problem in sequential population analysis: An investigation using cod fishery and simulated data. ICES Journal of Marine Science, 56: 473–488).
- For ease of use by the advice drafting group several figures/tables from EG reports are included in this document.
-

Table 1. Stocks reviewed ordered by expert group (EG), and type of assessment (Ass).

EG	Fish Stock	Stock Name	Assess. [1]	Assess. model
HAWG	her-3a22	Herring in Division IIIa and Subdivisions 22 - 24 (Western Baltic spring spawners)	Y	FLICA
HAWG	her-47d3	Herring in Subarea IV and Divisions IIIa and VIId (North Sea autumn spawners)	Y	FLICA
HAWG	spr-kask	Sprat in Division IIIa (Skagerrak - Kattegat)	N	Catch only
HAWG	spr-nsea	Sprat in Subarea IV (North Sea)	N	Trends
WGBFAS	cod-kat	Cod in Division IIIa East (Kattegat)	Y	SAM
WGBFAS	Sole-kask	Sole in Division IIIa (Skagerrak - Kattegat)	Y	SAM
WGNSSK	cod-347d	Cod in Subarea IV, Divison VIId & Division IIIa (Skagerrak)	Y	B-Adapt
WGNSSK	had-34	Haddock in Subarea IV (North Sea) and Division IIIa	Y	XSA
WGNSSK	sai-3a46	Saithe in Subarea IV (North Sea) Division IIIa West (Skagerrak) and Subarea VI	Y	XSA
WGNSSK	whg-47d	Whiting Subarea IV (North Sea) & Division VIId (Eastern Channel)	Y	XSA
WGNSSK	ple-eche	Plaice in Division VIId (Eastern Channel)	Y	XSA
WGNSSK	ple-nsea	Plaice Subarea IV (North Sea)	Y	XSA
WGNSSK	sol-eche	Sole in Division VIId (Eastern Channel)	Y	XSA
WGNSSK	sol-nsea	Sole in Subarea IV (North Sea)	Y	XSA
WGNSSK	nop-34	Norway Pout in Subarea IV and Division IIIa -- in year[3]	Y	S-XSA
WGNSSK	nep-5	*Nephrops* in Division IVbc (Botney Gut - Silver Pit, FU 5)	Y	trends
WGNSSK	nep-6	*Nephrops* in Division IVb (Farn Deeps, FU 6)	Y	UWTV[2]
WGNSSK	nep-7	*Nephrops* in Division IVa (Fladen Ground, FU 7)	Y	UWTV
WGNSSK	nep-8	*Nephrops* in Division IVb (Firth of Forth, FU8)	Y	UWTV
WGNSSK	nep-9	*Nephrops* in Division IVa (Moray Firth, FU9)	Y	UWTV
WGNSSK	nep-10	*Nephrops* in Division IVa (Noup, FU 10)	Y	Trends
WGNSSK	nep-32	*Nephrops* in Division IVa (Norwegian Deeps, FU 32)	Y	Trends
WGNSSK	nep-33	*Nephrops* in Division IVb (Off Horn Reef, FU 33)	Y	Trends
WGNSSK	nep-iiia	*Nephrops* in Division IIIa (Skagerak Kattegat, FU 3,4)	Y	Trends
WGNSSK	ple-kask	Plaice in Division IIIa (Skagerrak - Kattegat) [4]	Y	SURBA/ trends
WGNSSK	san-nsea	Sandeel in Subarea IV excluding the Shetland area	Y	S-XSA
WGNSSK	san-shet	Sandeel in Division IVa North of 59° N and West of 0 ° E – (Shetland area)	N	Catch only
WGNSSK	san-kask	Sandeel in Division IIIa (Skagerrak – Kattegatt	N	Catch only
WGNSSK	whg-kask	Whiting in Division IIIa (Skagerrak - Kattegat)	N	Catch only

1. Assessment to be ran Yes or No. no generally means there is only catch data available.

2. UWTV: Underwater TV survey results, see annexes for these stocks.

3. Norway Pout in Subarea IV and Division IIIa: In May, the in-year assessment for this stock is done, indicating the catch options for the rest of 2010.

4. Plaice in Division IIIa (Skagerrak - Kattegat) - ple-kask: In 2009, an exploratory assessment was run (and described in a stock annex). Since there was no change in the perception of the stock, no new advice was given. New advice will only be given for 2011 due to unresolved key issues. The WG will likely rerun the exploratory assessment and work further on improving this. If time allows, the RG is welcome to comment on the explorations and propose different options.

***Note: Stocks in bold were not reviewed because assessments were not available (SPR-KASK, SPR-NSEA, SAN-SHET, SAN-KASK, WHT-KASK), the stock is awaiting a benchmark in September (SAN-NSEA), or see bullet 4 (PLE-KASK).**

Stock: Her-3a22 (HAWG Section3: Herring in Division IIIa and Subdivisions 22-24)

1) **Assessment type:** Update assessment with one additional year of catch and survey data
2) **Assessment**: Analytical
3) **Forecast**: Presented (short term), long-term forecasts were not provided.
4) **Assessment model**: ICA – tuning by 1 commercial (total summed over all areas and fleets) + 3 surveys (2 acoustic and 1 larval).
5) **Consistency:** Update of 2008 benchmark assessment (previous year assessment considered reliable and consistent).
6) **Stock status**: F(0.5)>F_{msy}(0.25), no other reference points available, suggest SSB breakpoint=110,000t (lowest observed stock size). Current SSB at lowest level seen in time-series and high risk of continued recruitment failure.
7) **Man. Plan**: Suggest a severe reduction in F. Using F_{msy} framework where SSB below breakpoint gives F_{msy}-slope=0.167 resulting in an increase in SSB to 111,200t. Any F's significantly higher (including F_{msy}) lead to a continued SSB<SSB breakpoint and continued risk of recruitment failure.

General comments

The assessment result section was well done and very concise. The results were clearly presented and a thorough job was done of presenting the model diagnostics and explaining possible reasons for observed residual patterns.

The short term projection section was similarly well done. Due to the complications of assigning catch between areas and the numerous catch options this section could easily become unwieldy and unclear, but an excellent job of summarizing and explaining key points was done.

Map describing key banks and area names/numbers would be useful.

Technical comments

It would be of benefit to reviewers if more detailed information (in the annex or the assessment document itself) was provided on

- Otolith micro-structure techniques for splitting catch between WBSS and NSAS in division IIIa
- Acoustic survey procedures and techniques for estimating biomass and numbers at age

Conclusions

Overall the assessment appears very well done. Conclusions regarding stock status are accurate.

Questions that could use clarification:

- Is herring bycatch in sprat fishery kept or discarded? If kept then assumption of zero discards seems accurate given the fleet dynamics described.

- Is there a particular reason for the acoustic surveys not taking place during spring spawning times? It would seem that surveying the population during spawning and on spawning grounds would reduce the uncertainty associated with herring from other stock units being accidentally included in the survey.
- What is the constant M=0.2 for age-2+ ringers based on? If it is based on oldest ages seen or similar calculations, then only changing M of younger fish to account for MSVPA calculations might be inappropriate. It is likely that increasing M at younger ages would require decreasing M at older ages in order to maintain the same maximum age seen. Otherwise, M for all ages should be estimated from the MSVPA. Also, it would be worthwhile to investigate changes in M as increases might be a cause for the recent decline in stock productivity (especially if younger ages are undergoing stronger predation and not reaching maturity).

Comments/Suggestions:

- Commercial sampling seems appropriate as does the method of assigning catch and weight at age where no sampling is available. Some sectors provide no information on landings and some fleets (i.e. Norway Skaggerak) have no sampling.
- Assuming constant maturity can highly influence SSB estimates and it is inappropriate especially due to the observed yearly variations. Continued work to update maturity ogives should be a priority.
- Using a start date of 1991 for the model seems appropriate due to changes in fishing patterns and lack of reliable data for splitting NSAS and WBSS catch. However, by not using historical data the model cannot provide estimates of historical recruitment and SSB levels, which would be helpful to compare with current levels and inform decisions regarding overall stock health.
- The issue of insufficient sampling of catches in IVaE for splitting catch between NSAS and WBSS is extremely disturbing. Efforts should be made so that this is a priority in the future.
- Due to the extreme differences in the way that the fleets exploit the resource (i.e. directed vs. bycatch fisheries) it seems inadvisable to use a single selectivity pattern for all fleets. It might be of interest to investigate using a more flexible model that allows for multiple fleets with differing selectivity patterns.
- It appears that the fishery has been undergoing growth overfishing for much of the time-series, which could be another explanation for the low stock production. It appears that in the last year 50% of the catch has been age-2 or younger, while over the years of highest recruitment these ages have made up almost 75% of the catch in number (i.e. ~1996-2003; Figure 3.6.1.1). In addition, even though the age-2 and younger fish made up ~75% of the catch in numbers, they only accounted for ~less than 50% of the catch in weight indicating the more yield could be harvested from fewer older fish (Figure 3.6.1.2)

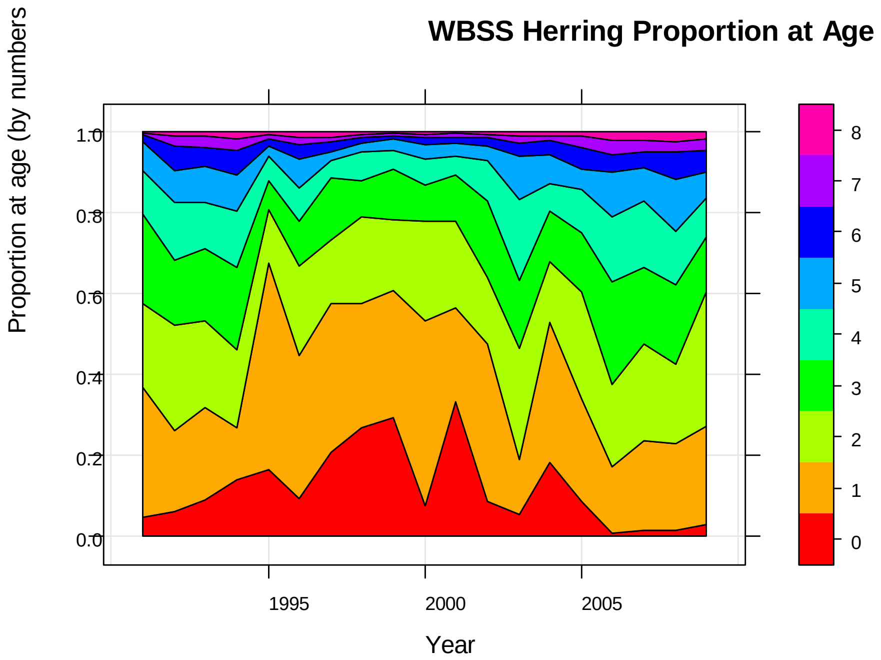

Figure 3.6.1.1 Western Baltic Spring Spawning Herring. Proportion (by numbers) of a given age (in winter rings) in the catch.

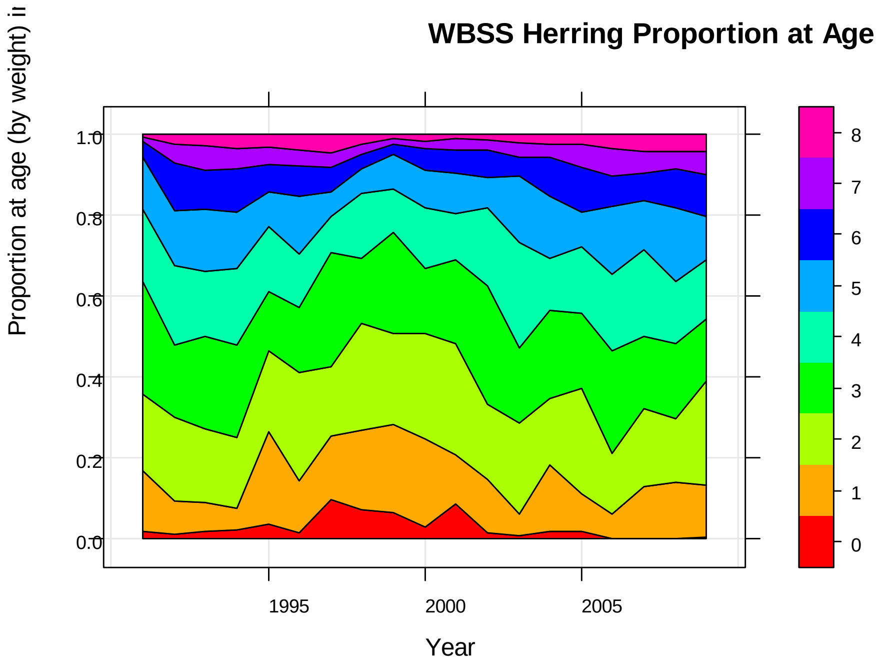

Figure 3.6.1.2 Western Baltic Spring Spawning Herring. Proportion (by weight) of a given age (in winter rings) in the catch.

Since only 20% of age-2 fish are mature this means that even when large recruitment events occur in the fishery they are unable to survive to maturation because of such high fishing pressure. Trends in SSB and recruitment appear to support this hypothesis. High recruitment events from 1996 to 2000 are also associated with some of the highest catch percentages associated with age-2 and younger fish. Only slight increases occur in subsequent years in SSB, while a series of such high recruitment events would be expected to produce large increase in SSB for a number of years following these events. After a short peak, SSB quickly declines and recruitment has been mostly decreasing since 2000 (Figure 3.6.4.2).

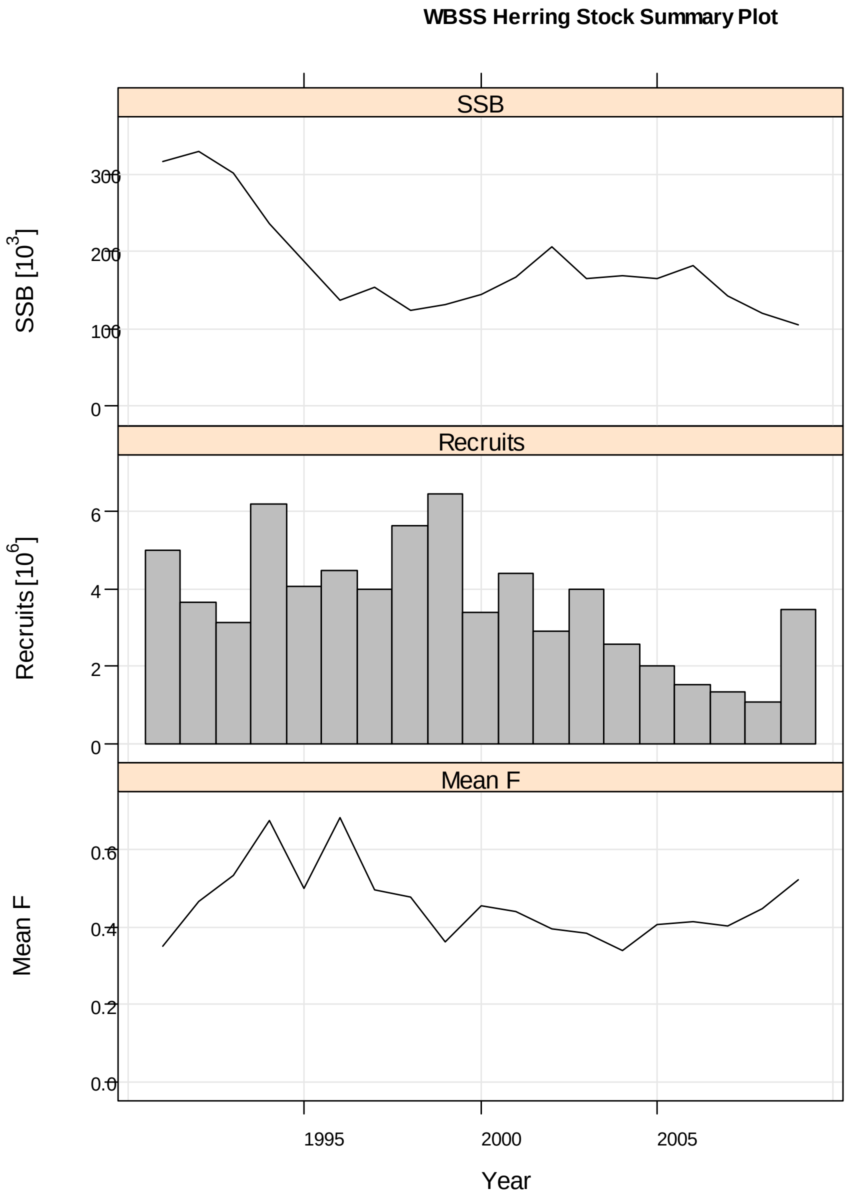

Figure 3.6.4.2 Western Baltic Spring Spawning Herring. Stock summary plot. Top panel: Spawning stock biomass. Second panel: Recruitment (at age 0-wr) as a function of time. Bottom panel:: Mean annual fishing mortality on ages 3-6 ringers as a function of time.

It is suggested that F should be decreased on all ages, but investigations on ways to decrease fishing mortality on the youngest ages should be made a research priority. This will help avoid growth overfishing in the future so that strong recruitment events will lead to rebuilding of SSB and hopefully higher stock production.

- It appears that, as for most herring species, there exists complex population structure within the WBSS statistical areas. Evidence suggests that local spawning areas, especially in many of the fjords, create discrete spawning populations. In addition, recent molecular genetics studies indicate multiple sub-populations within the WBSS management units. In the future, it might be appropriate to investigate the use of a stock synthesis type model, which allows for discrete growth patterns for individual sub-populations and allows for mixing between sub-populations. Also, a full meta-population model might be appropriate to account for different recruitment functions by sub-population, while allowing for mixing during various life stages. In order to pursue either model type it is probable that more information would need to be gathered on migration patterns and fine-scale population structure. The possibility of meta-population structure is important here because it has been shown that as individual sub-populations are fished out the stability and persistence of the overall meta-population is decreased. It is possible that such a situation is currently occurring in the area and could be another possible explanation for decreases in stock productivity.

Stock: Her-47d3 (HAWG Section 2: Herring in Subarea IV Division IIIa and VIId (North Sea))

1) **Assessment Type**: Updated
2) **Assessment**: Analytical
3) **Forecast**:
    - A short term (3-year) forecast was completed assuming the recruitment is constant and in a low level since 2002. The projection result indicates that the SSB will increase above B_{pa} in 2011 and above $B_{trigger}$ in 2012, as long as the management plan is adhered to.
    - The method used for predictions in 2010 is slightly different from the method in 2009. The difference in catch, recruitment has led to a significant increase in SSB.
    - Neither the medium term projection, nor the long term projection was done, but the medium term projections can be made as needed.
4) **Assessment method**: An integrated catch analysis (FLICA) was used and calibrated with catch, recruitment, the MLAI, MIK (IBTS age 0), bottom trawl survey (IBTS ages 1-5) and acoustic survey.
5) **Consistency**:
    - The current assessment method (FLICA) was the same as the previous assessment.
    - The benchmark stock assessment took place in 2006. Some 2010 data have been updated (e.g. IBTS survey); while the other input data are still in 2009.
    - The current fishery status of the North Sea herring is consistent to what the fishery status was in 2009.
    - There are some differences between the 2010 stock assessment results and the 2009 stock assessment results, e.g. mean fishing mortality (age 2 - age 6) is lower the biomass is higher and the maturation rate is higher.
    - In the Stock Annex 3, 6 years catch data are supposed to be used in the objective function; while only 5 years catch data were described in the stock assessment report. (The stock assessment report didn't indicate why one year catch data were eliminated. In addition, the subscription in the objective function in the Stock Annex 3 should also be updated).
    - Retrospective analysis has been done for the selectivity pattern, spawning stock biomass, recruits, mean fishing mortality (age 2 - age 6) and year class cohorts. Generally, these parameters are consistent over the last 10 years. (Page 58 the last fourth line: "An eight year analytic retrospective shows the current consistency of the assessment", should it be a 10-year analytical retrospective analysis?)

6) **Stock Status**:

   - SSB(1.29 million tonnes)< B_{pa}(1.3 million tons), SSB ~ B_{lim} (800,000 tons). $B_{trigger}$ = 1.5 million tonnes. The fishery is classified as being at the risk of having reduced reproductive capacity and is being harvested sustainably. The stock assessment report didn't provide any basis for biomass-based biological reference points.
   - F_{pa} is equal to F_{MSY} (F_{target}). There is no F_{lim}. The current $F_{2\text{-}6}$(0.11) is less than F_{target} (0.25). And there is 15% constraint in TAC. The fishing mortality-based biological reference point is based on an investigation of risk to falling below B_{lim}, F_{MSY} and consideration of fishery.

7) **Management Plan**: The EU-Norway management plan stipulates overall fishing mortalities for juveniles and adults. The total TAC limit for 2010 is 177, 877 t. The by-catch ceiling was also set for fleet B.

General Comments:

- Ecosystem considerations were slightly discussed in the stock assessment report and Stock Annex 3. But the information is too general to help advice and few references were cited.
- It is good to have the age-varying natural mortality. And it would be better to have a time-varying natural mortality.
- It might be a better idea to isolate the Downs herring as a separate stock in the stock assessment when the data are ready.

Technical Comments:

- Some discard data has been listed in tables, but not consistently available for whole time series. Some discard data may be underestimated, e.g. year 2009. It is also unclear if the discard data was applied in the model, and how it was applied in the stock assessment model. (The discard is in biomass unit and the input catch is in number.)
- The misreported and unallocated catches are another source of uncertainty. The negative values are very confusing, especially for some values < 100%, e.g. -185% in Table 2.2.5.
- The RSS of surveys, especially the acoustic survey take a large portion in the total RSS. It is better to standardize the survey before the RSS calculation.
- Table 2.2.1-Table 2.2.4: should the sum of the bottom 4 tables equals to the upper table?
- Figure 2.1.1: It would be better to have subregions indicated in the map.
- Table 2.2.1 and Table 2.2.2: wrong order.
- Figure 2.2.1 bottom figure: legend missing and no text related to this figure.
- Figure 2.3.1.2- Figure 2.3.1.3, Figure 2.3.2.1-Figure 2.3.2.4, although indicated in the note, scales are needed.
- Table 2.3.3.1: missing.
- Figure not in order, e.g. Figure 2.6.3.1 comes in section 2.5.2.

- Figure 2.6.1.18: didn't explain in the text.
- The order of figures should correspond to the description in text, e.g. 2.6.1.24 – Figure 2.6.1.31.
- When describing the "figures" in tables, please use "values".
- Page 47 the last third line: "were" should be "where".

Conclusion:

- The RG agrees with the WG that FLICA assessment is an acceptable update for the North Sea herring assessment.
- The SSB has been maintained close to B_{pa} and is expected to be above B_{pa} after 2011. The fishing mortality has been controlled the level lower than F_{pa}. The precautionary approach seems appropriate in managing the North Sea herring stock.
- For migration stock, such like the North Sea herring, it is better to set separate TACs and assess stock separately for each subregion.

Annex 13 Technical Minutes from RGCS

Review of ICES **Herring Assessment Working Group [HAWG] Report 2010** 15 - 23 March 2010

Reviewers:	Mike Armstrong (chair), Marie Storr-Paulsen, Jens Floeter, Yvonne Walther
Chair:	WG: Tomas Gröhsler, Germany and Maurice Clarke, Ireland
Secretariat:	Barbara Schoute, Diane Lindemann

Review process

The Review Group considered the following stocks:

- her-iris
- her-VIaN
- her-irlw
- her-nirs

These were reviewed along with all the ICES WGCSE stocks and two stocks from WGHMM. The Review Group conducted its work by correspondence and through Webex conference facilities organised by ICES. The reviews have been carried out according the Guidelines provided by ICES, particularly focusing on the need to Quality Assure the assessment results supporting the provision of fishery management advice by ICES in the annual ACOM advice sheets. All stocks were reviewed by at least two reviewers. This involved:

- Checking that update assessments have been correctly implemented using the methods described in the Stock Annexes;
- Checking that the assessments have been implemented correctly, which could involve re-running the assessments to ensure the results in the WG report can be replicated exactly;
- Ensuring the assessment results and forecast results are carried over correctly to the advice sheets and advising ICES of any errors detected;
- Evaluating the ability of the stock assessments for providing credible management advice, and suggesting alternative advice where assessments do not appear appropriate;
- Providing recommendations to the Working Group to help with future development of the assessments through benchmarking.

General comments

The WG report is very well organized and readable. The sharepoint site is well updated and structured.

The WG should ensure a consistent approach to stock names in the WG report, stock annex and sharepoint site to avoid confusion in matching up files. For example, the following names have been used for the same stock: *Herring in Celtic Sea and VIIj;*

Herring in Division VIIa South of 52° 30′ N and VIIg,h,j,k (Celtic Sea and South of Ireland). The WG should also try and ensure a consistent approach to formatting data in tables, for example numbers of trailing zeroes in F estimates. Some tables could be better presented as figures – e.g. length frequencies.

Stock: Herring in the Celtic Sea (Division VIIa South of 52° 30' N and VIIg,h,j,)

(report section 4)

- **Assessment type:** Update (benchmark in 2007)
- **Assessment**: Analytical
- **Forecast**: Presented
- **Assessment model**: FLICA
- **Consistency** The assessment is consistent with last year's results in showing a sharp decline in F since 2004 and an increase in SSB, although the estimates of SSB have been adjusted upwards and the F estimates downwards.
- **Stock status:** Recent SSB estimates have poor precision but have been above Bpa of 44,000t since 2006.
- **Man. Plan.**: No, although a rebuilding plan based on $F_{0.1}$ TACs is implemented by the Irish fishing industry and considered precautionary by ICES.

General comments

The report is generally well structured and easy to follow. The WG addressed the TORs relevant to providing advice and the assessment was carried out according to the stock annex description.

The RG found no errors in the implementation of the assessment and forecast, and the results were carried over correctly to the advice sheets apart from one error (the 2009 F was given instead of the 3-year-mean in the Advice sheet – this error was transmitted to the HAWG chair.)

The WG report includes ecosystem information, mainly in relation to the potential risks of gravel extraction on spawning beds and recent increases in sea temperature and salinity. However the WG states there is no evidence for environmental impacts on stock productivity.

There is no EU management plan, but a rebuilding plan introduced by Ireland has been evaluated by ICES and found to be precautionary provided there is not a run of poor recruitment.

Mixed fishery does not seem to be an issue. Area misreporting and discards/slippage has been recorded historically but the information is currently unavailable.

A benchmark assessment was performed in 2007, and the current assessment procedure was introduced in 2009.

Technical comments

1. The issue of discards is not clear. In section 4.1.3 it states that fishermen suggest that discarding is not a feature in the fishery at present. In section 4.2.2 it is stated that no information is available from this fishery. The WG should present any data on slippage or discarding when available.
2. The WG should highlight any inconsistencies between tables. Tables 4.6.1.12 (summary) and 4.6.1.14 (population numbers) are inconsistent – the population numbers show the 2009 1-ring estimate over-written by GM whilst the large total biomass in the summary table in 2009 (360012 t) includes the orig-

inal ICA estimate for 1-ringers. This is likely to be a general issue for all the ICA outputs.

3. The population numbers in the 6+ group are building up and becoming a large fraction of the catch, and this is likely to increase at the low F currently estimated along with the strong year classes entering the plus group. The WG should consider the implications of this for continuation of the update assessment approach and consider options for expanding the true age range although there are clear limitations with the acoustic survey estimates at age 6 and above (Table 4.3.1.1).
4. The WG should update the stock annex with the method adopted for determining the interim year catch (remaining Irish quota for the WG year plus a multiplier on the Q1 quota for the next year), if this is standard practice.
5. The WG should review the appropriateness of a 50% maturity assumption at age 1, given the likelihood that a large proportion of the immature component of the stock is not represented in the Celtic Sea samples at spawning time.
6. The WG should update the basic data explorations in the Stock Annex, some of which are several years out of date.

Conclusions

The RG considers the assessment is acceptable for providing advice in support of fishery management. The assessment is well performed with the available data.

The perception of rapidly reducing F and increasing SSB is a result of declining landings and recent large acoustic estimates, particularly for two recent strong year classes. The age compositions in 2009 remained truncated above age 5. Further years of data will be needed to confirm a low F shown by progressive expansion of the age composition. However the RG agrees that there is evidence that F is currently low and the SSB is well above Bpa, and that the rebuilding plan will be replaced by a long term management plan next year.

The main assessment quality issue is the dependence on a single survey series of short duration, which although revised to ensure consistency, shows year effects in the first part of the series and is not able to provide usable indices of 1-ringers. The WG has reviewed other available survey data and not found anything suitable for providing robust indices for young herring, which occur in both the Celtic Sea and Irish Sea.

Any future benchmark assessments for this stock should consider the impact of spatial segregation of components of the stock between the Celtic and Irish Sea on weights and maturity at age.

Stock: Herring in Divison VIa (North)

(report section 5)

- **Assessment type:** Update, SALY
- **Assessment**: Analytical
- **Forecast**: Short and Medium term
- **Assessment model**: FLICA
- **Consistency** The assessment is consistent with last year's results although large adjustments to SSB, F and recruitment are apparent in some previous years reflecting the noisy survey indices. Survey data have been revised, but the impact on the assessment is relatively small.
- **Stock status**: SSB is estimated to 87,000 t in 2010 which is above Blim (50,000t). F in 2009 is estimated to be below Fmsy of 0.25, and has been below Fmsy for 8 of the last 10 years. A value for $B_{trigger}$ is under development. There are no Fpa or Bpa reference points.
- **Man. Plan**.: A Management Plan has been implemented since 2008.Ftarget=0.25 according to management plan corresponds to TAC in 2011 of 22,300 t corresponding to a 9% decrease of F.

General comments

Both the stock annex and WG report was very well outlined and easy to read. Especially the table "Input data and types and characteristics" in the Stock annex was very helpful. The WG view of the management plan is clear and well explained.

The WG addressed the TORs relevant to providing advice. The assessment was carried out according to the stock annex description, and the RG found no errors in the implementation of the assessment and forecast. The results were carried over correctly to the advice sheets.

The WG report includes ecosystem information, mainly in relation to lack of bycatch and discarding in the fishery, predation by seals, and recent increases in sea temperature. The WG states that temperature changes may be associated with changes in stock productivity as recorded for the neighbouring North Sea stock.

The EU management plan (Council Regulation (EC) 1300/2008) is in operation. The WG has not evaluated the plan in relation to VIaN herring, but the advice sheets note that "a similar proposed management plan was evaluated by ICES in 2005 and found to be consistent with the precautionary approach. In 2008 ICES checked that the recent changes in stock dynamics and the changes to the plan had not significantly increased the risks. ICES gives advice based on the management plan."

There do not appear to be any mixed fishery issues.

The main general issue with this assessment is the inaccurate survey indices which are highly variable. In 2010 a revised survey series has been used due to discrepancies between original survey reports and data used in the PGHERS and HAWG. Although, (in principle) an updated time series should not be introduced at an update assessment the RG considered the new time series as an improvement, and the practical influence on the assessment has not been major (downscaled the SSB by 6% and upscaled the F by 6%).

A further important problem common to an extent with all the HAWG stocks, is the early date of the meeting resulting in the WG using preliminary catch estimates that may turn out to be inaccurate. In the case of VIaN herring the 2009 landings figures appeared underestimate by around 30%. See Technical comment 2 below.

There are some editorial issues with the WG report (e.g. incorrect table references) and Stock Annex. Also Section H.1 of the annex on biology of the species contains information that should be moved to the sections stock definition, ecosystem aspects and fishery.

Technical comments

1. The WG should describe where information on misreporting is derived from (very precise numbers are used). Is it from VMS?
2. The WG states that according to ICES FISHSTAT that landings in 2009 could have been 6400 t. This represents a possible 30% underestimate of landings in 2009 in the assessment. The WG was asked to re-run the assessment and forecast using the 2009 landings at age increased appropriately to explore the sensitivity of the assessment and forecast to this magnitude of underestimate of landings. The RG was shown the forecast table on the day the RG report was due to be submitted, but this had not yet been reviewed by other WG members. The results will be made available to the Advice Drafting Group and incorporated in the final HAWG report.
3. The WG should clarify if the total stock biomass estimate for 2009 in the summary table includes the ICA estimate for 1-ringers in 2009, which is replaced by a GM in the stock numbers table (see comments for Celtic Sea herring).
4. The survey design should be investigated in view of the poor internal consistency between many of the age classes and the tendency towards year effects in residuals.

Conclusion

The RG considers that the updated assessment is suitable for providing management advice, but notes the problem with the 2009 landings that was subsequently addressed by the WG.

The 2009 Review Group commented on the accuracy of the management plan. This year's HAWG considers the plan to be consistent with the ICES MSY approach. However the RG notes that F has been below the suggested FMSY for the major part of the last decade, even so the SSB has varied around a relatively low level (compared to 1960s-1970s) and since the late 1990s the stock has experienced some of its weakest year classes. The stock-recruit plot in the advice sheet would suggest a tendency for poor year classes at low SSB (though this is likely to be confounded by climate-related changes in productivity), and also suggests an inappropriately low Blim value (around the lowest in the series.

The SSB of the stock shows, as many other pelagics in this area, a strong decline in the late 70s. The background to this shift should be evaluated in relation to the choice of an appropriate $B_{trigger}$.

Stock: Herring in Division VIa South and VIIbc

o (report section 6)

- **Assessment type:** SALY
- **Assessment**: no assessment has been accepted in recent years
- **Forecast**: None
- **Assessment model**: Separable VPA
- **Consistency** The assessment is not accepted but the advice for the stock is the same as last year.
- **Stock status**: uncertain but a range of separable VPA scenarios indicate that SSB is below Blim
- **Man. Plan.:** None accepted at present time. The WG proposes that a rebuilding plan is urgently required.

General comments

The WG addressed the TORs relevant to providing advice. The exploratory assessment was carried out according to the stock annex description, and the RG found no errors in the implementation of the assessment. There is no forecast possible.

No new information other than in the Stock Annex is provided on ecosystem and climate aspects.

There is no management plan, However the Irish fishing industry and pelagic RAC have proposed a rebuilding plan based on $F_{0.1}$ TAC, which has not been adopted. With no short term forecast, it would not be possible to set such a TAC.

There do not appear to be mixed fishery issues with this stock.

The spawning stock appears to have declined continuously since the late 1980s as the strong recruitment of 1-ringers in 1997 became fished out, and fishing mortality appeared to increase rapidly in the 1990s, as shown by the age profile in the catches. Recent recruitment appears low. Although the acoustic survey indicates a larger abundance of 0-ringers in 2009 than in 2008, the survey has only been conducted in summer for the last two years so the reliability of the estimates for young herring is not known yet.

The results of the retrospective analysis suggest that using a terminal F of 0.5 produces more stable estimates of SSB and F than smaller or larger values. This suggests that recent F has been in the range of 0.5, which is above $F_{0.1}$

Input data were not available on the sharepoint or at the google site provided to the RG and could therefore not be checked against tables in the report.

Technical comments

1) The WG should consider in more detail the accuracy of the fishery data. The assessment is based solely on fishery catch at age, with no survey tuning. The historical accuracy of the fishery data appear questionable – the WG comments that the “management of the Irish fishery in recent years has tightened considerably and the accuracy of reported catches is believed to have improved”. Does this mean that historical reported catches could be substantial under-estimates? Also, the Stock Annex highlights issues

with the re-allocation of catches between VIaN and VIaS. Finally, it is noted that discarding/slipping is taking place, although not quantified.

2) The WG should have given the residual sums of squares of the separable VPA for each terminal F explored, as a diagnostic.

3) The Advice sheet notes that the industry is concerned that, "due to the change in fishing pattern because of restrictive quota, an incomplete account is being taken of the age structure and some "missing fish" have prevented an accurate stock assessment being conducted". It is difficult to see any evidence for this in the separable VPA residuals (Fig. 6.6.2.2). However a more detailed evaluation would have been useful to address industry concerns.

4) The WG should update the basic data explorations in the Stock Annex, some of which are several years out of date. Some of the reviewers found the section in the stock annex on surveys not very easy to read.

Conclusions

The RG agrees with the WG in not accepting the assessment as a basis for providing quantitative management advice. It appears suitable only for exploring longer-term trends (conditional on assumptions regarding accuracy of the historical fishery data). In the absence of no new information altering perception of the state of the stock, the advice should remain the same as last year.

The future of this assessment will depend on the outcomes of SGHERWAY, particularly following the change in acoustic survey design to a summer survey potentially covering several mixing populations from the Malin Shelf complex.

The WG recommends a rebuilding plan be put in place that will reduce the high F values. As the acoustic survey will require several more years to prove its use for tracking population abundance of Malin Shelf herring populations, the options for harvest control rules within a rebuilding plan for the VIaS component appear limited. It will be important to maintain stability in the survey design, given the many changes in survey design that have been apparent in the past.

Stock: Herring in Division VIIa North (Irish Sea)

1.1 (report section 7)

1) **Assessment type:** SALY
2) **Assessment**: Experimental
3) **Forecast**: None
4) **Assessment model**: FLICA
5) **Consistency** The assessment approach adopted in 2010 is not consistent with the 2009 assessment and stock annex, and has been adapted to account for lack of fishery sampling data in 2009.
6) **Stock status**: The assessment is suitable for evaluating trends only, although the general level of F estimates is informative. Acoustic surveys at spawning time indicate a growth in the spawning stock biomass in 2008 and 2009 although this is not reflected in the larval production index.
7) **Man. Plan.**: None

General comments

The WG addressed the TORs relevant to providing advice (SALY).

This was an exploratory assessment using the ICA method described in the Stock Annex but using various model settings and input data to try and overcome deficiencies in the data, primarily the absence of fishery sampling data for 2009. The WG resorted to including a short-term forecast of landings at age in 2009 in the ICA assessment and down-weighting all the catch at age data.

Given the number of exploratory runs the RG was not able to check the accuracy of each option explored. There is no forecast possible.

No new information other than in the Stock Annex is provided on ecosystem and climate aspects.

The WG made a good work on illustrating the surveys available. This is the main information available for evaluating trends in the last few years since there was no biological sampling in 2009. The information on within-season trends in biomass from the enhanced acoustic survey is extremely useful in highlighting the potential sensitivity of the acoustic estimates to survey timing. The enhanced survey programme provides consistent data on interannual variations in biomass, and gives confidence in the standard research acoustic survey.

In the three last years Ireland has not landed any catches presumably due to quota swaps with UK as in 2009 but this is not clearly outlined.

Technical comments

1. The WG noted divergent SSB signals given by the acoustic and larva surveys, and removed the larva index on the basis of a possible shift (delay) in spawning timing shown by reduced number of large larvae in recent years. This could also impact the acoustic survey used in the assessment, as the enhanced acoustic survey programme in 2007 – 2009 shows a sharp dip in biomass immediately after the typical period of the acoustic survey. The WG interpretation of the larva survey implies that this dip could have been earlier

in the previous years if peak spawning was earlier, and could therefore have interacted with the timing of the acoustic survey as well, which has historically shown year-effects. The WG has previously noted trends in the proportion of the herring biomass estimate on the west coast of the Isle of Man and on the spawning grounds off the east coast at the time of the survey.

2. The WG should plot the basic survey data series (acoustic SSB index and larval index) with the approximate confidence intervals so that the significance of any divergence can be better visualized. Given two noisy surveys prone to year effects, the poor internal consistency of the acoustic survey, and the down-weighting of the entire catch at age series, it is inevitable that removal of the larval index would cause the ICA model to follow the acoustic survey more closely. This does not necessarily mean that the result is a more accurate representation of the truth.

3. The Stock Annex describes the development of a 2-stage biomass dynamics model. The WG should explain why this has not been considered further.

Conclusions

The RG agrees with the WG that the exploratory assessments are suitable only for analysis of trends (conditional on assumptions regarding accuracy of the historical fishery data). There are strong indications of increasing biomass in recent years due to improved recruitment, but the extent of the recent downward trend in F over the same period will be highly uncertain.

A long-term increase in recruitment is evident from groundfish surveys, and will include Celtic Sea and Irish Sea juveniles. The work on disaggregating samples by stock using otolith analysis should be continued, as this could potentially improve the internal consistency of the survey series at the younger ages.

The RG notes that this stock is comparatively data-rich but continues to have problems in evaluating stock status due to consistency problems within and between series. Useful work is being conducted on disaggregating data by stock and investigating stock dynamics within the spawning season when the surveys take place. If the internal consistency and year-effect problems in the surveys can be resolved, the WG proposal to develop a management plan based on survey data could be appropriate and should be explored. However, the fishery catches are normally well sampled, the fishery is well defined, and catch reporting accuracy may no longer be an issue. Options for integrated assessment using fishery and survey data should not be discounted for future benchmarking unless there are stock mixing issues with fishery catches that cannot be adequately resolved.

Considering the concentration of the main catch component to a few UK trawlers, an onboard sampling scheme should be considered giving the needed biological samples and overviewing the discard/slippage patterns. There are currently no estimates of discarding/slippage, and the WG states that it is "not thought to be a feature of this fishery".

Annex 14 Erratum to Section-05 West of Scotland Herring.

After the working group revisions to theVIaN landings data were made. These changes required that the assessment and forecast were revised. The following section shows the changes that were made to Section 5.

TEXT changes

5.1.2. Changes in the VIa (North) Fishery.

Paragraph 2. "This trend has continued in 2009, with 84% of the quarter 3 catches taken north of the Hebrides and to the north of Scotland"

Replaced with "This trend has continued in 2009, with 82% of the quarter 3 catches taken north of the Hebrides and to the north of Scotland".

5.1.4. Catches in 2009 and Allocation of Catches to Area for VIa (N)

Paragraph 1. Official catch changed from 16 977 t to 21 036 t.

Paragraph 2. Working group catch changed from 14 179 t to 18 058 t.

Text on FishStat landings removed and replaced with "These are revised catch figures from those available to the HAWG, with an increase of 3 879 t. The revisons are all within the UK catch data".

5.2. Biological composition of the catch

Paragraph 1. Sentence "The Dutch and Scottish fleets each took a similar magnitude of catches in the area; the English fleet catch was 4% of the UK catch"

Replaced with "The Dutch and Scottish fleets each took a similar magnitude of catches in the area; the English fleet catch was slightly lower, at 26% of the UK catch"

5.6.2. Stock Assessment

Paragraph 1. Sentence "This is an update assessment using FLICA (Kell 2007, Patterson 1998a) with the same settings as in 2009, with the 8 year separable period moved forward one year to 2002 – 2009"

Replaced with "This is an update assessment using FLICA (Kell 2007, Patterson 1998a) with the same settings as in 2009, using the revised catch data, post HAWG 2010, with the 8 year separable period moved forward one year to 2002 – 2009".

5.6.2.1. State of the stock

Paragraph 1. "The assessment gives an SSB for 2009 of 83 140 t and a mean fishing mortality (3 to 6-ringers) of 0.17. The outcome of the assessment this year suggests that the SSB is relatively stable at around 20% below the average of the last 20 years, a slightly lower but similar position to last year's assessment and a change from the perception in 2007 that the stock was declining rapidly. Catch in 2009 is almost half the 2007 level and with the small decrease in SSB, F has increased to F=0.17. "**The as-**

sessment gives an SSB for 2009 of 79 755 t and a mean fishing mortality (3 to 6-ringers) of 0.22. SSB has been stable in recent years. However, the outcome of the assessment this year suggests a slightly lower position to last year's assessment with SSB around 20% below the average of the last 20 years. F has increased to F=0.22 from last year (F=0.16). Catch in 2009 increased by 15% compared to 2008".

5.7.1. Deterministic short-term projections

Paragraph 2. "Short-term projections were carried out using MFDP (Smith 2000), both with the same settings as last year (TAC constraint) and a second option based on the average catch uptake in 2008 and 2009 (catch constraint), as the uptake has been around two-thirds of the TAC in both years"

Replaced with "Short-term projections were carried out using MFDP (Smith 2000), with the same settings as last year (TAC constraint)".

Paragraph 3. "The results of the short-term projection using the TAC constraint are given in Tables 5.7.1.2 – 5.7.1.3. The results using the catch constraint are given in Tables 5.7.1.4 – 5.7.1.5"

Replaced with "The results of the short-term projection using the TAC constraint are given in Tables 5.7.1.2 – 5.7.1.3".

Paragraph 4. "For F in accordance with the management plan using the TAC constraint (SSB2011 < 94 000 t, F =0.25 in 2011, TAC decrease of 9%) catches are projected to be 22 300 t, and SSB rises to approximately 94 000 t in 2012"

Replaced with "For F in accordance with the management plan using the TAC constraint (SSB2011 < 88 000 t, F =0.25 in 2011, TAC decrease of 13%) catches are projected to be 21 200 t, and SSB rises to approximately 93 000 t in 2012".

Paragraph 5. "For F in accordance with the management plan but using the catch constraint (SSB2011 < 96 000 t, F =0.25 in 2011, TAC decrease of 2%) catches are projected to be 24 000 t, and SSB rises to approximately 98 000 t in 2012"

Deleted.

5.9. Quality of the Assessment

Paragraph 1. "This year's estimate of SSB for 2008 is around 96 000 t, compared with 92 000 t in last year's final assessment run, an increase of 4%"

Replaced with "This year's estimate of SSB for 2008 is around 99 000 t, compared with 92 000 t in last year's final assessment run, an increase of 4%"..

Text table of comparisons:

Category	Parameter	Assessment in 2009	Assessment in 2010	Diff 09-10 (+/-)%
ICA results	SSB 2007	91848	96696	5.28
	F(3-6) 2007	0.288	0.275	-4.51
	SSB 2008	91884	96019	4.50
	F(3-6) 2008	0.16	0.148	-7.50
	SSB 2009		83140	-13.36
	F(3-6) 2009		0.166	-33.60
Short-term forecast (2009)	Predicted SSB 2009	94252		
	Predicted F(3-6) 2009	0.25		

replaced with new text table below:

	2009 Assessment		**2010 Assessment**		**Percentage change in estimate 2009-2010**	
Year	**SSB**	F_{3-6}	**SSB**	F_{3-6}	**SSB**	F_{3-6}
2007	**91848**	**0.288**	**98903**	**0.267**	**7.68**	**-7.29**
2008	**91884**	**0.16**	**99141**	**0.143**	**7.90**	**-10.63**
2009*	**94252**	**0.25**	**79755**	**0.224**	**-15.38**	**-10.40**

5.10. Management Considerations

Sentence 1, paragraph 1. "An analytical assessment shows that SSB (in 2010) is approx. 1.7 times B_{lim}"

Replaced with "An analytical assessment shows that SSB (in 2010) is approx. 1.6 times B_{lim}".

Table changes

Table 5.1.1. Original catch data replaced with revised catch data as documented below:

	Original catch data	Revised catch data
Country	**2009**	**2009**
Faroes	1544	1544
France	1049	1049
Germany	27	27
Ireland	1935	1935
Netherlands	5675	5675
Norway		
UK	6747	11076
Unallocated		
Discards		
Total	16977	21306
Area-Misreported	-2798	-2798
WG Estimate	14179	18508
Source (WG)	2010	2010

Table 5.2.1.

Replaced with table giving revised catch and sampling effort by nations participating in the fishery in 2009.

Tables 5.6.2.1. to 5.6.2.21.

Replaced with new input and output tables from revised assessment.

Tables 5.7.1.1. to 5.7.1.3.

Replaced with revised short-term prediction tables.

Tables 5.7.1.4. and 5.7.1.5.

Deleted.

Figure changes

Figure 5.3.1.1.

Replaced with relevant revised assessment output figure.

Figures 5.6.2.1. to 5.6.2.13.

Replaced with relevant revised assessment output figures.

Figure 5.7.2.1.

Replaced with relevant revised assessment output figure.

Figure 5.9.1.

Replaced with relevant revised assessment output figure.