Advisory Committee on Fishery Management

ICES CM 1997/ASSESS:8

REPORT OF THE

HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62° N

ICES Headquarters
10-19 March 1997

Part 1 of 2

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

Section	Page

Section	Page

1 INTRODUCTION

1.1 Participants

Dalskov, J.	Denmark
Dickey-Collas M.	United Kingdom
Eltink, A.	Netherlands
Gröhsler, T.	Germany
Hammer, C.	Germany
Kirkegaard. E. (part time)	Denmark
Lassen, H.	Denmark
Modin, J.	Sweden
Molloy, J.	Ireland
Mosegaard, H.	Denmark
Munk, P.	Denmark
Nash, R.	United Kingdom
Nichols, J.	United Kingdom
Patterson, K.	United Kingdom
Pastoors, M.	Netherlands
Simmonds, J.	United Kingdom
Skagen, D.	Norway
Stevenson, D.	USA
Toresen, R. (Chairman)	Norway
Torstensen. E.	Norway
Vérin, Y.	France

1.2 Terms of Reference

The Working Group met at ICES Headquarters from 10-19 March 1997 with the following terms of reference (C.Res.1996/2:14:6):

a) assess the status of and provide catch options (fleet where possible) for 1997 and 1998 for the North Sea autumn-spawning herring stock in Division IIIa, Sub-area IV, and Division VIId (separately, if possible, for Divisions IVc and VIId), and for 1998 for the herring stocks in Division VIa and Sub-area VII, and the stock of spring-spawning herring in Division IIIa and Sub-divisions 22-24 (Western Baltic). In the case of North Sea autumn-spawning herring the forecasts should be provided by fleet for a range of fishing mortalities that have a high probability of rebuilding the stock to the MBAL level by spawning time in 1998;

b) for North Sea autumn-spawning herring provide medium-term forecasts of catch by fleet, and development of SSB, based on stochastic recruitment around a conventional stock-recruitment relationship for the stock; at levels of exploitation by fleets B,C,D, of: F=0; 0.1; 0.2; 0.3 while the levels of exploitation by fleet A are: F=0.2 and 0.3;

c) assess the status of and provide catch options for 1997 for the sprat stocks in Sub-area IV and Divisions IIIa and VIId,e;

d) provide the data required to carry out multispecies assessments (quarterly catches and mean weights at age in the catch and stock for 1996 by statistical rectangle of the North Sea for herring and sprat);

e) propose a definition of safe biological limits using target reference points based, where appropriate, on biomass, fishing mortality, maturity, growth, age structure, exploitation pattern, geographic distribution and other relevant parameters; based on the above parameters, propose limit reference points to be avoided with a high probability;

f) prepare medium-term forecasts of yield and SSB, taking into account uncertainties in data and assessments and assuming a stock-recruitment relationship, to indicate the probability of attaining target reference points and avoiding limit reference points;

g) provide information on quantities of discards by gear type and area for the stocks of fish and fisheries considered by this group [OSPAR 1997/5.3] and report to WGECO.

1.3 Request from EU and Norway

The Working Group received a request from the Chairman of ACFM to prepare information to respond to the following request from the European Commission and Norway:

ICES is requested to:

a) evaluate and advise on a fleet definition of the vessels catching herring in the North Sea (current fleets A and B) and Division IIIa (current fleets C-E) based on existing fisheries while regarding their fishing pattern, including the following fleets defined as:

   <u>North Sea</u>

Fleet A:	directed herring fisheries with purse seiners and trawlers using 32 mm
Fleet B:	all other vessels using mesh size 16 mm or less when trawling and where herring is taken as by-catch

   <u>Division IIIa</u>

Fleet C:	directed herring fisheries with purse seiners and trawlers using 32 mm
Fleet D:	vessels fishing for sprat with 16 mm trawls or purse seine
Fleet E:	all other vessels using mesh size 16 mm or less when trawling and where herring is taken as by-catch

   and if possible and required rebuild the data base corresponding to the new fleet definition retrospectively for the latest five years.

b) based on any new information about the abundance of herring and in the light of the possibly revised data base recalculate the predictions of catch by fleets A-E for 1997 and associated biomass.

c) calculate equilibrium spawning stock biomass and equilibrium yield for a full range of fishing mortality rates using a precautionary exploitation pattern. These equilibrium calculations should be based on a stochastic stock-recruitment relationship using the longest possible data set. In addition to showing the expected equilibrium values, these plots should show the 5, 10, 20, 30, 50, 80 and 90 percentiles for the distribution of SSB and yield. The calculation should include uncertainty in the estimates of as many parameters as possible.

d) do similar calculations for a range of exploitation patterns which consider relative changes in the magnitude of fishing by fleets B-E compared with fleet A. The range of exploitation by fleets B-E should be 0.75, 0.67, 0.5 and 0.25 relative to that for fleet A.

e) advise on appropriate reference points for fishing mortality and spawning stock biomass. In addition to nominal absolute values biomass reference points may also be based on a reference year in order to demonstrate problems of changes in scale.

f) advise on appropriate management regimes (i.e. "harvest control laws") including reference points at which immediate remedial action should be taken and appropriate time scale for actions, which might be used in future management of the stock and which takes into account sustainable exploitation rates and appropriate biomass thresholds.

g) evaluate the statistical reliability of the sampling data on which the operation of the current by-catch quotas depend.

h) estimate the ratio of admixture of North Sea herring and SW Baltic-Division IIIa spring spawning herring in Division IIIa and appropriate fishing mortality rates for the SW Baltic-Division IIIa spring spawning herring, to ensure that TACs for this fishery are set at a level that takes due account of the separate components in this fishery.

1.4 Report of the planning group for Herring Surveys in the North Sea

The Planning Group for Herring Surveys met in Lysekil in May 1996 and again in Aberdeen 24-28 February 1997, the first meeting was reported at the ICES Annual Science Conference, the results of the second meeting were presented in the Herring Assessment Working Group. The meeting was held to:

a) Coordinate the timing and area allocation of and methodologies for acoustic and larvae surveys for herring in the North Sea Divisions VIa and IIIa and the Western Baltic.
b) Combine the survey data to provide estimates of abundance for the populations within the area.
c) Evaluate the usefulness of the herring acoustic time series with respect to North Sea Assessment.
d) Discuss the outcome of studies of the consequences of reduced effort and area coverage for the herring larvae surveys.
e) Define the future data processing needs for combining future proposed acoustic and larvae surveys data from different countries and where this should be carried out over the next few years.
f) Develop a proposal for a survey plan for acoustic and larval surveys which will provide data required for future North Sea Assessments.

Review of the Survey Time Series

Four studies were presented: A review of the amplitude distributions from the Acoustic Surveys in the Orkney Shetland area from 1988 to 1996. A review of the spatial distribution of abundance for the full sequence of the Acoustic surveys from 1984 to 1996. The data from all surveys has been entered as numbers and biomass at age and maturity by ICES statistical rectangle and is available as a series of Excel spreadsheets. A review of the acoustic survey time series age dis-aggregated index with reference to the IBTS age dis-aggregated index. A missing catch stock model was presented to examine the implications of missing catch on the assessment.

Conclusions from the studies

The review of amplitude distributions from Orkney Shetland area.

1. The ratio of the number of zero and minimum class values changed through the period of study, the number of zero values increased.
2. The skew factor for the distribution increased during the period of the study.
3. The number of zero rectangles was greater after 1990.

Items 1 and 3 are incompatible with an increase in abundance due to changes in data treatment or due to changes in the mean as an estimator of the stock abundance value. However, there is a possibility that item 2 may be caused by underestimation of the largest schools in the early years due to saturation of the highest signals in the electronics, this could explain a change in survey efficiency between 1990 and 1991.

The distribution of abundance from the Acoustic surveys

The distribution maps show important changes in distribution both across the North Sea and East and West of Shetland. The maps show that the survey in 1988 has substantial high values on the Northern boundary and this may have resulted in a low estimate in this year due to a lack of coverage. The distribution shows some year to year variation in the abundance in the area west of Orkney and Shetland and North of the Minch. There is uncertainty as to the correct allocation of these fish to the North Sea or west of Scotland stocks.

Comparison between Acoustic Survey and IBTS time series

The ratio of the Acoustic Index with the IBTS from 1987 to 1994 shows considerable fluctuation with a low point in 1988, resulting in a factor of 1.7 or 1.2 between observations at the ends of this period, dependent on the method used to combine the year classes. The differences over the full available time series from 1984 to 1994 indicates a factor between 1.4 to 0.7 from the mid 1980s to the early 1990s. The study also present estimates of precision for the estimates of year-class strength, these are not of high quality but they do suggest that there is considerable overlap in the series and the acoustic series provides a more precise estimate of year-class strength at 2 to 4 ring.

Missing Catch Model

A population model similar in structure to the Working Group's assessment model but excluding catch information was used to investigate whether the perceptions of an increasing catchability in the acoustic survey biomass estimate are dependent on using reported catches in a VPA-type model structure. Some estimates of the variability in different data series were calculated. Overall the model suggests that the most reliable source of information are the acoustic survey estimates of age-structure and the IBTS spawning biomass estimates. These inferences are of course predicated on the assumptions detailed in Patterson (1996) and rely on ignoring process errors (e.g. changes in selection pattern, changes in natural mortality, etc.).

Use of Herring Acoustic Surveys in Assessment

There remained a number of unanswered questions:

Why is the age structure from the acoustic survey the most precise age index while the abundance index is the most divergent, when the abundance estimates are used to derive the age structure for a stock with spatially variable age structure?

Why does the IBTS abundance index perform best, during a period with changing adult age structure, while it is dominated by a single year class because it is derived from a survey with a fishing gear with a steep age selection function?

Why does the acoustic abundance index which shows the least year to year fluctuation give a stock trajectory that is different from other indices?

Conclusions from the studies

The problem of divergent indices is still present when the effect of the magnitude of unreported catch, with a linear increasing fishing mortality, is included in the analysis.

In the missing catch model the acoustic survey and the IBTS survey indices may be more self consistent than all the indices combined. It may also be preferable to use the full acoustic time series (84-97), as this reduces the slope of any long term trend between the surveys.

There was a general increase in the frequency of zero values (2.5NM sample values) in the acoustic survey of the Orkney Shetland area during the period 1987 to 1995. This would indicate a tendency to underestimate the population. The increase in skew in the amplitude distributions during this period could be caused by signal saturation for large schools, and thus could explain underestimation during this period.

There is a need to investigate the importance in the survey time series of abundance changes to the west of Orkney and Shetland and North of the Minch. If these are important the age and length structure of herring should be investigated and this should be used to advise on the split between North Sea and West Coast herring

An examination of the depth distribution of herring over the survey period should be carried out. These should be investigated in the light of depth dependant information on herring target strength information to estimate possible abundance changes over the survey period.

The use of Generalised Additive Models (GAM's) on age dis-aggregated spatial distributions of herring from Acoustic and IBTS surveys should be examined to see if these can be helpful.

Inferences drawn from the age structure and abundance indices may differ. This requires care when the indices are used in the assessment.

Perceptions of series divergence are dependant on the years, age ranges, and year class weighting given to different year classes.

There is a need to carry out studies of the implications of saturation in the electronics on surveys prior to 1991.

There is a need to increase confidence in the compatibility of multiple surveys used in the North Sea, Western Baltic and VIa. For this purpose it is proposed to include intercalibration during the survey, to exchange data on length and age distributions from hauls carried out during one year (1995) and to hold a workshop to study the interpretation stage of acoustic survey echo sounder output allocation to herring, this should be held in 1998.

The report provided a series of recommendations to address these issues, these are presented together as recommendations for the present Working Group.

Review of Larvae Surveys

The substantial decline in ship time and sampling effort allocated to the Herring Larvae Surveys in recent years, required a study of the effects on the estimates of larvae abundance and production derived from these surveys. A first step of this analysis was presented, considering a reduction in the number of sub-areas to be sampled and the required frequency of intermediate complete surveys. From the presentation and discussion of this study and comparison with results from a multiplicative model for the abundance index MLAI, the following main conclusions were drawn:

There is no long term stability in the relative importance of the different spawning areas and therefore the assumptions required for the multiplicative model used to overcome the problem of missing values in the data sets are not valid when based on extended time periods. The inclusion of interaction terms between survey areas may alleviate this problem.

For the calculation of abundance indices it would be prudent to concentrate effort on a few target areas rather than attempting to cover all spawning areas of the North Sea as has been done in the past. The precision of stock size estimates is not reduced when based on combined sampling results from Orkney/Shetland and Buchan or southern North Sea as compared to including all three areas or a complete coverage.

Complete coverage would nevertheless be required though less frequently, to observe long term trends in the relative importance of the different spawning areas and in the z/k values. From the multiplicative model there is evidence for temporal periodicity in the residuals of the larval abundance values of the order of approximately 6-8 years. In order to study this periodicity, complete coverage would be required every three years.

The residuals in the multiplicative model for the abundance index (MLAI) indicate that the results from different time periods within areas show differences similar to those between areas. It is thus not to be expected that a reduction in the survey frequency can be achieved without loss in precision of stock size estimates based on the MLAI. For LPE one coverage may be sufficient, as has previously been suggested by the Herring Larval Survey Working Group (ICES 1990/H:32). This has to be reviewed, however, in the light of an additional reduction in the areas covered.

The recommendations for the larvae surveys are collected in the recommendations from the present Working Group.

1.5 Assessment methods

Assessment methods available to the Working Group were as described in ICES (Anon: 1996/ASSESS:10 [Herring Assessment Working Group report]), where reasons for the choice of method are also documented. A detailed documentation of the separable model implementation used previously (ICA version 1.2) is given in Patterson and Melvin (1996). However, a new model implementation (ICA version 1.3) was provided to the Working Group for testing purposes (Patterson, WD 1997a) Although the model is unchanged from the previous version, the programme implementation has been improved. The principal changes to the programme have been:

1. An increase in the year and age range so that the full range of available data can be used in a consistent way.
2. Improvement in the presentation, detail and layout of the output tables.
3. Provision of a number of intermediate files for interfacing to existing Working Group software (e.g. TRENPLOT, WGFRANS, etc.).
4. Optional inclusion of a second selection pattern over a specified time period in the analysis.

After some minor revisions found to be necessary in the course of the meeting, the Working Group decided to use the new implementation for its assessments.

1.6 Recommendations

The following recommendations are numbered by the chapter number of origin. Recommendations that require to be specifically taken forward to the administrative sessions of the ICES Annual Science Conference are in **BOLD.**

A considerable number of stock assessments have difficulties due to sampling deficiencies in biological variables in the catch. These are due to two separate problems;

- samples that are taken are insufficient to describe the parameters required,
- there is a shortage of data specifically from catches that are landed in countries different from the origin of the vessel

Recommendations concerning this matter are combined into a single recommendation G.1.

The simulations presented in sections 2.9, 2.11 and 2.15 use in total four different stock-recruitment models. These models serve different purposes, i.e. equilibrium and medium term projections. Even though the models are derived on much the same basis there are some differences in the time series of data included in fitting the parameters and also in the structure of the models (the level of autoregressivity in the model).

The data series of stock and SSB available should be the longest possible. There are problems with the data representing the start of the available data set (1947 - 1960) and these problems should be resolved and an agreed data series constructed. A study group is proposed under recommendation G2.

1.1 due to inconclusive findings in an examination of the herring survey time series that further studies be carried out on:

a) the separation of West coast and North Sea herring stocks within the acoustic survey time series ,
b) depth related distribution of herring and its impact on the stock estimation,
c) the use of GAMs on acoustic and IBTS surveys,d) an examination of pre 1991 surveys for possible under estimation due to signal saturation in the electronics,

1.2 the acoustic surveys should be continued with each participant covering the same general areas to maintain consistency and a number of steps be taken to improve quality assessment in the acoustic surveys; the surveys should include inter-ship calibration, a study of between participant variability of trawl performance, a workshop be held in Bergen in January 1998 at the next planning group meeting to study variability in echogram scrutinising procedures between participants,

1.3 for the larvae surveys:

a) yearly surveys should focus on the southern North Sea as well as on the Orkney/Shetland and/or Buchan area, more detailed analyses of the historical data base is required to elucidate, which of the two northern areas should receive a higher priority,
b) efforts should be made to organise complete coverage every three years, out of phase with the Mackerel Egg Survey, starting in 1999,
c) the effect of survey timing on larvae abundance indices and production estimates should be examined in more detail from the historical data base, to confirm or disprove the indications so far available,
d) reliability and changes of the z/k values should be studied as the LPE is especially sensitive to this parameter, a standard procedure to estimate z/k should be defined and the existing data series revised accordingly,

1.4 the herring survey planning group should meet in Bergen, Norway from 19 to 23 January 1998 under the chairmanship of John Simmonds (UK) to:

a) coordinate the timing and area allocation of and methodologies for acoustic and larvae surveys for herring in the North Sea Divisions Via and IIIa and the Western Baltic with particular reference to the 1999 Larvae Survey,
b) combine the survey data to provide estimates of abundance for the populations within the area,
c) hold a workshop on acoustic echogram scrutiny,
d) assess the results of studies on: the separation of Western and North Sea herring stocks within the acoustic survey time series, the examination of pre 1991 surveys for possible under estimation due to signal saturation in the electronics, the inter-ship calibrations, study of variability of trawl performance between participants,
e) from the results of the above studies report on the applicability of a further study of the herring survey time series,

2.1 the 1-ringer indices of the IBTS survey be split in two components: 1-ringers from the "Downs" component (length below 13cm) and 1-ringers from the central and northern North Sea (length above 13cm) and this information be made available to the next ACFM meeting in May 1997,

3.1 in order to make fruitful contributions towards a full analytical assessment of spring spawners in the Division IIIa and Sub-divisions 22 and 24, the **Herring Assessment Working Group recommends that a Study Group should set up to meet in Lysekil January 12th to 16th, 1998 (Chairman Jørgen Dalskov, Denmark) with the following terms of reference:**

a. to formulate a migration model of the Baltic spring spawning herring that is consistent with present knowledge and which can be used on a routine basis for assessment purposes. The model should be linked to the results of an evaluation of the methodology on separation of stocks.

b. to compare the methodologies for stock discrimination by vertebrae counts or otolith analyses and start to update the historical split between spring and autumn spawning components in Division IIIa.

c. to review and update catch at age and mean weight at age data for all fishing fleets that catch herring in Division IIIa and Sub-divisions 22 and 24. The task should include the possibility of a revised sampling regime of the affected fleets.

d. to review and test the consistency among existing results from research surveys and to adapt future sampling to the requirements for validating the migration model.

4.1 for the Celtic Sea and DivisionVIIj: acoustic surveys should be continued for these areas and that sufficient resources be provided to ensure that the surveys are carried out with adequate biological and technical expertise,

6.1 for Division VIa (S) and DivisionVIIb acoustic surveys should be continued for these areas and that sufficient resources be provided to ensure that the surveys are carried out with adequate biological and technical expertise,

7.1 for Herring in VIIa (N) :

a) the present level of effort on acoustic and larval surveys for tuning indices should be maintained,
b) further targeted studies on the duration of the spawning season and the size of the SSB at spawning time should be carried out,
c) because of the migratory behaviour of herring in VIIa (N) the timing and size of population movement by both mature and juvenile herring between VIIa(N) and adjacent areas should be determined,

8.1 to improve the quality of the sprat assessment extra research is required, the acoustic surveys detect sprat and should be examined for the possibility of estimating sprat abundance, if feasible, the survey data should be reanalysed to obtain these estimates for as many years as possible.

G.1 to obtain good biological data on herring and sprat there is a general need to improve the biological sampling intensity in all fisheries in which they are caught,

where there are mixed fisheries nations should provide information on the level of sampling to determine species composition in all fisheries in which herring and sprat are caught,were vessels are landing into foreign ports flag countries should make arrangements to ensure adequate biological sampling is undertaken.

G.2 a study group on stock recruit relationships for autumn spawning North Sea herring be held in May 1998 at a location and with a chairman to be arranged to:-

- **Establish the data series of recruitments and SSB for as long a period as possible;**
- **Investigate the performance of different stock-recruitment models;**
- **Propose standard models to be used for different purposes.**

2 NORTH SEA HERRING

2.1 The Fishery

2.1.1 ACFM advice and management applicable to 1996 and 1997

At the ACFM meeting in 1995 it was stated that the stock was considered to be outside safe biological limits. SSB had declined since 1989 and the most recent assessment indicated that it had fallen below 800,000 t - the level which is considered to be the minimum biologically acceptable level (MBAL) for this stock.

The forecast for 1996 for North Sea autumn spawners taken in the North Sea and in Division IIIa using the same fishing mortality in 1996 as in 1994 gave a total catch of 572,000 t, of which 494,000 t should be taken in the North Sea and 78,000 t in Division IIIa.

ACFM recommended a significant reduction in exploitation in order to rebuild SSB and suggested that F in 1996 be reduced by at least 50% of the levels observed in 1994.

The TACs initially adopted by the management bodies for 1996 were: Divisions IVa,b: 263,000 t; Divisions IVc and VIId: 50,000 t.

Following the meeting of the HAWG in April 1996, ACFM reconsidered their advice for 1996 in the light of the new assessment. That assessment gave a more pessimistic view of the state of the stock than previously. This was based on the new information available from the 1995 fishery and surveys and was supported by data from the IBTS in 1996. As a result ACFM decided to modify their advice for 1996, and recommended that rapid action should be taken to rebuild the spawning stock and to reduce fishing mortality.

Specifically ACFM recommended :

For 1996 the total catch of North Sea autumn spawning herring should not be allowed to exceed 298,000 t and that catches by all fleets exploiting this stock should be counted against this figure. This recommendation corresponded to a 50% reduction in the fishing mortality for fleet A, to a TAC of 156,000 t of which no more than 25,000 t should be taken in Divisions IVc and VIId. They also recommended a 50% reduction in the fishing mortality on herring in the other four fleets.

For 1997 ACFM recommended that the fishing mortalities in all fleets should be reduced by 75% relative to the 1995 level, corresponding to an F_{2-6} of 0.2. They further recommended that if the catch in 1996 was not reduced in accordance with the above advice then no fishing on North Sea herring should take place in 1997.

In the southern North Sea and eastern English Channel, ACFM advised that fishing mortality should be reduced to the lowest possible level and that no directed fishing for herring should be allowed in Divisions IVc and VIId in 1996 and 1997. The larval surveys in 1995/96 indicated a sharp decline in the SSB of this component of the North Sea stock. The downward trend in this component was more pronounced than the trend for the rest of the North Sea.

The reasons for the rapid action taken by ACFM in 1996 were the indications that the SSB had already fallen to 500,000 t in 1995 and that the short term forecast indicated that even a complete cessation of fishing in 1997 would not return the SSB to above MBAL (800,000 t) in that year. Of particular concern were the similarities to the situation in the 1960's and early 1970's which led up to the stock collapse in the second half of the 1970's. There had been a high catch of juveniles in recent years (80% of the catch in numbers) and ACFM reiterated their advice that a reduction in the level of this catch would speed up the recovery of the stock. ,

In June 1996 the EU/Norway agreed to follow the May 1996 advice of the ACFM with the exception of the advice for Divisions IVc/VIId. In addition a special maximum by-catch ceiling of 44,000 tonnes was applied to fleet B. If this by-catch was exceeded then the small meshed fishery in the North Sea would be closed.

The final TAC's adopted by the management bodies for 1997 were Divisions IVa,b: 134,000 t; Divisions IVc, VIId: 25,000 t.

2.1.2 Catches in 1996

Total landings in 1996 are given in Table 2.1.1 for the total North Sea and for each Division in Tables 2.1.2 to 2.1.5. Unallocated landings in these tables include the misreported landings.

The total catch in 1996 of 263,400 t is the lowest since 1981 (174,880 t) and less than half the catch in 1995 (534,280 t). The reduction in catch was due to the 50% reduction in the TAC with a large decrease in landings by Denmark and Norway. Strict enforcement measures by Denmark to control the by-catch of herring in the small meshed fisheries contributed to a reduced impact on 0- ringers and 1- ringers.

In each of the last six years, TACs have been exceeded by a significant amount. This excess of the catches over the TACs for Sub-area IV and Division VIId, for the years 1991 to 1996, is shown in the text table below. It should be noted that the TAC applies only to the human consumption fishery in Sub-area IV and Division VIId and not to the herring by-catch in the small meshed fishery. It should be noted that the Working Group landings also include estimates of misreporting.

Year	1991	1992	1993	1994	1995	1996
TAC ('000 t)	420	430	430	440	440	156
Official Landings ('000 t)	400	403	409	414	415	136
Working Group Landings ('000 t)	561	544	521	465	534	263
Excess of landings over TAC ('000 t)	141	114	91	25	94	107

Misreporting of landings became an increasing problem in 1996. As in 1995 there were again strong indications that some landings taken in Division IVa were reported as having been taken in Division VIa North. In 1996 there was also evidence that some catches taken in IVc/VIId were reported from Divisions VIa North. There was reliable evidence to suggest that there was also misreporting of North Sea landings against the Atlanto-Scandian TAC in Division IIa. For some countries misreported catches are included in their reported landings As a result a total of 62,700 t of landings from Divisions VIa North and from IIa, have been transferred back to the North Sea in 1996. These were the only misreported landings transferred. Discards and slipping also occurred in the North Sea due to market conditions and due to high-grading. Estimates of discarding were only provided by The Netherlands in 1996. An EU funded project to estimate discards in all Danish fisheries began in 1995 and will continue for three years. In order to collect further data on discarding in the future, the EU have funded a joint project between Norway and Scotland to place observers on board purse seiners, fishing for herring and mackerel in the North Sea. The project begins on 1 June 1997 and will continue for two years.

In Divisions IVc and VIId, the estimated landings of 49,000 t are the lowest since 1988 but were almost double the revised TAC of 25,000 t. They include 15,000 t misreported into Division VIaN and 8,800 t misreported into Division IVb. It should be noted that only 10,000 t were landed from this area before the revised TAC came into effect in the middle of 1996 and therefore does not explain the excess of the landings over the TAC.

2.2 Biological Composition of the Catch

2.2.1 Revision of the catch in number data from 1984-1995

Herring catches reported in Division VIa between 4W and 5W from 1984-1995 were assumed to be misreported catches and were assumed to have been taken in Division IVa. In 1995 these misreported catches were removed from area VIa North for assessment purposes at last years Working Group meeting, but were not yet included in the assessment of the North Sea herring (ICES 1996/Assess:10). These 1995 misreported catches are listed in ICES (1996/Assess:10 Table 5.1.1). Therefore, at this Working Group meeting a revision has been made to the catch in numbers at age for the period 1984-1995 by raising the catch in number data for this time period according to the increase of the catch on the North Sea herring. The mean weights at age in the catch have not been changed.

2.2.2 Catch in numbers and mean weight at age

Quarterly and annual catches in numbers and mean weights at age were compiled for each Division and for the total North Sea. Table 2.2.1 provides a breakdown of numbers caught by age group for each division on a quarterly and annual basis for 1996. North Sea catches in numbers at age over the years 1970-1996 are given in Table 2.2.2.

The catches in numbers of Division IIIa-Western Baltic spring spawners caught in the North Sea in 1987-1996 and transferred to the Division IIIa-Western Baltic stock are presented in Table 2.2.3. The numbers of all year classes were low compared with the numbers in previous years. This was because the total catch off the Norwegian coast, in the area where spring spawners are normally taken, was very low in 1996 (5,200 t) compared with 1995 (27,000 t)

The estimated numbers of North Sea autumn spawners caught in Division IIIa in 1987-1996 and transferred to the North Sea assessment are given in Table 2.2.4.

Table 2.2.5 summarises the total catch in numbers at age of North Sea autumn spawners used in the assessment.

The total number of herring taken in the North Sea in 1996 (4 billion) is less than half the number taken in 1995. The catch of 0-ringers has been reduced considerably from 6.3 billion in 1995 to 1.8 billion in 1996. The catches of 1-ringers increased from 0.48 billion in 1995 to 0.74 billion in 1996 (see Table 2.2.2).

The percentage age composition of North Sea herring, as 2-ringers, 3-ringers and older, in the catch in 1996 is presented for each Division in Table 2.2.6. In 1995 the 2-ringers were dominant in the catches in Divisions IVa and IVb (ICES 1996/Assess:10). In 1996 the same year class (3-ringers) was still dominant in the catches in Division IVa (Table 2.2.6). In the Southern North Sea, in 1996, 2-ringers were dominant in the landings.

The SOP by age and division for each quarter is given in Table 2.2.7.

Catches of juvenile North Sea autumn spawners were also taken in Division IIIa. (Table 2.2.8). The catch of 0-ringers (0.63 billion) in 1996 showed a large reduction from the 1995 catch (1.7 billion). The catch of 1-ringers (0.87 billion) was lower than in the previous year (1.1 billion) This represents a change in the exploitation pattern on 0- and 1-ringers. This has been generated by the enforcement of severe management measures to reduce the catch of juvenile herring and a 25% reduction in the TAC. The 0-ringers recruit to the fishery later in the year by which time the restrictions on the fishery are beginning to come into effect. The result is that the restrictions affected the F on 0- and 1- ringer groups differently.

Table 2.2.8 gives the age compositions separately for the catch in the directed herring fishery (fleet A), the small-meshed fishery in the North Sea (fleet B), the directed herring fishery in Division IIIa (fleet C), the mixed clupeoid fishery in Division IIIa (fleet D) and the small meshed fisheries in Division IIIa (fleet E). It should be noted that, as in previous years, fleet B refers only to Denmark because it was not possible to split the small meshed catches from Norway. Norwegian small meshed catches are included in the fleet A catches.

This Working Group have made some changes to the description of the fleets C, D, and E in 1996. These changes and the rationale behind them are fully explained in section 2.15.

2.2.3 Quality of catch and biological data

Their is a large discrepancy between official and actual catches but the full extent of this is unknown. In 1996 more reliable information was obtained on misreporting from most countries fishing for herring in the North Sea. As a consequence estimated landings totalling 62,700 t were transferred from other areas into the North Sea and were used in the assessment. Estimates of discards were only provided by The Netherlands but discards are known to occur in the fisheries of most countries and they could represent a significant amount which is not included in the assessment. There is still a need to improve the quality of the landings data particularly in the North Sea in relation to discards. The efforts to quantify the extent of area misreporting, which were greatly improved in 1996, must be continued in 1997. Management measures to prevent area misreporting should be rigorously enforced.

Strict enforcement of new management measures in Division IIIa and improved sampling resulted in a marked improvement in the quality of the catch data from that area (see Section 2.15). However, there is still much uncertainty regarding the split of the North Sea autumn spawners and Baltic spring spawners from the total catch in that area.

Sampling of commercial landings for age, length and weight showed no improvement over recent years. It was low in some fisheries and in others no samples were taken in some quarters (Table 2.2.9). Once again this introduces uncertainties in the biological composition of the catches which in turn adversely affects the quality of the assessment.

The Working Group therefore continues to strongly recommend that adequate sampling of herring be carried out in all fisheries in the North Sea in which herring are caught.

2.2.4 Treatment of spring spawning herring in the North Sea

Norwegian spring spawners are taken close to the Norwegian coast under a separate TAC. These catches were very small in 1996 and are not included in the catch tables. Coastal spring spawners in the southern North Sea (Thames Estuary) are caught in small quantities regulated by a local TAC. These catches are given in Tables 2.1.1 and 2.1.5. With the exception of 1990, these catches are included in the assessment of the North Sea autumn spawners.

Western Baltic and Division IIIa spring spawners are taken in the deeper parts of the eastern North Sea during the summer feeding migration. These catches are included in Table 2.1.1. and listed as IIIa type. Table 2.2.3 details the catch in number at age of Division IIIa/Western Baltic spring spawners which are transferred from the North Sea assessment to the assessment of Division IIIa/Western Baltic in 1996. The methods of separating these fish are described in detail in former reports from this Working Group (ICES 1990/ Assess: 14).

Briefly the method assumes that for autumn spawners, the mean vertebral count is 56.5 and for spring spawners 55.80. The fractions of spring spawners (fsp) are estimated from the formula (56.50-v)/0.7, where v is the mean vertebral count of the (mixed) sample. The method is quite sensitive to within stock variation (e.g. between year classes) in mean vertebral counts. The same method has been applied to separate the two components in the summer acoustic survey.

To calculate the proportion of spring spawners caught in the transfer area only one sample, which was taken in May, was available for the second quarter (Figure 2.2.1), and six samples taken in July and August were used for the third quarter (Figure 2.2.2).

The resulting proportions of spring spawners and the quarterly catches of these in the transfer area in 1995 are as follows:

Quarter	2 - ring (%)	3 - ring (%)	4 + ring (%)	No of rectangles sampled	Total catch in the transfer area (t)	Catch of Spring Spawners in the North Sea (t)
Q.2	0	50	0	1	2 176	240
Q.3	0	38	33	5	3 092	615

The quarterly age distributions in Sub-division IVa East (Table 2.7.1) were applied to the catches in the whole area. The numbers of spring spawners by age were obtained by applying the estimated proportion by age.

2.3 Recruitment

2.3.1 The IBTS index of 1-ringer recruitment

The 1-ringer index is based on the IBTS, 1st quarter (GOV daytime catches in February 1996), using data for the entire survey area. Weighting procedures used in the calculation of the combined index are described in the Working Group report of 1995 (ICES 1995/ Assess:13).

The 1-ringer index for the period 1979-1997 (year classes 1977-1995) is given in Table 2.3.1 and the trend is illustrated in Figure 2.3.1. This year's index value of the year class 1995 is one of the highest on record, and represents a marked increase from the last year's recruitment. In Figure 2.3.2 the distribution of 1-ringers during the survey is illustrated, the abundance has increased throughout most of the area compared to 1996, outstandingly high catches were found in the southwestern area and in the IIIa.

2.3.2 The MIK index of recruitment

The 0-ringer index is based on night time catches during the IBTS in February using a fine-meshed ring-net (MIK). Index values are calculated as described in ICES (1996/ Assess:10). This year's index, based on 1997 sampling of the 1996 year class is calculated to 148.1. The density estimates within areas and the time series of estimates is given in Table 2.3.2. In Figure 2.3.1 the series is illustrated for year classes 1977 to 1996.

The spatial distribution of 0-ringers is shown for the year classes 1994 to 1996 in Figure 2.3.3. As last year, high concentrations of 0-ringers were observed in the central-west region, but in the present year additional concentrations of 0-ringers were found in the south-central regions.

2.3.3 Relationship between the MIK 0-ringer and the IBTS 1-ringer indices

The relationship between the two indices is illustrated in Figure 2.3.4. and described by the inserted linear regression. Last year's 0-ringer index of the year class correlate poorly to this year's 1-ringer index of the same year class. In order to evaluate the historic record of 0-ringer predictions of 1-ringer indices, the deviation from the linear relationship is analysed. The deviation is illustrated by the logarithm to observed/predicted 1-ringer values in Figure 2.3.5. A poor relationship between the two indices has historically been observed in a few cases when year classes was relatively small; the present discrepancy is the first case when indices are in the higher range. A number of factors might be responsible, additional information about the year class will be needed in order to evaluate their influence.

2.3.4 Recruitment prediction

As described in last years report (ICES 1996/ Assess:10) the prediction of recruitment is now based on the outcome of the ICA assessment.

The predictions of recruitment (in billions) of 0-ringers by the present years assessments are 50.5, 68.6 and 60.0 for the year classes 1994 to 1996 respectively. For 1-ringers the estimates are 10.1, 13.6 and 22.1 for year classes 1993 to 1995 respectively.

2.3.5 Trends in recruitment

The long term trend in recruitment of 1-ringers to the stock of North Sea autumn spawners is illustrated in Figure 2.3.6. Abundance estimates of year classes 1958-1995 is based on the present 1997 ICA assessment. The figure illustrates the decline through the sixties and the seventies, followed by the increase in the early eighties. From year class 1985 a new decline has been observed, while the last five year classes indicate a stabilised or increasing recruitment level.

2.4 Acoustic Surveys

The ICES Coordinated surveys were carried out during late June and July covering most of the continental shelf north of 54°N in the North Sea and North of 52°N to the west of Ireland and Scotland to a northern limit of 62°N. The eastern edge of the survey area is bounded by the Norwegian and the Swedish coasts, and to the west by the

Shelf edge at about 300m depth. The surveys are reported individually, and a combined report has been prepared from the data from all seven surveys and presented at the meeting (Simmonds et al, WD1997).

Seven Acoustic Surveys

Christina S	13 - 31 July	North of 56° 30'N west of 3°W
Dana	19 - 30 July	North of 57° east of 6°E
GO Sars	25 June - 14 July	North of 57°east of 1°E
Lough Foyle	15 July to 2 Aug	56° 30' N to 52°N, Ireland to 12°W
Scotia	13 - 30 July	North of 58° 30' between 4°W and 2°E
Tridens	24 June - 19 July	South of 59°N west of 2°E
W Herwig	23 June - 16 July	South of 57°N east of 2°E

The stock estimates have been calculated by age and maturity stage for 30'N-S by 1°E-W statistical rectangles for the ICES areas IIIa IVa, IVb VIa north, VIa south, and VIIb separately. Where the survey areas for individual vessels overlap the estimates by age and maturity stage have been calculated by survey effort (length of cruise track) weighted means. The data from areas IIIa, IVa and IVb have been split between North Sea and Baltic stocks by vertebral count, maturity stage and otolith microstructure methods. The combined survey results provide spatial distributions of herring abundance by number and biomass at age and maturity by stat rectangle.

Figure 2.4.1 shows survey areas for each vessel. The results for the seven surveys have been combined. Procedures and TS values are the same as for the 1994 surveys (Simmonds *et al.* 1995). Stock estimates for autumn spawning herring by number and biomass are shown in Tables 2.4.1 and 2.4.2 respectively, for areas VIa north, IVa south, VIIb, IVa, IVb, and IIIa separately. The mean weights at age are shown in Table 2.4.3. Figure 2.4.2 shows the distribution of numbers of all autumn spawning 1 ring and older herring for all areas surveyed. Figure 2.4.3 shows the distribution split by age of 1 ring, 2 ring and 3 ring and older herring. Figures 2.4.4 shows the density distribution of spawning stock biomass of autumn spawning herring as a contour plot.

The numbers of North Sea autumn spawning herring estimated from the acoustic survery are shown as a time series in Table 2.4.4, the table also shows the estimated total mortality calculated from 2+ to 3+ age classes from the time series.

Evidence of *Ichthyophonus* infection is now at unmeasurably low levels, only 2 of over 4,000 fish sampled for otoliths and *Ichthyophonus* showed macroscopic evidence of the infection. This compares with 0.2%, 0.8%, 3.6% and 5% in the previous 4 years 1995 to 1992 respectively.

2.5 Larvae Surveys

The preliminary report of the International Herring Larvae Surveys of the North Sea and Adjacent Waters for 1996/97 (Patterson *et al.* WD.1996) was presented. The report gives maps of the distribution of herring larvae by 1/9th ICES rectangles for all the areas and periods surveyed in the 1996/97 season. Effort on the larvae surveys in recent years has been reduced to approximately one quarter of the input in the 1980's and now only Germany and The Netherlands take part. Sampling effort showed some improvement in 1996/97 compared with 1995/96 with vessel days increasing from 26 to 37 and the number of samples taken from 419 to 469. In spite of this improvement, spatial and temporal coverage is still relatively poor.

In 1996 there was a single coverage only in the period 15 - 30 September in Orkney / Shetland, the Northern North Sea and in the Central North Sea. Coverage in the Buchan area in the period 16 - 30 September was adequate. There was no sampling in the survey area to the west of Orkney / Shetland and in the central North Sea the spatial coverage was also poor. An index was not calculated for either of those areas because of the poor coverage. The best coverage was achieved in the Southern Bight and Eastern Channel where the three sampling periods from mid-December 1996 to the end of January 1997 were well sampled.

The overall sampling levels were again too low to permit either the Larval Abundance Index (LAI) or the Larval Production Estimate (LPE) to be calculated. The individual sampling period, indices from the 1996/97 surveys, calculated as a sum of the numbers of herring larvae <10mm per m^2 (<17mm. Southern North Sea), are shown in Table 2.5.1. This table also shows the historic data series back to 1972 in the time periods required for calculating the larvae indices, clearly indicating the deterioration in the time series of data over the past five years.

The abundance of small larvae in the Southern North Sea was very low suggesting that there was very little spawning in that area in 1996/97. In the Eastern English Channel the larvae abundance shows a marked increase over the previous years very low value. This is referred to in more detail in section 2.8.3 which deals specifically with the management of the Downs stock component.

Although sampling has been extremely poor and the surveys are not expected to return robust estimates of stock size, the multiplicative model used for the 1995/96 surveys (Patterson and Beveridge 1996) has again been fitted in order to estimate historical trends in larval abundance. The model assumes that the abundance of the size categories of larvae, as analysed for the other two indices, is proportional to stock size in each of the sampling units. The model output was used as a new index in the assessment in 1996 and has been used again in the 1997 assessment.

The model used in the assessment in 1996 and 1997 was fitted to the abundance of newly hatched larvae of <10mm (<16mm in IVc/VIId) as used for the calculation of the Larval Abundance Index (LAI). The Larval Production Estimate (LPE) allows the inclusion of all sizes of larvae with an explicit adjustment for growth and mortality. A simple abundance index, based on all sizes of larvae without a growth/mortality function included, was calculated in order to test whether such a simple calculation would yield a less variable index than the one based on newly hatched larvae. A multiplicative model was fitted to this index of all sizes of larvae and the results tested as a tuning index in an assessment run. The MLAI based on this revised data set was not used in the final assessment.

The Working Group again expressed regret at the loss of the LPE as a tuning index. It has proved to be a robust index of SSB for many years until survey effort was substantially reduced in 1992. At a recent meeting of the herring survey planning group in Aberdeen, consideration was given to the possibility of increasing the effort on the larvae surveys on a triennial. basis. This would provide a picture of larval distribution and abundance, a validation of the assumptions behind the MLAI and permit a full index of larvae production to be calculated once every three years. Although no commitments could be made general interest was expressed in the idea, both at the planning group and at this Working Group The possibilities of committing research vessel time to this proposed programme will be explored by Working Group members before the Annual Science Conference in 1997. The possibility of EU funding for the programme will also be investigated. As a result it is hoped that the first of the triennial series of larvae surveys can be planned for 1999 at the next meeting of the herring survey planning group in 1998.

2.6 August Scottish Groundfish Surveys

The Scottish August Groundish surveys were briefly described in (ICES CM 1996/Assess:13 [Herring Assessment Working Group report 1996]). Although they were not included in the assessment of the stock, the data set has been extended to include the August 1995 survey. The historical time series of catch rates of herring (2 rings and older) from this survey are given in Table 2.6.1.

2.7 Mean weights-at-age and maturity-at-age

2.7.1 Mean weights at age

The mean weights at age of fish in the catches in 1996 (weighted by the numbers caught) are presented by ICES division and by quarter in Table 2.7.1. Table 2.7.2 shows a comparison of mean weights at age, 2-ringers and older over the years 1987 to 1996.

For Division IVa the mean weight of all ages in the catch are in the upper 25% of the range. For Divisions IVb, IVc and VIId the mean weight at all ages are close to the 10 year mean. For the whole area the mean weight at age in the catch is very close the 10 year mean.

Table 2.7.3 presents the mean weights at age in the catch during the 3rd quarter in Divisions IVa and IVb for 1987 to 1996. In this quarter most fish are approaching their peak weights just prior to spawning. For comparison the mean weights in the stock from the last six years of summer acoustic surveys are shown in the same table. (From Table 2.4.3 for the 1996 values). The mean weights at age are close to the high values observed in 1994.

The year effect in mean weight at age in the observed values in the population is considerable and the issue of the correct values to be used in the assessment was addressed in detail in 1996 (ICES 1996/Assess:10). The cause of the year effect is likely to be the result of variability in the estimates of abundance in different parts of the survey area. This is most likely due to sampling variability in the acoustic survey, as the local abundance is required to weight the mean weights at age from differing parts of the area. To reduce the impact of this sampling variability in the assessment a 3 year running mean was chosen in 1996 and the same method has been used this year to smooth the year effect in mean weight at age.

The mean weight in the catches of 1 ring herring in the first and second quarter in 1996 is very low. This result from catches in the Danish small mesh fishery which had an estimated catch of 4,105 tones and 1,153 tonnes in quarters 1 and 2 respectively. In the first quarter 9 samples were taken, 433 fish measured and aged. The mean length of 1 ring herring was 10cm. There are no indications to suggest errors in this data. No samples were taken in quarter 2 and due to the lower catch in quarter 2 the estimates of catch in number and mean weights were derived from the age and mean weight data from quarter 1.

2.7.2 Maturity Ogive

The percentage of North Sea autumn spawning herring (at age) that spawned in 1996 was estimated from the acoustic survey. This was determined from samples of herring from the research vessel catches examined for maturity stage, and raised by the local abundance. All herring at maturity stage between 3 and 6 inclusive in June or July were assumed to spawn in the autumn. The method and justification for the use of values derived from a single years data was described fully in ICES (1996/Assess:10). The maturity in 1996 was within the normal range of values (over the last 9 years). The proportion of herring found to be mature were slightly lower than average for 2 ring and a slightly higher than average for 3 ring. The percentages are given in the table below.

Year \Age (W ring)	2	3	>3
1988	65.6	87.7	100
1989	78.7	93.9	100
1990	72.6	97.0	100
1991	63.8	98.0	100
1992	51.3	100	100
1993	47.1*	62.9	100
1994	72.1	85.8	100
1995	72.6	95.4	100
1996	60.5	97.5	100

(* The 2 ring value in 1993 has been checked and corrected in this table and matches the correct value that has been used in the assessment for the last 2 years).

2.8 Stock Assessment

2.8.1 Data Exploration and Preliminary Modelling

Assessment of the stock was done by fitting an integrated catch-at-age model including a separable constraint over a five years period (Deriso *et. al* 1985; Gudmundsson, 1986). Further details are in section 1.5.

The information available was the catches in number at age and year (Section 2.2), the MIK index of 0-ringer abundance (Section 2.3), the acoustic survey index (Section 2.4), the IBTS survey information (Section 1.4), including the first quarter index traditionally used by the Working Group. The short time series of the 2nd, 3rd and 4th quarter IBTS indices have not been tested this year since they were not used in last years assessment on account of high variance. In addition, larvae survey information including the multiplicative larvae abundance index (MLAI) was available, and a time series of Scottish groundfish surveys (Section 2.6). The Working Group attempted to evaluate the consistency of these different sources of information.

The present ICA version allows a longer year-range to be calculated so that there was no longer a need to use a conventional VPA model to calculate the earlier years in the analysis as was done in last year's assessment. The full year range of 1960 to 1996 has been chosen for the assessment thereby excluding the years 1947 to 1959 on account of the large discrepancies in the sum of products in those earlier years.

In a number of exploratory analyses, the model was fitted to the catch at age matrix and to each survey index separately. The fishing mortalities at reference age (4) (the fishing mortalities +/- the standard error) for each model fit are plotted in Figure 2.8.1 to show the fishing mortalities indicated by the different survey indices under different assumptions about the relationship that they bear to stock abundance. All the models include a fit to the catch at age matrix.

Data Exploration by Abundance index

In the assessments made before 1995 of this stock the traditional LPE index was used from 1983 - 1992. However, information from **larvae surveys** carried out from 1993 onwards was not used in the 1995 assessment (ICES 1995/Assess: 13) as survey coverage had declined to such an extent that the LPE measure of abundance could no longer be calculated. Consequently, the LPE index has been replaced in 1996 by the multiplicative larvae abundance index (MLAI), which covers the time period 1973 - 1996 and therefore uses also the information on larvae abundance during the period 1993 - 1996 (see Section 2.5). In last years assessment the starting year of the MLAI index was 1976. However, in this years assessment this is changed to 1977, since all indices of 1973-1976 were regarded to be inapropriate. This measure of stock size is more robust to the decline in larvae survey coverage than the traditional indices. Patterson *et al.* (1997 WD) presented a working document on the calculation of the MLAI. Three different sizes of larvae could be included in the calculation: smaller than 10 mm, between 10 and 15 mm, and smaller than 15 mm. In the working document it is argued that the inclusion of larger larvae reduces the mean squared residuals for the multiplicative model fits and that therefore these larger larvae might be preferable to the smaller larvae index. Three MLAI indices were tested using the year range of 1977 to 1996 and all assuming a power relationship of index value to stock abundance as in last year's assessment (Fits 9,10 and 11 in Figure 2.8.1). The MLAI index for larvae smaller than 10 millimeter gave the lowest estimation of fishing mortality (between 0.24 and 0.38) and the index for larvae between 10 and 15 millimeter the highest estimation (between 0.36 and 0.65). The strategy for herring larvae surveys are currently under review (see section 1.3). In that perspective the same larvae abundance index has been used as in last year's assessment, i.e. an index for larvae smaller than 10 mm (an MLAI<15 in stead of MLAI<10 in the run with the indices for the final assessment indicates a SSB of 475,000 t compared to the 539,000 t in the final assessment). Figure 2.8.2 shows the spawing stock biomass as indicated by the MLAI<10 indices which provide information on the adult biomass.

The series of **acoustic survey** indices have been used for the period 1989 to 1996. The reasons for using this restricted period have been discussed ICES (1995/Assess:13 and 1996/Assess:10) and are further discussed in Section 2.4.

The acoustic survey time-series have been tested in three separate runs:
1. age 1-9+, years 1984-1996
2. age 2-9+, years 1984-1996
3. age 2-9+, years 1989-1996 (as in last year's assessment)

The performances of the acoustic indices are shown in Figure 2.8.1 (fits 1, 2 and 3). Inclusion of the 1-ringer group in the index did not have a substantial influence on the average fishing mortality as might be expected since the acoustic survey is primarily aimed at estimating the adult stock. The inclusion of the earlier years (1984-1996) in the index resulted in a lower estimate of F compared to the shorter time-series (1989-1996). The reasons for excluding the earlier years was addressed in ICES (1996/Assess:10). Figure 2.8.2 shows the spawing stock biomass as indicated by the acoustic indices which provide information on the adult biomass.

The **IBTS survey indices for the 2- to 5+-ringers** indicate the highest F compared to the other indices (Figure 2.8.1, fit 4), leading to an estimate of fishing mortality between 0.6 and 0.9. As in earlier years the age disaggregated IBTS survey indices were split in two sets: the IBTS 1-ringer indices and the IBTS indices for 2- to 5+-ringers. The 1-ringer index is used principally to predict recruitment and the 2-5 ringer index has been used as an index of adult stock size, and this structure has been maintained for the present assessment. The IBTS survey (ages 2-5+) has performed consistently as an estimator of herring spawning stock size in previous assessments, and no strong trends were noticeable in the residuals. Figure 2.8.2 shows the spawning stock biomass as indicated by the IBTS 2-5+ indices which provide information on the adult biomass.

The two recruitment indices (**IBTS age 1 and MIK**) have also been tested in separate fits in order to evaluate their fits to the population models (Figure 2.8.1, Fits 5 and 8). Both appeared to fit well to the historic recruitment information, but are apparently poor predictors of adult stock size and fishing mortality. They were both used as recruitment indices in the final assessment.

The **Scottish groundfish survey (SGFS)** has also been tested in a separate model fit (Figure 2.8.1, Fit 6). It was found to have strong year-effects in the residuals. Catch rates in 1984 appeared to be outlying values and the fit was repeated excluding these observations (Figure 2.8.1, Fit 7). This made little change to the estimate of fishing mortality. Additional pertinent considerations are that the Scottish Groundfish survey only covers a part of the North Sea herring summer distribution, and does so with a fishing gear that is very inefficient at catching herring. Catch rates in the survey were exceptionally low. For the reasons given above this tuning series was excluded from the final assessment.

Range of SSB and F in 1996

The IBTS 2-5+ and the IBTS-1 provide the most extreme SSB's and F's of all indices used in the final assessment (Figure 2.8.3). These indicate roughly in what range the SSB and F might be in 1996 taking into account all uncertainties concerning the assessment. This indicates that the SSB in 1996 must be regarded to be still below MBAL.

Indices chosen for the assessment

The indices chosen for the assessment are: acoustic survey 1989-1996 (2-9+), IBTS 1983-1997 (2-5+), IBTS 1979-1997 (1), MIK 1977-1997 (0), MLAI<10 (biomass index). These correspond in Figure 2.8.1 to fits: 3, 4, 5, 8 and 9.

Catch-at-age matrix

At the working group it was concluded that the catch at age matrix that was used in previous assessments needed revision since the catches that had been misreported in Division VIa were taken out of the VIa assessment but had not been added to the North Sea assessment (see section 2.2.1). In the current assessment this correction has been implemented going back to 1984. The differences between the new catch at age matrix and the old one are explored in section 2.8.2. The time series 1947-1959 of the catch at age numbers has not been used in the assessment, because of very large difference in the SOP (=som of products). The SOP's are shown in the text table below:

Year	SOP	Year	SOP	Year	SOP	Year	SOP
1947	180	1952	139	1957	116	1962	117
1948	167	1953	127	1958	117	1963	86
1949	175	1954	130	1959	143	1964	106
1950	155	1955	106	1960	118	1965	114
1951	152	1956	127	1961	113	1966	107

2.8.2 Stock Assessment

The Working Group used the same stock assessment model as in ICES (1996/Assess:10) with the following minor modifications:

1. ICA version 1.3 was used instead of the version 1.2 of last year

2. The assumption of separability was extended to a five year period, covering 1992 to 1996 rather than a four year range (1992 to 1995) used previously. Recent catch data appear to conform well to the assumption of separability except for the 0- and 1-ringers. Changes in the management regime introduced in July 1996 make the separability assumption invalid for these year classes. This is further discussed below and in section 2.2.2.

The stock-recruitment model was weighted by 0.1 as in last year's assessment in order to prevent bias in the assessment due to this model component.

Details on input parameters for the final ICA are presented in Tables 2.8.1 and 2.8.2.

Defining the following variables:

a,y	age and year subscripts
C	Catch in number at age and year
C'	Catch in number at age and year predicted by the structural model
SSB	Spawning stock biomass
SSB'	Spawning stock biomass in the structural model (estimated)
IBTSA	IBTS survey estimates of abundance at age 2-5+
IBTSY	IBTS survey estimates of abundage at age 1
MLAI	Multiplicative larval abundance index for larvae smaller than 10 mm
ACOUST	Acoustic survey estimates of abundance at age
$N_{a,y}^{IBTSA}$	Population abundance at the time of the IBTSA survey at age a and in year y. Similar notations are used for the other age index surveys.
QV	Coefficient of proportionality ('catchability') for larvae survey estimates of spawning stock biomass
QI	Coefficient of proportionality ('catchability') for IBTS 2-5+-ringer survey estimates of stock abundance
QL	Coefficient of proportionality ('catchability') for IBTS 1-ringer survey estimates of stock abundance
QA	Coefficient of proportionality ('catchability') for acoustic 2-9+-ringer survey estimates of stock abundance
QM	Coefficient of proportionality ('catchability') for MIK 0-ringer survey estimates of stock abundance
K	Power coefficient for the MLAI estimate of stock abundance
$\lambda_{a,y}$	Weighting factor for the catch at age *a* in year *y*: $\lambda_{0,1996}$=0.01 and $\lambda_{1,1996}$=0.01
λ_{SSR}	Weighting factor for the stock recruitment relation (= 0.1)
A,B	Parameters of the Beverton-Holt stock recruit relationship

The final objective function chosen for the stock assessment model was:

$$\sum_{a=0,y=1992}^{a=8,y=1996} \lambda_{a,y} (\ln(C_{a,y}) - \ln(C_{a,y}))^2 +$$

$$\sum_{y=1977}^{y=1996} (\ln(QV.SSB'^{K}_{y}) - \ln(MLAI_y))^2 +$$

$$\sum_{a=2,y=1983}^{a=5+,y=1997} (\ln(QI_a . N_{a,y}^{IBTSA}) - \ln(IBTSA_{a,y}))^2 +$$

$$\sum_{a=1,1979}^{a=1,1997} (\ln(QL. N_{1,y}^{IBTSY}) - \ln(IBTSY_{1,y}))^2 +$$

$$\sum_{a=2,y=1989}^{a=9+,y=1996} (\ln(QA_a . N_{a,y}^{ACOUST}) - \ln(ACOUST_{a,y}))^2 +$$

$$\sum_{a=0,y=1977}^{a=0,y=1997} (\ln(QM. N_{0,y}^{MIK}) - \ln(MIK_y))^2 +$$

$$\lambda_{SSR} \sum_{y=1960}^{y=1996} (\ln(N_{0,y+1}) - \ln\left(\frac{A.SSB_y}{B+SSB_y}\right))^2$$

The stock numbers at age at the time of the IBTSA survey are derived from:

$$N_{a,y}^{IBTSA} = N_{a,y}.e^{[-(-F_y S_a)PF_{IBTSA} - M_{a,y} PM_{IBTSA}]}$$

where PF_{IBTSA} is the proportion of F before the IBTSA survey and PM_{IBTSA} is the proportion of the natural mortality before the IBTSA survey. Similar estimates are given for the other age-structured indices.

Errors both in the acoustic survey and the age-disaggregated IBTS (2-5+) index were assumed to be correlated by age for each survey.

The standard assessment presented in earlier years includes the assumption of the exploitation pattern being constant between recent years, i.e. the separability assumption.

The regulations affected the various components of the fishery differently. The TACs for fleets A was reduces to 50% and C by 25% and a by-catch ceiling of 44,000 t for herring was introduced for the small meshed fisheries in the North Sea (fleet B). For Division IIIa (Fleets D and E) such ceilings have been introduced for 1997. As a result the separability assumption is likely to be violated.

The actual by-catch ceiling in the North Sea was 44,000 tonnes while the corresponding catch was 38,000 tonnes. Even so the structure of the Danish small mesh fishery (fleet B) was drastically affected. The by-catch regulation particularly affected the sprat fishery which usually takes most of the 0-wr herring. The period 1 July - 15 August was closed for this fishery and control of by-catch limitations were intensified. About 40 boats lost their licences for one month for trespassing these limits. Because of low abundance of sprat in the third and fourth quarters the effort in this component of the fleet B was substantially reduced compared to previous years.

The MIK index obtained at the IBTS (February) in 1996 suggest that the 0-wr herring year class in the autumn 1996 should be of average strength. Prediction based on an unchanged fishing mortality (average 1992-1995) would suggest that the catch of 0-wr in the autumn 1996 would be around 8,000 million fish while the catch recorded for 1996 was only 2,400 million fish indicating a substantial reduction in the exploitation on 0-wr herring.

Because of the reduced fishing mortality the survival of 0-wr herring was higher than in previous years. Reduction of fish mortality to 0 for 0-ringers must lead to 1.4 times the average measured as 1-wr. This is the maximum gain in stock abundance estimated for 0-wr as a result of the drastic regulations introduced in July 1996. However, the IBTS (February 1997) 1-wr index is substantially higher about twice the average year class measured as 1-wr and at the same level as in 1988.

In order to resolve these problems of the possible violation of the separability and conflicting trends between the MIK(96) and IBTS(February 97) 1-wr indices, the Working Group decided to base its assessment on an ICA run where the catches of 0-wr and 1-wr for 1996 were not included in the fit of fishing mortalities and stock sizes. This was technically done by introducing a low weight (0.01) for these two catch data items in the sum of squares for the ln(catch) residuals. The results of the final run are given in Table 2.8.3. The fishing mortalities presented for 0-wr and 1-wr for 1996 are based on the separable exploitation pattern and these values are therefore not valid estimates for 1996. Therefore fishing mortalities for 0-wr and 1-wr were recalculated by solving the Baranov equation with the 1997 stock estimate and catches for 1996. Also stock numbers at 1 January 1996 were calculated in this way:

Age (wr)	F-at-age for 1996 (Total population)	Stock (mill. ind.) 1. January 1997
0	0.062	63,563
1	0.194	14,194
2	0.309	4,300
3	0.350	1,430
4	0.372	920
5	0.356	460
6	0.353	120
7	0.348	60
8	0.372	30
9	0.372	60

These estimates were used for the projections presented in section 2.10 and 2.11.

Compared to an ICA run including the full separability model also for 0-wr and 1-wr the stock numbers for 1996 of 0-wr was unchanged while the 1-wr increased by about 20 %. The spawning stock biomss was reduced by 6%. The fishing mortality was in this trial run almost three times higher for 0-wr but only about 75 % of the F for 1-wr. All runs indicate a substantial reduction between 1995 and 1996 in the fishing mortality for all ages.

The ICA output is presented in Table 2.8.3 and Figures 2.8.4 - 2.8.12. The spawning stock at spawning time 1996 remained at the same level as estimated since 1994.

The effect by different options on the assessment for 1996 is presented in the table below:

	Recruiment (billions 0-wr)	SSB ('000 t)	F (0-wr)	F (1-wr)	F (2-6 wr)
Final Assessment with downweighting of 0+1 wr catches in separable VPA. F(0-wr) and F(1-wr) 1996 calculated from Baranov equation between catches and stock estimates	68.6	539	0.06	0.19	0.35
Final Assessment with downweighting of 0+1 wr catches in separable VPA. F(0-wr) and F(1-wr) 1996 from separable VPA	68.6	539	0.13	0.15	0.35
No downweighting 0+1 wr catches in separable VPA	55.5	569	0.11	0.15	0.32
Excluding misreportings 1984-1996 No downweighting 0+1 wr catches in separable VPA. F(0-wr) and F(1-wr) 1996 from Baranov equation between catches and stock estimates	66.2	535	0.06	0.21	0.30

To show the extreme diffences in F and SSB as indicated by the ICA runs with the separate indices.

Long-term trends in yield, fishing mortality, spawning stock biomass and recruitment are given in Figure 2.8.13. The information for the period 1947 to 1959 has been excluded on account of very large SOP discrepancies which have been detected in the ICES database for these years.

The quality of the assessment is further discussed in section 2.8.14.

2.8.3 Stock in Division IVc and VIId

The difference in age structure between the catches in Division IVc, VIId and in the rest of the North Sea clearly indicates that the development of the southern North Sea/Channel population ("Downs herring") is different from that in the rest of the North Sea.

The herring larvae surveys in the southern North Sea and eastern Channel indicated last year that the spawning stock biomass in 1995 has decreased to a level as low as in 1980 when the herring fishery was closed (ICES, 1996/Assess:10). In May 1996 ACFM recommended that: **"the fishing mortality on this stock component should be reduced to the lowest possible level and that no directed fishing for herring should be allowed in Division IVc and VIId in 1996 and 1997"**. In the middle of 1996 the TAC for human consumption herring was revised in the current year to half the agreed TAC and the same TAC was set for 1997 (to avoid a complete closure of the herring fishery in 1997). However, the advice that no directed fishing for herring should be allowed in Division IVc and VIId in 1996 and 1997 was not followed by EU regulations both in 1996 and 1997.

Figure 2.8.14 shows the age composition of the herring in Divisions IVc and VIId in the Dutch catches from December 1980-1996. Figure 2.8.15 shows information on the larvae abundance over the same period and in addition the changes in the mean age in the Dutch herring catches in December. In genereal it appears that the spawning stock biomass decreases when in the preceding year age 4 has been more abundant than age 3 (compare larvae abundance in Figure 2.8.15 with the age composition in Figure 2.8.14). In these cases a weak recruitment at age 3 appears to be recruited to the "Downs" spawning stock. Year classes 1990 and 1991 appear to have been weak and seem to have contributed to the fast decline in spawning stock biomass. Year classes 1992 and 1993 appear to have been at least average and probably explain the increase in spawning stock in 1996.

The mean age in the catch seems to be related to the herring larvae abundance and therefore also to the spawning stock biomass (Figure 2.8.15). Since 1991 the spawning stock biomass and the mean age have decreased considerably, but not yet to the low mean age of 3.2 in 1980.

For the management advice of "Downs" herring it is important to know what year class strength will recruit to the adult spawning component. The IBTS survey supplies recruitment indices of 1-ringers (2 year olds), but these indices are for the whole North Sea herring population. Part of these 2-year olds will recruit to the "Downs" herring. Length distributions of the 1-ringers of the IBTS survey show very often a bimodal distribution. The fish of the smallest distribution are "Down" herring recruits (born later), while fish of the largest distribution are recruits from the central and northern North Sea (born earlier). On average the minimum between the two modes in the length distribution occurs at 13 cm. The index of the strength of the "Downs" 1-ringers possibly predicts what the strength is of the recruiting year class to the spawning stock. **The Working Group recommends that the 1-ringer indices of the IBTS survey be split in two components: 1-ringers from the "Downs" component (length below 13cm) and 1-ringers from the central and northern North Sea (length above 13cm) and this information be made available to the next ACFM meeting in May 1997.**

ACFM catches have overshoot the agreed TAC's considerably since 1988 (see Figure 2.8.16). Considerable catches taken in Divisions IVc and VIId were misreported to other Divisions. The high catches together with the weaker year classes 1990 and 1991 have contributed to a fast decline in spawning stock biomass over the period 1991-1995. This southern component of the North Sea herring does not seem to be able to sustain the recent high catch level.

2.9 Target and limit reference points

Appropriate Reference Points

Target reference points are interpreted as signposts that can be aimed at in order to reach management objectives, and limit reference points as values of F or SSB that should be avoided (United Nations 1995). It is recognized that limit reference points may be of variable nature, ranging from representing immediate danger, to limitations on the freedom to choose targets within the framework of the precautionary approach.

In the present case, certain of the traditional reference points are considered unhelpful. The Fmed reference point (F=0.60) and the associated Fhigh (0.85) and Flow (0.32) reference values are markers of the historic exploitation of the stock and are not considered a useful guideline to planning future exploitation. Reference points based on yield-per-recruit considerations ($F_{0.1}$ =0.13 and Fmax =0.33) are also not considered to be useful references for a stock in which the dependency of recruitment on adult stock size can be quantified comparatively well.

The long-standing Minimum Biologically-Acceptable Level of spawning stock biomass has been reviewed by the Working Group recently (ICES 1996/Assess:10) and found to be appropriate as a level below which lowered recruitmentment is expected to occur.

However, this MBAL figure is model-specific. To avoid potential problems, the Working Group suggests that this figure be redefined in relation to some historic time period, e.g. the mean level of the SSB in the years 1985 - 1987. Currently this amuonts to 809 000 t which can be rounded for convenience to the 800 000 t. Redefining the MBAL in this way is likely to avoid possible future discrepancies between stock assessments (which are prone to changing assumptions and structures) and the long-term reference points (which should be independent of such structures).

Application of the MBAL concept, which is well-founded in this case, means that the SSB should at all times be above this 800 000 t. The Working Group's interpretation of this is that a target fishing level could be chosen if it has a low risk that the stock will fall below MBAL in the long term. Defining a low risk as a 5% probability, this implies that the lower 5 % fractile of the SSB distribution should be 800,000 t or above for the chosen fishing mortality rate. Therefore, any target fishing mortality respecting this MBAL limit would have as an upper limit the restriction imposed by the lower 5% fractile of the SSB distribution.

A further restriction on the range of appropriate target fishing mortalities can be inferred from the precautionary approach, which implies that F_{MSY} is a limit for the fishing mortality.

A modelling investigation

In the present case, appropriate fishing mortalities for juvenile and for adult fish (for a given risk of stock size falling below MBAL) are obviously interdependent. However, the form of this interdependence in a stochastic process is not obvious and has been studied in some detail.

A stochastic model was developed to evaluate the probability (risk) of SSB < 800 000 t at equilibrium and the MSY (Skagen, Working Document 1997a). The model includes the recruitment, weights at age and maturity ogive as stochastic variables. Equilibrium is taken as the state where the distributions of SSB and of recruitment are stationary, i.e. do not change over time. A stochastic stock recruitment function represents a transform of the SSB-distribution to recruitments, and the SSB is a weighted sum of the recent recruitments. The program genereates a distribution of recruitments from a distribution of SSB's and a new distribution of SSB's from the distribution of recruitments until the distributions do not change any more.

The recruitment function was the Beverton - Holt function where the stochastic term ε is normally distributed log residuals, i.e.

$$R = a*S/(b+S)*\exp(\varepsilon)$$

The parameters a and b were estimated by nonlinear minimisation of the variance of the residual term ε, with the constraints that ε should be uncorrelated to the spawning stock biomass in the historical data, and that the modelled R's corresponding to historical data should be unbiased. These parameters are therefore different from those used in simulations with ICAPROJ elsewhere. Stochastic weights at age and maturity ogive were taken from the last 10 years of input data, by drawing a year randomly each time such a value is needed, and using the data from that year. The separable fishing pattern from the 1996 assessment was used (ICES 1996/Assess:10), but fishing mortalities for ages 0-1 and for ages 2+ were scaled separately, and referenced by the average $F_{0\text{-}1}$ (F_{juv}) and $F_{2\text{-}6}$ (F_{ad}) respectively. Again, there is a discrepancy to the ICAPROJ runs, since these reference the fisheries mortalities for fleets B-E by F at age 1.

Figures 2.9.1a and b show how the probability of SSB < 800 000 tonnes depends on F_{ad} for various levels of F_{juv}, and vice versa. Figure 2.9.1c shows the 5% probability isoline in the F_{juv}-F_{ad} plane. This isoline is quite straight, and is close to a diagonal in the plane. It should be noted that the curves, once a low risk is reached, rise quite rapidly. It should also be borne in mind that position of the 5% isoline is very sensitive to both model assumptions and to which data are treated as stochastic and how this is done. For comparison, two combinations representing deterministic F_{crash} are given in the text table below:

F_{juv}	F_{ad}
0.0	1.0
0.5	0.7

Figure 2.9.2 shows the median catch of adults as function of F_{ad}, for various levels of F_{juv}. These curves are almost congruent and quite flat-topped, with a maximum at F_{ad} = 0.20. This is somewhat lower than the often proposed target F of 0.3, and also than the present deterministic F_{MSY} which is approximatly 0.25, and reflects that the net effect of the stochastic terms are in the direction of lowering the potential catch at higher F's.

As an alternative approach, the ICAPROJ was run based on the ICA-assessment on the same data (as reported in ICES 1996/Assess:10), for 100 years forwards, taking the last 10 years as representing the equilibrium state. The same fishing pattern as above was used, but with the same F-multiplier for all ages. A selection of percentiles for a range of F-multipliers, expressed as $F_{2\text{-}6}$, for the SSB and for the various fleets, assuming that their relative partial fishing mortalities are the same, are shown in Figure 2.15.1. The results are quite close to those obtained by the other method, although the 5% risk isoline for the SSB is at slightly lower F-levels. It also shows that the risk of bringing the SSB below 800 000 tonnes is above 90% at fishing mortalities above 0.6.

The simulations suggest that an F of 0.20 for adults should be regarded as an upper limit for the admissible target reference F's for adult herring. Due to the uncertainty of the exact position of the risk isoline, the F on juveniles should not exceed 0.3, unless the adult F is considerably below 0.2. Given the sensitivity of this line both to assumptions about uncertainties in the input data and the problems with estimating the fishing mortality with high precision from year to year, it would be advisable to stay well away from this line.

The choice of target F's within this region is a matter of how priority is given to fishery for juveniles at the expense of fishery for adults, as illustrated in Figure 2.9.2.

2.10 Short term projection by area and fleet

Fleet Definitions

The fleet definitions were changed compared to the assessment presented in CM (1996/Assess:10) as discussed in section 2.15 *ad* 1.3 a). The database was modified although the full rebuilding was not possible. For details, see section 2.15 *ad* 1.3 a).

The new definitions are:

North Sea

Fleet A: Directed herring fisheries with purse seiners and trawlers
Fleet B: All other vessels where herring is taken as by-catch

Division IIIa

Fleet C: Directed herring fisheries with purse seiners and trawlers
Fleet D: Vessels fishing under the mixed clupeoid (sprat) quota
Fleet E: All other vessels participating in fisheries where herring is taken as by-catch

Input Data for Short Term Projections

The starting point for the projection is the stock of North Sea autumn-spawners in the North Sea and Division IIIa combined at 1 January 1997. The ICA estimate of all age groups from 0 - 9+ is used (Table 2.8.3). 0-ringers at 1 January 1998 are set at 44,000 million.

The input data used for the short term predictions are given in table 2.10.1-3. In summary:

Catches by Fleet: 1996-data from Input Files Table 2.2.8.

Stock numbers:
For 1996 the total stock number was taken from ICA (Population Abundance year 1996).
For 1997 the total stock number was taken from ICA (Population abundance year 1997).
For the 1998 0-ringer the stock number was set to 44,000 million which is the arithmetic average for 1959-1995 rounded to billions.

Fishing Mortalities: Fishing mortalities of 0- and 1-ringers by fleet are calculated from catch and stock numbers in 1996. For 2-8+ -ringers the data are taken from Table 2.8.3 for 1996.

Mean Weights at Age in the Stock: the average of the last 2 years is given in Table 2.8.3 (Weights at age in the stock), 1996 values.

Maturity at Age: Unchanged, from ICES (1996/Assess:10), Table 2.8.3.

Mean Weights in the Catch by Fleet: A mean of the last two years was taken, *i.e.* 1995 and 1996, Table 2.10.3.

Natural Mortality: Unchanged, from CM (1996/Assess:10), Table 2.8.3.

Proportion of M and F before spawning: Unchanged, from CM (1996/Assess:10), Table 2.8.3.

To get a projection as realistic as possible, the calculations were carried out by fleet and area. The proportion of 0- and 1-ringers that occur in Division IIIa is likely to vary between years depending on the size of the year class. The procedure for splitting and the results are shown below.

The split factor used for the short term predictions distinguishes the proportions of autumn spawners being caught in the North Sea and the IIIa area. It does not separate between the IIIa autumn and spring spawners.

For the **1996 split** (Table 2.10.1-3) the IBTS 1-ringer split factor from 1997 was used for the 0-ringer in the previous year with updated rectangle area weights, since it is assumed that the distribution of 0- and 1-ringer between the North Sea and IIIa is equal. Based on this the IIIa proportion was 0.3. For the 1-ringer in 1996 the IBTS distribution of the same year was used and was 0.45 for IIIa.

For the **1997 split** the proportion of 1-ringer was 0.3, as stated above. The 0-ringer proportion was determined by the linear MIK regression (proportion of 1-ringer in IIIa = 0.0019 * MIK (0-ringer) + 0.0644, R=0.6237), where MIK refers to1997 (year class 1996) yielding a proportion of 0.35 for an MIK index of 148.1, (see Table 2.10.5).

For the **1998 split** the 1-ringer were estimated by the regression line from the MIK value for 1997 (y.c. 1996). For the 0-ringer an average MIK index over 1981-1996 y.c. (136.3) was used in order to deriving the proportion of 1-ringer in 1999 (0.32), and the same split was used for the 0-ringer in 1998.

Assessment year	0-ringer distribution	1-ringer distribution
1996	The split-factor of 0-ringers in the assessment-year 1996 is equal to the split-factor of IBTS-1 ringers in 1997.	The split-factor of 1-ringers in 1996 is equal to the split-factor of the IBTS 1-ringers in 1996.
1997 (assessment year)	The split-factor of 0-ringers in 1997 is equal to the regressed 1-ringer distribution of 1998 which is obtained by regressing the MIK value for 1997 (yearclass 1996) to the IBTS split-factor in 1998.	The split-factor of 1-ringers in 1997 is equal to the split-factor of the IBTS 1-ringers in 1997.
1998	The split-factor of 0-ringers in 1998 is estimated by taking the average MIK index for the year class 1981-1996 and using the regression.	The split-factor of 1-ringers in 1998 is obtained from the regression line using the MIK value for 1997 (year class 1996).
		The split-factor of 1-ringers in 1999 is estimated by taking the average MIK index for the year class 1981-1996 and using the regression. The split-factor for 1999 is only used to estimate the split-factor for 0-ringers in 1998.

Comments on earlier short-term projections by area and fleet

A working document was presented (Basson, WD.1997) comparing two short term projection methods for the North Sea herring catches by fleet. The methods compared were the one in current use, which incorporates a 'migration factor' between the North Sea and Division IIIa, and a simpler version based on partial fleet-specific fishing mortalities.

The 'migration factor' is based on a linear regression of the MIK index of lagged recruitment on proportions of 1- ringers in Division IIIa. The validity of this regression was questioned since the y-variate is a proportion and therefore the variance is unlikely to be constant. Furthermore it has the potential to go above one at high MIK indices and to also to go below zero.

Two alternative forms of the regression were explored, a linear model with binomial errors and one with a gamma error distribution. The binomial model has the advantage of being confined to the proportion range 0 to 1 but in fact performs no better than the linear model producing a strong trend in the residuals. The general linear model with Gamma error distribution stabilises the variance and gives a much better fit to the data. The working document concluded that if the method to split the predictions between the fleets using a migration factor is used then the general linear model with Gamma error distribution should be selected rather than the standard regression. However the standard regression would perform adequately over the middle of the range of MIK net indices.

A simpler method using the partial F's by fleet was compared with the standard method. Four versions of the simpler method were explored all using the same basic inputs as the standard method but each with a different method of calculating the partial fleet F's. The first from the catches of the previous year, the second and third using partial Fs from the previous two years and previous three years respectively. These three methods all used weight at age in the catch whilst the fourth version used weight at age from the previous two years and partial Fs from the previous year. Comparisons were made using a series of statistical tests to determine their performance as predictors of fleet catches. The tests applied were the relative sums of squares; percentage bias in the predicted versus the observed catch; the average relative percentage bias and the average absolute difference.

The simpler model using the partial Fs from the previous years catches and weight at age in catch performed as well as or better than any of the other versions of this model.

The comparisons between the migration model and the simpler model showed that the simpler model predicted catches by fleet at least as well as the migration factor model and in some cases it performed better. The results were strongly influenced by the high catch predicted by the migration model for 1993, which caused the model to perform badly compared with the simpler version. Even with the 1993 data removed the simpler model performed as well as the migration factor model.

The Working Group was grateful for the contribution by Basson which stimulated much discussion and focused attention on the problem. In particular the listing of inconsistencies in the input data highlighted potential problems with the current spreadsheet system causing the Working Group to consider these carefully for the 1997 prediction, listing the factors and reasons for their choice.

For the 1997 prediction it was decided not to make any changes to the prediction model or MIK index regression which it uses. It was accepted that whilst the regression with Gamma error distribution was superior in the long term, for 1997 it would make little difference because the MIK index is in the middle of its current range.

The Working Group received a further Working Document on this topic (O'Brien and Darby) but there was not sufficient time to consider it appropriately. This document will be reviewed before the next Working Group meeting.

The Working Group encourages further work to investigate the problems of the fleet prediction method and propose alternative solutions before their 1998 meeting.

Prediction for 1997 and management option table for 1998

Predictions for 1997 based on status quo (1996) fishing mortalities give catches which are significantly above the set TACs. It is however expected that misreportings from the North Sea for Fleet A will continue at the current or even higher level. Therefore, a projection based on fishing mortalities constrained by the TACs are not considered to reflect the total removals from the stock and would overestimate the SSB in autumn 1997. The management option table assuming that the 1997 fishery continues at the 1996 level is given in Table 2.10.4.

The assessments were updated to include misreportings, hence the projections for 1998 account for total removal from the stock. Therefore applying these estimates as TAC to achieve a given level of fishing mortality implies that misreporting will be zero. The Working Group has accounted for an estimated misreporting of around 35,000 t in recent years, increasing to 63,000 t in 1996, although additional misreporting is likely to take place. Use of the catch projection figures provided here for management purposes, should take this into account.

The predicted SSB for autumn 1997 is 688,000 t representing an increase over the autumn 1996 estimate of 539,000 t (Table 2.8.3). This is a result of the reduction in fishing mortality achieved between 1995 and 1996. The estimate of autumn 1996 SSB is higher in this assessment compared to that presented in 1996 assessment of 496,000 t (CM 1996 / Assess:10). This is due to the inclusion of the misreporting in this new assessment. However, the target SSB should be significantly above the MBAL of 800,000 t, (see 2.12) and therefore restrictive management will be required also for 1998 and in the near future.

The *Status quo* (1996) assumption for 1997

While the TAC for fleet A may not reflect the removals made by this fleet, the other fleet TACs could constrain the fisheries. The projection for fleet E for 1997 suggests that the by-catch ceiling under status quo fishing will not be restrictive. A more realistic option may be to assume that TACs or by-catch ceiling for fleets B and D will be restrictive but not a TAC to fleets A and a ceiling for E. Fleet C catches have a dominant contribution of Baltic spring spawning herring and it is therefore difficult to assess if the TAC (including both autumn and spring spawning herring) for this fleet will be restrictive. For the purpose of the short term predictions presented below fleet C is assumed not to be restricted by the TAC. The text table below presents for 1997 the projected yield by fleet and the SSB for autumn 1997.

1997 ('000 tonnes)	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	SSB(autumn)
TAC / by-catch ceiling	159	24	80	10	20	
Status quo (1996) fishing mortalities	257	58	24	13	10	688
Status quo (1996) Fleet A, C and E, restricted fleets B and D as explained in text	257	24	24	10	10	689

Comment: The TACs for fleet C-E include catches of spring spawners.

This scenario is continued into 1998 where it is assumed that the F= 0.2 regime is implemented and misreporting has come to a halt and is presented to show the effect for the short term prediction in 1998 of the *status quo* assumption for 1997 made for calculation of Table 2.10.3.

Projected yield and SSB (autumn 1998) based on a F = 0.2 regime for 1998, see section 2.15 *ad* 1.3 b) for details

1998 ('000 tonnes)	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	SSB(autumn)
Status quo (1996) fishing mortalities	223	29	19	7	6	1061
Unrestricted Fleet A, C and E restricted fleets B and D as explained in text	221	29	33	7	6	1055

2.11 Medium-term projections

The Working Group considered point (b) in the terms of reference in which it is asked for medium-term forecasts of catch by fleet, and the development of SSB on stochastic recruitment around a conventional stock-recruitment relationship. In the terms of reference, the following levels of exploitation are specified:

- Fleets B,C, and D (and also assumed for fleet E):
  levels of fishing mortality of 0, 0.1, 0.2 and 0.3.
- Fleet A: levels of fishing mortality of 0.2 and 0.3

The method used for the calculation of stochastic medium-term projections was the same used in last years' assessment and follows the procedure described in ICES (1996/Assess:10). It is summarised here again for convenience. The vector of parameters **X** (comprising the fishing mortality at reference age, the selections at age, the fitted populations in 1995 and the expected recruitment in 1996) is estimated by the assessment procedure on a logarithmic scale with variance-covariance matrix **C.** The projection method is based on drawing Monte-Carlo pseudo-data sets to initiate the projections with a mean **X** and multivariate normal errors **C.** Recruitment, however, is treated differently. A Beverton-Holt stock-recruit relationship fitted with an assumption of first-order autocorrelated errors was assumed, as recommended by ICES (1995/Assess:13). A non-parametric bootstrap method was used to generate recruitments in the pseudo-data sets used for the projections. An updated version of the 'ICPROJ' software (named ICP3) was used which is compatible with the new 'ICAv1.3' assessment software, but implements the same method.

- The working group has interpreted the request as to hold that the human consumption fleet in the North Sea (Fleet A) should subject the stock to a fishing mortality of 0.2 or 0.3 (defined as an arithmetic mean from ages 2 to 6 w.r.). The fleets B (industrial by-catch in the North Sea), C, (IIIa human consumption), D(IIIa mixed clupeoid) and E (IIIa industrial) were supposed to be of primary importance for the juvenile autumn-spawning herring. Forecasts based on fishing mortality on age 1w.r. by these fleets at levels of F=0, 0.1, 0.2 or 0.3 were calculated.

The following options are as specified for the short-term options (see Section 2.10. and are described here again for convenience:

- The maturity ogive as measured in 1996 has been assumed to hold for the years 1997 and thereafter.
- The natural mortality that was used for the assessment has been assumed to hold for the years 1997 and thereafter.
- The proportions of F and M before spawning in the projections were as used in the assessment.
- The weight at age in the stock for forecasting purposes was taken as the mean value from 1995 and 1996.
- The weights at age in the catches by fleet were also taken as the mean values from 1995 and 1996
- The projections start from the populations on 1 January 1997 calculated in the assessment procedure. The exploitation in 1997 was assumed to be as for 1996. Therefore, the two sets of projections (see next paragraph) assume different F-at-age vectors for 1997. Therefore, the starting population on 1 January 1998 differs with respect to age-groups 1-w.r. and 2-w.r. The optional F-regimes all begin in 1998.

Two choices of selection pattern were made for forecasting purposes and all options (except for Fjuv =0, for obvious reasons) were calculated with either selection pattern. In the first series of forecasts, the selection pattern used was that estimated in the separable model fit, *ie* a pattern fitted over the period 1992 to 1996 with catch residuals for 1996 for age-groups 0-w.r. and 1w.r. downweighted. If however new management arrangements imposed in 1996 to reduce the mortality of juvenile fish continue to be imposed in the future, that pattern could be unrepresentative of future developments. In order to make forecasts consistent with such an assumption, a second series of forecasts was made with an adjustment to the selection pattern made in order to reflect the selection for juveniles in the fishery observed in 1996. This was done by replacing the separable fishing mortality estimates for ages 0 and 1 with Baranov catch equation estimates consequent upon the fitted cohort abundance on 1 January 1997 and the reported catches at age of 0 and 1 ring fish in 1996. Making this adjustment changes the selection at age 0 from 0.3600 to 0.1660 and at age 1 from 0.3994 to 0.5216.

A summary of input data (additional to that used in the assessment) is given in Table 2.11.1. In this example, fishing mortality for fleet A has been set to 0.3 (by using an F-multiplier of 0.921for fleet A), and the fishing mortality at age 1 has been set to 0.2 by setting an F-multiplier for fleets B-E of 1.347.

The stock-recruit relationship used is shown in Figure 2.11.1. In trials, it was found that the fitted parameters were quite strongly dependent on the year-range chosen for the analysis, due in part to an outlier in 1959 (low recruitment at high stock size). The matter could not be resolved in the time available, but it was a matter of significant concern to the working group. A need was identified to re-validate the entire historic time series of catch-at-age data and the use of maturity ogives before the question could be resolved appropriately.

The medium-term projection scenarios modelled are summarised in Figure 2.11.2 and also given in detail in Figures 2.11.3-2.11.10 using the separable (1991-1996) selection pattern, and in Figures 2.11.11-2.11.16 using the selection pattern adjusted for altered exploitation of 0 and 1-ringers observed in 1996. Note that these figures are drawn with automatic scaling, and that the y-axes are different among different sets of projections.

2.12 Management Considerations

The 1996 assessment shows the stock to be in a serious state and well below the firmly established MBAL of 800,000 t. The 1996 SSB is estimated at 539,000 t and the 1997 SSB is predicted to be 688,00 t. There is strong evidence that this is a reasonable MBAL for this stock (ICES 1996/Assess:10). It is therefore of paramount importance that the SSB is brought back above this level quickly. With recruitment (1-ringers) in 1997 above the average of recent years and the MIK (0-ringers) surveys in 1997 suggesting an average recruitment, the spawning stock biomass could become above the MBAL in 1998, if the ACFM strategy is followed, with a spawning stock biomass above around 1 million tonnes.

The Working Group considers that the management measures for these fisheries for North Sea autumn spawners should aim at a spawning stock biomass in following years well above the MBAL level and the fishing mortalities choosen should be guided by the precautionary approach as is outlined in Section 2.9. Section 2.15 provides further information on target and limit reference points.

The by-catch of herring in the small mesh fisheries decreased in 1996 compared with the level of 1995. The Working Group considered that this decrease was related to the management measures to regulate the industrial fisheries. The Working Group continues to be concerned about the impact that the industrial fisheries, taking juvenile herring, have on herring recruitment and SSB. It is also worth noting that the total catch of North Sea autumn spawners, taken in all areas in 1996, still comprises more than 75% immature fish (in numbers), which is still high and similar to the 80% in 1995, despite the change in mangement measures.

The Working Group continues to be aware of large scale misreporting of catches in several parts of the North Sea into adjacent areas (see Sections 2.1.2 and 2.2.1). Misreported catches from 1984-1996 from Division IVa to VIaN at the 4°/5° boundary was included in the catch in numbers used for the assessment by the Working Group. This allowed those catches to be moved into the North Sea assessment for the first time, with some confidence. However, it is expected that even more misreporting takes place of which the Working Group is not aware.

The larvae surveys suggest that spawning stock biomass has declined in 1995 to the lowest level since 1980, but increased in 1996 to about an average level. The situation in the southern North Sea and eastern English Channel area appears to be less serious than last year, because of recent relatively good recruitment. The spawning stock biomass is separately managed in this component of the North Sea stock.

2.13 Requests from the multispecies Working Group

The Multispecies Assessment Working Group requested data on quaterly catches and mean weights at age in the catch and stocks for 1996, by statistical rectangle of the North sea for herring. But these data, at this level of detail are not available, and they are provided in the same form as previous years.

2.13.1 Quarterly data base (numbers and mean weights at age)

Quarterly catch-at-age data, together with quarterly weights at age in the catch and in the stock at spawning time for North Sea herring for 1996 are provided in Table 2.13.1.

Weight-at-age data for the stock at spawning time are best provided by samples taken during the July acoustic surveys which cover Divisions IVa and IVb, and these are shown in the bottom line of Table 2.13.1.

A comparable breakdown of catches of spring spawners taken in the North Sea and transferred to Division IIIa is shown in Table 2.2.3.

2.13.2 Geographical distribution of the catches in the North Sea in 1996

Data on the geographical distribution of catches in the North Sea (sub-areas IV and Division VIId) in 1996 were available from Denmark, the Netherlands, Norway, Sweden, the U.K. (Scotland and England), Germany and France. The data represents the total catch (both juveniles and adults), but misreporting (from VIa) are not include. Figures 2.13.1 - 2.13.12 show the catch by ICES rectangles for each month.

2.14 Quality of the Assessment

The assessments carried out from 1990 onwards show a systematic overestimate of the spawning stock biomass. At the assessment Working Group meetings in 1991-1997 the spawning stock biomass has considerably been reduced by each following assessment until 1996 (Figure 2.14.1). The Working Group tried to explore what might have caused this downward re-evaluation of spawning stock biomass over such a long time period.

The trends in biomass from three different surveys that include biomass information on the adult part of the stock were examined over the period 1984 - 1996/1997 (Figure 2.14.2). The adult biomass from the acoustic survey, the MLAI index from the herring larval surveys and the adult biomass from the 1st quarter IBTS survey were compared to the biomass estimate from this years assessment. To make these indices comparable they were normalised to 1 over the period 1984-1996. The information from the catch in number data (see biomass from this years assessment) does not agree with the survey indices on adult biomass. Up to 1988 the catch in number data indicated a higher biomass than the survey indices, while after 1990 this changed and the opposite was observed. This might have caused this trend in SSB overestimation during the years 1991-1996. Another factor, which might have affected the estimation of SSB, are the missing catches. These missing catches also could include loss of fish by the *Ichthophonus* disease. Patterson (1997b WD and 1996) used a population model similar to the Working Group's assessment model but excluding catch information to investigate what change in perception in stock size, fishing mortality and landings occurs when the assumption that catches are estimated without bias is relaxed to the assumption that catches are unknown. Figure 2.14.3 shows that especially the SSB is underestimated when the missing catches are high (1987-1991). The successive downward re-evaluation of the spawning stock biomass during the period 1991-1995 might have been caused by these missing catches.

The effect of uncertainty in the stock assessment model parameters on the present perception of stock size due to stochastic noise (ie excluding possible model mis-specification) was considered by a simple procedure. Conventional separable VPAs were initiated with fishing mortalities of F +se and F -se (where F and se are the estimated reference fishing mortality in 1996 and the corresponding estimate of the standard error of this parameter). Spawning biomass trends so estimated are plotted together with the Working Group's final assessment model estimates of SSB (Figure 2.14.4). This shows that the model fit appears to give reasonably precise estimates of stock size, and the biomass corresponding to the lower standard error of estimated fishing mortality is well below the MBAL. Such considerations obviously exclude parameter correlations, but may provide an indication that the perception that current stock size is less than MBAL is fairly robust to noise in the data.

The assessment procedure used prior to 1995 included shrinkage to mean biomass. In a period of decreasing biomass this would plausibly lead to overestimation in stock size in addition to the matters considered above.

Furthermore the uncertainty on the unallocated/misreported catches also influences the assessment.

2.15 Request from the European Commission and joint request from the European Commision and Norway

These requests are listed in Section 1.3. The letters below refer to that list.

ad 1.3 a)-b) Fleet Structure for short term forecasts

ad 1.3 a)

The Herring Working Group recognises that the fleet definitions are made for management purposes. The stock assessment is based on estimates of total removals from the stock combined with a series of stock indicators obtained from research vessel surveys. The stock estimates therefore only depend on the fleet definitions in as much as the catch and effort statistics and the biological sampling use these "fleet" for stratification in the sampling schemes.

The fleet definitions presented above differs from those previously used when presenting catch-at-age data. These definitions differed between countries. The Norwegian definition was based on which quota the herring catch was counted against. The Danish and Swedish definition were based on whether the fish were landed for reduction or for direct human consumption purposes. There was also a difference in the definition of fleets C and E between Denmark and Sweden. Fleet E (Denmark) was the fisheries for Norway pout and sandeel plus in some years, sprat. Fleet C (Denmark) was the directed herring fishery. For Sweden fleet C was the proportion of the catches from the directed herring fishery that went for human consumption while another proportion was recorded under fleet E since that proportion was used for reduction purposes. Therefore application of the above fleet definition requires rebuilding of the catch-at-age by fleet database.

The herring fisheries in the North Sea and in Division IIIa may be grouped into:

- Directed herring fisheries (Fleets A and C).
- Fisheries where herring is taken as by-catch (Fleets B, D and E).

The first group of fisheries include both trawlers and purse seiners. Most of the trawlers use 32 mm but there is little difference in the size compositions with mesh size. Likewise the trawlers catch composition differs little from that of the purse seiners as the trawlers and the purse seiners exploit the same fishing grounds and land herring for the same market. Of course all these vessels aim to obtain a quality and a size composition giving the highest price. The landings from vessels participating in this fishery may be sorted and some proportion sold for direct human consumption while the remainder of the landings are used for reduction. In other cases the entire landing goes for either human consumption or reduction. The earlier definition that includes the usage made of the herring is not adequate for fleet definitions. A definition based on the use of 32 mm or not is not relevant either since similar catch compositions can be obtained both with 32 mm and smaller meshes. The key factor is whether the fishery is directed for herring or not. This is determined by season and fishing grounds.

The second group includes the industrial fisheries for sprat, Norway pout and sandeel. These fisheries are conducted with 16 mm or less. Herring appears as by-catch in various proportions in these fisheries. However the Norwegian industrial fisheries have previously been grouped with fleet A. This was a consequence of the Norwegian point of view that all herring landings should be counted against a quota.

The fleet D (mixed clupeoids) is defined because of the specific regulation for this "fleet". The vessels fishing under this set of regulations only do so for some period of the year and the same vessels will in other seasons be part of fleet C or E or be fishing in the Baltic Sea. Sweden conducts under this regulation a small (about 5,000 tonnes annually) fairly clean sprat fishery. Herring is only a minor by-catch in these catches.

The gillnet fishery for herring in Division IIIa produces catches with very different size compositions from those of the trawlers and the purse seiners. However this fishery is small and is ignored for the present analysis.

The redefinition following the EC proposal would make it easier to relate the various herring quotas and by-catch ceilings to the landings.

The EC definition of the fleets is therefore proposed to be changed to:

North Sea

Fleet A: Directed herring fisheries with purse seiners and trawlers
Fleet B: All other vessels where herring is taken as by-catch

Division IIIa

Fleet C: Directed herring fisheries with purse seiners and trawlers
Fleet D: Vessels fishing under the mixed clupeoid (sprat) quota
Fleet E: All other vessels participating in fisheries where herring is taken as by-catch

These definitions have been used in the attempt to rebuild the database reported below.

The industrial species referred to below are blue whiting, Norway pout, sandeel and sprat.
The changes in the database required to follow the above fleet definitions are then:

- Norwegian fisheries for industrial species for should refer to fleet B.
- Swedish fisheries in Division IIIa for herring should all refer to fleet C.
- UK (Scotland) fisheries for industrial species should refer to fleet B
- Danish (Faroe Islands) fisheries for industrial species should refer to fleet B.

Because of the short notice given to the Working Group on the additional requests it has not been possible to deal with all aspects of rebuilding the database. It was only possible partly to rebuild the database for 1996. No attempt to rebuild the database for 1995 and earlier years was made.

The Norwegian catches of herring in 1996 in her fishery for blue whiting, Norway pout and sandeels amounted to 630 tonnes and those in her sprat fishery to 778 tonnes. However in the short time available it was not possible to recalculate the age compositions of these specific components. Therefore the age compositions presented for 1996 in Table 2.2.8 include these catches under fleet A. There is data available for 1994 and 1995 that allow rebuilding this part of the database.

Swedish data were available which allowed the Group to rebuild the data base and the age compositions for 1996 presented in Table 2.2.8 include these Swedish catches under fleet C instead of as under fleet E as in previous years. There are data available for 1995 that allow a rebuilding for this year. No data exist for earlier years. Whether it may be possible to rebuild the database based on Danish data for these earlier years can only be answered after analysis which due to time constraints was not possible at this meeting.

Concerning the UK (Scotland) and Denmark (Faroe Islands) catches there were no biological data available and their catches are included under fleet A. Apparently there is no biological data available for 1996 and earlier years which pertain to these catches. However it may be reasonable to apply Danish samples from Esbjerg to these minor catches.

In conclusion:

- The rebuilding of the database was only attempted for 1996 and this rebuilding was not complete
- There are data available for the most recent years which will allow a complete. rebuilding of the data base. National laboratories however need some time to extract and analyse these data.
- It is unlikely that a reliable rebuilt database based on the new fleet definition will be possible for years prior to 1994, and most likely data for that year will be unsatisfactory for rebuilding the database.

Rebuilding of the database is most likely best dealt with at an ad-hoc meeting between EC and Norway with participation from national statistical offices and from the research laboratories. Definition and reliability of sampling schemes for species compositions for the industrial fisheries were previously dealt with in this manner.

ad 1.3 b) Recalculation of catch predictions for 1997 and associated biomass

The target for 1997 set by ACFM in May 1996 was that the fishing mortality in 1997 of all fleets be reduced from the 1995 level by 75 % corresponding to an $F_{2\text{-}6}$ of 0.2. Based on the assessment presented in Table 2.8.3 the fishing mortalities by age were:

	1995	1996	1997 = 0.25 * F(1995)
F 1-wr	0.3482	0.204	0.0871
F 2-6 wr	0.8158	0.3482	0.204

The projection presented below applies a reduction factor of 0.204/0.3482 = 0.586 to fleet A and a reduction factor of 0.0871/0.204 = 0.427 to fleets B, C, D and E to the exploitation pattern and level for 1996. The stock sizes and other stock descriptors are as described in Section 2.10.

	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	Total Catch	SSB (Autumn 1997)
ACFM May 1996 Table 2 Option C	159	24	11	3	21	218	700
Revised Prediction based on assessment presented in section 2.8	162	25.6	11	5.7	4.6	209	758

ad 1.3 c) Calculation of equilibrium spawning biomass and equilibrium yield

A calculation of equilibrium spawning biomass and equilibrium yield was made under the assumption that growth and mortality are stock-independent and can be represented by a long-term mean, and by recent Working Group assumptions respectively. An assumption of long-term stochasticity in recruitment is also made.

The calculating method used was to calculate 100-year age-structured stock projections under constant-F regimes, with starting values and parameter estimates taken from CM (1995/Assess:10). The projections were run for 100 years forwards, taking the last 10 years as representing the equilibrium state. Choice of input parameter and treatment of uncertainty are summarised below:

Natural Mortality: Working Group assumptions used, no uncertainty modelled.

Exploitation pattern: As calculation of equilibrium SSB and yield as function of the level of fishing mortality clearly requires the specification of an exploitation pattern, and in the absence of a working definition of a precautionary exploitation pattern, the Group has used the average pattern 1991-1995 exploitation pattern by fleet (ICES 1996/Assess:10). This differs from the 1996 pattern. No uncertainty modelled.

Fishing Mortality: Treated as a control variable and therefore no uncertainty modelled. Fishing mortality by fleet was modelled as the product of a fleet-specific F-multiplier and a fleet-specific exploitation pattern. In the simulations, the same F-multiplier was used for fleets B-E

Weights at age in catches: Mean values 1991-1996 by fleet used. No uncertainty modelled.

Weights at age in the stock: Mean values 1991-1996 used. Uncertainty based on historic variability (as log-transformed normal variate).

Maturity Ogive : Mean values 1976-1995 used. Uncertainty modelled based on historic variability (As arcsine-transformed normal variate).

Recruitment: A Beverton - Holt stock recruitment relation extended with a 1-year lag autocorrelation was used. The parameters were estimated based on the estimates of SSB's and the strength of 0-ringers for the years 1958-1996. This relation is fairly similar to the one used for equilibrium studies (Section 2.9) and for simulation of management regimes below. The stochastic model was bootstrapping (resampling with replacement) of the log residuals in the above mentioned fit.

For the purposes of equilibrium calculations, it is appropriate to take population parameter values over as long time span as possible. Choices made over year ranges are therefore different to those made for medium term projection purposes (Section 2.11)

ad 1.3 d)

The calculation was made for a range of fishing mortalities (F-Multipliers referenced to the F in 1995 as estimated by ICES 1996 CM/Assess:10) as below:

Fleet A: (referenced to Mean F at ages 2-6 = 0.8010) : range 0.1 to 0.8.

Fleets B-E (referenced to F at age 1 =0.3756): either: scaled as above, or scaled =0.75, 0.67, 0.5 or 0.25 relative to the fleet A F-multiplier.

Appropriate percentiles of the distributions of the estimated equilibrium stock size, the catch by all fleets, and the catch by fleet so obtained are given in Figures 2.15.1-2.15.10 . This information is provided in response to terms (c) and (d) of the request by EU and Norway.

ad 1.3.e) Reference Points for Fishing Mortality and Stock Biomass

The answer to this request is covered by the considerations in Section 2.9

as 1.3 f). Harvest control laws

Achieving the objective of keeping the risk of SSB<800 000 tonnes below 5%, depends on the management regime (the harvest control law applied). The simulations presented in Section 2.9 are based on the particular regime of a fixed target fishing mortality being applied every year to the stock.

Some consequences of one possible alternative class of harvest scenarios has been considered here using a management simulation approach. A harvest control law has been modelled in which management actions are taken in response to the current perception of stock size from an assessment procedure.

Representing the current perception of stock size as SSB, and two reference levels of stock size used for management purposes as Limit 1 and Limit 2 (e.g. MBAL), corresponding management actions may be taken, e.g.

Assessment - SSB estimate	Level	Fishing mortality used for setting TAC
Limit 2 < SSB	High	Limited by precautionary upper limits
Limit 1 (MBAL) < SSB < Limit 2	Medium	Limited by some factor, e.g. 0.5, of precautionary limits
SSB < Limit 1 (MBAL)	Low	0 and a small by-catch allocation (F=0.05)

The introduction of such a safety zone, betweeen limit 1 and limit 2, should not lead to higher target F's than specified by the precautionary calculation presented under ad 1.3 c) and in section 2.9, and the limit of this zone should not be taken as a target.

The range of safety zone should be set to absorb the variability in the development in the stock, but also the uncertainty in the yearly assessments. These uncertainties include mis- and non-reporting of catches. Uncontrolled fisheries, e.g. in international waters, will add to the uncertainty of the predicted effects of a set TAC.

Some characteristics of the performance of such a control regime has been investigated by simulation. In these trials, recruitment was modelled using the Beverton - Holt parameters as described in Section 2.9. A four- term autoregressive model was applied. Other input data were according to this years assessment. In order to illustrate the performance of such a three level system, simulations were compared to a system where the TAC was set to a fixed target independent of the assessed state of stock.

The lower limit (limit 1) has in all simulations been set to MBAL 800,000 tonnes. The effect of the upper limit (limit 2) was investigated for three levels (1 mill tons, 1.2 mill tons and 1.5 mill tons) these simulations are made under the assumption that the assessment is perfectly precise and that the catches actually taken are exactly those decided by the management rule.

A target fishing mortality was calculated as that value which gives a 5 % risk of the SSB falling below MBAL at least once in ten years. This value was calculated for each of the four simulated scenarios.

The decision rule used was

Level	Estimated SSB	Decision
3	SSB above limit 2	TACs set at target Fs
2	Limit 2> SSB > Limit 1	TACs set at 0.5 of target Fs
1	SSB below Limit 1	TACs set at 0 but assuming a residual fishing mortality of F = 0.05 for all fisheries

The comparisons were done on three parameters

- The probability that the SSB would drop below limit 1 (MBAL) at least once in the coming ten years (1998-2007).
- Probability of being in each of the levels in the 10'th year.
- The total cumulated yield over this ten year.
- The lower 10 % percentile and the upper 90 % percentile of the total cumulated yield for these 10 years.
- The year-to-year variation, expressed as the range of the catches in the last five years 2003-2007 divided by the average catch for these years.

The results are shown in the text table below. It may be noted that the exact probability of SSB<Limit 1 is quite sensitive to small changes in the fishing mortality level. Therefore, the scenarios in the table can be considered comparable with respect to risk level.

	Fishing mortality above Limit 2	**Probability**		**Cumulated catch (1000 tonnes)**			**Year-to-year varia-tion**
		SSB<MBAL at least once in 10 years	Level 1 - 2 - 3 in year 10	10% Fleets B-E Fleet A	50% Fleets B-E Fleet A	90 % Fleet B-E Fleet A	
Fixed F	0.37	0.05		680 3700	1057 5100	1608 7409	73 38
Three level System Limit 2 = 1,000,000 tonnes	0.50	0.02	0 - 23 - 77	672 3650	1213 5121	1949 7648	93 83
Three level System Limit 2 = 1,200,000 tonnes	0.65	0.03	1 - 55 - 44	668 3721	1174 5200	2165 7391	122 108
Three level System Limit 2 = 1,500,000 tonnes	0.70	0.03	0 - 82 - 18	652 3687	1083 5160	2013 7529	120 109

These results show that by setting a level 2, a higher fishing mortality can beapplied in the upper level, at comparable levels of risk of SSB<Limit 1. In practise, however, if Limit 2 is relatively high, the stock will most likely be in Level 2, where the fishing mortality is comparable to that in the Fixed F regime, the medium term catch will be approximately the same, and the year-to-year variations much larger. With a lower Limit 2, the fishing mortality cannot be increased much, and again, the year-to-year variation increased considerably.

Perceptions of risk (in terms of P(SSB<MBAL)) obtained above are predicated on the assumption that the population dynamics model is appropriate for the stock and that unbiased estimates of stock size are returned by the survey and assessment procedure. If a systematic bias in stock size estimation occurs, as is thought to have happened from 1991 to 1994, then perceptions of risk are significantly altered. Effects of assessment overestimation have been investigated briefly by simulating a positive bias in the annual SSB estimation with a stochastic distribution of N(20%,s.d. 10%). For the fixed F scenario the risk changes from 5% to 40% and for the other simulations the change is from 5% to a range from 64% to 88% depending on the modelled scenario. The fixed-F strategy is therefore much more robust to assessment errors.

ad 1.3 g) The statistical reliability of the sampling data on which the operation of the current by-catch quotas depend

EC has held several expert meetings where the term of reference has been to evaluate the monitoring schemes in EU countries and Norway. The first meeting was held in 1993 in Bergen, Norway, the second and third one in Bruxelles, Belgium.

At the Herring Assessment Working Group meeting 1997, a Working Document (Dalskov, 1997) was presented. This WD deals with the Danish monitoring scheme and presents estimates of uncertainties in the estimations of catch by species.

Danish Regulation and management scheme in 1996

By-catches of herring in the small meshed fishery.

Denmark after July 1996 has used a sampling scheme of its small mesh fisheries for continuous monitoring of the species composition for management purposes. This scheme was implemented in 1991 but before July 1996 was only used for scientific purposes. The management actions taken based on the monitoring scheme is to close fisheries in areas or in periods in order to maintain by-catches of herring within permitted levels.

The Danish plan for management of landings with herring by-catches implemented from the 2. half of 1996 included upgrading of the Danish monitoring scheme on species composition, a licence scheme, effort limitations and tightened control. Fishing vessels shall communicate entry into and exit from fishing areas as well as transit through an area closed for small meshed fishery. Vessels holding a special fishing permit for small meshed fishery shall be willing to receive observers on board.

The Danish sampling scheme operates in **all** Danish ports where landings from the small meshed fishery can take place.

The number of samples from the small meshed fishery was increased from a level around 900 to approximately 1300 between 1995 and 1996. This extra sampling effort was used in the period from 1 August to mid December, the period where, historically, by-catches of herring often occur.

The key to a reliable statistical sampling program is random sampling. Therefore a computer based random number generator was introduced to select vessels for sampling of their landings. The selection of vessels for sampling is made by the central authorities. In order to facilitate this selection process the vessels shall announce landings 6 hours before entry to port. Finally, in order to improve the effectiveness of available personnel and control resources, small meshed landings were forbidden on weekends and limited to certain hours of the day.

The sampling level goal was 1 sample per 1,000 tons landed. The sampling is not proportional to the landing size as this would overrepresent large vessels. Therefore the program gives landings by small vessels a higher weight. In addition, samples for scientific purposes were collected.

The desired sampling level for 1996 was more than reached. In 1996 1 sample per 630 tons landed was taken.

The total number of samples taken in landings from the North Sea, Skagerrak and Kattegat in the years 1991 to 1996 are given in the Text Table below.

	1991	1992	1993	1994	1995	1996
Species composition	824	1,109	819	847	931	1,307
Scientific	307	422	467	364	360	268
Total number of samples	1,131	1,531	1,286	1,211	1,291	1,575
Landings ('000 tonnes)	1,207	1,376	1,973	1,225	1,345	1,004

Uncertainty of catches and age-distribution in the small meshed fishery

The most important species caught in the small meshed fishery in the North Sea are sandeel, Norway pout and sprat with by-catches of herring, haddock and whiting. The estimation of the catch in weight and number together with uncertainty in the estimations of the catches of all these species is discussed by Lewy (1995, 1996) based on data from 1993. The main results are:

The coefficient of variation for catch weight per species in the small meshed fisheries in the North Sea in 1993, in percent.

Sandeel	Norway pout	Herring	Sprat	Whiting	Haddock
1.1	2.8	6.5	4.6	10.2	15.6

The 95 percent confidence interval for the total catch in thousand tonnes for each species in the small meshed fisheries in the North Sea were correspondingly estimated as

Sandeel	Norway pout	Herring	Sprat	Whiting	Haddock
472 - 492	92 - 102	88 - 114	139 - 167	14 - 22	4.9 - 15.6

The relative uncertainty of the estimated catch weight is minor for sandeel and Norway pout, moderate for herring and sprat and larger for haddock and whiting.

Norwegian monitoring scheme for small meshed landings

Norwegian fisheries for Norway pout, sandeel, blue whiting, sprat and horse mackerel are sampled according to a revised sampling program which was started in autumn 1996.

Samples of the landings are taken following the guidelines shown below

Fishery	Samples for species distributions	Samples for length measurements
Norway pout	20 % of landings	10 % of landings
Sandeel	10 % of landings	10 % of landings
Blue whiting	10 % of landings	10 % of landings
Sprat	33 % of landings	33 % of landings
Horse mackerel	20 % of landings	5 % of landings

The number of samples taken from the Norwegian small meshed fishery has increased over the years. In 1994, 191 samples, in 1995, 350 samples and in 1996, 578 samples were taken.

On top of this sampling the purse seine fishery for sprat was sampled. In 1996, 25 samples were taken.

There was no information available on the scheme for selection of which landing to be sampled.

Swedish monitoring scheme for small meshed landings

In 1996 a monitoring scheme started in Sweden. In Sweden there is only one fish meal and oil factory, Engholmen. At this factory all landings since April 1st 1996 have been sampled. In the beginning of 1997 Denmark and Sweden agreed that the Danish Fishery control will sample landings by Swedish vessels in Danish port.

At Engholmen three samples are taken from each landing and for Swedish landings in Denmark the Danish selection scheme will apply.

Scottish monitoring scheme for small meshed landings

No information on the Scottish monitoring scheme for small meshed landings were available for the Working Group.

***ad* 1.3 h) Ratio of Admixture of North Sea herring and SW Baltic-IIIa spring spawning herring in Division IIIa**

This problem is currently under investigation by an EC project (study project 1996/073) which started 1st March 1997 and is expected to report by early 2000. The summary presented below is therefore very preliminary. The rate of admixture is discussed in more details in Section 3.2.3-6.

Data are mainly available from R/V cruises. However the analysis on the vertebrae counts presented in Figure 3.2.5 indicates that R/V data underestimate the admixture of North Sea herring in the catches.

The methods for identifying spring spawning herring in the catches has been improved recently, (Mosegaard and Popp Madsen 1996). Data for 1996 were obtained by this new method, data for earlier years were obtained by older methods. The new method is considered superior to older methods and therefore these older data are discarded for the time being until their validity are further investigated by the EC project.

The salient points of the analysis presented in Sections 3.2.3-6 are:

1. Based on R/V data it appears that:

   - The 0 wr herring in Division IIIa are dominated by autumn spawners.
   - The 2 wr herring in Division IIIa are dominated by spring spawners in the 2nd half of the year.
   - The 3+ wr herring in Division IIIa are all spring spawners.

   The three above points are in agcement with the assumption made for the short term prediction for the North Sea autumn spawning herrring.

   - The admixture for 1+wr differ between Skagerrak and Kattegat.

2. There is no analytical assessment for the SW Baltic Division IIIa herring complex available and it is therefore not possible to construct a model which annaully predicts the contribution of spring spawning herring to the catches in Division IIIa based on projected recruitments.

Because of the lack of an analytical assessment of the spring spawners the best advice possible at present would be to use an overall admixture rate based on R/V data for 1996. Based on data presented in the text table in Section 3.2.3 this admixtures in weight by fleet are given below:

	Fleet C	Fleet D	Fleet E
Admixture of spring spawning herring % wt	74.6	9.5	29.0

_ad_ 1.3. h) Appropriate fishing mortality rates for the SW Baltic-IIIa spring spawning herring

In the absence of an analytical assessment, this question cannot be addressed at present.

Annex to 2.15 Description of management simulation program

In order to explore a three-level regime, a medium term simulation program was developed, (Skagen, Working Document 1997b). It takes into account several sources of uncertainty of the developement of the stock, and in addition allows for exploring the effects of bias in the assessments and in discrepancies between quotas and actual catches.

This program is essentially a routine for Monte-Carlo simulation of medium term predictions over 10 years. Connected to this is a decision model, by which a decision on quotas is taken every year according to a predefined rule, based on the projected SSB (with optional bias) in the year when the quotas apply.

In the present version, the predictions start with random initial stock numbers, drawn assuming a multiple lognormal distribution with means and variances - covariances taken from the ICA assessment. Recruitments are drawn assuming a Beverton - Holt function with normally distributed log residuals. The log residuals may optionally be modelled as an autoregressive process driven by a normally distributed noise term. Stochastic weights in the stock and in the catches, as well as maturities at ages were obtained by using the input data for the assessment for the last 10 years, by drawing, each time such a number is needed, a random year and using the data from that year.

The model assumes that decisions are taken each year about catch quotas according to predefined rules. The rules include 3 levels of SSB as described above. Separate rules apply to fishery for 0 - 1 ringers (juveniles), and for older fish (adults). For each level and each fishery, an F-value and a maximum catch is specified. The F-values represent F_{0-1} and F_{2-6} respectively, under a given selection pattern. In addition to a combined regime, a fixed F regime can be simulated by setting the maximum catch extremely high, and a fixed catch regime can be simulated by setting the F-value extremely high.

There is an option to multiply the true SSB in the stock with a random factor - normally distributed with specified mean and SD, which is to simulate the effect of uncertainty in the assessment. The decision of which level to apply is taken based on the predicted SSB in the year where the decision applies, as this SSB is assumed by the decision maker. The F-values to be applied are translated into quotas using the stock numbers according to the assumed population. A multiplier can also be applied to the catches, so that the actual catch influencing the stock can differ from the quota decided by the manager. The catches as they really are, are transferred back to true fishing mortalities which are used to model the further development of the true stock.

Finally, there is an option to use the 30 percentile of the recruitment distribution at the assumed SSB instead of the actually drawn recruitment to set the quota for fisheries that include 0- ringers, as the recruitment will largely be unknown at the time the decision is taken. This option is not used in the present simulations.

Table 2.1.1 North Sea HERRING (Sub-area IV and Division VIId). Catch in tonnes by country, 1983-1994. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1985	1986	1987	1988	1989	1990
Belgium	3,482	414	39	4	434	180
Denmark	129,305	121,631	138,596	263,006	210,315[2]	159,280[2]
Faroe Islands	-	623	2,228	810	1,916	633
France	14,400	9,729	7,266	8,384	29,085	23,480
Germany, Fed.Rep.	8,930	3,934	5,552	13,824	38,707	43,191
Netherlands	79,335	85,998	91,478	82,267	84,178	69,828
Norway[4]	159,947	223,058	241,765	222,719	221,891[2]	157,850[2]
Sweden	2,442	1,872	1,725	1,819	4,774	3,754
UK (England)	5,564	1,404	873	8,097	7,980	8,333
UK (Scotland)	55,795	77,459	76,413	64,108	68,106	56,812
UK (N.Ireland)	-	-	-	-	-	-
Unallocated landings	74,220	21,089	58,972	33,411	26,749[2]	21,081
Total landings	533,420	547,211	624,907	698,449	694,135[2]	544,422
Discards[3]	-	-	-	-	4,000	8,660
Total catch	533,420	547,211	624,907	698,449	698,135	553,082
Estimates of the parts of the catches which have been allocated to spring spawning stocks						
IIIa type	6,958	17,386	19,654	23,306	19,869	8,357
Coastal type	520	905	490	250	2,283	1,136

Country	1991	1992	1993	1994	1995	1996[1]
Belgium	163	242	56	144	12	-
Denmark	194,358[2]	193,968[2]	164,817	121,559	153,361	67,496
Faroe Islands	334	-	-	-	-	-
France	24,625	16,587	12,627	27,941	29,504	12,500
Germany	41,791	42,665	41,669	38,394	43,798	14,215
Netherlands	75,135	75,683	79,190	76,155	78,491	35,276
Norway[4]	124,991[2]	116,863	122,815	125,522	131,026	43,739
Sweden	5,866	4,939	5,782	5,425	5,017	3,090
UK (England)	11,548	11,314	19,853	14,216	14,676	6,881
UK (Scotland)	57,572	56,171	55,531	49,919	44,802	17,473
UK (N.Ireland)	92	-	-	-	-	-
Unallocated landings	24,435	25,867	18,410	5,749	33,594	62,729
Total landings	560,910	544,299	520,550	465,024	534,281	263,399
Discards[3]	4,617	4,950	3,470	2,510	-	1,469
Total catch	565,527	549,249	524,020	467,534	534,281	264,868
Estimates of the parts of the catches which have been allocated to spring spawning stocks						
IIIa type	7,894	7,854	8,928	13,228	10,315	855
Coastal type	252[5]	202[5]	201[5]	215[5]	203[5]	168[5]

[1]Preliminary.
[2]Working Group estimates.
[3]Any discards prior to 1989 were included in unallocated landings.
[4]Catches of Norwegian spring spawners removed (taken under a separate TAC).
[5]Landings from the Thames estuary area.

Table 2.1.2 HERRING, catch in tonnes in Division IVa West. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1987	1988	1989	1990	1991
Denmark	50,184	25,268	29,298	9,037	5,980
Faroe Islands	102	810	1,916	633	334
France	285	266	-[1]	2,581	3,393
Germany, Fed.Rep.	3,250	9,308	26,528	20,422	20,608
Netherlands	44,358	32,639	24,600	29,729	29,563
Norway	55,311	30,657	41,768	24,239	37,674
Sweden	768	1,197	742	-	1,130
UK (N.Ireland)	-	-	-	-	92
UK (England)	4,820	4,820	5,104	3,337	4,873
UK (Scotland)	66,774	48,791	58,455	46,431	42,745
Unallocated landings	16,092	-	3,173	4,621	5,492
Total Landings	221,032	153,751	191,584	141,030	151,884
Discards[2]	-	-	900	750	883
Total catch	237,124	153,751	192,484	141,780	152,767

Country	1992	1993	1994	1995	1996[3]
Denmark	10,751	10,604	20,017	17,748	3,237
Faroe Islands	-	-	-	-	-
France	4,714[4]	3,362	11,658	10,427	3,177
Germany	21,836	17,342[4]	18,364	17,095	2,167
Netherlands	29,845	28,616	16,944	24,696	2,978
Norway	39,244	33,442	56,422	56,124	22,187
Sweden	985	1,372	2,159	1,007	2,398
UK (N.Ireland)	-	-	-	-	-
UK (England)	4,916	4,742	3,862	3,091	2,391
UK (Scotland)	39,269	36,628[4]	44,687	40,159	12,762
Unallocated landings	4,855	-8,271[5]	2,944	26,018	48,213
Total Landings	156,415	127,837	177,327	196,365	99,510
Discards[2]	850	825	550	-	356
Total catch	157,265	128,662	177,877	196,365	99,866

[1]Included in Division IVb.
[2]Any discards prior to 1989 were included in unallocated.
[3]Preliminary.
[4]Including IVa East.
[5]Negative unallocated catches due to misreporting from other areas.

Table 2.1.3 HERRING, catch in tonnes in Division IVa East. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1985	1986	1987	1988	1989	1990
Denmark	-	4,540	7,101	47,183	44,269	44,364
Faroe Islands	-	-	2,126	-	-	-
France	-	-	159	45	-	892
Netherlands	-	-	-	200	-	-
Norway[1]	109,975	118,408	145,843	153,496	168,365	121,405
Sweden	-	-	957	622	612	2,482
UK (Scotland)	-	-	-	-	-	-
Germany, Fed.Rep.	-	-	-	-	-	5,604
Unallocated landings	-	-	-	-	-	-
Total landings	109,975	122,348	156,186	201,546	213,246	174,747
Discards[2]	-	-	-	-	-	-
Total catch	109,975	122,948	156,186	201,546	213,246	174,747

Country	1991	1992[3]	1993	1994	1995[3]	1996
Denmark	48,875	53,692	43,224	43,787	45,257	19,166
Faroe Islands	-	-	-		-	-
France	-	-[4]	4	14	+	-
Netherlands	-	-	-		-	-
Norway[1]	77,465	61,379	56,215	40,658	62,224	18,256
Sweden	114	508	711	1,010	2,081	693
UK (Scotland)	173	196	-[4]		-	-
Germany	-[4]	-[4]	-[4]		-	-
Unallocated landings	-	-	-		-	-
Total landings	126,627	115,775	100,154	85,469	109,562	38,115
Discards[2]	-	-	-		-	-
Total catch	126,627	115,775	100,154	85,469	109,562	38,115

[1]Catches of Norwegian spring spawners herring removed (taken under a separate TAC).
[2]Any discards prior to 1989 would have been included in unallocated.
[3]Preliminary.
[4]Included in IVa West.

Table 2.1.4 HERRING, catch in tonnes in Division IVb. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1987	1988	1989	1990	1991
Denmark	81,280	190,555	136,239	105,614	138,555
Belgium	-	-	-	-	3
France	387	617	14,415[5]	10,289	4,120
Faroe Islands	-	-	-	-	-
Germany, Fed.Rep.	2,302	4,516	11,880	17,165	20,479
Netherlands[4]	31,371	37,192	47,388	28,402	26,266
Norway	40,111	38,566	11,758	12,207	9,852
Sweden	-	-	3,420	1,276	4,622
UK (England)	329	2,011	957	3,200	2,715
UK (Scotland)	9,639	15,317	9,651	10,381	14,587
Unallocated landings	20,829	1,969	-23,947[7]	-15,616[7]	3,180
Total landings	186,248	290,743	211,711	172,914	224,376
Discards[4]	-	-	1,900	2,560	1,072
Total catch	186,248	290,743	213,611	175,474	225,448

Country	1992	1993	1994	1995	1996[6]
Denmark	125,229	109,994	55,060	87,917	43,749
Belgium	13	-	-	-	-
France	2,313	2,086	5,492	7,639	2,373
Faroe Islands	-	-	-	-	-
Germany	20,005	23,628	14,796	21,707	11,052
Netherlands[4]	26,987	31,370	39,052	30,065	18,474
Norway	16,240	33,158	28,442	12,678	3,296
Sweden	3,446	3,699	2,256	1,929	-
UK (England)	3,026	3,804	7,337	9,688	2,757
UK (Scotland)	16,707	18,904	5,101	4,654	4,449
Unallocated landings	-13,637[7]	-16,415[7]	-26,988[7]	10,831[7]	-8,826[7]
Total landings	200,329	210,228	130,548	165,355	77,324
Discards[4]	1,900	245	460-	-	592
Total catch	202,229	210,473	131,008	165,455	77,916

[1]Includes catches misreported from Division IVc.
[2]Includes Division IVa catches.
[3]Included in Division IVa.
[4]Any discards prior to 1989 were included in unallocated.
[5]Includes catch in Division IVa.
[6]Preliminary.
[7]Negative unallocated catches due to misreporting from other areas.

Table 2.1.5 HERRING, catch in tonnes in Divisions IVc and VIId. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1987	1988	1989	1990	1991
Belgium	39	4	434	180	163
Denmark	31	-	509	265	948
France	6,435	7,456	14,670	9,718	17,112
Germany, Fed.Rep.	-	-	299	-	704
Netherlands	15,749	12,236	12,240	11,697	19,306
Norway	-	-	-	-	-
UK (England)	544	1,266	1,919	1,796	3,960
UK (Scotland)	-	-	-	-	67
Unallocated landings	22,051	31,442	47,523	32,076	15,763
Total landings	44,849	52,404	77,594	55,732	58,023
Discards[1]	-	-	1,200	5,350	2,662
Total catch	44,849	52,404	78,794	61,082	60,685
Coastal spring spawners included above	250	250	2,283	1,136	252

Country	1992	1993	1994	1995	1996[2]
Belgium	229	56	144	12	-
Denmark	4,296	995	2,695	2,441	1,344
France	9,560	7,171	10,777	11,433	6,950
Germany	824	649	4,964	4,996	997
Netherlands	18,851	19,204	20,159	23,730	13,824
Norway	-	-	-	-	-
UK (England)	3,372	11,307	3,016	1,896	1,733
UK (Scotland)	-	-	131	-	262
Unallocated landings	34,649	43,096	29,792	18,397	23,934
Total landings	71,781	82,478	71,678	62,905	49,044
Discards[1]	2,200	2,400	2,400	-	521
Total catch	73,981	84,878	74,078	62,905	49,565
Coastal spring spawners included above	202	201	215	203	168

[1]Any discards prior to 1989 would have been included in unallocated.
[2]Preliminary.

Table 2.2.1 North Sea Herring, Millions caught by age group (winter ring), year class, division and quarter.

Catches in : 1996

Division	Quarter	0 1995	1 1994	2 1993	3 1992	4 1991	5 1990	6 1989	7 1988	8 1987	9+ 1986	Total	0+1 ring
	I	0.0	1.9	5.3	15.0	3.0	0.6	0.1	0.1	0.1	0.1	26.1	1.9
	II	0.0	0.0	77.4	106.8	18.6	3.9	1.6	0.1	0.0	1.5	210.0	0.0
(West of 2E)	III	0.0	0.0	117.9	107.7	52.7	15.2	5.0	3.1	1.9	6.9	310.5	0.0
	IV	12.6	0.0	15.5	16.6	5.9	1.1	0.4	0.3	0.3	0.5	53.2	12.6
	Total	12.6	2.0	216.1	246.1	80.1	20.9	7.1	3.6	2.3	9.0	599.8	14.6
	I	0.0	0.2	15.3	80.7	19.3	4.6	0.4	0.9	0.4	0.4	122.4	0.2
	II	0.0	0.2	15.8	3.9	0.9	0.1	0.0	0.0	0.0	0.2	21.1	0.2
(East of 2E)	III	0.0	0.0	5.0	6.0	5.0	2.5	0.6	0.4	0.4	1.0	20.9	0.0
	IV	0.0	0.0	29.6	39.9	14.0	3.5	0.9	1.2	2.0	1.3	92.3	0.0
	Total	0.0	0.4	65.6	130.5	39.2	10.7	1.9	2.5	2.9	3.0	256.7	0.4
	I	0.0	432.7	29.9	2.7	0.4	0.0	0.0	0.0	0.0	0.0	465.7	432.7
	II	0.0	147.4	29.7	12.8	2.5	1.0	0.7	0.2	0.0	0.2	194.5	147.4
IVb	III	550.9	2.3	28.3	48.4	19.4	6.3	0.4	2.2	0.5	4.0	662.7	553.2
	IV	1231.7	64.3	17.7	31.6	12.0	2.8	0.5	1.4	1.8	1.9	1365.6	1296.0
	Total	1782.6	646.7	105.6	95.6	34.2	10.0	1.6	3.8	2.2	6.1	2688.5	2429.3
	I	0.0	88.8	10.0	41.3	15.7	8.1	6.1	0.9	0.3	0.0	171.2	88.8
	II	0.0	0.0	0.3	1.6	0.6	0.3	0.2	0.0	0.0	0.0	3.1	0.0
IVc + VIId	III	0.0	0.0	0.7	4.5	1.7	0.9	0.7	0.1	0.0	0.0	8.6	0.0
	IV	0.6	0.0	150.6	80.8	25.0	8.7	2.9	0.1	0.2	0.2	269.1	0.6
													0.0
	Total	0.6	88.8	161.6	128.2	43.0	18.0	9.9	1.2	0.5	0.2	452.0	89.4
	I	0.0	523.6	60.6	139.7	38.3	13.4	6.6	1.9	0.8	0.5	785.4	523.6
Total	II	0.0	147.6	123.1	125.2	22.6	5.3	2.5	0.4	0.0	2.0	428.8	147.6
North	III	550.9	2.4	151.9	166.6	78.7	24.8	6.7	5.8	2.9	12.0	1002.8	553.3
Sea	IV	1244.8	64.4	213.4	168.8	56.9	16.1	4.6	3.0	4.2	3.9	1780.1	1309.2
	Total	1795.7	737.9	549.0	600.4	196.6	59.7	20.5	11.1	7.9	18.3	3997.1	2533.7

Table 2.2.2 Numbers (millions) of herring caught per age group (winter rings) in the North Sea, 1970-1996.

Year	Winter ring									
	0	1	2	3	4	5	6	7	8	9+	Total
1970	898.1	1196.2	2002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5249.3
1971	684.0	4378.5	1146.8	662.5	208.3	26.9	30.5	26.8		12.4	7176.7
1972	750.4	3340.6	1440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6045.5
1973	289.4	2368.0	1344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4906.6
1974	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3189.3
1975	263.8	2460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3753.3
1976	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1482.0
1977	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7	+	656.3
1978	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	542.0	159.2	34.1	10.0	10.1	2.1	0.2	0.8	0.6	0.1	759.2
1980	791.7	161.2	108.1	91.8	32.1	21.8	2.3	1.4	0.4	0.2	1211.0
1981	7888.7	447.0	264.3	56.9	39.5	28.5	22.7	18.7	5.5	1.1	8772.9
1982	9556.7	840.4	268.4	230.1	33.7	14.4	6.8	7.8	3.6	1.1	10963.0
1983	10029.9	1146.6	544.8	216.4	105.1	26.2	22.8	12.8	11.4	12.2	12128.2
1984	2189.4	561.1	986.5	417.1	189.9	77.8	21.7	24.2	10.6	17.8	4496.1
1985	1292.9	1620.2	1223.2	1187.6	367.6	124.1	43.5	20.0	13.2	15.9	5908.2
1986	704.0	1763.2	1155.1	827.1	458.3	127.7	61.1	20.2	13.4	14.6	5144.7
1987	1797.5	3522.4	2005.4	687.2	481.1	248.9	75.7	23.9	7.9	8.1	8858.1
1988	1292.9	1970.8	1955.5	1185.1	398.1	260.6	128.6	37.9	15.1	8.4	7253.0
1989	1955.8	1899.5	927.7	1383.6	828.1	218.3	129.4	63.3	20.7	8.7	7435.1
1990	853.9	1477.4	592.8	763.3	849.1	375.9	80.1	54.4	28.4	11.8	5087.1
1991	1594.2	1244.4	771.2	553.1	548.5	493.5	201.4	38.8	25.0	12.6	5482.7
1992	7598.2	643.4	960.9	411.8	334.6	341.5	360.1	144.7	37.7	23.2	10856.1
1993	6981.7	1283.9	760.4	597.7	306.7	216.2	223.7	185.9	85.8	41.2	10683.2
1994	3717.3	450.5	1391.9	491.3	345.4	114.2	95.5	75.7	69.5	44.8	6796.1
1995	6279.8	483.1	1389.7	863.7	244.6	118.8	55.5	40.8	51.3	68.7	9595.7
1996	1795.7	737.9	549.0	600.4	196.6	59.7	20.5	11.1	7.9	18.3	3997.1

Table 2.2.3 Catches(numbers in millions) of IIIa spring spawners taken in the North Sea, and transfered to assessement of IIIa spring spawning stock. (1987-1996)

Year	Winter ring										
	0	1	2	3	4	5	6	7	8	9+	Total
1987			35.5	35.0	25.0	8.9	2.8	0.7	0.1	0.1	108.1
1988			44.6	108.9	19.5	8.2	2.2	0.4			183.8
1989			27.3	52.7	38.3	11.6	8.7	3.8	1.7	0.2	144.3
1990			12.4	14.7	21.8	3.6	3.0	2.1	0.7	0.4	58.7
1991			6.7	15.1	18.0	9.1	3.1	0.8	0.3		53.0
1992			0.3	9.9	11.1	8.4	8.6	2.5	0.7	0.6	42.1
1993			4.2	10.8	12.3	8.4	5.9	4.7	1.7	1.0	49.0
1994			8.8	28.2	16.3	11.0	8.6	3.4	3.2	0.7	80.2
1995			22.4	11.0	14.9	4.0	2.9	1.9	0.5	0.2	57.8
1996			0.0	2.8	0.8	0.4	0.1	0.1	0.1	0.2	4.4

Table 2.2.4 Catches(numbers in millions) of North Sea autumn spawners taken in IIIa, and transfered to assessement of North Sea autumn spawners.

Year	Winter ring										
	0	1	2	3	4	5	6	7	8	9+	Total
1987	6238.0	3153.0	117.0								9508.0
1998	1830.0	5792.0	292.0								7914.0
1989	1028.2	1170.5	654.8								2853.5
1990	397.9	1424.3	283.7								2105.9
1991	712.3	822.7	330.2								1865.2
1992	2407.5	1587.1	283.8	26.8	26.6	16.0	12.3	5.5	1.0		4366.6
1993	2910.7	2403.8	377.5								5691.9
1994	542.2	1239.7	305.2								2087.1
1995	1722.84	1069.58	126.37								2918.8
1996	632.07	869.53	159.35	31.52							1692.47

Table 2.2.5 Estimated total catch (numbers in millions) per age of North Sea autumn spawning stock used for assessment

Year	Winter ring										
	0	1	2	3	4	5	6	7	8	9+	Total
1987	8256.7	6859.1	2144.3	670.1	468.7	246.6	74.9	23.8	8.0	8.2	18760.4
1988	3208.8	7976.4	2263.5	1105.8	389.0	259.3	129.9	38.5	15.5	8.6	15395.3
1989	3066.1	3154.5	1598.0	1367.5	811.5	212.4	124.0	61.1	19.5	8.7	10423.3
1990	1286.3	2981.6	887.9	769.2	850.1	382.5	79.2	53.7	28.5	11.7	7330.7
1991	2370.0	2124.0	1124.9	552.8	545.1	497.7	203.9	39.0	25.4	12.9	7495.7
1992	10281.1	2291.9	1278.6	440.5	359.7	358.7	373.8	151.7	39.0	23.2	15598.2
1993	10164.7	3789.2	1164.8	603.1	302.5	213.5	223.8	186.2	86.4	41.3	16775.5
1994	4376.7	1736.7	1734.8	475.8	338.2	106.0	89.3	74.3	68.1	45.3	9045.2
1995	8517.7	1652.6	1589.8	907.6	244.5	122.2	56.0	41.4	54.1	72.9	13258.7
1996	2427.8	1607.5	708.3	629.1	195.8	59.3	20.4	11.0	7.9	18.1	5685.2

Table 2.2.6 Percentage age composition of North Sea HERRING (2-ringers and olders) in the catch.
Catches in : 1996

Division	age in W.Rings Quarter	2	3	Older >= 4	Total (millions)
	I	21.9	61.9	16.2	24.2
IVa West	II	36.9	50.9	12.3	210.0
	III	38.0	34.7	27.3	310.5
	IV	38.1	40.8	21.0	40.6
	Total	36.9	42.1	21.0	585.3
	I	12.6	66.1	21.4	122.2
IV a East	II	75.3	18.8	5.9	20.9
	III	23.8	28.5	47.6	20.9
	IV	32.0	43.2	24.8	92.3
	Total	25.6	50.9	23.5	256.3
	I	90.7	8.2	1.1	33.0
IVb	II	63.0	27.1	9.8	47.1
	III	25.8	44.2	29.9	109.5
	IV	25.5	45.5	29.1	69.6
	Total	40.8	36.9	22.4	259.2
	I	12.1	50.1	37.8	82.4
IVc + VIId	II	8.5	52.1	39.3	3.1
	III	8.5	52.1	39.3	8.6
	IV	56.1	30.1	13.8	268.5
	Total	44.6	35.3	20.1	362.7
	I	28.2	54.9	16.9	179.4
IVa + IVb	II	44.2	44.4	11.4	278.1
	III	34.3	36.8	28.9	440.9
	IV	31.0	43.5	25.5	202.4
	Total	35.2	42.9	21.9	1100.8
	I	23.1	53.4	23.5	261.8
Total	II	43.8	44.5	11.7	281.2
North	III	33.8	37.1	29.1	449.5
Sea	IV	45.3	35.9	18.8	470.9
	Total	37.5	41.0	21.5	1463.4

Table 2.2.7 Catches (SOP, tons) of North Sea Herring, by quarter and division.
Catches in : 1996

		0	1	2	3	4	5	6	7	8	9+	SOP
Quarter	Division	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	Total
	IVa W	0	60	636	1940	434	101	13	21	12	12	3229
I	IVa E	0	3	1475	9678	2679	666	85	143	90	90	14910
	IVb	0	2596	2065	334	55	0	0	0	0	0	5050
	VIId/IVc	0	533	711	4049	1897	1100	1002	180	46	0	9516
	Total	0	3192	4887	16001	5065	1867	1099	344	147	102	32705
	IVa W	0	0	9885	17706	3633	784	353	27	6	412	32806
II	IVa E	0	15	1808	578	149	11	0	3	2	41	2608
	IVb	0	926	2785	1723	423	182	141	46	0	45	6271
	VIId/IVc	0	0	21	160	75	43	40	7	2	0	348
	Total	0	941	14500	20167	4280	1020	534	83	10	498	42034
	IVa W	0	4	16243	19974	11935	3516	1295	876	520	2154	56517
III	IVa E	0	0	795	1203	1120	582	152	115	121	312	4399
	IVb	10522	175	3943	9187	4220	1534	121	636	145	1073	31556
	VIId/IVc	0	0	59	440	206	119	109	20	5	0	957
	Total	10522	179	21040	30803	17481	5751	1678	1646	791	3539	93430
	IVa W	145	1	2182	3086	1296	244	79	70	92	126	7321
IV	IVa E	0	0	4489	6944	2630	827	177	277	481	333	16157
	IVb	18598	2938	2435	5810	2600	671	123	340	460	495	34469
	VIId/IVc	9	1	18236	13263	4448	1952	643	33	41	41	38668
	Total	18752	2940	27343	29103	10975	3693	1022	720	1074	995	96616
Total N. Sea	1996	29274	7252	67770	96075	37800	12331	4333	2792	2022	5134	264784

Table 2.2.8 Total catch in the North Sea and Div. IIIa 1996

North Sea Autumn Spawners

Catch in numbers (millions) and mean weight (g) at age by fleet.

	Fleet A		Fleet B		Fleet C		Fleet D		Fleet E		TOTAL	
Total Winter rings	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight	Numbers	Mean Weight
0			1,795.71	16.3	9.12	17.4	537.77	11.0	85.18	10.1	2,427.78	14.9
1	5.89	84.6	732.01	9.4	181.56	48.1	363.72	14.7	324.25	17.3	1,607.43	16.8
2	523.60	126.3	25.40	54.5	143.86	75.7	3.96	41.1	11.53	50.5	708.35	111.8
3	596.07	160.3	4.33	122.4	26.94	131.0	2.59	55.8	1.98	73.6	631.92	158.1
4	195.27	192.4	1.33	137.5							196.60	192.0
5	59.21	207.5	0.49	140.6							59.70	207.0
6	20.23	211.9	0.27	140.7							20.50	211.0
7	11.01	252.1	0.09	235.7							11.10	252.0
8+	26.00	273.2	0.20	249.5							26.20	273.0
TOTAL	1,437.28		2,559.83		361.49		908.04		422.94		5,689.57	
Land. (SOP)(t)		226,194		38,426		23,320		11,575		7,194		306,709

E:\acfm\hawg97\T-2-2-8.xls

Table 2.2.9 Sampling of commercial landings in 1996 : number of samples, number of fish measured and aged by quarter. (Divisions IV and IVIId)

Country	Quarter	Landings in ' 000 tons	Number of samples	Number of fish Measured	Aged
Denmark	I	21.3	16	934	931
	II	1.8	4	77	77
	III	10.9	7	32	27
	IV	33.5	13	516	516
	Total	67.5	40	1,559	1,551
France	I	1.2	-	-	-
	II	2.2	-	-	-
	III	3.5	-	-	-
	IV	5.6	-	-	-
	Total	12.5	-	-	-
Germany	I	0.3	-	-	-
	II	0.2	-	-	-
	III	4.6	-	-	-
	IV	9.1	-	-	-
	Total	14.2	-	-	-
Norway	I	1.5	33	1,651	400
	II	24.0	121	5,019	1,158
	III	7.0	44	1,673	924
	IV	11.3	31	1,021	276
	Total	43.8	229	9,364	2,758
Sweden	I	0.0	-	-	-
	II	1.2	-	-	-
	III	1.5	-	-	-
	IV	0.3	-	-	-
	Total	3.0	-	-	-
The Netherlands	I	7.8	10	1,258	250
	II	1.5	1	118	25
	III	21.4	8	897	200
	IV	30.6	12	1,303	300
	Total	61.3	31	3,576	775
U.K. (England)	I	0.1	-	-	-
	II	1.4	-	-	-
	III	4.3	-	-	-
	IV	1.0	-	-	-
	Total	6.8	-	-	-
U.K. (Scotland)	I	0.2			
	II	5.6	18	4,520	1,008
	III	38.4	43	7,583	3,683
	IV	4.0	61	12,103	4,691
	Total	48.2			
All Countries	I	32.4	59	3,843	1,581
	II	37.9	144	9,734	2,268
	III	91.6	102	10,185	4,834
	IV	95.4	117	14,943	5,783
	Total	257.3	422	38,705	14,466

Table 2.3.1 IBTS 1-ringer indices (1st quarter)

Year class	Year of sampling	1-ringer index
1977	1979	172
1978	1980	312
1979	1981	431
1980	1982	772
1981	1983	1260
1982	1984	1443
1983	1985	2083
1984	1986	2542
1985	1987	3684
1986	1988	4530
1987	1989	2313
1988	1990	1016
1989	1991	1159
1990	1992	1162
1991	1993	2943
1992	1994	1667
1993	1995	1188
1994	1996	1729
1995	1997	4192

Table 2.3.2 Density and abundance estimates of 0-ringers caught in February during the IBTS. Values given for year classes by areas are density estimates in numbers per square metre. Total abundance is found by multiplying density by area and summing up.

Area	North west	North east	Central west	Central east	South west	South east	Division IIIa	South Bight	0-ringers abundance
Area $m^2 \times 10^9$	83	34	86	102	37	93	31	31	no. in10^9
Year class									
1976	0.054	0.014	0.122	0.005	0.008	0.002	0.002	0.016	17.1
1977	0.024	0.024	0.050	0.015	0.056	0.013	0.006	0.034	13.1
1978	0.176	0.031	0.061	0.020	0.010	0.005	0.074	0.000	52.1
1979	0.061	0.195	0.262	0.408	0.226	0.143	0.099	0.053	101.1
1980	0.052	0.001	0.145	0.115	0.089	0.339	0.248	0.187	76.7
1981	0.197	0.000	0.289	0.199	0.215	0.645	0.109	0.036	133.9
1982	0.025	0.011	0.068	0.248	0.290	0.309	0.470	0.140	91.8
1983	0.019	0.007	0.114	0.268	0.271	0.473	0.339	0.377	115.0
1984	0.083	0.019	0.303	0.259	0.996	0.718	0.277	0.298	181.3
1985	0.116	0.057	0.421	0.344	0.464	0.777	0.085	0.084	177.4
1986	0.317	0.029	0.730	0.557	0.830	0.933	0.048	0.244	270.9
1987	0.078	0.031	0.417	0.314	0.159	0.618	0.483	0.495	168.9
1988	0.036	0.020	0.095	0.096	0.151	0.411	0.181	0.016	71.4
1989	0.083	0.030	0.040	0.094	0.013	0.035	0.041	0.000	25.9
1990	0.075	0.053	0.202	0.158	0.121	0.198	0.086	0.196	69.9
1991	0.255	0.390	0.431	0.539	0.500	0.369	0.298	0.395	200.7
1992	0.168	0.039	0.672	0.444	0.734	0.268	0.345	0.285	190.1
1993	0.358	0.212	0.260	0.187	0.120	0.119	0.223	0.028	101.7
1994	0.148	0.024	0.417	0.381	0.332	0.148	0.252	0.169	126.9
1995	0.260	0.086	0.699	0.092	0.266	0.018	0.001	0.020	106.2
1996	0.003	0.004	0.935	0.135	0.436	0.379	0.039	0.032	148.1

Table 2.4.1 Numbers (millions) of Autumn Spawning Herring (combined survey 1996)

	IIIa	IVa	IVb	Total NS	Mat NS
0	602.47	0.29	2701.37	3304.13	0.00%
1	1391.70	578.60	4219.12	6189.42	0.00%
2i	177.27	607.08	1012.93		
2m	177.27	2212.06	364.04	4550.65	60.51%
3i	5.11	29.92	34.82		
3m	29.25	2452.35	271.67	2823.12	97.53%
4	13.32	1016.43	57.60	1087.35	100.00%
5	7.58	284.74	18.62	310.93	100.00%
6	1.95	94.34	2.44	98.73	100.00%
7	0.95	79.07	2.81	82.83	100.00%
8	0.10	132.49	0.29	132.88	100.00%
9+	0.08	203.31	2.65	206.04	100.00%
Imm	2176.55	1215.89	7968.24	11360.68	
Mature	230.49	6474.80	720.12	7425.42	
Total	2407.04	7690.69	8688.36	18786.09	

Table 2.4.2 Biomass (thousands of tonnes) of Autumn Spawning Herring (combined survey 1996)

	IIIa	IVa	IVb	Total NS	Mat NS
0	2.00	0.00	7.21	9.21	0.00%
1	68.05	31.97	173.98	274.00	0.00%
2i	13.84	70.00	73.27		
2m	13.84	325.25	40.32	536.52	70.72%
3i	0.48	4.39	4.26		
3m	2.74	500.76	39.58	552.22	98.35%
4	1.28	263.77	9.74	274.79	100.00%
5	0.80	76.98	3.71	81.48	100.00%
6	0.22	28.82	0.51	29.54	100.00%
7	0.10	24.82	0.42	25.34	100.00%
8	0.02	43.08	0.08	43.18	100.00%
9+	0.02	68.55	0.48	69.06	100.00%
Imm	84.36	106.37	258.73	449.46	
Mature	19.02	1332.03	94.84	1445.88	
Total	103.38	1438.40	353.56	1895.34	

Table 2.4.3 Mean Weights (g) of Autumn Spawning Herring (combined survey 1996)

	IIIa	IVa	IVb	Total NS
0	3.32	2.20	2.67	2.79
1	48.90	55.25	41.24	44.27
2i	78.04	115.31	72.34	
2m	78.04	147.03	110.77	117.90
3i	93.98	146.76	122.43	
3m	93.79	204.20	145.69	195.61
4	96.08	259.51	169.12	252.72
5	105.66	270.34	199.06	262.06
6	111.40	305.46	207.77	299.21
7	101.83	313.92	150.28	305.95
8	256.10	325.12	256.10	324.92
9+	256.10	337.19	181.39	335.16
Imm	38.76	87.48	32.47	39.56
Mature	82.51	205.73	131.69	194.72
Total	42.95	187.03	40.69	100.89

Table 2.4.4 Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1984-1996. For 1984-1986 the estimates are the sum of those from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc, VIId winter survey. The 1987 to 1995 estimates are from the summer survey in Divisions IVa,b, and IIIa excluding estimates of Division IIIa/Baltic spring spawners.

Age (rings)	Numbers (millions)												
	Year												
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1	551	726	1,639	13,736	6,431	6,333	6,249	3,182	6,351	10,399	3,646	4,202	6,189
2	3,194	2,789	3,206	4,303	4,202	3,726	2,971	2,834	4,179	3,710	3,280	3,799	4,550
3	1,005	1,433	1,637	955	1,732	3,751	3,530	1,501	1,633	1,855	957	2,056	2,823
4	394	323	833	657	528	1,612	3,370	2,102	1,397	909	429	656	1,087
5	158	113	135	368	349	488	1,349	1,984	1,510	795	363	272	310.9
6	44	41	36	77	174	281	395	748	1,311	788	321	175	98.75
7	52	17	24	38	43	120	211	262	474	546	238	135	82.83
8	39	23	6	11	23	44	134	112	155	178	220	110	133
9+	41	19	8	20	14	22	43	56	163	116	132	84	206
Total	5,478	5,484	7,542	20,165	13,496	16,377	18,262	12,781	17,173	19,326	13,003	11,220	18,786
Z(2+/3+)		0.92	0.57	1.01	0.81	0.11	0.11	0.56	0.37	0.73	1.17	0.55	0.45
Smoothed Z(2+/3+)		0.79	0.78	0.76	0.60	0.34	0.26	0.35	0.56	0.76	0.82	0.80	0.55
SSB('000 t)	807	697	942	817	897	1,637	2,174	1,874	1,545	1,216	1,035	1,082	1,445

SSB defined as all fish >maturity stage III.

E:\ACFM\HAWG97\T-2-4-4.DOC

Table 2.5.1 Estimated abundance of herring larvae <10 mm long, by standard sampling area and standard time periods. The numbers of larvae are expressed as mean number per m^2 per ICES rectangle $*10^9$

Year	Orkney and Shetland		Buchan		Central North Sea				Southern North Sea/Eastern Channel		
	1-15 Sept.	16-30 Sept.	1-15 Sept.	16-30 Sept.	1-15 Sept.	16-30 Sept	1-15 Oct.	16-31 Oct	16-31 Dec.	1-15 Jan.	16-31 Jan.
1972	1049	4628	7		200	91	135	23	22	52	1
1973	1495	761	6	5	496	862	1400	174	7		5
1974	769	438	90	281	8		1238		2	11	
1975	373	50	270			140	79	14	4	2	
1976	555	74		1	71	217	5	12		3	
1977	1116	203	198	30	520	286	91	3	2		1
1978	3619	56		140	1415	132	297	3	53	3	
1979	3248	2364	191	9	101	132	507	10	3	143	107
1980	3137	651	17	1	321	190	15	11	291	135	44
1981	3654	285		2	14	1044	239	171	1481		67
1982	2667	1128	355	393	95	65	1079	32	2108	288	79
1983	2530	815	3677	805	1897	282	70		539	250	70
1984	1630	1908	2376	1914	485	2426	829	450	565	185	43
1985	7069	3418	2531	1819	129	13060	1803	217	1445	511	49
1986	3587	1913	3433	347	·1683	6112	253	52	845	123	24
1987	7478	1877	2628	680	799	4922	2045	112	941	301	229
1988	7685	8817	6904	5415	5533	4074	1965	212	1645	175	[illegible]7
1989	11659	5765	6164	776	1442	5012	2362		1871	2182	609
1990		10594	4628	3277	20720	1295	1193		2566	1275	
1991	1185	2954		2065	4824	2112	1370		4396	873	
1992				1210		167	170		196		
1993				253		686	107		1622	1280	
1994		1260				1465	50		450	675	
1995		8741							73	232	196
1996				192					343	798	734

Table 2.6.1 Abundance of herring from August Scottish Groundfish Surveys. Recorded catch rates of herring per 10 hours' fishing.

Year	Valid Hauls	Age						
		2	3	4	5	6	7	8
1982	76	535	154	56	41	20	24	8
1983	78	1143	353	141	45	36	21	13
1984	82	399	75	28	8	2	3	3
1985	83	1798	645	161	130	11	9	7
1986	79	564	311	158	22	9	3	1
1987	73	917	261	149	105	19	6	1
1988	85	2033	1008	190	89	49	11	1
1989	86	1104	1233	458	79	66	38	1
1990	85	585	770	642	188	56	19	5
1991	90	1784	943	635	433	177	44	17
1992	87	541	246	128	117	136	21	6
1993	87	844	307	128	105	93	73	17
1994	87	2096	368	128	49	42	27	18
1995	87	1637	528	124	156	66	38	26
1996	85	1396	826	282	73	25	45	24

Table 2.7.1 North sea Herring,
Mean weight (g) at age (w.r.) and year class weighted by number caught

Catches in : 1996

Division	Quarter	0 1995	1 1994	2 1993	3 1992	4 1991	5 1990	6 1989	7 1988	8 1987	9+ 1986
	I	0	32	120	130	146	155	200	175	210	210
IV a	II	0	0	128	166	195	198	224	239	244	269
(W of 2E)	III	0	87	138	185	226	231	257	285	271	312
	IV	12	87	141	186	220	215	192	256	269	266
	Total	12	33	134	174	216	222	245	278	269	302
	I	0	14	96	120	139	144	197	167	210	210
IV a	II	0	78	115	147	161	146	0	167	210	204
(E of 2 E)	III	0	0	159	202	225	236	248	265	273	298
	IV	0	0	152	174	188	234	205	239	243	250
	Total	0	43	130	141	168	195	217	218	243	258
	I	0	6	69	123	148	0	0	0	0	0
IV b	II	0	6	94	135	171	187	197	192	0	190
	III	19	75	139	190	218	245	288	290	300	267
	IV	15	46	137	184	217	242	272	245	262	262
	Total	16	10	106	178	213	238	243	268	270	263
	I	0	6	71	98	121	135	164	196	155	0
IVc	II	0	0	80	98	121	135	164	196	155	0
+	III	0	0	80	98	121	135	164	196	155	0
VIId	IV	15	45	121	164	178	225	220	239	250	250
	Total	15	6	118	140	154	178	181	201	186	250
IVa	Total	12	35	133	162	200	213	239	253	254	291
	I	0	6	81	121	140	145	197	167	210	210
IVa	II	0	6	118	161	191	195	215	205	235	250
+	III	19	75	139	188	225	235	259	285	278	295
IVb	IV	15	46	145	180	205	235	219	243	253	259
	Total	16	10	126	165	203	219	240	258	259	281
	I	0	6	80	114	132	139	166	181	189	210
Total	II	0	6	117	161	188	191	209	204	215	250
North	III	19	75	138	185	222	232	249	284	277	295
Sea	IV	15	46	128	172	192	230	220	243	253	258
	Total	16	10	123	160	192	207	211	252	255	281

Table 2.7.2 Comparison between mean weights (g) at age in catch of North Sea Herring (adults) from earlier years and 1985-1994.

		Age in winter rings							
Division	Year	2	3	4	5	6	7	8	9+
IVa	1987	118	157	186	214	237	260	278	304
	1988	126	150	176	200	218	237	260	263
	1989	129	157	175	210	233	246	268	256
	1990	123	154	177	194	229	234	251	295
	1991	146	164	181	198	214	231	263	275
	1992	149	184	189	208	223	240	243	285
	1993	133	156	193	210	234	249	268	319
	1994	135	171	201	223	246	258	278	295
	1995	142	172	208	220	260	253	284	290
IVb	1987	70	131	179	215	233	225	273	244
	1988	98	136	175	195	208	244	228	205
	1989	93	162	199	225	280	276	273	333
	1990	102	145	194	219	250	272	259	277
	1991	119	173	196	220	225	277	257	263
	1992	81	179	198	213	232	255	272	313
	1993	102	146	199	220	236	261	275	306
	1994	122	150	177	205	237	251	255	245
	1995	135	174	197	205	261	266	272	282
IVa+IVb	1986	122	158	184	210	223	245	253	263
	1987	99	152	186	214	237	259	278	304
	1988	112	147	176	199	217	238	257	263
	1989	116	158	179	212	237	250	269	259
	1990	113	152	181	198	232	238	252	290
	1991	131	167	184	203	217	239	262	272
	1992	100	183	191	209	224	243	250	290
	1993	116	152	195	212	234	251	269	317
	1994	131	164	192	218	245	258	277	292
	1995	140	173	205	216	260	256	283	289
IVc+VIId	1986	108	139	164	185	208	174	202	232
	1987	105	128	148	164	198	211	197	234
	1988	103	132	156	178	197	185	165	
	1989	110	127	151	182	198	201	198	179
	1990	118	131	152	171	195	216	208	231
	1991	123	165	184	200	212	196	237	161
	1992	100	183	191	209	224	243	250	290
	1993	113	139	152	174	182	191	211	216
	1994	117	145	172	191	209	224	229	218
	1995	114	130	161	177	203	208	184	241
Total North Sea	1986	121	153	182	207	221	238	252	262
	1987	99	149	180	211	234	258	278	295
	1988	111	145	174	197	216	237	253	263
	1989	115	153	173	208	231	247	265	259
	1990	114	149	177	193	229	236	250	287
	1991	130	166	184	203	217	235	259	271
	1992	103	175	189	207	223	237	249	287
	1993	115	145	189	204	228	244	256	310
	1994	130	159	181	214	240	255	273	281
	1995	136	167	196	200	247	249	278	287

Table 2.7.3 Herring mean weight at age in the third quarter in Divisions IVa and IVb.

AGE	Mean weigths (g) at age in the catch													
	Third quarter (Divisions IVa and IVb)									July Acoustic Survey				
(w.r.)	1987	1988	1989	1990	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
1	54	58	42	58	73	51	53	55	52	65	78	69	60	58
2	134	124	126	128	164	127	145	131	151	158	142	115	138	132
3	182	179	179	180	189	200	161	164	190	198	209	147	209	180
4	219	207	207	208	210	215	179	192	221	224	219	202	220	200
5	248	244	244	228	229	235	199	218	231	236	243	225	251	195
6	265	274	274	256	246	252	221	245	277	260	255	277	289	228
7	286	288	288	267	276	276	239	258	276	275	272	286	315	257
8	310	296	296	272	296	286	240	277	316	298	312	305	323	302
9+	342	350	350	295	293	330	283	292	316	317	311	340	346	324

e:\acfm\hawg96\t-2-7-3.xls

Table 2.8.1 INPUT parameters of the final ICA assessment of North Sea herring

Reference age at :	4
Reference F for ages :	2 - 6
S to be fixed on last age :	1
time lag between spawning and 0-ringers :	1
Shrinkage to final populations :	No

	file name	Range of years	Range of ages
Catch in numbers	caton	1960 - 1996	0 - 9+
Catch in tonnes	canum	1960 - 1996	-
Avg. weight in catch	weca	1960 - 1996	0 - 9+
Avg. weight in stock	west	1960 - 1996	0 - 9+
Natural mortality	natmor	1960 - 1996	0 - 9+
Proportion mature at age	matprop	1960 - 1996	0 - 9+
Proportion F before spawning	fprop	1960 - 1996	0 - 9+
Proportion M before spawning	mprop	1960 - 1996	0 - 9+

	DATA SET	Range of years	Range of ages	Catchability model	Model weighting	Weighting by age group
Years of seperable constraint:	Catch in n/age	1992 - 1996	0 - 8	Linear	1	All groups and years equal weighting except: year 1996, age 0 = 0.01 and year 1996, age 1 = 0.01
Biomass index 1	MLAI<10mm	1977 - 1996	-	Power	1	
Aged index 1	Acoustic survey	1989 - 1996	2 - 9+	Linear	1	All age groups have equal weighting of 1
Aged index 2	IBTSY	1979 - 1997	1	Linear	1	All age groups have equal weighting of 1
Aged index 3	IBTSA	1983 - 1997	2 - 5+	Linear	1	All age groups have equal weighting of 1
Aged index 4	MIK	1977 - 1997	0	Linear	1	All age groups have equal weighting of 1
Stock recruitment model		1960 - 1996	-	-	0.1	-

G:\ACFM\HAWG\HER_47D3\2-8-1.xls

Table 2.8.2 Input-screen to the final ICA assessment

```
Integrated Catch at Age Analysis
Version 1.3

SOAFD Marine Laboratory
Aberdeen
Reading /users/fish/ifad/ifapwork/hawg/her_47d3/CANUM.I45
/users/fish/ifad/ifapwork/hawg/her_47d3/WECA.I45
Reading  /users/fish/ifad/ifapwork/hawg/her_47d3/WEST.I45
Stock weights in  1997  assumed = stock weights in  1996
Reading /users/fish/ifad/ifapwork/hawg/her_47d3/NATMOR.I45
M in  1997  assumed = M  in 1996
Reading /users/fish/ifad/ifapwork/hawg/her_47d3/MATPROP.I45
Ogive in  1997  assumed = ogive in  1996
Reading /users/fish/ifad/ifapwork/hawg/her_47d3/FPROP.I45
Reading  /users/fish/ifad/ifapwork/hawg/her_47d3/MPROP.I45
Reading /users/fish/ifad/ifapwork/hawg/her_47d3/FLEET.I45
Reading /users/fish/ifad/ifapwork/hawg/her_47d3/SSB.I45
MLAI1: MLAI < 10 mm (Catch: Unknown) (Effort: Unknown)

No of years for separable constraint ? --> 5
Reference age for separable constraint ?  --> 4
Constant selection pattern model (Y/N) ? -->y
                S to be fixed on last age ? --> 1
First age for calculation of reference F --> 2
Last age for calculation of reference F  --> 6
             Use default weighting (Y/N) ?  --> n
Enter relative weights at age
  Weight for age     0  --> 1
  Weight for age     1  --> 1
  Weight for age     2  --> 1
  Weight for age     3  --> 1
  Weight for age     4  --> 1
  Weight for age     5  --> 1
  Weight for age     6  --> 1
  Weight for age     7  --> 1
  Weight for age     8  --> 1
  Weight for age     9  --> 1

 Enter relative weights by year
 Weight for year  1992  --> 1
 Weight for year  1993  --> 1
 Weight for year  1994  --> 1
 Weight for year  1995  --> 1
 Weight for year  1996  --> 1
 Specify weights for year and age:
Enter year, age, new weight or -1,-1,-1 to finish
1996,0,0.01
1996,1,0.01
-1,-1,-1
Is the last age of AC089: acoustic data from 1989 a plus group ? (Y/N)--> y
Is the last age of IBTSA: international bottom tr a plus group ? (Y/N)--> y
Is the last age of IBTSY: international bottom tr a plus group ? (Y/N)--> n
Is the last age of MIK: MIK 0-ringer index (Catch a plus group ? (Y/N)--> n

 You must choose a catchability model for each index.

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

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

Model for   INDEX1                       is to be (A/L/P) ?--> p
Model for ACO89: acoustic data from 1989 is to be (A/L/P) ?--> l
Model for IBTSA: international bottom tr is to be (A/L/P) ?--> l
Model for IBTSY: international bottom tr is to be (A/L/P) ?--> l
Model for MIK: MIK 0-ringer index (Catch is to be (A/L/P) ?--> l

          Fit a stock-recruit relationship (Y/N) ?  --> y

Enter the time lag in entire years between spawning and the stock size
of fish aged 0   on 1 January  -->  1
(Usually 1 for herring, 0 for ordinary fish)

                    Enter lowest feasible F  --> 0.05
                    Enter highest feasible F --> 1

-----------------------------------------------------------------
No of years for separable analysis :  5
Age range in the analysis          :  0 9
Year range in the analysis         :  1960 1996
Number of indices of SSB           :  1
Number of age-structured indices   :  4
Stock-Recruit relationship to be fitted.
Parameters to estimate             :  44
Number of observations             :  265

 Conventional single selection vector model to be fitted.
-----------------------------------------------------------------

Weighting options :
  1  - Recalculate all survey weights iteratively.
  2  - Enter survey weights by hand.

 Enter your choice --> 2
 Enter weight for    INDEX1                                 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  2 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  3 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  4 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  5 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  6 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  7 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  8 --> 1
 Enter weight for ACO89: acoustic data from 1989 at age  9 --> 1
 Enter weight for IBTSA: international bottom tr at age  2 --> 1
 Enter weight for IBTSA: international bottom tr at age  3 --> 1
 Enter weight for IBTSA: international bottom tr at age  4 --> 1
 Enter weight for IBTSA: international bottom tr at age  5 --> 1
 Enter weight for IBTSY: international bottom tr at age  1 --> 1
 Enter weight for MIK: MIK 0-ringer index (Catch at age  0 --> 1
 Enter weight for stock-recruit model --> 0.1

 You should enter estimates of the extent to which
 errors in each age of the age structured indices
 are correlated. These may range from zero
 (independence) to 1 (correlated errors) .
 Enter value for aged index  1 --> 1
 Enter value for aged index  2 --> 1
 Enter value for aged index  3 --> 1
 Enter value for aged index  4 --> 1
 Do you want to shrink the final populations ? (Y/N) --> n
```

Table 2.8.3 Output of ICA North Sea herring 1997

STOCK SUMMARY (IFAP run code: I45)

Year	Recruits Age 0 thousands	Total Biomass tonnes	Spawning Biomass tonnes	Landings tonnes	Yield/ SSB ratio	Mean F Ages 2- 6	SoP (%)
1960	12118390	3900843	2021053	696200	.3445	.3186	118
1961	108915000	4475765	1766169	696700	.3945	.4105	113
1962	46289430	4492728	1204845	627800	.5211	.4953	117
1963	47657790	4719367	2273702	716000	.3149	.2193	86
1964	62794340	4869079	2099044	871200	.4150	.3373	106
1965	34900220	4402969	1506718	1168800	.7757	.6881	114
1966	27865830	3352640	1315568	895500	.6807	.6174	107
1967	40262930	2829973	935341	695500	.7436	.7952	117
1968	38701390	2526634	418583	717800	1.7148	1.3333	125
1969	21586570	1908053	426805	546700	1.2809	1.1034	96
1970	41089420	1923287	375794	563100	1.4984	1.1002	96
1971	32335910	1851115	267167	520100	1.9467	1.3800	107
1972	20869100	1551120	289159	497500	1.7205	.6905	91
1973	10166210	1158448	234593	484000	2.0631	1.1268	95
1974	21771390	915636	163332	275100	1.6843	1.0449	96
1975	2961160	686233	83963	312800	3.7254	1.4360	93
1976	2805560	365983	81293	174800	2.1502	1.3490	95
1977	4411100	219380	52743	46000	.8721	.7159	119
1978	4690320	235503	71444	11000	.1540	.0469	121
1979	10658210	393265	114613	25100	.2190	.0598	100
1980	16831360	642995	139628	70764	.5068	.2682	109
1981	38037280	1174039	205423	174879	.8513	.3268	100
1982	65178560	1864678	289050	275079	.9517	.2549	97
1983	62265380	2511255	448039	387202	.8642	.3260	107
1984	53951980	2763217	729398	420759	.5769	.4303	105
1985	81494370	3330781	760997	613927	.8067	.6298	106
1986	97378800	3837509	775432	669540	.8634	.5543	115
1987	86191770	4220184	890695	792313	.8895	.5335	102
1988	42360080	3851683	1141341	887762	.7778	.5253	118
1989	39239040	3380250	1265076	787980	.6229	.5344	103
1990	34630310	3150212	1154078	645148	.5590	.4325	103
1991	35613370	2957685	949692	654147	.6888	.4894	101
1992	65698270	3012836	691979	716903	1.0360	.6324	98
1993	58976770	3045028	464538	671155	1.4448	.7656	101
1994	35622900	2506444	547082	562619	1.0284	.6760	103
1995	50491850	2113080	550544	640794	1.1639	.8158	102
1996	68579700	1816505	538841	306018	.5679	.3482	100

Table 2.8.3 Output of ICA North Sea herring 1997

Catch in number (millions)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	195.	1269.	142.	443.	497.	157.	375.	645.	839.	112.	898.	684.	750.	289.	996.
1	2393.	336.	2147.	1262.	2972.	3209.	1383.	1674.	2425.	2503.	1196.	4379.	3341.	2368.	846.
2	1142.	1889.	270.	2961.	1548.	2218.	2570.	1172.	1795.	1883.	2003.	1147.	1441.	1344.	773.
3	1967.	480.	797.	177.	2243.	1325.	741.	1365.	1494.	296.	884.	663.	344.	659.	362.
4	166.	1456.	335.	158.	148.	2039.	450.	372.	621.	133.	125.	208.	131.	150.	126.
5	168.	124.	1082.	81.	149.	145.	890.	298.	157.	191.	50.	27.	33.	59.	56.
6	113.	158.	127.	230.	95.	152.	45.	393.	145.	50.	61.	31.	5.	31.	22.
7	126.	61.	145.	22.	256.	118.	65.	68.	163.	43.	8.	27.	0.	4.	5.
8	129.	56.	86.	42.	26.	413.	96.	82.	14.	27.	12.	0.	1.	1.	2.
9	142.	88.	87.	51.	58.	78.	236.	173.	92.	25.	12.	12.	0.	1.	1.

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	264.	238.	257.	130.	542.	1263.	9520.	11957.	13297.	6845.	4294.	3765.	8257.	3209.	3066.
1	2461.	127.	144.	169.	159.	245.	872.	1116.	2449.	1785.	3317.	4853.	6859.	7976.	3155.
2	542.	902.	45.	5.	34.	134.	284.	299.	574.	1125.	1352.	1280.	2144.	2264.	1598.
3	260.	117.	186.	6.	10.	92.	57.	230.	216.	433.	1206.	850.	670.	1106.	1368.
4	141.	52.	11.	5.	10.	32.	40.	34.	105.	198.	376.	471.	469.	389.	812.
5	57.	35.	7.	0.	2.	22.	29.	14.	26.	80.	127.	131.	247.	259.	212.
6	16.	6.	4.	0.	0.	2.	23.	7.	23.	22.	45.	63.	75.	130.	124.
7	9.	4.	2.	0.	1.	1.	19.	8.	13.	25.	21.	21.	24.	39.	61.
8	3.	1.	1.	0.	1.	0.	6.	4.	11.	11.	13.	14.	8.	16.	20.
9	1.	0.	0.	0.	0.	0.	1.	1.	12.	18.	16.	15.	8.	9.	9.

Age	1990	1991	1992	1993	1994	1995	1996
0	1286.	2370.	10281.	10165.	4377.	8518.	2428.
1	2982.	2124.	2292.	3789.	1737.	1653.	1608.
2	888.	1125.	1279.	1165.	1735.	1590.	708.
3	769.	553.	441.	603.	476.	908.	629.
4	850.	545.	360.	303.	338.	245.	196.
5	383.	498.	359.	214.	106.	122.	59.
6	79.	204.	374.	224.	89.	56.	20.
7	54.	39.	152.	186.	74.	41.	11.
8	29.	25.	39.	86.	68.	54.	8.
9	12.	13.	23.	41.	45.	73.	18.

Table 2.8.3 Output of ICA North Sea herring 1997

Predicted Catch in Number (millions)

Age	1992	1993	1994	1995	1996
0	9147.0	9740.3	5266.3	8819.1	5494.7
1	1793.8	3429.0	2621.5	1932.1	1199.4
2	1208.0	1428.7	1990.6	2020.3	607.9
3	544.0	668.1	559.4	1051.0	430.9
4	411.9	292.6	252.9	286.0	218.3
5	395.7	209.7	104.2	122.3	55.5
6	330.6	213.0	79.3	53.4	25.2
7	143.3	177.9	80.5	40.6	11.0
8	38.7	82.4	72.1	44.0	9.0

Table 2.8.3 Output of ICA North Sea herring 1997

Weights at age in the catches (Kg)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500
1	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000
2	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600	.12600
3	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600	.17600
4	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100	.21100
5	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300	.24300
6	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100	.25100
7	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26700
8	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100
9	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27100

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	.01500	.01500	.01500	.01500	.01500	.01500	.00700	.01000	.01000	.01000	.00900	.00600	.01100	.01100	.01700
1	.05000	.05000	.05000	.05000	.05000	.05000	.04900	.05900	.05900	.05900	.03600	.06700	.03500	.05500	.04300
2	.12600	.12600	.12600	.12600	.12600	.12600	.11800	.11800	.11800	.11800	.12800	.12100	.09900	.11100	.11500
3	.17600	.17600	.17600	.17600	.17600	.17600	.14200	.14900	.14900	.14900	.16400	.15300	.15000	.14500	.15300
4	.21100	.21100	.21100	.21100	.21100	.21100	.18900	.17900	.17900	.17900	.19400	.18200	.18000	.17400	.17300
5	.24300	.24300	.24300	.24300	.24300	.24300	.21100	.21700	.21700	.21700	.21100	.20800	.21100	.19700	.20800
6	.25100	.25100	.25100	.25100	.25100	.25100	.22200	.23800	.23800	.23800	.22000	.22100	.23400	.21600	.23100
7	.26700	.26700	.26700	.26700	.26700	.26700	.26700	.26500	.26500	.26500	.25800	.23800	.25800	.23700	.24700
8	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27400	.27400	.27400	.27000	.25200	.27700	.25300	.26500
9	.27100	.27100	.27100	.27100	.27100	.27100	.27100	.27500	.27500	.27500	.29200	.26200	.29900	.26300	.25900

Age	1990	1991	1992	1993	1994	1995	1996
0	.01900	.01700	.01000	.01000	.00600	.00900	.01600
1	.05500	.05800	.05300	.03300	.05600	.04800	.01000
2	.11400	.13000	.10200	.11500	.13000	.13600	.12300
3	.14900	.16600	.17500	.14500	.15900	.16700	.16000
4	.17700	.18400	.18900	.18900	.18100	.19600	.19200
5	.19300	.20300	.20700	.20400	.21400	.20000	.20700
6	.22900	.21700	.22300	.22800	.24000	.24700	.21100
7	.23600	.23500	.23700	.24400	.25500	.24900	.25200
8	.25000	.25900	.24900	.25600	.27300	.27800	.25400
9	.28700	.27100	.28700	.31000	.28100	.28700	.28100

Table 2.8.3 Output of ICA North Sea herring 1997

Weights at age in the stock (Kg)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500
1	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000
2	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500
3	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700
4	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300
5	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900
6	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600
7	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900
8	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600
9	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01500	.01300	.01000	.00700	.00600	.00800	.01200
1	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05000	.05400	.06400	.06400	.05700	.04800	.05300
2	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15500	.15000	.14700	.14000	.13400	.13200	.13600
3	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18700	.18900	.19000	.18900	.17900	.17500	.17600
4	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22300	.22500	.22500	.22400	.22000	.21500	.21100
5	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.23900	.24200	.24500	.24800	.24500	.24700	.24200
6	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27600	.27000	.27200	.26700	.27100	.27200	.27000
7	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29900	.29500	.29100	.28300	.28300	.28200
8	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.30600	.31000	.31700	.31900	.31200	.30800	.29700
9	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.31200	.33100	.34100	.33900	.33800	.33000

Age	1990	1991	1992	1993	1994	1995	1996
0	.01500	.01400	.01200	.00900	.00800	.00600	.00300
1	.06000	.06900	.07100	.07000	.06400	.05500	.05200
2	.14800	.14800	.13800	.13200	.12800	.12900	.12500
3	.18700	.19800	.18500	.18600	.17700	.19300	.18900
4	.21400	.21700	.21500	.21300	.20700	.22300	.22600
5	.24100	.23700	.23500	.23900	.22300	.23500	.22900
6	.26700	.25700	.26400	.27400	.26500	.27200	.26400
7	.28200	.27600	.27800	.29100	.28600	.29200	.28100
8	.29700	.29600	.30500	.31300	.31000	.31700	.31300
9	.33300	.31500	.32300	.33200	.33700	.33500	.33000

Table 2.8.3 Output of ICA North Sea herring 1997

Natural Mortality (per year)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000
3	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000
4	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
5	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
6	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
7	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
8	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
9	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000	.3000
3	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000	.2000
4	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
5	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
6	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
7	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
8	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000
9	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000	.1000

Age	1990	1991	1992	1993	1994	1995	1996
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2	.3000	.3000	.3000	.3000	.3000	.3000	.3000
3	.2000	.2000	.2000	.2000	.2000	.2000	.2000
4	.1000	.1000	.1000	.1000	.1000	.1000	.1000
5	.1000	.1000	.1000	.1000	.1000	.1000	.1000
6	.1000	.1000	.1000	.1000	.1000	.1000	.1000
7	.1000	.1000	.1000	.1000	.1000	.1000	.1000
8	.1000	.1000	.1000	.1000	.1000	.1000	.1000
9	.1000	.1000	.1000	.1000	.1000	.1000	.1000

Table 2.8.3 Output of ICA North Sea herring 1997

Proportion of fish spawning

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.8200	.8200	.8200
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.8200	.8200	.8200	.8200	.8200	.8200	.8200	.8200	.8200	.8200	.7000	.7500	.6300	.6600	.7900
3	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	.9000	.9400
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Age	1990	1991	1992	1993	1994	1995	1996
0	.0000	.0000	.0000	.0000	.0000	.0000	.0000
1	.0000	.0000	.0000	.0000	.0000	.0000	.0000
2	.7300	.6400	.5100	.4700	.7200	.7300	.6100
3	.9700	.9700	1.0000	.6300	.8600	.9500	.9800
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.8.3 Output of ICA North Sea herring 1997

INDICES OF SPAWNING BIOMASS

MLAI

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	2.07	3.41	4.61	3.26	6.68	12.65	17.99	27.99	42.35	22.76	40.08	72.10	85.88	112.62	56.04

	1992	1993	1994	1995	1996
1	11.73	25.08	15.74	25.87	45.88

AGE - STRUCTURED INDICES

AC089: acoustic data from 1989 (Catch: N

Age	1989	1990	1991	1992	1993	1994	1995	1996
2	3726.0	2971.0	2834.0	4179.0	3710.0	3280.0	3799.0	4550.6
3	3751.0	3530.0	1501.0	1633.0	1885.0	957.0	2056.0	2823.1
4	1612.0	3370.0	2102.0	1397.0	909.0	429.0	656.0	1087.3
5	488.0	1349.0	1984.0	1510.0	795.0	363.0	272.0	310.9
6	281.0	395.0	748.0	1311.0	788.0	321.0	175.0	98.7
7	120.0	211.0	262.0	474.0	546.0	328.0	135.0	82.8
8	44.0	134.0	112.0	155.0	178.0	220.0	110.0	132.9
9	22.0	43.0	56.0	163.0	116.0	132.0	84.0	206.0

IBTSA: international bottom trawl survey

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	109.0	161.0	716.0	661.0	838.0	4100.0	775.0	580.0	794.0	377.0	762.0	1090.0	1285.0	195.0	391.0
3	42.0	75.0	256.0	235.0	117.0	783.0	411.0	322.0	283.0	181.0	236.0	199.0	152.0	46.0	85.0
4	14.0	32.0	26.0	57.0	56.0	55.0	86.0	271.0	250.0	63.0	45.0	64.0	46.0	14.0	26.0
5	34.0	7.0	36.0	17.0	44.0	26.0	10.0	70.0	170.0	102.0	64.0	40.0	9.0	9.0	18.0

Table 2.8.3 Output of ICA North Sea herring 1997

IBTSY: international bottom trawl survey

Age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	172.0	312.0	431.0	772.0	1260.0	1440.0	2080.0	2540.0	3680.0	4530.0	2310.0	1020.0	1160.0	1160.0	2940.0

Age	1994	1995	1996	1997
1	1667.0	1186.0	1729.0	4192.0

MIK: MIK 0-ringer index (Catch: Number)

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	17.10	13.10	52.10	101.10	76.70	133.90	91.80	115.00	181.30	177.40	270.90	168.90	71.40	25.90	69.90

Age	1992	1993	1994	1995	1996	1997
0	200.70	190.10	101.70	127.00	106.50	148.10

Table 2.8.3 Output of ICA North Sea herring 1997

Fishing Mortality (per year)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	.0257	.0186	.0049	.0148	.0126	.0071	.0215	.0256	.0348	.0082	.0351	.0339	.0583	.0459	.0747
1	.2546	.1290	.0896	.1240	.3084	.2461	.1852	.2980	.3002	.3291	.2680	.6018	.5776	.6735	.4484
2	.4256	.6123	.2494	.2973	.3888	.7753	.5919	.4221	1.3263	.7841	.9727	.8822	.8113	1.0196	1.0271
3	.3169	.3399	.6179	.2744	.4120	.7383	.7082	.8042	1.8708	.9106	1.2658	1.2141	.8006	1.3297	.9666
4	.3206	.3882	.3999	.2220	.3682	.7753	.5710	.9244	1.0702	.8720	1.3223	1.2225	.7986	.9853	.9845
5	.2436	.3741	.4929	.1404	.2990	.6537	.8314	.8253	1.2338	1.0506	.8705	1.0635	.5455	.9485	1.1771
6	.2862	.3379	.7167	.1624	.2184	.4976	.3843	1.0002	1.1656	1.8998	1.0696	2.5174	.4965	1.3511	1.0694
7	.5118	.2222	.5237	.2297	.2450	.4055	.3629	1.4678	1.5431	1.2658	4.0597	2.5254	.0879	.7440	.7324
8	.4158	.3991	.4873	.2493	.4072	.6786	.5945	.9314	1.3677	1.1515	1.5558	1.6496	.7511	1.2173	1.0729
9	.4158	.3991	.4873	.2493	.4072	.6786	.5945	.9314	1.3677	1.1515	1.5558	1.6496	.7511	1.2173	1.0729

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	.1499	.1424	.0958	.0447	.0833	.1250	.4795	.3320	.3963	.2196	.0864	.0628	.1620	.1263	.1305
1	.6847	.2351	.2866	.1960	.1632	.1126	.2833	.2234	.2493	.1988	.3845	.3176	.3752	.5910	.4321
2	1.2884	1.3209	.2092	.0232	.0925	.3541	.3220	.2580	.2992	.3038	.4056	.4576	.4060	.3643	.4055
3	1.4962	1.3429	1.3405	.0391	.0636	.4066	.2655	.5033	.3202	.4142	.6692	.5194	.4975	.4056	.4191
4	1.3436	1.6917	.3693	.0942	.0858	.2817	.2906	.2357	.4296	.5137	.7302	.5719	.5772	.5741	.5584
5	1.8078	1.4614	1.0844	.0139	.0469	.2388	.3828	.1462	.2592	.5953	.6462	.5373	.5916	.6486	.6307
6	1.2438	.9282	.5763	.0644	.0103	.0599	.3731	.1315	.3218	.3243	.6976	.6855	.5953	.6340	.6586
7	1.9480	1.3662	.5397	.0431	.3470	.0837	.8019	.1888	.3451	.6075	.4980	.7360	.5327	.6200	.6166
8	1.6403	1.3234	.7258	.1118	.1578	.2605	.4744	.3047	.3905	.4902	.6907	.6487	.6213	.7046	.6552
9	1.6403	1.3234	.7258	.1118	.1578	.2605	.4744	.3047	.3905	.4902	.6907	.6487	.6213	.7046	.6552

Age	1990	1991	1992	1993	1994	1995	1996
0	.0603	.1102	.2433	.2945	.2600	.3138	.1340
1	.4449	.3188	.2699	.3268	.2885	.3482	.1486
2	.3717	.5619	.5618	.6801	.6006	.7248	.3094
3	.3723	.4483	.6364	.7704	.6802	.8210	.3504
4	.4741	.4664	.6758	.8181	.7224	.8718	.3721
5	.4940	.4982	.6464	.7825	.6910	.8339	.3559
6	.4505	.4723	.6415	.7767	.6858	.8277	.3533
7	.5912	.3710	.6312	.7641	.6747	.8143	.3476
8	.5792	.5474	.6758	.8181	.7224	.8718	.3721
9	.5792	.5474	.6758	.8181	.7224	.8718	.3721

Table 2.8.3 Output of ICA North Sea herring 1997

Population Abundance (1 January) - billions

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	12.12	108.92	46.29	47.66	62.79	34.90	27.87	40.26	38.70	21.59	41.09	32.34	20.87	10.17	21.77
1	16.50	4.35	39.33	16.95	17.27	22.81	12.75	10.03	14.44	13.75	7.88	14.59	11.50	7.24	3.57
2	3.77	4.70	1.40	13.23	5.51	4.67	6.56	3.90	2.74	3.93	3.64	2.22	2.94	2.37	1.36
3	7.95	1.83	1.89	.81	7.28	2.77	1.59	2.69	1.89	.54	1.33	1.02	.68	.97	.63
4	.63	4.74	1.06	.83	.50	3.95	1.08	.64	.99	.24	.18	.31	.25	.25	.21
5	.81	.42	2.91	.65	.60	.32	1.64	.55	.23	.31	.09	.04	.08	.10	.08
6	.48	.58	.26	1.61	.51	.41	.15	.65	.22	.06	.10	.03	.01	.04	.04
7	.33	.32	.37	.11	1.24	.37	.22	.09	.22	.06	.01	.03	.00	.01	.01
8	.40	.18	.23	.20	.08	.88	.22	.14	.02	.04	.02	.00	.00	.00	.00
9	.44	.28	.24	.24	.18	.17	.55	.30	.13	.04	.02	.02	.00	.00	.00

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	2.96	2.81	4.41	4.69	10.66	16.83	38.04	65.18	62.27	53.95	81.49	97.38	86.19	42.36	39.24
1	7.43	.94	.90	1.47	1.65	3.61	5.46	8.66	17.20	15.41	15.93	27.50	33.64	26.97	13.74
2	.84	1.38	.27	.25	.45	.52	1.19	1.51	2.55	4.93	4.65	3.99	7.36	8.50	5.49
3	.36	.17	.27	.16	.18	.30	.27	.64	.87	1.40	2.70	2.30	1.87	3.63	4.38
4	.20	.07	.04	.06	.13	.14	.16	.17	.32	.52	.76	1.13	1.12	.93	1.98
5	.07	.05	.01	.02	.05	.11	.09	.11	.12	.19	.28	.33	.58	.57	.47
6	.02	.01	.01	.00	.02	.04	.08	.06	.09	.08	.09	.13	.17	.29	.27
7	.01	.01	.00	.00	.00	.02	.04	.05	.05	.06	.05	.04	.06	.09	.14
8	.00	.00	.00	.00	.00	.00	.02	.01	.04	.03	.03	.03	.02	.03	.04
9	.00	.00	.00	.00	.00	.00	.00	.00	.04	.05	.03	.03	.02	.02	.02

Age	1990	1991	1992	1993	1994	1995	1996	1997
0	34.63	35.61	65.70	58.98	35.62	50.49	68.58	60.00
1	12.67	11.99	11.73	18.95	16.16	10.10	13.57	22.07
2	3.28	2.99	3.21	3.30	5.03	4.46	2.62	4.30
3	2.71	1.68	1.26	1.36	1.24	2.04	1.60	1.43
4	2.36	1.53	.88	.55	.51	.51	.74	.92
5	1.03	1.33	.87	.40	.22	.23	.19	.46
6	.23	.57	.73	.41	.17	.10	.09	.12
7	.13	.13	.32	.35	.17	.08	.04	.06
8	.07	.06	.08	.15	.15	.08	.03	.03
9	.03	.03	.05	.08	.09	.13	.06	.06

Table 2.8.3 Output of ICA North Sea herring 1997

Weighting factors for the catches in number

Age	1992	1993	1994	1995	1996
0	1.0000	1.0000	1.0000	1.0000	.0100
1	1.0000	1.0000	1.0000	1.0000	.0100
2	1.0000	1.0000	1.0000	1.0000	1.0000
3	1.0000	1.0000	1.0000	1.0000	1.0000
4	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0000	1.0000	1.0000	1.0000	1.0000
6	1.0000	1.0000	1.0000	1.0000	1.0000
7	1.0000	1.0000	1.0000	1.0000	1.0000
8	1.0000	1.0000	1.0000	1.0000	1.0000

Predicted SSB Index values

MLAI x 10 ^ -3

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	1712.	2423.	4162.	5218.	8117.	12000.	19817.	34618.	36340.	37130.	43512.	57793.	65019.	58532.	46827.

	1992	1993	1994	1995	1996
1	32593.	20655.	24907.	25088.	24478.

Predicted Age-Structured Index Values

AC089: acoustic data from 1989 (Catch: NPredicted

Age	1989	1990	1991	1992	1993	1994	1995	1996
2	5733.3	3487.4	2860.3	3072.2	2957.2	4713.5	3900.8	2887.2
3	5303.2	3372.9	1997.7	1356.3	1353.4	1297.9	1984.5	2011.7
4	2601.9	3237.8	2111.9	1077.3	621.5	615.4	566.1	1069.5
5	694.1	1618.8	2087.4	1259.4	542.5	308.7	295.0	330.0
6	401.5	383.1	938.9	1100.9	576.8	245.7	134.8	156.7
7	223.4	205.4	242.9	510.9	516.0	267.3	109.8	73.0
8	72.4	120.7	114.2	139.0	240.5	241.1	119.8	60.8
9	30.7	47.2	55.2	79.3	114.6	144.1	188.6	115.9

Table 2.8.3 Output of ICA North Sea herring 1997

IBTSA: international bottom trawl surveyPredicted

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	362.6	701.2	652.4	556.6	1033.6	1199.9	771.1	462.4	411.2	441.6	447.0	688.8	600.9	372.8	611.3
3	82.4	131.6	245.5	212.9	174.0	342.0	411.1	256.3	156.8	115.3	121.8	112.4	182.5	151.5	135.1
4	19.1	30.9	44.2	67.3	66.5	55.4	118.3	142.0	92.3	51.5	31.5	30.0	29.4	44.9	56.3
5	12.1	14.6	17.3	20.2	30.3	35.2	33.5	53.3	76.7	72.7	48.6	28.0	21.1	15.2	26.5

IBTSY: international bottom trawl surveyPredicted

Age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	183.8	404.4	599.6	957.7	1895.7	1709.0	1726.4	3004.3	3649.2	2847.1	1479.2	1362.3	1310.3	1289.7	2067.9

Age	1994	1995	1996	1997
1	1772.1	1099.7	1514.3	2462.2

MIK: MIK 0-ringer index (Catch: Number) Predicted

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	10.94	11.71	26.48	41.60	89.93	156.96	148.74	131.76	202.37	242.53	212.02	104.67	96.90	86.28	88.17

Age	1992	1993	1994	1995	1996	1997
0	159.98	142.69	86.56	121.87	169.29	148.10

Table 2.8.3 Output of ICA North Sea herring 1997

Fitted Selection Pattern

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
0	.0801	.0479	.0121	.0666	.0342	.0092	.0376	.0277	.0325	.0094	.0265	.0278	.0730	.0466	.0758
1	.7941	.3324	.2241	.5586	.8377	.3174	.3244	.3223	.2805	.3774	.2027	.4923	.7232	.6836	.4555
2	1.3274	1.5773	.6237	1.3392	1.0559	1.0000	1.0367	.4567	1.2393	.8992	.7356	.7216	1.0159	1.0348	1.0432
3	.9884	.8757	1.5452	1.2358	1.1189	.9522	1.2404	.8700	1.7480	1.0443	.9573	.9931	1.0025	1.3495	.9817
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	.7597	.9637	1.2327	.6322	.8120	.8431	1.4561	.8927	1.1529	1.2048	.6584	.8699	.6831	.9627	1.1956
6	.8927	.8705	1.7923	.7315	.5931	.6418	.6730	1.0820	1.0891	2.1787	.8089	2.0592	.6217	1.3713	1.0862
7	1.5963	.5725	1.3097	1.0344	.6654	.5230	.6355	1.5879	1.4419	1.4516	3.0703	2.0657	.1100	.7551	.7439
8	1.2968	1.0281	1.2187	1.1229	1.1059	.8752	1.0411	1.0076	1.2779	1.3206	1.1766	1.3493	.9406	1.2355	1.0897
9	1.2968	1.0281	1.2187	1.1229	1.1059	.8752	1.0411	1.0076	1.2779	1.3206	1.1766	1.3493	.9406	1.2355	1.0897

Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	.1116	.0842	.2595	.4744	.9708	.4436	1.6497	1.4084	.9224	.4275	.1183	.1098	.2807	.2199	.2336
1	.5096	.1390	.7759	2.0819	1.9030	.3997	.9747	.9477	.5802	.3870	.5265	.5553	.6501	1.0295	.7738
2	.9589	.7808	.5664	.2463	1.0780	1.2568	1.1078	1.0944	.6966	.5915	.5555	.8000	.7034	.6345	.7261
3	1.1135	.7938	3.6296	.4153	.7411	1.4433	.9134	2.1352	.7453	.8063	.9164	.9081	.8619	.7065	.7504
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.3455	.8639	2.9361	.1471	.5472	.8475	1.3171	.6204	.6034	1.1588	.8849	.9394	1.0250	1.1298	1.1294
6	.9257	.5487	1.5605	.6834	.1204	.2127	1.2838	.5579	.7491	.6313	.9552	1.1986	1.0314	1.1044	1.1794
7	1.4498	.8076	1.4613	.4580	4.0448	.2970	2.7589	.8008	.8034	1.1826	.6820	1.2869	.9230	1.0799	1.1042
8	1.2208	.7823	1.9652	1.1876	1.8396	.9247	1.6322	1.2929	.9089	.9542	.9458	1.1342	1.0765	1.2274	1.1733
9	1.2208	.7823	1.9652	1.1876	1.8396	.9247	1.6322	1.2929	.9089	.9542	.9458	1.1342	1.0765	1.2274	1.1733

Age	1990	1991	1992	1993	1994	1995	1996
0	.1271	.2362	.3600	.3600	.3600	.3600	.3600
1	.9385	.6835	.3994	.3994	.3994	.3994	.3994
2	.7840	1.2048	.8314	.8314	.8314	.8314	.8314
3	.7854	.9613	.9417	.9417	.9417	.9417	.9417
4	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5	1.0419	1.0682	.9565	.9565	.9565	.9565	.9565
6	.9503	1.0125	.9493	.9493	.9493	.9493	.9493
7	1.2470	.7953	.9340	.9340	.9340	.9340	.9340
8	1.2217	1.1737	1.0000	1.0000	1.0000	1.0000	1.0000
9	1.2217	1.1737	1.0000	1.0000	1.0000	1.0000	1.0000

Table 2.8.3 Output of ICA North Sea herring 1997

```
No of years for separable analysis :  5
Age range in the analysis          :  0 9
Year range in the analysis         :  1960 1996
Number of indices of SSB           :  1
Number of age-structured indices   :  4
Stock-Recruit relationship to be fitted.
Parameters to estimate             :  44
Number of observations             :  265

 Conventional single selection vector model to be fitted.
```

PARAMETER ESTIMATES

Parm No.		Maximum Likelih. Estimate	CV (%)	Lower 95% CL	Upper 95% CL	-s.e.	+s.e.	Mean of Param. distrib.
Separable Model: Reference F by year								
1	1992	.6758	13	.5230	.8732	.5930	.7702	.6816
2	1993	.8181	12	.6396	1.0465	.7215	.9276	.8246
3	1994	.7224	13	.5576	.9359	.6330	.8244	.7287
4	1995	.8718	14	.6589	1.1537	.7557	1.0058	.8808
5	1996	.3721	18	.2569	.5391	.3080	.4496	.3788
Separable Model: Selection (S) by age								
6	0	.3600	17	.2560	.5061	.3025	.4283	.3654
7	1	.3994	17	.2844	.5610	.3359	.4750	.4055
8	2	.8314	15	.6143	1.1250	.7125	.9701	.8413
9	3	.9417	15	.6920	1.2814	.8047	1.1019	.9534
	4	1.0000			Fixed : Reference age			
10	5	.9565	15	.7102	1.2882	.8217	1.1134	.9676
11	6	.9493	14	.7175	1.2561	.8229	1.0951	.9591
12	7	.9340	14	.7084	1.2315	.8112	1.0755	.9434
	8	1.0000			Fixed : last true age			

Table 2.8.3 Output of ICA North Sea herring 1997

Separable Model: Populations in year 1996

13	0	68579704	19	46401679	101357879	56186685	83706234	69955563
14	1	13571556	17	9643749	19099121	11400494	16156066	13779332
15	2	2624013	14	1984206	3470126	2275296	3026176	2650827
16	3	1598853	14	1214912	2104129	1389824	1839321	1614624
17	4	736007	14	551176	982818	635045	853019	744061
18	5	194051	16	139889	269184	164210	229315	196775
19	6	88669	18	61738	127350	73715	106657	90195
20	7	39133	20	26341	58137	31977	47891	39939
21	8	30481	22	19681	47206	24384	38102	31249

Separable Model: Populations at age 8

22	1992	82310	27	47599	142335	62244	108846	85587
23	1993	153995	21	100428	236132	123819	191525	157701
24	1994	146501	20	98980	216837	119938	178947	149462
25	1995	78989	19	54254	115002	65213	95676	80454

Recruitment in Year 1997

26	1996	59995807	28	34076994	105628357	44955658	80067717	62547052

SSB Index catchabilities

MLAI

27	1	Q	3.141	14	2.551	4.435	2.921	3.874	3.398
28	1	K	.6736E-05	14	.1244E-04	.2162E-04	.1424E-04	.1888E-04	.1760E-04

Age-structured index catchabilities

ACO89: acoustic data from 1989 (Catch: N

Linear model fitted. Slopes at age:

29	2	Q	1.538	28	1.171	3.571	1.538	2.717	2.129
30	3	Q	1.703	28	1.296	3.957	1.703	3.011	2.358
31	4	Q	1.884	28	1.432	4.386	1.884	3.335	2.611
32	5	Q	2.185	28	1.660	5.105	2.185	3.877	3.033
33	6	Q	2.268	28	1.720	5.324	2.268	4.037	3.154
34	7	Q	2.387	29	1.804	5.668	2.387	4.282	3.337
35	8	Q	2.587	29	1.940	6.284	2.587	4.713	3.652
36	9	Q	2.462	29	1.861	5.834	2.462	4.410	3.438

Table 2.8.3 Output of ICA North Sea herring 1997

IBTSA: international bottom trawl survey

Linear model fitted. Slopes at age:

37	2	Q	..1533E-03	14	.1330E-03	.2375E-03	.1533E-03	.2060E-03	.1797E-03
38	3	Q	.1015E-03	14	.8802E-04	.1574E-03	.1015E-03	.1365E-03	.1190E-03
39	4	Q	.6473E-04	14	.5612E-04	.1005E-03	.6473E-04	.8714E-04	.7594E-04
40	5	Q	.3889E-04	14	.3370E-04	.6052E-04	.3889E-04	.5243E-04	.4566E-04

IBTSY: international bottom trawl survey

Linear model fitted. Slopes at age:

41	1	Q	.1288E-03	6	.1207E-03	.1575E-03	.1288E-03	.1476E-03	.1382E-03

MIK: MIK 0-ringer index (Catch: Number)

Linear model fitted. Slopes at age:

42	0	Q	.2844E-05	6	.2672E-05	.3448E-05	.2844E-05	.3240E-05	.3042E-05

Parameters of the B.H. stock-recruit relationship

43	1	a	.8434E+08	42	.5601E+08	.2980E+09	.8434E+08	.1979E+09	.1415E+09
44	1	b	.6893E+06	70	.3492E+06	.5608E+07	.6893E+06	.2841E+07	.1798E+07

Table 2.8.3 Output of ICA North Sea herring 1997

RESIDUALS ABOUT THE MODEL FIT

Separable Model Residuals

Age	1992	1993	1994	1995	1996
0	.1169	.0426	-.1850	-.0348	-.8168
1	.2451	.0999	-.4117	-.1563	.2928
2	.0568	-.2042	-.1375	-.2396	.1529
3	-.2110	-.1024	-.1619	-.1467	.3785
4	-.1355	.0333	.2908	-.1567	-.1088
5	-.0982	.0181	.0170	-.0007	.0668
6	.1228	.0493	.1193	.0481	-.2108
7	.0573	.0458	-.0800	.0198	.0031
8	.0079	.0470	-.0577	.2055	-.1350

Units

SPAWNING BIOMASS INDEX RESIDUALS

MLAI

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	.190	.342	.102	-.470	-.195	.053	-.097	-.213	.153	-.489	-.082	.221	.278	.654	.180

	1992	1993	1994	1995	1996
1	-1.022	.194	-.459	.031	.628

Units

Table 2.8.3 Output of ICA North Sea herring 1997

AGE - STRUCTURED INDEX RESIDUALS

AC089: acoustic data from 1989 (Catch: N

Age	1989	1990	1991	1992	1993	1994	1995	1996
2	-.4310	-.1602	-.0093	.3077	.2268	-.3626	-.0264	.4550
3	-.3463	.0455	-.2859	.1856	.3313	-.3047	.0354	.3389
4	-.4787	.0400	-.0047	.2599	.3802	-.3608	.1474	.0166
5	-.3522	-.1823	-.0508	.1815	.3822	.1620	-.0812	-.0596
6	-.3568	.0307	-.2273	.1747	.3119	.2674	.2613	-.4623
7	-.6217	.0270	.0757	-.0750	.0565	.2048	.2065	.1257
8	-.4983	.1043	-.0196	.1090	-.3008	-.0917	-.0850	.7814
9	-.3347	-.0923	.0145	.7205	.0118	-.0875	-.8087	.5756

IBTSA: international bottom trawl survey

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
2	-1.202	-1.471	.093	.172	-.210	1.229	.005	.227	.658	-.158	.533	.459	.760	-.648	-.447
3	-.674	-.562	.042	.099	-.397	.828	.000	.228	.591	.451	.661	.571	-.183	-1.192	-.464
4	-.310	.035	-.531	-.166	-.172	-.008	-.319	.646	.996	.202	.355	.758	.448	-1.166	-.772
5	1.033	-.735	.731	-.173	.373	-.304	-1.208	.273	.796	.339	.276	.357	-.852	-.523	-.385

IBTSY: international bottom trawl survey

Age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1	-.0663	-.2593	-.3301	-.2155	-.4085	-.1712	.1863	-.1679	.0084	.4644	.4457	-.2894	-.1218	-.1060	.3519

Age	1994	1995	1996	1997
1	-.0611	.0756	.1326	.5321

Table 2.8.3 Output of ICA North Sea herring 1997

MIK: MIK 0-ringer index (Catch: Number)

Age	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.447	.112	.677	.888	-.159	-.159	-.483	-.136	-.110	-.313	.245	.479	-.305	-1.203	-.232

Age	1992	1993	1994	1995	1996	1997
0	.227	.287	.161	.041	-.463	.000

PARAMETERS OF THE DISTRIBUTION OF ln CATCHES AT AGE

Separable model fitted from 1992 to 1996

Variance	:	.0512
Skewness test statistic	:	-.5527
Kurtosis test statistic	:	.4153
Partial chi-square	:	.0778
Significance in fit	:	.0000
Degrees of freedom	:	20

PARAMETERS OF THE DISTRIBUTION OF THE SSB INDICES

DISTRIBUTION STATISTICS FOR INDEX1

Power catchability relationship assumed.
Last age is a plus-group.

Variance	:	.1680
Skewness test statistic	:	-1.2082
Kurtosis test statistic	:	.4758
Partial chi-square	:	1.0955
Significance in fit	:	.0000
Number of observations	:	20
Degrees of freedom	:	18
Weight in the analysis	:	1.0000

Table 2.8.3 Output of ICA North Sea herring 1997

PARAMETERS OF THE DISTRIBUTION OF THE AGE-STRUCTURED INDICES

DISTRIBUTION STATISTICS FOR ACO89: acoustic data from 1989 (Catch: N

Linear catchability relationship assumed.

Age	2	3	4	5	6	7	8	9
Variance	.0124	.0099	.0106	.0067	.0118	.0090	.0176	.0292
Skewness test stat.	.0176	-.0892	-.5757	.2191	-.5059	-2.0255	1.0877	-.0047
Kurtosis test stat.	-.7150	-.8964	-.4876	-.4311	-.8370	1.0756	.3635	-.3123
Partial chi-square	.0057	.0048	.0053	.0035	.0066	.0051	.0110	.0176
Significance in fit	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
Number of data	8	8	8	8	8	8	8	8
Degrees of freedom	7	7	7	7	7	7	7	7
Weight in analysis	.1250	.1250	.1250	.1250	.1250	.1250	.1250	.1250

DISTRIBUTION STATISTICS FOR IBTSA: international bottom trawl survey

Linear catchability relationship assumed.

Age	2	3	4	5
Variance	.1322	.0832	.0865	.1078
Skewness test stat.	-.7452	-.6023	-.2452	-.3446
Kurtosis test stat.	-.2250	-.5549	-.4268	-.7647
Partial chi-square	.2891	.2331	.3065	.4855
Significance in fit	.0000	.0000	.0000	.0000
Number of data	15	15	15	15
Degrees of freedom	14	14	14	14
Weight in analysis	.2500	.2500	.2500	.2500

Table 2.8.3 Output of ICA North Sea herring 1997

DISTRIBUTION STATISTICS FOR IBTSY: international bottom trawl survey

Linear catchability relationship assumed.

Age	:	1
Variance	:	.0802
Skewness test stat.	:	.9970
Kurtosis test stat.	:	-.7367
Partial chi-square	:	.1958
Significance in fit	:	.0000
Number of data	:	19
Degrees of freedom	:	18
Weight in analysis	:	1.0000

DISTRIBUTION STATISTICS FOR MIK: MIK 0-ringer index (Catch: Number)

Linear catchability relationship assumed.

Age	:	0
Variance	:	.2066
Skewness test stat.	:	-.7890
Kurtosis test stat.	:	.8285
Partial chi-square	:	1.0135
Significance in fit	:	.0000
Number of data	:	21
Degrees of freedom	:	20
Weight in analysis	:	1.0000

ANALYSIS OF VARIANCE TABLE

Unweighted Statistics

	SSQ	Data	Params	d.f.	Variance
Total for Model	52.9174	265	44	221	.2394
Catches at Age	1.7703	45	25	20	.0885
SSB Indices					
INDEX1	3.0246	20	2	18	.1680
Aged Indices					
AC089: acoustic data from 1989 (Catch:	6.0084	64	8	56	.1073
IBTSA: international bottom trawl surve	22.9461	60	4	56	.4098
IBTSY: international bottom trawl surve	1.4444	19	1	18	.0802
MIK: MIK 0-ringer index (Catch: Number)	4.1313	21	1	20	.2066
SRR Model	13.5922	36	2	34	.3998

Weighted Statistics

	SSQ	Data	Params	d.f.	Variance
Total for Model	24.7455	265	44	221	.1120
Catches at Age	1.0249	45	25	20	.0512
SSB Indices					
INDEX1	3.0246	20	2	18	.1680
Aged Indices					
AC089: acoustic data from 1989 (Catch:	.0939	64	8	56	.0017
IBTSA: international bottom trawl surve	1.4341	60	4	56	.0256
IBTSY: international bottom trawl surve	1.4444	19	1	18	.0802
MIK: MIK 0-ringer index (Catch: Number)	4.1313	21	1	20	.2066
SRR Model	13.5922	36	2	34	.3998

Table 2.10.1 Computation of reference Fs for catch prediction of North Sea Herring

CALCULATION OF REFRENCE "AREA-FISHING-MORTALITIES" **REF.-F**

Revised by P. Sparre 15. May 1995

Age	North Sea Catches			**Div.III a Catches**				Total	Total
	Fleet A	Fleet B	Total N.S.	Fleet C	Fleet D	Fleet E	Total IIIa	Stock	Catch
0	0.00	1795.71	1795.71	9.12	537.77	85.18	632.07		2427.78
1	5.89	732.01	737.90	181.56	363.72	324.25	869.53		1607.43
2	523.60	25.40	549.00	143.86	3.96	11.53	159.35	708.35	708.35
3	596.07	4.33	600.40	26.94	2.59	1.98	31.52		631.92
4	195.27	1.33	196.60						196.60
5	59.21	0.49	59.70						59.70
6	20.23	0.27	20.50						20.50
7	11.01	0.09	11.10						11.10
8	26.00	0.20	26.20						26.20
9			0.00						0.00

Catches by Fleet (B-E) from Table 2.2.8.
Data on Input File

a) N(1.Dec)= (N(1.Jan)*exp(-M/2) - C)*exp(-M/2)

Age	M	exp(-M/2)	1996 Total Stock N	1995-Split factors		Stock N 1. Jan		Stock N 31. Dec. a)		F b)	F b)
				N.S.	IIIa	N.S.	III a	N.S.	III a	N.S.	III a
0	1.00	0.6065	63563.4	0.70	0.30	44494.4	19069.0	15279.4	6631.7	0.0689	0.0562
1	1.00	0.6065	14194.0	0.55	0.45	7806.7	6387.3	2424.4	1822.4	0.1694	0.2542
2	0.30	0.8607	2620.0	1.00	1.00	2620.0	2620.0				
3	0.2	0.9048	1600.0	1.00	1.00	1600.0	1600.0				

F = ln(N(1.Jan)/N(31.Dec))-M

Data from ICA run Table 2.8.3 (Population abundance, 1996)
Split factors based see description "Split Factors"

Age	F referring to North Sea Catches			F referring to IIIa Catches			
	Fleet A	Fleet B	Total N.S.	Fleet C	Fleet D	Fleet E	Total IIIa
0	0.000	0.069	0.069	0.001	0.048	0.008	0.056
1	0.001	0.168	0.169	0.053	0.106	0.095	0.254
2	0.229	0.011	0.309	0.063	0.002	0.005	
3	0.348	0.003	0.350				
4	0.370	0.003	0.372				
5	0.353	0.003	0.356				
6	0.349	0.005	0.353				
7	0.345	0.003	0.348				
8	0.369	0.003	0.372				

Age group 2 is the total F (from ICA) distributed on all 5 fleets

These are the Fs from ICA, including age gr 2

Data from ICA 2.8.3

Table 2.10.1. Computation of reference Fs for catch prediction of North Sea herring

Table 2.10.2

Calculations

Revised by P. Sparre 15. May 1995

SHEET 1

Revised by P. Sparre and H. Sparholt 30.10.95 and further by H. Sparholt 31.10.95.

Input data revised by:

NORTH SEA HERRING SHORT TERM PREDICTION PROGRAM, WG **1997**

Fleet	Description	
A:	IV HC	*North Sea directed herring fisheries*
B:	IV IND	*North Sea*
C:	IIIa HC	*IIIa directed herring fisheries*
D:	IIIa MC	*IIIa "Mixed Clupeid"*
E:	IIIa IND.	*IIIa herring by catches*
F:	Fl. 22+24	*Western Baltic Combined fisheries*

The prediction is based on the following assumptions:
Age group 0 : Some migrate to IIIa, depending on year class
Age group 1 : Some migrate to IIIa, depending on year class
Age group 2: All fish in III a migrates back to the North Sea during the year
Age groups >3: Only in North Sea

Age group 0 Migration takes place 1 January
Age group 1 (distribution from MIK)
Age group 2: (distribution from IBTS)
(Total "area-mixing" assumed)
Age gr 3+: (No area-mixing assumed, only in North Sea)

INPUT DATA (indicated with Bold Italic)
Comments in Italic

1997 | 1997

Table 1

NORTH SEA HERRING STOCK SIZE 1. JANUARY					*1997*		
	STOCK NUMBER	MEAN WEIGHT AT AGE IN THE STOCK		MATURITY OGIVE	NATURAL MORTALITY		
AGE		*SPAW.*	*1. JAN.*		M	M/2	exp(-M/2)
0	***60000***	***3***	***3***	***0.00***	***1.00***	0.50	0.6065
1	***22070***	***52***	***52***	***0.00***	***1.00***	0.50	0.6065
2	***4300***	***125***	***125***	***0.61***	***0.30***	0.15	0.8607
3	***1430***	***189***	***189***	***0.98***	***0.20***	0.10	0.9048
4	***920***	***226***	***226***	***1.00***	***0.10***	0.05	0.9512
5	***460***	***229***	***229***	***1.00***	***0.10***	0.05	0.9512
6	***120***	***264***	***264***	***1.00***	***0.10***	0.05	0.9512
7	***60***	***281***	***281***	***1.00***	***0.10***	0.05	0.9512
8	***30***	***313***	***313***	***1.00***	***0.10***	0.05	0.9512
9+	***60***	***330***	***330***	***1.00***	***0.10***	0.05	0.9512
TOTAL	89450.0						0.9512

Data from ICA Table 2.8.2 (stock abundance, weights at age in stock, prop.fish spawn.)
For natural mortality as in previous year Mean weight at age in stock from 2 year mean

Table 2

NORTH SEA HERRING. MEAN WEIGHT AT AGE IN THE CATCH BY FLEET						1996
	IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
AGE	A	B	C	D	E	F
0	***30.70***	***12.30***	***18.12***	***13.09***	***10.37***	***0***
1	***81.85***	***21.35***	***48.65***	***15.53***	***23.17***	***0***
2	***132.20***	***63.45***	***69.70***	***37.61***	***46.28***	***0***
3	***163.66***	***130.90***	***130.97***	***55.80***	***73.60***	***0***
4	***194.29***	***149.75***	***0***	***0***	***0***	***0***
5	***206.41***	***159.05***	***0***	***0***	***0***	***0***
6	***234.61***	***182.00***	***0***	***0***	***0***	***0***
7	***255.60***	***215.00***	***0***	***0***	***0***	***0***
8	***272.26***	***237.35***	***0***	***0***	***0***	***0***
9+	***272.26***	***237.35***	***0***	***0***	***0***	***0***

Data from Table "Total catch in autumn spawners North Sea and IIIa", mean over two last years

Table 2.10.2

Table 3

0

FISHING MORTALITY BY FLEET RELATIVE TO AREA *)	*1996*

Calculations

AGE	IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
	A	B	C	D	E	F
0	0.0000	0.0689	0.0008	0.0478	0.0076	0
1	0.0014	0.1681	0.0531	0.1063	0.0948	0
2	0.2287	0.0111	0.0628	0.0017	0.0050	0
3	0.3479	0.0025	0	0	0	0
4	0.3696	0.0025	0	0	0	0
5	0.3530	0.0029	0	0	0	0
6	0.3486	0.0047	0	0	0	0
7	0.3448	0.0028	0	0	0	0
8	0.3693	0.0028	0	0	0	0
9	0.3693	0.0028	0	0	0	0

*) These are "area-mortalities", NOT tradititional fishing mortalities computed in sheet 2

Table 2.8.xx.C EXCEL 5 "work book" for short term prediction of North Sea Herring

SHEET 2 (NSHER94)

1997

1997

Table 4 1997

NORTH SEA HERRING STOCK SIZE 1. JANUARY					
	TOTAL NUMBER from table 1	STOCK NUMBERS BY AREA (Split factor) * (Total Numbe		1996 split factors	
a	*b*	*c*	*d*	*e*	*f*
AGE	Total	IV a)	IIIa b)	IV a)	IIIa b)
0	60000.0	39252.6	20747.4	***0.65***	***0.35***
1	22070.0	15449.0	6621.0	***0.70***	***0.30***
2	4300.0	4300.0	4300.0	***1***	***1***
3	1430.0	1430.0	0.0	1	0
4	920.0	920.0	0.0	1	0
5	460.0	460.0	0.0	1	0
6	120.0	120.0	0.0	1	0
7	60.0	60.0	0.0	1	0
8	30.0	30.0	0.0	1	0
9+	60.0	60.0	0.0	1	0
TOTAL	89450.0	62081.6	31668.4		

Table 5 1997

1997		NORTH SEA HERRING. F-FACTORS					
		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
	TOTAL	A	B	C	D	E	F
F-Factor	***1***	***1***	***1***	***1***	***1***	***1***	***0***
(Total Factor)*(F-Factor		1	1	1	1	1	0

Z = Ftotal + M, where *Ftotal = Fleet(1)*Factor(1)+..+Fleet(n)*Factor(n)*

Table 6 1997

TOTAL FISHING MORTALITY BY FLEET RELATIVE TO AREA					
	Total North Sea F		Total IIIa F		
AGE	F(N.S.)	Z(N.S.)	F(IIIa)	Z(IIIa)	
0	0.0689	1.0689	0.0562	1.0562	
1	0.1694	1.1694	0.2542	1.2542	
2	0.3094	0.6790	0.0696	0.6790	
3	0.3504	0.5504	0.0000	0.0000	
4	0.3721	0.4721	0.0000	0.0000	
5	0.3559	0.4559	0.0000	0.0000	
6	0.3533	0.4533	0.0000	0.0000	
7	0.3476	0.4476	0.0000	0.0000	
8	0.3721	0.4721	0.0000	0.0000	

9	0.3721	0.4721	0.0000	0.0000	

Table 7 1997 0

1997	NORTH SEA HERRING. CATCH AT AGE BY FLEET						
N(North Sea) * F(fleet) * (1-exp(-Z))/Z(North Se				N(IIIa) * F(fleet) * (1-exp(-Z(IIIa)))/Z(IIIa)			
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
AGE	TOTAL e)	A	B	C	D	E	F
0	2380.3	0.0	1660.3	10.4	612.6	97.0	
1	2502.1	12.3	1530.7	200.2	401.1	357.6	
2	965.7	713.9	34.6	196.1	5.4	15.7	
3	385.3	382.6	2.8				
4	272.9	271.0	1.8				
5	131.5	130.4	1.1				
6	34.1	33.6	0.4				
7	16.8	16.7	0.1				
8	8.9	8.8	0.1				
9+	17.8	17.7	0.1				
TOTAL	6715.4	1587.0	3232.2	406.8	1019.1	470.4	

Table 2.8.xx.D EXCEL 5 "work book" for short term prediction of North Sea Herring

SHEET 3

Table 8 *1997*

NORTH SEA HERRING. FISHING MORTALITY BY FLEET (TOTAL) *)						1997	
		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
a	b	c	d	e	f	g	h
AGE	TOTAL a)	A b)	B	C	D	E	F
0	0.068	0.000	0.047	0.000	0.017	0.003	0.000
1	0.207	0.001	0.127	0.017	0.033	0.030	0.000
2	0.302	0.224	0.011	0.061	0.002	0.005	0.000
3	0.354	0.351	0.003				
4	0.374	0.371	0.003				
5	0.357	0.354	0.003				
6	0.355	0.350	0.005				
7	0.349	0.346	0.003				
8	0.374	0.371	0.003				
9+	0.374	0.371	0.003				
AVG 2-6	0.348	0.330	0.005	0.061	0.002	0.005	0.000

a) = ln(N(o)/{N(o)*exp(-M/2)-C} *exp(-M/2) - M b) = F(total) * C(fleet)/C(total)

Table 9 1997

1997	NORTH SEA HERRING. YIELD AT AGE BY FLEET						
C * W (body weight)				C * W (body weight)			
a	b	*c*	*d*	*e*	*f*	*g*	*h*
AGE	TOTAL e)	A a)	B a)	C b)	D c)	E c)	F c)
0	29638.3	0.0	20422.0	188.4	8021.8	1006.1	
1	57946.6	1008.2	32681.3	9741.3	6228.3	8287.6	
2	111167.0	94368.8	2197.2	13670.5	202.9	727.7	
3	62975.2	62611.4	363.8				
4	52932.8	52656.3	276.4				
5	27087.3	26915.6	171.6				
6	7974.0	7892.2	81.7				
7	4291.9	4262.6	29.3				
8	2420.2	2404.0	16.1				
9+	4840.4	4808.1	32.2				
TOTAL	361273.6	256927.3	56271.7	23600.1	14453.0	10021.4	

0.000

Table 10 1997

NORTH SEA HERRING STOCK SIZE and SSB				
	TOTAL NUMBER	STOCK BIOMASS a)	b)	1997
	from table 1	1st Jan.	Spaw.time	Spaw.time
AGE	Total	Biomass	SS numbers	SSB c)
0	60000.0	180000.0	0.0	0
1	22070.0	1147640.0	0.0	0
2	4300.0	537500.0	1752.0	218994
3	1430.0	270270.0	967.1	182790
4	920.0	207920.0	669.8	151379
5	460.0	105340.0	338.6	77538
6	120.0	31680.0	88.5	23360
7	60.0	16860.0	44.4	12480
8	30.0	9390.0	21.8	6837
9+	60.0	19800.0	43.7	14416
TOTAL	89450.0	2526400.0	3925.9	687793

a) = N*w(1.jan)

b) = N*Maturity*exp(-Z*.67)

c) = N*w(spaw.time)*Maturity*exp(-Z*.67)

Table 11 SUMMARY RESULTS FOR YEAR 1997

		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
	TOTAL	A	B	C	D	E	F
CATCH	6715.4	1587.0	3232.2	406.8	1019.1	470.4	0.0
YIELD	361273.6	256927.3	56271.7	23600.1	14453.0	10021.4	0.0
SSB	687792.9		AVG F 2-6	0.348			

Table 2.8.xx.E EXCEL 5 "work book" for short term prediction of North Sea Herring (Sheet NSHER94)

SHEET 4

1998   1998

Table 1 1998

NORTH SEA HERRING STOCK SIZE 1. JANUARY					
	TOTAL NUMBER	STOCK NUMBERS BY AREA			
	from table 1	(Split factor) * (Total Numbe		1997 split factors	
AGE	Total a)	IV a)	IIIa b)	IV c)	IIIa d)
0	*44000.0*	29775.4	14224.6	0.68	0.32
1	20629.0	13495.7	7133.3	0.65	0.35
2	6601.5	6601.5	6601.5	*1*	*1*
3	2354.3	2354.3	0.0	1	0
4	822.1	822.1	0.0	1	0
5	572.9	572.9	0.0	1	0
6	291.2	291.2	0.0	1	0
7	76.2	76.2	0.0	1	0
8	38.3	38.3	0.0	1	0
9+	56.0	56.0	0.0	1	0
TOTAL	75441.5	54083.6	27959.5		

a) = N(a+1, y+1) =
(N(a,y)*exp(-M/2) - C(a,y))*exp(-M/2)
for ages 1-9. N(o) is input

c) for age group 0 based on ave. MIK:
c) for age group 1 based on MIK 1995 y.c.:
for age group 2: both split factor = 1.0

d) for age group 0 base
d) for age group 1 based on MIK 1995 y.c.:
for age group 2: both split factor = 1.0

Table 2 1998

0.35441		NORTH SEA HERRING. F-FACTORS					
		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
	TOTAL	A	B	C	D	E	F
F-Factor	*1*	***0***	***0***	***0***	***0***	***0***	***0***
(Total Factor)*(F-Factor		0	0	0	0	0	0

Z = Ftotal + M, where *Ftotal = Fleet(1)*Factor(1)+..+Fleet(n)*Factor(n)*

Table 3 1998 0.000

TOTAL FISHING MORTALITY BY FLEET RELATIVE TO AREA					
	Total North Sea F		Total IIIa F		
AGE	F(N.S.)	Z(N.S.)	F(IIIa)	Z(IIIa)	
0	0.0000	1.0000	0.0000	1.0000	
1	0.0000	1.0000	0.0000	1.0000	
2	0.0000	0.3000	0.0000	0.3000	
3	0.0000	0.2000			
4	0.0000	0.1000			
5	0.0000	0.1000			
6	0.0000	0.1000			
7	0.0000	0.1000			
8	0.0000	0.1000			
9	0.0000	0.1000			

Table 4 1998

1998	NORTH SEA HERRING. CATCH AT AGE BY FLEET							number at end of year
	N(North Sea) * F(fleet) * (1-exp(-Z))/Z(North Sea			N(IIIa) * F(fleet) * (1-exp(-Z(IIIa)))/Z(IIIa)				
AGE	TOTAL	A	B	C	D	E	F	
0	0.0	0.0	0.0	0.0	0.0	0.0		no value
1	0.0	0.0	0.0	0.0	0.0	0.0		16186.7
2	0.0	0.0	0.0	0.0	0.0	0.0		7589.0
3	0.0	0.0	0.0					4890.5
4	0.0	0.0	0.0					1927.5
5	0.0	0.0	0.0					743.9
6	0.0	0.0	0.0					518.4
7	0.0	0.0	0.0					263.5
8	0.0	0.0	0.0					68.9
9+	0.0	0.0	0.0					34.7
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0		50.7

Table 2.8.xx.F EXCEL 5 "work book" for short term prediction of North Sea Herring

SHEET 3

Table 5 *1998*

NORTH SEA HERRING. FISHING MORTALITY BY FLEET (TOTAL) *)						**1998**	
		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24
AGE	TOTAL a)	A b)	B	C	D	E	F
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000				
4	0.000	0.000	0.000				
5	0.000	0.000	0.000				
6	0.000	0.000	0.000				
7	0.000	0.000	0.000				
8	0.000	0.000	0.000				
9+	0.000	0.000	0.000				
AVG 2-6	0.000	0.000	0.000	0.000	0.000	0.000	0.000

a) = ln(N(o)/{N(o)*exp(-M/2)-C} *exp(-M/2) - M b) = F(total) * C(fleet)/C(total)

Table 6 1998 0.000

0.354412	NORTH SEA HERRING. YIELD AT AGE BY FLEET							
C * W (body weight)				C * W (body weight)				
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	
AGE	TOTAL e)	A	B	C	D	E	F	**Yield 1997**
0	0.0	0.0	0.0	0.0	0.0	0.0		

1	0.0	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0				
4	0.0	0.0	0.0				
5	0.0	0.0	0.0				
6	0.0	0.0	0.0				
7	0.0	0.0	0.0				
8	0.0	0.0	0.0				
9+	0.0	0.0	0.0				
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	

Table 7 **1998**

NORTH SEA HERRING STOCK SIZE and SSB				
	TOTAL NUMBER	STOCK BIOMASS a)	b)	**0**
	from table 1	1st Jan.	Spaw.time	Spaw.time
a	*b*	*c*	*d*	*e*
AGE	**Total**	**Biomass**	**SS numbers**	**SSB c)**
0	44000.0	132000.0	0.0	0
1	20629.0	1072708.6	0.0	0
2	6601.5	825190.6	3293.7	411710
3	2354.3	444963.8	2017.9	381378
4	822.1	185796.8	768.8	173756
5	572.9	131191.2	535.8	122689
6	291.2	76866.9	272.3	71886
7	76.2	21399.5	71.2	20013
8	38.3	11986.9	35.8	11210
9+	56.0	18494.3	52.4	17296
TOTAL	75441.5	2920598.6	7047.9	1209937

a) = N*w(1.jan)

b) = N*Maturity*exp(-Z*.67)

c) = N*w(spaw.time)*Maturity*exp(-Z*.67)

Table 8 SUMMARY RESULTS FOR YEAR **1998**

		IV HC	**IV IND**	**IIIa HC**	**IIIa MC**	**IIIa IND.**	**Fl. 22+24**
	TOTAL	**A**	**B**	**C**	**D**	**E**	**F**
CATCH	0	0.0	0.0	0.0	0.0	0.0	0.0
YIELD	0	0.0	0.0	0.0	0.0	0.0	0.0
SSB	1209937		AVG F 2-6	0.000			

1999 **1999**

Table 1 **1999**

NORTH SEA HERRING STOCK SIZE 1. JANUARY and SSB		
	NUMBER from table 4	
a	*b*	**total**
AGE	**Total a)**	**biomass**
1	16186.7	841708
2	7589.0	948624
3	4890.5	924310
4	1927.5	435625
5	743.9	170348
6	518.4	136850
7	263.5	74031
8	68.9	21568
9+	34.7	11435
TOTAL	32223.0	3564498

Table 2.8.xx.G EXCEL 5 "work book" for short term prediction of North Sea Herring

Table 2.10.3 Input data for the Short Term Prediction. North Sea and IIIa total catch mean weight at age in the catch by fleet using the new fleet definitions for 1
recalculated with new fleets for 1995, and the mean over the last 2 years for projections.

1995	Fleet A		Fleet B		Fleet C		Fleet D		Fleet E		TOTAL	
Total												
Winter rings	Numbers	Weight	Numbers	Weight	Number	Weight	Number	Weight	Number	Weight	Numbers	Weight
0	11.57	30.7	6,268.13	8.3	235.00	18.8	176.34	15.2	945.45	10.6	7,636.49	9.1
1	156.03	79.1	327.09	33.3	672.53	49.2	254.23	16.3	209.17	29.1	1.619 05	41.1
2	1359.40	138.1	14.62	72.4	147.50	63.7	2.65	34.2	20.10	42.1	1.544 26	128.9
3	859.91	167.1	3.58	139.4							863.49	166.9
4	244.43	196.2	0.25	162.0							244.68	196.2
5	115.85	205.3	0.05	177.5							115.90	205.3
6	53.27	257.3	0.03	223.3							53.30	257.3
7	39.28	259.1	0.02	194.3							39.30	259.0
8+	119.45	271.3	0.05	225.2							119.50	271.3
TOTAL	2,959.19		6,613 82		1055.03		433.22		1174.71		12,235.98	
Land. (SOP)(t)		472,075		64,546		46,883		6,920		16,944		607,368

1996	Fleet A		Fleet B		Fleet C		Fleet D		Fleet E		TOTAL	
Total												
Winter rings	Numbers	Weight	Numbers	Weight	Number	Weight	Number	Weight	Number	Weight	Numbers	Weight
0			1,795.71	16.3	9.12	17.4	537.77	11.0	85.18	10.1	2,427.78	14.9
1	5.89	84.6	732.01	9.4	181.56	48.1	363.72	14.7	324.25	17.3	1,607.43	16.8
2	523.60	126.3	25.40	54.5	143.86	75.7	3.96	41.1	11.53	50 5	708.35	111.8
3	596.07	160.3	4.33	122.4	26.94	131.0	2.59	55.8	1.98	73.6	631.92	158.1
4	195.27	192.4	1.33	137.5							196.60	192.0
5	59.21	207.5	0.49	140.6							59.70	207.0
6	20.23	211.9	0.27	140.7							20.50	211.0
7	11.01	252.1	0.09	235.7							11.10	252.0
8+	26.00	273.2	0 20	249.5							26.20	273.0
TOTAL	1,437.28		2,559.83		361.49		908.04		422.94		5,689.57	
Land. (SOP)(t)		226,194		38,426		23,320		11,575		7,194		306,709

Mean over 1995/1996	Fleet A		Fleet B		Fleet C		Fleet D		Fleet E		TOTAL	
Total												
Winter rings	Numbers	Weight	Numbers	Weight	Number	Weight	Number	Weight	Number	Weight	Numbers	Weight
0	11.57	30.70	4031.92	12.30	122.06	18.12	357.06	13.09	515.31	10.37	5,037.92	12.3
1	80.96	81.85	529.55	21.35	427.05	48.65	308.98	15.53	266.71	23.17	1,613.24	30.8
2	941.50	132.20	20.01	63.45	145.68	69.70	3.30	37.61	15.82	46.28	1,126.31	121.4
3	727.99	163.66	3.96	130.90	26.94	130.97	2.59	55.80	1.98	73.60	763 46	161.7
4	219.85	194.29	0.79	149.75							220 64	194.1
5	87.53	206.41	0.27	159.05							87.80	206.3
6	36.75	234.61	0.15	182.00							36.90	234.4
7	25.15	255.60	0.06	215.00							25.20	255.5
8+	72.73	272.26	0 13	237.35							72.85	272.2
TOTAL	2,204.02		4,586 83		721 73		671.93		799.81		8,984.32	
Land. (SOP)(t)		346,219		62,916		36,670		9,742		12,402		467,948

SHEET 1

NORTH SEA HERRING SHORT TERM PREDICTION PROGRAM 1997

SUMMARY OF CALCULATIONS Revised by P. Sparre 15. May 1995

This version 30.10.1995

Further revised by H. Sparholt 31.10. 1995

Input data revised by K.Patterson, E.Kirkegaard and H.Sparholt 9.11.1995

Fleet	Description
A:	IV HC *North Sea, directed herring fisheries*
B:	IV IND *North Sea*
C:	IIIa HC *IIIa*
D:	IIIa MC *IIIa "Mixed Clupeid"*
E:	IIIa *IIIa herring by catches*
F:	Fl. 22+24 *Western Baltic Combined fisheries*

Table 1 1997

1997	NORTH SEA HERRING. F-FACTORS								
	IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24	A+B	C+D+E+F
TOTAL a	A	B	C	D	E	F	IV	IIIa
F-Facto *1*	*1*	*1*	*1*	*1*	*1*	*0*	*1*	*1*
(Total Fac 1	1	1	1	1	1	0		

Input to sheet 3

Table 2 SUMMARY RESULTS FOR YEAR 1997

		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24	A+B	C+D+E+F
	TOTAL	A	B	C	D	E	F	IV	IIIa
CATCH	6715	1587	3232	407	1019	470	0	4819	1896
YIELD	361274	256927	56272	23600	14453	10021	0	313199	48074
SSB*.00	688		AVG F 2	0.348					

Copied from sheet 3

Table 3 1998

1998	NORTH SEA HERRING. F-FACTORS								
	IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24	A+B	C+D+E+F
TOTAL	A	B	C	D	E	F	IV	IIIa
F-Facto *1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*
(Total Factor)*(F-Fa	1	1	1	1	1	1		

Input to sheet 3

Table 4 SUMMARY RESULTS FOR YEAR 1998

		IV HC	IV IND	IIIa HC	IIIa MC	IIIa IND.	Fl. 22+24	A+B	C+D+E+F
	TOTAL	A	B	C	D	E	F	IV	IIIa
CATCH	6797	2277	2659	524	860	476	0	4936	1860
YIELD	465629	362000	48760	31612	12521	10736	0	410760	54869
SSB*.00	964		AVG F 2	0.348					

Copied from sheet: 3

BIOMASS AT 1st JANU. 1999	2831

Table 2.10.4

Option Tables for 1998

Basis: F(97)=F(96), no misreporting included here

Regulation by Effort

'000 t

Option	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	av.F(2-6)	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	Total Catch	SSB
A	0	0	0	0	0	0.00	0	0	0	0	0	0	1210
B	0.1	0.1	0.1	0.1	0.1	0.03	42	5	4	1	1	54	1183
C	0.2	0.2	0.2	0.2	0.2	0.07	83	10	7	3	2	105	1156
D	0.3	0.3	0.3	0.3	0.3	0.10	122	15	11	4	3	155	1130
E	0.4	0.4	0.4	0.4	0.4	0.14	160	20	14	5	5	204	1104
F	0.5	0.5	0.5	0.5	0.5	0.17	197	25	17	6	6	251	1079
G	0.6	0.6	0.6	0.6	0.6	0.21	232	30	20	8	7	297	1055
H	0.7	0.7	0.7	0.7	0.7	0.24	266	35	23	9	8	341	1032
I	0.8	0.8	0.8	0.8	0.8	0.28	299	40	26	10	9	384	1008
J	0.9	0.9	0.9	0.9	0.9	0.31	331	44	29	11	10	425	986
K	1	1	1	1	1	0.35	362	49	32	13	11	466	964
L	1.1	1.1	1.1	1.1	1.1	0.38	392	53	34	14	12	505	942
M	1.2	1.2	1.2	1.2	1.2	0.42	420	58	37	15	13	542	921
N	1.3	1.3	1.3	1.3	1.3	0.45	448	62	39	16	14	579	901
O	1.4	1.4	1.4	1.4	1.4	0.49	475	67	42	17	14	615	880
P	1.5	1.5	1.5	1.5	1.5	0.52	501	71	44	18	15	649	861
Q	1.8	1.8	1.8	1.8	1.8	0.63	573	83	51	21	18	746	805
R	2	2	2	2	2	0.70	617	92	55	23	19	807	769

Regulation by Fishing Mortality

Option	F(98) multiplier rel to F(96) by fleet					av.F(98)	catch (98) by fleet ('000 t)					total	('000 t)
	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	(2-6)	Fleet A	Fleet B	Fleet C	Fleet D	Fleet E	catch	SSB (98)
A	0	0	0	0	0	0.00	0	0	0	0	0	0	1210
B	0.286	0.286	0.286	0.286	0.286	0.10	117	15	10	4	3	149	1133
C	0.575	0.575	0.575	0.575	0.575	0.20	223	29	19	7	6	286	1061
D	0.86	0.86	0.86	0.86	0.86	0.30	319	42	28	11	9	409	995
E	1.148	1.148	1.148	1.148	1.148	0.40	406	55	36	14	12	523	932
F	1.435	1.435	1.435	1.435	1.435	0.50	484	68	43	17	15	627	874
G	1.724	1.724	1.724	1.724	1.724	0.60	555	80	49	21	17	723	819
E	2.008	2.008	2.008	2.008	2.008	0.70	619	92	55	24	19	809	768

Table 2.10.5 Calculation of basis for split factors

Yearclass	Proportion of 1-ringers in IIIa	MIK-index 0-ringers North Sea and IIIa	Number of 1-ringers in IV (weighted catch per haul)	Number of 1-ringers in IIIa (weighted catch per haul)
1981	0.254	133.9	909.7	345.9
1982	0.276	91.8	1029.8	410.2
1983	0.255	115	1513.1	554.2
1984	0.439	181.3	1364.4	1166.7
1985	0.267	177.4	2570.6	1142.2
1986	0.636	270.9	1616.6	2927.7
1987	0.3	168.9	1633.5	673.6
1988	0.177	71.4	833.6	190.8
1989	0.134	25.9	996.5	157.5
1990	0.199	69.9	929.5	223.7
1991	0.611	200.7	881.3	1969.3
1992	0.25	190.1	1246.6	404.3
1993	0.23	101.7	873.0	275.7
1994	0.45	126.9	926.4	768.9
1995	0.3	106.2	2881.1	1246.4
1996	*0.35*	*148.1*		
avg(81-95)	*0.32*	*136.3*	avg(81-96)	

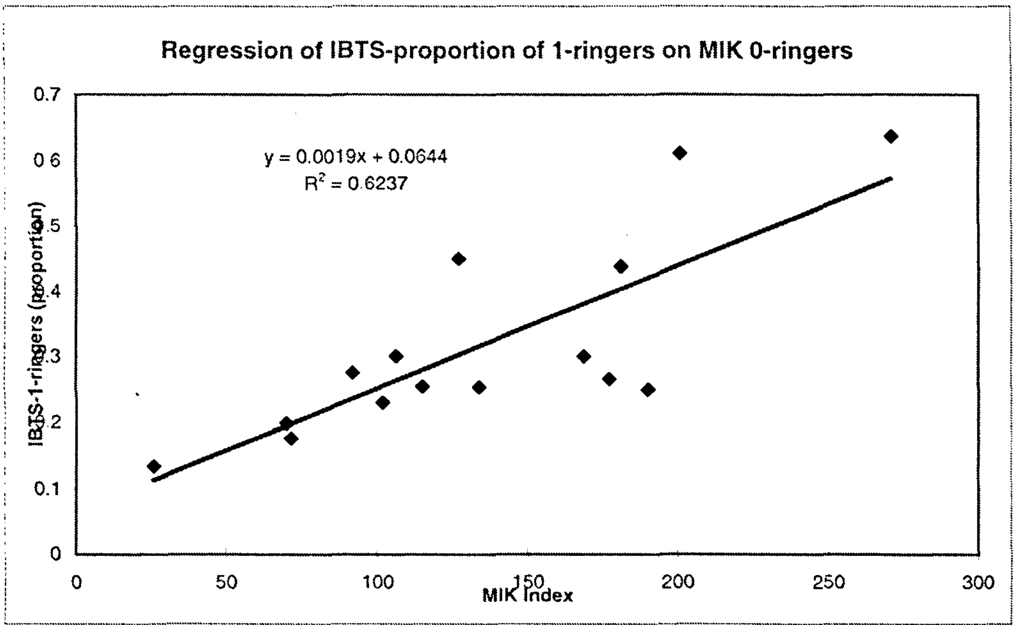


Table 2.11.1. Example of a projection input file, for options F(adult) = 0.3 and F(juv)=0.2. Note that negative exploitation constraints are F-multipliers relative to 1996. In this case the management procedure simulation option was not used.

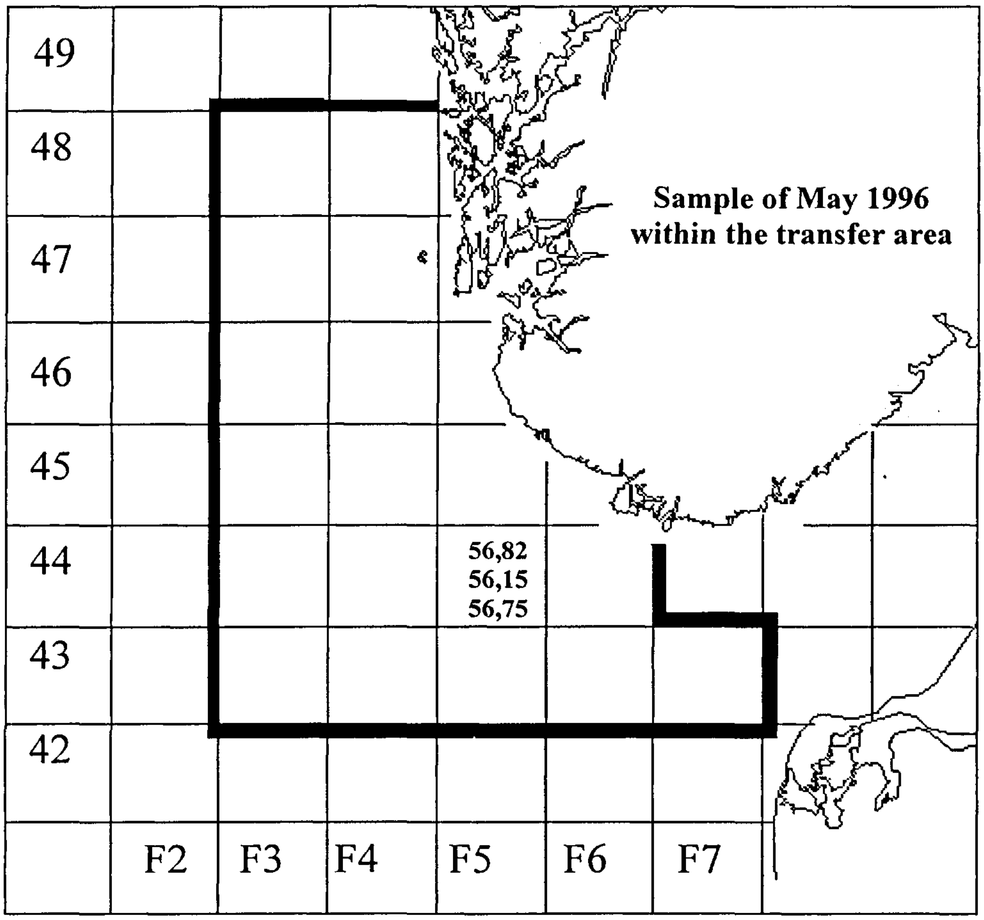
```
Projection input file for ICP3
Number of fleets           Number of Years
  5                           7
Catch Ratio for each fleet at age in 1997 : Including discarded fish
Age    Fleet A       Fleet B      Fleet D      Fleet E        Fleet F
0    0.000    0.740   0.004   0.222   0.035
1    0.004    0.455   0.113   0.226   0.202
2    0.739    0.036   0.203   0.006   0.016
3    0.943    0.007   0.043   0.004   0.003
4    0.993    0.007   0.000   0.000   0.000
5    0.992    0.008   0.000   0.000   0.000
6    0.987    0.013   0.000   0.000   0.000
7    0.992    0.008   0.000   0.000   0.000
8    0.992    0.008   0.000   0.000   0.000
9    0.992    0.008   0.000   0.000   0.000
Retention Ogive for each fleet by Age in All years
0          1.          1.       1.          1.            1.
1          1.          1.       1.          1.            1.
2          1.          1.       1.          1.            1.
3          1.          1.       1.          1.            1.
4          1.          1.       1.          1.            1.
5          1.          1.       1.          1.            1.
6          1.          1.       1.          1.            1.
7          1.          1.       1.          1.            1.
8          1.          1.       1.          1.            1.
9          1.          1.       1.          1.            1.
Exploitation  Constraint by Year; F(1997) = F(1996); then F adult = 0.3, Fjuv= 0.2
1997   -1.0         -1.0          -1.0       -1.0   -1.0
1998   -0.921    -1.347       -1.347      -1.347  -1.347
1999   -0.921    -1.347       -1.347      -1.347  -1.347
2000   -0.921    -1.347       -1.347      -1.347  -1.347
2001   -0.921    -1.347       -1.347      -1.347  -1.347
2002   -0.921    -1.347       -1.347      -1.347  -1.347
2003   -0.921    -1.347       -1.347      -1.347  -1.347
Mean weight at age in the catches of each fleet
       0   0.031   0.012   0.018   0.013   0.010
       1   0.082   0.021   0.049   0.016   0.023
       2   0.132   0.063   0.070   0.038   0.046
       3   0.164   0.131   0.131   0.056   0.074
       4   0.194   0.150  00.0     00.0    00.0
       5   0.206   0.159  00.0     00.0    00.0
       6   0.235   0.182  00.0     00.0    00.0
       7   0.256   0.215  00.0     00.0    00.0
       8   0.272   0.237  00.0     00.0    00.0
       9   0.272   0.237  00.0     00.0    00.0
Mean weights at age in the discards by each fleet
       0   0.031   0.012   0.018   0.013   0.010
       1   0.082   0.021   0.049   0.016   0.023
       2   0.132   0.063   0.070   0.038   0.046
       3   0.164   0.131   0.131   0.056   0.074
       4   0.194   0.150  00.0     00.0    00.0
       5   0.206   0.159  00.0     00.0    00.0
       6   0.235   0.182  00.0     00.0    00.0
       7   0.256   0.215  00.0     00.0    00.0
       8   0.272   0.237  00.0     00.0    00.0
       9   0.272   0.237  00.0     00.0    00.0
First year for management simulations
2007
Target F-Multipiers by fleet and by year
2007   -1.0       -1.0        -1.0       -1.0  -1.0
```

Table 2.13.1 Herring total North sea, 1996
Numbers (millions) and weights (g) at age (winter rings) per year clas of herring caught in each quarter. Spring spawners transferred to Division IIIa, and North Sea autumn spawners caught in Division IIIa are not included.

	Age (rings)	0	1	2	3	4	5	6	7	8	9	Total	
	Year class	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	(numbers)	SOP (' 000t)
Quarter	Nb	0.0	523.6	60.6	139.7	38.3	13.4	6.6	1.9	0.8	0.5	785.4	
I	W		6.1	80.7	114.5	132.1	139.2	166.5	181.3	188.9	209.5		32.7
II	Nb	0.0	147.6	123.1	125.2	22.6	5.3	2.5	0.4	0.0	2.0	428.8	
	W		6.4	117.7	161.1	189.4	191.7	210.7	204.1	215.2	252.5		42.0
III	Nb	550.9	2.4	151.9	166.6	78.7	24.8	6.7	5.8	2.9	12.0	1002.8	
	W	19.1	75.5	138.5	184.9	222.0	231.7	249.1	283.9	274.6	295.7		93.4
IV	NB	1244.8	64.4	213.4	168.8	56.9	16.1	4.6	3.0	4.2	3.9	1780.1	
	W	15.1	45.7	128.2	172.4	192.8	229.3	219.9	243.3	253.2	258.1		96.6
Total	Nb	1795.7	737.9	549.0	600.4	196.6	59.7	20.5	11.1	7.9	18.3	3997.1	
	W	16.3	9.8	123.4	160.0	192.3	206.7	211.1	252.5	254.4	280.8		264.8

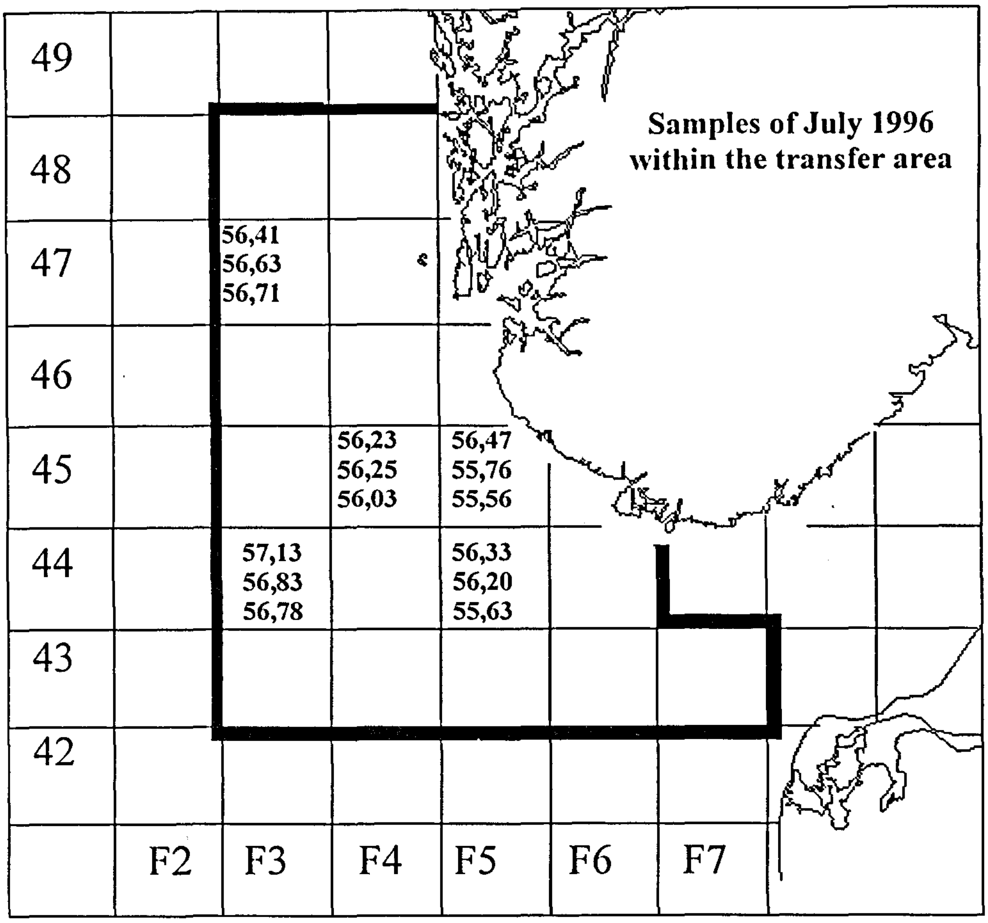
The stocks weights shown below are derived from acoustic survey samples taken in July from Divisions IVa,b and used in SSVPA.

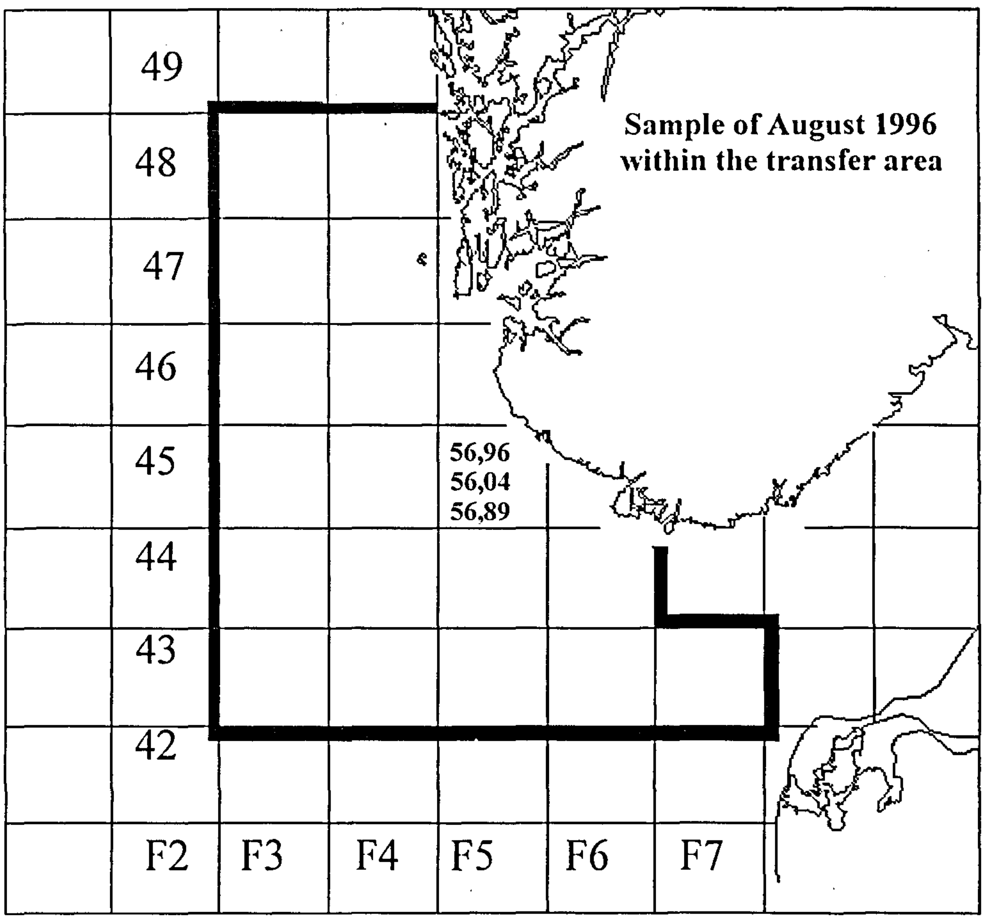
Age (w.ring)	1	2	3	4	5	6	7	8	9
Year class	1994	1993	1992	1991	1990	1989	1988	1987	1986
Stocks weights	44	118	196	253	262	299	305	324	335



Winter ring	Mean Vs	Percentage of spring spawners
2	56.82	0
3	56.15	50
4+	56.75	0

Figure 2.2.1 Mean vertebral counts of 2,3 and 4 ring herring. Quarter 2 - 1996.





Winter ring	Mean Vs	Percentage of spring spawners
2	56.58	0
3	56.23	38
4+	56.26	33

Figure 2.2.2 Mean vertebral counts of 2,3 and 4 ring herring. Quarter 3 - 1996.

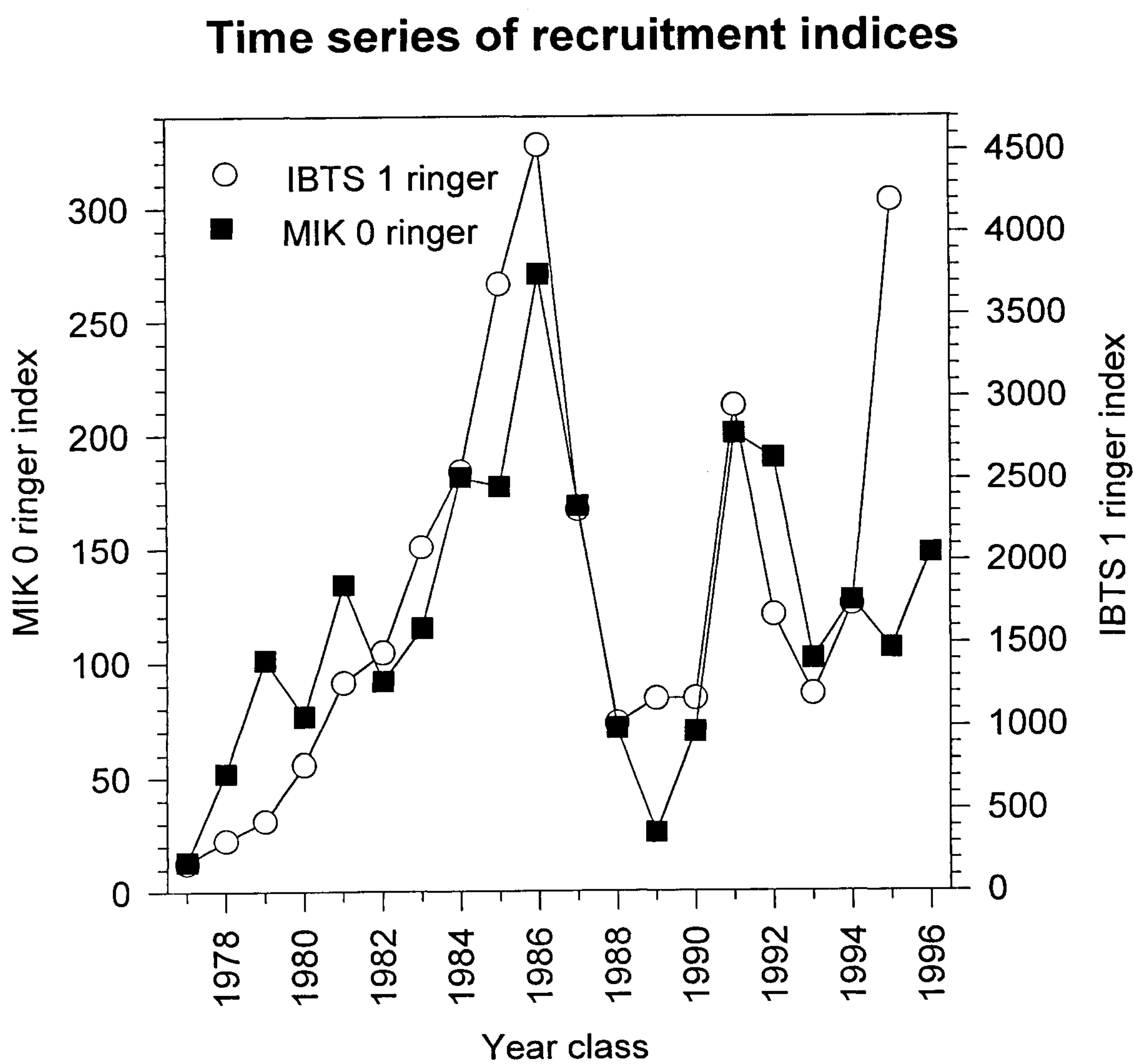


Figure 2.3.1 Trend in MIK 0-ringer and IBTS 1-ringer indices for the year classes 1977-1996.

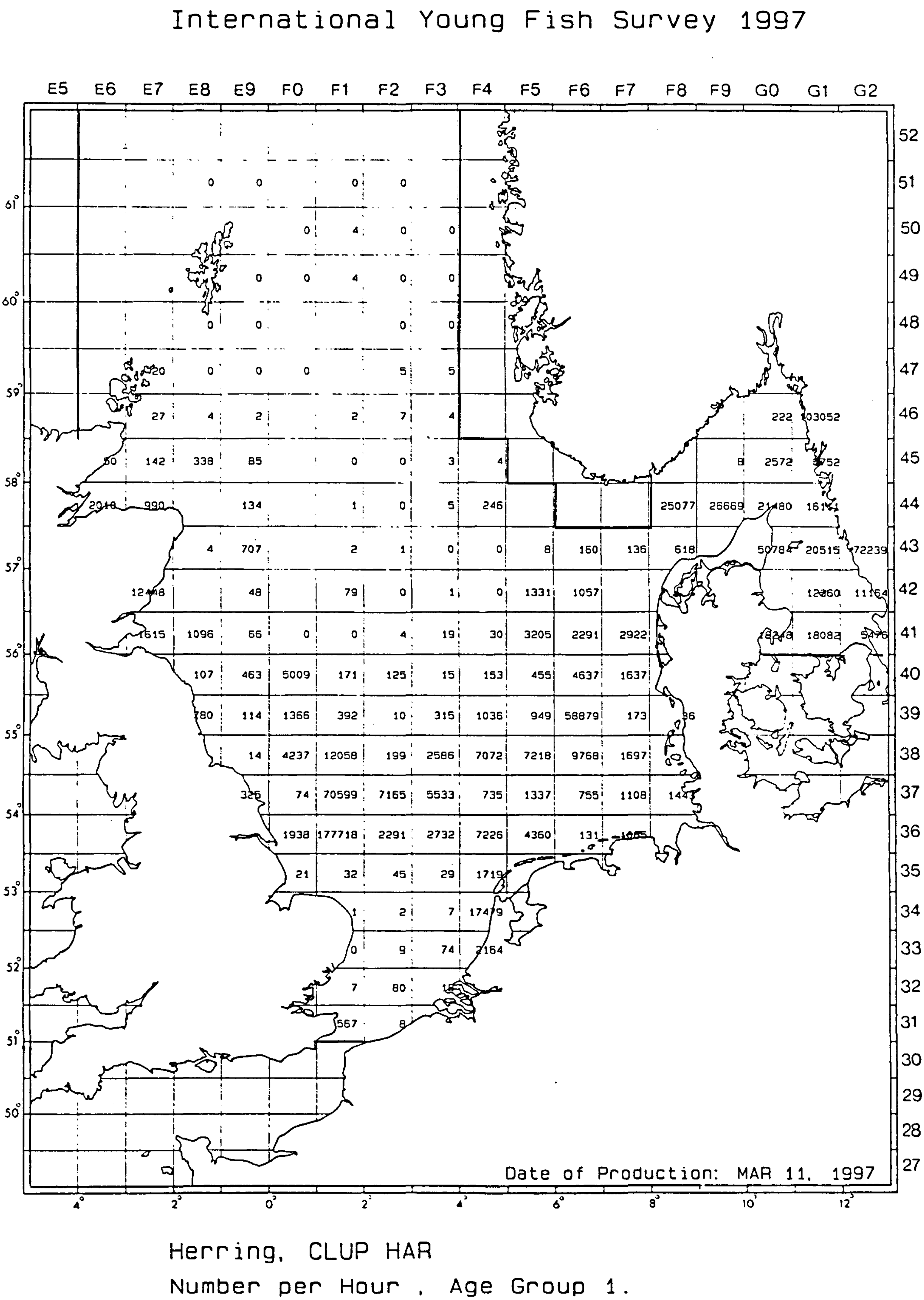


Figure 2.3.2 Abundance estimates of 1-ringer herring from IBTS, first quarter. Values are catch estimates for each statistical rectangle in numbers caught per hour.

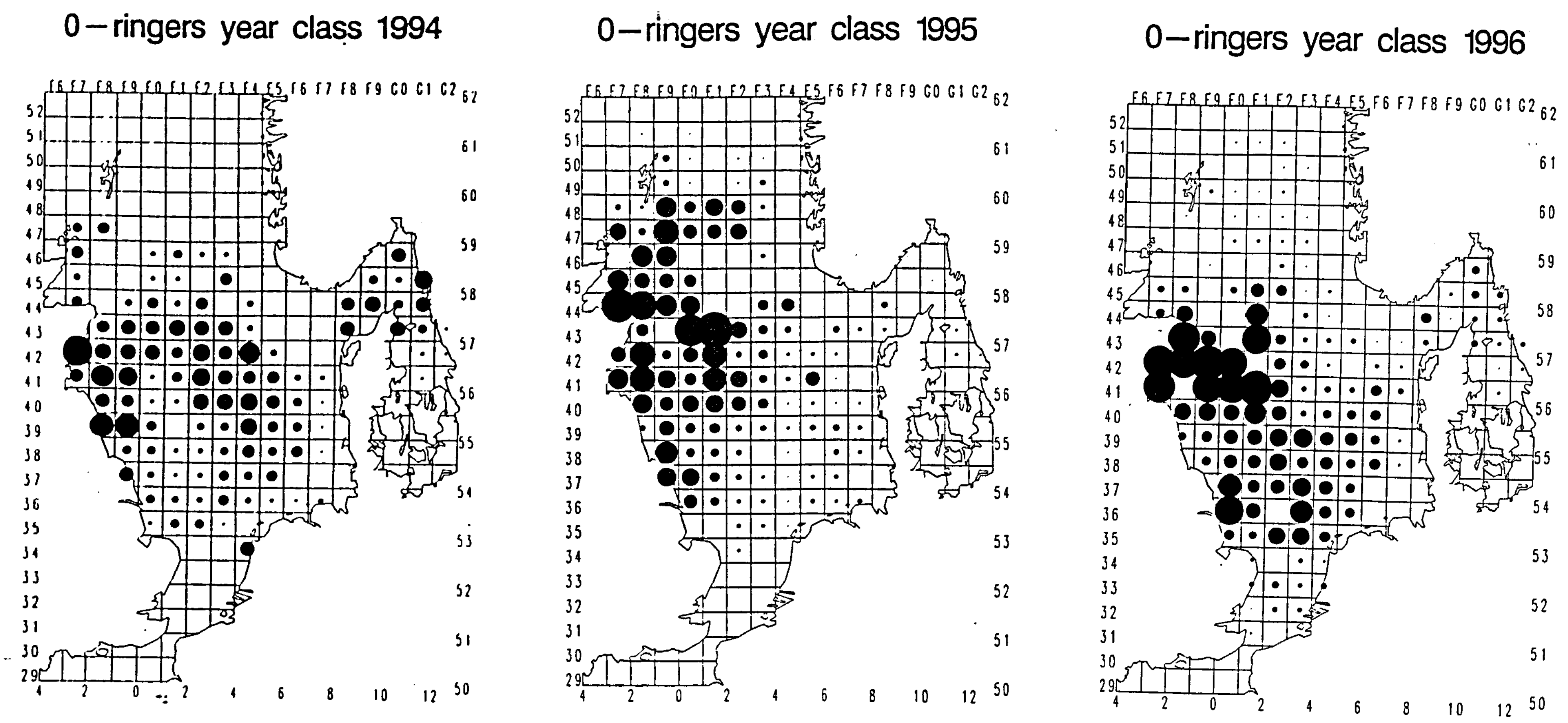


Figure 2.3.3 Distribution of 0-ringer herring, year classes 1993-1995. Abundance estimates of 0-ringers within each statistical rectangle based on MIK catches during IBTS in February. Areas of filled circles illustrate densities in no m^{-2}, the area of a circle extending to the border of a rectangle represents 1.5 m^{-2}.

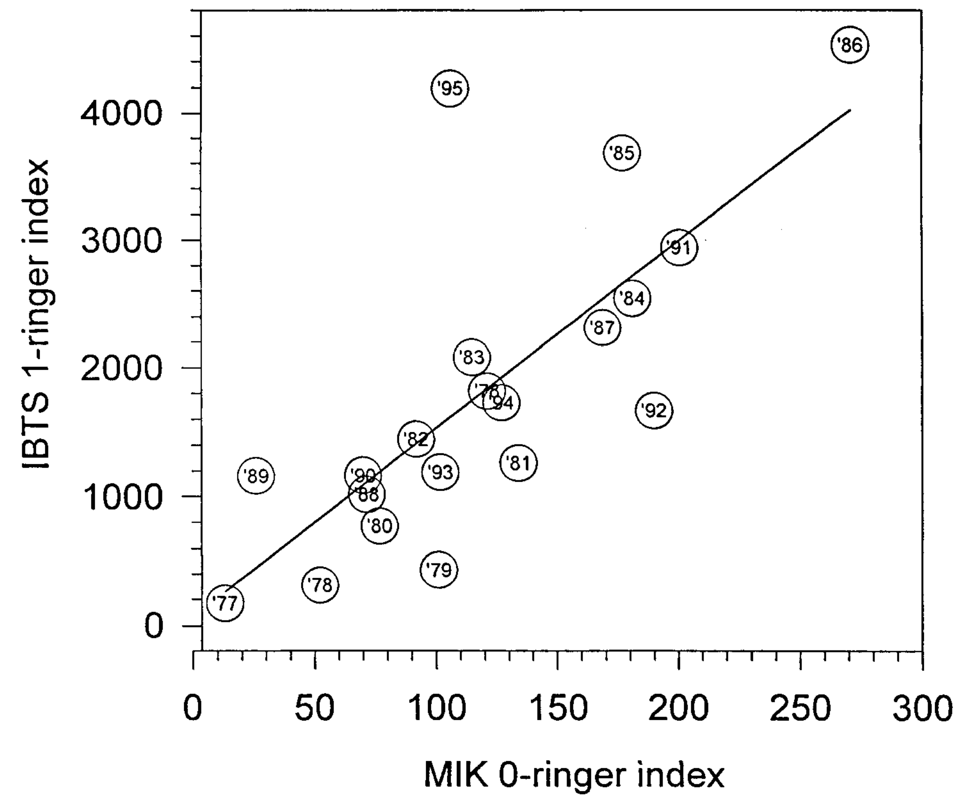


Figure 2.3.4 Regression between the MIK 0-ringer index and the IBTS 1-ringer indices for year classes 1977 to 1995. Numbers in symbols indicate year class.

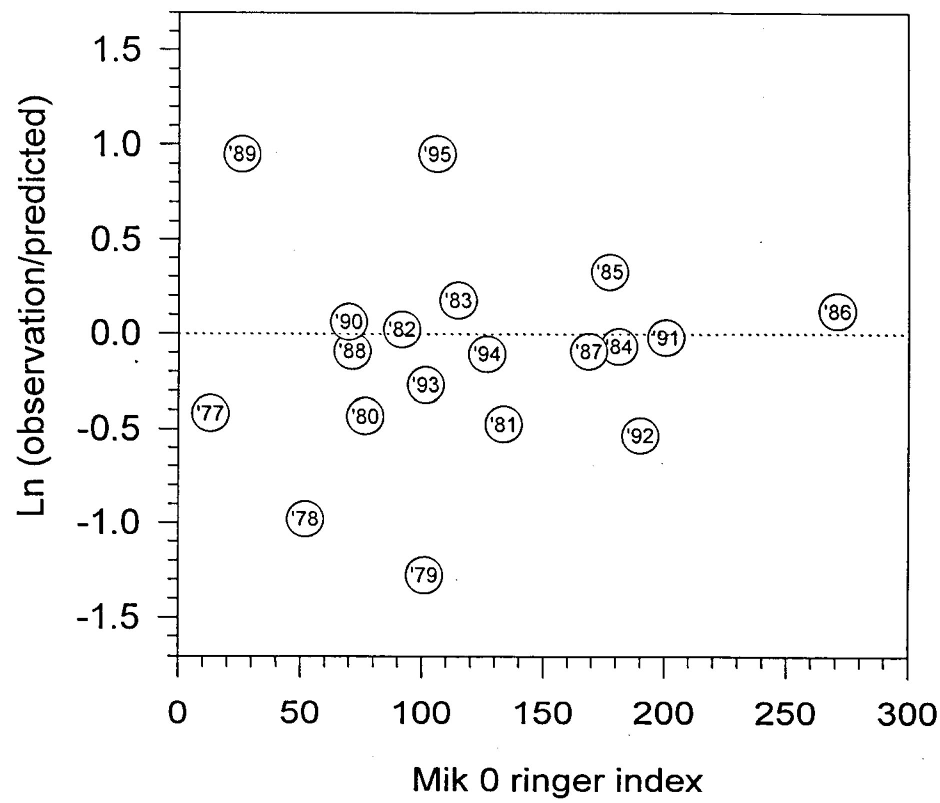


Figure 2.3.5 Illustration of deviation from the linear regression of 1-ringer versus 0-ringer indices. The natural logarithm of 'observed 1-ringer index versus predicted 1-ringer index'. Numbers in symbols indicate year classes.

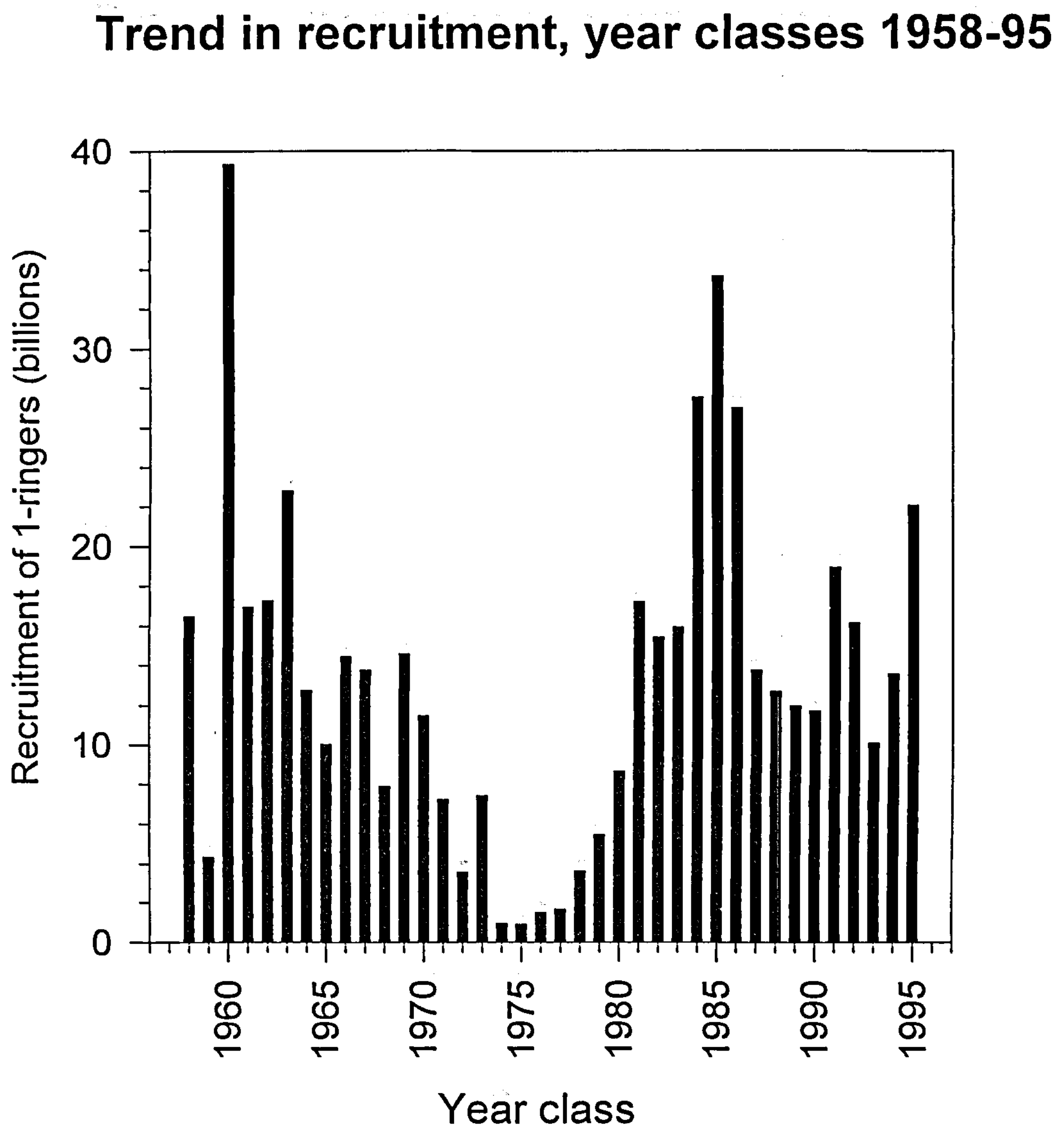


Figure 2.3.6 Trend in recruitment of 1-ringer North Sea herring for year classes 1958 to 1995.

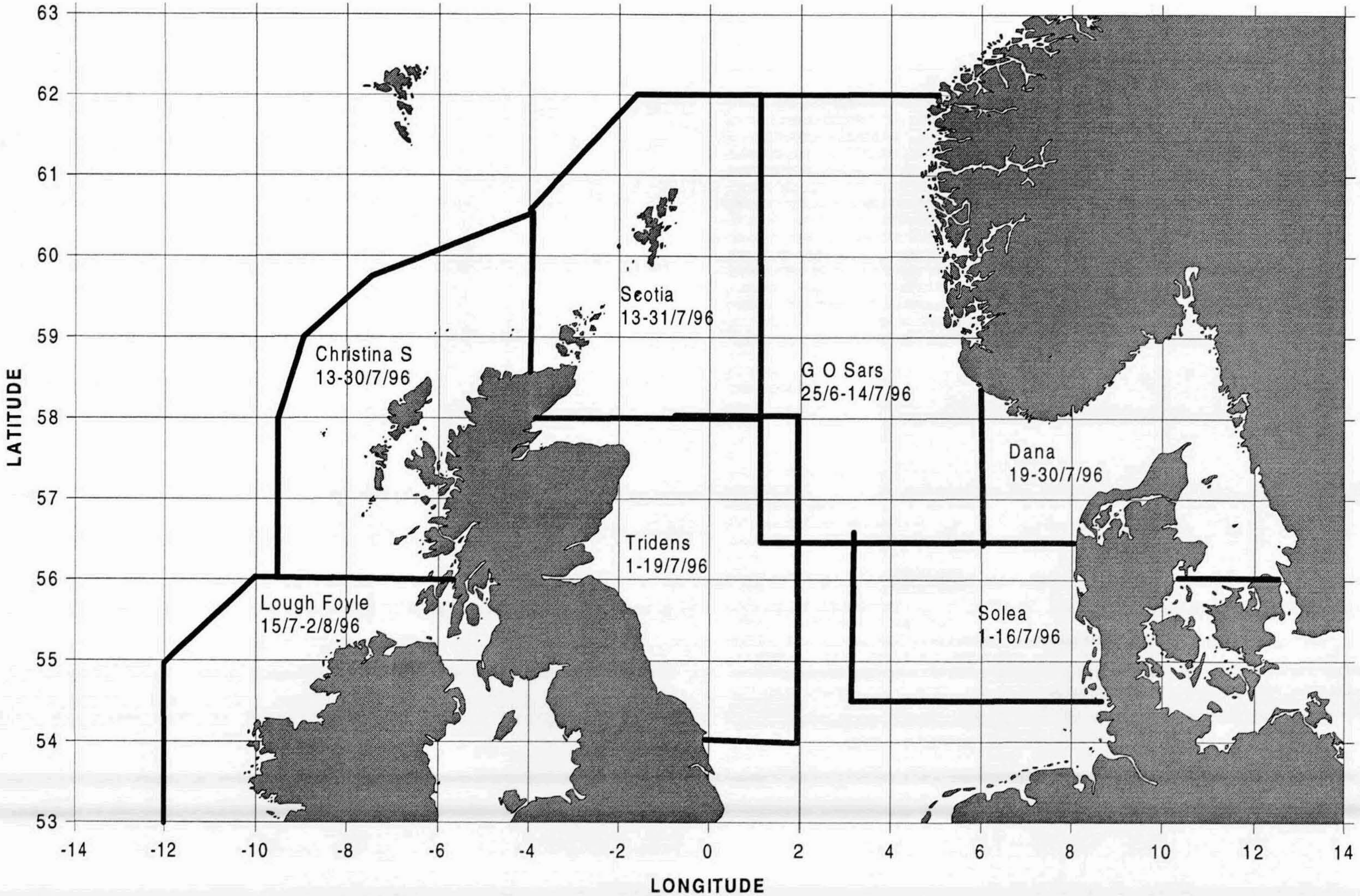


Figure 2.4.1 Survey areas and dates for combined acoustic surveys June-August 1996.

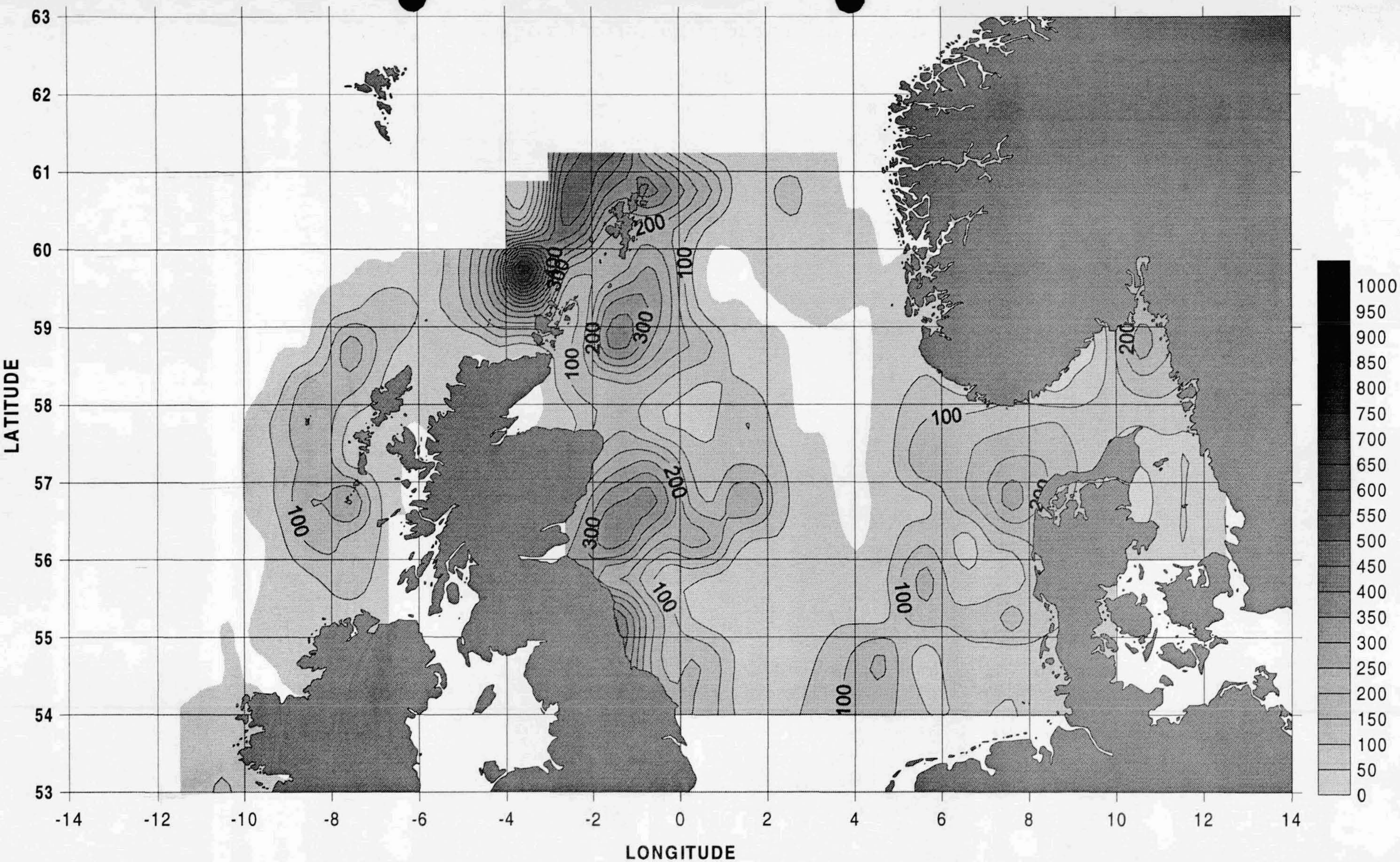


Figure 2.4.2. Numbers (millions) of 1 - 9+ autumn spawners (1996).

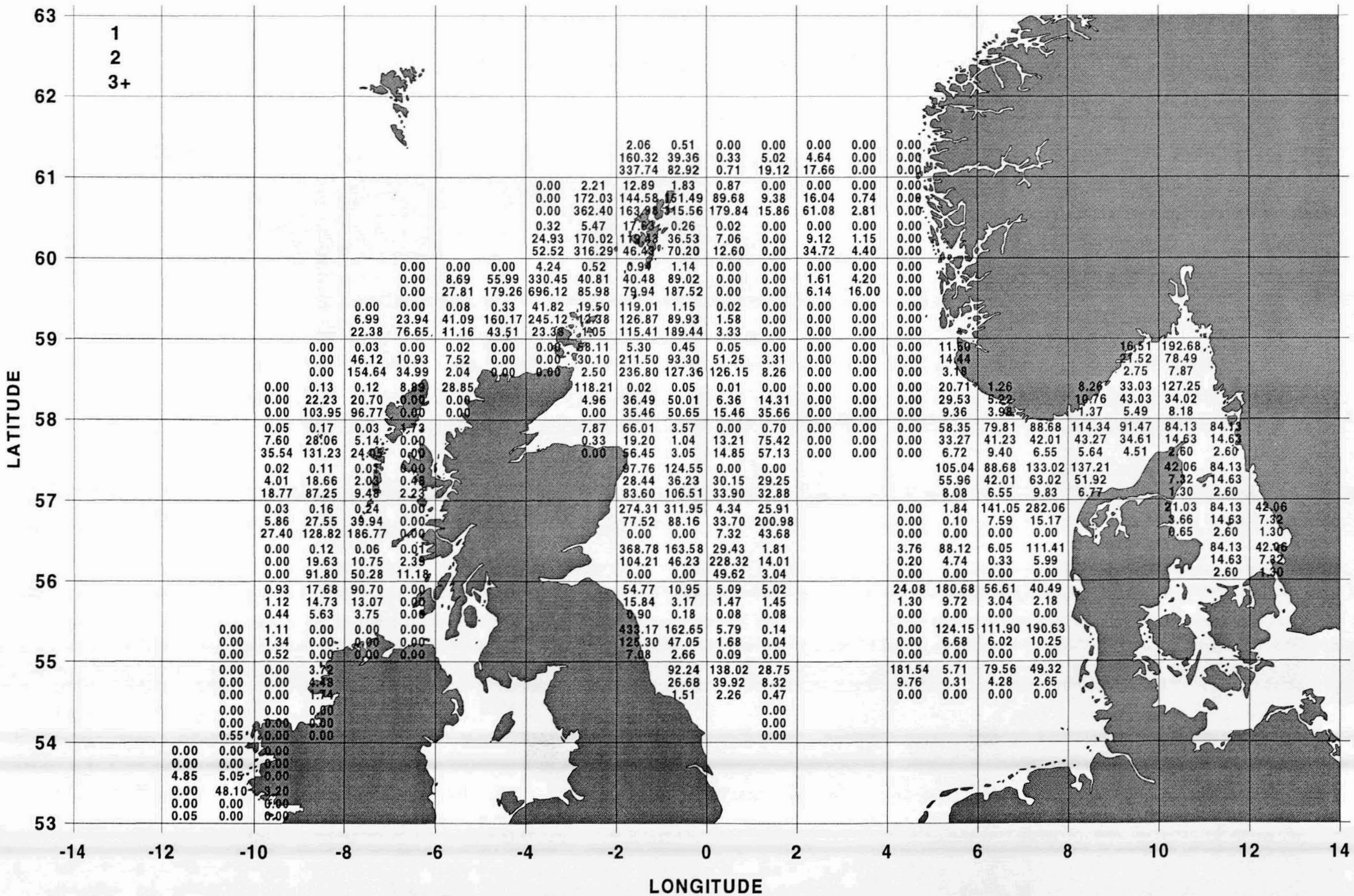


Figure 2.4.3. Numbers (millions) of 1, 2 and 3+ autumn spawners (1996).

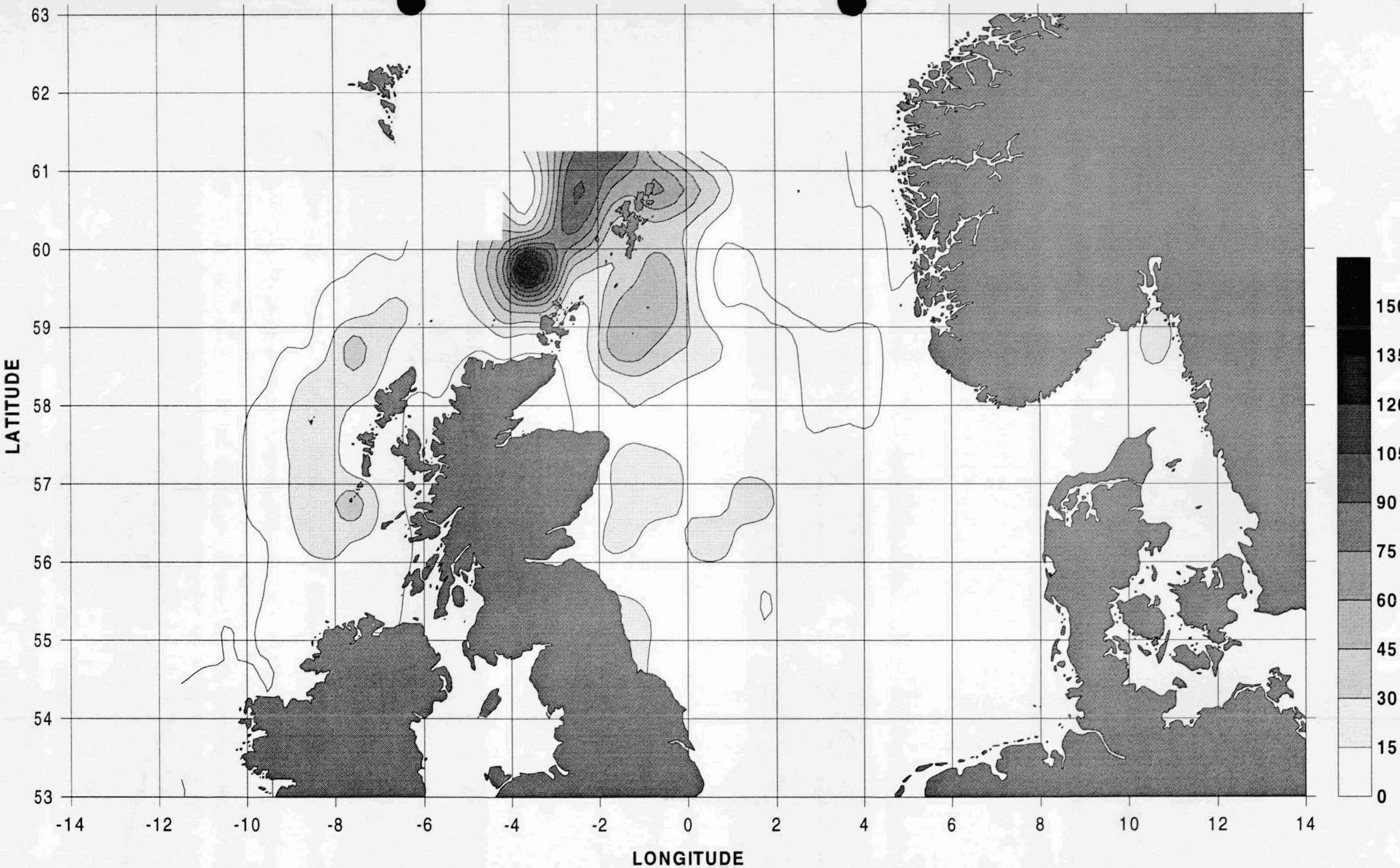


Figure 2.4.4. Biomass ('000 tonnes) autumn spawners, 0 - 9+ age groups (1996).

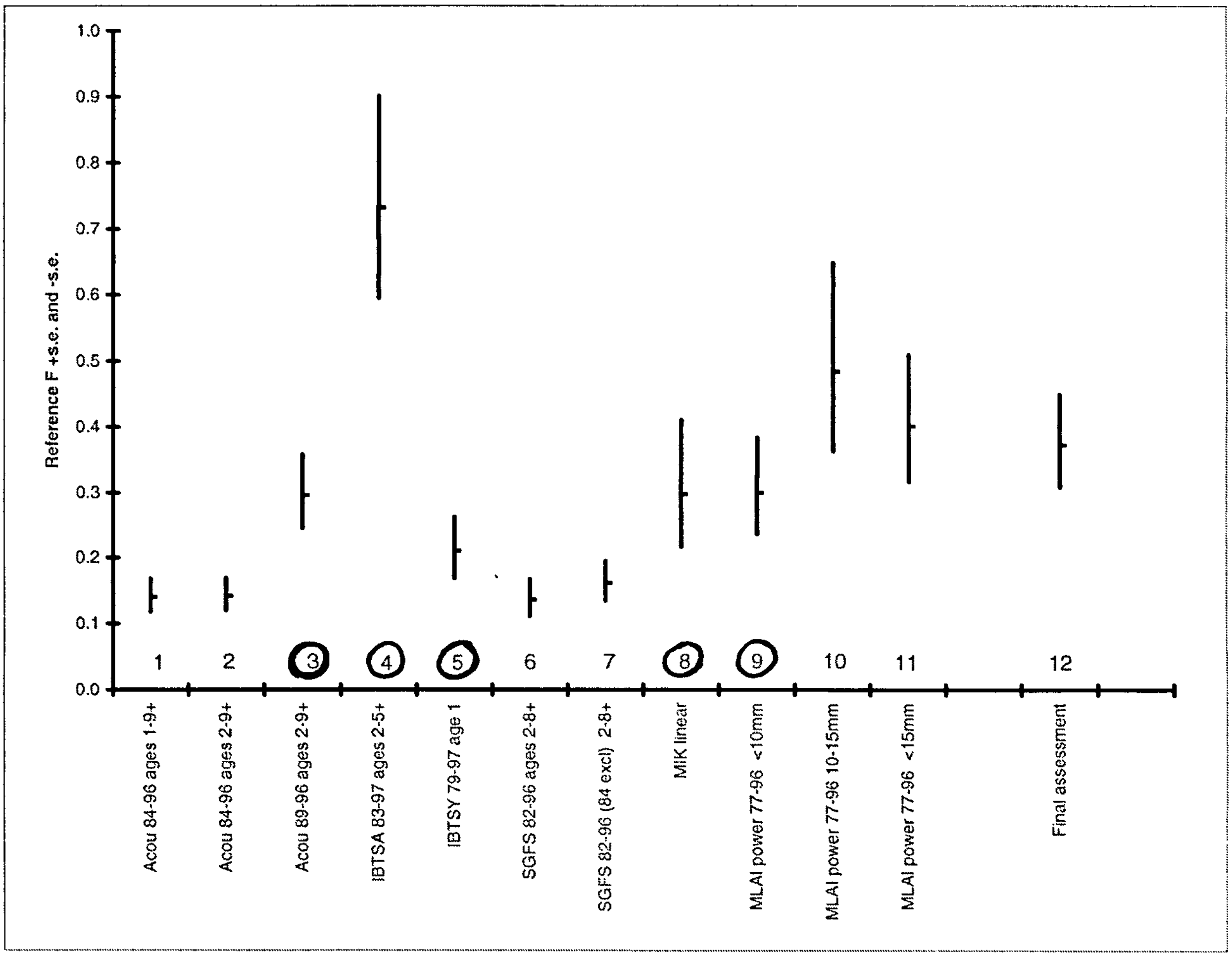


Figure 2.8.1 Herring in Sub-area IV, Divisions VIId and IIIa. Estimates of fishing mortality (+/- se) in population models fitted to the different indices. Base line model fits are given equal weights.
The encircled index numbers indicate which indices are used in the final assessment.

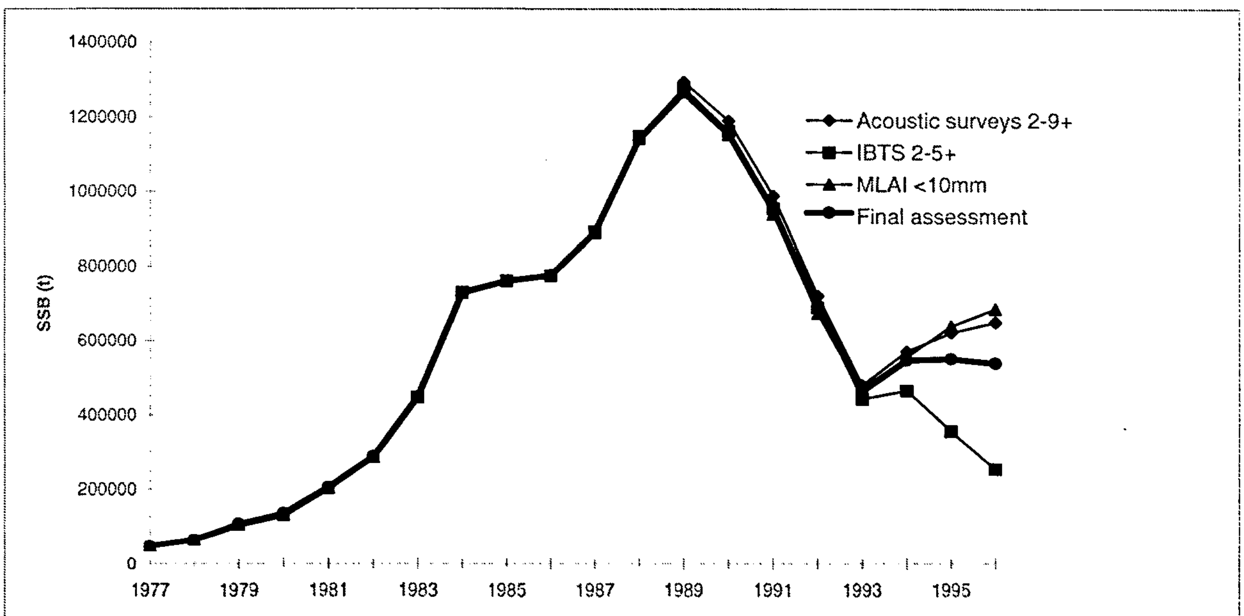
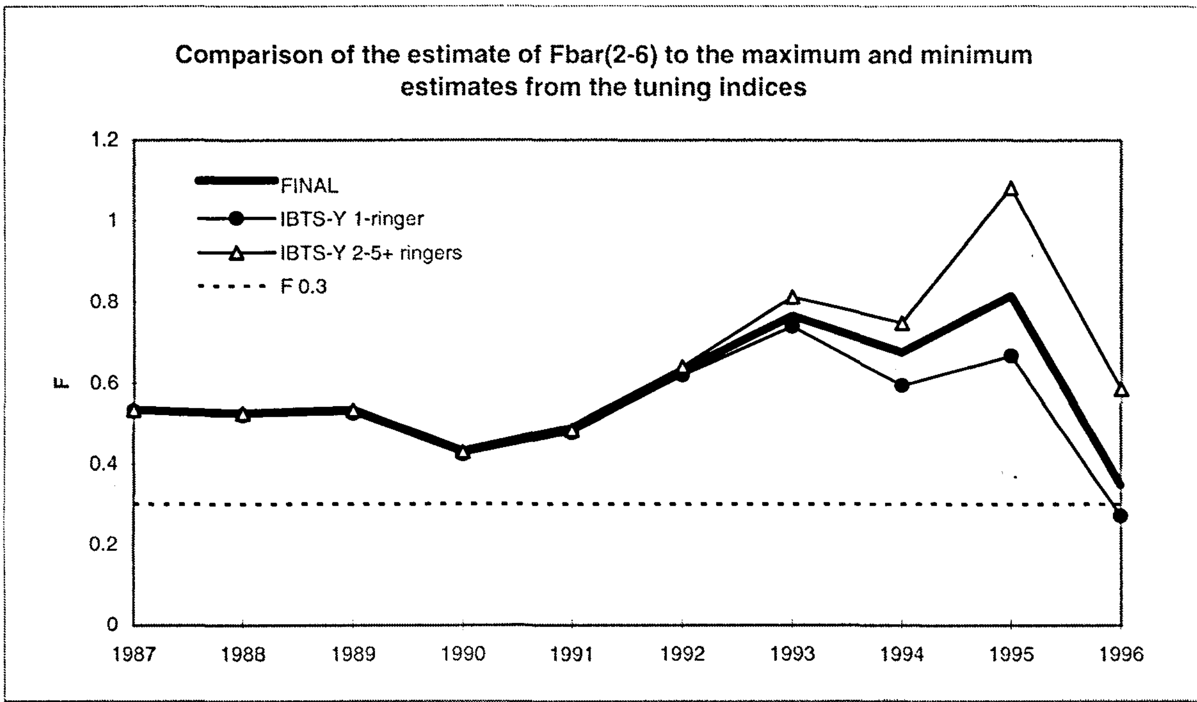


Figure 2.8.2 SSB estimates obtained from separate indices compared to the SSB estimate from the final assessment.

Figure 2.8.3 Minimum and maximum estimates of Fbar(2-6) and SSB based on the tuning indices used in the assessment



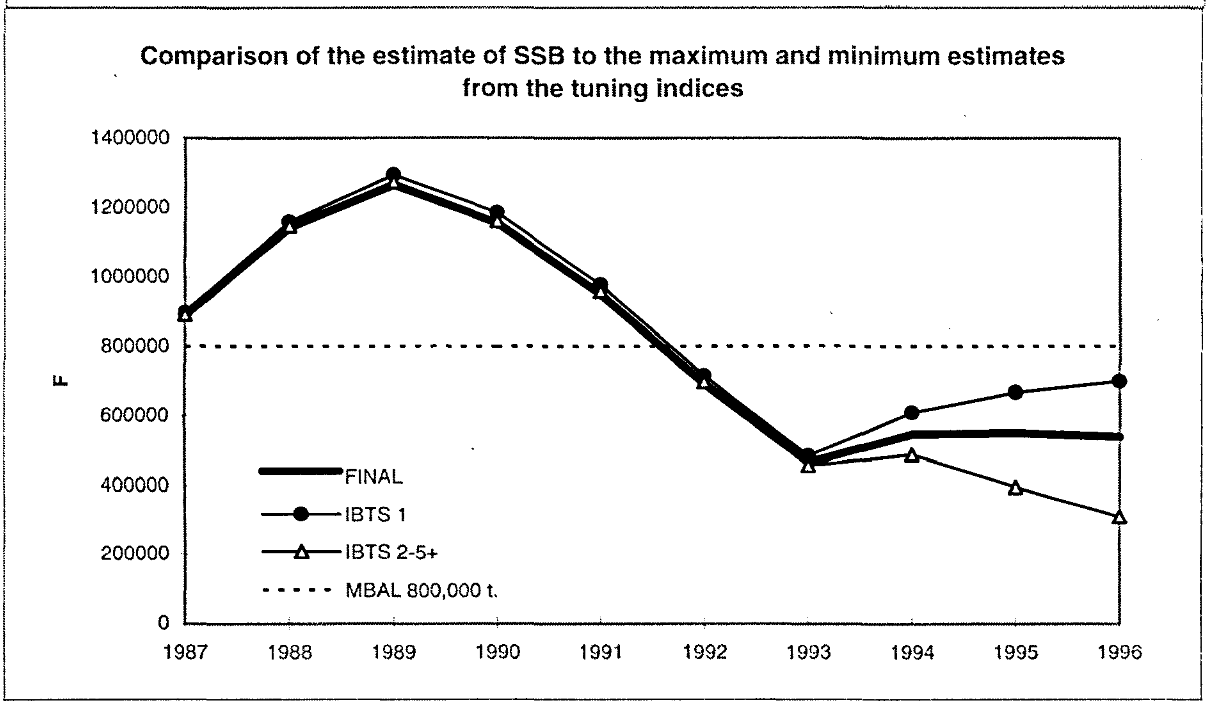


Figure 2.8.4 Herring in Section IV. Results of baseline assessment. **Upper panel:** Sum of Squares (SSQ) surfaces for the tuning indexes. INDEX1 refers to the MLAI estimate of total biomass, the age-indices 1 to 4 refer to the acoustic survey (1), the IBTS 2-5+ index (2), the IBTS 1-ringer index (3) and the MIK index (4). **Lower panel:** Summary of estimates of landings, fishing mortality at age 4, recruitment at age 0, stock size on 1 January and spawning stock size at spawning time.

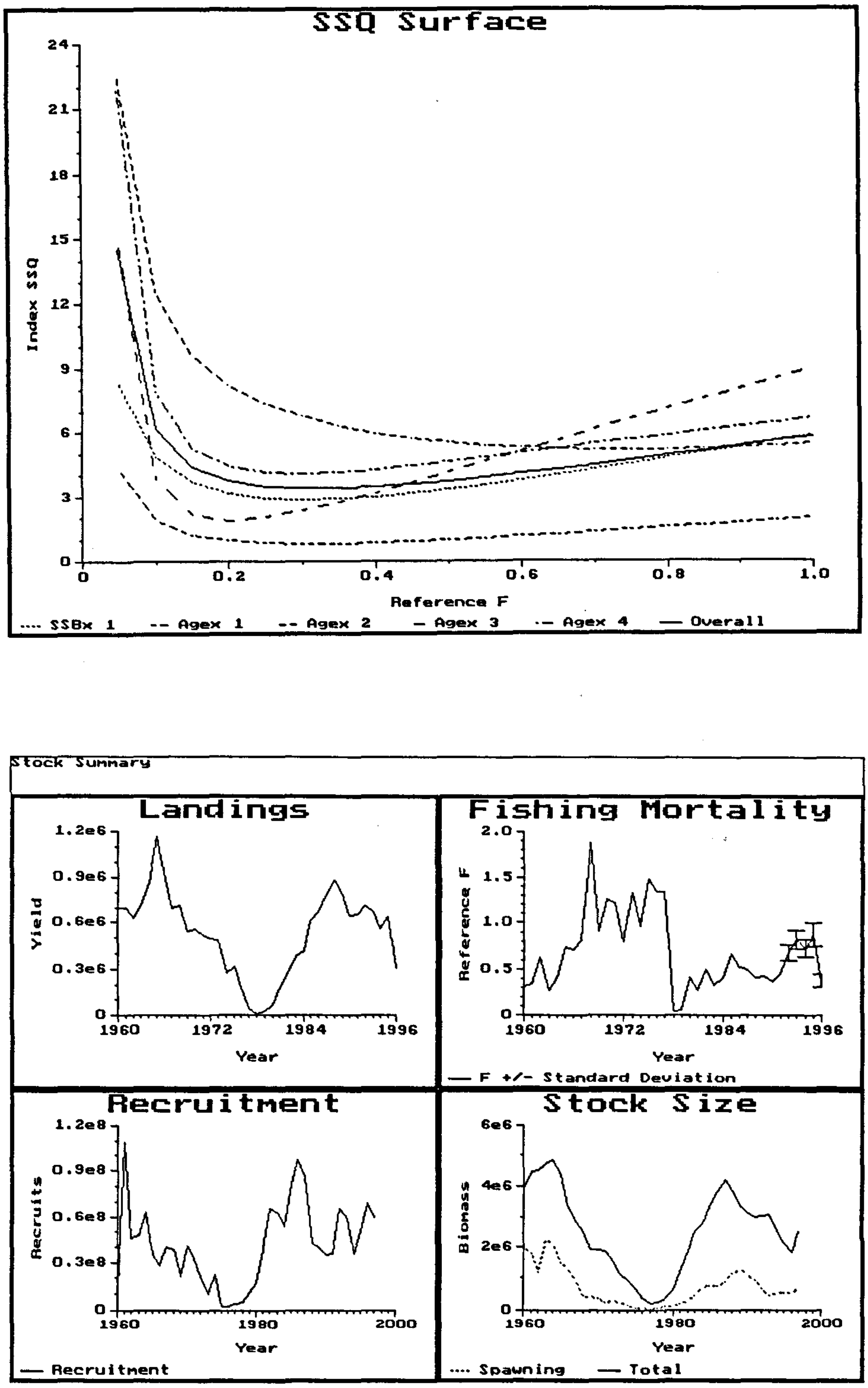


Figure 2.8.5 Herring in Section IV. Results of baseline assessment. **Upper panel:** Selection pattern diagnostics. Top left, contour plot of selection pattern residuals. Top right, estimated selection (relative to age 4) +/- standard deviation. Bottom, marginal totals of residuals by year and age. **Lower panel:** Diagnostics of the fit of the Multiplicative larval abundance index (MLAI) against the estimated spawning biomass. Top left, spawning biomass from the fitted populations (line), and predictions of spawning biomass in each year made from the index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of spawning biomass from the fitted populations and larval survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

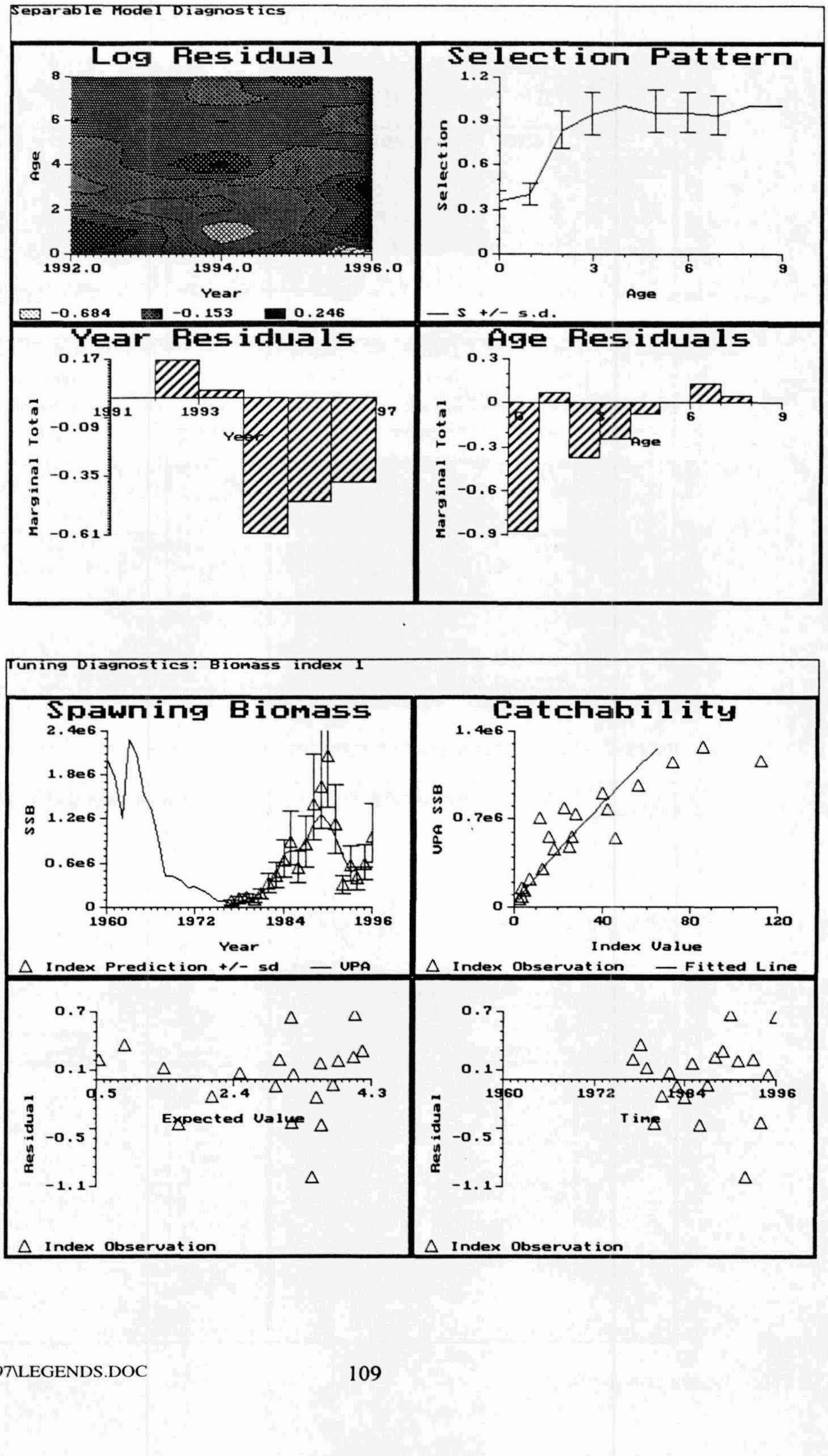
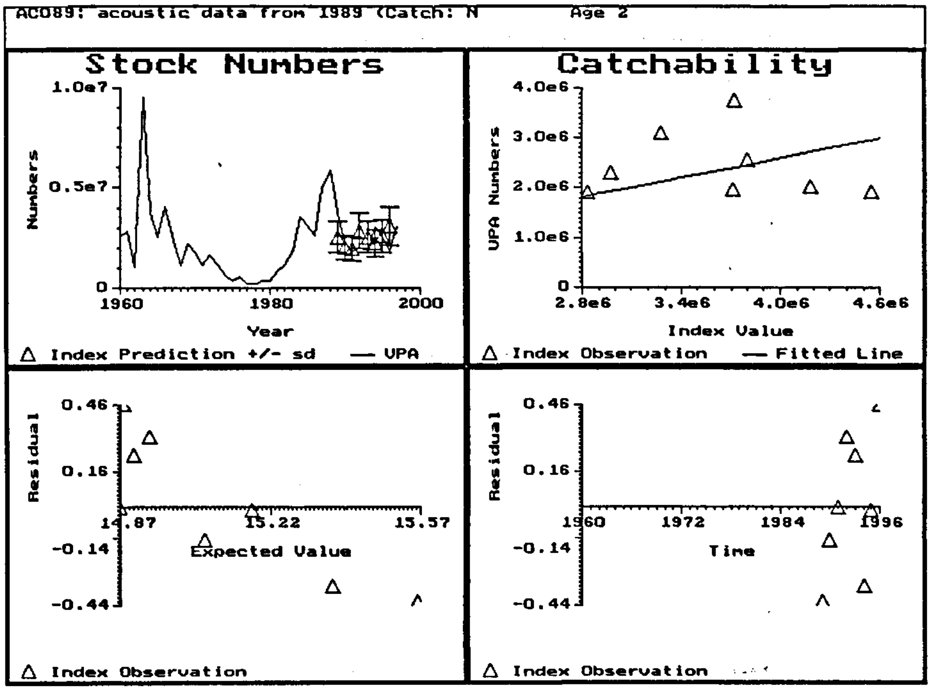


Figure 2.8.6 Herring in Section IV. Results of baseline assessment. **Upper panel:** Diagnostics of the fit of the acoustic index at age 2 against the estimated populations at age 2. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the acoustic index at age 3 against the estimated populations at age 3. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.



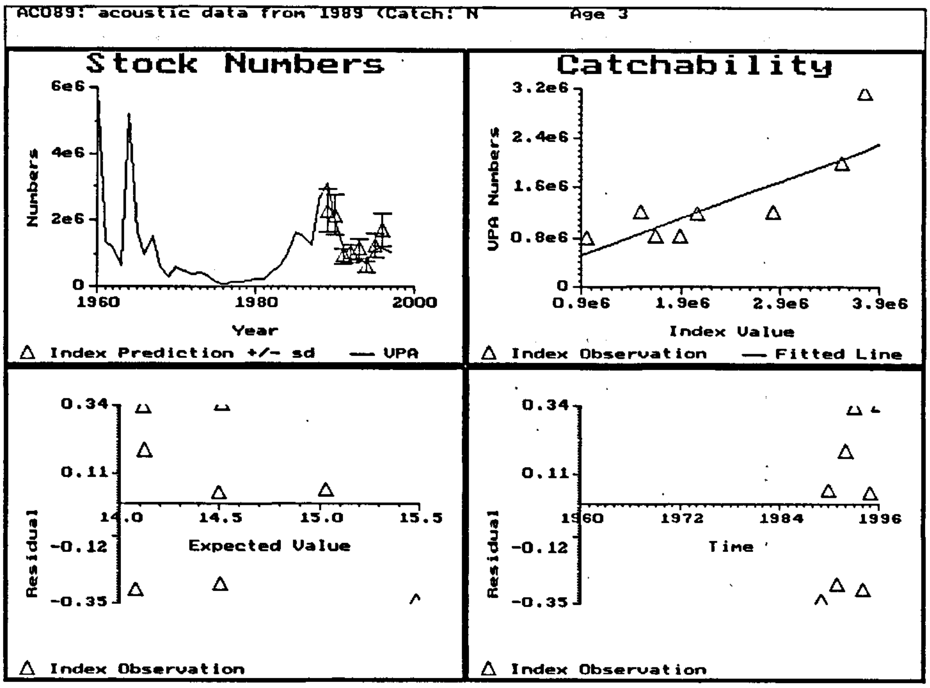


Figure 2.8.7 Herring in Section IV. Results of baseline assessment.. **Upper panel:** Diagnostics of the fit of the acoustic index at age 4 against the estimated populations at age 4. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the acoustic index at age 5 against the estimated populations at age 5. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

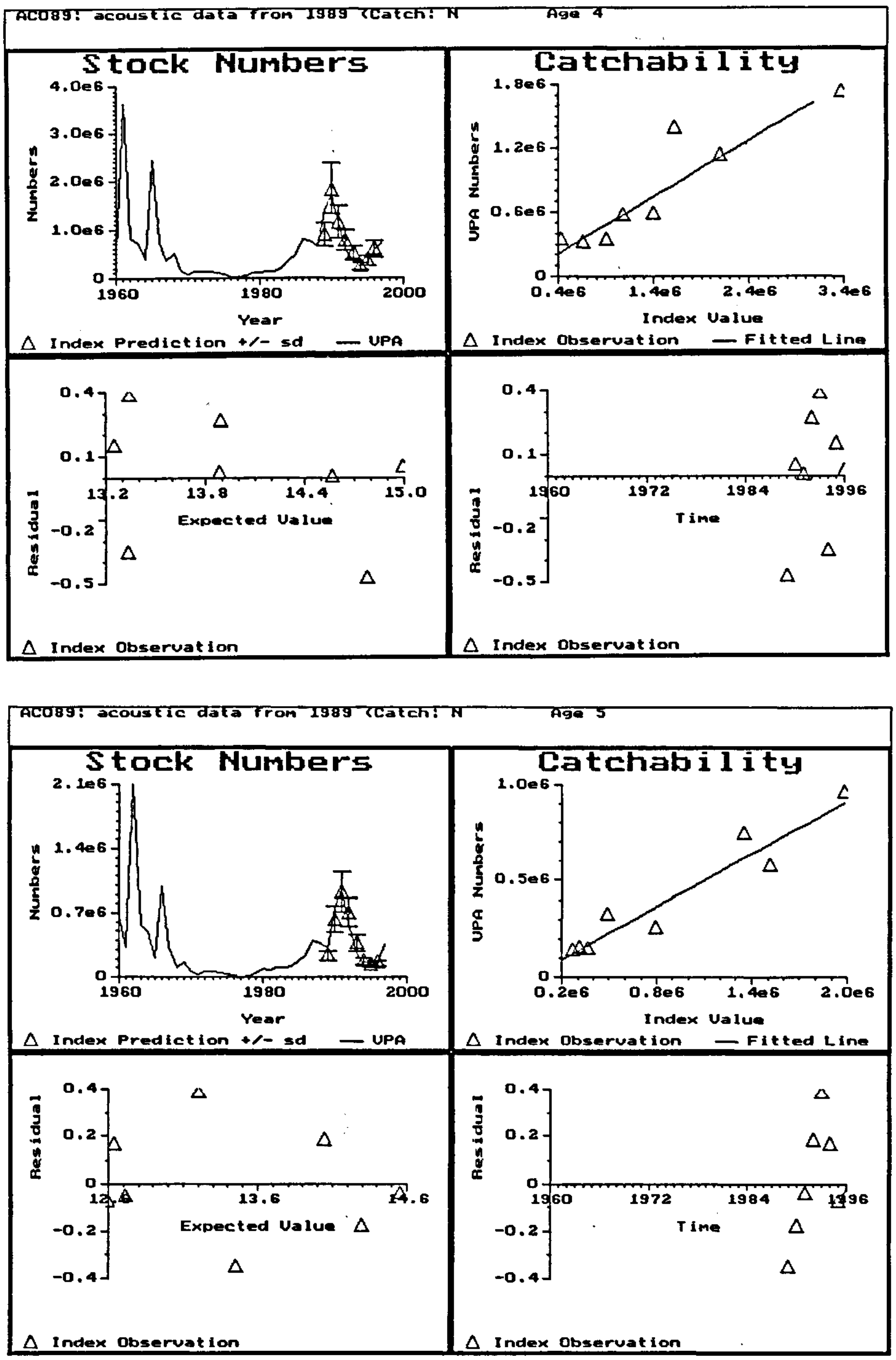
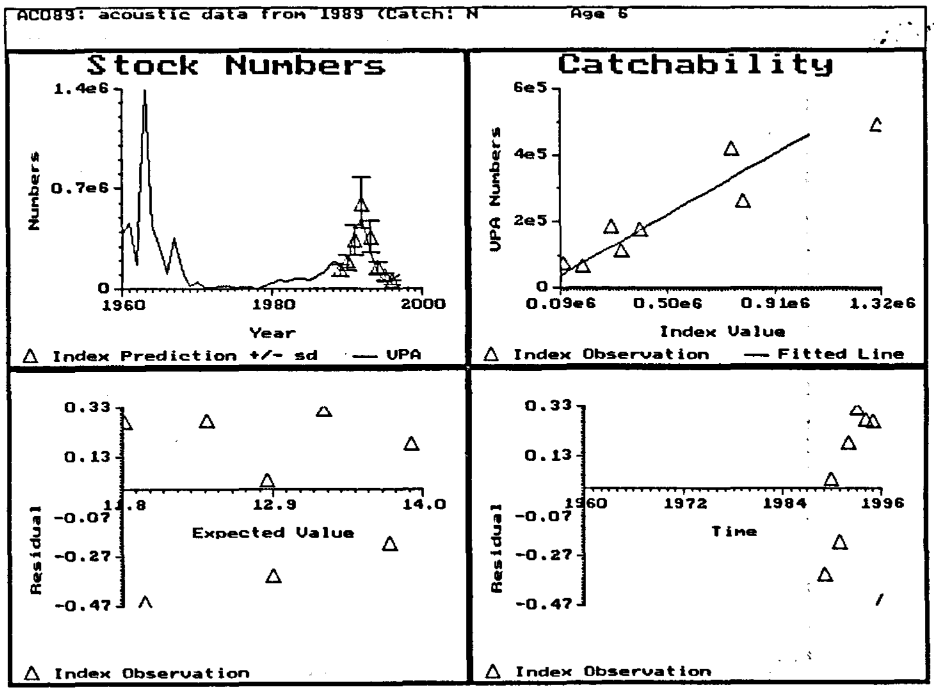


Figure 2.8.8 Herring in Section IV. Results of baseline assessment. **Upper panel:** Diagnostics of the fit of the acoustic index at age 6 against the estimated populations at age 6. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the acoustic index at age 7 against the estimated populations at age 7. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.



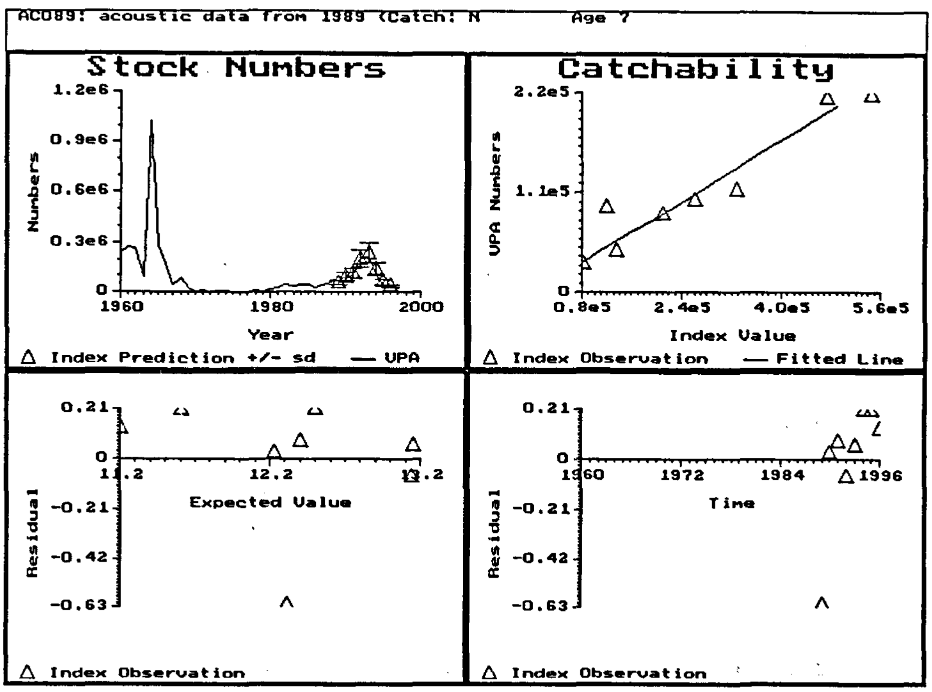
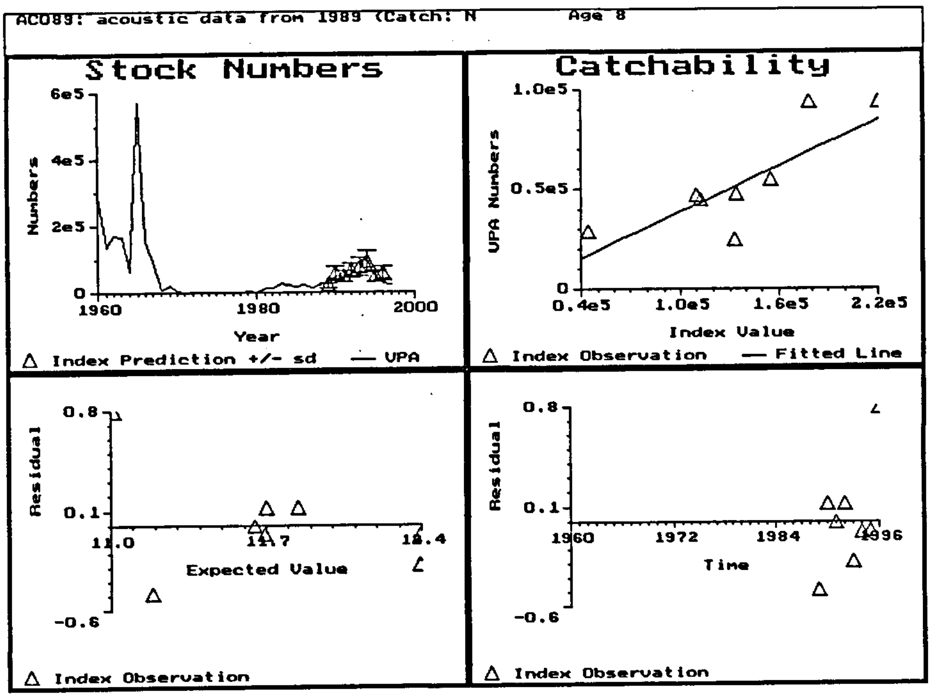


Figure 2.8.9 Herring in VIa(N). Results of the baseline assessment. **Upper panel:** Diagnostics of the fit of the acoustic index at age 8 against the estimated populations at age 8. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the acoustic index at age 9+ against the estimated populations at age 9+. Top left, fitted populations (line), and predictions of abundance in each year made from the acoustic index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and acoustic survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.



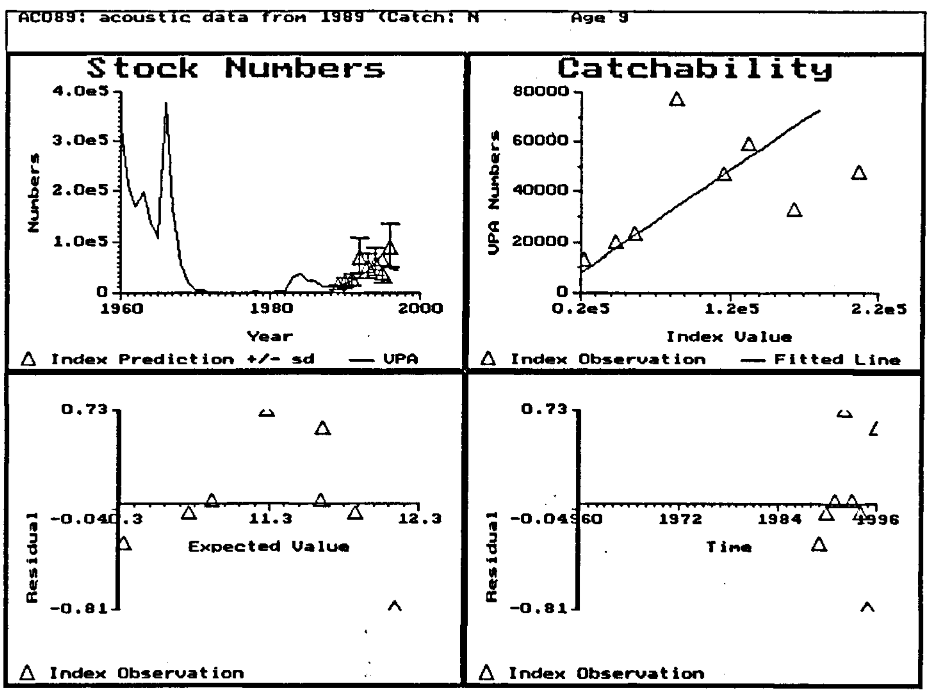


Figure 2.8.10 Herring in IV. Results of the baseline assessment. **Upper panel:** Diagnostics of the fit of the IBTS index at age 2 against the estimated populations at age 2. Top left, fitted populations (line), and predictions of abundance in each year made from the IBTS index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and IBTS survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the IBTS index at age 3 against the estimated populations at age 3. Top left, fitted populations (line), and predictions of abundance in each year made from the IBTS index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and IBTS survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

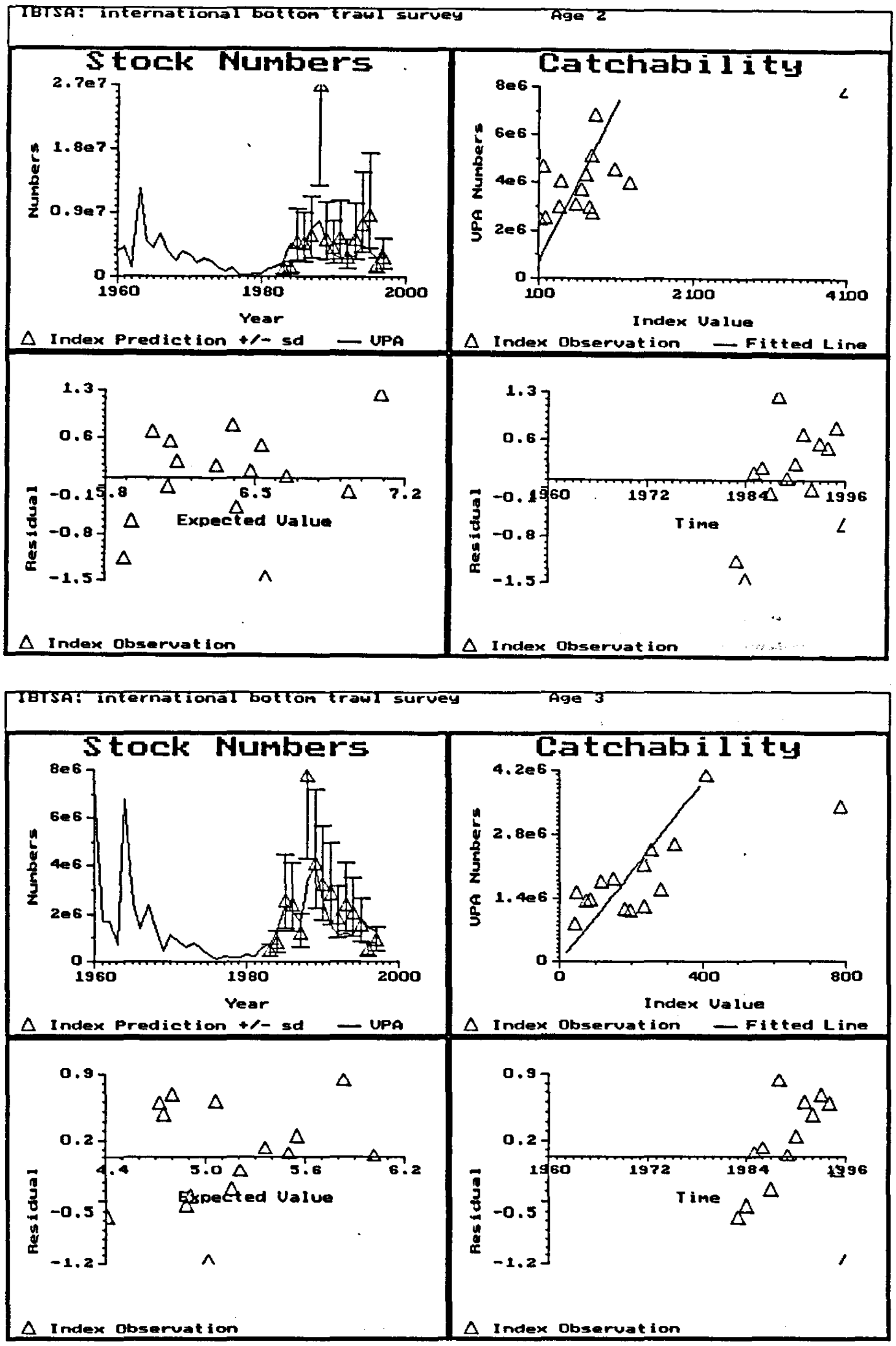


Figure 2.8.11 Herring in IV. Results of the baseline assessment. **Upper panel:** Diagnostics of the fit of the IBTS index at age 4 against the estimated populations at age 4. Top left, fitted populations (line), and predictions of abundance in each year made from the IBTS index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and IBTS survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the IBTS index at age 5+ against the estimated populations at age 5+. Top left, fitted populations (line), and predictions of abundance in each year made from the IBTS index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and IBTS survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

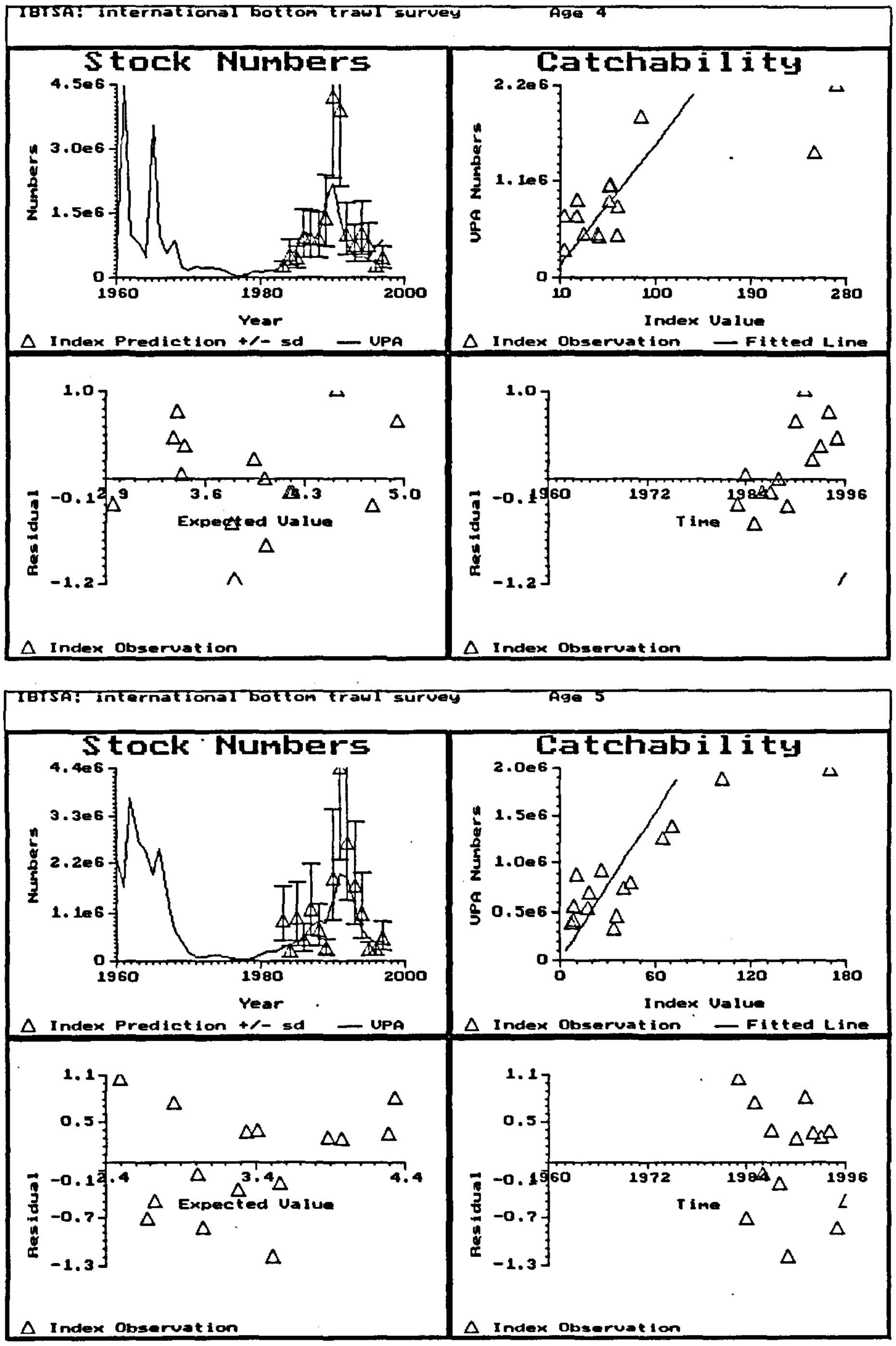


Figure 2.8.12 Herring in IV. Results of the baseline assessment. **Upper panel:** Diagnostics of the fit of the IBTS index at age 1 against the estimated populations at age 1. Top left, fitted populations (line), and predictions of abundance in each year made from the IBTS index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and IBTS survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time. **Lower panel:** Diagnostics of the fit of the MIK index at age 0 against the estimated populations at age 0. Top left, fitted populations (line), and predictions of abundance in each year made from the MIK index observations and the estimated catchability (triangles +/- standard deviation), plotted by year. Top right, scatterplot and fitted relationship of the fitted populations and MIK survey index observations. Bottom, residuals, as (ln(observed index) - ln(expected index) plotted against expected values and against time.

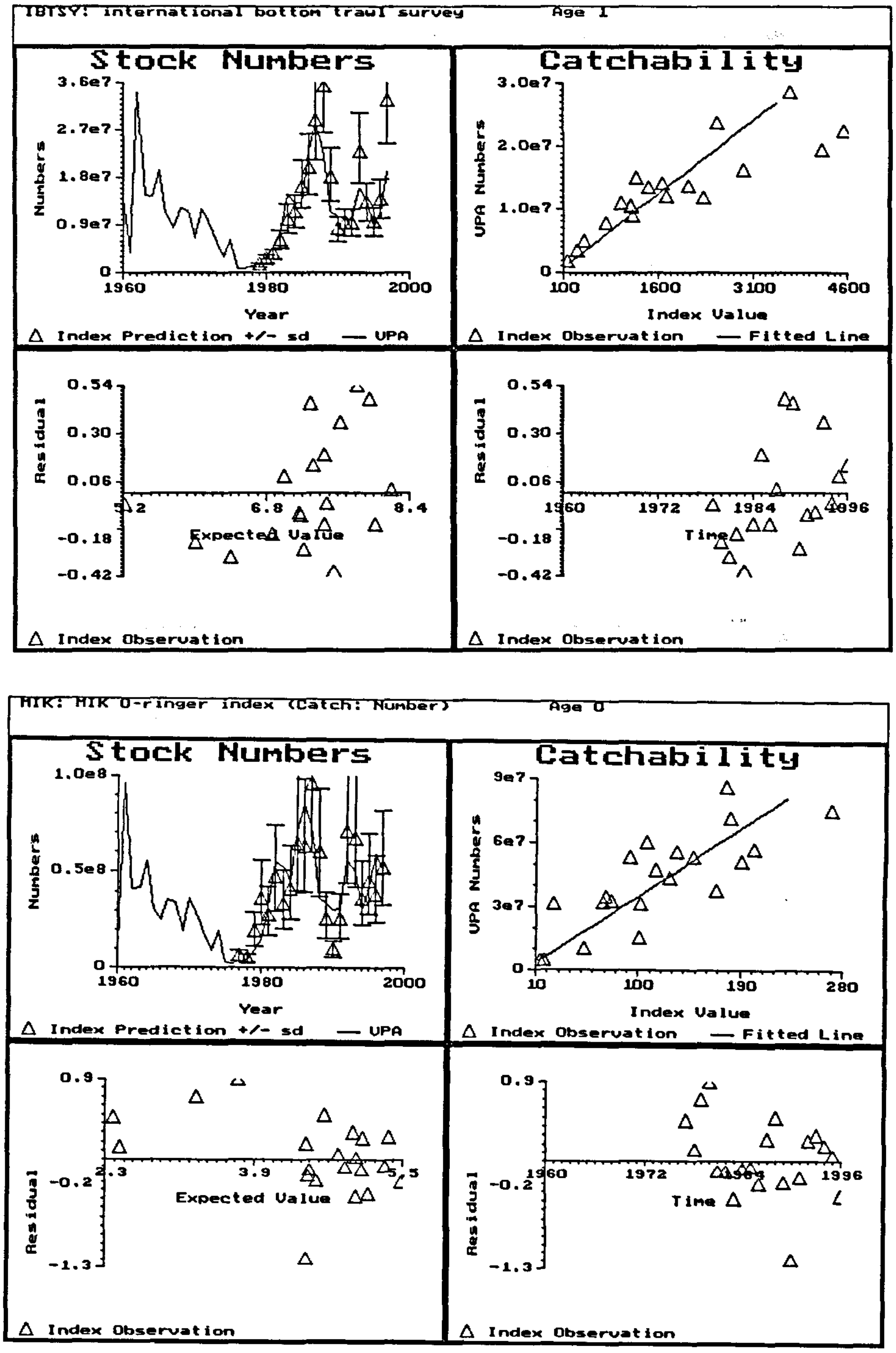
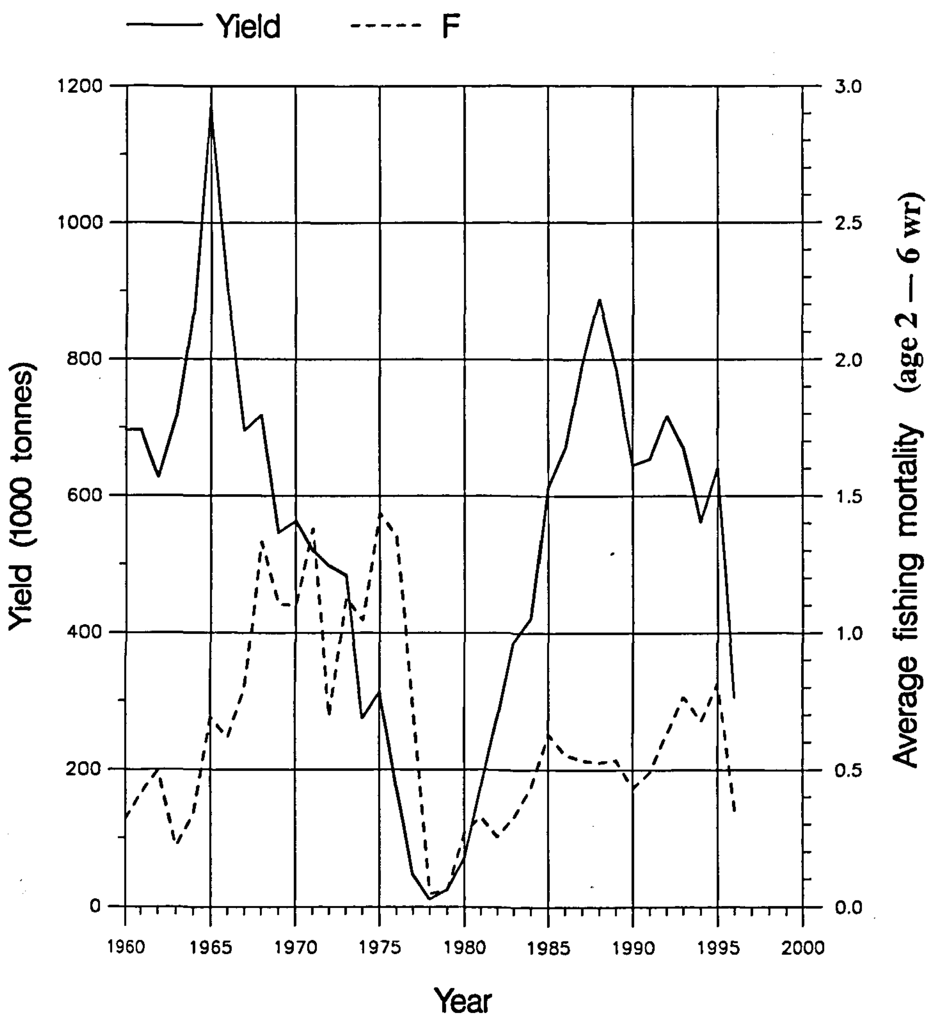


Figure 2.8.13

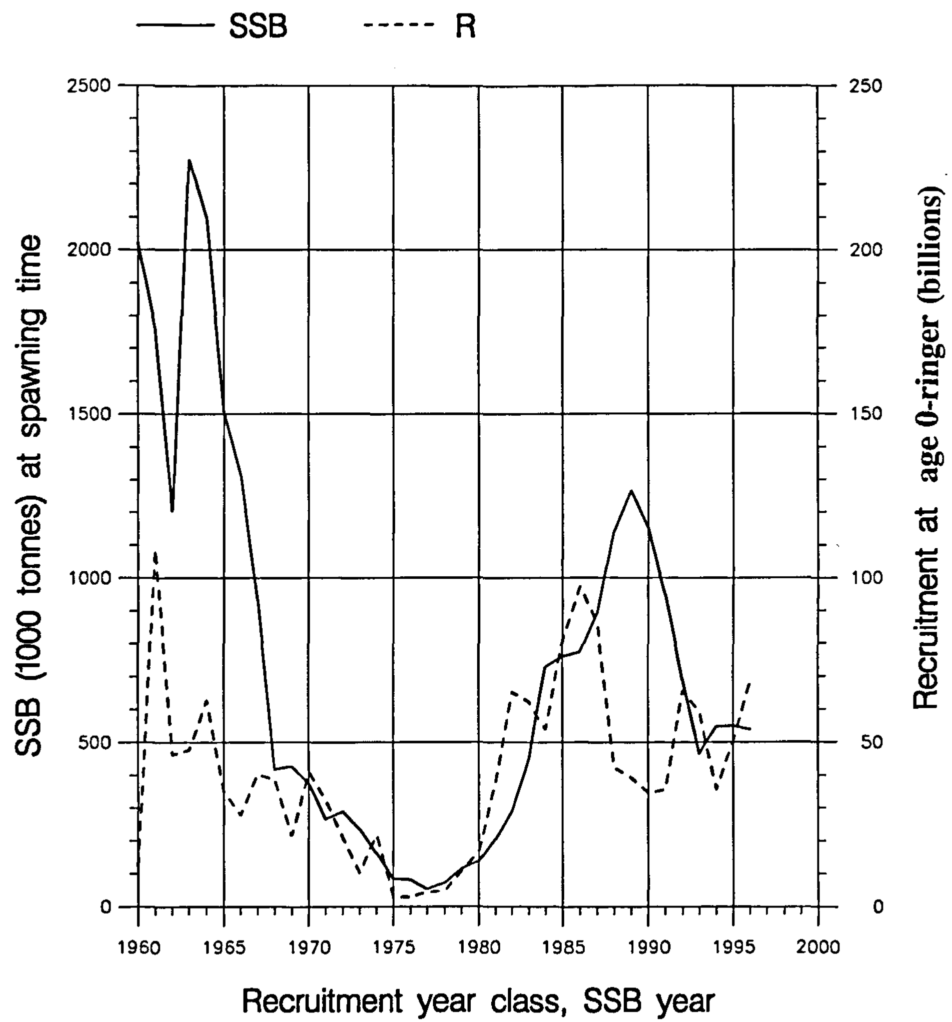
Fish Stock Summary
Herring in Sub-area IV, Divisions VIId & IIIa (autumn-spawners)
17-3-1997

Yield and fishing mortality



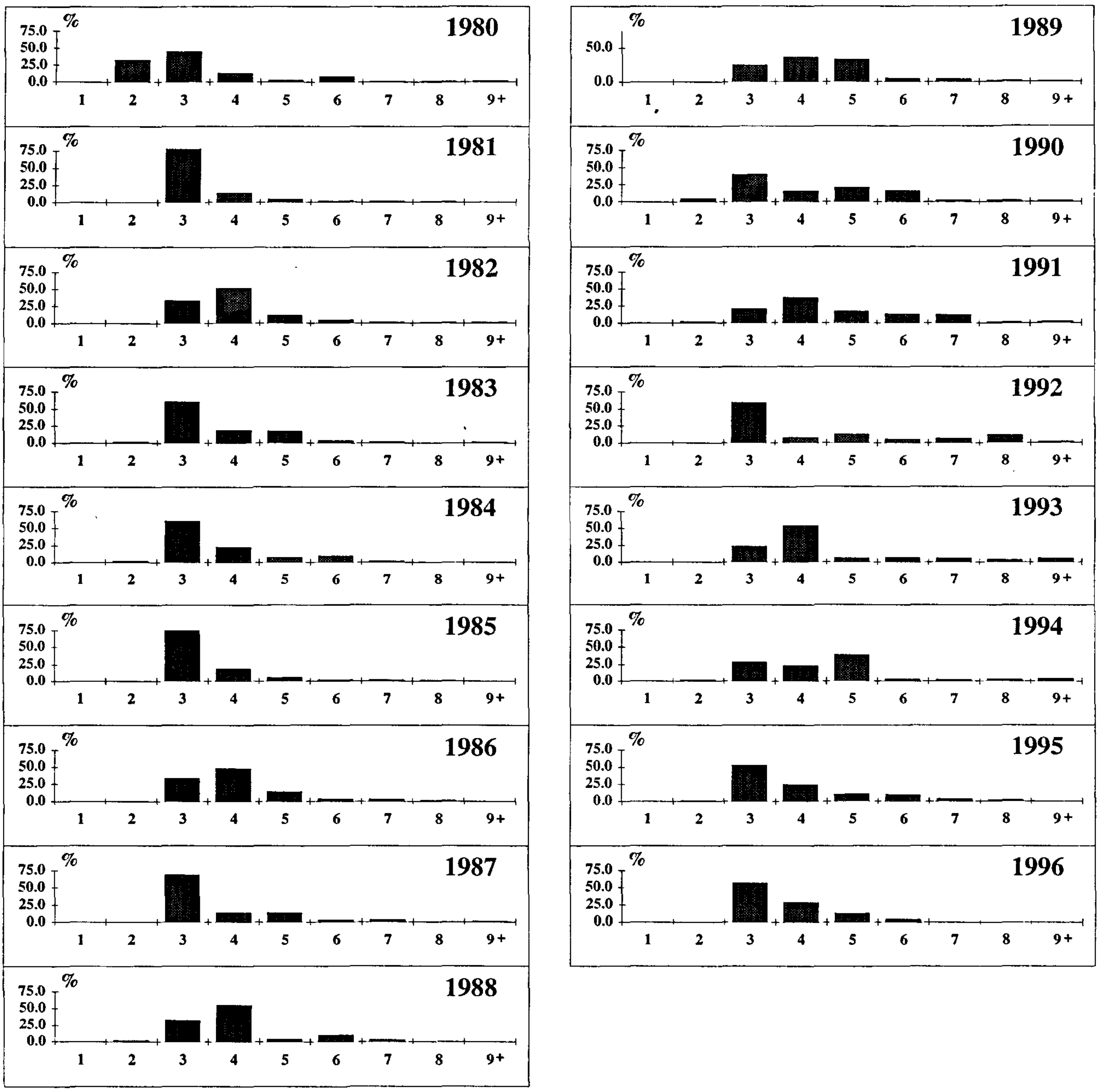
(run: ICAMAP45) A

Spawning stock and recruitment



(run: ICAMAP45) B

Figure 2.8.14 The age composition of herring in Divisions IVc and VIID in the Dutch catches from December 1980–1996.



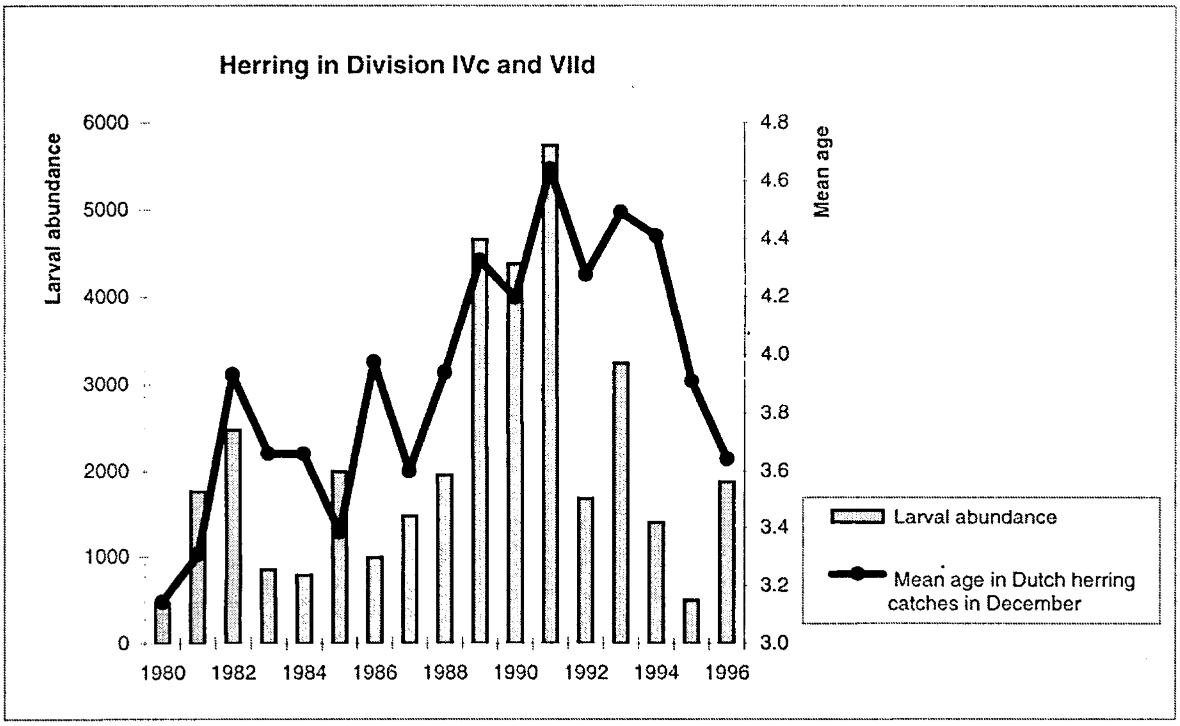


Figure 2.8.15 Changes in the herring larval abundance compared to changes in the mean age in the Dutch herring catches in December.

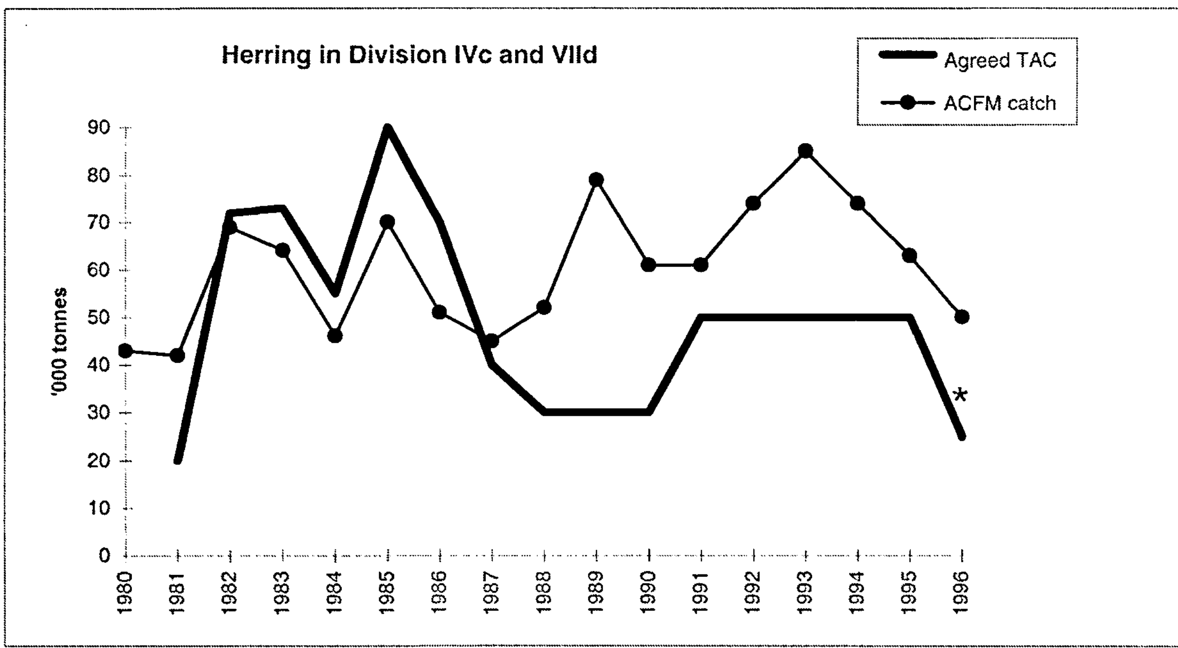
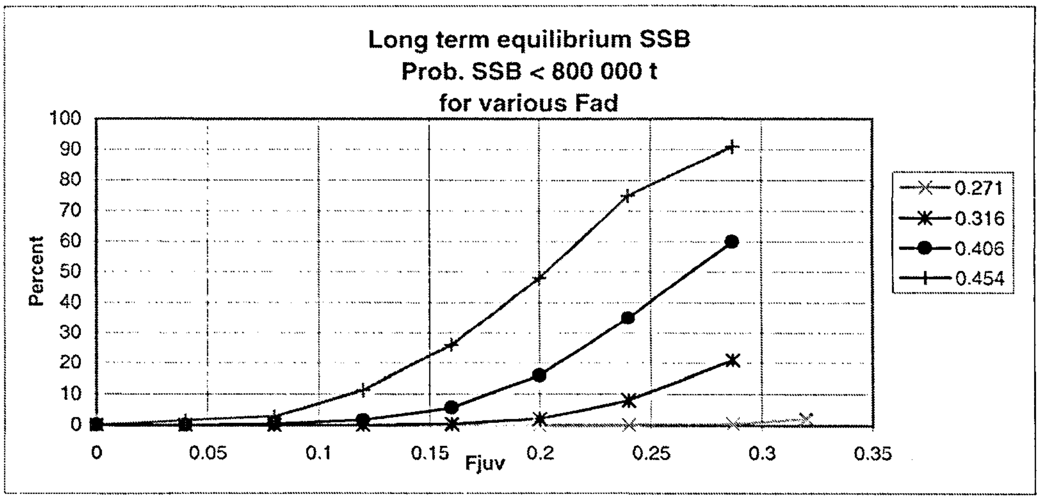
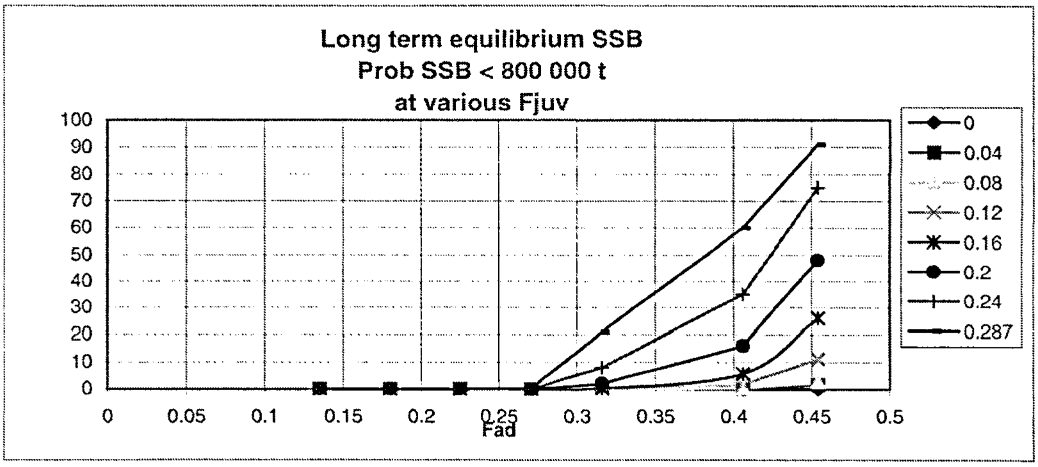


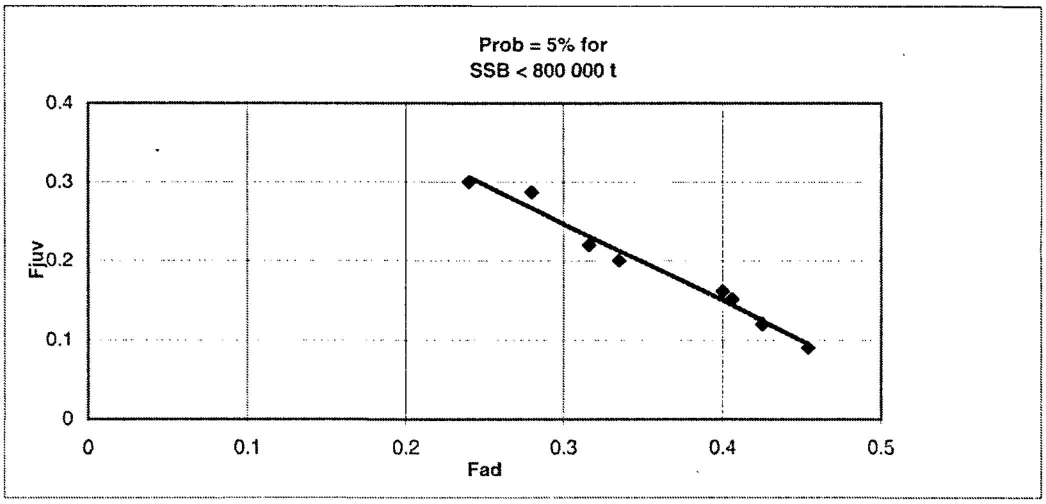
Figure 2.8.16 The agreed TAC for Divisions IVc and VIId compared to the ACFM catch in that area. In 1996 the agreed TAC value is only 50% of the agreed TAC, because of a change in the middle of 1996 (see *).



a) The risk as a function of Fjuv, for levels of Fad as indicated.



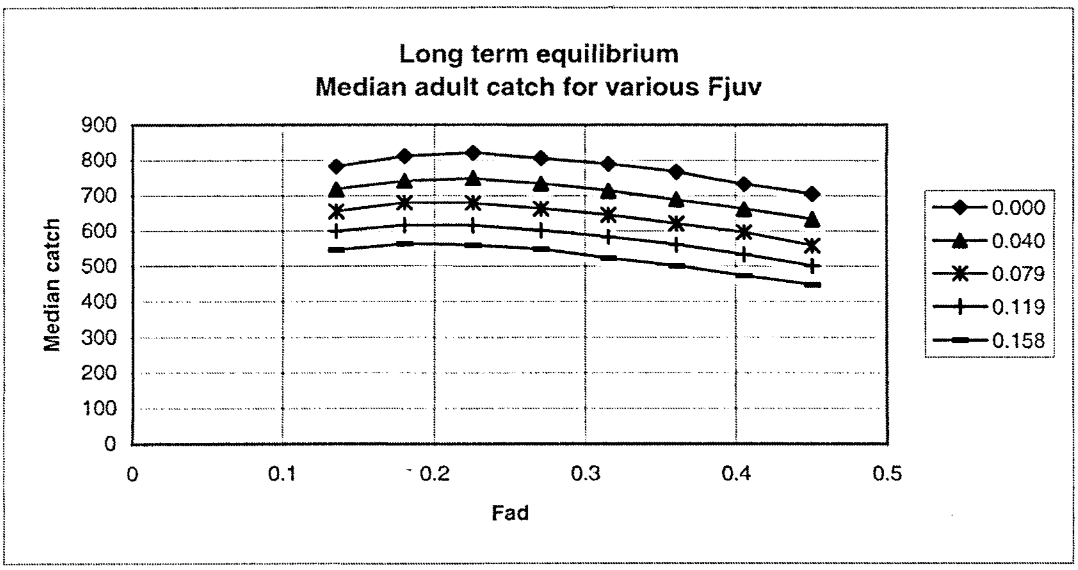
b) The risk as function of Fad, for levels of Fjuv as indicated.



c) Points representing combinations of Fjuv and Fad where the risk is approximately 5% with a straight line fitted to these points.

Figure 2.9.1 Probabilities (risks) of SSB<800,000 tonnes in long term equilibrium.

Figure 2.9.2 Median catch as function of Fad, for levels of Fjuv as indicated, at long term equilibrium.



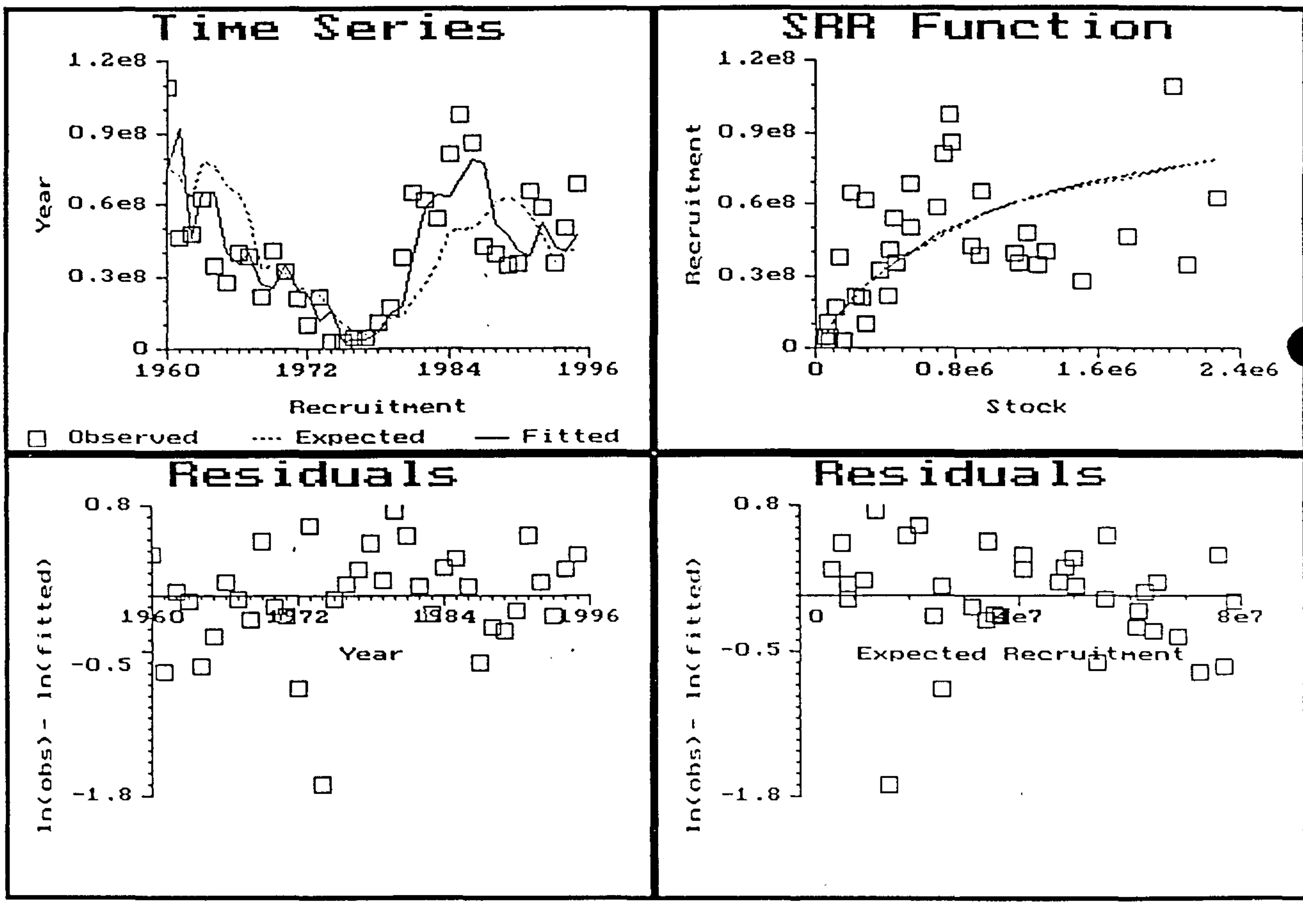
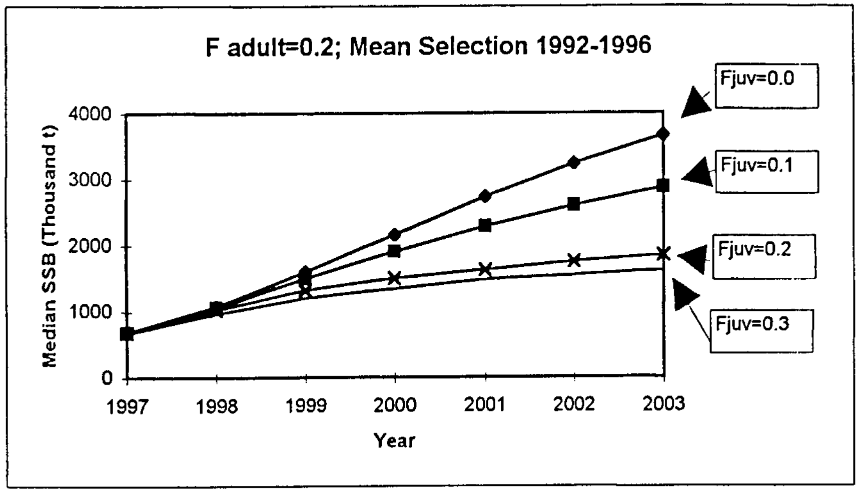
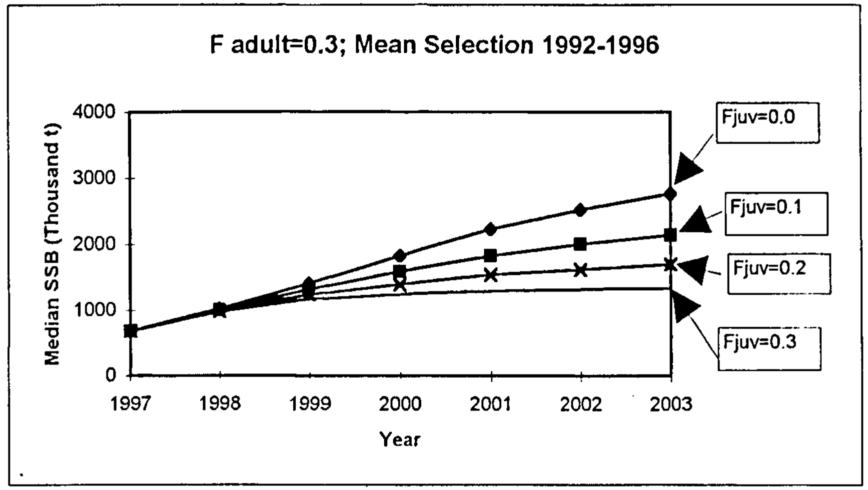
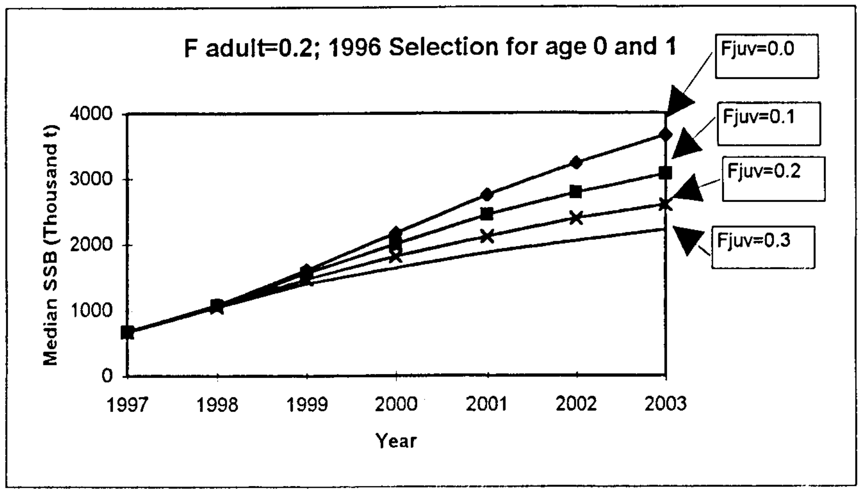


Figure 2.11.1. North Sea Herring. Stock-recruitment relationship used for the medium-term projections. A Beverton-Holt model with first-order autocorrelation is fitted. Clockwise from top left, first panel: Time series of recruitment (ICA estimates, open squares), expected recruitments (Expectation from Beverton-Holt Model) and fitted recruitments (including autocorrelation term). Second panel, the stock-recruit function and the observed and expected recruitments plotted in the stock-recruitment plane.Third panel, scatterplot of residuals on time. Fourth panel, scatterplot of residuals on expected value.

Figure 2.11.12. North Sea Herring. Summary of medium-term projections, as median of projected SSBs for the various options modelled.







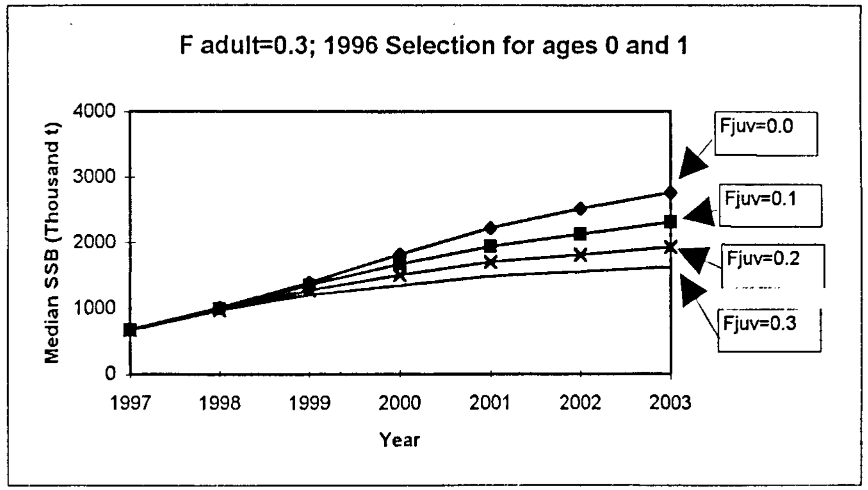


Figure 2.11.3a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E}=0.0. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

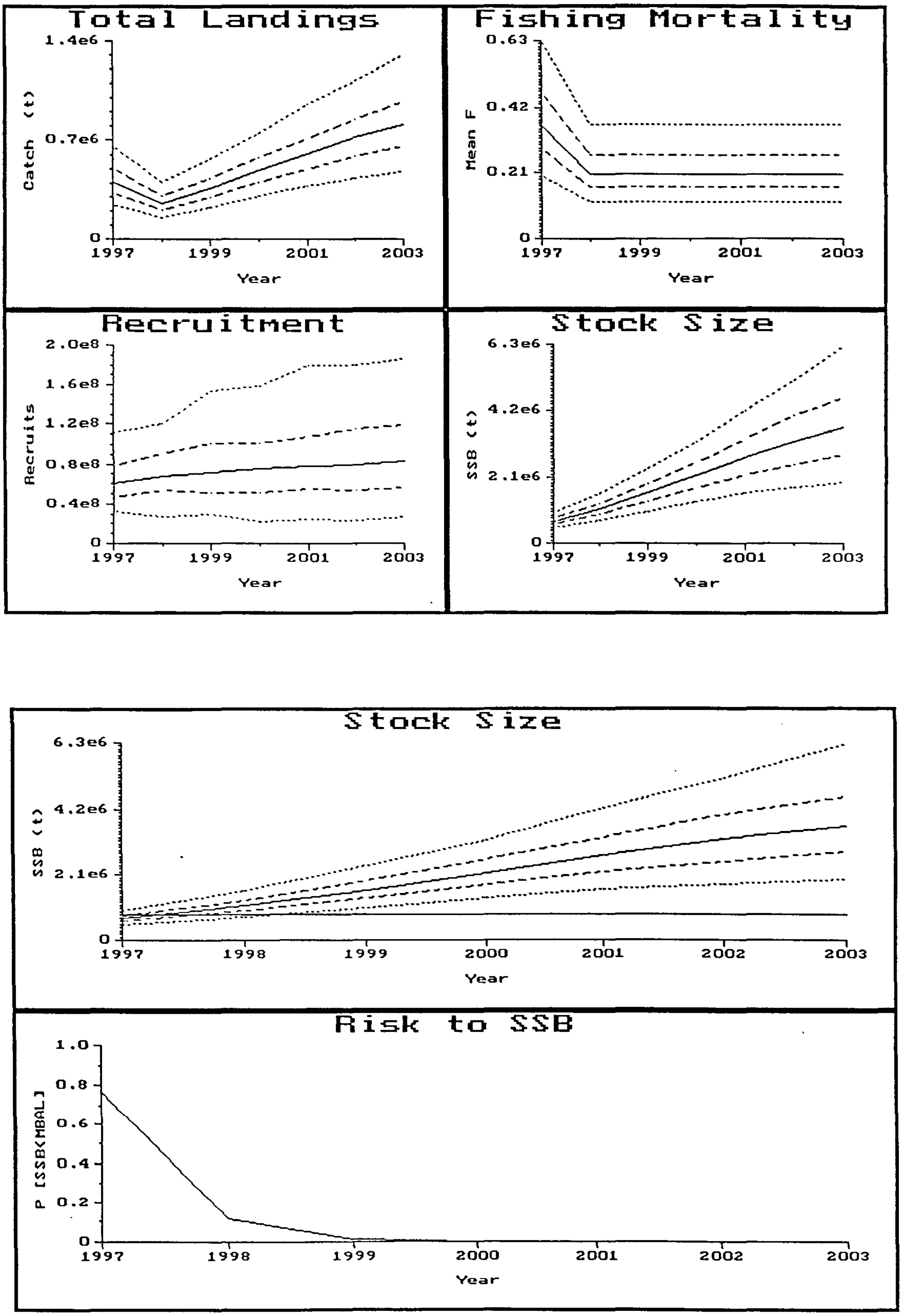


Figure 2.11.3b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.0. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

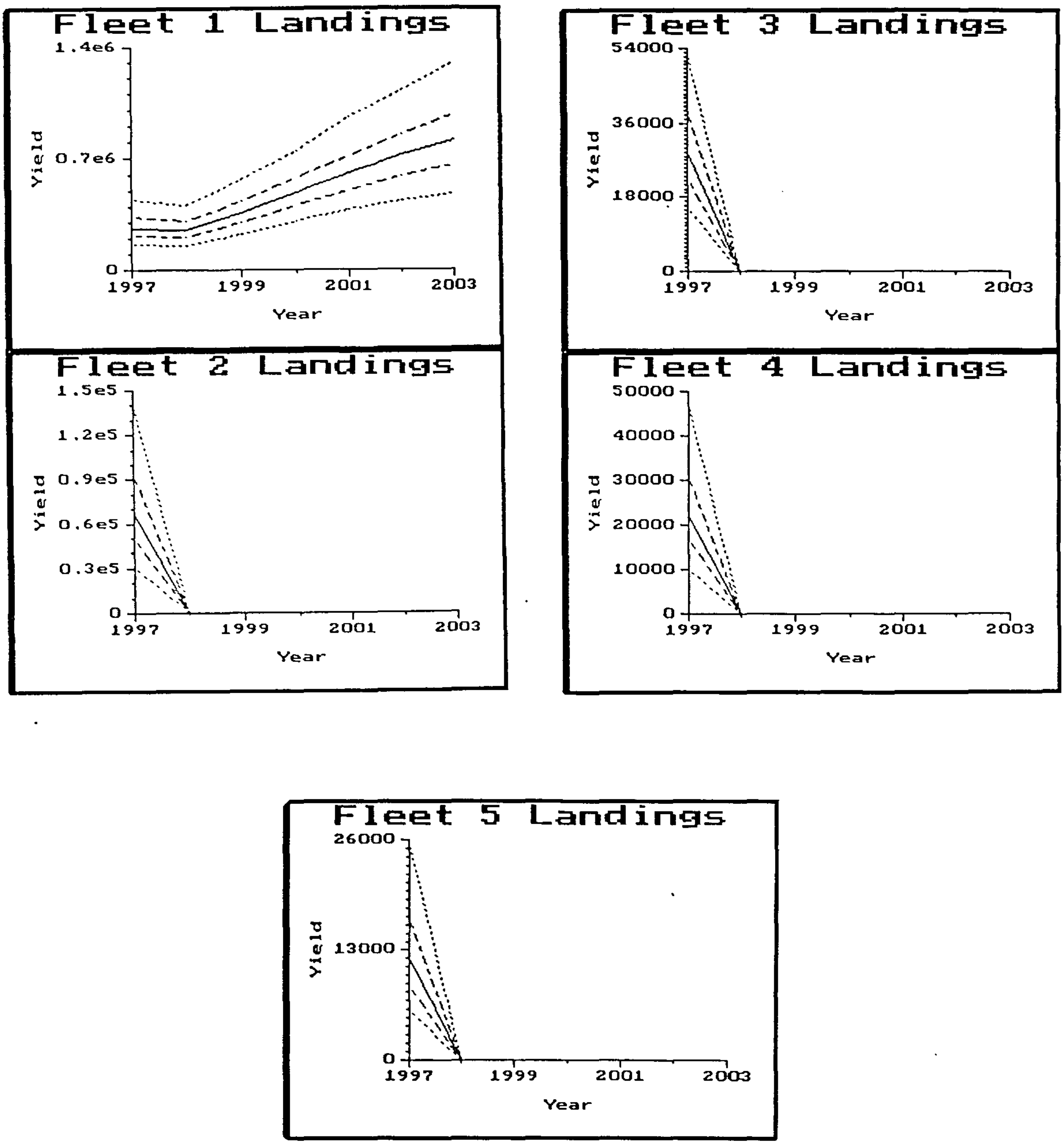


Figure 2.11.4a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E}=0.1. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

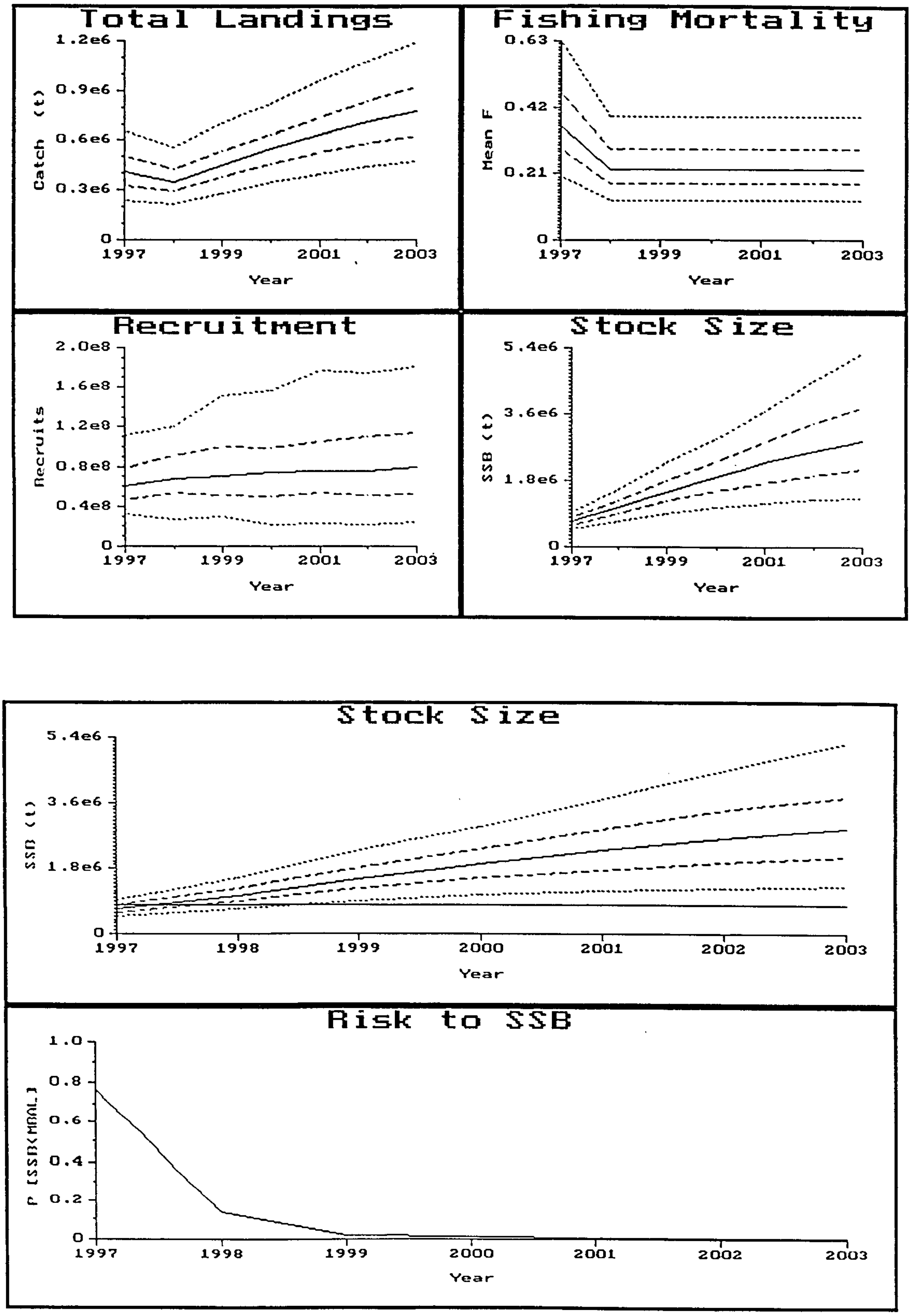


Figure 2.11.4b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.1. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

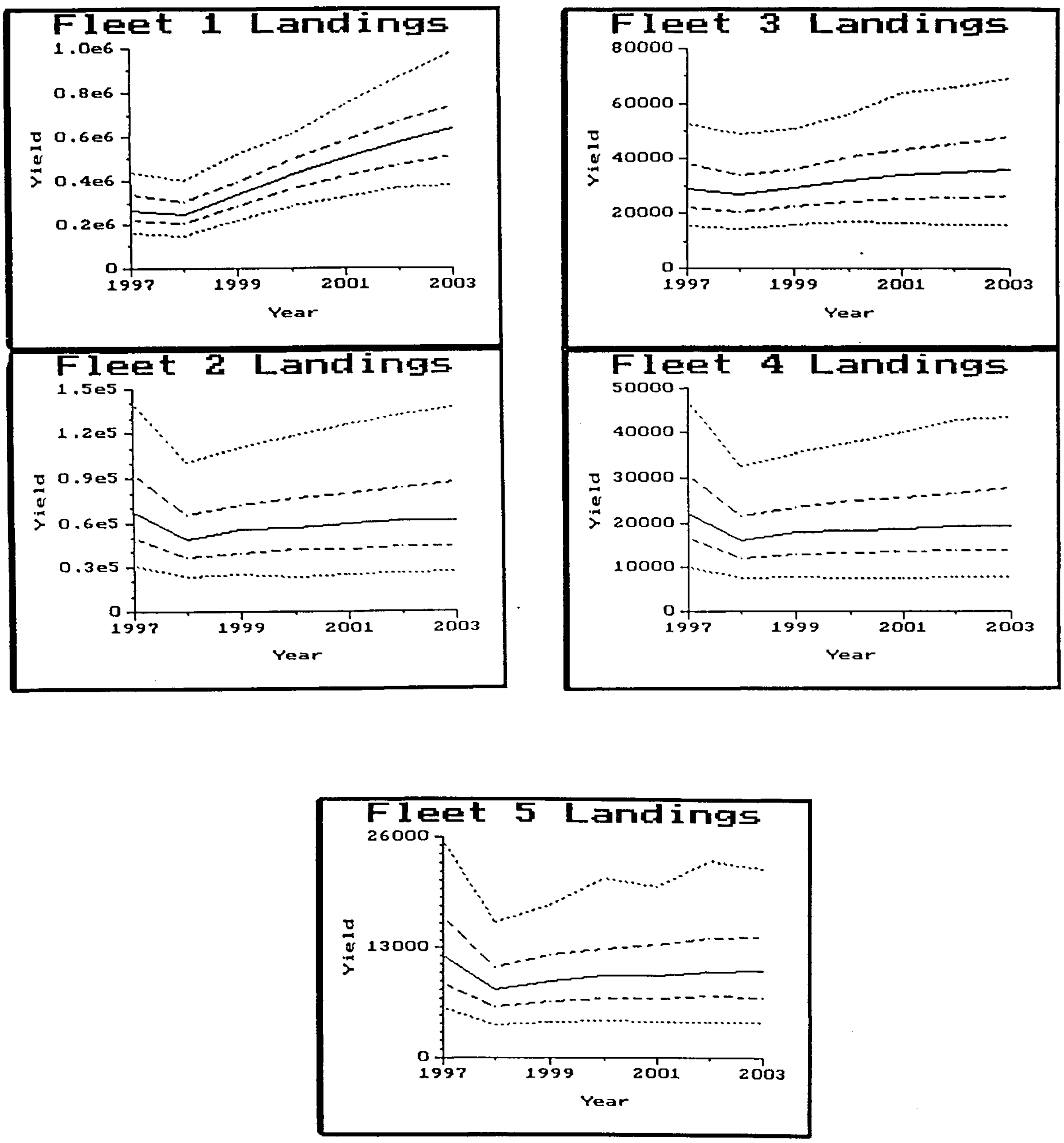


Figure 2.11.5a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E} =0.2. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

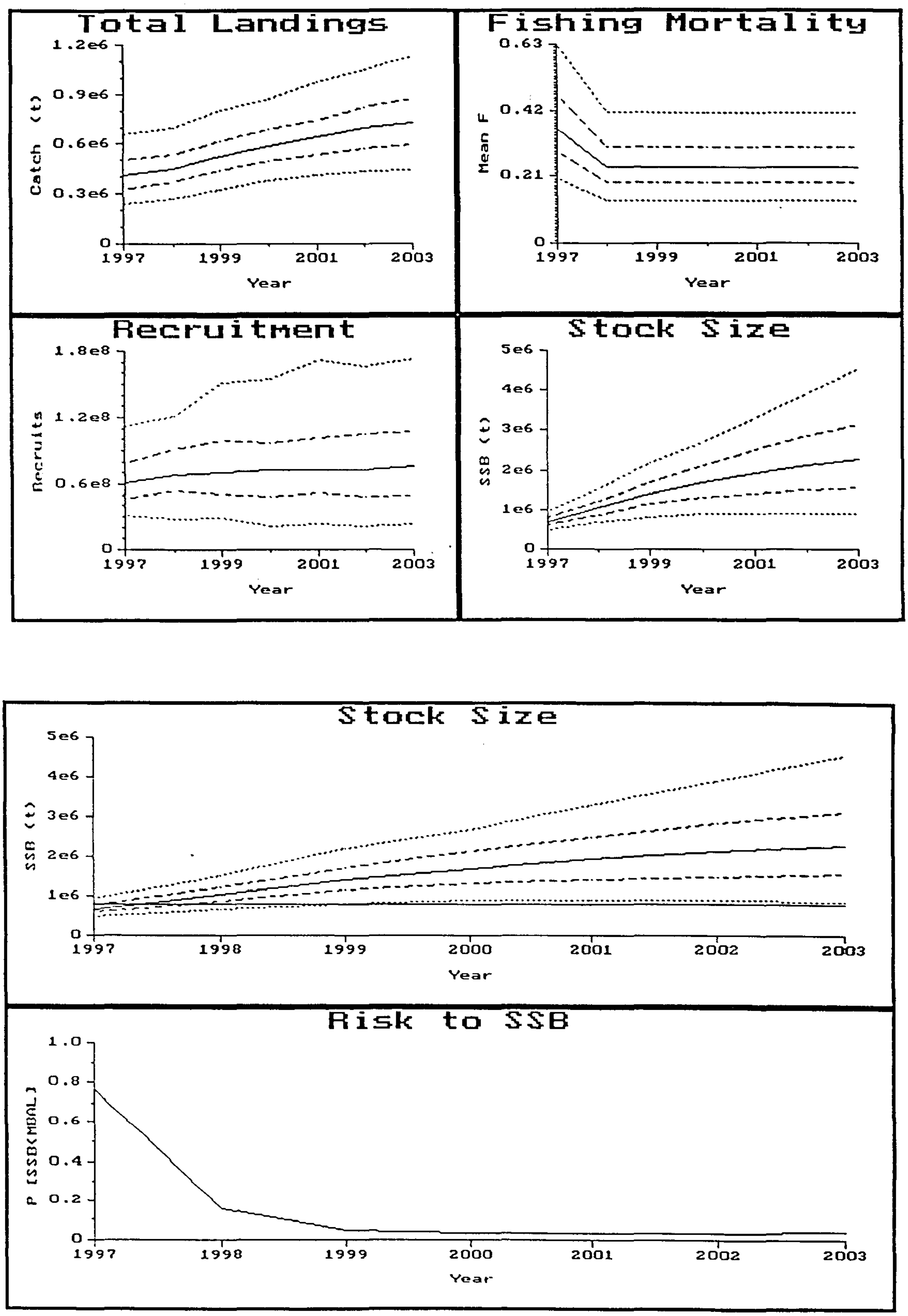


Figure 2.11.5b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.2. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

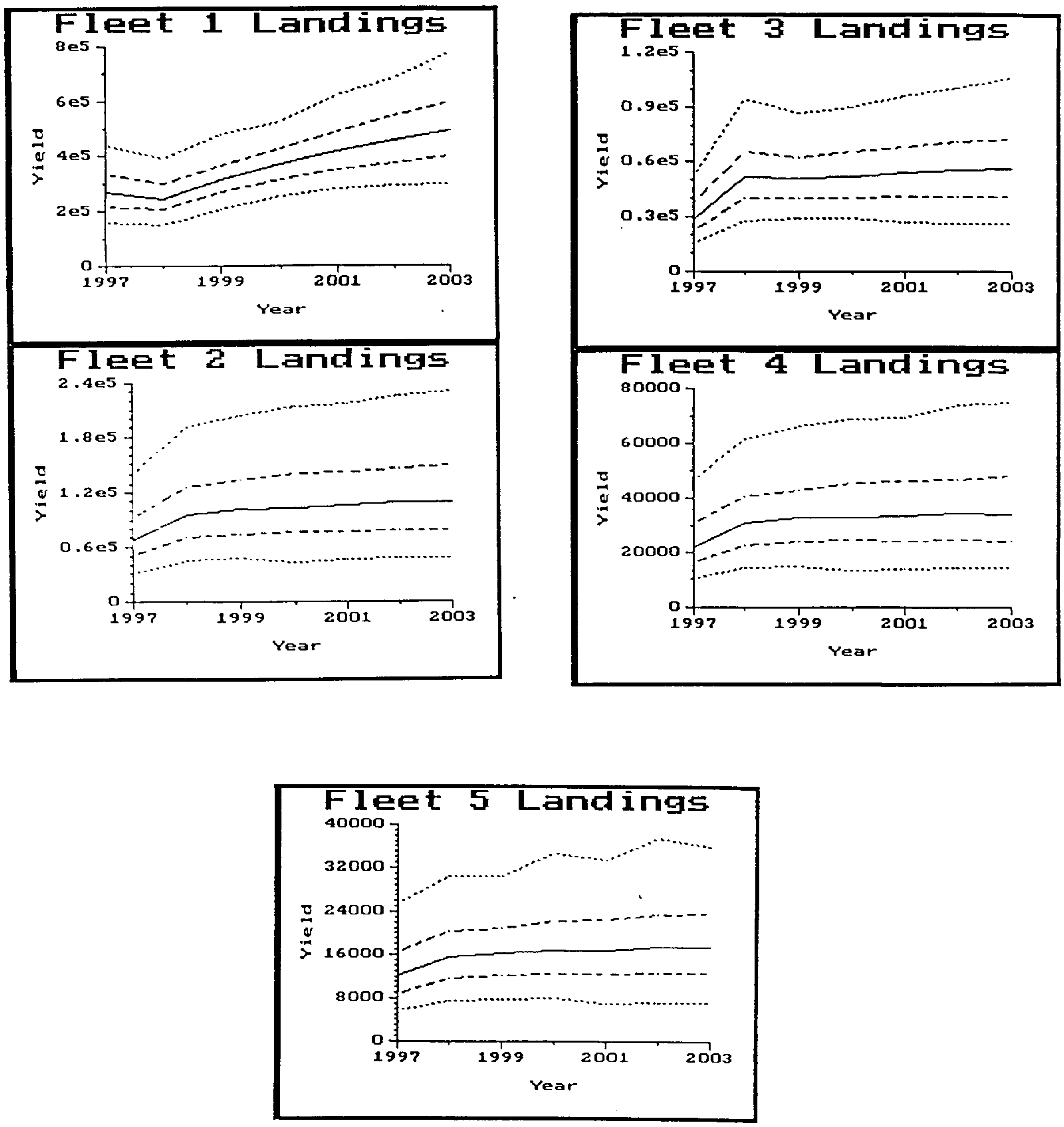


Figure 2.11.6a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E}=0.3. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

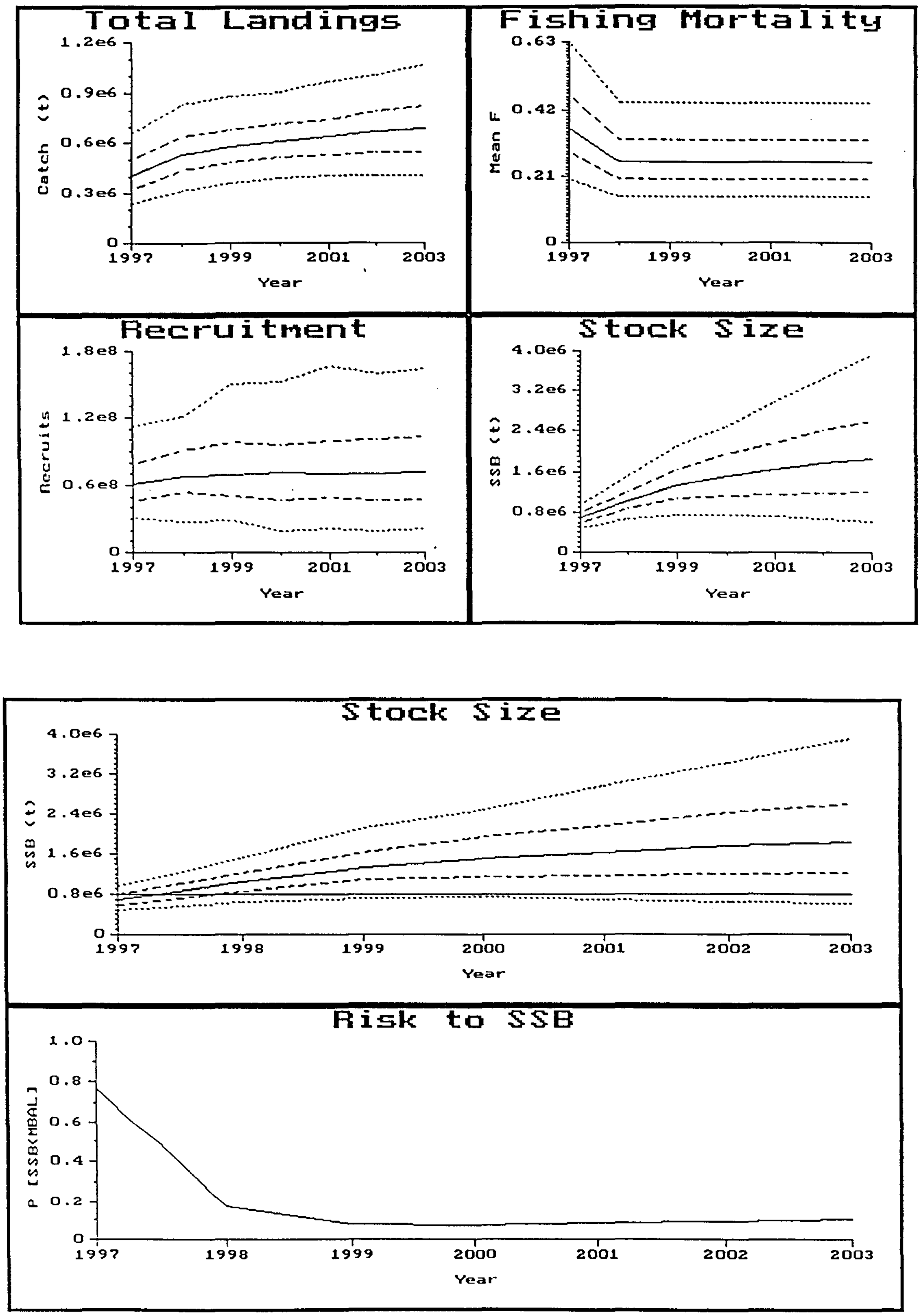


Figure 2.11.6b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.3. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

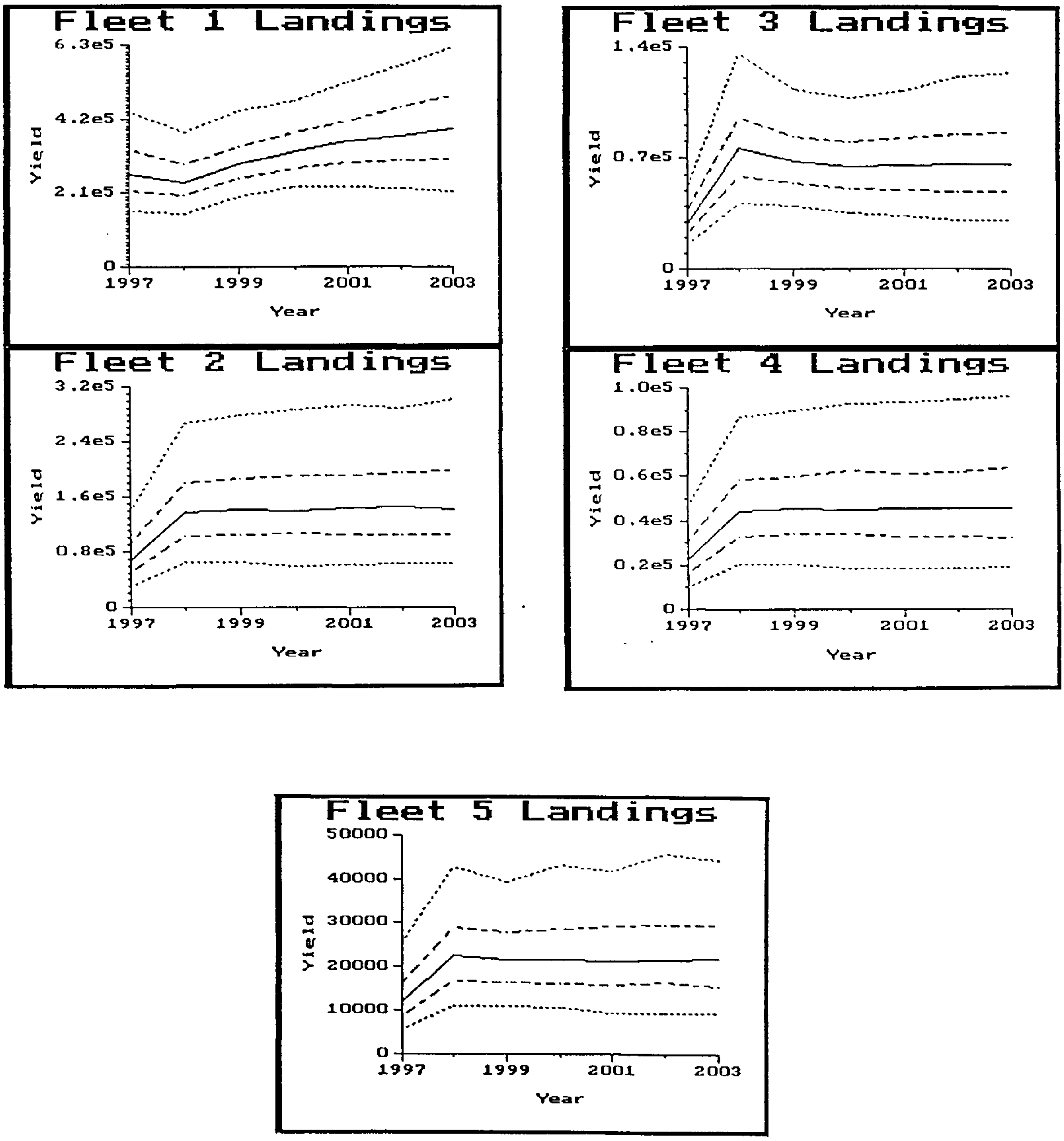


Figure 2.11.7a North Sea Herring.Medium-term projections assuming F_A=0.3 and F_{B-E}=0.0. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

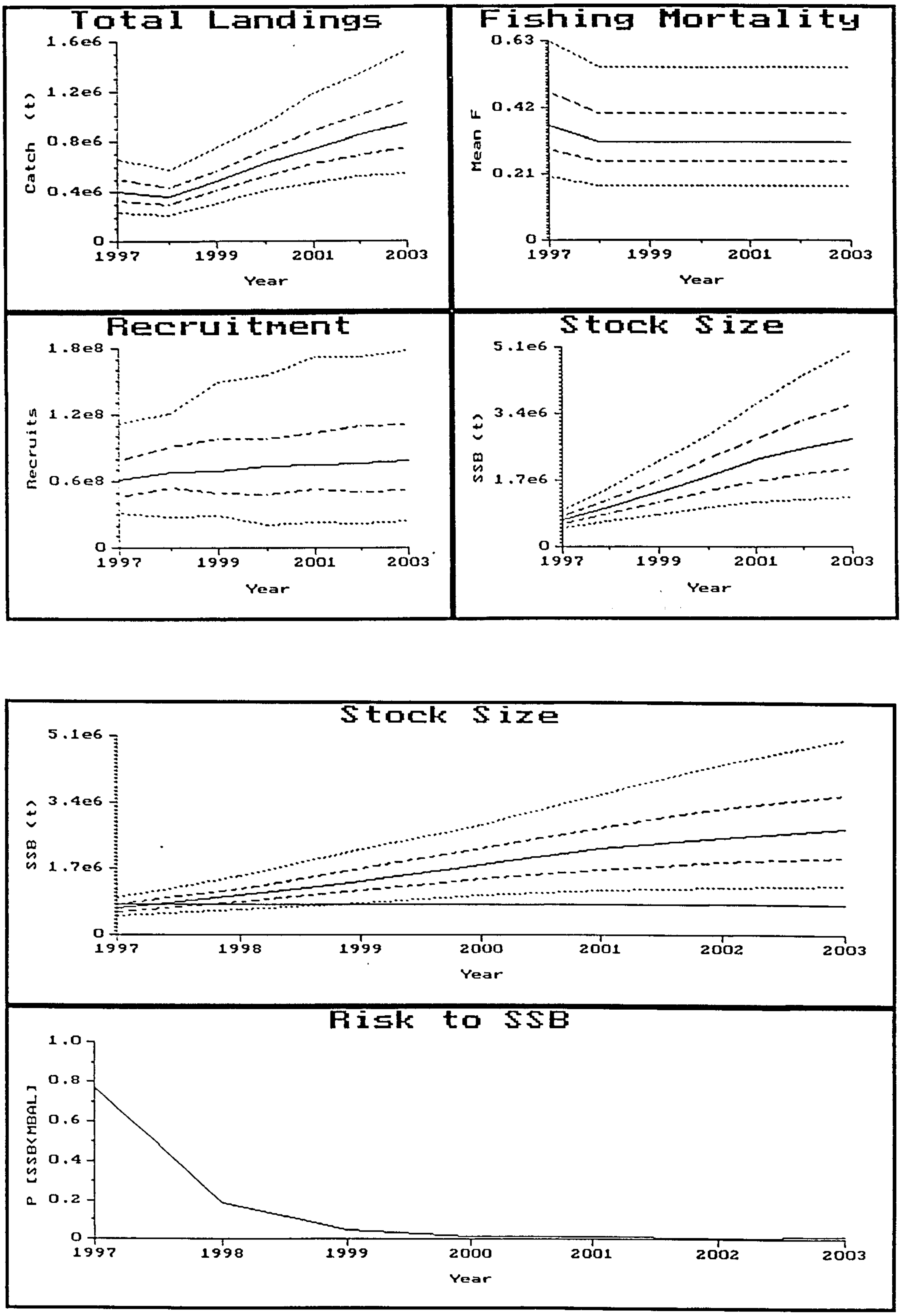


Figure 2.11.7b. North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.0. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

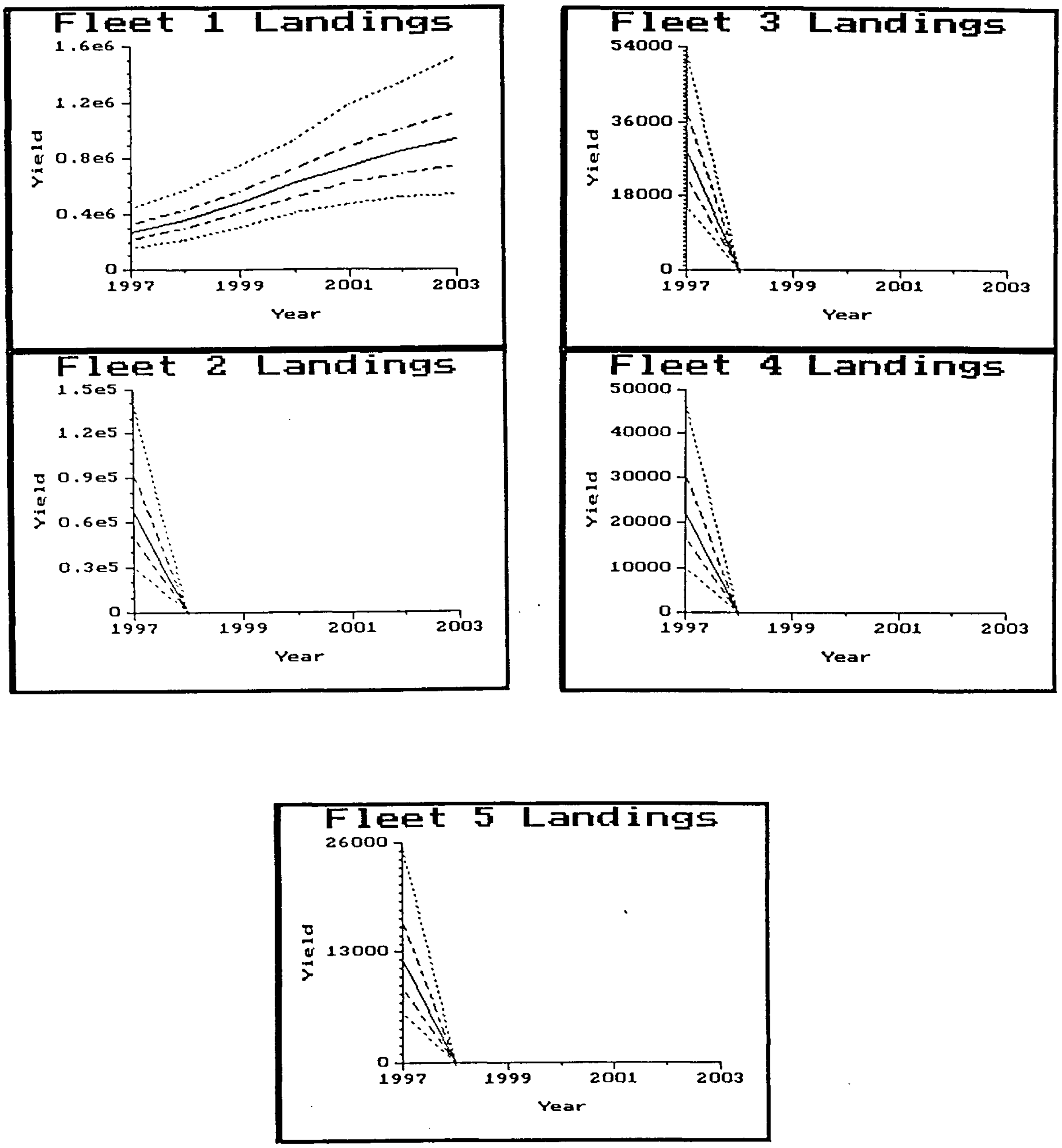


Figure 2.11.8a North Sea Herring.Medium-term projections assuming F_A=0.3 and F_{B-E}=0.1. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

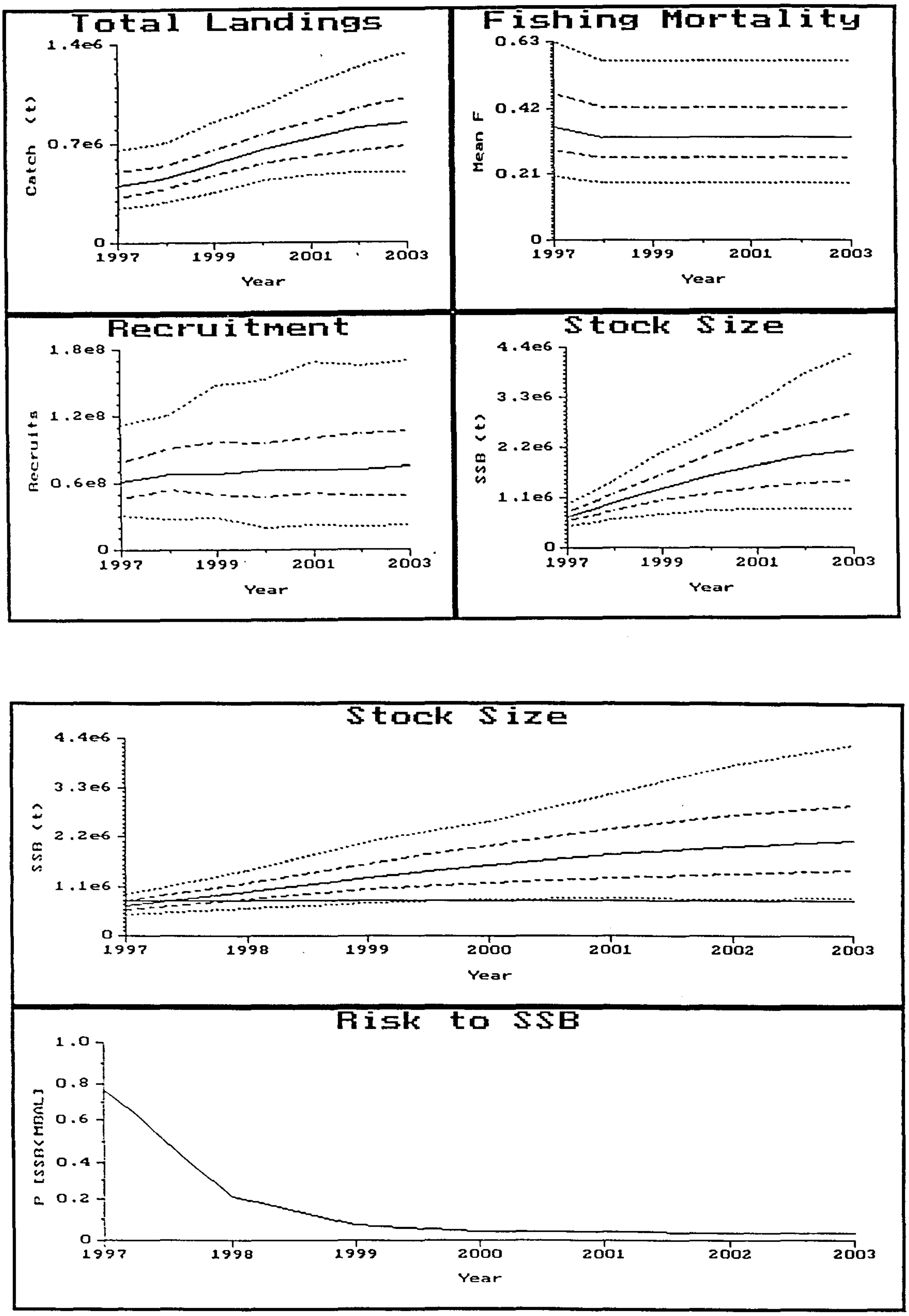


Figure 2.11.8b. North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.1. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

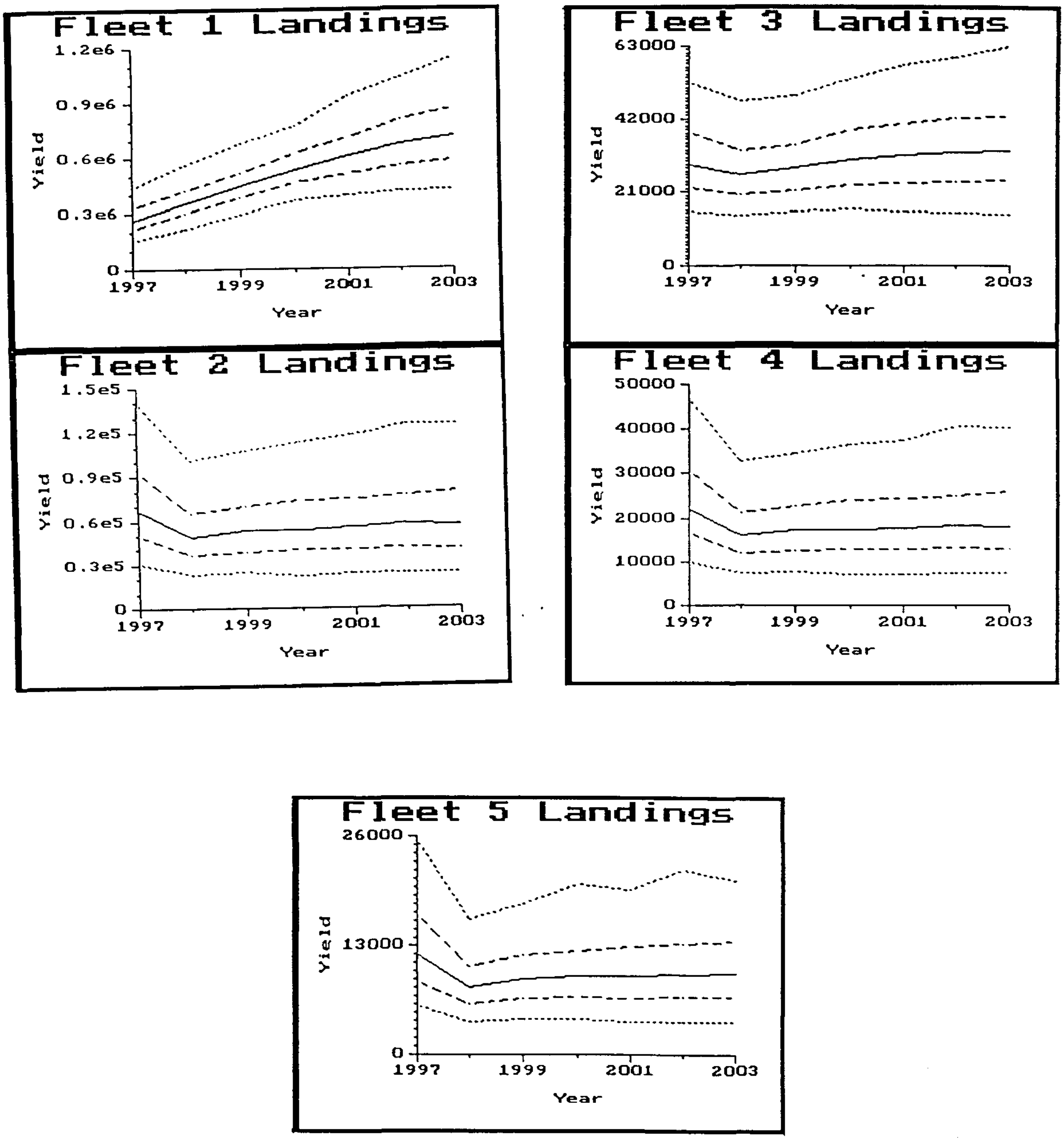


Figure 2.11.9a North Sea Herring.Medium-term projections assuming F_A=0.3 and F_{B-E}=0.2. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

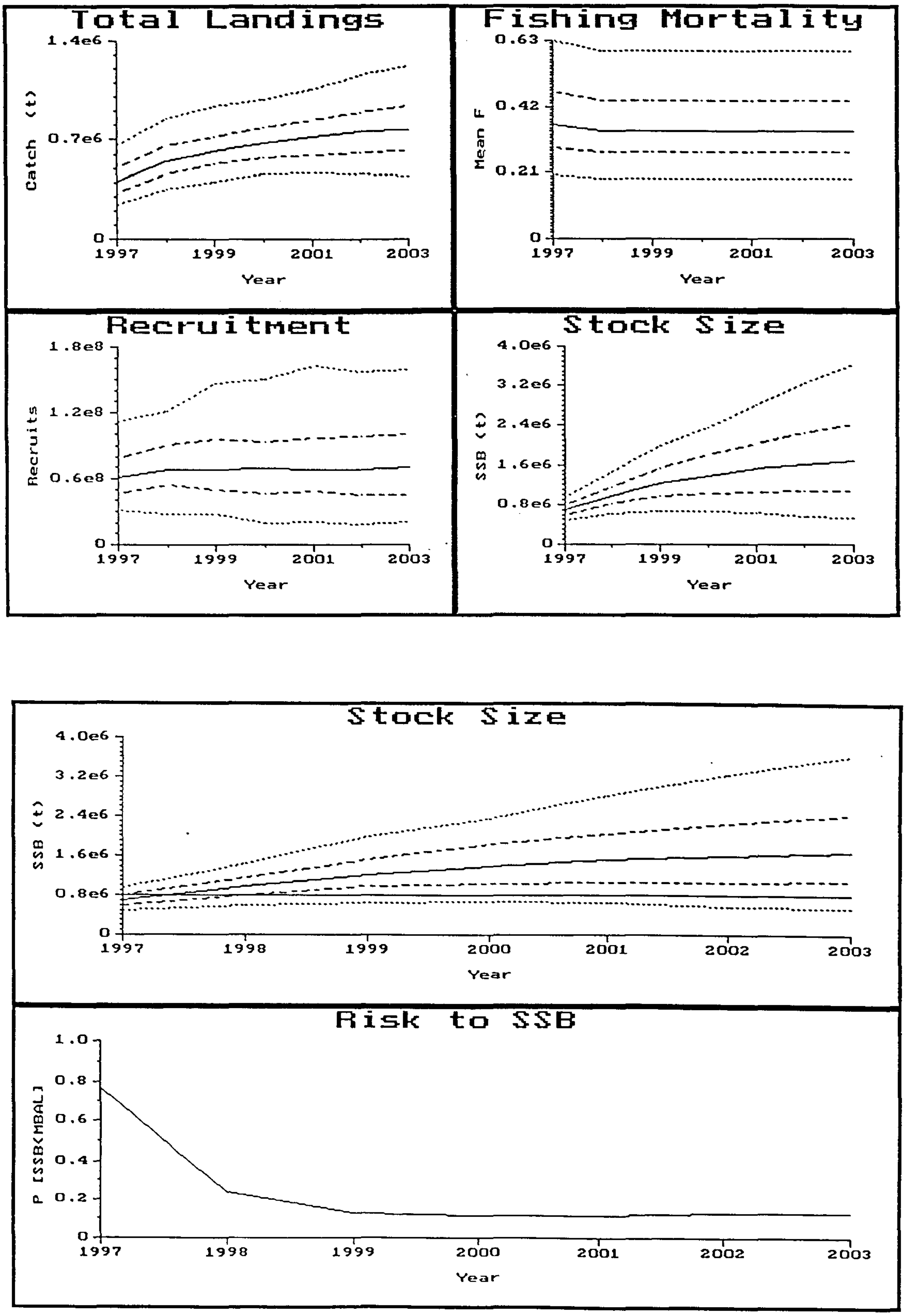


Figure 2.11.9b. North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.2. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

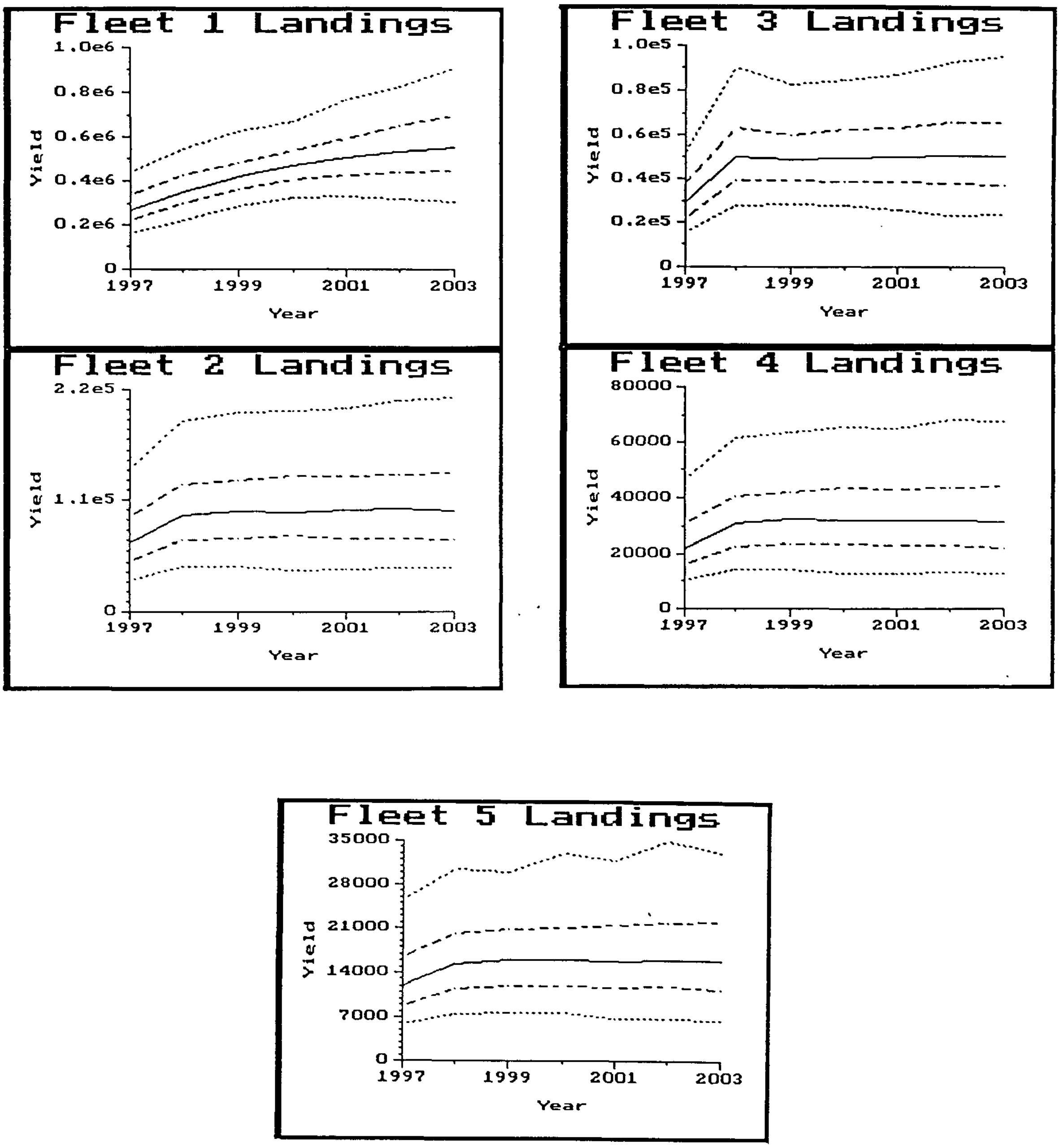


Figure 2.11.10a North Sea Herring.Medium-term projections assuming F_A=0.3 and F_{B-E}=0.3. Separable (1992-1996) selection pattern assumed. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

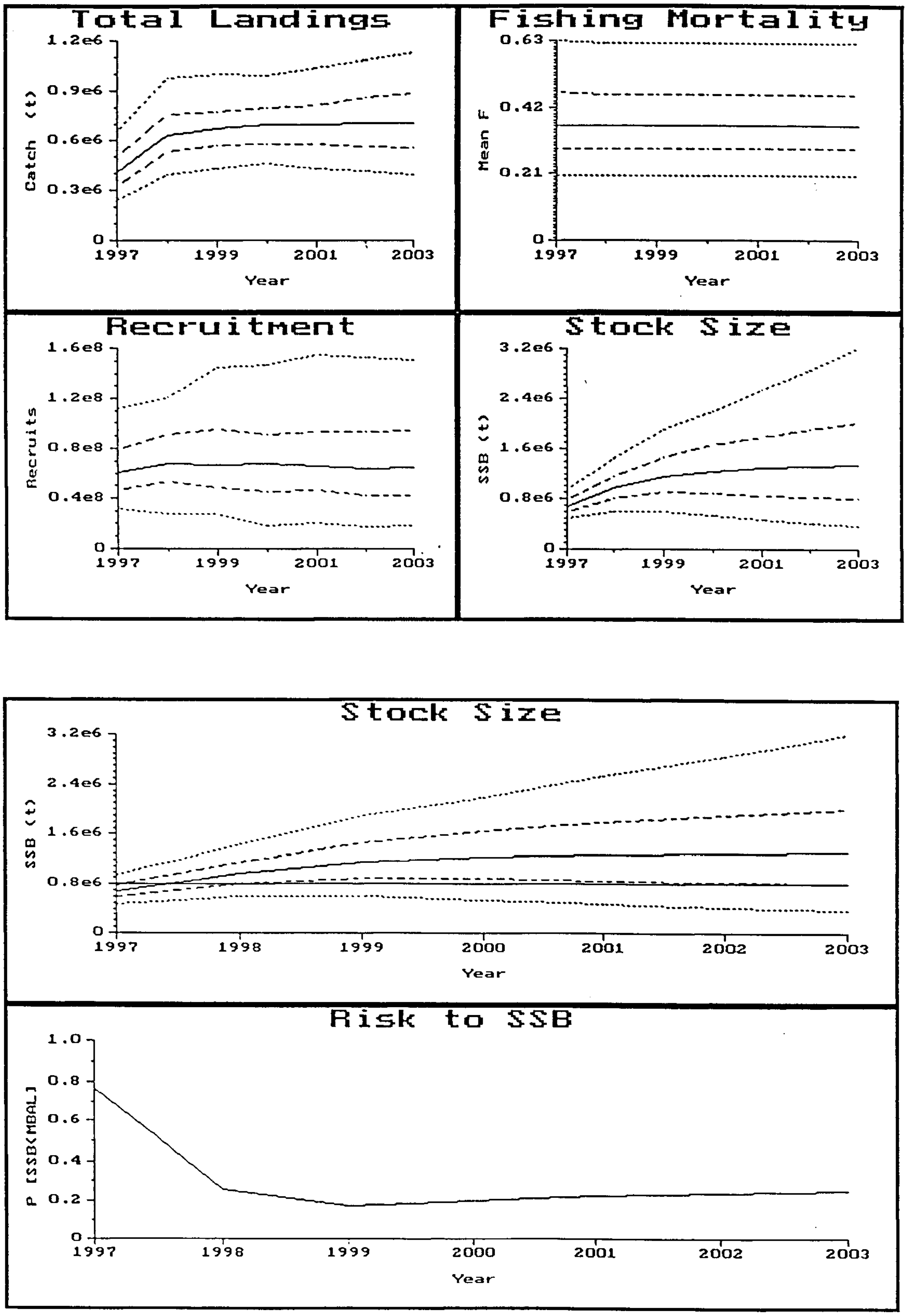


Figure 2.11.10b. North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.3. Separable (1992-1996) selection pattern assumed. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

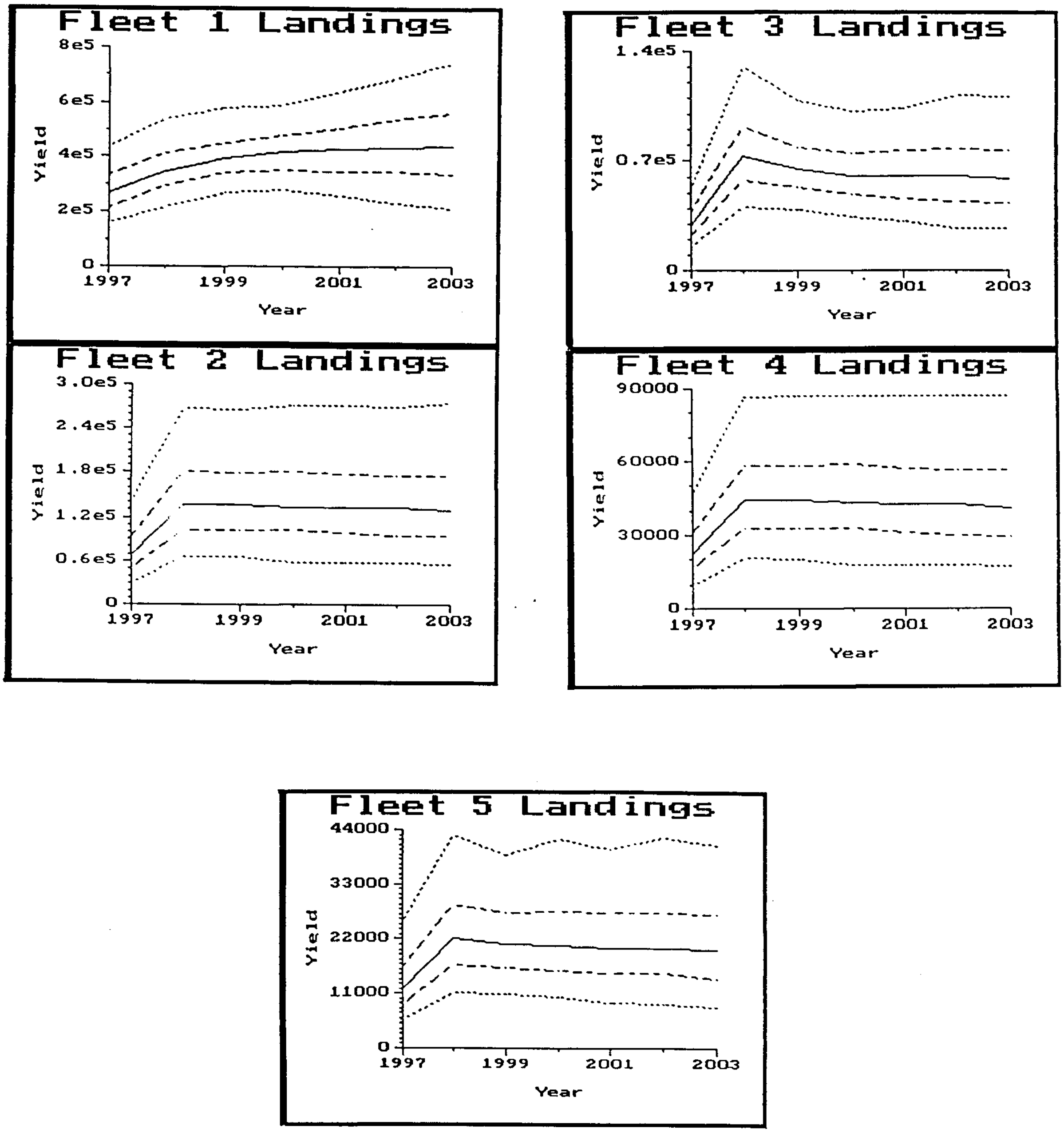
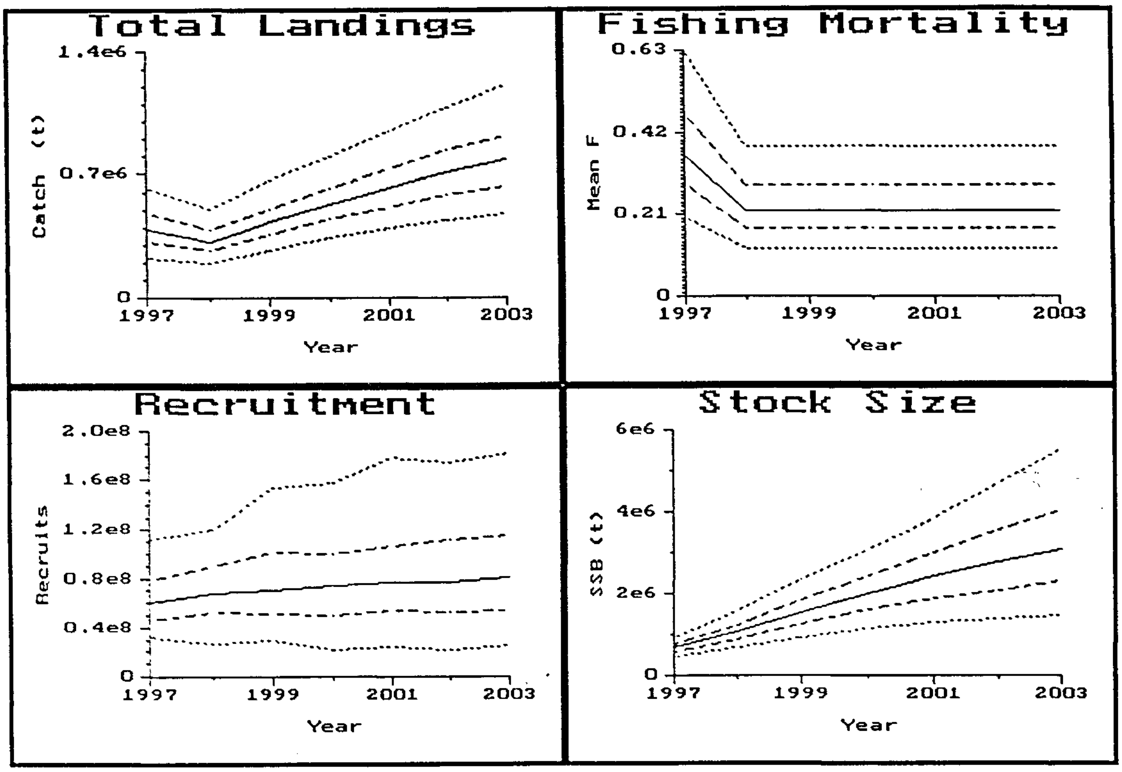


Figure 2.11.11a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E}=0.1. Selection pattern for juveniles calculated according to observed selection in 1996. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.



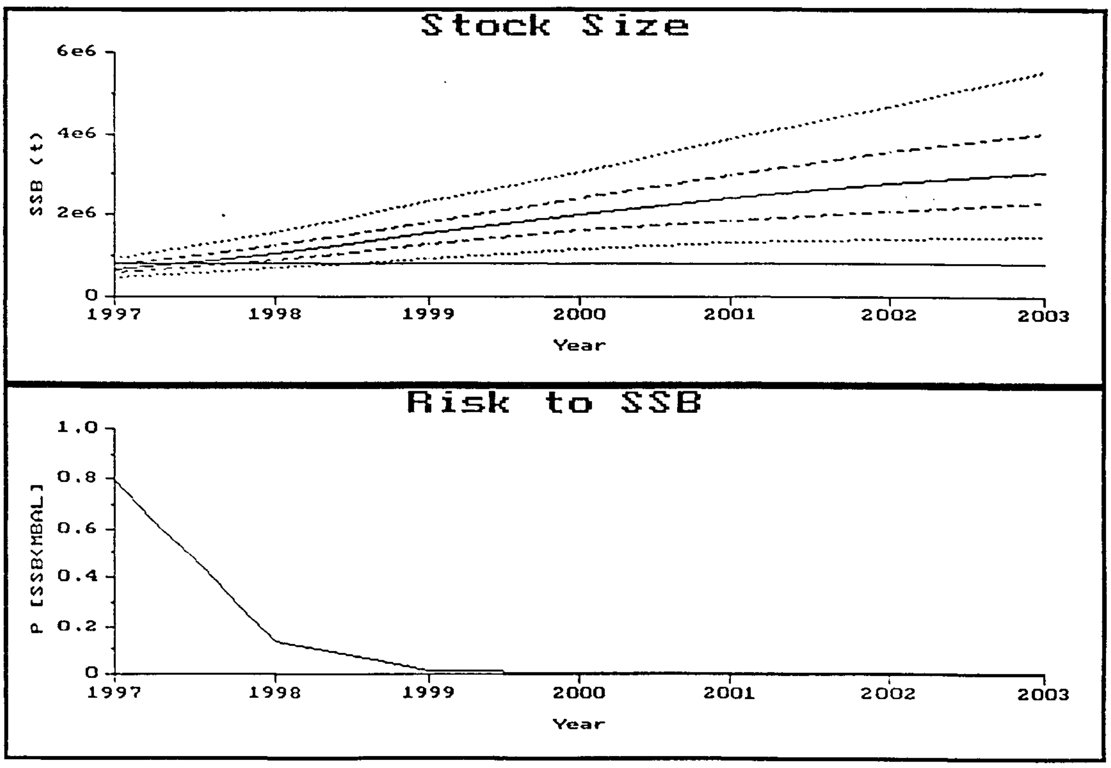


Figure 2.11.11b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.1. Selection pattern for juveniles calculated according to observed selection in 1996. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

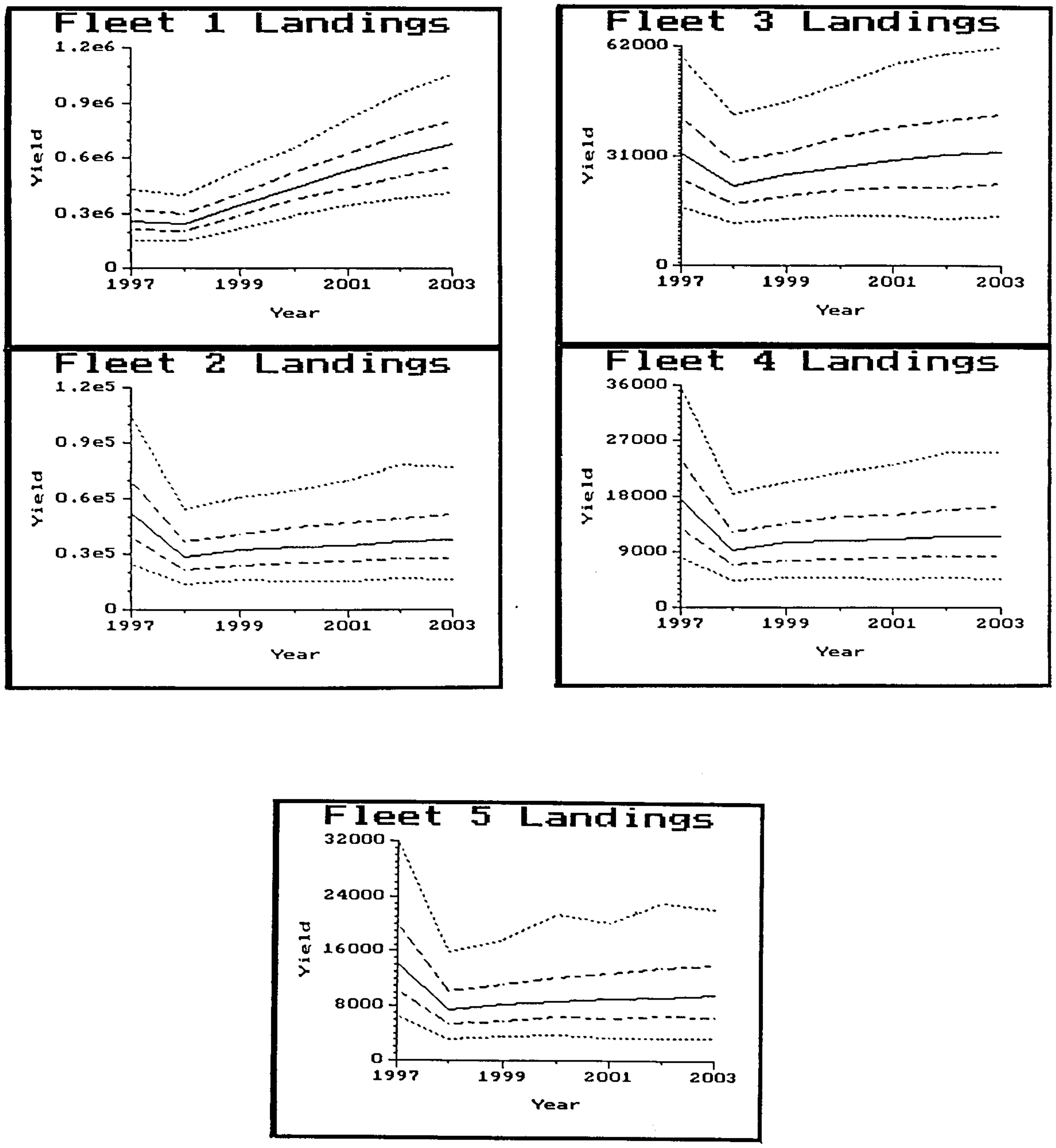
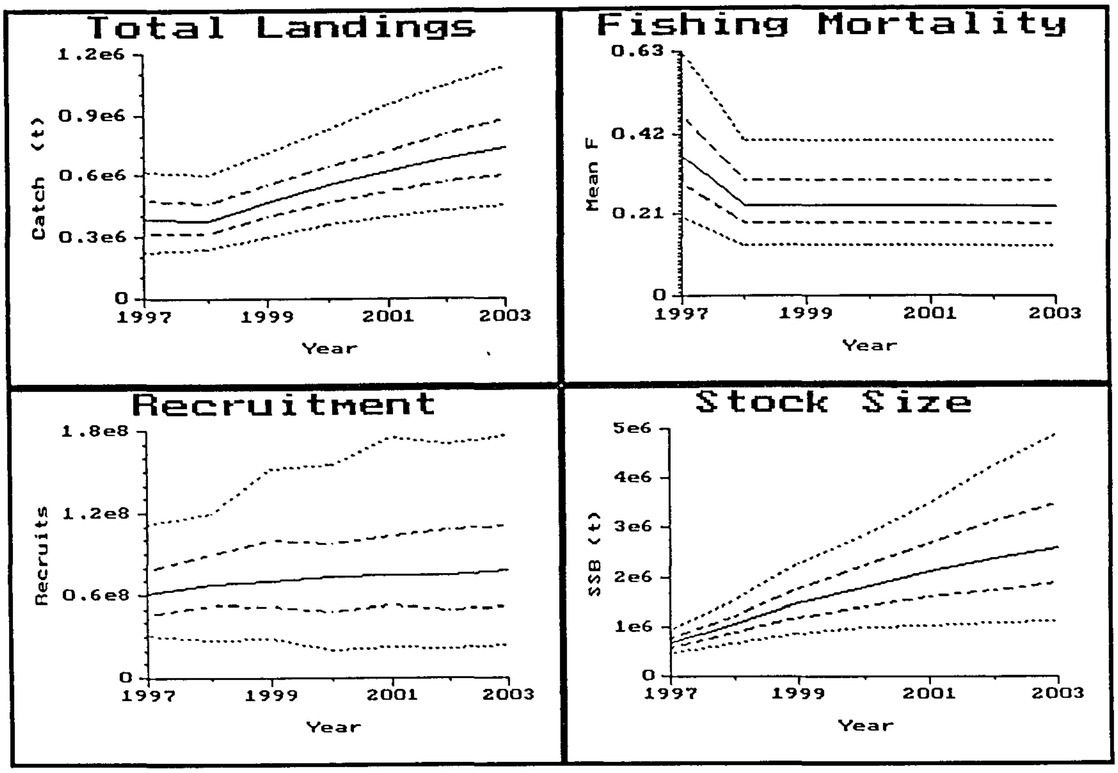


Figure 2.11.12a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E}=0.2. Selection pattern for juveniles calculated according to observed selection in 1996. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.



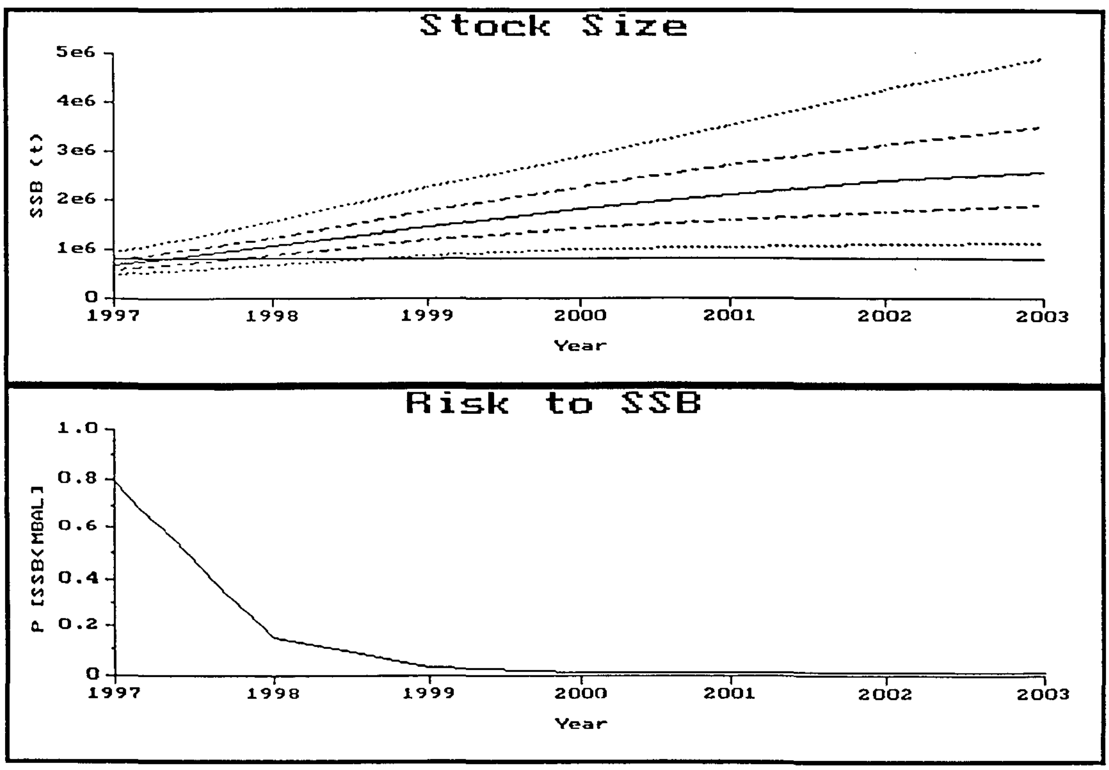


Figure 2.11.12b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.2. Selection pattern for juveniles calculated according to observed selection in 1996. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

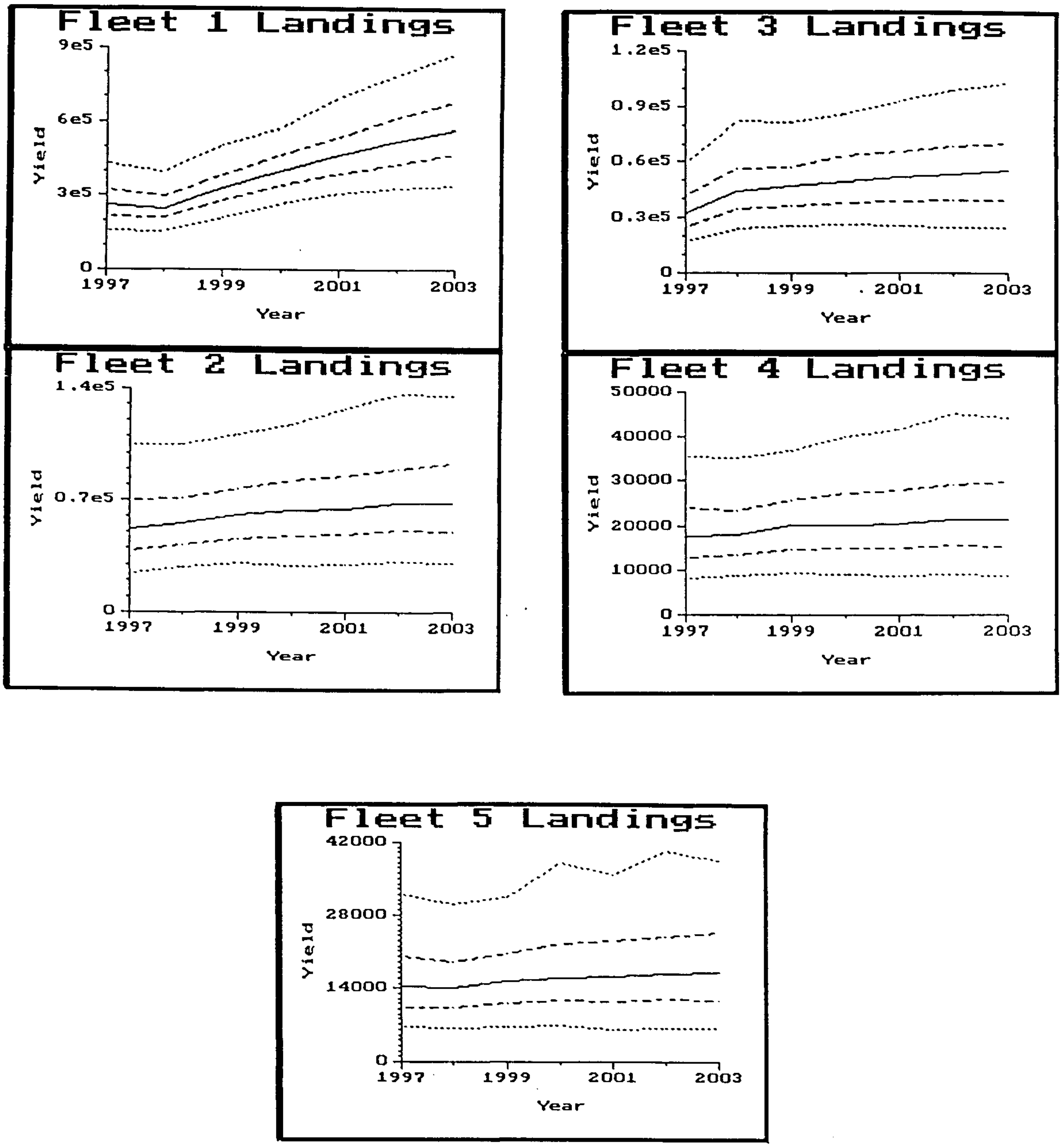
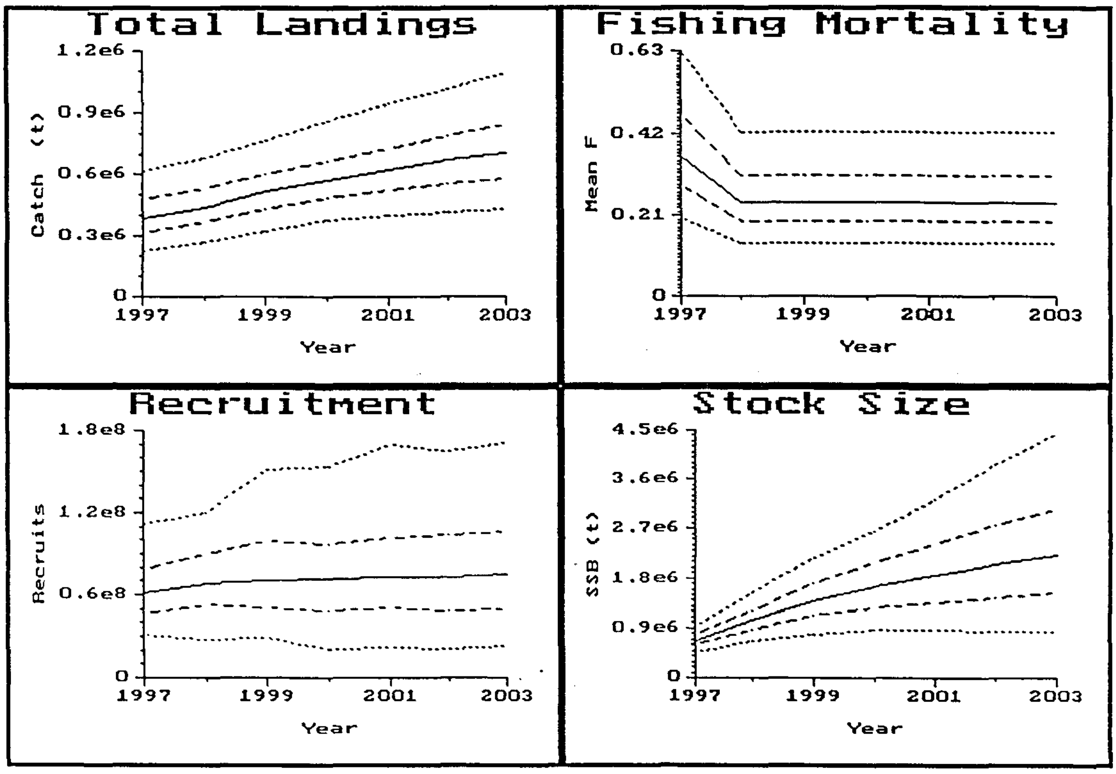


Figure 2.11.13a North Sea Herring.Medium-term projections assuming F_A=0.2 and F_{B-E}=0.3. Selection pattern for juveniles calculated according to observed selection in 1996. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.



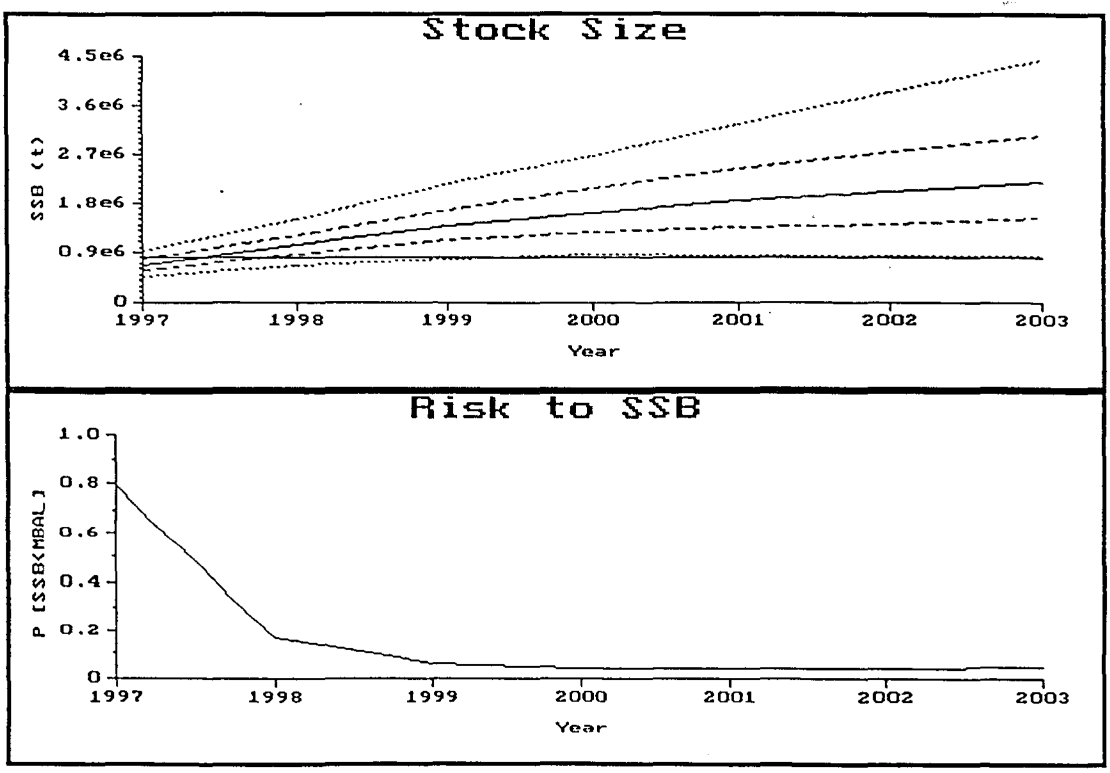


Figure 2.11.13b. North Sea Herring. Medium-term projections assuming F_A=0.2 and F_{B-E}=0.3. Selection pattern for juveniles calculated according to observed selection in 1996. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

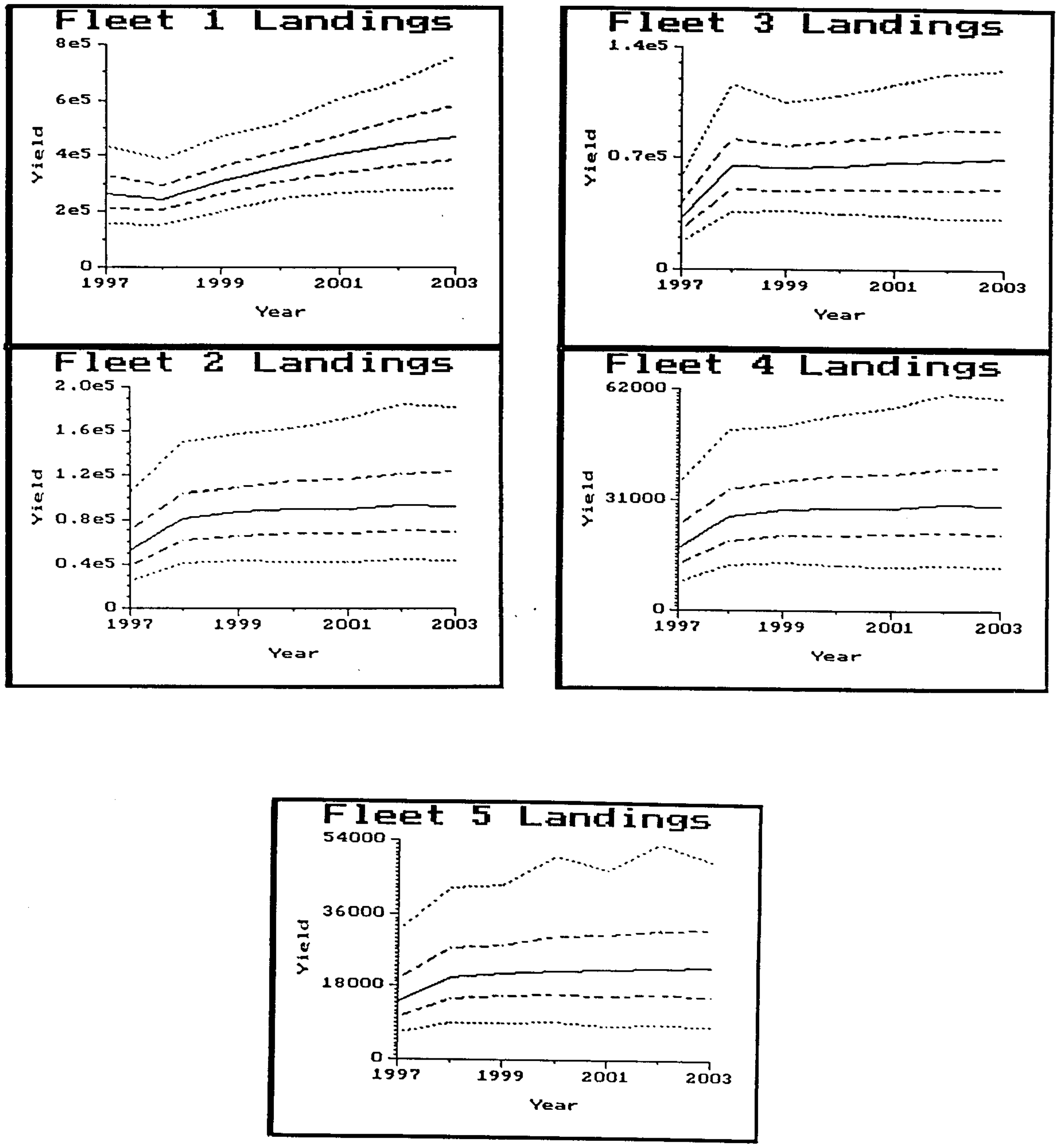


Figure 2.11.14a North Sea Herring.Medium-term projections assuming F_A=0.3 and F_{B-E}=0.1. Selection pattern for juveniles calculated according to observed selection in 1996. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

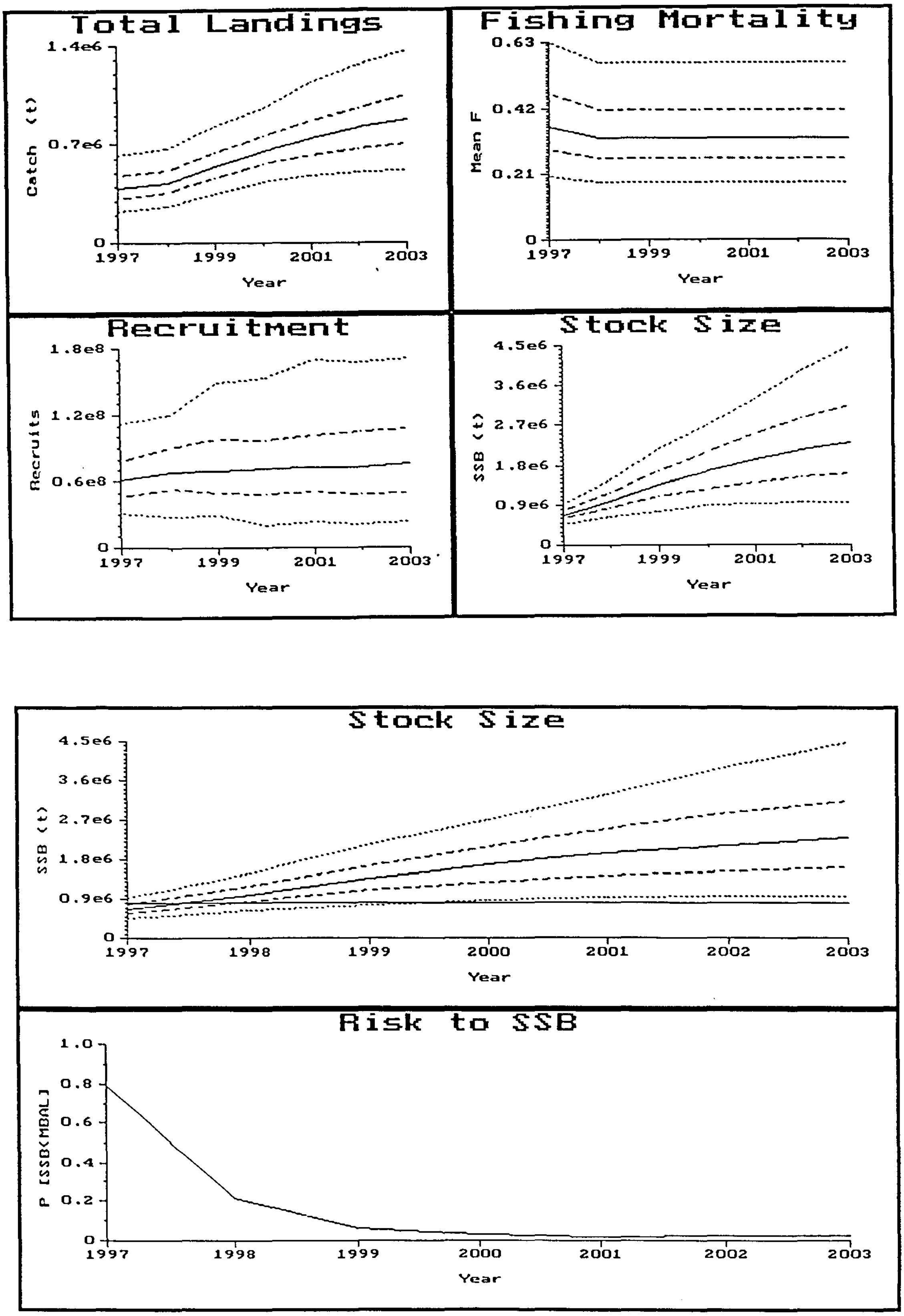


Figure 2.11.14b. North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.1. Selection pattern for juveniles calculated according to observed selection in 1996. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

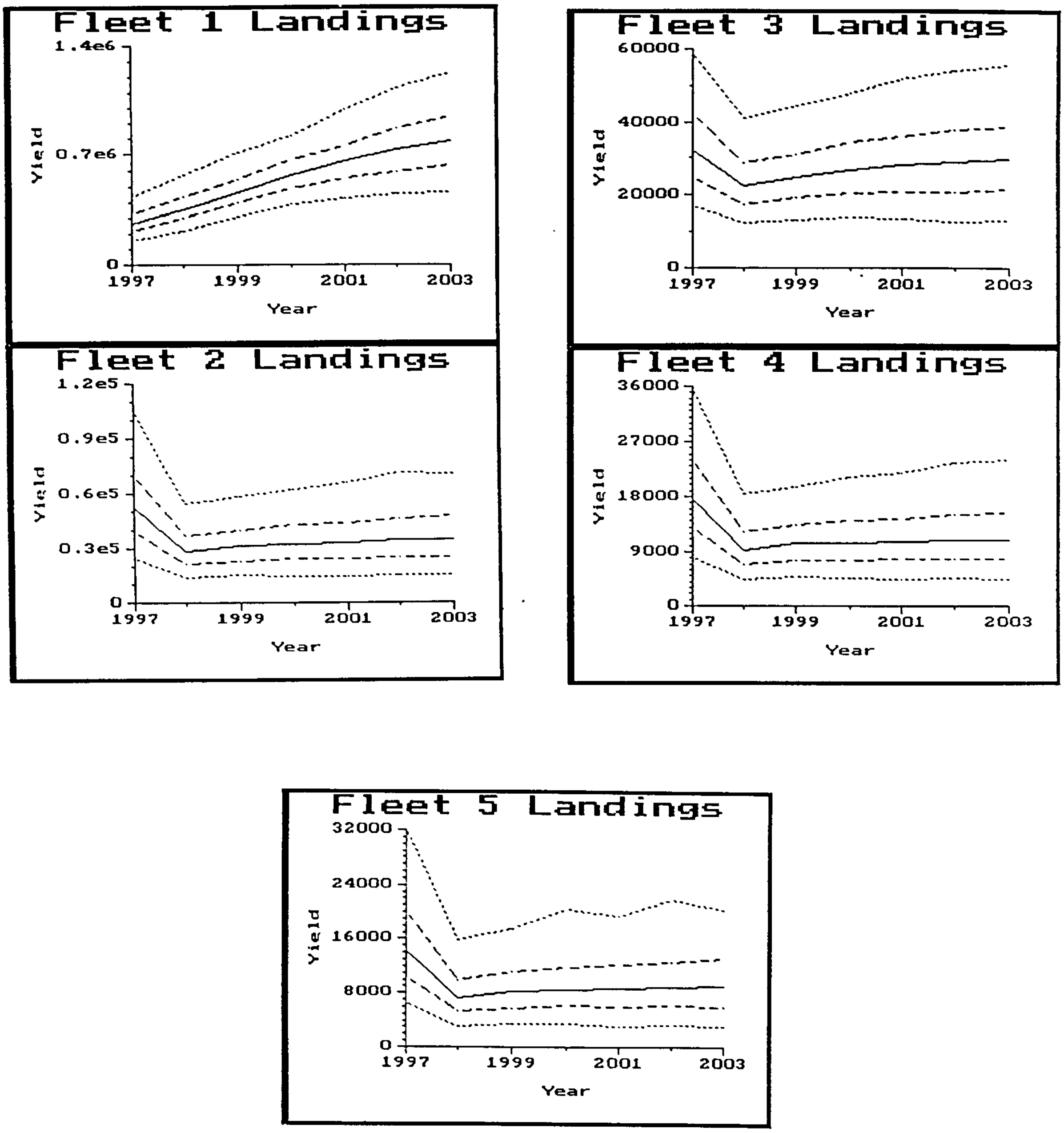


Figure 2.11.15a North Sea Herring.Medium-term projections assuming F_A=0.3 and F_{B-E}=0.2. Selection pattern for juveniles calculated according to observed selection in 1996. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

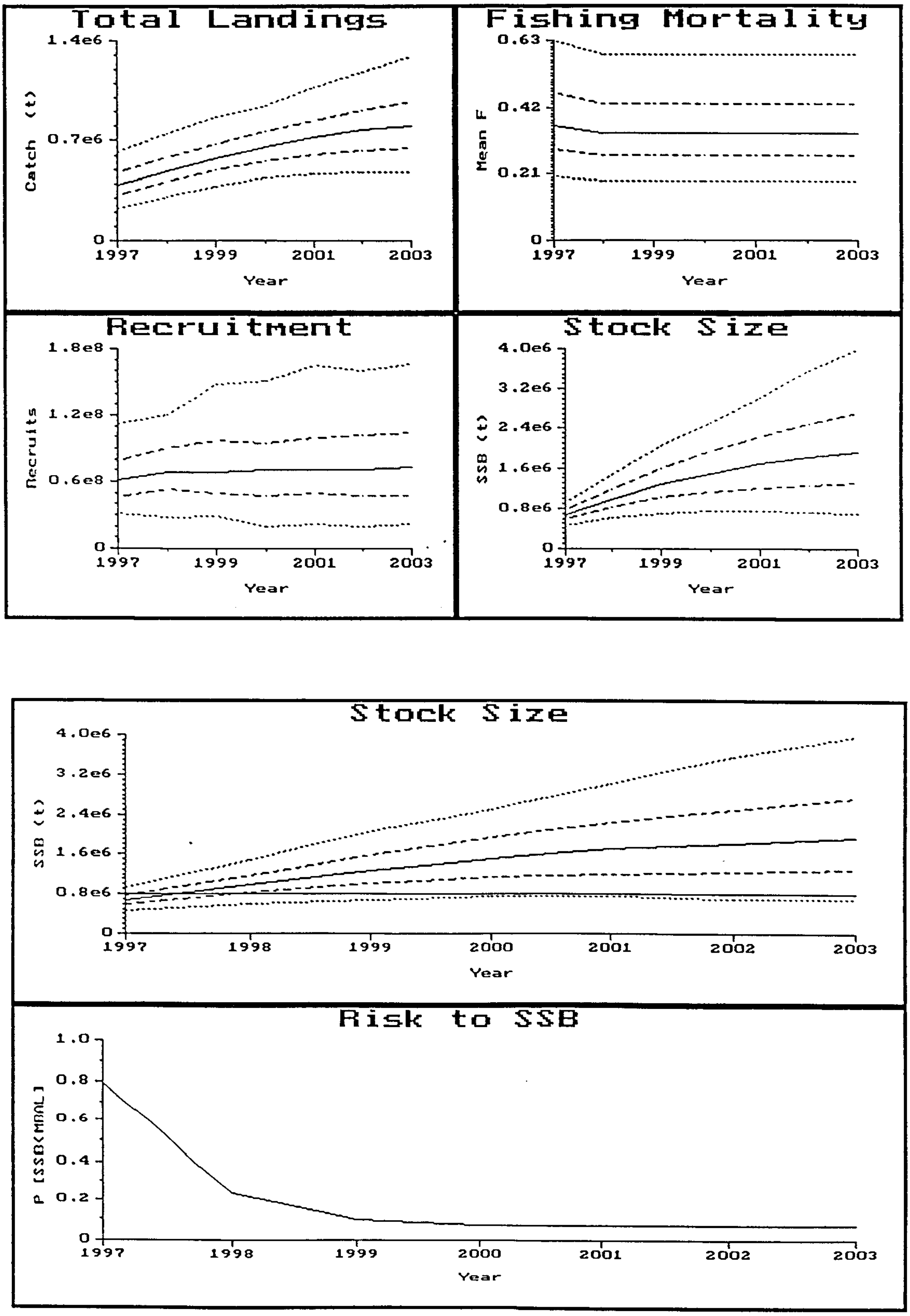


Figure 2.11.15b. North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.2. Selection pattern for juveniles calculated according to observed selection in 1996. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)

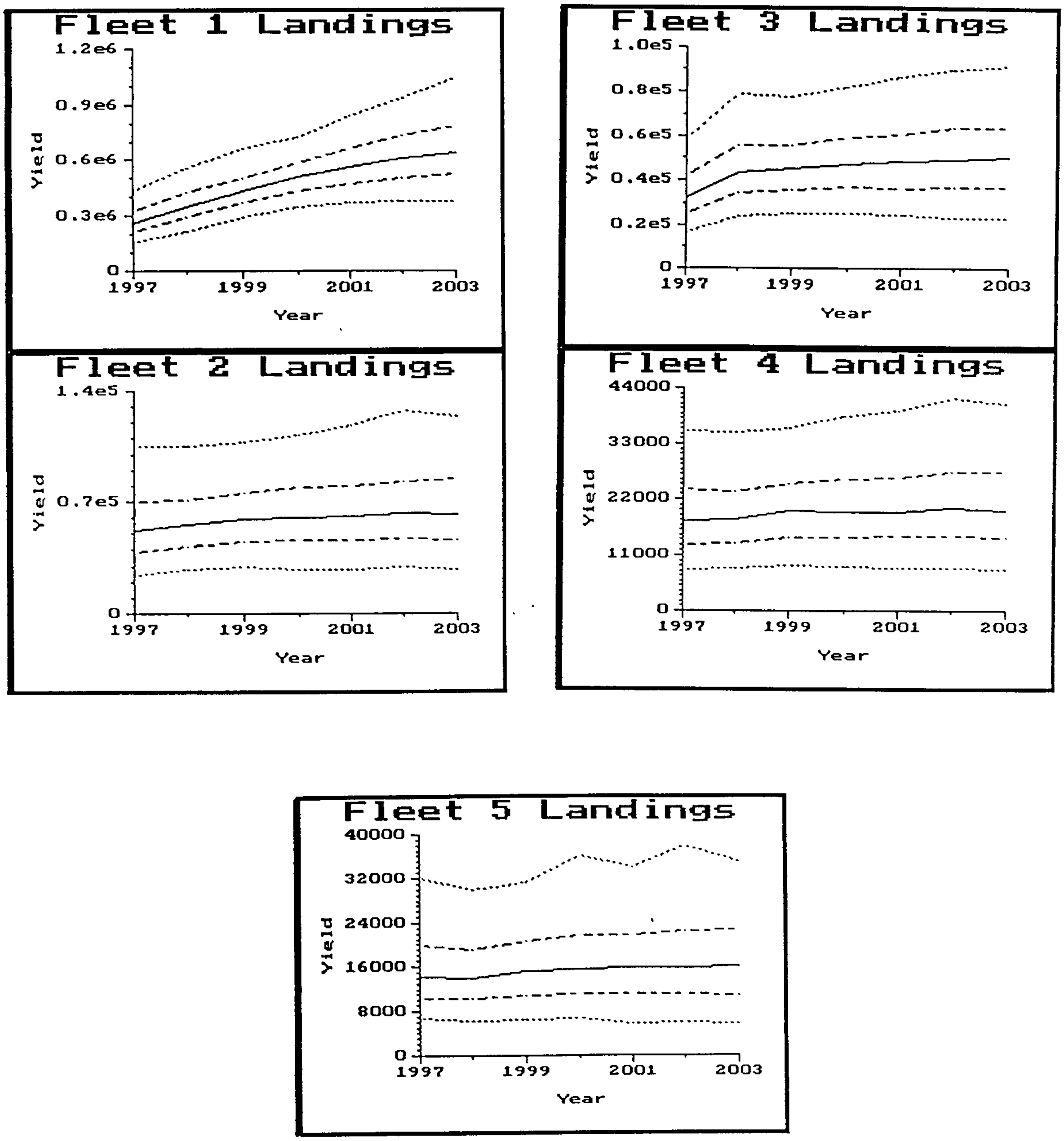


Figure 2.11.16a North Sea Herring. Medium-term projections assuming F_A=0.3 and F_{B-E}=0.3. Selection pattern for juveniles calculated according to observed selection in 1996. Dotted lines indicate 5th and 95th percentiles, dashed lines indicate 25th and 75th percentiles, unbroken line indicates median. **Upper panel**: Top left, landing by all fleets. Top right, fishing mortality (Mean from ages 2 to 6 by all fleets). Bottom left, recruitment at age 0. Bottom right: spawning stock biomass at spawning time. **Lower Panel**: Top, trajectory of spawning stock size. Bottom, estimates of risk that the spawning stock should fall below 800 000t.

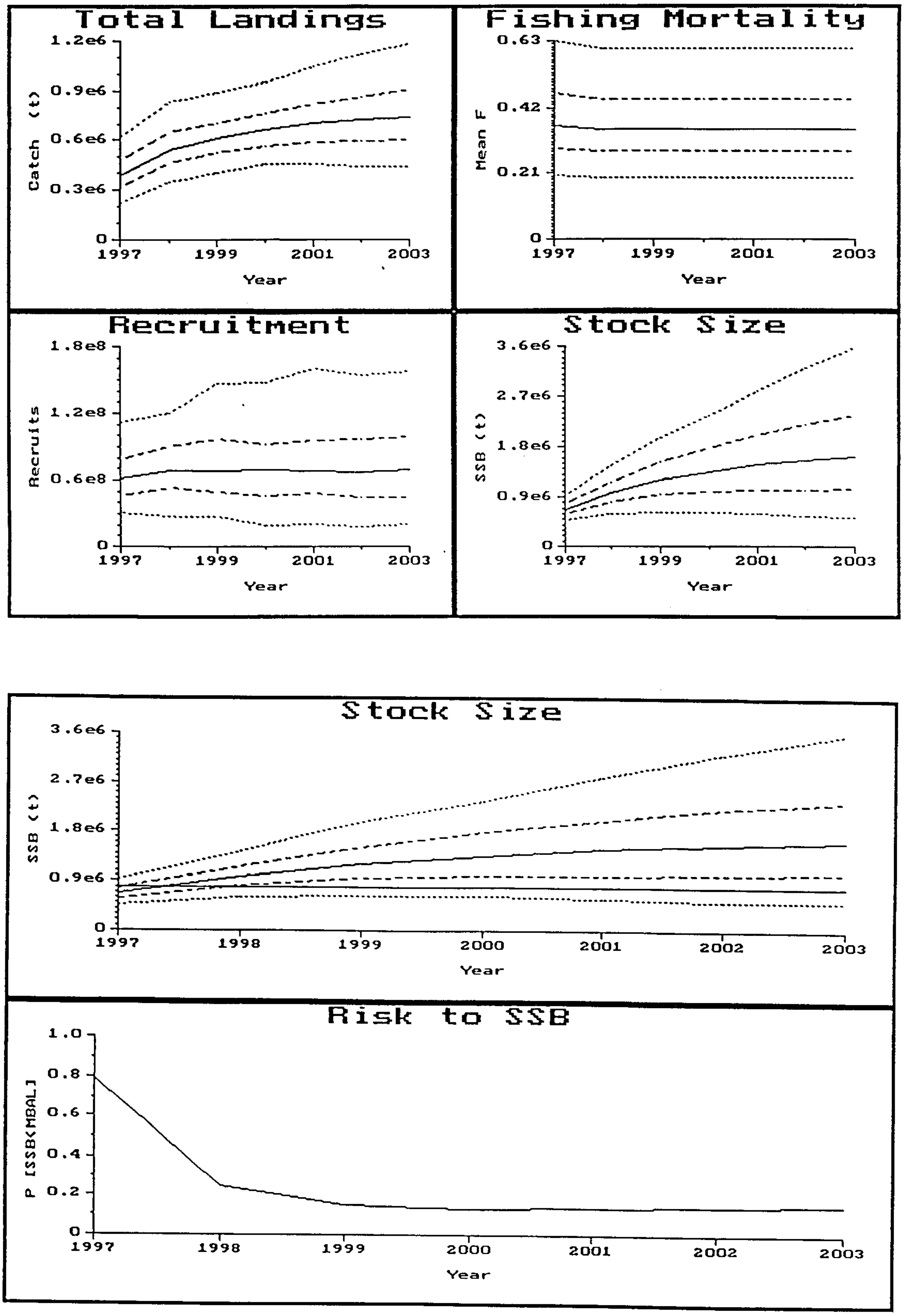
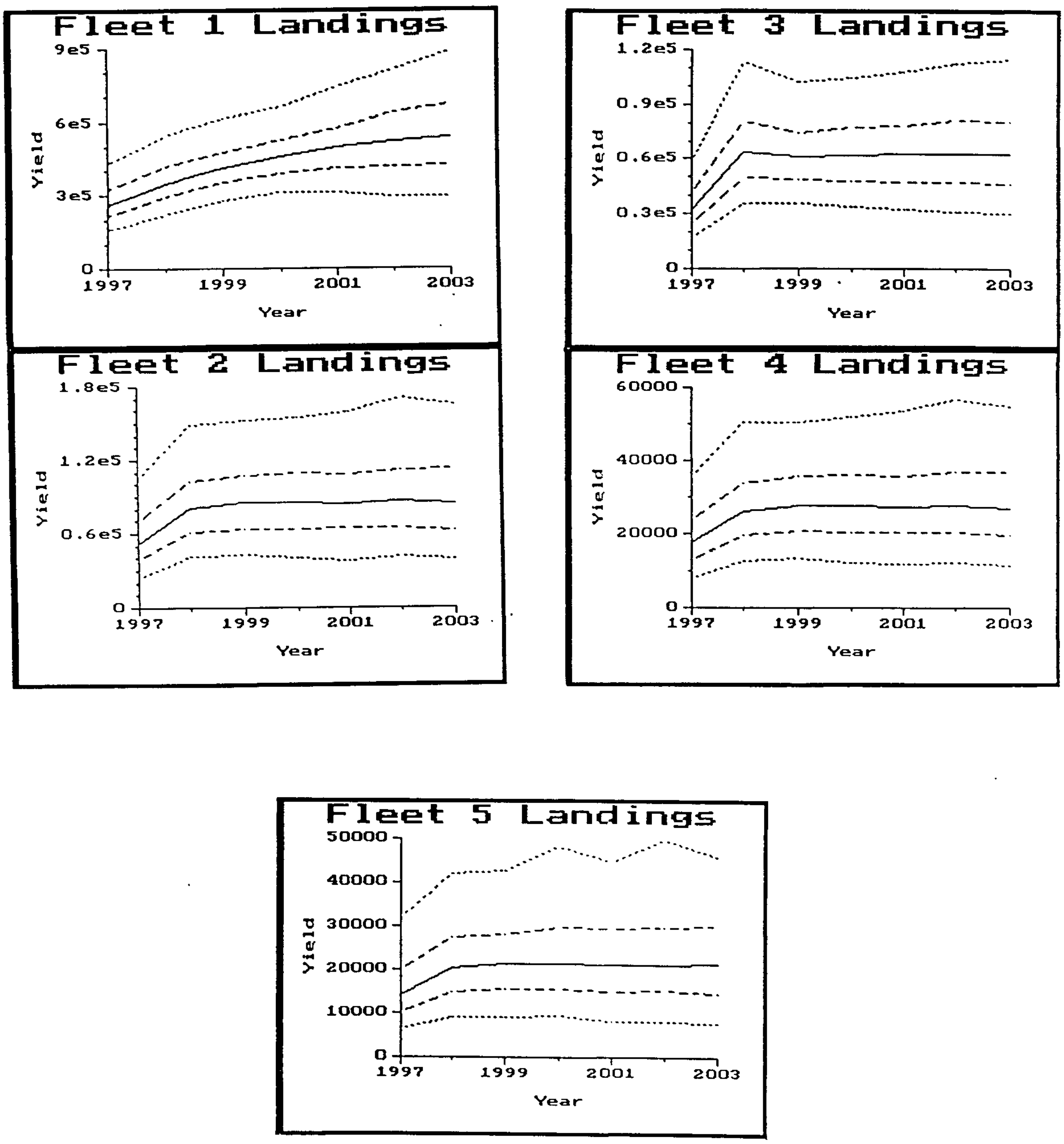


Figure 2.11.16b. North Sea Herring. Medium-term projections assuming F_A=0.3 and $F_{B\text{-}E}$=0.3. Selection pattern for juveniles calculated according to observed selection in 1996. Projected landings by fleets A to E (labelled as fleets 1 to 5 respectively)



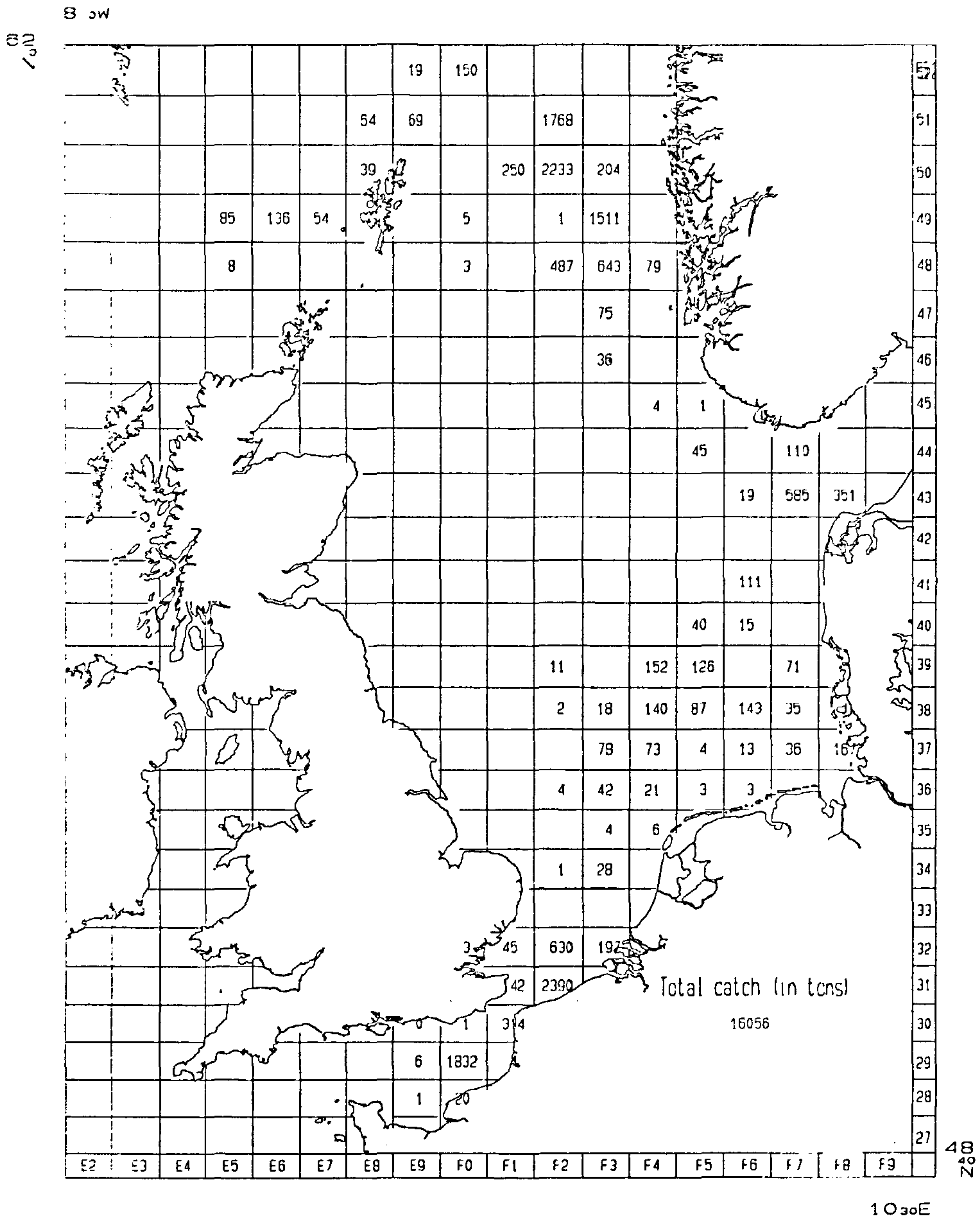


Figure 2.13.1 Herring North Sea catches. January 1996.

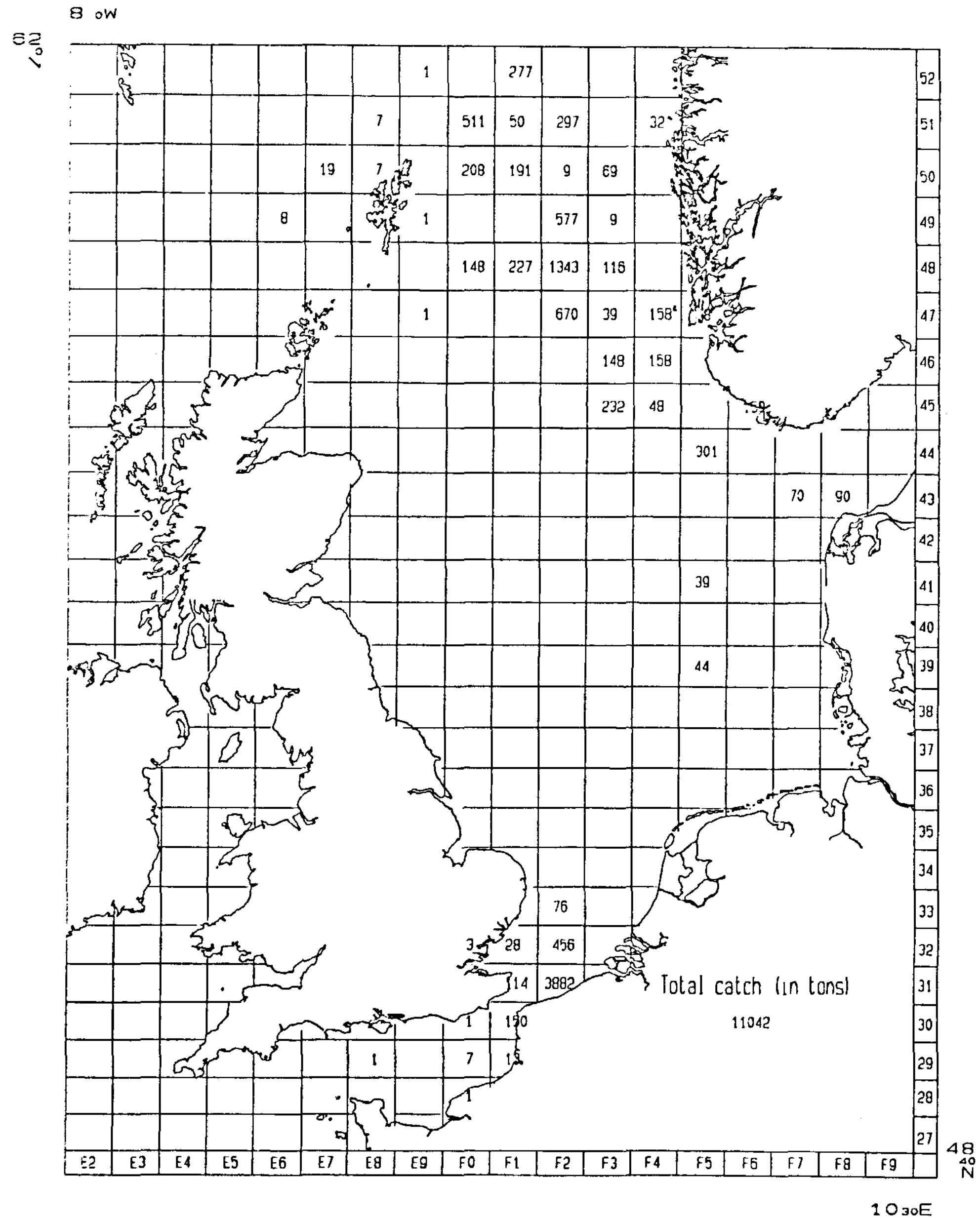


Figure 2.13.2 Herring North Sea catches . February 1996.

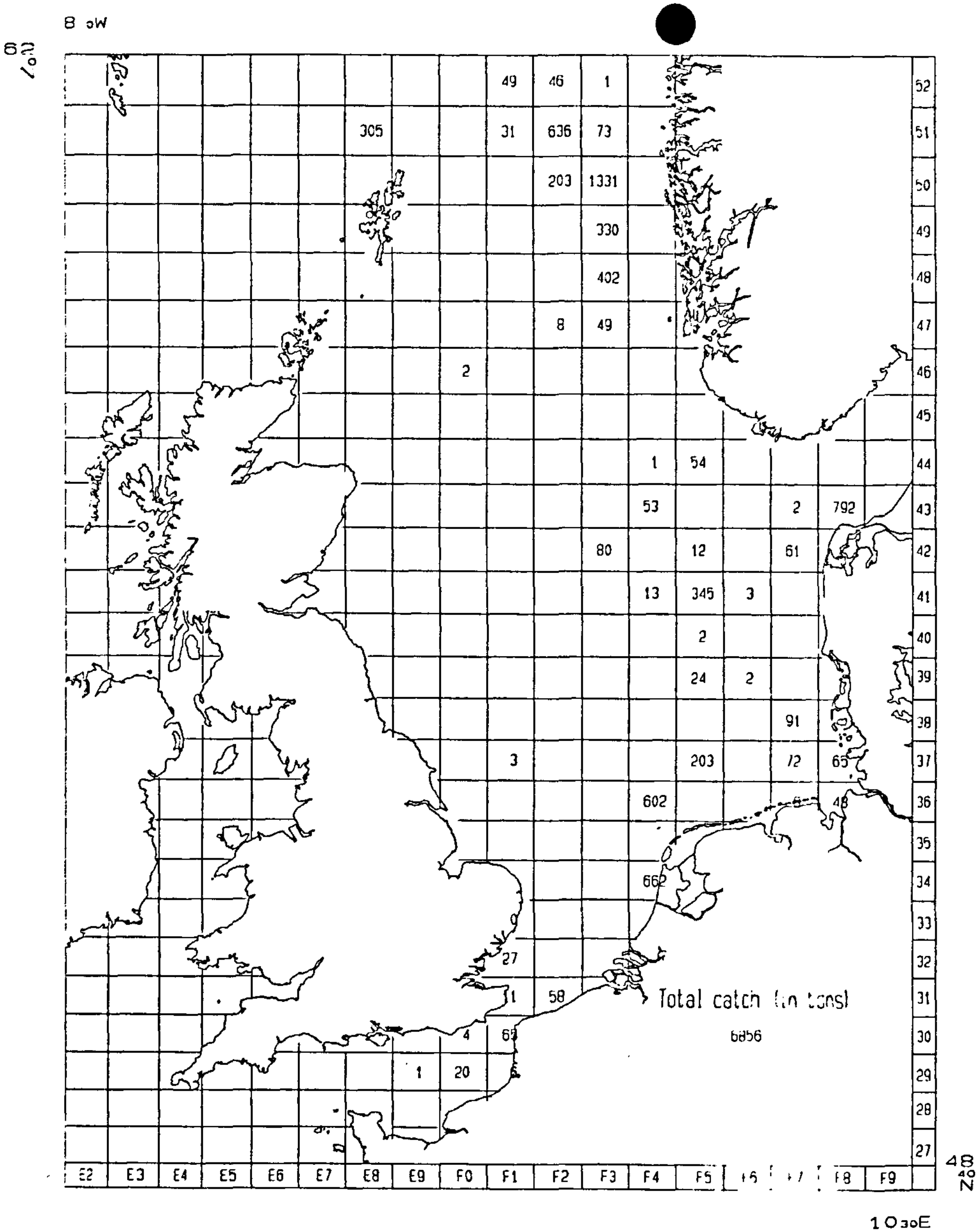


Figure 2.13.3 Herring North Sea catches . March 1996.

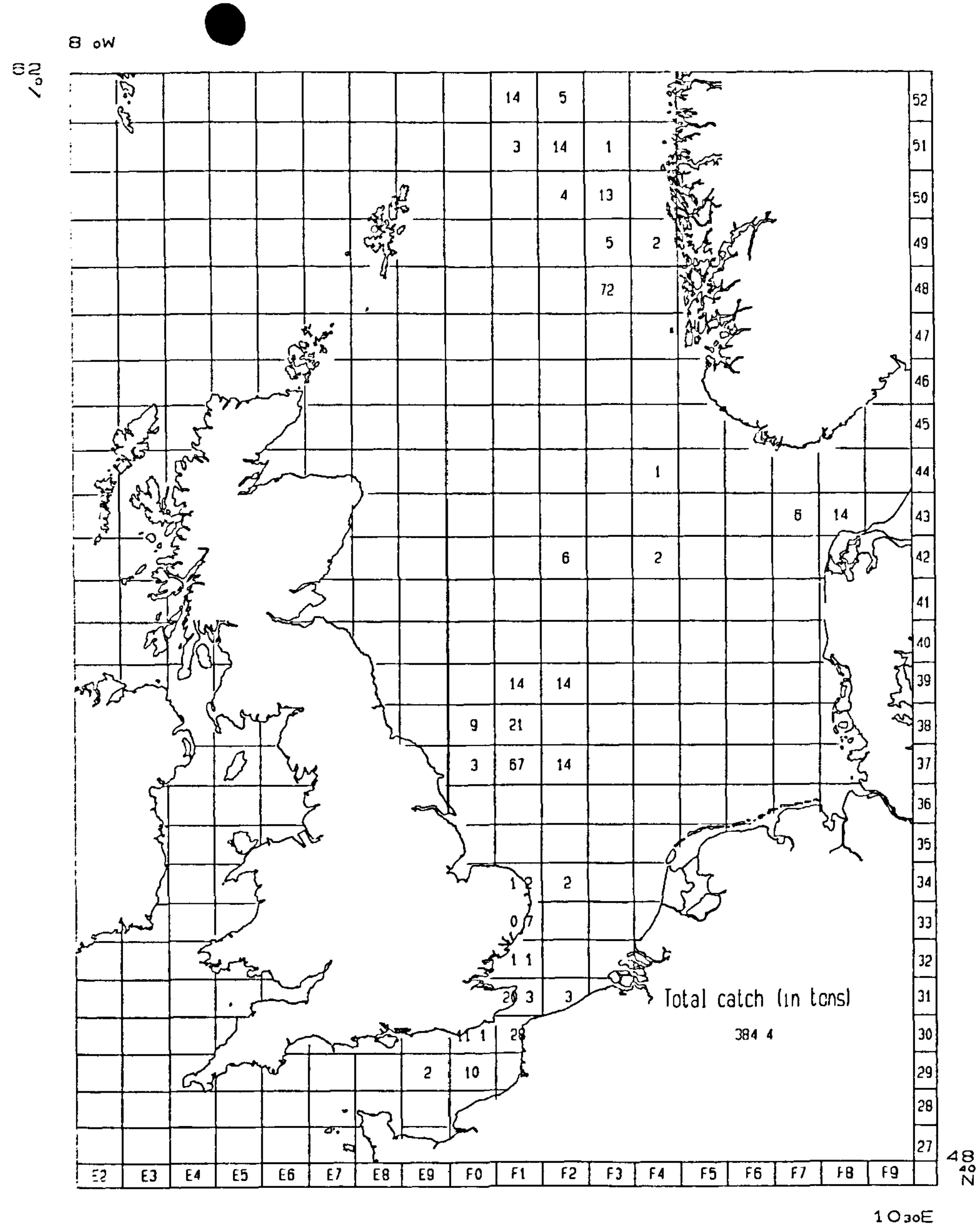


Figure 2.13.4 Herring North Sea catches. April 1996.

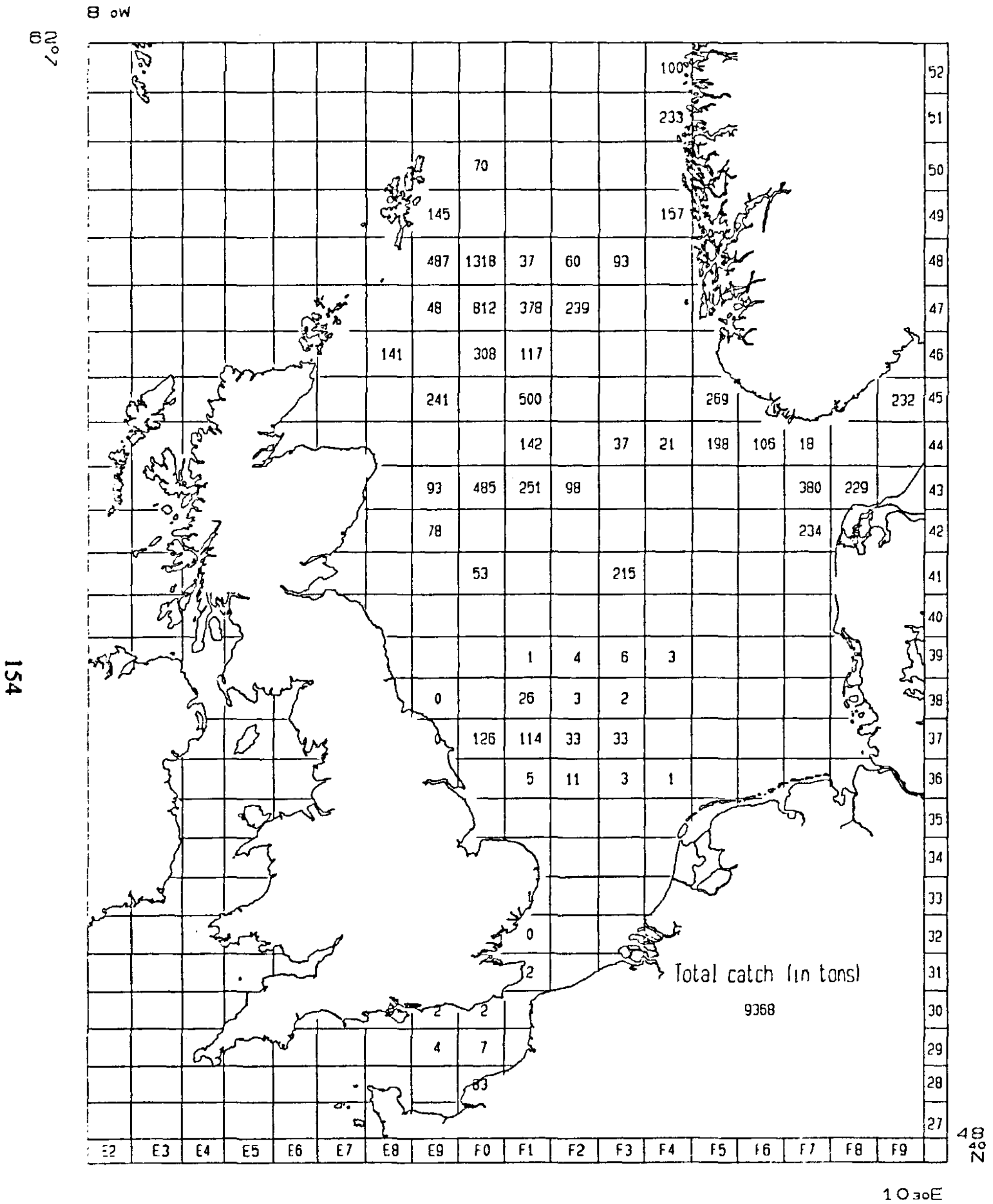


Figure 2.13.5 Herring North Sea catches. May 1996.

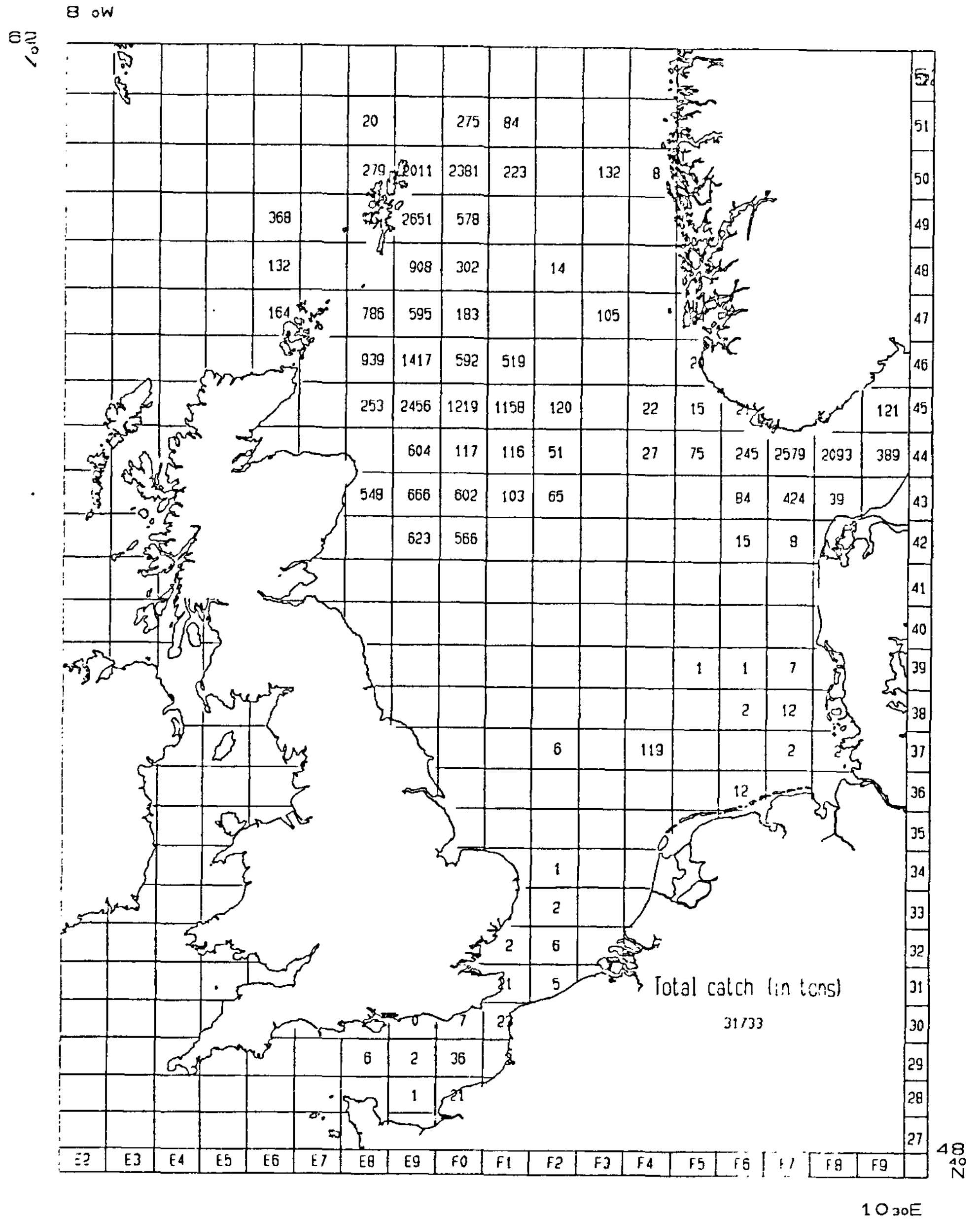


Figure 2.13.6 : Herring North Sea catches. June 1996

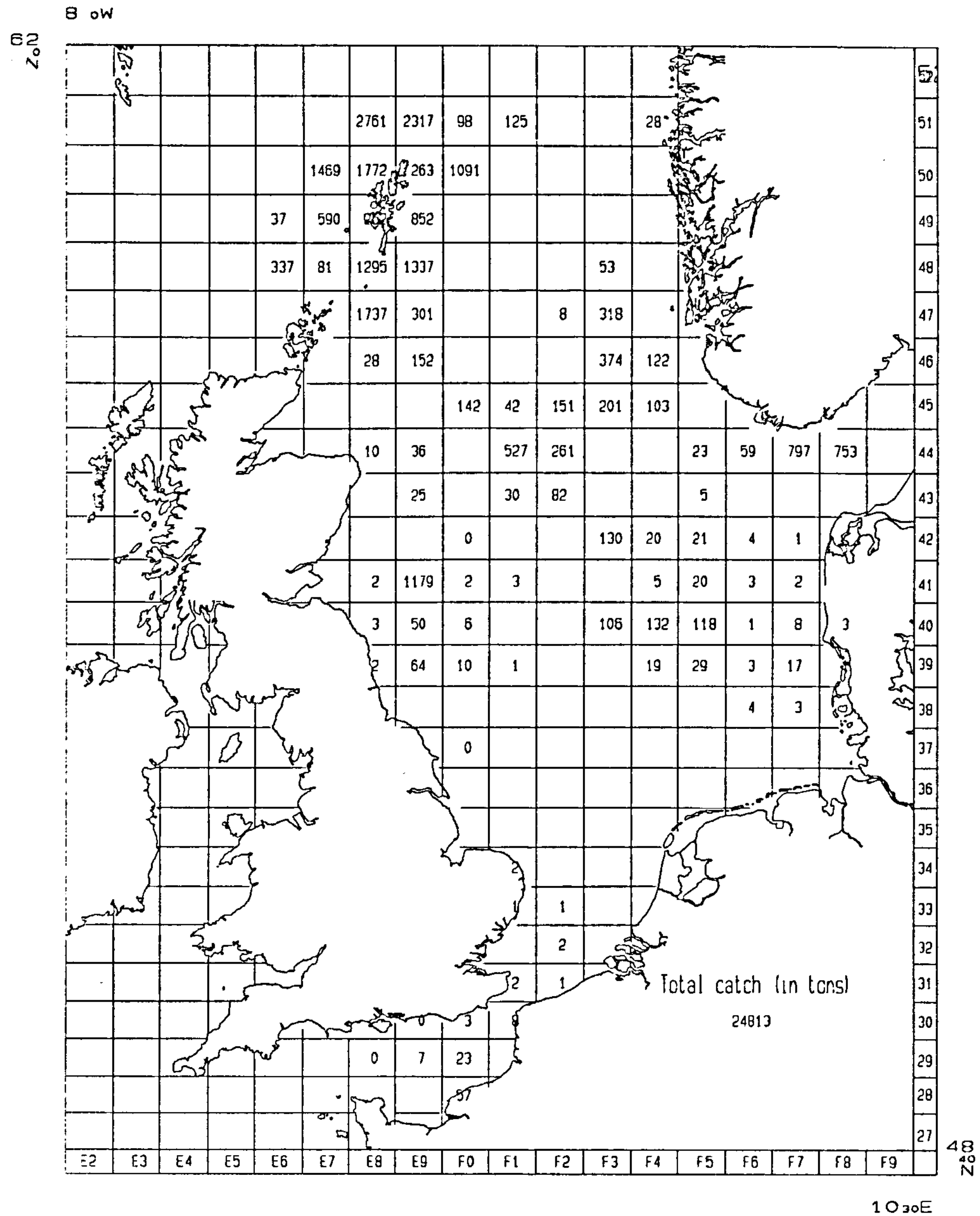


Figure 2.13.7 Herring North Sea catches. July 1996

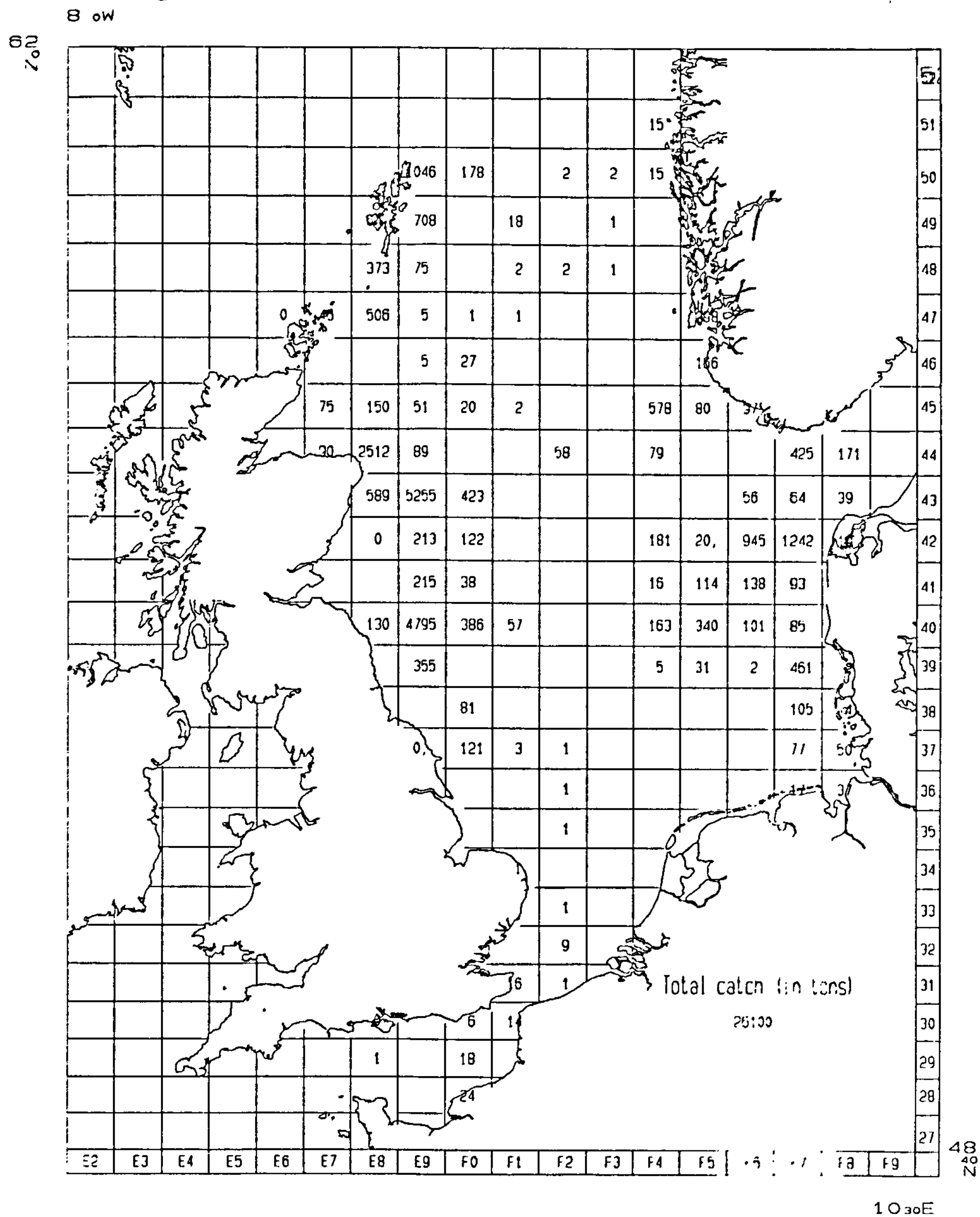


Figure 2.13.8 Herring North Sea catches. August 1996.

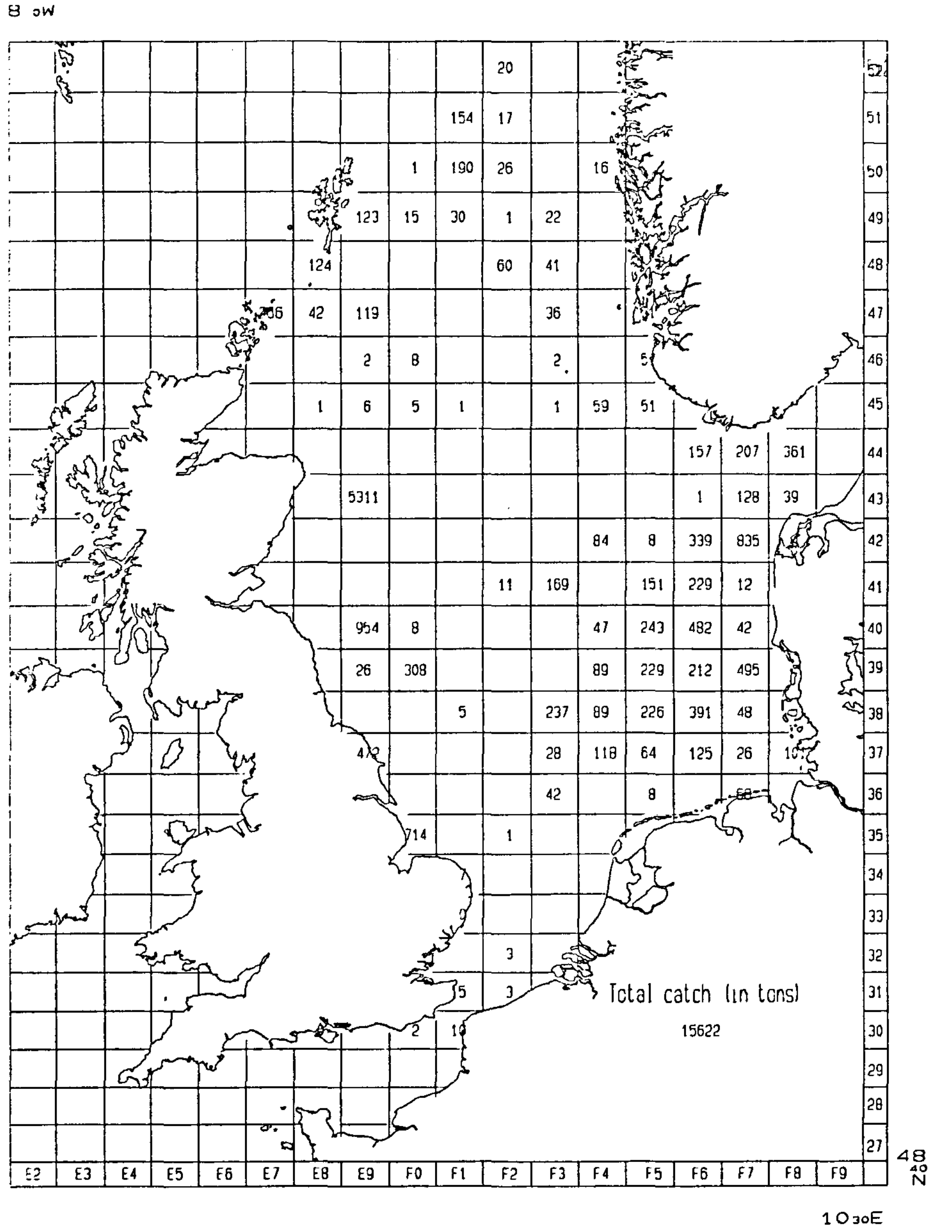


Figure 2.13.9 Herring North Sea catches. September 1996.

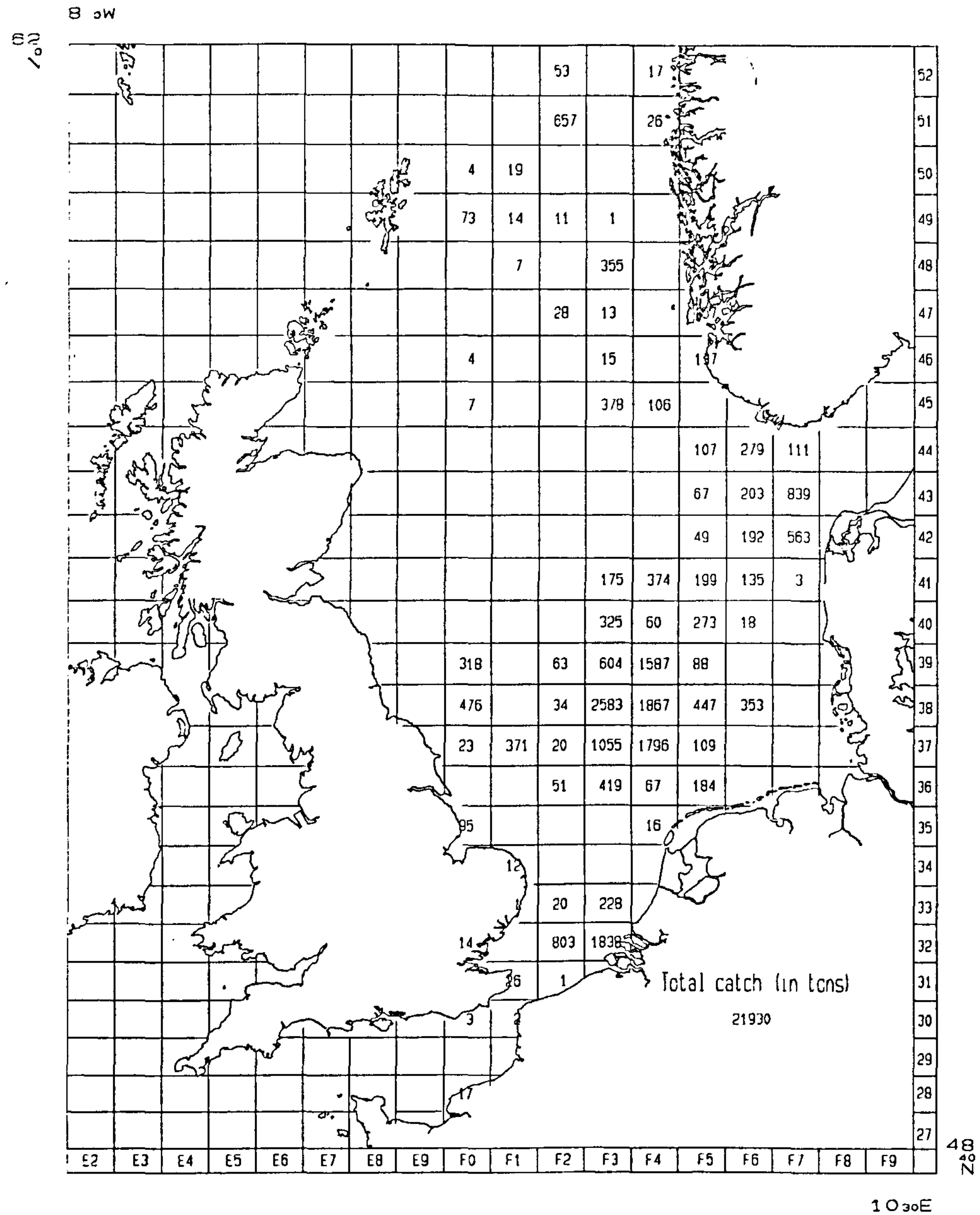


Figure 2.13.10 Herring North Sea catches. October 1996.

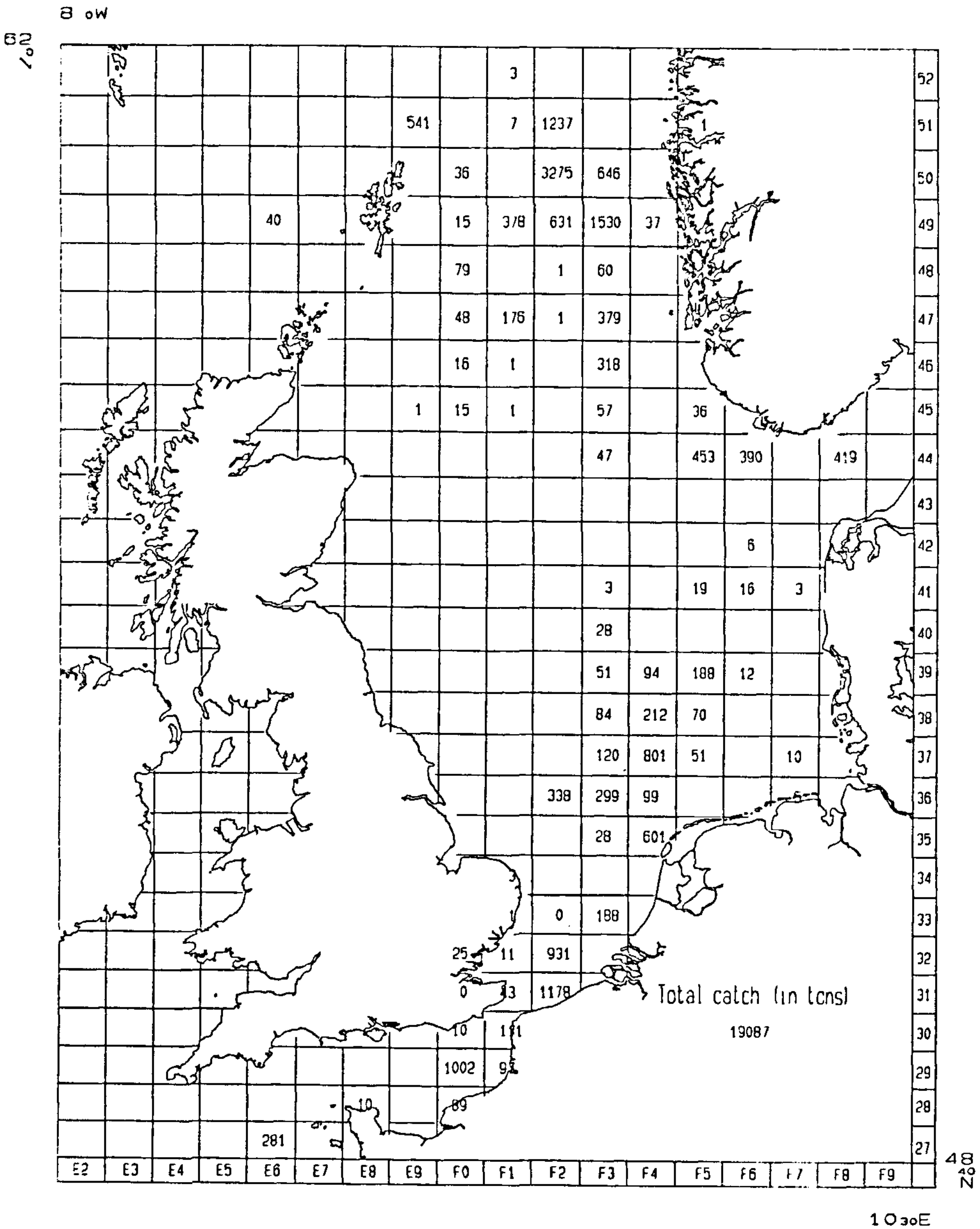


Figure 2.13.11 Herring North Sea catches. November 1996.

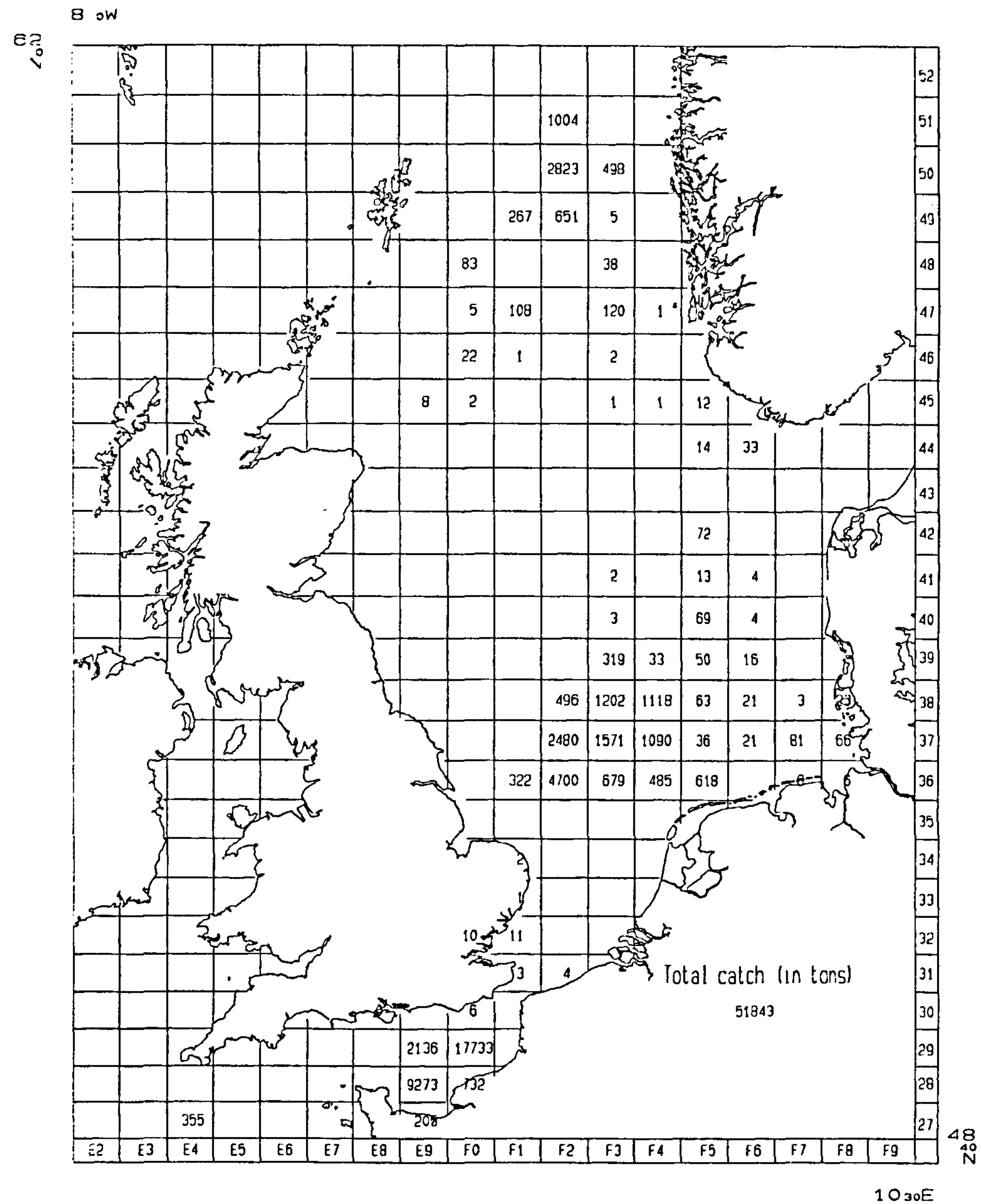


Figure 2.13.12 Herring North Sea catches. December 1996.

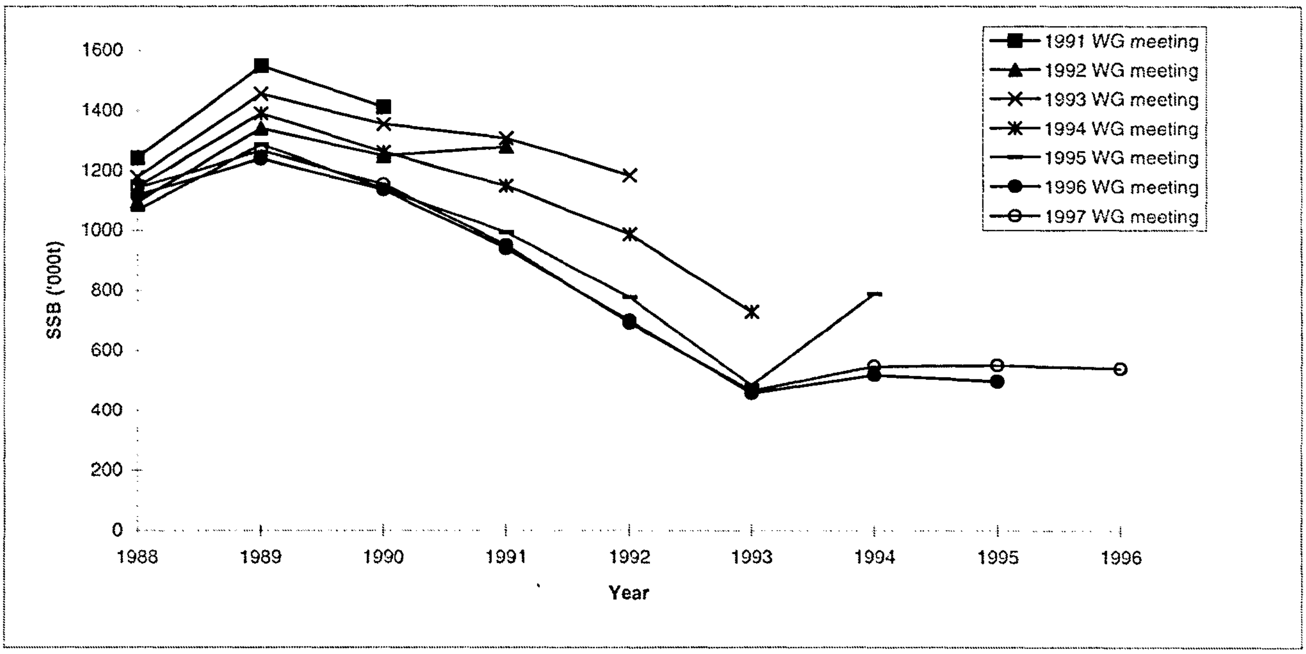


Figure 2.14.1 Spawning stock biomass estimated at the Herring Assessment Working Group meetings from 1991 - 1997. The assessments carried out at Working Group meetings in 1991-1995 show a systematic overestimate of the spawning stock biomass.

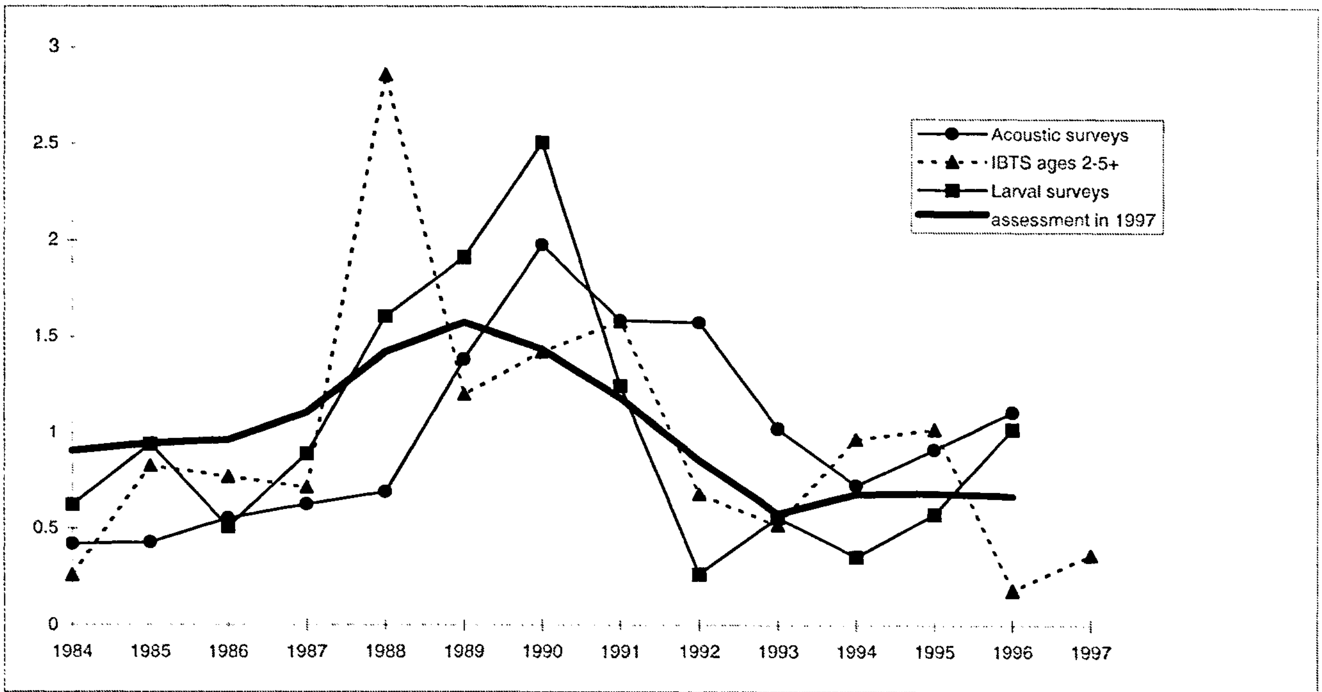


Figure 2.14.2 Biomass normalised to 1 over the period 1984-1996 from the 3 indices that provide information on adult fish compared to the spawning stock biomass of this years assessment.

E:\acfm\hawg97\F-2141.XLS

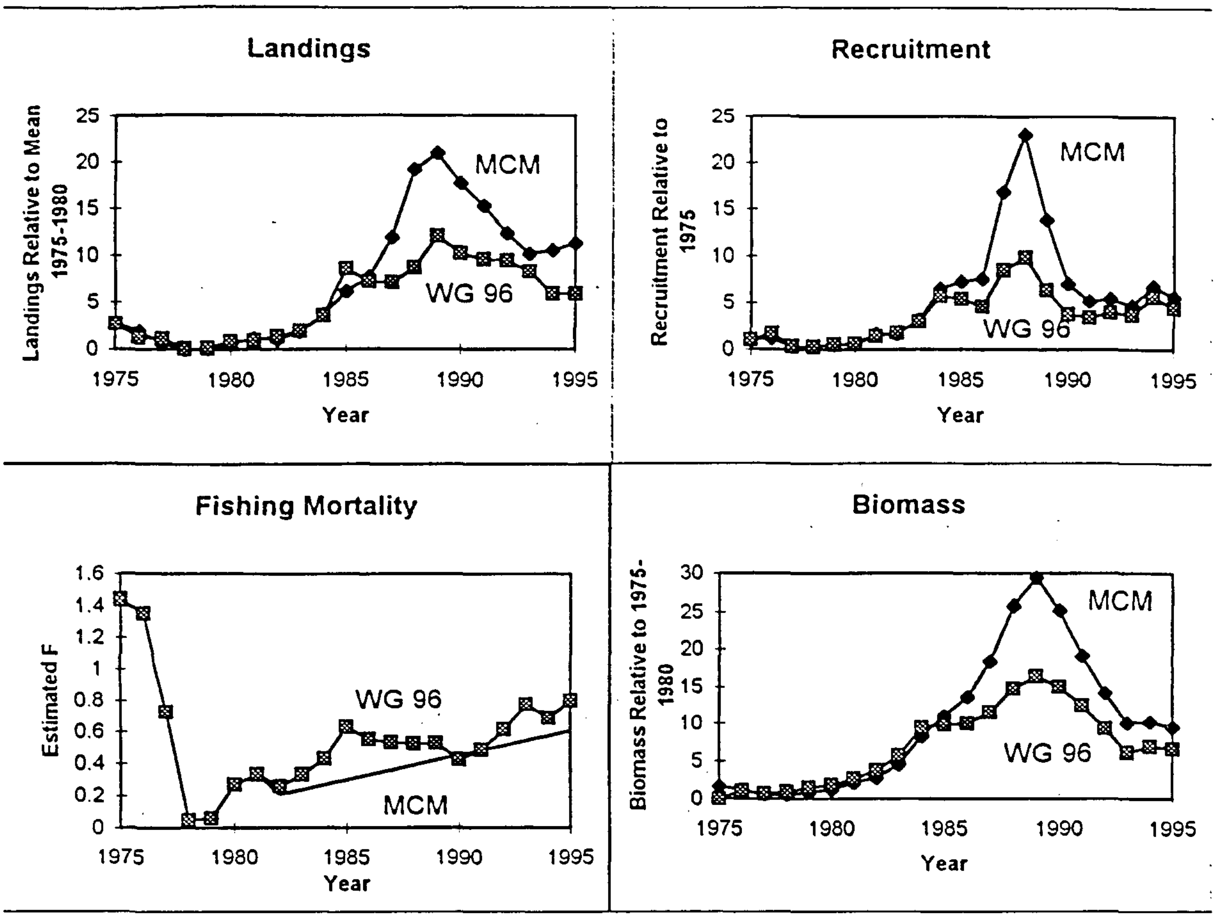


Figure 2.14.3 Summary of missing catch model fit compared with the assessment model fit given in Anon. (1996).

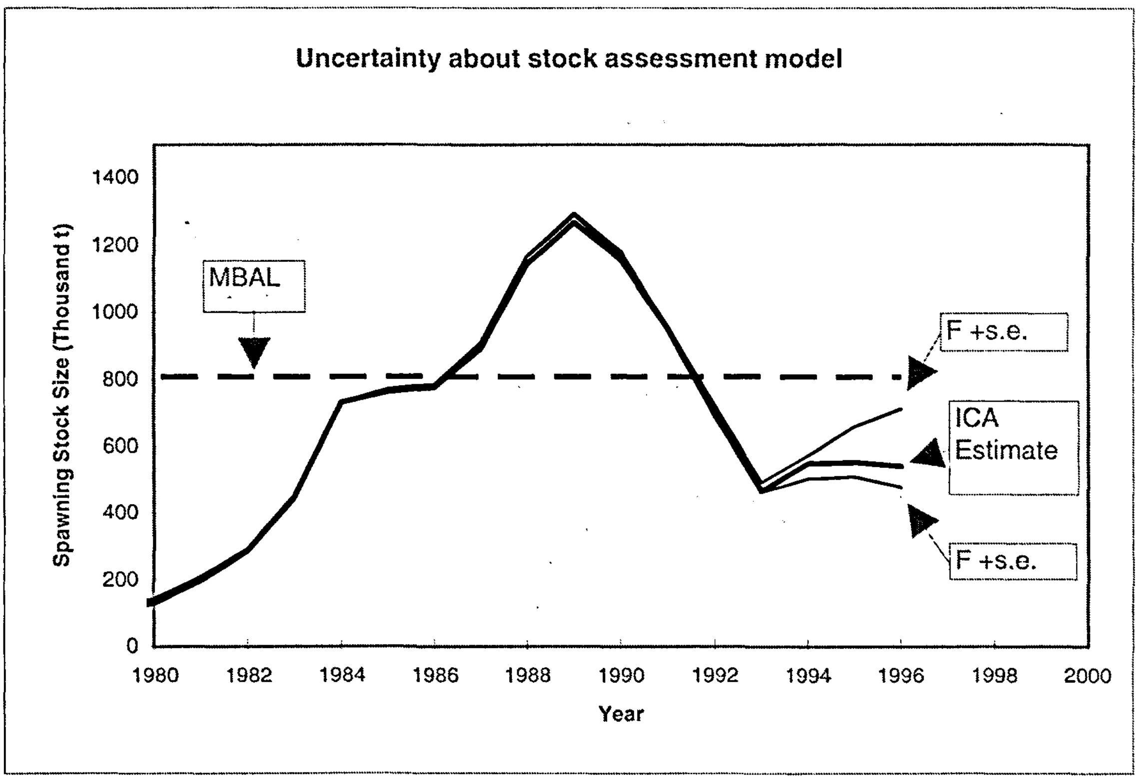


Figure 2.14.4 North Sea Herring. An illustration of uncertainty introduced by stochastic noise around the Working Group's final assessment model. Bold line, ICA estimate of spawing biomass. Fine lines, estimates of biomass obtained by initiating conventional separable VPAs with fishing mortalities at F +se and F-se, where se is the estimated standard error of the estimate of reference fishing mortality in 1996.

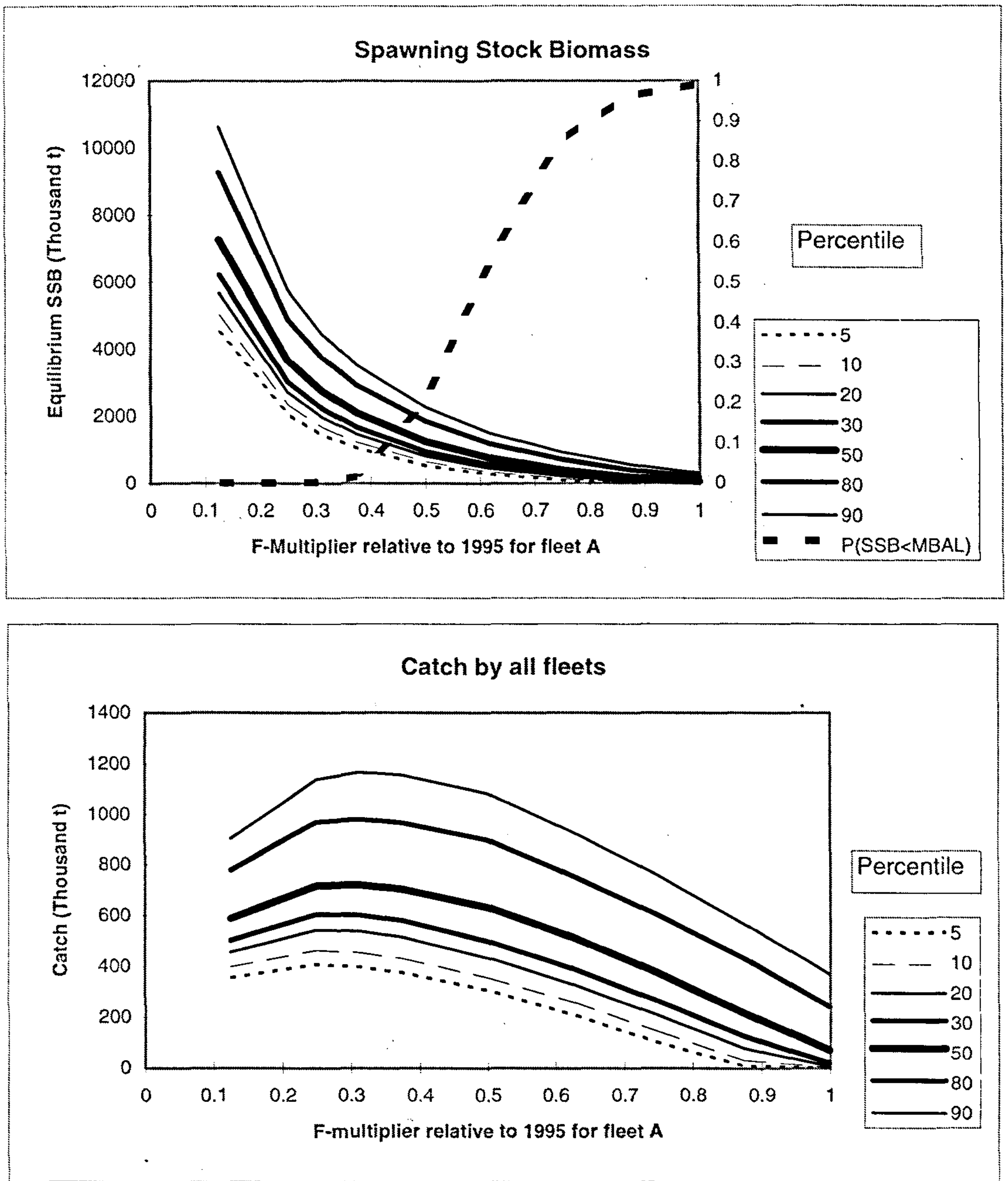


Figure 2.15.1 Estimates of equilbrium stock size, probability that the stock size will fall under 800 000t, and of catch by all fleets for different levels of fishing mortality relative to estimates of fishing mortality in 1995.

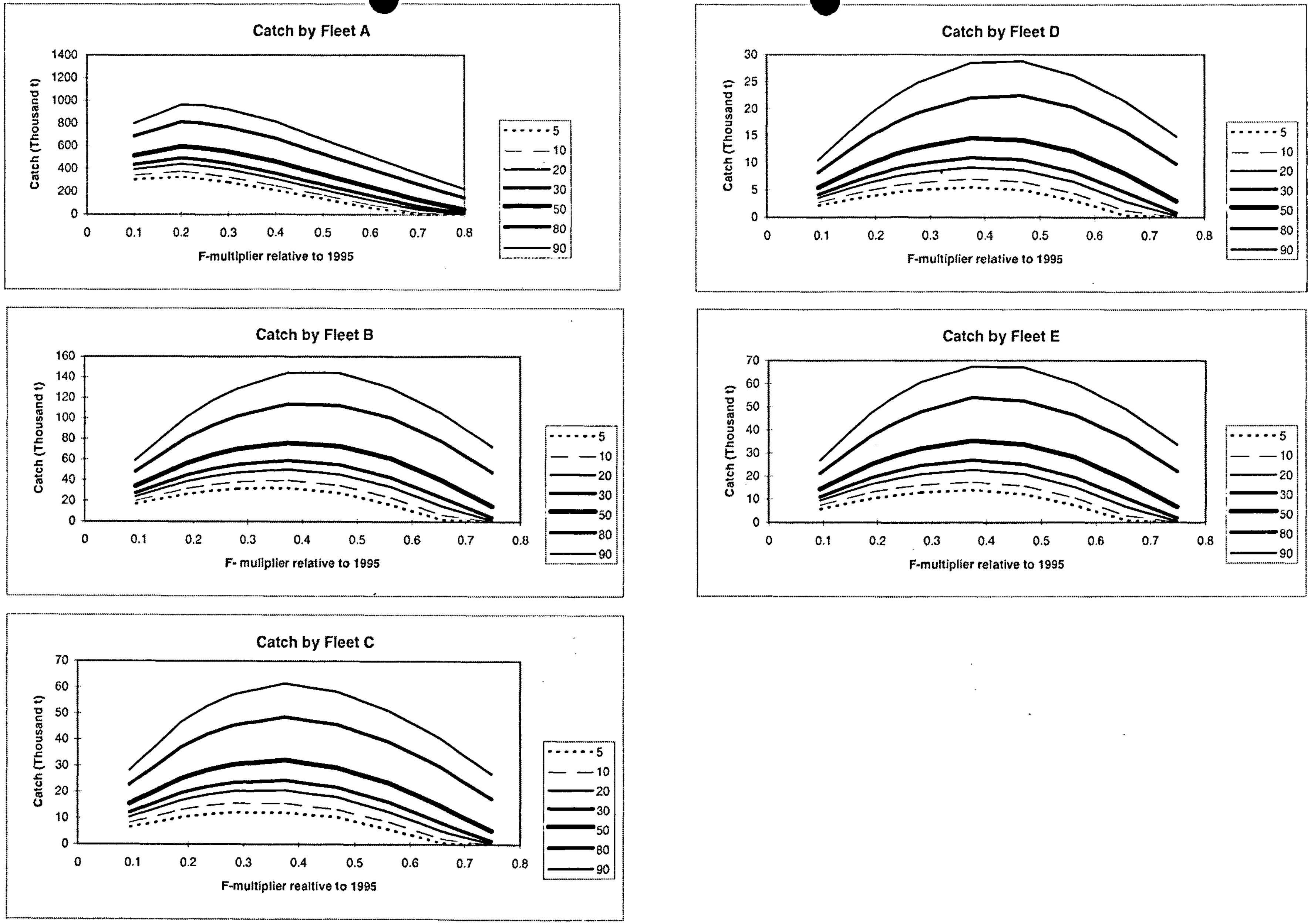
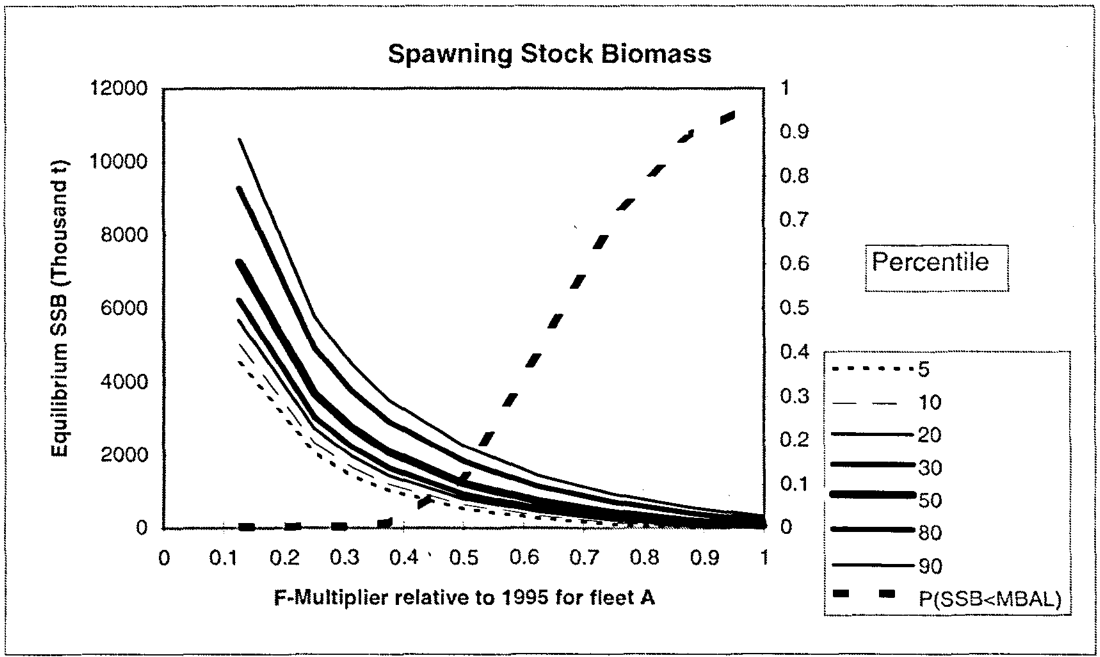


Figure 2.15.2 Estimates of equilbrium catch by fleet for different levels of fishing mortality relative to 1995 estimates of fishing mortality.

E:\acfm\hawg97\F-2152.XLS



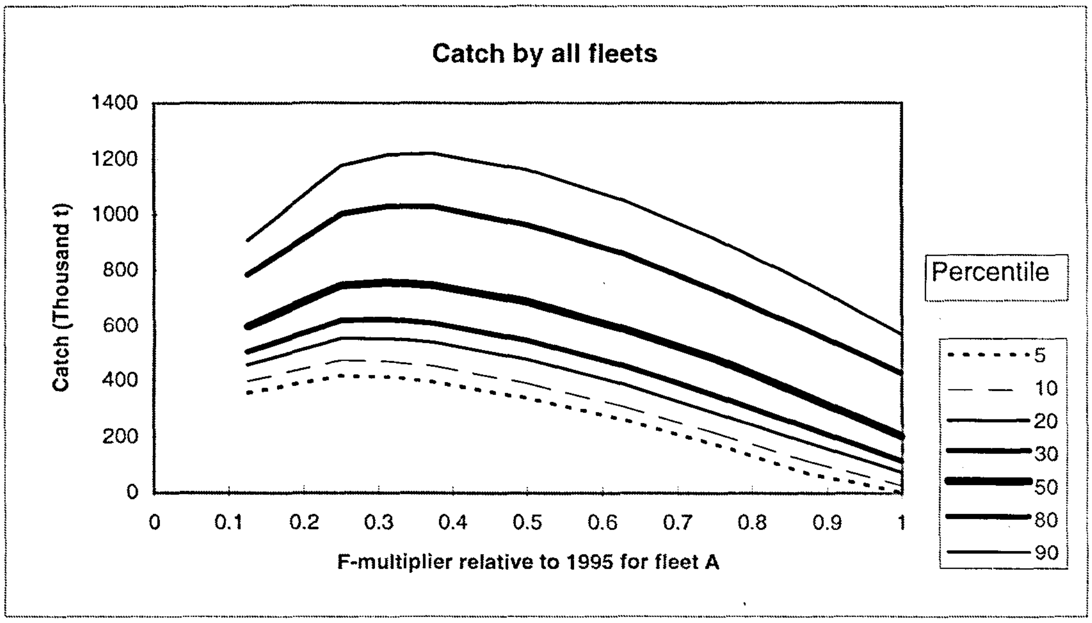
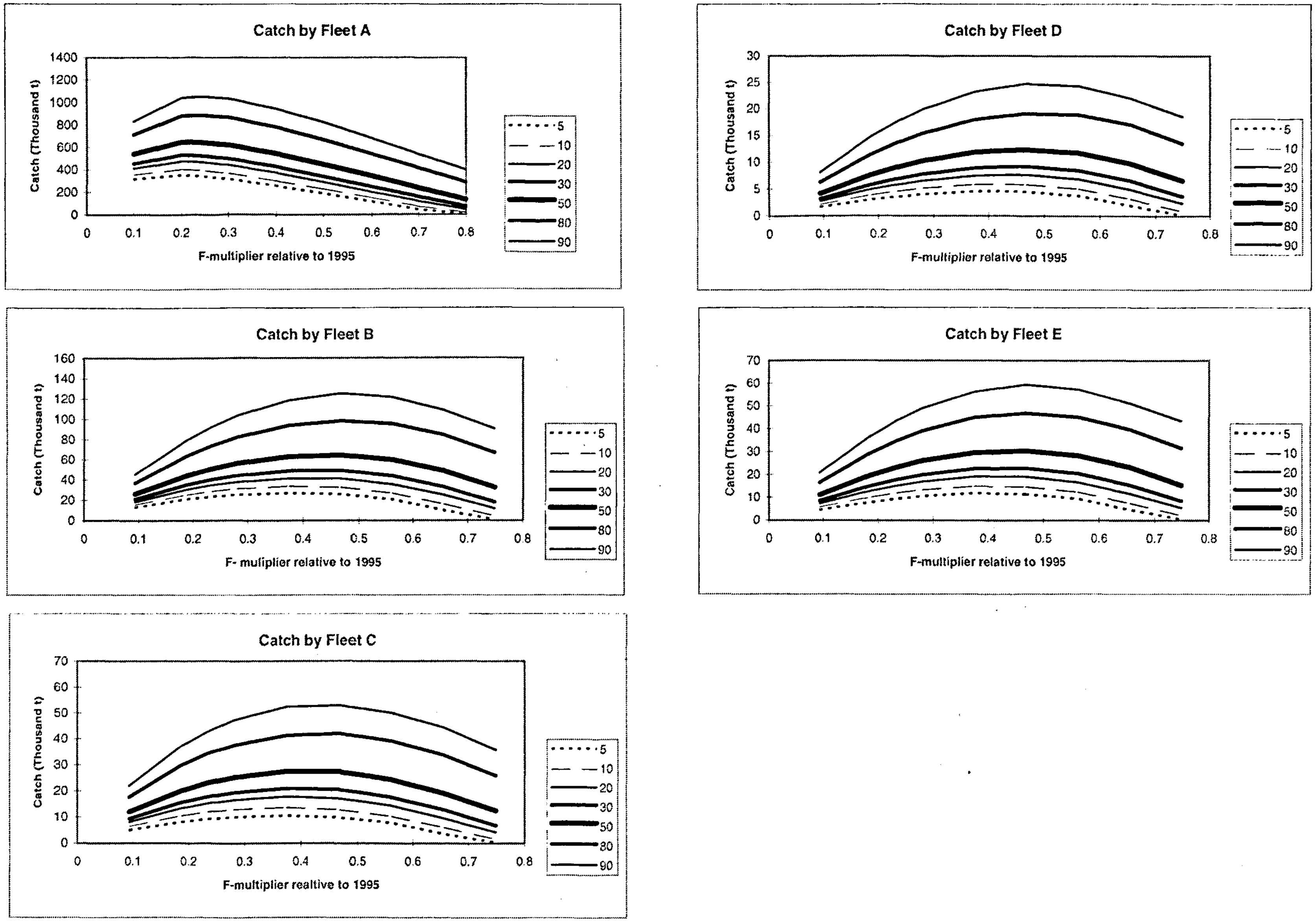


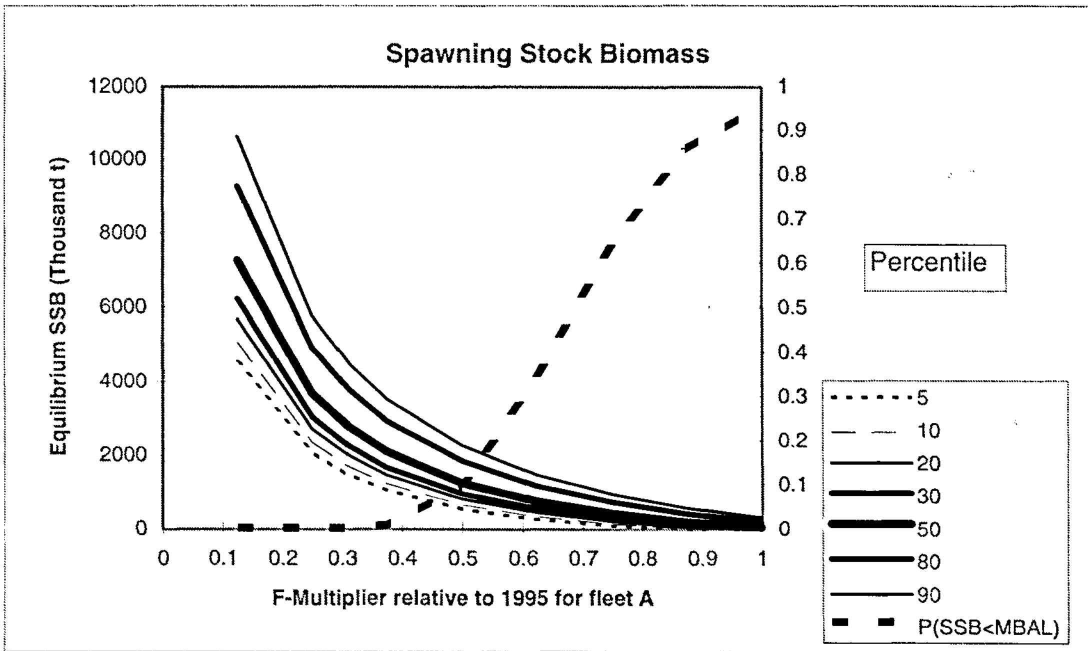
Figure 2.15.3 Estimates of equilbrium stock size, probability that the stock size will fall under 800 000t, and of catch by all fleets for different levels of fishing mortality relative to estimates of fishing mortality in 1995. F by fleets B-E scaled by 0.75 relative to fleet A.



F by fleets B-E scaled by 0.75 relative to fleet A

Figure 2.15.4 Estimates of equilbrium catch by fleet for different levels of fishing mortality relative to 1995 estimates of fishing mortality. F by fleets B-E scaled by 0.75 relative to fleet A.

E:\acfm\hawg97\F-2154.XLS



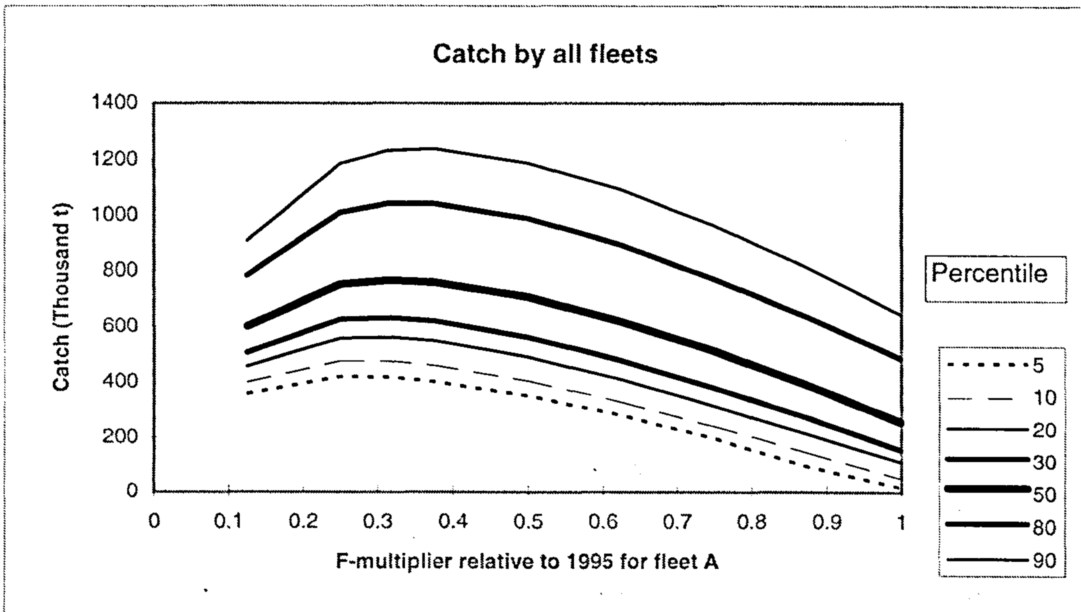


Figure 2.15.5. Estimates of equilbrium stock size, probability that the stock size will fall under 800 000t, and of catch by all fleets for different levels of fishing mortality relative to estimates of fishing mortality in 1995. F by fleets B-E scaled by 0.67 relative to fleet A

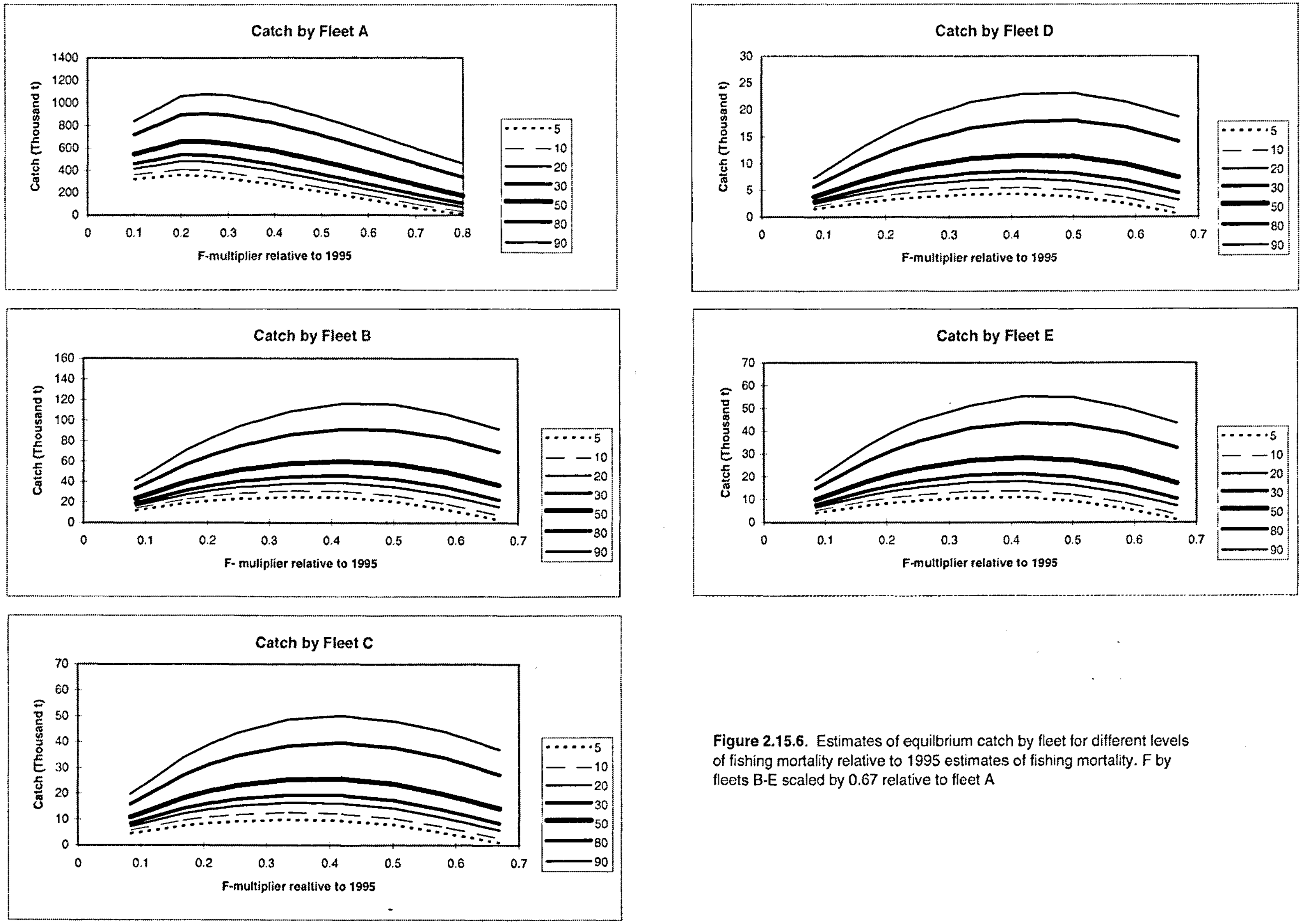
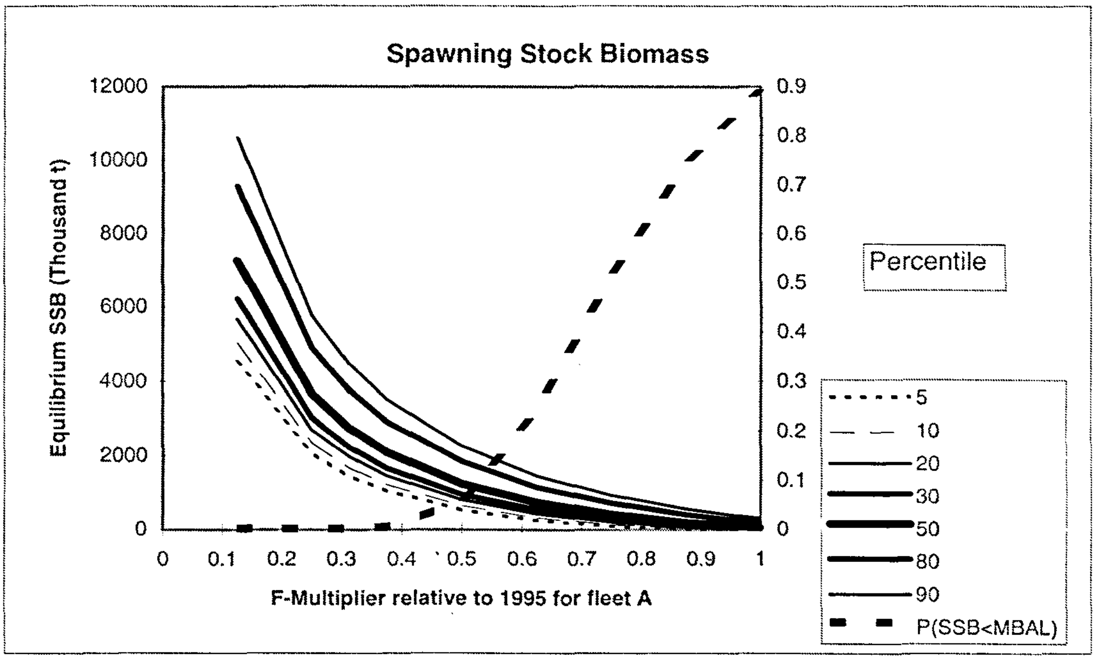


Figure 2.15.6. Estimates of equilbrium catch by fleet for different levels of fishing mortality relative to 1995 estimates of fishing mortality. F by fleets B-E scaled by 0.67 relative to fleet A



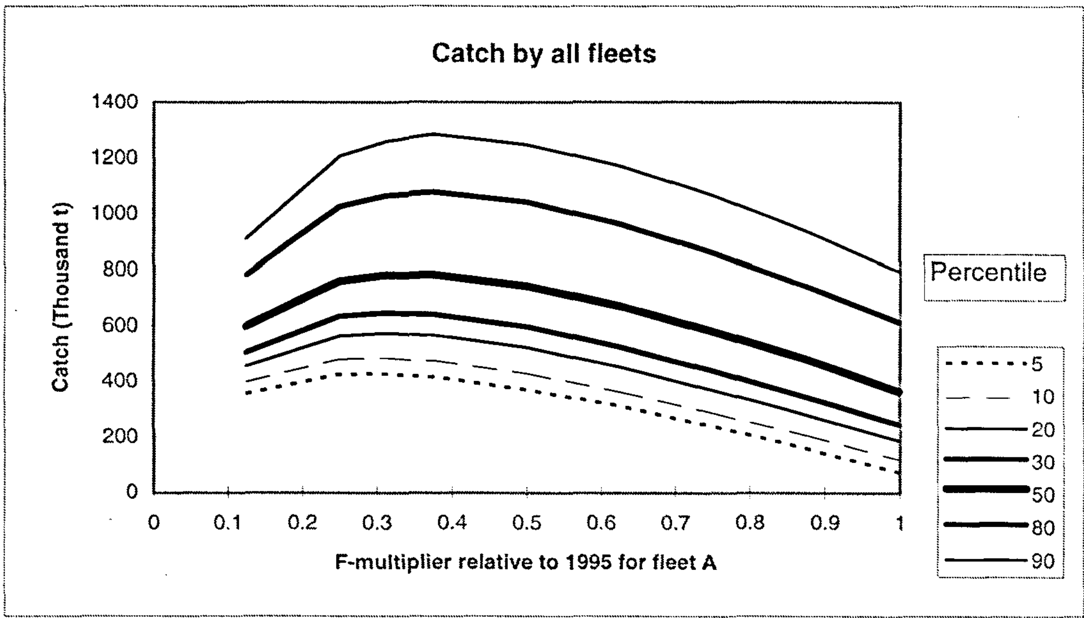


Figure 2.15.7. Estimates of equilbrium stock size, probability that the stock size will fall under 800 000t, and of catch by all fleets for different levels of fishing mortality relative to estimates of fishing mortality in 1995. F by fleets B-E scaled by 0.5 relative to fleet A

g:\acfm\hawg\patterso\equil50.xls

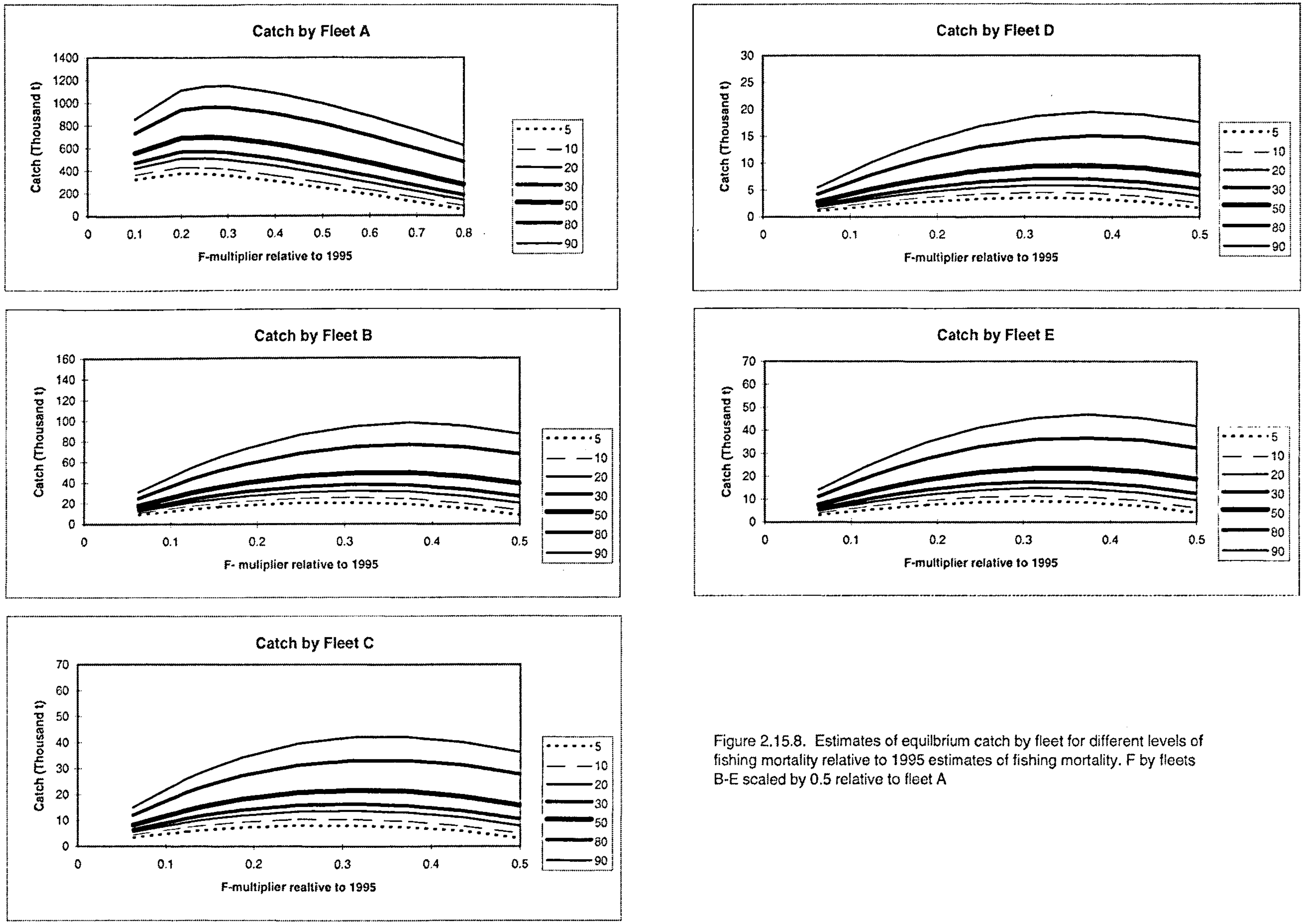
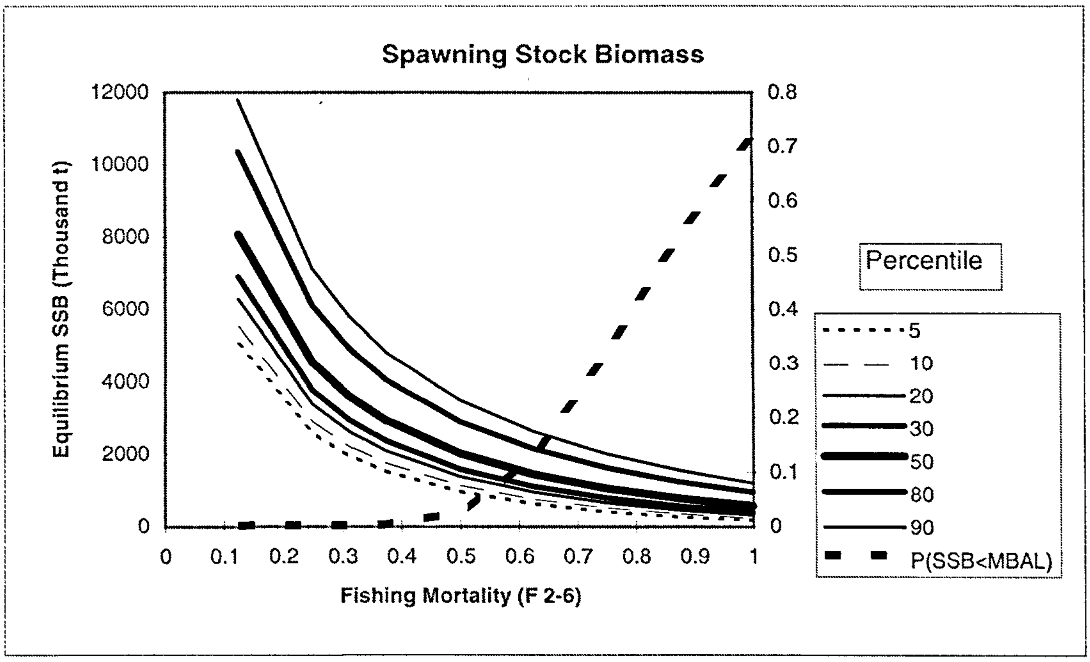


Figure 2.15.8. Estimates of equilbrium catch by fleet for different levels of fishing mortality relative to 1995 estimates of fishing mortality. F by fleets B-E scaled by 0.5 relative to fleet A

E:\acfm\hawg97\F-2158.xls



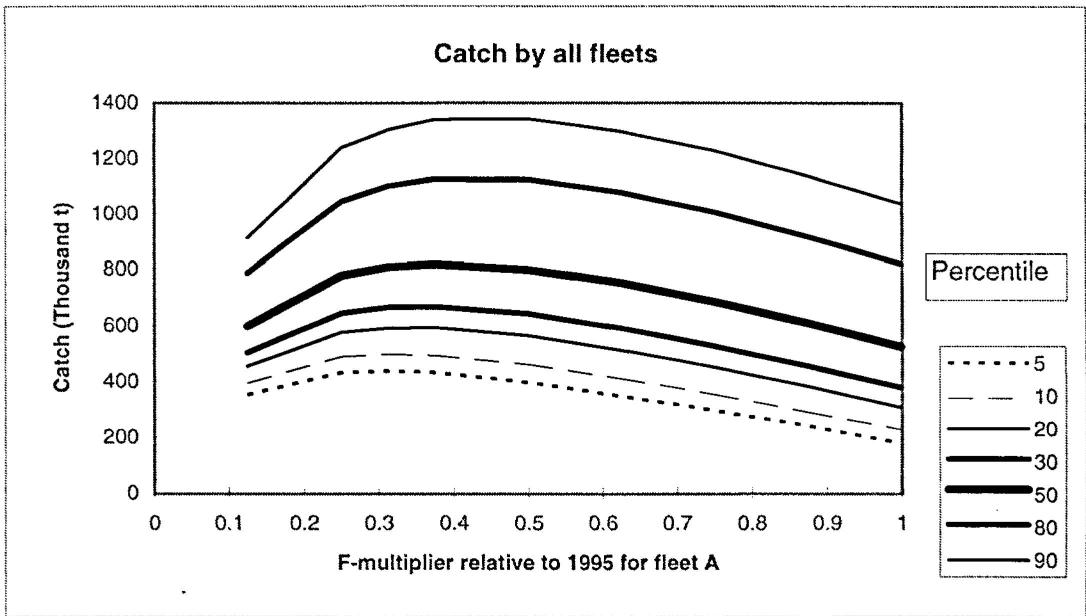
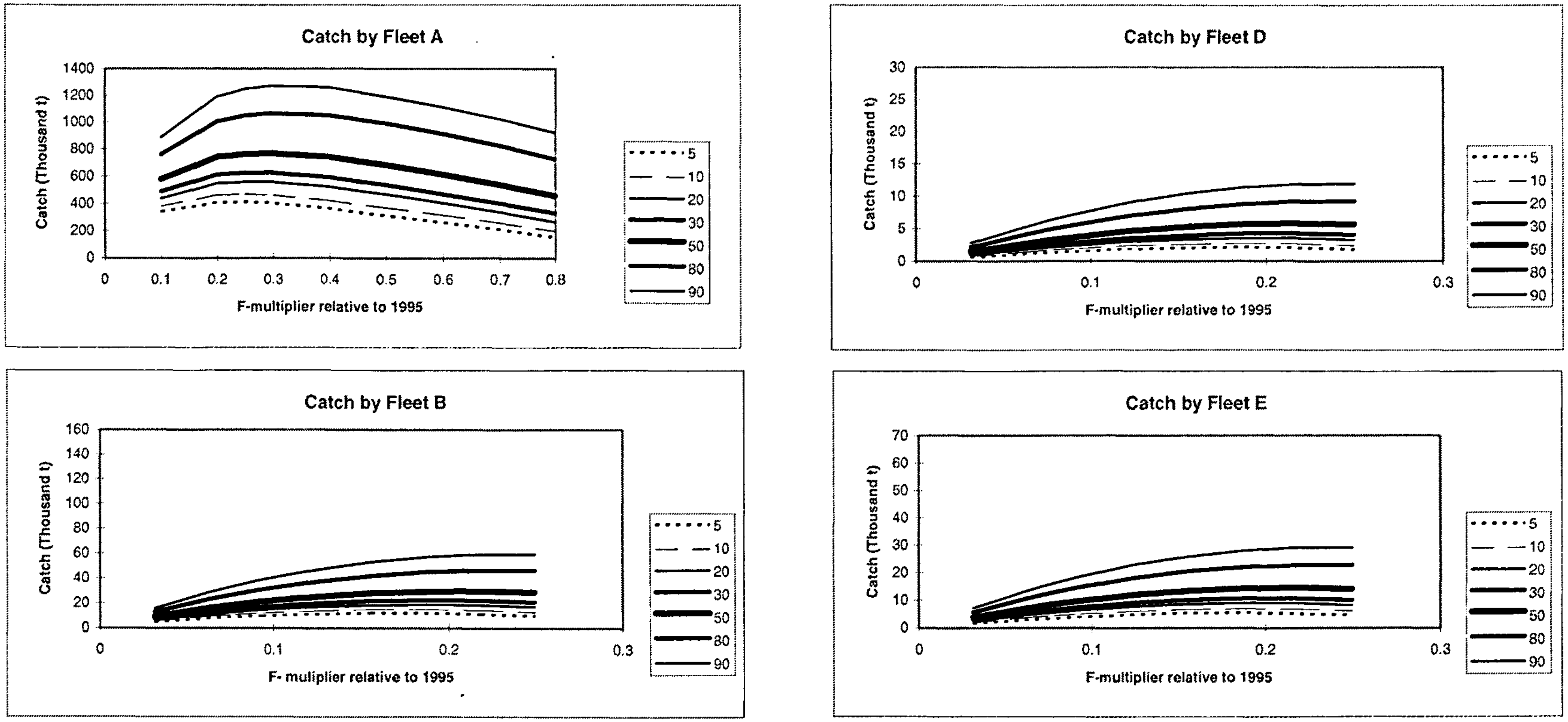


Figure 2.15.9. Estimates of equilbrium stock size, probability that the stock size will fall under 800 000t, and of catch by all fleets for different levels of fishing mortality relative to estimates of fishing mortality in 1995. F by fleets B-E scaled by 0.25 relative to fleet A



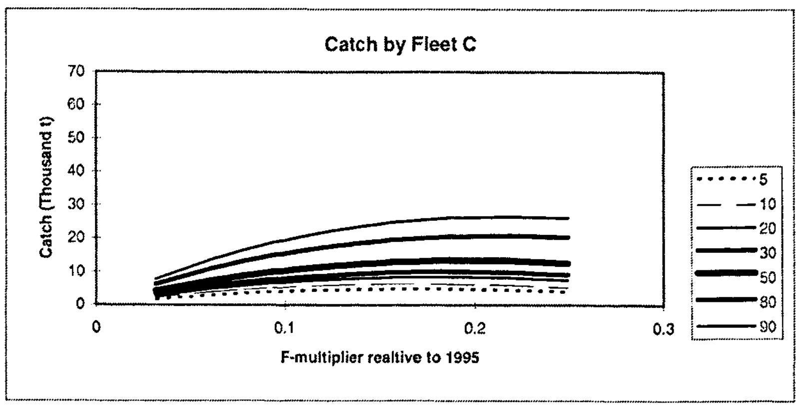


Figure 2.15.10. Estimates of equilbrium catch by fleet for different levels of fishing mortality relative to 1995 estimates of fishing mortality. F by fleets B-E scaled by 0.25 relative to fleet A