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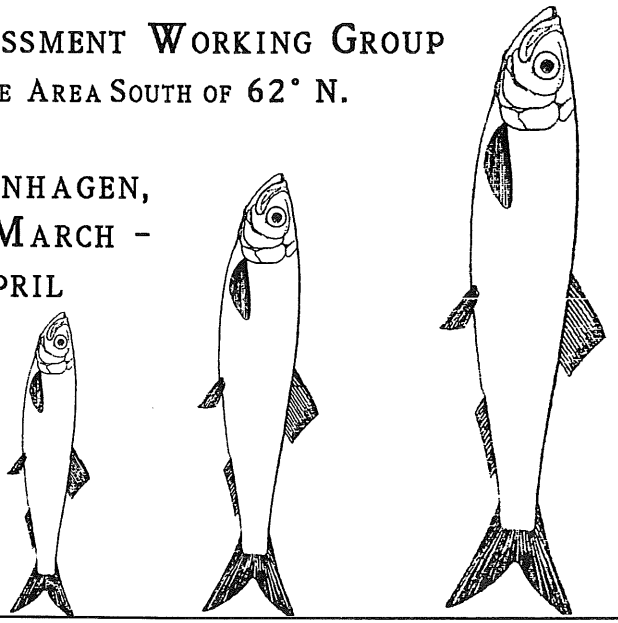
PART 1

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

COPENHAGEN, 27 MARCH - 6 APRIL



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1 INTRODUCTION

1.1 Participants

A. Aglen	Norway
R. Bailey	UK (Scotland)
A. Corten (Chairman)	Netherlands
J. Dalskov	Denmark
O. Hagström	Sweden
P. Hopkins	UK (Scotland)
P. Johnson	UK (England)
T. Jörgensen	Norway
P. Lorance	France
J. Molloy	Ireland
P. Munk	Denmark
R. Nash	UK (Isle of Man)
H. Sparholt	Denmark
G. Winters	Canada

Mr E. Kirkegård attended the meeting for one day to present results from the acoustic surveys.

1.2 Terms of Reference

In accordance with C.Res.1989/2:4:11, the Herring Assessment Working Group for the Area South of 62°N (Chairman: Mr A. Corten) met at ICES Headquarters from 27 March - 6 April 1990 to:

a) consider the Report of the Multispecies Assessment Working Group;

b) assess the status of and provide catch options for 1991 within safe biological limits for the herring stocks in Division IIIa, Sub-area IV (separately, if possible, for Divisions IVa,b and Divisions IVc and VIId), Division VIa, and Sub-area VII;

c) provide quarterly catch-at-age and catch and stock mean weight-at-age data and information on the relative distribution at different ages by quarter for North Sea herring for 1989 as input for the multispecies VPA;

d) provide data on the stock composition of herring catches in Division IIIa.

1.3 Evaluation of Multispecies Assessment Working Group (MSWG) Report

The discrepancies between the quarterly catch data on North Sea herring provided for the multispecies VPA (MSVPA) and those used in the present Working Group are still not resolved. The cause of the discrepancies is discrepancies in the national data given to the MSWG and to the present Working Group. These problems should be solved at the national level in each laboratory. If this proves impossible, it could be considered to raise the quarterly data used in the MSVPA to match the annual data used by the present Working Group.

The Multispecies Working Group (Anon., 1989a) ask all the single species assessment working groups for revised quarterly catch-at-age data from the second last data year. For herring, there is no revision of either the 1987 or the 1988 data.

The MSVPA key run made by Anon. (1989a) differed only slightly from the previous key run. Catch data for an additional year (1988) were added, and the whiting stomach data for 1985 and 1986 were revised.

The new values of natural mortalities are shown below (Anon., 1989a, Table 2.8.2c) as mean values for 1981-1986, together with the values used by the present Working Group:

Age (rings)	MSVPA 1981-1986	SSVPA
0	0.52[1]	1.0
1	0.97	1.0
2	0.50	0.3
3	0.30	0.2
4	0.17	0.1
5	0.13	0.1
6	0.18	0.1
≥7	0.10	0.1

[1] Mortality rate per half year.

The M value for 0-groups from the MSVPA is a half-yearly rate and represents only the second half of the year. If the single species VPA (SSVPA) M value for 0-groups is split equally into the two halves of the year, the MSVPA and the SSVPA M values are almost equal for the second half of the year.

The total M values from MSVPA are higher than those used by the present Working Group in ages 2-6. The present Working Group nevertheless retained the existing values to preserve consistency in TAC estimation on the grounds that the new values are not very different from those previously estimated by the MSVPA.

1.4 The Use of Up-to-Date Information for Management

The Working Group has commented several times on the problems in using more up-to-date information for stock prediction and management advice. With the present timing of the Working Group meeting in March/April, no use can be made of the results from the acoustic surveys in July in the North Sea on predicting the stock size for the following year. A similar problem exists in the Clyde, where the results of the summer acoustic surveys in the current year are not available at the time of the Working Group meeting.

Shifting of the Working Group meeting towards the autumn has been rejected by ACFM for practical reasons (too many other working group meetings in the autumn already). Besides, the Working Group considers that the gain of such a shift would be marginal, as there will be no new data available from larvae surveys in autumn.

A better solution would be to keep the Working Group meeting in spring, and allowing the possibility of a TAC revision for the current year immediately after the ACFM meeting in May. Any moderate upward revision of the TAC is expected to present no major problems for management or industry.

The situation may be more difficult in the case of a last-minute downward revision of the TAC. The Working Group thinks that the risk of such a revision should be reduced as much as possible, and that in such a case, the TAC advice should be adjusted by ACFM at their November meeting. In the event that the July acoustic survey in the North Sea shows an estimate that is considerably below the predicted level, some members of the Working Group should try and prepare a working document for the November ACFM meeting, suggesting how the new information could be handled in an ad hoc assessment.

1.5 Quality of Catch Statistics

The Working Group has in the past expressed its concern about the accuracy of official landing figures, and sometimes substituted official landing figures by Working Group estimates. This approach is now encouraged by ACFM, who advise working groups to use those estimates of catches which they consider to be the most accurate.

In discussing the accuracy of the 1989 catch statistics, the Working Group noted that in cases where biologists had independant information on commercial catches, these data were sometimes quite different from the official data. The Working Group, therefore, had to conclude that official monitoring of commercial landings is still inadequate in certain areas.

For this reason, a number of official landing data for 1989 were replaced by Working Group estimates. In some cases, offical figures were considered accurate enough, and left unamended. In other cases, official figures were given as national landings, the difference between official figures and best Working Group estimates was included in the category "unallocated landings".

Although discards are suspected to be significant in some areas and seasons, few quantitative estimates have been made so far. In cases where discards have been estimated, the figures for different countries have been combined into one extra line in the catch tables.

2 NORTH SEA HERRING

2.1 The Fishery

2.1.1 ACFM advice applicable to 1989

The 1988 ACFM meeting recommended the following TACs for 1989:

Divisions IVa,b: 484,000 t (including 35,000 t of 1-ring herring); Divisions IVc, VIId: 30,000 t.

The agreed TACs adopted by the management bodies were:

Divisions IVa,b: 484,000 t (including 35,000 t of 1-ring herring); Divisions IVc, VIId: 30,000 t.

It was additionally recommended that existing regulations designed to protect juvenile and spawning herring be maintained, i.e., sprat box closures, 20 cm minimum landing size, 10% weight by-catch regulation, and spawning ground closures in the western part of Division IVb.

2.1.2 Catches in 1989

Officially- and unofficially-reported landings for 1989 are shown by countries in Table 2.1.1 for the total North Sea and for each division in Tables 2.1.2-2.1.5.

The total catch of 2-ring and older herring in Divisions IVa and IVb was estimated at 504,100 t (including 19,900 t of spring spawners transferred to the Division IIIa assessment), which, combined with an estimated catch of 82,800 t 1-ring fish in these divisions, produces a grand total of 586,900 t.

This compares with the ACFM recommended and agreed TAC of 484,000 t (including 35,000 t of 1-ring herring) for Divisions IVa,b. The excess catch in 1989 for Divisions IVa,b thus amounted to some 102,900 t, of which excess 1-ringers accounted for 47,800 t.

In Divisions IVc and VIId, the estimated catch of 75,800 t 2-ring and older herring considerably exceeded the 30,000 t recommended and agreed TAC.

The total provisional catch was 698,947 t close to that (698,449 t) recorded for 1988. Unallocated catches amounted to 26,749 t (3.8% of the total) compared with 33,411 t (4.8% of the total) in 1988.

The Netherlands catches included an additional estimate to allow for discards. Discards are recorded separately (Table 2.1.1).

Further small changes have been made to the catch figures reported by Norway over the period 1979-1987 in Division IVa(East). These remove a component of Atlanto-Scandian spring-spawning herring, but the adjustments will not require alterations to the relevant catch in numbers tables since these landings were not included in the original assessments.

Adult Herring Catches (2-ring and older)

A breakdown of adult herring catches (2-ring and older) by ICES divisions and quarters of the year is shown in the following text table. The tonnages were derived from the sums of products of estimated numbers and mean weights at age provided by Working Group members.

Division	Quarter 1989 I	II	III	IV	Total
IVa (W of 2^0E)	18.9	20.2	121.0	29.3	189.4
IVa (E of 2^0E)	48.2	47.2	35.5	70.4	201.3
IVb	8.9	5.5	72.0	7.1	93.5
IVc + VIId	7.0	0.3	0.2	68.3	75.8
Total	83.0	73.2	228.7	175.1	560.0

Weights in '000 t. (SOPs)

This table excludes catches of spring-spawning herring amounting to 19,869 t transferred to Division IIIa; these were taken in the eastern parts of Divisions IVaE and IVb during the second and third quarters. The methods for separating autumn and spring spawners are described in Section 2.2.4.

It can be seen that in Divisions IVa(W) and IVb, the largest catches were taken in the third quarter (64% and 77%, respectively), these basically involving fully mature and spawning herring fisheries.

In Division IVa(E), the proportion of annual catch was highest (35%) in the fourth quarter, with the remainder fairly uniformly spread over the first three quarters. The Division IVa(E) fisheries mainly exploit overwintering recovering spents and feeding herring.

The Divisions IVc and VIId catches were clearly concentrated in the fourth quarter, when the fishery is targeted on winter-spawning herring.

Most of the adult herring were taken in purse seine and trawl fisheries using a minimum mesh of 32 mm.

Juvenile Herring Catches (0- and 1-ring)

A catch breakdown by divisions and quarters for 0- and 1-ring juvenile herring is presented in the text table below, these catches are also estimated from data supplied by Working Group members.

Division	Age group	Quarter 1989 I	II	III	IV	Total
IVa (W of 2^0E)	0	-	-	-	-	-
	1	0.3	0.3	0.4	1.5	2.5
IVa (E of 2^0E)	0	-	-	0.2	0.2	0.4
	1	+	0.2	0.1	2.8	3.1
IVb	0	-	-	19.0	12.8	31.8
	1	1.1	0.6	67.0	8.5	77.2
IVc + VIId	0	-	-	+	0.1	0.1
	1	-	+	0.3	0.6	0.9
Total	0	-	-	19.2	13.1	32.3
	1	1.4	1.1	67.8	13.4	83.7

Weights in '000 t.
+ Less than 50 t.

The total catch of 0- and 1-ring herring thus amounted to 116,000 t, a reduction of 8,100 t on the juvenile catch in 1988. However, the 0-ring catch in 1989 showed an increase of 17,500 t over 1988, whilst 1-ringers were reduced by 25,600 t. Most of the juvenile landings were reported from the eastern half of Division IVb during the third and fourth quarters, amounting to about 31,800 t of 0-ring (98.5% of all 0-ring), and 85,100 t of 1-ringers (89.7% of the total).

Small quantities of 1-ringers also appear in catches from other divisions, mainly during the fourth quarter of the year.

Most of the 0- and smaller 1-ring fish are taken in shallow water coastal fisheries by vessels using small mesh (16 mm) bottom trawls. Larger 1-ring fish are caught in more offshore deeper water areas during the second half of the year by larger industrial trawlers using both 32 mm and smaller mesh trawls, and also by purse-seiners (graded human consumption catches).

2.2 Catch Composition

2.2.1 Catch in number at age

Quarterly and annual catches in numbers and mean weights at age were compiled for each division and the total North Sea, using data submitted by the main countries fishing herring in the North Sea during 1989 (see Section 1.5 and Table 2.2.1).

Where countries submitted only catch data, conversions to equivalent age distributions were made by raising to the most appropriate fisheries in time and area for which full information was available.

Table 2.2.1 provides a breakdown on numbers caught by age group for each division on a quarterly and annual basis, whilst Table 2.2.2 presents a comparison of total North Sea catches in number at age over the years 1970-1989.

Table 2.2.3 shows for the years 1980-1989 the estimated numbers (see Sections 3.1.2 and 3.1.3) of autumn spawned 0-, 1-, and 2-ring fish taken in the Division IIIa fisheries which were

transferred for addition to North Sea catch in numbers, and used in the alternative assessment made in 1989 to take account of Division IIIa catches of North Sea herring.

In 1989, catch in numbers of 1-ring fish registered a small reduction compared with 1988. They contributed about 25% in number and 12% by weight to the total North Sea catch (excluding spring spawner transfers to Division IIIa). The comparable values in 1988 were 27% by number and 10% by weight. In 1989, about 85% of the 1-ringers were taken during the third quarter, mainly from the eastern half of Division IVb.

However, there was a marked increase in the numbers of 0-ring fish taken in 1989, of which about 83% were taken in the third quarter, mainly from the eastern half of Division IVb.

Percentage contributions by number of 2-ring, 3-ring and older fish (excluding 0- and 1-ringers) are presented in Table 2.2.4 by divisions, quarters, and for the year.

Abundance indices for the 1986 year class shown in earlier years by the IYFS, 0-ring (IKMT) in 1987, and 1-ring in 1988, suggested it was of similar magnitude to that of 1985 (see Section 2.3). Its representation in the 1989 North Sea fisheries as 2-ring fish was less than expected, and in most areas and quarters it was outnumbered by the 1985 year class as 3-ringers. This was also confirmed by the age breakdown of the July acoustic survey samples (Section 2.4). A comparison between the representation of mature 2-ringers in the survey samples and third quarter catches from Divisions IVa and IVb gave values of 32% and 27%, respectively.

3-ringers (1985 year class) made up 39% of both the survey samples and catches. The 1985 and 1986 year classes were both heavily exploited as 1-ring fish in the North Sea and Division IIIa fisheries. The combined catches from both areas amounted to 6,675 million of the 1985 year class and 7,763 million of the 1986 year class. The high level of these catches probably significantly reduced the recruitment of both these year classes to the adult fishery (see Section 3.1.3).

The proportion of 2-ringers in 1989 was highest in first quarter catches from Division IVa (W) (56%) and Division IVb (90%), and second quarter catches from Division IVb (74%). The only division in which they exceeded 3-ringers (1985 year class) in the whole year totals was Division IVb (57%), although 3-ringers predominated in the third quarter catches and the overall age structure was very similar to that found in Division IVa (W) catches for the same quarter. At this time most of the herring caught would have been fully mature or spawning fish.

As noted earlier, 3-ringers (1985 year class) exceeded 2-ringers in most quarters and divisions, and typically constituted 35-45% of the catches during the last half of 1989.

Older fish (4+ ringers) were most strongly represented in catches from Divisions IVa (E) and Divisions IVc and VIId.

The quarterly patterns of age distribution for the total North Sea were remarkably similar, which contrasts with the often large differences and changes between quarters and divisions brought

about by movements of populations over the year.

2.2.2 Quality of catch and biological sampling data

Table 2.2.5 summarises the biological sampling data on commercial catches that were available to the Working Group. The general level of sampling in 1989 seems to have been acceptable. Some areas, however, should have been sampled more intensively for racial characters (Section 2.2.4).

Estimates of discards were available for only a few fisheries. No assumptions about discards have been made for fisheries for which no estimates were available. This means that the total amount of discarding in 1989 has probably been underestimated by the Working Group.

The accuracy of official landings statistics is commented upon in Section 1.5. In some cases, official estimates of landings were replaced by Working Group estimates. Where official figures have been retained by the Working Group, it is not always clear how accurate these figures are.

2.2.3 Treatment of spring-spawning herring in North Sea catches

The following notes should clarify the treatment of spring-spawning herring identified in catches of herring in the North Sea area, and mentioned as footnotes to a number of tables. There are basically three broad groups as follows:-

1. Atlanto-Scandian Herring

These are taken in coastal areas of Division IVa (E of 2^0E) and covered by a separate TAC. They are consequently removed from the (Norwegian) catches and not included in the North Sea assessment or catch tables.

2. Division IIIa and Southwest Baltic Populations

These undertake an annual feeding migration when 2-ring and older into the northeastern North Sea (see Figure 2.2.1). Any catches taken are included in the catch in tonnes tables, since they come under the North Sea TAC, but are not included in North Sea catch in number tables or assessment.

They are most abundantly represented in catches during the second and third quarters of the year (principally May-September) and separated on the basis of meristic characters (see Section 2.1).

The catches deducted from the defined area and quarters are subsequently transferred to Division IIIa and southwest Baltic assessment.

3. Coastal Type Spring Spawners

These are mainly found in the southern North Sea (Division IVc) and east Channel (Division VIId) fisheries. However, they are usually caught in relatively small quantities in most years, and are included in the North Sea catch in number tables and assessment.

2.2.4 Baltic and Division IIIa spring spawners in the North Sea

Previous Working Group meetings have considered all 3-ringers and older fish and a part of the 2-ringers taken in a defined "transfer area" (Figure 2.2.1) in the period May-September to be Division IIIa/Baltic spring spawners. Since 1984, when the catches started to increase in this area, these catches have been taken out of the North Sea assessment and applied in the Division IIIa/Baltic assessment. The basis for this transfer has been vertebral count/length frequency analysis.

From the 1989 acoustic summer survey (July-August), 11 samples from the transfer area and neighbouring rectangles were subjected to discriminant analysis on several morphometric and meristic measurements, and one sample subjected to vertebral count/length frequency analysis. In addition, average vertebral count by age was available for two samples from the area in May, two in June, seven in July, and three in September. Figure 2.2.1 shows average vertebral count for 2-ringers and for older fish in each sample.

To have an estimate of the fraction of spring spawners (fsp) for the samples where only mean vertebral count by age (v) was available, the equation

$$fsp = (56.5 - v)/0.8$$

was applied. This equation gives an accurate estimate if the mean vertebral count of spring spawners is 55.7 and that for autumn spawners is 56.5 in all samples. Although mean vertebral count for each component is likely to vary between samples, this method seems to agree with the other two methods (Table 2.2.6). Since this latter method is the only method which can make use of all the samples from the period May-September, this was used to estimate the average fraction of spring spawners for the period (unweighted average of all samples). On this basis, 25% of the 2-ringers and 42% of the older fish taken in the transfer area in Division IVa E in the period May-September were transferred, and 38% of the 2-ringers and 73% of the older fish taken in the transfer area in Division IVb were transferred. The total transfer of catches in 1989 is 19,867 t.

The years for which catch at age breakdown and mean weights-at-age are available are shown in Table 2.2.7. The basis for defining the transfer time and area is weak in all years. The number of samples are limited and their distribution over time and area are scattered. Most of the available samples come from acoustic surveys concentrated to July-August and samples from commercial catches are rather low.

The result of the separation in 1989 shows high proportions of spring spawners in Division IVa E and especially in Division IVb E by the end of September, indicating that the migration to Division IIIa has not yet commenced. A delayed migration is also corroborated by reports from the fisheries in Skagerrak-Kattegat in recent years, when large herring were scarce in the catches taken in August-September but showed an increase later in the autumn.

Altogether this indicates that the present transfers of spring-spawning herring caught in the North Sea could be underestimated. If the catches in the North Sea are underestimated, it will sup-

port one of the explanations for the constant high fishing mortality (about 0.8) of adult herring in this stock, as was discussed by the Working Group on the Assessment of Pelagic Stocks in the Baltic (Anon., 1989c).

2.3 Recruitment

2.3.1 IYFS indices

An updated series of indices of 1-ring herring from the IYFS is given in Table 2.3.1. The final figures for the 1989 survey are taken from Anon. (1989b). The provisional figures for the 1990 survey are based on length compositions from all countries and age compositions from all but two countries taking part.

The regression of VPA estimates of 1-ringers on IYFS indices of the same year classes from 1976 onwards was updated using the new VPA given in Section 2.7. The scatter plot and fitted regression line are given in Figure 2.3.1. The intercept is not significantly different from zero, and for prediction purposes the regression has been forced through the origin. The resulting equation is slightly different from last year's, largely because the large 1985 year class is now included in the regression. The new equation is:

$$y = 0.00506\ x$$

where x is the IYFS index (no./hr in standard area), and y the VPA estimate of 1-ringers in billions.

The 1986 and 1987 year classes, also plotted in Figure 2.3.1, were not included in the regression. The provisional VPA estimate of the 1986 year class (15.5 billion) is lower than predicted from the VPA/IYFS regression (21.2 billion).

Indices of 2-ringer abundance from IYFS for the total North Sea are also given in Table 2.3.1, together with VPA estimates. The time series of converged VPA estimates is still too short to evaluate the usefulness of this index as an estimator of 2-ringer abundance. However, as pointed out last year, the exceptionally high index of the 1985 year class in 1988 is not reflected in either the VPA or in the IYFS 1-ringer index.

2.3.2 IKMT indices

An updated series of IKMT indices from the IYFS is given in Tables 2.3.2 and 2.3.3, based on the area breakdown shown in Figure 2.3.2 of the 1988 report (C.M.1988/Assess:17). The updated scatter plot and regression of 0-ringer abundance from VPA on the IKMT index values is given in Figure 2.3.2. The promising relationship found in previous years' data has been considerably obscured by inclusion of the 1986 year class which is now seen to be much weaker in the VPA. The slope of the new regression plotted in Figure 2.3.2 is nevertheless significant, and the intercept is not significantly different from zero (Table 2.3.3). For prediction purposes, the regression has been forced through the origin.

It should be noted that the North Sea VPA, on which the above

regression is based, does not take account of catches of 0- and 1-group North Sea herring in Division IIIa. A further comparison was, therefore, made between provisional 0-group estimates from the combined North Sea and Division IIIa VPA described in Section 2.9.3, and the IKMT indices (data in Table 2.3.3). The scatter plot and fitted regression line are shown in Figure 2.3.3. This regression fits the data much more closely than the one based on North Sea data alone (see Table 2.3.3 for regression diagnostics). This can be attributed to the fact that there is considerable annual variability in the transport of herring larvae into Division IIIa. This variability is illustrated by the proportion of North Sea autumn-spawner 1-ringers that are found in Division IIIa, as estimated by the IYFS in the two areas (Table 2.3.4).

Since last year, Table 2.3.4 has been corrected for all years to take account of the fact that the index of abundance in Division IIIa only applies to certain depth strata. The indices of autumn-spawners have been corrected assuming that the corresponding area in Division IIIa is 8,782 nm^2, equivalent to approximately 9.8 statistical rectangles. Table 2.3.4 indicates that a much lower proportion of 1-ringers was present in Division IIIa in some years than suggested in last year's report.

In the present context, it is noteworthy that the 1986 year class (survey year 1988) was concentrated in Division IIIa in contrast to most other year classes. This explains why it may have been underestimated by the North Sea VPA.

2.3.3 Recruitment forecast 1987 year class

The revised IYFS index of this year class as 1-ringers of 3,468 is almost identical to the preliminary index given in last year's report. The predicted recruitment as 1-ringers from the VPA/IYFS index regression is 17.54 billion (compared with a prediction of 18.40 billion last year). A preliminary estimate of the size of this year class from VPA is 19.43 billion.

A further estimate of this year class in 1989 is available from the acoustic surveys in the North Sea and Division IIIa. The estimated abundance of North Sea 1-ringers in the North Sea and Division IIIa combined at 1 July was 6,333 million. To estimate the number alive at 1 January 1989, this figure has been corrected by the catches in the first half of the year in the North Sea (72 million) and in Division IIIa (644 million) and an assumed natural mortality of 0.5 (half the annual figure for 1-ringers). The estimated number alive at 1 January 1989 is 11.34 billion, which is lower than the preliminary VPA estimate of 19.43 billion, and lower than the value predicted from the IYFS (17.54 billion).

Projecting forward from this estimate, based on the acoustic survey, using the annual catch of 1-ringers in the North Sea (1,899 million) and Division IIIa (1,039 million) and an M of 1.0, gives an estimated 2.53 billion 2-ringers at 1 January 1990. The corresponding annual fishing mortality rate of 1-ringers in 1989 is 0.50.

The projected estimate of 2-ringers at 1 January 1990, based on the predicted number of 1-ringers from the 1989 IYFS and from 1989 catches of 1-ringers in the North Sea, is 5.36 billion. The

relative distribution of this year class as 1-ringers between the North Sea and Division IIIa is shown in Table 2.3.4.

2.3.4 Recruitment forecast of 1988 year class

The preliminary index of 1-ringers in the standard area during the 1990 IYFS was 2,111. Using the new regression equation, the year-class strength is predicted to be 10.68 billion. This is the lowest estimated year-class strength since the 1980 year class.

The IKMT index of this year class in 1989 was also relatively low. The estimated proportion of this year class in Division IIIa from the IYFS was 21% as 1-ringer (Table 2.3.4), much lower than the previous two year classes.

2.3.5 Recruitment forecast of 1989 year class

The IKMT index of this year class in 1990 is the lowest since the 1977 year class and not much higher than the index of the very weak year classes in the mid-1970s (Table 2.3.3). The predicted year-class strength as 0-group using a regression through the origin is 7.66 billion. Using the regression based on the combined VPA of the North Sea and Division IIIa gives a predicted value of 11.04 billion. Both regressions indicate the likelihood that this will be a very poor year class.

The distribution of 0-group in the 1990 IYFS is shown in Figure 2.3.4.

2.3.6 Trends in recruitment

The time series of 1-ringer recruitment from 1947 to the present is shown in Figure 2.3.5.

2.3.7 Application of GLM analysis on the IYFS data

A working document dealing with a GLM (General Linear Model) analysis of the IYFS data was presented to the Working Group by H. Sparholt. The objective of this analysis was to investigate variations in catch rate due to differences between ships, time of the day, depth, and area. By correcting catches for these variations, the accuracy of the survey indices could possibly be improved. Correcting catch rate for time of the day would also mean that night hauls could be included for herring, which would increase the number of hauls used to calculate the herring indices.

The catch rates of 1-, 2-, and 3+ringed herring were examined by the model as follows:-

log(catch) = year + ship + area + time of day + depth + (year x area) + epsilon

where year, ship, area, time of day, and depth were included as class variables. Year times area was included as an interaction effect, and epsilon is the error term. Data from the North Sea for 1982-1989 were considered in this analysis.

All effects considered were found to be highly significant, except the time of the day for 3+ringers. The model explains about half of the variation seen in the catches. The time of the day seems to contribute the least to the variation of the catch rates for all age groups. For 1-ringers, the ship effect is greater than the year effect, indicating large differences between ships. Area seems very important, as well as year times area. Also the depth contributed greatly to the variation in catch rates. The ship effect decreases from 1-ringers to 2-ringers, and further to 3+ringers.

New indices for 1-, 2-, and 3+ringers were calculated, using the correction factors for ship, depth, etc., estimated by the GLM analysis. These indices were regressed against VPA estimates of year-class strength, and the results were compared with the performance of the standard indices used so far. For 1-ringers, the GLM index showed a higher correlation with the VPA estimates than the standard index (Table 2.3.5). The correlation could be further increased by including Division IIIa juveniles in the GLM index. For 2- and 3+ringers, the GLM indices showed a lower correlation with VPA estimates than the traditional indices.

2.4 Acoustic Surveys

2.4.1 Northern and Central North Sea (Divisions IVa,b) and Division IIIa summer survey

Four vessels covered the area without any area overlap. "Scotia" (5-25 July) and "Eldjarn" (28 June-20 July) covered most of the area between 56^{0}N and 62^{0}N, "Dana" (19 July-9 August) covered the rest of Division IVb and outer Skagerrak and "Argos" (1-5 August) covered the Kattegat and the inner Skagerrak.

The estimates are given in Table 2.4.1 and the mean-weights-at-age are given in Table 2.4.2. In Division IVaE, the estimates were split on North Sea autumn spawners and Division IIIa/Baltic spring spawners on the basis of discriminant analysis of morphometric and meristic characters (Working Document by T. Jørgensen). In Divisions IVbE and IIIa, spring and autumn spawners were split on the basis of vertebral count/length frequency analysis.

The total estimate was 9.0×10^9 (1.6 million t) maturing autumn spawners and 2.3×10^9 (256,000 t) spring spawners. The estimated spawning biomass in Division IVaW (1.35 million t) represents 82.5% of the total estimate of autumn spawners. The total estimate is considerably higher than the 1988 estimate (897,000 t). Table 2.4.3 compares the estimates for the years 1984-1989 and shows mortalities calculated from the 2+ estimate in one year and the 3+ estimate next year. The mortality from 1988 to 1989 is remarkably lower than the earlier years, even lower than the assumed natural mortality. This is the case for all the year classes dominating the spawning stock. The Working Group discussed the possible sources of overestimation in 1989 and/or underestimation in 1988. It was pointed out that in both years the northern and western distribution limit was not properly determined and in both years schools occurred above the transducer depth in some areas. There was no basis for assuming that this situation lead to larger biases in 1988 than in 1989. It was argued that these biases, like other biases inherent in the

method, are likely to vary between years. The conclusion was, that all the surveys in the time series have to be considered equally accurate.

The survey also indicates a slight increase in mean weight at age (Table 2.4.2), and in the proportion of mature 2- and 3-ringers. The estimated spawning stock biomass, therefore, shows a slightly larger increase from 1988 than the estimated numbers of fish do.

2.4.2 Eastern part of North Sea

A Norwegian vessel surveyed the area east of 3^0E in Division IVb and parts of Skagerrak during the latter half of November 1989. The estimates of 0- and 1-ringers are compared to earlier years in the text table below.

Survey year	Division IVb (E of 2^0E)		Division IIIa		Total	
	0-ringers	1-ringers	0-ringers	1-ringers	0-ringers	1-ringers
1985	3,723	153	5,814	574	9,537	727
1986	4,098	2,431	6,513	489	10,611	2,920
1987	3,792	1,986	10,192	3,619	13,984	5,605
1988	1,495	297	2,527	2,803	3,752	3,100
1989	984	554	(224)	(375)	1,208	929

The time series show a decreasing trend in 0- and 1-ringer abundance since 1987.

2.5 Herring Larvae Surveys

2.5.1 Herring larvae surveys in 1989/1990

A total of 111 days of ship time was available for the 1989/1990 surveys in Sub-area IV and Division VIId, compared with 85 days in 1988/1989. The coverage of each of the areas is summarized in the text table below:

Area	Country	Dates	No. samples
Orkney-Shetland	Germany	310889 - 090989	146
	Scotland	080989 - 080989	8
		190989 - 280989	126
Buchan	Scotland	020989 - 080989	110
	Denmark	190989 - 290989	98
Central North Sea	Netherlands	050989 - 130989	96
		180989 - 280989	105
		021089 - 121089	121
	England	071089 - 101089	47
		251089 - 271089	27
		291089 - 301089	20
Southern North Sea	Netherlands	111289 - 141289	52
		181289 - 201289	45
	England	040190 - 090190	77
	Germany[1]	120190 - 210190	112

[1] Data not available at the time of the Working Group meeting.

The data from the surveys were collected at the DAFS Marine Laboratory, Aberdeen, Scotland.

2.5.2 Larvae production estimates (LPE)

Calculations of LPEs were made available by DIFMAR, Charlottenlund. The estimates were calculated as described in the 1987 Herring Assessment Working Group report (Anon., 1987).

The production estimates are based on estimates of mortality rates (z/k) calculated from the larvae data. These are given in Table 2.5.1. A combined mortality rate is shown for Division VIa(N) and Orkney-Shetland, as well as the mortality rates for the standard North Sea areas. This is because there can be a problem estimating the mortality rates for these two areas separately because of the drift of larvae from Division VIa to the North Sea. However, the series of LPE indices used in this report are based on the mortality rates which were estimated independently. As in previous years, growth rates were assumed to be 0.35 mm per day in all areas.

LPE values for the standard areas and for Division VIa(N) and Orkney-Shetland combined are given in Table 2.5.2. The LPE for Divisions IVc+VIId is preliminary. The LPE values corrected by differences in fecundity are shown in Table 2.5.3, and it is these values which are used as indices of SSB in all subsequent analyses. No new fecundity data were available to the Working Group.

2.5.3 Indices based on small larvae (LAI)

The larvae abundance indices were calculated as described by Saville and Rankine (1985). The LAIs for 1972-1989 are given in Table 2.5.4.

The LAI for the Orkney-Shetland area is the highest on record, about 6% higher than the 1988 estimate which was itself very much higher than the indices in previous years. For the Buchan area, the LAI is a little more than half the 1988 estimate. This may partly be due to early spawning, since over 40% of the larvae caught during the first survey time were >10 mm. The LAI for the Central North Sea is slightly less than the 1988 value, but maintains the rather stable series over the last 5 or 6 years.

A final LAI could not be calculated for the Southern North Sea and Eastern Channel, because at the time of the Working Group meeting, the data from the third survey period (16-31 January) were unavailable. Instead, a provisional index was calculated by raising the larvae abundance during the first two periods (12-31 December and 1-15 January) by the ratio of the third period to the sum of the first two periods in the years 1983/1984 - 1988/1989. This varied from 15% to 39%, with a mean of 23%. The LAI based on the first two periods in 1989/1990 is 6,116, itself a marked increase compared to previous years. Adjusting by 23% to compensate for the missing data from the third period increases the provisional LAI to 7,523.

The individual LAIs can be added to give LAIs over large areas, except that the Central North Sea LAI should first be multiplied by four. This is because this index is expressed as the mean of four half-month periods, whereas the indices for the other areas are expressed as the sum of the half-month periods. The LAIs for the total North Sea for the years 1972-1988 and the provisional estimates for 1989 are shown in Table 2.5.4.

2.6 Mean Weight and Maturity at Age

2.6.1 Mean weight at age in the catch and stock

The mean weights at age (weighted by numbers caught) of fish in the catch during 1989 are presented by divisions and quarters in Table 2.6.1. A decrease in annual mean weights at age was first commented upon by the Working Group in 1985 (Anon., 1986), and up to 1988 a clear downward trend was evident.

In the 1988 Working Group report (Anon., 1988), it was noted that a more valid comparison for examining these changes would be on a quarterly basis, since annual mean values weighted by numbers taken in each quarter could be influenced by variation in quarterly distributions of catches between years. Table 2.6.2 thus presents quarterly mean weights at age over the years 1986-1989 for Divisions IVa and IVb and Divisions IVc and VIId, grouped by quarters for ease of comparison.

It is evident that in 1989, the generally declining trend in mean weight-at-age noted between 1986 and 1988 in Divisions IVa and IVb, appears to have stopped, with generally higher mean weights at age in 2-ring and older age groups.

It was noted in last year's report that there was no clearly defined trend evident in Divisions IVc and VIId, and the values for 1989 again show no consistent pattern of change among years and age groups over the period 1986-1989.

The following text table provides a convenient comparison for changes in third quarter mean weights-at-age in the catch from Divisions IVa and IVb for the years 1986-1989. In this quarter, most fish will be at or approaching their peak weights just prior to spawning.

	Mean Weights (g) at Age in the Catch				
	Third Quarter (Divisions IVa and IVb)				
Age (W.R.)	1986	1987	1988	1989	July 1989 Acoustic Survey
1	78	54	58	42	54
2	146	134	124	136	134
3	190	182	178	179	168
4	224	219	217	207	215
5	248	248	239	244	240
6	282	265	261	274	270
7	288	286	283	288	277
8	327	310	283	296	297
9+	364	342	296	350	310

The mean weights-at-age for mature 2-ring and older fish recorded during the July 1989 acoustic survey (see Section 2.4) are also included, and as in previous years these were close to those found in the third quarter catches and consequently used as best estimates of stock weights-at-age in the VPA (see Section 2.7).

Also of relevance to this section on changes in mean weights at age, is the analysis of longer-term changes in mean lengths at age presented in Section 8.

2.6.2 Maturity ogive

The percentage of 2- and 3-ringers likely to mature in 1989 was estimated from research vessel samples taken on the July acoustic survey. which covered the entire herring population in Divisions IVa,b.

The proportions likely to have spawned in 1989 (maturity stage 3 and above) were as follows:

2-ring	78.7%	(65.6%)
3-ring	93.9%	(89.7%)
Older	100.0%	(100.0%)

Values in parantheses are those for 1988.

There seems to have been a substantial increase in the proportion of potentially mature 2-ring fish in 1989, and, to a lesser extent, in 3-ringers.

2.7 State of the Stocks

2.7.1 Total North Sea

2.7.1.1 Data available for VPA

Fishery-independent estimates of stock size from larvae surveys and echo surveys in 1989 are presented and discussed in Sections 2.4 and 2.5. In addition, the average catch rates by age in the IYFS were considered. The estimates are compared to the time series in Tables 2.7.1 and 2.7.8. In Table 2.7.1, the estimates are given by age groups. The acoustic estimates are back-calculated to 1 January each year to take account of a variable proportion of catches taken before the survey. The larval production estimates (LPE) were age-disaggregated by using the age distribution estimated at the acoustic surveys. Except for 1987, the LPE corresponds to the date of 67% cumulative annual catch (Figure 2.7.1), which is the reference date for the spawning stock estimated by the VPA. The 1987 LPE is decreased by 9%, because the catches of spawners between the survey date (1 September) and the 67% catch date (3 November) was 9% (75,000 t) (Table 2.7.10 in Anon., 1989d) of the 1989 VPA estimate of the spawning stock in 1987.

2.7.1.2 Choice of VPA-tuning method

Based on Table 2.7.1, a VPA was made following the ACFM recommendations for tuning VPAs as given in the "blue pages".

By applying the age distribution from the acoustic survey on the LPE index, the LPE index will only be used to adjust the acoustic SSB level, although the age distribution from the acoustic survey will be weighted slightly more compared to the IYFS data than otherwise.

The LAI was not used because its information is contained in the LPE, and because an analysis showed that the residuals from a correlation of the LAI with the VPA were highly correlated with the residuals from a correlation of the LPE with the VPA. The other input data are given in Tables 2.7.2-2.7.4. The tuning diagnostics and the outputs are given in Tables 2.7.5-2.7.7.

The Working Group had difficulties in accepting the above VPA for the following reasons:

1) According to Figure 2.7.1, the acoustic estimates are very close to the absolute SSB estimates for the converged part of the VPA, here regarded as estimates from 1986 and backwards in time. The VPA gave a very high SSB estimate in 1989 of 1,530,000 t, which is slightly higher than the acoustic survey estimate of 1,490,000 t, but the SSB estimates from the VPA for 1987 and 1988 were very much higher than the acoustic estimates (1,010,000 t compared to 670,000 t in 1987, and 1,260,000 t compared to 800,000 t in 1988). In a tuned VPA, it would be preferable to have a kind of minimum sum of squared deviation between the tuning data and the VPA.

2) The Working Group had difficulties in interpreting the estimation of catchabilities (q) in the tuning procedure in terms of more standard statistical procedures, such as least square mean or maximum likelihood estimates; the Working Group had the impression that the ACFM procedure seemed to amplify the variation in the tuning data instead of damping it, at least in the present situation.

The last point was illustrated by running a tuning of the VPA only using the acoustic surveys. The result of this tuning in terms of SSB is shown in Figure 2.7.2, where SSB is plotted against acoustic estimates. As can be seen, the SSB from the VPA for the last three years are very much above the regression line fitted using the converged part of the VPA, i.e., before 1986. The VPA-estimated SSBs are 1,120,000 t in 1987, 1,500,000 t in 1988, and 1,960,000 t in 1989. Thus, by using the acoustic data alone, the VPA estimates a much higher SSB than the acoustic estimate itself in 1989, and for 1987 and 1988, the VPA values are very much higher. From the figure it can further be seen that the VPA from the tuning is not given the least sum of squares deviation between SSB and acoustic estimates. The reason for that can be found in the calculation procedure used by the tuning programme which is as follows:

1. A starting VPA is done.
2. Based on this, catchabilities (q) are calculated and means of q are used in a new VPA.
3. New qs are calculated.
4. A new VPA is done.
5. Go to 2,

until 10 VPA's have been done. If the acoustic estimate in the second last year is an underestimate, the q in the last year will be underestimated too. This is because it is calculated as the mean over a given range of years and if the acoustic herring survey in the North Sea is an overestimate in 1989 the tuning procecdure will amplify this overestimate, especially if only a few years are included in the tuning as recommended. However, the main problem is that there is no mechanism in the tuning procedure that produces the least sum of squares (ls mean) estimate.

Therefore, instead of the method recommended by ACFM, the procedure used last year was again used this year. However, it was recognized that it is not the optimal method, because it does not take into account the age structure in the tuning data and because it is a non-standardized ad hoc method.

2.7.1.3 Agreed VPA tuning procedure and VPA results

Fishery-independent estimates of spawning stock biomass derived from IYFS, larvae surveys, and acoustic surveys are shown in Table 2.7.8, together with the spawning stock estimates from the reasonably converged part of the VPA. The acoustic estimates are reduced by the catches of spawners taken between the time of survey and the 67% catch date ("spawning time" in the VPA). Each time series of survey estimates were regressed individually with the converged part of the VPA by using the RCRTINX program. Predictions based on each regression were weighted inversely to its variance to give average weighted predictions for the years 1987-1989.

The larvae abundance indices (LAI) and the larvae production estimates (LPE) contain the same information, and the LAI was shown to have the largest variance. Therefore, the LAI was not included for the average predictions. Because of the likely time trend in the spawning stock, the predictions were not shrunk towards the mean. The output of the RCRTINX program is shown in Table 2.7.9.

Separable VPA runs with different input Fs were made, and the one giving the least sum of squared residuals for the VPA spawning stock compared to the weighted predicted values for 1987-1989 was chosen.

The outputs are shown in Tables 2.7.10-2.7.12 and Figures 2.8.1A and B. This present assessment shows a constant fishing mortality at about 0.5 for 3-ringer and older fish during the years 1986-1989. The spawning stock has during the same period increased from 0.85 to 1.26 million t. The latter value is about 30% above the spawning stock predicted at the 1989 Working Group meeting, in spite of a considerable overshooting of the TAC (Section 2.1.1). The present assessment shows a spawning stock of 1.10 million t in 1988 compared to 0.82 million t in last year's assessment. The main reason for these differences seems to be the variability in the survey estimates. In addition, slightly increased values of mean weight at age and proportion of maturity are applied for the year 1989 in the present assessment.

2.7.2 Southern North Sea (Divisions IVc, VIId)

The southern North Sea is considered a separate management unit within the North Sea, because the population spawning in this area is clearly separated from the other North Sea components during a large part of the year (October-February). Historically, this population has always been exploited at a higher rate than other North Sea populations, probably due to the accessibility of the smooth spawning grounds to bottom trawling. Because of the higher vulnerability of this population, attempts have been made to give it special protection in the form of a separate TAC for Divisions IVc and VIId within the overall North Sea TAC.

Assessment of the southern North Sea herring has been hampered by the lack of information concerning the catches taken from this population in summer, when the fish are mixed with other North Sea components. A VPA performed on catches taken in the southern North Sea (Table 2.7.13-2.7.15) will give a rough estimate of Z in earlier years, but a misleading picture of absolute stock sizes. It cannot be used, therefore, as a starting point for a stock and catch prognosis. An additional problem is that 1-ringed recruits to this population cannot be separated from other North Sea recruits, and that a separate recruitment forecast for the southern North Sea, therefore, cannot be made.

Assessments of this population in previous years have been based on results of larvae surveys, and on the age composition of catches taken in the southern North Sea. Larvae surveys showed a rapid increase in stock size from 1978 to 1981, but since then the increase in stock size was halted (Tables 2.5.2-2.5.4). The catch composition in the years since 1980 has always shown a low number of fish with more than 3 rings, which, in combination with a constant stock size, indicated a high total mortality (in the

order of 1.0).

Data from the commercial fishery and from larvae surveys in the 1989/1990 season indicate a renewed recovery of the population, after a stand-still of 8 years. Results from larvae surveys, although incomplete, show an increase of the LAI by more than 80% compared to the previous 4 years. It should of course be noted that results of larvae surveys are generally too variable to use them as point estimates of stock size. However, the increase in larvae in 1989/1990 is sufficiently great to take as an indication of an increase in stock size. The information from larvae results is corroborated by information from fishermen who reported a sharp increase in abundance of herring in the southern North Sea.

The breakdown of the catch in numbers at age for 1989 shows an increase in the number of older fish. The percentage of 4+ ringers increased from less than 20% prior to 1987, to 20-40% in 1987-1989. Combining this information with the apparent increase in stock size, it may be taken as a first indication of a decrease in F on this stock.

2.8 Projection of Catch and Stock Size - Total North Sea

Input data used for the prediction are presented in Table 2.8.1. Recruitment of 1-ringers for 1 January 1990 was set equal to the 1990 IYFS estimate. To calculate the recruitment in 1991, the regression between IKMT indices and VPA estimates of 0-ringers was used to estimate the abundance of 0-ringers in 1990 from the 1990 IKMT index. This number was then projected forward to 1 January 1991, based on the assumption that the mortality rate for 0-ringers was equal to the average for the years 1985-1988 as calculated by VPA. The geometric mean of VPA estimates of 1-ringers for the years 1983-1988 was used for recruitment in 1992.

Number of 2-ringers at 1 January 1990 was taken as the arithmetic mean of the 1989 IYFS and acoustic survey estimates after both had been projected forward to 1 January 1990.

The remaining input values for the prediction are either calculated from the 1990 separable VPA or used as input to it.

Table 2.8.2 and Figure 2.8.1D present the prognosis for 1990, 1991, and 1992. It is based on an assumed catch in 1990 equal to the agreed TAC of 415,000 t. This catch corresponds to an average fishing mortality rate for age groups 2-6 of 0.33 and a spawning stock in 1990 of approximately 1.26 million t. These values are close to those predicted by the 1989 assessment. Also shown is a prediction based on a catch of 559,000 t in 1990, which is equivalent to F = 0.47, the same as in 1989 (Figure 2.8.1E).

For 1991 and 1992, the predictions are given for catch options corresponding to an average fishing mortality rate of $F_{0.1}$, F = 0.3, F_{max}, and the actual F for 1989.

A more detailed output of the predictions for 1990, 1991, and 1992 with an F = 0.3 in 1991 and 1992 is presented in Table 2.8.3.

Table 2.8.4 shows the prognosis using an age 2 knife-edge matu-

rity ogive, but otherwise the same input data as shown in Table 2.8.1.

2.9 Management Considerations

2.9.1 Management advice for total North Sea

The management objective in recent years has been to increase the North Sea spawning stock to a level of 1.5 - 2.0 million t (or even 2.2 million t) in order to buffer the annual TAC against recruitment fluctuations.

Although the results of the present assessment indicate a spawning stock size which is considerably larger than the one estimated last year, the target level of at least 1.5 million t has not been reached. Predictions for the next two years show that the present spawning stock size of 1.2 million t is not expected to grow any further, due to a declining trend in recruitment. It can be stabilised by reducing F to a level of 0.30 in 1990 and subsequent years. In this case, the TAC in 1991 and 1992 can be kept at the same level (360,000 t). If the reduction in F will not be introduced until 1991 (and F remains the same in 1990 as it was in 1989) the reduction in catch between 1990 and 1991 will be much larger: from 560,000 t in 1990 to 320,000 t in 1991.

A continuation of the present F until 1992 will reduce the stock below 800,000 t, which is considered to be the minimum level necessary for the production of average recruitment. In this case, very drastic measures may be required in 1992 and subsequent years. It should be pointed out that the evidence for a decline in recruitment is rather firm, and that warnings for a decline in stock size should, therefore, be taken seriously. The Working Group thus advises no revision of the TAC for 1990. The present TAC of 415,000 t will result in an F of 0.33, which is already somewhat above the target F of 0.30.

If the TAC of 415,000 t in 1990 is adhered to, the TAC for 1991 could be set at a maximum of 360,000 t. However, if fishing mortality in 1990 is kept at the same level as in 1989, the TAC will be considerably overshot, and the actual catch will be around 550,000 t. In this case, the TAC for 1991 should be set at 320,000 t in order to achieve a reduction of F to 0.30.

The Working Group, therefore, advises that enforcement of the TAC regulations should be improved in 1990. If this is not done, a sharp reduction of catch will be necessary from 1990 to 1991, in order to bring F down to the required level.

In view of the downward trend in recruitment, further efforts should be made to conserve juvenile herring, both in the North Sea and in Division IIIa. In the North Sea, this could be achieved both by a better enforcement of existing regulations for the industrial fishery (minimum landing size and correct reporting of species composition), and by a reduction of discards in the consumption fisheries. Protection of juvenile North Sea herring could also be achieved by a further reduction of the mixed clupeoid TAC in Division IIIa and a reduction of juvenile herring by-catches in this area (see Section 2.9.3).

The Working Group recommends the continuation of existing measures concerning sprat box, minimum landing size, mesh size, and spawning ground closures in the central North Sea.

2.9.2 Management advice for southern North Sea (Divisions IVc, VIId

The precautionary TACs of 30,000 t that applied to this area in recent years was intended to reduce F below the very high level experienced in the early 1980s, and to rebuild the population of southern North Sea herring towards the size it had prior to the period of overfishing. The TAC of 30,000 t was considered as a kind of precautionary TAC, which would be increased once there would be clear signs of an increase in population size, and a reduction in F.

The assessment presented in Section 2.7.2 indicates that there have been indications of an increase in stock size in 1989. It may be argued, therefore, that a moderate increase in TAC level would now be justified. One has to be very careful, however, not to over-react to the first sign of stock increase. It cannot be quantified how large the increase on stock size really is, and what the present level of F is. Also, considering the downward trend on overall recruitment in the North Sea stock, it is uncertain whether recruitment to the southern North Sea population will keep at its present level in the next years. However, considering that the population has shown an increase in recent years, a modest increase of the TAC to a level of 40,000 t, starting with the 1990 season, seems to be justified.

The Working Group is concerned about the very large over-shooting of TACs in recent years. Without better enforcement, the present TAC has very little conservation value. If catches keep exceeding the TAC in future years, it is most likely that the recovery will soon come to an end, and turn into a decline again. In that case, there will be no alternative but to protect the herring in this area by introducing closed seasons, an option which is strongly objected to by some of the fleets exploiting this resource. The Working Group, therefore, stresses that management bodies should try to improve the enforcement of the TAC in this area.

2.9.3 Management of juvenile fisheries

Table 2.2.2 shows the number of 0- and 1-ringers taken in the North Sea since 1970, and Table 2.2.3 shows the estimated number of 0- and 1-ringer autumn spawners taken in Division IIIa. Sections 3.1.2 and 3.1.3 describe how the figures in Table 2.2.3 are estimated.

The estimated Division IIIa catches of 0- and 1-ringers are for some years higher than the North Sea catches of the same year classes. Those for 2-ringers are generally low except during 1989 when it was 61% of the catch of 2-ringers in the North Sea.

Even if the basis for the racial split for the years prior to 1987 is rather weak, the Working Group considered that these catches give additional information on the North Sea year classes as 0- and 1-ringers, and a catch-at-age table, including these catches, was worked out (Table 2.9.2). In this table, the Divi-

sion IIIa catches prior to 1980 are not taken into account. The Division IIIa juvenile catches were rather low in the period 1976-1979, and the autumn spawners contained in these catches would presumably make only a small impact on the North Sea plus Division IIIa catch.

To run a VPA based on the North Sea plus Division IIIa catches of North Sea autumn spawners, the reference F for 4-ringers (0.50), derived from the tuning on North Sea catches alone, was used as input for a new separable VPA. The resulting selection pattern is shown in Table 2.9.1. As this VPA is based on increased catch figures for 0-, 1- and 2-ringers, the resulting selection values for these age groups are larger than those given in Table 2.7.10, while those for older fish are quite similar in the two tables. The other input data for this VPA are the same as those used for the VPA based on the North Sea catches alone (Section 2.7.1).

The output of the VPA including Division IIIa catches of North Sea herring is shown in Tables 2.9.3 and 2.9.4. The estimated year-class strength as 0-ringers shows an increase of about 30% for the year classes 1983-1986, when compared to the VPA not including transfers (Table 2.7.12). The average fishing mortality for the year classes 1983-1986 as 0-ringers increases from 0.051 to 0.124 (Tables 2.7.11 and 2.9.3).

When comparing Tables 2.2.2 and 2.2.3, it appears that the exploitation on juvenile North Sea herring was heaviest in the North Sea during 1980-1983, then shifted over to Division IIIa for the period 1984-1988, and shifted back to the North Sea in 1989.

The largest Division IIIa catches of juveniles occurred in 1988. These catches correspond to a 318,000 t loss in yield of 2+ herring in the North Sea, according to the conversion factors suggested by the 1989 Working Group (Section 2.9.3.3, Anon., 1989). As the juvenile catches in 1988 amounted to 182,000 t, the net loss in yield for the North Sea and Division IIIa fishery combined is 136,000 t. The corresponding loss in contribution to the spawning stock is in the same order of magnitude as the loss in yield of the 2+ stock.

The juvenile catches in Division IIIa plus the North Sea decreased in 1989. This decrease is partly due to weaker year classes and partly due to the fact that the vessels exploiting juvenile herring have switched over to other fisheries.

The VPA (Table 2.9.3) shows that the fishing mortality for 0-ringers fell slightly below 0.1 following the introduction of the sprat boxes in 1984. A similar fishing mortality for the year 1989 seems to overestimate the strength of the 1988 year class compared to the IYFS-estimates (Section 2.3). This indicates that the fishing mortality on 0-ringers might have increased in 1989.

It is important to allow as much as possible of the 1988 and 1989 year classes to contribute to the spawning stock, as the projection shows a decline in spawning stock in 1982 at even moderate fishing mortalities. To achieve this, stricter enforcement of existing conservation measures is required. The agreed TAC for 1990 for the Division IIIa mixed clupeoid fishery of 65,000 t is a step in the right direction compared to the TAC of 80,000 t during earlier years. However, as the 1989 year class seems par-

ticularly weak, this quota alone may quite well lead to a considerable increase in the fishing mortality on 0-ringers. Therefore, to reduce the risk of a drastic decline in the North Sea spawning stock before a new strong year class appears, it is important to bring the TAC on the Division IIIa mixed clupeoid fishery down to zero as soon as possible, unless the species composition of the mixed small clupeoid fishery shows a drastic change towards sprat.

2.10 Requests from the Multispecies Working Group

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

The Multispecies Working Group have requested annual provision of quarterly catch-at-age data, together with weights-at-age in the catch and stock at spawning time for North Sea herring. The data for 1989 are provided in Table 2.10.1.

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 2.10.1.

A comparable breakdown of catches of spring spawners taken in the North Sea and transferred to Division IIIa is shown in Table 3.1.1.

2.10.2 VPA estimates of total biomass

The Multispecies Working Group has commented on the large differences in total biomass of North Sea herring estimated by the multispecies VPA and the single species VPA.

This difference is mainly explained by differences in mean weight at age. The single species VPA applies third quarter weights-at-age when estimating stock biomass, even at 1 January when the 0-ringers and 1-ringers are less than half their third quarter weights.

To have more realistic estimates, the present VPA outputs show total stock biomass at 1 September in addition to the unrealistic estimates for the beginning of the year (Tables 2.7.12 and 2.9.4).

2.10.3 Geographical distribution of the catches in the North Sea 1989

Data on the geographical distribution of catches in the North Sea (Sub-area IV and Division VIId) in 1989 were available from Denmark, the Netherlands, Norway, and the UK. The data represent about 95% of the total catch, and include both juveniles and adults. Figures 2.10.1-2.10.12 show the catch by ICES rectangles for each month, and the cumulative catch by month for the total North Sea is shown in Figure 2.7.1.

3 DIVISION IIIa HERRING

3.1 Stock Composition

3.1.1 Baltic and Division IIIa spring spawners in the North Sea

Details on the separation of the catches of spring spawners in the North Sea are given in Section 2.2.4.

The transferred spring herring totalled 19,869 t. Catch-at-age data with corresponding mean weights-at-age are shown in Table 3.1.1.

3.1.2 Stock composition in Division IIIa

The 0-group herring in all quarters and over the whole area was shown by vertebral counts to be totally dominated by North Sea autumn spawners. The vertebral counts for 1- and 2-group herring indicate a mixture of local spring spawners and North Sea herring. Aggregated length frequencies and mean vertebral counts per age group were available from the Swedish catches except from the catches of 1-group in the first two quarters in the Skagerrak. A modal length analysis was applied on disaggregated length frequencies by quarters and for the Skagerrak and the Kattegat separately. The results of the analysis were verified by mean vertebral values for each component.

The results of the analysis of the 1-group and the 2-group are shown in Table 3.1.2, and the proportions are summarized in the text table below.

		1-group		2-group	
Area	Quarter	N.S.	S.P.	N.S.	S.P.
Skagerrak	1	1.0	-	1.0	-
	2	1.0	-	1.0	-
	3	1.0	-	0.14	0.86
	4	1.0	-	0.16	0.84
Kattegat	1	1.0	-	1.0	-
	2	1.0	-	0.10	0.90
	3	-	1.0	-	1.0
	4	-	1.0	-	1.0

N.S. = North Sea autumn spawners.
S.P. = Spring spawners.

3.1.3 Division IIIa catches of North Sea herring during earlier years

Earlier Working Groups have made attempts to split the catches into spring and autumn spawners. Statements from the Working Group reports (1981-1989) are summarized in Table 3.1.4. Only in the catches for 1987 and 1988 is this proportion quantified for the whole catch.

Age breakdown for the total Division IIIa catches is available

from 1974 on, except for 1985 and 1986 (Table 3.1.3). Gross estimates for these two years are obtained as follows:

151,000 t of the catch in 1985 were split into age groups, giving 1,245 million 0-ringers and 1,208 million 1-ringers (Table 3.2.2, Anon., 1986). In addition, about 90,000 t of 0- and 1-ringers were taken in the industrial fishery in last half of the year. If it is assumed that 45,000 t is taken in each of the quarters 3 and 4, and the proportion between 0- and 1-ringers in each quarter is the same as that in the sampled part of the catch, also the mean weights are 10 and 40 grams in the third quarter and 15 and 55 grams in the fourth quarter, then the 90,000 t divides into 2,698 million 0-ringers and 1,240 million 1-ringers. These figures are added to the sampled part of the catch and the sum is rounded off in Table 3.1.3.

The lastest figure for the total Division IIIa catch in 1986 is 212,349 t (Table 3.2.1). The 1987 Working Group reported that 65,007 t of 2-ringers and older were taken in Division IIIa (not including spring spawners taken in the North Sea). This means that the remaining 147,342 t were 0- and 1-ringers. The sampling in 1986 was inadequate to split the catch of juveniles into age groups or to estimate mean weights by age. The IYFS in 1986 showed a very high abundance of 1-ringers, whereas the 0-ringers seem to have been comparatively "weak" in 1986 judging from the IYFS index for 1-ringers in early 1987 (Table 3.4.1). It is, therefore, reasonable to assume that the juvenile catches had a larger proportion of 1-ringers in 1986 than in the previous years. If we assume an equal catch in numbers of 0- and 1-ringers and annual mean weights equal to the average for 1987 and 1988 (10 and 30 grams, Table 3.2.4), then we arrive at the rounded off figures given in Table 3.1.3.

For the years 1980-1986, the IYFS catches of 1- and 2-ringers are split into spring and autumn spawners (Table 3.1.5). These have been used to estimate an annual average which is considered as a best estimate of the proportion in the catch in cases where they are not in conflict with statements in the reports (Table 3.1.4). The annual average proportion of North Sea 0-group is assumed equal to the proportion observed for 1-ringers in the IYFS for the same year class. The annual average of 1-ringers is assumed equal to the average IYFS proportion of 1-ringers in the same year and 2-ringers the following year. The annual average for 2-ringers is assumed equal to half the IYFS proportion of 2-ringers. These estimates of annual means are listed in Table 3.1.5, together with the best estimates of the proportion of North Sea herring in the catches. The best estimates are applied to the catches given in Table 3.1.3 to arrive at the catches of North Sea Herring in Division IIIa (Table 3.1.6)

3.2 The Fishery

3.2.1 Landings

The landings from Division IIIa by countries are shown in Table 3.2.1. Preliminary data provided by Working Group members show a total catch in 1989 of 172,000 t, which is significantly lower than the 1988 landings of 330,000 t. The total catch in 1989 is lower than the catches in the 6 previous years. The relative decrease is 57% in the Skagerrak and about 34% in the Kattegat.

The proportion of landings from the small mesh clupeoid fishery was about 30%, and the rest was taken in the human consumption fishery with 32 mm mesh as in 1988.

The total Danish industrial landings from Division IIIa were reduced from 1988 to 1989 with approximately 135,000 t. One of the reasons for this reduction in the landings is a shift in a part of the fleet from herring to Nephrops fishery and high Nephrops prices.

The major part of the Swedish landings was taken in a 32 mm fishery directed at herring. The Swedish landings of herring have declined from 107,000 t in 1988 to about 66,000 t in 1989.

3.2.2 Catch in number at age

National age distributions were applied to national catches when adequate data were available. A Swedish age distribution for trash herring in the Skagerrak in the second quarter, was combined with the age composition data for the first quarter and used to convert the catch in the first quarter to numbers. These data were applied to the Danish catches in first and second quarters. The results obtained in this way are shown in Table 3.2.2. The table includes all herring caught in Division IIIa.

The estimated catches in number and age of all spring spawners caught in the North Sea and Division IIIa are given in Table 3.2.3. These data will be added to the catches in southwestern Baltic to form the basis for the assessment.

The number at age of North Sea herring estimated to be taken in Division IIIa are shown in Table 3.2.4

3.2.3 Quality of catch and biological sampling data

Discarding has not been observed in the Division IIIa herring fishery during the last 10 years. Uncertainties concerning landings and species composition have mostly related to the small mesh fishery for industrial purpose and by-catches in the consumption fishery using 32 mm mesh. The landing statistics for herring for the consumption market have been of much better quality; misreportings of catches have been limited and when detected have been taken account of.

In 1989, Danish sampling for species composition covered the major fisheries, and the quality of total herring landings data is very much improved. Swedish sampling of all landings from the Kattegat was adequate, while sampling of by-catches in the Skagerrak fishery was less adequate, particularly in the first and second quarters when only one sample of trash herring was obtained. The Swedish log book statistics did, however, match the landings rather well in 1989.

The biological sampling by country and quarters are shown in Table 3.2.5. The total number of samples in 1989 was high but there are gaps, particularly in the second quarter in Skagerrak when the total catch of about 13,000 t was covered by only two samples. Overall, the quality of both landings data and biolo-

gical sampling in 1989 were an improvement compared to previous years.

3.2.4 ACFM advice and management applicable to 1989 and 1990

1989

In 1988, ACFM advised that the TAC for 1989 should not exceed 174,000 t for the adult spring-spawning stock in Division IIIa and Sub-divisions 22-24. To provide the management bodies with separate catch options for Sub-divisions 22-24 and Division IIIa, ACFM calculated the proportion of catches that would be taken in the two areas. The calculation was based on the assumption that the relative levels of fishing mortality and exploitation pattern in the two areas remain the same as in recent years. The predicted catch of 2-group and older in 1989 was 84,000 t in Division IIIa. The TAC for "mixed clupeoids" was recommended to be set at not more than 80,000 t in 1989.

The agreed TACs for Division IIIa were 138,000 t in the herring fishery and 80,000 t in the mixed fishery giving a total of 218,000 t, which was the same as agreed in 1987 and 1988.

The preliminary estimate of the total herring landings in 1989 of 172,000 t represents about 80% utilisation of the agreed TACs. The landings of 2-group and older were about 71,300 t, and this represents 85% of the predicted catch in Division IIIa.

1990

The recommended TACs for the herring fisheries in Division IIIa are:

- adult herring 67,000 t,
- mixed fishing not more than 60,000 t.

The agreed TACs of 1990 are:

- herring fishery 120,000 t,
- mixed fishery 65,000 t.

The agreed TACs represent a minor reduction compared to the TACs in 1987-1989.

3.3 Acoustic Surveys

Acoustic surveys in 1989 were carried out in June-August and in November - early December. The summer survey covered the whole of Division IIIa and the autumn survey mainly the Skagerrak. Details of the surveys are given in Section 2.4.1 and in the Report of the Acoustic Surveys in Sub-Area IV and Divison IIIa (Anon., 1990).

The estimated stock of Division IIIa and Baltic spring spawners in the eastern North Sea and Division IIIa was 2.3 x 10^9 herring or 256,000 t (Table 3.3.1). The estimate of the adult stock of 3-group and older, 184,000 t, is close to the spawning stock of 220,000 t predicted in 1989, allowing for catches taken prior to

the survey.

The abundance of 0- and 1-group (mainly North Sea autumn spawners) was very much lower than in recent years. The trend of reduced abundance of juvenile herring in Division IIIa is corroborated by the acoustic estimate in November-December and by the IYFS results in 1990 (see Section 3.4).

3.4 Recruitment

3.4.1 General remarks on the 1990 IYFS

The 1990 IYFS was carried out in February and a total of 45 hauls were made. All standard stations were sampled. The survey was hampered by unusually bad weather conditions with almost continuous gale force winds and frequent storms. The water temperature was higher than normal.

3.4.2 Abundance of 1-group herring

The final index of 1-group herring in 1990 was 3,544, which is very much lower than the indices in 1985-1989, and only 5% of the very high 1988 index. Indices from the IYFS during 1980-1990 are given in Table 3.4.1. The mean vertebral counts of the aggregated 1-group herring per depth strata reveal that all herring were North Sea autumn spawners as shown in the text table below.

Stratum (m)	Mean length (cm)	Mean VS
1. 10-34	16.8	56.38
2. 34-44	17.0	56.38
3. 45-65	16.2	56.29
4. 66-100	15.7	56.35

3.4.3 Abundance of 2-group herring

The 2-group total index in 1990 was 3,876 which is slightly above the mean for the period 1980-1989 (Table 3.4.1). The length frequency distribution indicated at least two modes and a modal length analysis was applied. The results of the split are shown in Table 3.4.2. The mean VS of the components suggest that the separation in strata 1 and 2 was good with VS close to expected pure stocks values. In strata 3 and 4, mainly the northern Kattegat and Skagerrak, the VS values of 56.05 and 56.06 indicate that these components are not pure spring spawners; nevertheless, two components have been assigned to spring spawners as the values indicate a majority of spring spawners. The abundance of 2-group herring in strata 3 and 4 was low compared to the other strata but the area weights for strata 3 and 4 are low and so the effect on the indices of spring and autumn spawners will be minor. The resulting indices are given in Table 3.4.1, and the proportion of spring and autumn spawners per stratum are given in the text table below.

Stratum (m)	Spring spawners	Autumn spawners
1. 10-34	0.85	0.15
2. 35-44	0.66	0.34
3. 45.65	0.61	0.39
4. 66-150	0.42	0.58

3.5 State of the Stock and Management Considerations

3.5.1 General remarks

The assessment of the combined Division IIIa and Sub-divisions 22-24 herring is the task of the Working Group on the Assessment of Pelagic Stocks in the Baltic. The results of the 1990 assessment will be given by that Working Group.

3.5.2 Management of juvenile fisheries

The juvenile fisheries in Division IIIa mainly exploit the North Sea autumn spawners, and the management and the consequences of this fishery are discussed in Section 2.9.3.

4 CELTIC SEA AND DIVISION VIIj HERRING

4.1 Introduction

The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj are considered to exploit the same stock. For purposes of stock assessments and management, these areas have been combined since 1982. The areas for which the assessment is now made together with the area for which the TAC is set by the EC are shown in Figure 4.1.1. It should be noted that, although the management unit covers all of Divisions VIIg,h,j and k and the southern part of Division VIIa, all the catches in recent years have come from the southern part of Division VIIa and from Divisions VIIg and j.

4.2 The Fishery in 1989-1990

4.2.1 Advice and management applicable to 1989 and 1990

The preliminary landings figure for 1989 was about 19,000 t, while the figure for the 1989/1990 season (1 April - 31 March) was about 19,600 t.

The TAC recommended by ACFM for this area for 1989 was 20,000 t. The figure was subsequently agreed and adopted by the EC.

The management of the fishery conducted by Ireland, which in 1989 took nearly 90% of the attributable catches, was conducted along similar lines as in 1988. The fishery was not opened until October 1989 and was closed again in February 1990. The system whereby selected spawning grounds are closed on a rotating basis and which was first introduced in 1988, was again continued

during 1989. The spawning grounds thus closed during 1989 included the important ones in the middle section of the Celtic Sea, as suggested by ACFM in 1989. In general, this closure was well observed and no illegal fishing took place in the area.

The total Irish quota was, as in recent seasons, divided into weekly quotas and further divided into boat quotas per week. All boats participating in the fishery are required to carry licenses, and the number of boats participating in the fishery was about the same as in 1989, i.e., 75. A small number of boats was required to leave the area for breaches of their licensing conditions. In general, it is felt that the overall management of the fishery has improved considerably in recent years, although there is still some doubt about the actual catches recorded by vessels.

4.2.2 Catch data

The reported catches from the combined areas by year and by season (1 April - 31 March) are given in Tables 4.2.1 and 4.2.2, respectively. The reported catch taken during 1989-1990 was 19,600 t, compared with 17,000 t during 1988/1989. This reported catch, as in recent years, does not include quantities of herring which were discarded at sea.

The main catch taken from the fishery during 1989/1990 was by Irish boats which exploited the spawning concentrations along the Irish coast during the October to February period. Over 2,600 t (i.e., 13%) of the total catch was placed in the "unallocated" category. As in recent years, the fishery was almost totally dependent on the Japanese "roe" market.

As has been pointed out in many of the recent Working Group reports, the level of discards has been a serious cause for concern. Herring are mainly discarded because they are not considered suitable for the Japanese roe market - either because the ovaries are not ripe or else because they may have a poor yield. Even though the level of discarding has been considered a serious problem, it has not been possible to obtain any reliable estimates of the total quantities involved. During 1989/1990, however, attempts were made to obtain some preliminary estimates by interviewing various people involved in the fishery. It was concluded that discarding during 1989/1990 was not as serious a problem as in 1988, and that it mainly occurred at the beginning of the season. Various estimates for the rate of discards were suggested - ranging from 10% to 50% of the overall catch. Since discarding began shortly after the re-opening of the fishery in 1982 and the subsequent development of the roe fishery, it is suggested that the true catches from 1983-1989 should be increased by approximately 20%. Although there is no firm evidence to select a figure of 20%, it does recognize the fact that discards are an appreciable problem in this fishery.

The length distributions of catches by the Irish fleet per quarter are shown in Table 4.2.3.

4.2.3 Quality of catch and biological data

As mentioned in the preceding section, the quality of the landing data has improved in recent years with the improved management, and more reliance can now be placed on the data. However, it is considered extremely important to obtain more reliable estimates about the level of discarding. There is a very good biological sampling of the landings throughout the season, and it is considered that the fishery is adequately sampled. The sampling data are shown in Table 4.2.4.

4.2.4 Catches in numbers at age

The total catches in numbers at age are shown in Table 4.2.5 and in percentages in Table 4.2.6.

As discussed in Section 4.2.2, a minimum estimate for discards of 20% of the overall catch has been suggested for the period 1983-1989/1990. The corresponding catch in number data for this period have, therefore, been raised accordingly.

The catches in numbers at age are based mainly on a large number of samples obtained from the Irish inshore fishery, but samples have also been obtained from the Dutch fishery. The catches throughout the season were dominated mainly by 3-winter fish, i.e., the 1985/1986 year class. This year class, which also dominated the catches during the previous season, was consistently well represented in all areas throughout 1989/1990.

4.3 Mean Weights at Age

In this fishery, most of the catch is now taken throughout the spawning period (i.e., October to February). The mean weights at age of the catch are, therefore, considered to be equivalent to the mean weights in the stock at spawning time. The mean weights, based on samples obtained from the Irish fishery, are shown below, compared with those for the previous three seasons.

Season	1	2	3	4	5	6	7	8
1986/1987	119	155	172	187	215	248	236	284
1987/1988	96	138	186	192	204	231	255	267
1988/1989	97	132	168	203	209	215	237	257
1989/1990	106	129	151	169	194	199	210	221

In most age groups, there has been a considerable decrease in the mean weight in 1989/1990 compared with recent seasons. As there has been no apparent change in sampling techniques during 1989/1990, and a similar decrease is observed in the mean lengths, the decrease must be considered to be a genuine one although there is as yet no apparent reason for it. The 1989/1990 values have, therefore, been used to update the values in the VPA data base but the values used for prediction purposes have been based on the means for the 1986/1987-1989/1990 period.

4.4 Stock Assessment

4.4.1 Herring larvae surveys

Larval surveys were resumed in this area during the 1989/1990 season. Surveys had been discontinued after the 1984/1985 season, having continued uninterrupted since they were started in 1978/1979. The 1988 Working Group had examined the relationship between the larval indices obtained from 1978/1979 to 1983/1984 and the estimates of SSB obtained from VPAs, and had suggested that the larval surveys would appear to give a reliable indication of spawning stock.

Six surveys were carried out from October 1989 to March 1990, using the RV "Lough Foyle" according to the procedures recommended by the International Herring Larval Working Group. The first three surveys, carried out during October and December, included both the Celtic Sea and Division VIIj and thus covered all the spawning grounds of the autumn-spawning components. The surveys during January to March were restricted to the spawning grounds of the winter-spawning component.

Results

In general, the surveys were severely hampered by the bad weather throughout the season. Water temperatures appeared to be unusually high (approximately 1.5 C^0 higher in 1989/1990 than the average of recent years), and spawning of both the autumn- and winter-spawning components appeared to be later than ususal. The abundance indices calculated from each survey are shown below:

Survey	Abundance Index (10^{-6})			Stations
	< 10 mm	10-15 mm	> 15 mm	
23-30 Oct.	71,150	15,650	3,704	72
21-25 Nov.	200,244	62,000	28,600	75
	< 11 mm	11-16 mm	> 16 mm	
12-19 Dec.	6,197	2,516	1,153	76
9-13 Jan.	0	1,524	703	53
12-13 Feb.	19,510	0	0	23
6-8 March	14,150	0	0	43

During the first survey (October) small larvae were located on a number of well-known spawning grounds south of Cork Harbour and north of Dingle Peninsula. Small larvae were distributed over a large area during the second survey (November) with high numbers being located off Dingle Peninsula, off Bantry Bay, Cape Clear Is, and off Dunmore East. The third survey (December) indicated reduced numbers of small larvae located mainly in the west of the survey area. No small larvae were located during the fourth survey (January), while the fifth survey (February) located small larvae on the traditional winter spawning areas off Cork Harbour and Helvick Head. An additional survey was carried out in March because the maturity distributions of fish indicated that spawning was later than usual. This survey located small larvae in the eastern part of the survey area, but failed to locate any larvae off Cork Harbour where the main fishery had taken place

for spawning herring in mid-February.

Estimation of Abundance Index

The abundance index for small larvae (< 10 mm for autumn spawners and <11 mm for winter spawners) has been calculated in the same manner as in previous years and has been described in the 1983 Working Group report (Anon., 1983).

The mean abundance for all surveys has been taken for both autumn-and winter-spawning components. The winter-spawning component has then been raised by a factor of 1.465 to allow for the different fecundity of both components. The mean abundance for both components are then summed to give an estimate for the total stock. The abundance indices (x 10^{-3}) thus estimated are:

Autumn Component	Winter Component (x 1.465)	Total
151.1	15.6	166.7

A comparison between the indices from the 1989/1990 surveys and the results from surveys carried out during 1978-1985 is shown below (number of surveys in brackets).

Year	Autumn	Winter (x1.465)	Total
1978/1979	10.8 (3)	1.0 (3)	10.9
1979/1980	14.4 (5)	3.4 (5)	17.8
1980/1981	11.5 (4)	8.9 (4)	20.4
1981/1982	24.6 (5)	1.5 (5)	26.1
1982/1983	22.0 (5)	5.2 (6)	27.2
1983/1984	58.5 (5)	15.6 (5)	74.1
1984/1985	56.3 (5)	53.4 (5)	109.7
1989/1990	151,1 (2)	15.6 (4)	166.7

The overall index is by far the highest recorded since the larval surveys were initiated. However, it should be pointed out that the high index for the autumn-spawning component was largely generated by a small number of stations which would not have been sampled in the surveys prior to 1983. The total Celtic Sea and Division VIIj areas were only surveyed in 1983/1984 and 1984/1985. In order to get an overall index for the whole area for the earlier surveys, the indices were, therefore, relcalculated, using a raising factor based on the production in both areas (Anon., 1985). The low numbers of larvae recorded during March do not seem to adequately reflect the spawning activity in the western part of the Celtic Sea during February, as indicated by the significant catches taken. The larvae may have been washed ashore because of the persistent gales or else the herring were prevented from spawning by the fishing activities.

4.4.2 Acoustic surveys

Acoustic surveys of Celtic Sea and Division VIIj were undertaken in October 1989 and January/February 1990. The surveys were made from RV "Lough Foyle" using a 38 kHz echosounder. In October, the survey covered the coastal area (within 17 nm of the coast) from

Loop Head on the west coast ($52^0$10'N) round to the east coast ($52^0$30'N). The acoustic survey gave disappointingly low estimates of herring, with very few significant soundings being recorded. The main areas of herring concentrations were in small bays on the west coast and near Cork on the south coast. These data do not agree with the data from the larval surveys which showed a large spawning off the west coast (see Section 4.4.1). However, the acoustic survey was approximately one month earlier than the larval survey.

In January/February, the acoustic survey was restricted to the south coast only, to reflect the major spawning areas at this time of the year. The acoustic survey once again gave disappointingly low estimates of herring with very few large aggregations being seen. However, both surveys were curtailed by very bad weather conditions. The surprising point was that fairly large catches, on substantial concentrations, were being made by the commercial fishery during the survey, in areas which were being surveyed. A large aggregation of herring was noted in the vicinity of Cork Harbour just after the completion of the February survey. This was, of course, not included in the survey.

The data for the acoustic survey are not presented here, as the January/February survey results are not available at present. Both survey results are required for a full acoustic assessment of this stock.

Further acoustic surveys of these areas are planned for 1990/1991.

4.4.3 Estimates of stock size from VPA

In recent years the Working Group has been unable to make any realistic estimates of stock size for this area. This was mainly because of the lack of fishery-independent estimates of stock size and doubts about the catches in number data because of the uncertainty about the level of discards. The last VPA on what was then considered to be reliable data was carried out by the Working Group in 1986. This gave estimates of spawning stock biomass of between 74,000 t and 87,000 t in 1983 and 1984. A VPA was also carried out by the 1988 Working Group but was used only as a method of obtaining converged values of SSB which were then used to compare with the larval abundance indices (LAI) for the period 1978-1983. However, because of the most recent information available about the recent catches which have been revised to include discards, both these VPAs must be considered to be unreliable. If the 1989/1990 estimate of LAI is used to calculate SSB, using the regression calculated by the 1986 Working Group, the value of SSB obtained is unrealistically high. Unfortunately, therefore, the 1989/1990 LAI cannot be used, as had been hoped, to obtain an estimate of SSB.

Both the 1989 Working Group and ACFM at its May 1989 meeting had expressed concern about the high proportion of young fish present (60% 1985/1986 year class) in the 1988/1989 catches in numbers at age and in the relative scarcity of older fish. It was suggested, in the absence of any information on recruitment, that this high dependence on young fish could have meant a rapid increase in fishing mortality in 1988/1989. However, catch curves have not been used to estimate F, because, as pointed out by ACFM, their

use in time of high recruitment is not very desirable.

The 1989/1990 catches in numbers at age, however, have again contained a large proportion of the 1985/1986 year class distributed throughout the catches. This year class is also very well represented in the catches in the adjacent areas (Divisions VIIa, VIa (South), and VIIb) and also in the North Sea. Therefore, it can be assumed with some confidence to be a strong one. At the same time, although the LAI obtained from the surveys carried out during 1988/1990 cannot be used to calculate the spawning stock, the index is itself the highest recorded and would not suggest a stock that is in danger of collapse.

The fishery in recent years has been carried out along very similar lines and both the catches and catches in numbers at age have been very consistent since 1984. In addition, the fishery has been affected by poor markets which have largely curtailed effort at about the same level. It is, therefore, reasonable to assume that the levels of fishing mortality could have been somewhat stable in recent years. A series of VPA was run on the catches in numbers at age, which include the estimates of discards in an effort to select a value which would indicate some stability in F in the recent years and would suggest an increase in SSB which is consistent with the increase in SSB suggested by the larval surveys. The most appropriate input F_{1-7} value appeared to lie somewhere around 0.3. However, an examination of F values over the 1958-1989 period showed that F_{1-7} values in the past have not reached as low a value of 0.3. An input F_{1-7} value of about 0.4 in 1989 indicated a stable stock biomass of around 80,000 t between 1988 and 1989 and was considered to be a more conservative value and was accepted as more appropriate because of doubts about the quality of the data.

4.4.4 Results from VPA

A separable VPA was carried out, using reference for age 2-rings, terminal S of 1.00 and terminal F of 0.4 (Table 4.4.1). The maximum exploitation at age 2 rings was chosen because this age group has in recent years dominated the catches with the exception of the most recent season. The exploitation pattern derived from SVPA was domeshaped with maximum exploitation of 4 and 5 ringers. An ordinary VPA was then carried out, using the exploitation pattern derived from the SVPA and the terminal population numbers. The results of the VPA are shown in Tables 4.4.2 and 4.4.3 and Figures 4.2.A and 4.2.B. The average F values calculated are as always for this stock quite high and have fluctuated very considerably since 1970, ranging from 0.82 in 1984 to 0.33 in 1988. Even in the period of the partial closure from 1977 to 1982, average values of F_{1-7} = 0.51 were recorded. The spawning stock biomass has been reasonably stable since 1983, averaging about 66,000 t. Recruitment of 1-ring fish appears to have been at a high level from 1981-1988 compared with low levels during the 1974 to 1980 period.

It must be emphasized that although this VPA is the most realistic that can be carried out on the available data, the results must be treated with caution. This is particularly so because of the tentative estimates on the levels of discards. The VPA shows very clearly the consistently high levels of F which have always been a feature of this stock.

The stock/recruitment plot is shown in Figure 4.1.

4.5 Recruitment

There are no independent estimates of recruitment for this stock. Previous Working Groups have used geometric means of the numbers of 1-ring fish calculated for different periods from the VPA to obtain an estimate for the prediction. The numbers of 1-ringers that have been calculated by VPA show a period of relatively high recruitment from 1981 to 1987 which followed a long series of low recruitments from 1970 to 1980. The geometric mean level of recruitment was, therefore, calculated over the ten year period 1978-1987. This figure was calculated as 390 million.

4.6 Catch and Stock Prediction

Catch and stock predictions were carried out for this stock, using the stock numbers calculated from VPA and GM recruitment of 390 million fish for 1990-1992. The input parameters are shown in Table 4.6.1. The catches, which include discards, assumed for 1990 are 17,500 t, which is equal to the agreed TAC, and 23,000 t, which is at about the same level as the catch in 1989. Catch options for 1991 were based on $F_{0.1} = 0.16$; $F_{91} = F_{90}$, and $F_{med} = 0.24$. The results are shown below for both options and Figure 4.2D shows the results for Option B.

Option A

1990			1991			1992
F	SSB	Catch[1]	F	SSB	Catch[1]	SSB
0.28	72,200	17,500	$F_{0.1} = 0.16$	72,000	10,500	76,500
			$F_{med} = 0.24$	70.800	15,300	71,100
			$F_{90} = 0.28$	70.200	17,700	68,300

Option B

1990			1991			1992
F	SSB	Catch[1]	F	SSB	Catch[1]	SSB
0.39	70,800	23,000	$F_{0.1} = 0.16$	67,000	9,600	72,600
			$F_{med} = 0.24$	65,900	13,900	67,600
			$F_{90} = 0.39$	64,000	21,300	59,300

[1] Including discards.

The prediction for both options show that a continuation of the F at the 1990 level or at F_{med} will produce a small decrease in the spawning stock between 1990 and 1992, whereas fishing at $F_{0.1}$ will produce a small increase in the spawning stock but reduce catch levels to about 10,000 t.

4.7 Management Considerations

As has been pointed out, this assessment and prediction are based on very limited data, and the conclusions must be treated with caution. However, the analysis indicates that the present catches will produce a decrease in spawning stock. It is difficult to decide at what level catches should be maintained. A continuation of the present TAC level (17,500 t) in 1991 would result in a decrease in SSB under both options. It must be emphasized strongly, however, that any recommended TAC based on the above analysis must include discards. Because of this, it is imperative that the management of this fishery should include sufficient measures that will ensure that either discards are eliminated or they are included in the overall catch statistics which are used to monitor the TAC.

4.8 Management Considerations about Closures of Spawning Areas

The closures of spawning areas were discussed in detail in the report of the 1989 Working Group.

The system of rotational closures of selected parts of the spawning areas was introduced during the 1988/1989 season and was continued during 1989/1990. It will again be implemented during the 1990/1991 season when the third selected areas, i.e., the important spawning beds in the eastern part of the Celtic Sea will be closed for a period during January 1991. In an effort to evaluate the effectiveness of these spawning bed closures, ACFM suggested in May 1989 that larval surveys and controlled trial fishing should be carried out during the closed season and that an analysis of past maturity data and catch data should be undertaken. These suggestions have only partly been carried out. Larval surveys were carried out during 1989 in the spawning box which was closed during November. However, no small larvae were taken during the survey, and it is not possible to speculate on the extent of the spawning, if any, which may have occurred. The Working Group is unable to quantify the effectiveness of these spawning closures without the provision of the required data. It is, therefore, suggested that the subject be reviewed at the 1991 meeting of the Working Group before the system is re-introduced during 1991. The Working Group, however, stresses that, in general, they are in agreement with the views expressed about the closures of these spawning areas and it believes that this type of management measure should be supported.

5 WEST OF SCOTLAND HERRING

5.1 Division VIa (North)

5.1.1 ACFM advice applicable to 1989 and 1990

The recent levels of fishing mortality on this stock are estimated at less than $F_{0.1}$. The ACFM advice is to keep fishing mortality at $F_{0.1}$ in order to maintain a buffer stock and allow stable catches. It was also pointed out that F_{med} would be an unstable target F in this case, because of its sensitivity to a few recent year classes in the stock and recruitment plot.

5.1.2 The fishery

The catches reported for each country are given in Table 5.1.1. For the second year in succession the TAC was not reached. The agreed TAC in 1989 was 58,000 t and the preliminary total catch is 53,039 t. These compare with an agreed TAC of 49,800 t and a catch of 47,354 t in 1988. Both catches are considerably lower than in previous years (63,007 t in 1987 and 81,699 t in 1986). The reduction can be accounted for by the reduction in the levels of unallocated catches (including discards) from 37,840 t in 1986 to 3,673 t in 1989.

5.1.3 Catch in numbers at age

Age composition data for 1989 were available from Scotland and the Netherlands. Unallocated catches and catches by Ireland, France, the Federal Republic of Germany, and England were converted to numbers at age using the Dutch catch-at-age data. As in previous years, the Scottish data were not used for other landings because of the high proportion of catches from the Minch. The sampling effort used to derive the catch in numbers is summarized in Table 5.1.2.

The estimated catch in numbers at age for the years 1970-1989 are given in Table 5.1.3.

5.1.4 Larvae surveys

Final estimates of both the larvae abundance index (LAI) and the larval production estimate (LPE) were available to the Working Group. The series of both indices from 1973-1989 are shown in Table 5.1.4.

The 1989 value of the LAI is 4,320. This is about 35% lower than in 1988, halting the increasing trend since 1984. The LPE index shows a similar decrease from 1988 to 1989.

5.1.5 Acoustic survey

Acoustic surveys in Division VIa(N) have been carried out by RV "Scotia" during November in 1983, in 1985-1987, and during December 1988. Another survey in the series was attempted during January 1990, but severe weather prevented coverage adequate for even minimum estimates of stock biomass. No acoustic survey estimate is, therefore, available.

5.1.6 Recruitment

In previous assessments, information on recruitment was obtained from the number of 1-ringers found during the winter acoustic surveys and from an index of 2-ringer abundance from bottom trawl surveys carried out in March each year.

Neither figure has been reliable. The acoustic surveys were originally carried out in November when the migration of 1-ringers from the North Sea may not have been complete. The survey was moved to December in 1988 and then to January in 1990

in an attempt to improve the recruitment estimate. Unfortunately, poor weather disrupted these last two surveys and prevented any estimates of recruitment. The index from the trawl survey is based on the mean catch rates of 2-ringers in statistical rectangles 46E4-E6, 47E4-E6, 44E3-E4 and 45E3-E4). The index is very variable and is only used as qualitative evidence of year-class strength.

The series of indices and the number of hauls used in their calculation are shown in Table 5.1.5. The indices for 1989 and 1990 are preliminary since they are based on the age/length key from the North Sea IYFS. The 1990 index would suggest poor recruitment in 1990, but until a time series is established which is long enough to evaluate indices, the likely level of recruitment in 1990 and 1992 was assumed to be the geometric mean of 2-ringers over the years 1980-1987 (586 million).

5.1.7 Mean weight at age

Weight-at-age data from the 1989 fishery were available from Scotland and the Netherlands and are shown in Table 5.1.6. The SOP for 1989 is 1.8% more than the reported catch. The mean weights at age in the stock are as used in previous years (Table 5.1.6).

5.1.8 Spawning stock biomass and fishing mortality in 1989

For the second year in succession no acoustic estimate of stock size is available. Last year's assessment was tuned to the 1987 acoustic survey estimate on the grounds that this was the most reliable recent estimate available. The larvae indices indicated stock sizes well outside the range of the converged part of the VPA and were thought to be unreliable.

This year's assessment cannot further rely on the 1987 acoustic survey, and the larvae indices are the only other fishery-independent estimates of stock size. Using the RCRTINX2 program, both the LAI and LPE indices were used to predict SSB in 1989. This was done by using the SSB estimates over the years 1973 to 1985 taken from last year's VPA to predict SSB from 1986-1989. The input F for 1989 was then chosen such that the sum of squared residuals between the predicted SSBs and those from the VPA for the years 1986-1989 was minimized.

5.1.9 Results of the assessment

Separable VPAs were run to examine the catch-at-age data. Down-weighting all years prior to 1982 and using S values of 1 at ages 3 and 8 again produced a dip in the exploitation pattern at age 7. In last year's assessment this was attributed to anomalies in the catch in numbers of 7- and 8-ringers in 1985/1986. Down-weighting these years resulted in a reasonably flat exploitation pattern over ages 3 - 8. A similar procedure was adopted in the present assessment, again producing a reasonably flat exploitation pattern and supporting the assumption that the catch data in 1985/1986 were indeed anomalous. The results of the separable VPA using an F of 0.145 are given in Table 5.1.7.

Last year, a completely flat exploitation pattern was assumed for ages 2 - 8, despite the results of the SVPA which suggested that 2-ringers were more lightly exploited. A similar result is found in the present analysis, so it was decided this year to use the SVPA fishing mortalities based on terminal populations directly.

In the RCRTINX2 program, all years were weighted equally in order to make full use of the converged part of the VPA, and the predicted values were shrunk towards the mean. The latter option recognises that the larvae indices are well outside the range of the converged part of the regression and maintains an element of caution. The sum of squared residuals for the years 1986-1989 was minimised at F = 0.145 (Figure 5.1.1). Figure 5.1.2 shows the trend in SSB from 1973 to 1989 using F = 0.145 in 1989. Also shown are the trends in SSB estimates at input fishing mortalities of 0.1 and 0.2. This illustrates that the VPA for this stock has largely converged by 1985, the last year used for the regression in RCRTINX2. The results of the RCRTINX2 analysis are given in Table 5.1.8. The SSB estimates for the years 1986-1989 are summarised in the text table below.

Year	VPA estimate (1989 assessment)	Weighted average prediction	VPA estimate (F = 0.145)
1986	330	337	248
1987	361	321	252
1988	492	449	444
1989	-	407	449

Figures 5.1.3 and 5.1.4 show the relation between the LAI and LPE indices and spawning stock biomass.

The results of the assessment are given in Tables 5.1.9 to 5.1.10 and in Figures 5.1.5 and 5.1.6A and B. These suggest that SSB in 1989 is approximately the same as in 1988 at around 450,000 t, but that the mean fishing mortality on ages 3-6 has decreased from 0.195 to 0.149. This compares with a fishing mortality of 0.125 in 1988 estimated by the 1989 Working Group. The SSB in 1989 is about 40,000 t less than that predicted by the 1989 Working Group. It would seem that the 1987 acoustic survey, which was used to tune the VPA in the previous 2 years, was an overestimate of stock size. The current VPA estimates the spawning stock biomass in 1987 to have been 252,000 t, whereas the acoustic estimate was 364,000 t.

5.1.10 Projection

The catches of 1-ringers in this area are not thought to reflect year-class strength and are excluded from the analysis.

The projections were made on the assumption that the catch in 1990 will be the agreed TAC of 75,000 t. The parameters used in the projection are given in Table 5.1.11 and the results are shown in Figure 5.1.6D. $F_{0.1}$ was estimated to be 0.179 with F_{med} estimated at 0.391 (Figure 5.1.5). The higher value for $F_{0.1}$ in 1989 refelects the change in the assumed exploitation pattern away from 2-ringers (Section 5.1.9).

Selected management options are given in the text Table below.

1990					1991				1992	
Stock biom. (2+)	SSB	F	Catch (2+)	Management option	Stock biom. (2+)	SSB	F	Catch	Stock biom. (2+)	SSB
545	430	0.22	75	F91=F89	515	422	0.15	51	511	421
				$F_{0.1}$		414	0.18	61	499	402
				F_{med}		360	0.39	121	423	297

Weights in '000 t.
Stock biomass calculated at 1 January = SSB at 1 January.
SSB calculated at spawning time, i.e., 1 September.

The results indicate a slight reduction in spawning stock size in 1991 and 1992 if the agreed TAC is reached. Reducing catches to the 1989 level will stabilize the stock size, given average levels of recruitment. The detailed prediction assuming $F_{91} = F_{89}$ is given in Table 5.1.12.

5.1.11 Management considerations

Recent levels of fishing mortality have been moderate at around $F_{0.1}$, and have allowed a rapid increase in stock size. For the past two years, the TAC has not been reached, and it is thought that this is due to strict enforcement of the TAC regulations. Although current levels of fishing mortality are considerably lower than F_{med} it is preferable to maintain a buffer against recruitment fluctuations than to substantially increase catches. It must also be emphasised that because of the difficulty of using larvae indices which are beyond the range of a converged VPA, the magnitude of the recent increases in stock size are rather uncertain.

5.1.12 Research and data requirements

Catch and biological data for this stock are generally satisfactory. However, the assessments over the last few years have been dependent on very limited fishery-independent information. It is important that the acoustic surveys and larvae surveys are continued.

5.2 Clyde Herring

5.2.1 Management of the fishery

ACFM recommended that landings in 1989 should be stabilized in the range 2,900-3,400 t, and the management body adopted a TAC of 3,200 t. The management body also adopted an ACFM recommendation that no fishing for herring should be carried out in the period 1 January - 15 April to provide protection for the indigenous spring-spawning stock.

5.2.2 The fishery in 1989

The directed pair-trawl fishery opened on 16 July 1989 and continued until almost the end of the year.

Annual landings and catches are given in Table 5.2.1. The reported landings in 1989 were 2,135 t against a TAC of 3,200 t. Of the total, 1,944 t were taken in the directed pair-trawl fishery, and the remainder as by-catch in bottom trawl fisheries. Allowing for overweight boxes the total landings in 1989 are estimated to be 2,343 t. No discard sampling was carried out in 1989, but it is understood from local reports that discarding was at a low level.

Landings in numbers at age in 1989 were estimated from monthly samples (Table 5.2.2) and revised figures were provided for 1988. To obtain estimates of catch in numbers at age, it is assumed that discarding was zero in 1989. Estimated numbers at length in landings in 1988 and 1989 are given in Table 5.2.3.

The number of days absence from port by pair-trawlers in 1989 is given in Table 5.2.4. As in previous years, the effort was raised by the ratio of total to pair-trawl landings to give an estimate of total effort. Effort in 1989 remained at approximately the same level as in 1988.

5.2.3 Weight at age and stock composition

Weights at age in the catch for the period 1970-1989 are given in Table 5.2.5. In the younger age groups (2-4 rings), the mean weights at age in 1989 were slightly lower than in 1988, whereas for older age groups they were higher. The difference was particularly noticeable in 3-ringers (174 g compared with 194 g in 1988).

Estimated percentages of herring at each maturity stage in the landings in each month in 1989 are consistent with an increase in the percentage of spring spawners in the landings. This is supported by monthly estimates of mean vertebral count at each maturity stage, which indicated that a high proportion of the landings in the period July-December were spring-spawned fish. Over the year as a whole, an estimated 73% of the fish landed were spring spawners. An analysis by age groups indicates that the large catches of 3-ringers made in the autumn and early winter contained a high proportion of spring spawners.

5.2.4 Acoustic survey

The fifth in a consecutive series of annual acoustic surveys was carried out in July 1989. Estimates of biomass and numbers and mean weights at age are given in Table 5.2.6. The high percentage of 3-ringers is consistent with the strong contribution of this year class in 1987 and 1988.

The estimated biomass of 2-ringers and older in 1989 was 18,300 t of which 3-ringers (the 1986 year class of spring spawners) contributed 14,100 t. The surveys indicate that the abundance of subsequent year classes is low.

5.2.5 Egg survey of Ballantrae Bank spawning ground

Further grab surveys for eggs were carried out in March-April 1989. In 1989, the spawning patch covered an area of 436,000 m^2, over five times that in 1988, and at approximately the same level as in the mid-1960s. The estimated number of eggs in the patch was 5.83×10^{11}. The mean fecundity was calculated from a historic fecundity-length relationship weighted by the length distribution of the spawning population in 1989 (29,600 eggs per fish). Assuming an equal sex ratio, the estimated number of spawners was 39.4×10^6. At a mean weight of 132 g (the mean weight in May 1989), this is equivalent to a spawning biomass of 5,200 t. In 1989, the spawning population was dominated by 3-ringers (the 1986 year class). From the low percentage of 2-ringers on the spawning grounds in 1988, it is clear that the 1986 year class recruited at three years of age.

5.2.6 Stock assessment

To tune a VPA, effort data in the pair trawl fishery are available from 1974-1989 (Table 5.2.4), and acoustic estimates of population in numbers at age in July from 1985-1989 (Table 5.2.6). The data used in the tuning program are given in Table 5.2.7. The tuning was carried out using a tricubic downweighting of the data, and the outputs are given in Table 5.2.8. The diagnostics are acceptable for the main age groups in the fishery (3-6 ringers) and indicate that greater weighting was attributed to the acoustic survey results.

A separable VPA was also carried out but there was little reduction in squared residuals indicating that the data for this area are not well described by the separable model.

The outputs from a VPA using terminal mortalities from the tuning module are given in Tables 5.2.9-5.2.11. These indicate a dramatic drop in mean fishing mortality rate in 1989, which is mirrored by the drop in catch of ages 4 and older, and an increase in catch of 3-ringers. The reason for this decrease in F on the older age group is not clear but may be related to the fact that the fishery was very late in 1989 (77% of the catch was taken after 1 September) so that immigrant autumn spawners, mainly 4-ringers and older, were not available. This is also shown by the much lower catchabilities in 1989 in the tuning outputs (Table 5.2.8).

A high proportion of the mature fish in 1989 was spring spawners. To obtain a consistent time series, the time of spawning was changed to 31 March, and the proportion of F and M before spawning changed to zero and 0.25, respectively. The maturity ogive was also changed to knife-edge maturity at an age of 3. Mean weights in the stock at spawning time are not adequately estimated, and so weights in the catch were used for 1988 and 1989, the values for earlier years remaining unchanged (Table 5.2.5).

The results from the VPA indicate that the spawning stock (3-ringers and older) increased in 1989 to its highest recorded level (17,900 t). The estimated recruitment of the 1986 year class at 2 years of age was over three times higher than the highest in the period 1970-1987. The first estimate of 2-ringer recruitment in 1989 is at about the geometric mean level. The VPA

estimate of total stock size at 1 January 1989 (128 million fish or 22,000 t) compares with an acoustic estimate of 102 million fish and 18,300 t in July.

The historic series of catch, population, and mortality estimates for Clyde herring are given in Table 5.2.12 and Figure 5.2A and 5.2B.

5.2.7 Projections

To provide a basis for projections, the estimated stock in number at 1 January 1990 was used from the VPA (Table 5.2.13). Recruitment of 2-ringers in 1990, 1991, and 1992 was assumed to be at the geometric mean level over the period 1970-1988 (23 million). The exploitation pattern was taken from the mean exploitation pattern over the years 1987-1989 from the VPA. (To do this, the mean Fs in each of these years were scaled to the mean F in 1989.) Mean weights at age in the catch and stock were taken as the mean over the years 1987-1989. The reference F is the unweighted mean on 2-6 ringers. The estimated value of $F_{0.1}$ is 0.112. The predictions are based on the assumption that no discarding will take place in 1990 and 1991 as in 1989.

In May 1989, ACFM recommended that fishing mortality in 1990 should not be allowed to increase, with a corresponding TAC of not more than 2,400 t. Taking into account preliminary results from the acoustic survey carried out in July 1989, ACFM revised this advice at its meeting in November 1989 and recommended a TAC of not more than 2,600 t, which was subsequently adopted by the management body. For prediction purposes, it is assumed that 2,600 t will be taken in 1990.

The results of the predictions are given in the text table below in '000 t (and in Figure 5.2D).

1990				1991				1992	
Stock biomass (2+)	SSB	F (2+)	Catch (2+)	Management options	Stock biomass (2+)	SSB	F	Catch (2+)	Stock biomass (2+)	SSB
22.2	18.2	0.14	2.60	$F_{0.1}$	21.8	17.8	0.11	2.32	21.4	17.4
				$F_{91} = F_{90}$	21.8	17.8	0.14	2.86	20.9	16.9
				$F_{91} = F_{89}$	21.8	17.8	0.16	3.25	20.5	16.5

At all options in the above table, there is expected to be a small decrease in SSB by 1991, simply because the expected level of recruitment is less than that of the large 1986 year class in 1988. Detailed output is given in Table 5.2.14.

5.2.8 Management considerations

Both the VPA and the acoustic survey indicate that there has been a considerable increase in the abundance of herring in the Clyde, following the strong recruitment of the 1986 year class of spring spawners. Unless there is further good recruitment, the spawning stock size will decrease, but at current levels of fishing morta-

lity this decrease is expected to be gradual. Since the chances of further recovery are likely to be enhanced by maintaining a reasonable level of spawning stock of spring spawners, it is appropriate to restrict fishing mortality to its current level.

ACFM has also recommended that no fishing for herring should be carried out in the period 1 January - 15 April in order to provide protection for the indigenous spring-spawning stock. This advice was incorporated as part of the TAC regulation in 1990, with a concession for up to 200 t to be taken in the period January - mid-April to allow the landing of by-catches in bottom trawl fisheries.

In addition to these regulations, Scottish inshore fisheries legislation was revised in 1989 and now includes a total ban on all forms of active fishing in a limited area covering the spawning grounds on Ballantrae Bank in the period 1 February to 30 April. The purpose of this legislation is to protect both pre-spawning shoals and the spawn beds from disturbance.

The Working Group supports the continuation of both the above measures.

6 HERRING IN DIVISIONS VIa (SOUTH) AND VIIb,c

6.1 The Fishery

6.1.1 Advice and management applicable to 1989

The TAC set by EC for this area for 1989 was 20,000 t. The catch level recommended by ACFM was 15,000 t. The total catch which was estimated to have been taken during the year was about 29,000 t, which was almost identical to the catch taken during 1988. The total catch from this area was, as it has been for many years, nearly twice the advised level.

The main catches, attributable to any nations, in 1989 were taken by the Irish fleet. The catches of this fleet during the year were regulated by monthly boat quotas, and the fishery was closed in October when the yearly quota was reached. About 7,000 t of the total catch was misreported as having been taken in Division VIa(N).

6.1.2 Catch data

The catches taken by country fishing in this area for 1980-1988 are shown in Table 6.1.1., together with the preliminary estimates for 1989. Estimates of herring caught but discarded have been included for 1989 for the Dutch fleet. Catch figures are supplied by Working Group members. It has not been found necessary to make any revisions to the 1988 catch data.

In general, the location and distribution of the fishery was similar to that of recent years, with the exception of 1988 when the Irish fishery was closed in June.

6.1.3 Catches in numbers at age

The catch in numbers at age for this fishery since 1978 is shown in Table 6.1.2. No revisions have been made to the 1988 data. The catch in numbers at age have been based mainly on samples obtained from the Irish fishery throughout the year and from a small number of samples from the Dutch fishery in the 2nd and 3rd quarters. The catch in numbers at age in 1989 was dominated by two year classes, the 1981 year class which first entered the fishery in 1984 and still constitutes over 13% of the catch, and the 1985 year class, which mainly recruited in 1989, and constituted over 47% of the catch. The 1985 year class was well represented in the catches taken throughout all the area and would thus appear to be strong. The catches of 2 winter-ring fish (i.e., 1986 year class) appeared to be extremely low in comparison with numbers taken in recent years. This year class also constituted less than 6% of the preliminary data on catch in number at age for the 1st quarter of 1990.

6.1.4 Quality of catch and biological data

Although there are still substantial unallocated catches and misreported catches for this fishery, the Working Group is satisfied that the most recent estimates of the total catch taken are acceptable. The level of biological samples, mainly from the catches of the Irish fleet, are also satisfactory. The number of samples are shown in Table 6.1.3. Length distribution of Irish catches per quarter is shown in Table 6.1.4.

6.2 Mean Weights at Age

The mean weights at age in the catches are shown below. These are for the period 1986-1988. These values are based on a combination of Irish and Dutch data. ACFM had commented on the low mean weights at age in the catches during 1988 compared with the mean weights of the stock at spawning time. The low values in 1988 are partly explained by the closure of the Irish fishery in June of that year, which resulted in a large proportion of the catch being taken in the first and second quarter. The 1989 values are slightly higher than those of 1988 but still show a general decrease on those of the previous years.

	Mean weights in the catches (g)							
	Age (winter-rings)							
Year	1	2	3	4	5	6	7	8
1986	95	138	164	194	212	225	239	208
1987	85	102	150	169	177	193	205	215
1988	-	098	133	153	166	171	183	191
1989	80	130	141	164	174	183	192	193

The mean weights of the stock at spawning time for 1989 have shown a significant decrease on the values for 1988. The average decrease for ages 2-8 is nearly 20%. It has not been possible to find a satifactory explanation for a decrease of this magnitude,

although it may be partly due to reduced growth in the area. A change of this extent, however, has a major effect on the spawning stock estimated for 1989 by VPA.

The values for the mean weights for the spawning stock for 1989 compared with those used by the 1988 Working Group are shown below:

	Mean weights in the stock (g)								
	Age (winter-rings)								
Year	1	2	3	4	5	6	7	8	>8
1988		164	206	233	252	271	280	296	317
1989		157	168	182	200	217	227	238	245

The 1989 values have been used to update the VPA, but the values used in the prediction have been based on the average value for the period 1986-1988. A further prediction was also carried out with the low weights at age for 1989.

6.3 Larval Surveys

Larval surveys in this area, which had been carried out by Ireland from 1981 to 1988, were not carried out in 1989. Recent Working Groups have been unable to find any relationship between the larval indices and the spawning stock biomasses estimated from various VPA runs. It is not clear whether this is due to errors in the VPA or in the larval abundance indices. In the absence of any relationship, the larval indices were, therefore, not used in recent years to calculate stock sizes.

6.4 Stock Assessment

Recent Working Groups have had extreme difficulty in carrying out an assessment on the stock in this area. This was mainly because it was not possible to relate the larval indices to the spawning stock biomass estimate. Apart from the larval surveys there, are, however, no other fishery-independent estimates of stock size. Although the larval surveys have not been used to calculate spawning stock, they indicate an increasing trend and the very high value recorded for 1988 may have been the result of the first spawning of the strong 1985 year class. The 1989 Working Group estimated a Z value for recent years by comparing a series of catch curves constructed over different periods of catch levels. From this it was concluded that the $F_{(2-7,u)}$ in most recent years may have been about 0.34. A VPA was, therefore, carried out by the 1989 Working Group using a value of 0.40 which was considered to be slightly more conservative. In the prediction calculated from this VPA, catches in 1989 at about the same level as those of 1988 (i.e., 29,000 t) were estimated to generate an $F_{(2-7,u)}$ in 1989 of about 0.29. The catches during 1989 have been almost identical to those of 1988, and the age distribution of the catches still contains a large proportion of the 1981 year class. The inclusion of the 1989 age distribution into the catch curves calculated by the 1989 Working Group has the

effect of slightly reducing the level of F in the most recent period. In the circumstances, therefore, the predicted level of $F_{(2-7,u)}$ = 0.29 for 1989 calculated by the 1989 Working Group appears to have been reasonable.

A separable VPA was, therefore, carried out on ages 2-8, and a terminal F of 0.30 on age 4 and a terminal S of 1.0 were selected. The results of this separable VPA are shown in Table 6.4.1. The exploitation pattern is flat-topped from ages 4-8 and very similar to that calculated by the 1989 Working Group. A conventional VPA was then carried out on fish of 2 winter-rings and older using an input F = 0.30 and the exploitation pattern derived from the SVPA.

6.4.1 Results from VPA

The results from the VPA are shown in Tables 6.4.2 and 6.4.3 and in Figures 6.6.1A and B. The estimates of F_{2-7} are reasonably stable for this stock and have fluctuated from 0.18 to 0.37 over the period 1977-1986. The rather high value of 0.43 for 1987 was a result of the high catch taken in that year. The SSBs estimated from this VPA are higher than those estimated by the 1988 Working Group but show a sharp deline from 1988 to 1989. This apparently has been caused by a combination of the extremely small numbers of 2 winter-ring fish in the 1989 stock in numbers and the 20% decrease in the mean weights used for the 1989 stock. The spawning stock in 1989 is now estimated to be about 98,000 t compared with that predicted by the 1989 Working Group of 154,000 t. The numbers of 3 winter-ring fish present in the stock indicate that the 1985 year class is very strong and the highest to recruit to the stock since 1970, apart from the exceptionally strong 1981 year class. The preliminary estimates of 2 winter-ring fish in 1989 would suggest that the 1986 year class may be poor.

The stock/recruitment plot is shown in Figure 6.4.1.

The Working Group would like to emphasize that the above analysis is the best that can be done with the existing data. It should, therefore, be born in mind that any analysis that relies completeely on the age composition of the catches may give misleading results, particularly if the strengths of the year classes are very variable. In this area, year classes fluctuate considerably with strong year classes dominating the catches for long periods. This assessment is, therefore, considered to be unreliable, and the Working Group would like to stress that no improvement will take place until independent stock estimates become available.

6.5 Recruitment

No recruitment surveys have been carried out on this stock during 1989. The only indication, therefore, of the strength of the recruiting year classes comes from the 1989 and 1990 catch in number data and the estimates derived by VPA. The catch in number data suggest that the 1986 year class may be very poor and, as has already been mentioned, the 1985 year class appears to be strong. The geometric mean calculated over the period 1980-1988 gave a value of 319 million fish. This was assumed as the

recruitment level for 1990-1992 for the prediction programme.

6.6 Stock and Catch Predictions

Stock and catch projections were made using the stock numbers at 1 January 1990, calculated from VPA. The level of recruitment was assumed to be 319 million 2-winter-ring fish. The predictions were based on two catch levels for 1990: a) a catch of 25,000 t which is equal to the agreed TAC (Option A) and b)a catch of about 30,000 t (Option B),which is approximately the same as that recorded in 1988 and 1989. Catch levels have been assumed for 1991 at levels of $F_{0.1}$ = 0.15; F_{med} = 0.26, and F_{91} = F_{89}, i.e. = 0.30. The input data are shown in Table 6.6.1 and Figure 6.6.1D. The detailed results of the projection (F_{med} under Option A) are given in Table 6.6.2. The results of Option A are plotted in Figure 6.6.1D.

The results of the prediction show that the spawning stock, which had decreased considerably in 1989 because of the very poor 1986 year class and the low mean weights, will increase in 1990. Catches in 1990 of 25,000 t (Option A) will generate an $F_{(2-7,\mu)}$ of 0.30 and will result in an increase of the spawning stock to 124,000 t in 1990. A continuation at this fishing mortality in 1991 will yield catches of 27,000 t and result in a slight increase in spawning stock. Catches in 1990 of 30,000 t (Option B) will generate an F = 0.37, but the spawning stock will still increase. Continuation of fishing at this level will produce a stable spawning stock. The increase in spawning stock is a result of the assumed GM recruitment of 319 million fish, which is considerably higher than the very low 1986 year class which joined the adult stock in 1989.

A summary of both options of the prediction is as follows:

Option A

1990			1991			1992		
Catch	F	SSB	Catch	F	SSB	Catch	F	SSB
25,000	.30	124,000	15,000 27,000	$F_{0.1}$= .15 F_{91-90}= .30	140,000 128,000	30,000 28,000	$F_{0.1}$=.16 =.30	118,000 130,000

Option B

1990			1991			1992		
Catch	F	SSB	Catch	F	SSB	Catch	F	SSB
30,000	.37	119,000	30,000	.36	118,600	30,000	.36	118,000

A prediction on the stock was also carried out using the low mean weights which were estimated for the stock at spawning time 1990. These mean weights were found to be about 20% lower than in the previous years, but had been used to update the VPA. The low mean weights were used in the prediction because it could be assumed that the low mean weights observed in 1989 could prevail during 1991 and 1990.

The results of this prediction (Option C), shown below, indicate significantly lower spawning stock biomasses, e.g., SSB in 1990 is calculated to be 106,000 t, compared with 119,000 t for similar catch levels (i.e., a decrease of 11%). The difference will increase to about 16% in 1992.

Option C

1990			1991			1992		
Catch	F	SSB	Catch	F	SSB	Catch	F	SSB
30,000	.37	106,000	31,000	.37	100,000	30,600	.37	99,000
			22,000	F_{med}=.26	107,000	24,200	.26	113,200
			14,700	$F_{0.1}$=.16	113,000	17,000	.16	127,000

6.7 Management Considerations

The predictions shown in the previous section demonstrate very clearly why this assessment should be treated with caution. Considerable differences in stock sizes and catch levels can be calculated with the different sets of mean weights. Nevertheless, under conditions of average recruitment, catches of 30,000 t will maintain a reasonably stable stock, while catches of around 25,000 t will result in an increasing stock size. The assessment does contain a number of conservative factors, e.g., the very low numbers of 1986 year class included in the 1989 stock size and the reduced mean weights. In addition, the calculated $F_{(2-7,u)}$ values of 0.30 in 1989 might be considered high in comparison with the observed value in the adjacent Division VIa(N). In these circumstances the Working Group would suggest that, although the assessment and prediction should be treated wuith caution, the predicted catch levels may be suitable for predicting TACs rather than imposing a precautionary TAC which would be based on the average catch of recent years. It should also be born in mind that the TAC in this area has for a number of years been consistently exceeded. Although ACFM has pointed out on a number of occasions that the stock in this area has been underestimated, the history of the poor management of this stock must be considered. The Working Group would, therefore, suggest that a continuation of a TAC of around 25,000 t in 1991 should be maintained. This catch level will also ensure some increase in stock size.

It should again be pointed out that it will not be possible to provide any more accurate advice on the correct catch level until fishery-independent methods of stock assessments become available. It has also been pointed out by recent Working Groups that some of the difficulties that arise in making an assessment of this stock may arise from the fact that the management unit (Divisions VIa(S) and VIIb) may not cover the entire area of distribution of the stock. Considerable spawning is known to occur on the boundary of Divisions VIIb and VIIj, and it is possible that the stock may be exploited in both areas.

7 IRISH SEA HERRING (DIVISION VIIa)

7.1 The Fishery

7.1.1 Advice and management applicable to 1989

The 1988 assessment of this stock indicated that SSB would continue to rise slowly if the catches were held at 6,000 t, no matter whether there was an $F_{(2-7,u)}$ of 0.3 or 0.66. ACFM recommended a TAC of 5,500 t and the EC adopted a TAC of 6,000 t. This was partitioned as a 4,440 t quota for the UK and 1,560 t for the Republic of Ireland. In the UK, sectoral quotas were allocated as follows: Anglo-North Irish Fish Producers Organisation 638 t; Northern Ireland Fish Producers Organisation 2,114 t; Scottish Fishermen's Organisation 394 t; Fish Producers' Organisation 638 t. In addition, 255 t were allocated to the non-sectoral industry (Manx and Scottish) and 400 t to the Mourne fishery.

The UK fishery opened in the second week of June. The closed areas around the Manx spawning grounds and along the Mourne shore were in operation from the 21 September to the end of the year. Fishing from the Republic of Ireland was regulated on a weekly vessel quota basis within the period of the second week in August to the end of September.

7.1.2 The fishery 1989

The catches reported by each country fishing in Division VIIa(N) from 1979-1989 are given in Table 7.1.1. The total catch in 1989 of 4,962 t was well within the TAC of 6,000 t agreed by the EC. The UK fishery continued into December and was then closed as a result of falling catches rather than an exhausted quota. The UK undershot its quota by 908 t, and the Republic of Ireland by 130 t. This was probably due to low market demand and concern for potential overshooting the TAC by management and is certainly not due to a lack of fish. The extent of discarding, especially early in the season (June), is still an unknown quantity.

Once again the catches were not split into Manx and Mourne components due to the problems of separating the catches in the earlier part of the season. However, landings from the UK vessels in September 1989 were mainly from the Douglas Bank fishery and these amounted to more than 1,600 t. Although the total catch appears less than the TAC there are, once again, serious concerns that considerable under-reporting of catches may have taken place. In fact, at least one operation was deemed to be under-reporting and prohibited from fishing further. However, the extent of under-reporting could not be estimated and, therefore, could not be considered in this report. The problem of under-reporting is of major concern in this fishery which needs to be thoroughly examined.

7.1.3 Quality of catch and biological data

As mentioned previously, there are still serious concerns about under-reporting in this fishery. The level of discarding has not been investigated. However, there is good biological sampling of the landings from this fishery throughout the season (Table 7.1.2).

7.1.4 Catches in numbers at age

Catches in numbers at age are given in Table 7.1.3 for the years 1972 to 1989. In 1989, the dominant group were 3 ring fish (1985 year class) with significant numbers of 2 (1986 year class) and 4 ring (1984 year class) fish. The catch in numbers at length is given in Table 7.1.4, and the 1988 data are shown for comparison. There was an increase in the modal length which was expected with the increase in age of the dominant year class.

7.2 Mean Length, Weight, and Maturity at Age

Mean lengths at age in August, calculated from Northern Ireland, Republic of Ireland, and Isle of Man data are given in Table 7.2.1 for the years 1985 to 1989. Mean lengths at age appear to have stabilized at a level below that of 1985.

Mean weight at age is given in Table 7.2.2 for the years 1976-1983 and 1984 to 1989. In general, mean weight at age is similar to that seen over the last few years.

The maturity ogive, expressed as proportions of sampled population at stage 3+, has changed very little over the last few years, and the 1989 ogive very closely resembled the previous estimates. Therefore, the maturity ogive of the previous year (0.08 for age 1, 0.85 for age 2, and 1.00 for ages 3-8+) was used again..

7.3 Stock Assessment

7.3.1 Acoustic surveys

An acoustic survey of the Manx spawning stock was undertaken in September 1989, in the area to the east of the Isle of Man, over an area known to contain the major spawning grounds (Bowers, 1969). A rectangular grid pattern, with 1 mile spacing between survey lines, was used. A daytime survey in early September indicated a singular lack of fish. This may have been due to the fish not being aggregated and a daytime tendency to be close to the bottom. Surveys at night on the 26 and 27 September recorded herring schools through much of the known spawning area.

The length-weight relationship, mean length and subsequently mean weight was calculated from the last commercial catch in the vicinity of Douglas Bank. The survey was undertaken using a 50kHz echosounder and all data were subject to standard echosquare integration. For this assessment, only one large aggregation was used to estimate the SSB of Manx herring. This aggregation was approximately 2.44 km^3, eight crossings were used to determine its dimensions. The dimensions and location of the aggregation was fairly stable over at least three days. Mean echosquare integration of the aggregation alone was used to calculate the total number of fish and hence biomass. A target strength at 38kHz was used, with a subsequent raising of 2.4% of the estimated biomass to correct for the 50kHz survey frequency, to give estimate a biomass of 18,000 t for this aggregation.

A number of other schools were seen in the area, but not covered by this survey, which suggests the Manx SSB may be greater than

estimated by an undetermined amount. It should be pointed out that, currently, Division VIIa(N) assessments include both the Manx and Mourne components, yet this acoustic assessment only covers the Manx component. To obtain an estimate of the Division VIIa(N) SSB, as used in VPA, it is necessary to estimate the Mourne SSB component. This has not been done due to the lack of any information on the Mourne component. In general, it appears that the SSB of Division VIIa(N) is higher than previously estimated by VPA.

7.3.2 Estimation of fishing mortality

There were only very limited data for this stock this year. Once again, the effort data were felt not to be of use in trying to tune the VPA. The only information readily available was the one acoustic assessment undertaken on the Manx spawning stock. The estimate of spawning stock size (not taking into account the Mourne component) was used to tune the VPA. F values were examined which would give an SSB in the order of 18,000 t. A number of trial VPAs indicated that the most plausible $F_{(2-7,u)}$ value was 0.2. SSB trends from a number of input Fs (0.2, 0.3, and 0.4) are given in Figure 7.3.

7.3.3 Exploitation pattern

Separable VPAs were run with a reference age of 3, a terminal S of 1, and an F_{89} of 0.2, 0.3, and 0.4. Since an F of 0.2 was adopted as the most reasonable for this stock, only the output of SVPA for F = 0.2 is given in Table 7.3.3. These analyses indicated a flat-topped selection pattern with 0.075 on 1-ringers, 0.84 on 2-ringers, and 1.0 on ages 3-7 ringers. There is no evidence of a change in exploitation pattern in this fishery.

7.3.4 Results of VPA

As stated previously, a number of VPA runs were performed, however, only that of F = 0.2 is given here. For these analyses, the natural mortality was assumed to be the same as last year, namely 1.0 on 1-ringers, 0.3 on 2-ringers, 0.2 on 3-ringers, and 0.1 or 4-8 ringers. F on the oldest age group were taken from the separable VPA.

The results of the VPA (Figure 7.5A-B and Tables 7.3.4 and 7.3.5) suggest that the F_{88} = 0.66, assumed last year, was probably too high. The spawning stock biomass appears to have been relatively stable since 1985. However, the recruitment over that last few years has shown a dramatic decline. The average fishing mortality on ages 2-7 appears to have fluctuated between 0.16 in 1984 and 0.39 in 1988.

The spawning stock biomass and recruitment data from the VPA are presented in Figure 7.4.

7.4 Recruitment

The Irish young fish survey was discontinued in 1989 and has not been restarted or replaced with any other survey. Therefore,

there are no other estimates of recruitment in 1990 for this stock.

ACFM indicated the recruitment level used for projections made last year was possibly too high. Within this stock there appears to have been a fairly large decline in recruitment at age 1 ring from the 1985 to the 1987 year class (292 million - 123 million). This poses a problem in selecting projected recruitment levels for the 1988-1990 year classes. From using the VPA with input $F_{(2-7,u)}$ = 0.2 for 1989, the geometric mean recruitment during 1984-1988 is 184 million. This value is higher than that used in 1989 for projected recruitment for 1989-1991. In fact, the previous Working Group used 144 million for the projected recruitment for the years 1988-1990. There is still some uncertainty of recruitment levels in this stock. Some independent estimate of recruitment levels needs to be considered for this stock.

7.5 Stock and Catch Projections

The input to the yield-per-recruit analysis and predictions are shown in Table 7.5.1 and results are shown in Figure 7.5C and D. Using a reference F for 2-7 ringers, $F_{0.1}$ = 0.17, and there was no F_{max}. F_{high}, F_{med} and F_{low} were calculated from the gradients of the lines drawn on the stock-recruitment graph (Figure 7.4). They were found to be F_{high} = 0.84, F_{med} = 0.38, F_{low} = 0.20. These values are comparable to those given in 1988 (Anon., 1988). Projections were performed for $F_{0.1}$ = 0.17, $F_{91} = F_{89} = F_{low}$, and $F_{91} = F_{90}$. It is assumed that the TAC will be taken in 1990, giving a total catch of 7,000 t. This generates an $F_{(2-7,u)}$ of 0.33. The various options are summarized in the table below.

1990				1991					1992	
Stock biom.	Spawn. stock biom.	F	Catch	Management option	Stock biom.	Spawn. stock biom.	F	Catch	Stock biom.	Spawn. stock biom.
43.0	18.1	0.328	7.0	$F_{0.1}$	42.8	20.1	0.17	3.9	45.7	22.2
				$F_{91} = F_{low}$	42.8	19.5	0.20	4.5	45.1	21.1
				$F_{91} = F_{90}$	42.8	17.6	0.32	6.8	42.7	17.5

Weight in '000 t.
Stock biomass at 1 January.
SSB at spawning time.

The results indicate that fishing mortalities at $F_{0.1}$ and F_{low} will result in an increase of SSB over the period 1990-1991. Maintaining a fishing mortality at the 1990 level will result in a small decrease in SSB to 1991. It should be pointed out that these projections are to a certain extent dependent on the estimated recruitment (see Section 7.4). However, these projections are consistent with the comments made in 1989 (Anon., 1989) with respect to a 6,000 t TAC for 1990 not damaging the stock. The detailed prediction for the $F_{0.1} = F_{low}$ option is given in Table 7.5.2.

7.6 Management Considerations

7.6.1 Catch limits

It should be stressed that the analysis of this stock is based on a single acoustic survey of the Manx component, and there are no independent data on recruitment. Figure 7.5B indicates that the SSB may be stabilizing.

In 1989, ACFM expressed concern that the recruitment figures (long-term average) used in the prediction were too high. They recommended using an average level of recruitment based on a recent period when recruitment was projected to be lower. ACFM also pointed out that there has been an increase in numbers of older fish and suggested this might be related to a recovery. ACFM expressed concern at the lack of fishery-independent data for this stock and, as a consequence, recommended a precautionary TAC of 5,700 t for 1990. The EC subsequently adopted a TAC of 7,000 t for 1990. This has been allocated as 1,820 t to the Republic of Ireland and 5,180 t to the UK. Spawning closures were retained as for 1989.

The 1990 TAC has now been set well above the recommended TAC. If continued in 1991, this level of exploitation will result in a slight decline in SSB. It is appropriate to consider here, as well, the implications of recruitment. If the recruitment for 1990 and 1991 is lower than that projected, then decline in SSB will be amplified. Unfortunately, we have no independent estimate of recruitment.

The Working Group recommends a lower TAC (and F) for 1991 than that agreed for 1990 in order to allow further recovery of this stock. A lowering of the TAC (as recommended by ACFM for 1990) would allow catches to be more stable.

7.6.2 Spawning and nursery area closures

Given the continued uncertainty about the size of this stock, and the fact that the majority of the fish form a single shoal at spawning time (as shown for the Manx stock), the spawning and nursery area closures currently in force should be maintained in 1991.

8 GROWTH CHANGES

Recent Working Groups have noted an apparent simultaneous decrease in weight at age among several herring stocks. This change has taken place at a time of generally increasing stock sizes. The 1989 Working Group felt that the establishment of a relationship between stock density and growth could have important implications for management and concluded that it would be valuable to determine if there are patterns in the length at age changes within and especially among stocks. The Working Group, therefore, urged its members to compile data to allow a review on

growth changes.

A number of studies have been made of the within-stock growth changes for herring, especially of a possible inverse relationship between growth rate and stock size. No clear picture has emerged from these studies, but measurements of growth rates and abundance indices are probably in many cases not sufficiently accurate to detect possible effects of stock abundance on growth. An analysis requires reliable time series of both stock abundance and mean length at age over age intervals of maximum growth. Furthermore, the time series must cover a period of change in stock abundance. Where a relationship was found, the results indicated that the effect is mainly confined to the juvenile stages.

8.1 Material and Methods

8.1.1 Adults

Time series of mean length at age of mature adults were available to the Working Group for the eastern English Channel (1964-1989), the northeastern coast of England (1970-1987), Kattegat/Skagerrak (1980-1989), Divisions IVa and IVb (1945-1989), Division VIa (1976-1989), the Celtic Sea (1958-1987), and the Irish Sea (1945-1989). It was decided to select time series for which data had been collected at the spawning grounds to avoid the confounding effect of differences between stocks or stock components.

Determination of possible relationships between stock abundance and growth in length was investigated, using the data for the northeastern coast of England and the Celtic Sea. 2-5 ringers were selected as they had the greatest sampling intensity. Relative annual growth rates, defined as the ratio of the age-specific length increment to the initial length, were aggregated across age group (as described in Winters *et al.*, 1986). Average annual growth rates for each stock were then compared with VPA estimates of spawning stock biomass.

8.1.2 Juveniles

Data on mean length at age for 1-ringers in the North Sea were available from the IYFS for the years 1981-1988. Data were also available for 1-ringers in the Kattegat for 1980-1989. For the other herring stocks, 1-ringers were not sufficiently well represented to carry out an investigation. The IYFS is carried out in the first quarter of the year, and the length of the 1-ringers at this time, therefore, reflects the growth rate during their first year of life. Length of 1-ringers was related to VPA estimates of the same age group for the North Sea and to IYFS abundance indices for the Kattegat.

8.2 Results

8.2.1 Growth related to stock size

While there were considerable annual differences in length-corrected growth increments, the results did not demonstrate any statistical relationship between spawning stock biomss and annual growth rate of adult herring for either the North Sea, the Irish Sea, or the Celtic Sea herring (Figure 8.1). Both sets of data covered a wide range of stock sizes, with a ratio of highest to lowest spawning stock biomass of 4 for the Celtic Sea, 6 for the Irish Sea, and 10 for the North Sea.

No signifciant correlation was found between the mean length of 1-ringers in the North Sea (Divisions IVb and IVc) and VPA estimates for the same age group (Figure 8.2). The length of 1-ringers in the Kattegat was significantly correlated with their abundance, but the significance of the relationship was mainly due to the outlying 1986 year class (Figure 8.2).

8.2.2 Synchronicity of growth changes between stocks

The available time series of mean length at age all showed the same overall pattern; an increasing trend up to the late 1970s/ early 1980s, and thereafter a marked decline (Figure 8.3). The maximum difference in mean length at age was generally of the order of 4-5 cm for the 2- and 3-ringers, declining to 1-2 cm for 6-ringers and older fish (Figure 8.4).

8.3 Discussion

The results of the above exercise have indicated a possible link between abundance and growth in length of 1-ring herring. The conclusion is, however, based on a rather restricted number of observations and its predictive value remains to be proven. The lack of a relationship between growth and stock size in older herring agrees with previous studies (e.g., Hubold, 1978; Burd, 1985; Winters et al., 1986) in that any effect of competition on growth seems to be confined to the juvenile stages.

The above analysis can only demonstrate in a general way the possible effects of stock size on the growth of herring. A more sophisticated analysis could be made, but this was not possible in the time available to the Working Group meeting.

Clear trends in mean length at age have been shown (Figure 8.4), and of particular interest is the notable similarity of variation between stocks, which suggests a common causal effect. This may be due to similarities in patterns of recruitment to different stocks, and density-dependent juvenile growth may be the fundamental underlying cause for the observed variation in length at age of adult herring. However, the similarity of trends in the different stocks could suggest an environmental factor.

9 FUTURE RESEARCH REQUIREMENTS

North Sea

1. It is requested that the IYFS results are fully available at the time of the Herring Asssessment Working Group meeting, and

both length and age data for herring should be submitted to ICES as soon as possible after completion of the surveys.

2. Herring larvae surveys should be maintained, since the LPE values have contributed significantly to the RCRTINX2 and VPA tuning in the 1990 assessment. They are also of great value in providing indicators of individual stock changes, particularly in the case of the southern North Sea, where it is not possible to make an analytical assessment.

It is also requested that results from the herring larvae surveys should be sent to Aberdeen for analysis at least two weeks before the start of the Herring Assessment Working Group meeting.

3. It is also important that the current level of IKMT sampling be maintained on the IYFS or possibly improved.

The results have proved very useful in providing an indication of future trends in recruitment, a year sooner than provided by the 1-ring indices.

4. Acoustic survey participants should make preliminary results available to the coordinator as soon as possible after the completion of surveys so that a provisional report may be prepared for submission to the November ACFM meeting.

5. Increased sampling of catches taken in the north-eastern North Sea is requested to ensure a better separation of Division IIIa and SW Baltic spring spawners from North Sea autumn spawners. Discriminant function analysis has proved a promising technique for separation of the two types. The method should also consider differences between age groups within each population.

6. The Working Group proposes the establishment of a Stock Separation Workshop for 1992, which could examine a range of possible techniques for separating herring sub-stocks.

7. Further studies should be made on growth rate changes in herring at the 1991 Herring Assessment Working Group meeting. Participants are requested not only to provide basic data, but also to analyze them before the Working Group meeting. Special attention should be given to inter-annual variations in the growth of the adult population.

8. A time series of IYFS length distributions for all age groups of herring in the North Sea and Division IIIa should be made available by ICES to the Herring Assessment Working Group over as long as time period as possible for use at the 1991 meeting.

Irish Sea, Division VIIa (North)

1. The Working Group welcomed the introduction of an acoustic survey to provide a fishery-independent measure of SSB for the Manx herring in 1989. It firmly supported the need to continue such surveys and extend them to include the Mourne spawning stock to enable a complete assessment of the spawning stock in Division VIIa (North).

Celtic Sea/Division VIIj

1. The continuation of fishery-independent measures of spawning

stock by acoustic and larvae surveys is essential.

2. Information concerning the distribution and abundance of juveniles is required to provide measures of recruitment.

Divisions VIa (South) and VIIb

1. Fishery-independent measures of the stocks in this area are urgently needed, and both acoustic and larvae surveys would be of value in carrying out an analytical assessment on these stocks.

2. Recruitment indices are also required for a full assessment in this area.

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Table 2.1.1 HERRING. Catch in tonnes, 1979-1989, North Sea, Sub-area IV, and Division VIId by country. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1979	1980	1981	1982	1983	1984
Belgium	-	-	-	9,700	5,969	5,080
Denmark	10,546	4,431	21,146	67,851	10,467	38,777
Faroe Islands	10	-	-	-	-	-
France	2,560	5,527	15,099	15,310	16,353	20,320
Germany, Fed.Rep.	10	147	2,300	349	1,837	11,609
Netherlands	-	509	7,700	22,300	40,045	44,308
Norway[4]	2,367	2,165	-	-	32,512	98,706
Sweden	-	-	-	-	284	886
UK (England)	2,253	77	303	3,703	111	1,689
UK (Scotland)	-	610	45	1,780	17,260	31,393
USSR	162	-	-	-	-	-
Unallocated landings	-	47,528	94,309	114,252	181,116	64,487
Total landings	17,908	60,994	140,902	235,245	305,954	317,255
Discards[3]	-	-	-	-	-	-
Total catch	17,908	60,994	140,902	235,245	305,954	317,255
Catches of Div.IIIa spring spawners (included above)	-	-	-	-	-	6,958

Country	1985	1986	1987	1988	1989[1]
Belgium	3,482	414	39	4	434
Denmark	129,305	121,631	138,596	263,006	210,315[2]
Faroe Islands	-	623	2,228	810	1,916
France	14,400	9,729	7,266	8,384	29,085
Germany, Fed.Rep.	8,930	3,934	5,552	13,824	38,707
Netherlands	79,335	85,998	91,478	82,267	84,178
Norway[4]	159,947	223,058	241,765	222,719	221,891[2]
Sweden	2,442	1,872	1,725	1,819	5,586
UK (England)	5,564	1,404	873	8,097	7,980
UK (Scotland)	55,795	77,459	76,413	64,108	68,106
USSR	-	-	-	-	-
Unallocated landings	74,220	21,089	58,972	33,411	26,749[2]
Total landings	533,420	547,191	624,907	698,449	694,947[2]
Discards[3]	-	-	-	-	4,000[3]
Total catch	53,420	547,191	624,907	698,449	698,947[2]
Catches of Div.IIIa spring spawners (included above)	17,386	19,654	14,207	23,306	19,869[2]

[1] Preliminary.
[2] Working Group estimates (only applicable to 1989).
[3] In previous years any discard estimates were included in unallocated landings.
[4] Catches of Atlanto-Scandian spring spawners removed (taken under a separate TAC).

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	1980	1981	1982	1983	1984
Denmark	687	11,357	3,155	4,282	26,786
Faroe Islands	-	-	-	-	-
France	651	1,851	1,970	680	1,408
Germany, Fed.Rep.	-	-	-	1,542	12,092
Netherlands[2]	-	-	-	15,745	19,143
Norway	-	-	-	16,971	21,305
Sweden	-	-	-	213	-[1]
UK (England)	-	-	-	-	-
UK (Scotland)	18	2	1,706	16,136	24,634
Unallocated	1,762	6,492	300	3,955	24,030
Total	3,118	19,702	7,179	61,738	129,398

Country	1985	1986	1987	1988	1989
Denmark	77,788	48,590	50,184	25,268	29,298
Faroe Islands	-	275	102	810	1,916
France	2,075	462	285	266	-[1]
Germany, Fed.Rep.	4,790	2,510	3,250	9,308	26,528
Netherlands[2]	49,965	42,900	44,358	32,639	24,600
Norway	10,507	63,848	55,311	30,657	41,768
Sweden	-[1]	-[1]	768	1,197	742
UK (England)	-	-	4,820	4,820	5,104
UK (Scotland)	52,100	71,285	66,774	48,791	58,455
Unallocated	4,249	-	16,092	-	3,173
Discards[3]	-	-	-		900
Total	201,474	229,870	237,124	153,751	192,484

[1] Included in Division IVb.
[2] Netherlands discard estimates included in "unallocated" from 1980-1988.
[3] Any discards prior to 1989 would have been included in unallocated.

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	1980	1981	1982	1983	1984
Denmark	-	-	491	-	126
Faroe Islands	-	-	-	-	-
France	-	-	-	-	-
Netherlands	-	-	-	-	-
Norway[1]	21	-	-	-	51,581
Sweden	-	-	-	-	-
UK (Scotland)	-	-	-	257	74
Unallocated	2,476	937	-	431	-
Total	2,497	937	491	688	51,781

Country	1985	1986	1987	1988	
Denmark	-	4,540	7,101	47,183	44,269
Faroe Islands	-	-	2,126	-	-
France	-	-	159	45	-
Netherlands	-	-	-	200	-
Norway[1]	109,975	118,408	145,843	153,496	168,365
Sweden	-	-	957	622	1,424
UK (Scotland)	-	-	-	-	-
Unallocated	-	-	-	-	-
Discards[2]	-	-	-	-	-
Total	109,975	122,948	156,186	201,546	214,053

[1] Catches of Atlanto-Scandian herring removed (taken under a separate TAC).
[2] Any discards prior to 1989 would have been included in unallocated.

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	1980	1981	1982	1983	1984
Denmark	3,733	9,689	64,205	6,050	13,808
France	176	524	561	705	2,299
Faroe Islands	-	-	-	-	-
Germany, Fed.Rep.	147	2,300	118	-	2
Netherlands[4]	35	-	219	300	4,600
Norway	1,607	-	-	14,156	25,820
Sweden	-	-	-	71	884
UK (England)	76	13	3,128	40	1,956
UK (Scotland)	592	43	74	867	2,477
Unallocated	9,258	65,811	90,262	159,124	41,294
Total	15,624	78,380	158,567	181,313	93,140

Country	1985	1986	1987	1988	1989
Denmark	51,517	67,966	81,280	190,555	136,239[5]
France	1,037	605	387	617	14,415[5]
Faroe Islands	-	348	-	-	-
Germany, Fed.Rep.	4,139	1,424	2,302	4,516	11,880
Netherlands[4]	-[3]	21,101	31,371	37,192	47,388
Norway	39,465	40,682[2]	40,111	38,566	11,758
Sweden	2,442[2]	1,872[2]	-	-	3,420
UK (England)	5,214	1,101[1]	329	2,011	957
UK (Scotland)	2,894	6,057	9,639	15,317	9,651
Unallocated	47,799	1,594	20,829	1,969	-23,947
Discards[6]	-	-	-	-	1,900
Total	154,507	142,750	186,248	290,743	213,611

[1] Includes catches misreported from Division IVc.
[2] Includes Division IVa catches.
[3] Included in Division IVa.
[4] Netherlands discard estimates included in "unallocated" from 1980-1988.
[5] Includes catch in Division IVa.

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	1980	1981	1982	1983	1984
Belgium	-	-	9,700	5,969	5,080
Denmark	11	100	-	135	53
France	4,700	12,724	12,799	14,968	16,613
Germany, Fed.Rep.	-	-	183	295	-
Netherlands	474	7,700	22,081	24,000	21,922
Norway	482	-	-	1,385	-
UK (England)	1	290	602	71	571
UK (Scotland)	-	-	-	-	-
Unallocated	37,418	21,069	23,307	17,606	1,788
Total	43,086	41,883	68,652	64,430	46,027
Coastal spring spawners included above:					(520)

Country	1985	1986	1987	1988	1989
Belgium	3,482	414	39	4	434
Denmark	-	535	31	-	509
France	11,288	8,662	6,435	7,456	14,670
Germany, Fed.Rep.	-	-	-	-	299
Netherlands	32,370	21,997	15,749	12,236	12,240
Norway	-	-	-	-	-
UK (England)	350	303	544	1,266	1,919
UK (Scotland)	799	117	-	-	-
Unallocated	21,595	19,495	22,051	31,442	47,523
Discards[1]	-	-	-	-	1,200
Total	69,884	51,523	44,849	52,404	78,794
Coastal spring spawners included above:	(905)	(496)	(250)	(250)	(2,283)

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

Table 2.2.1 NORTH SEA HERRING. Millions caught by age group (winter rings). Catches in 1989. Year class, Division and quarter.

Division	Quarter	0 1988	1 1987	2 1986	3 1985	4 1984	5 1983	6 1982	7 1981	8 1980	9+ <1979	Total	0 + 1 ring
IVa (W of 2^0E)	I	-	2.8	86.5	50.0	13.6	1.7	0.7	0.7	-	-	156.1	2.8
	II	-	3.8	33.7	63.4	22.1	3.0	3.3	2.8	0.4	0.3	132.8	3.8
	III	-	5.2	161.7	265.7	107.3	42.2	26.9	12.9	5.6	2.5	630.1	5.2
	IV	-	17.2	56.1	75.6	28.8	13.0	5.5	3.4	3.2	-	202.8	17.2
	Total	-	29.1	338.0	454.7	171.8	59.9	36.5	19.8	9.2	2.8	1,121.8	29.1
IVa (E of 2^0E)	I	-	0.2	23.8	174.0	104.8	29.9	15.5	9.5	2.0	1.9	361.6	0.2
	II	-	2.4	32.4	112.6	107.3	18.0	12.4	4.1	1.1	0.3	290.6	2.4
	III	16.8	0.8	22.1	65.3	56.3	17.1	14.0	6.8	3.4	0.5	203.2	17.6
	IV	18.1	30.9	107.1	154.7	108.4	35.9	21.2	12.5	1.8	2.8	493.4	49.1
	Total	34.9	34.3	185.4	506.5	376.8	101.0	63.1	32.9	8.4	5.5	1,348.8	69.2
IVb	I	-	44.5	120.6	13.1	<0.1	-	<0.1	-	-	-	178.2	44.5
	II	-	18.6	44.8	10.6	3.2	1.3	0.3	0.3	0.2	-	79.3	18.6
	III	1,598.2	1,608.2	116.5	177.8	82.7	22.5	9.6	5.7	1.8	0.3	3,623.4	3,206.4
	IV	319.5	152.3	16.3	15.4	11.5	2.2	0.4	1.1	-	-	518.8	471.8
	Total	1,917.7	1,823.5	298.2	216.9	97.5	26.0	10.4	7.1	2.0	0.3	4,260.1	3,741.3
IVc + VIId	I	-	-	3.0	27.7	31.0	5.0	2.5	0.8	<0.1	-	70.1	-
	II	-	<0.1	0.1	0.3	0.6	0.5	0.3	0.1	<0.1	<0.1	1.9	<0.1
	III	0.5	6.2	0.2	0.3	0.2	0.1	0.2	0.1	<0.1	-	7.8	6.7
	IV	2.6	6.4	102.8	177.1	150.2	25.9	16.4	2.4	1.0	-	485.0	9.0
	Total	3.1	12.6										
Total North Sea	I	-	47.5	233.8	264.8	149.5	36.7	18.8	11.0	2.1	1.9	766.0	47.5
	II	-	24.8	111.1	186.9	133.2	22.8	16.3	7.3	1.7	0.6	504.7	24.8
	III	1,615.5	1,620.4	300.5	509.1	246.5	81.9	50.8	25.6	10.9	3.3	4,464.4	3,235.9
	IV	340.3	206.8	282.3	422.8	298.9	77.0	43.6	19.5	6.1	2.8	1,700.0	547.1
	Total	1,955.8	1,899.5	927.7	1,383.6	828.1	218.3	129.4	63.3	20.7	8.7	7,435.1	3,855.3

Spring spawners transferred to Division IIIa are not included.

Table 2.2.2 Millions of HERRING caught annually per age group (winter rings) in the North Sea, 1970-1989.

Year	Winter ring										Total
	0	1	2	3	4	5	6	7	8	>8	
1970	898.1	1,196.2	2,002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5,294.3
1971	684.0	4,378.5	1,146.8	662.5	208.3	26.9	30.5	26.8	-	12.4	7,176.7
1972	750.4	3,340.6	1,440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6,045.5
1973	289.4	2,368.0	1,344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4,906.6
1974	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3,189.3
1975	263.8	2,460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3,753.3
1976	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1,482.0
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	1,211.0
1981	7,888.7	447.0	264.3	56.9	39.5	28.5	22.7	18.7	5.5	1.1	8,772.9
1982	9,556.7	840.4	268.4	230.1	33.7	14.4	6.8	7.8	3.6	1.1	10,963.0
1983	10,029.9	1,146.6	544.8	216.4	105.1	26.2	22.8	12.8	11.4	12.2	12,128.2
1984	2,189.4	561.1	986.5	417.1	189.9	77.8	21.7	24.2	10.6	17.8	4,496.1
1985	1,292.9	1,620.2	1,223.2	1,187.6	367.6	124.1	43.5	20.0	13.2	15.9	5,908.3
1986	704.0	1,763.2	1,155.1	827.1	458.3	127.7	61.1	20.2	13.4	14.6	5,144.7
1987	1,797.5	3,522.4	2,005.4	687.2	481.6	248.9	75.7	23.9	7.9	8.1	8,859.7
1988	1,292.9	1,970.8	1,955.5	1,185.1	398.1	260.6	128.6	37.9	15.1	8.4	7,252.8
1989	1,955.8	1,899.5	927.7	1,383.6	828.1	218.3	124.4	63.3	20.7	8.7	7,435.1

Table 2.2.3 Transfers of juvenile autumn spawners from Division IIIa (used in alternative North Sea assessment). Numbers (millions) per age group winter rings).

Year	0-r	1-r	2-r
1980	471	84	26
1981	1,631	425	20
1982	2,400	276	31
1983	3,267	1,302	29
1984	4,472	1,177	119
1985	2,886	1,608	93
1986	2,960	2,960	91
1987	6,238	3,153	117
1988	1,830	5,792	292
1989	1,003	1,039	563

Table 2.2.4 Percentage age composition of NORTH SEA HERRING (2-ring and older) in the catch in 1989.

Division	Quarter	2 (1986)	3 (1985)	Older	Total (millions)
IVa (W of 2^0E)	I	56.5	32.6	10.9	153.2
	II	26.1	49.2	24.7	129.0
	III	25.9	42.59.2	31.6	624.9
	IV	30.2	40.7	29.1	185.5
	Total	30.9	41.6	27.5	1,092.6
IVa (E of 2^0E)	I	6.6	48.2	45.2	361.4
	II	11.3	39.1	49.6	288.2
	III	11.9	35.2	52.9	185.6
	IV	24.1	34.8	41.1	444.4
	Total	14.5	39.6	41.1	444.4
IVb	I	90.2	9.8	<0.1	133.7
	II	73.9	17.5	8.6	60.7
	III	27.9	42.7	8.6	60.7
	IV	34.7	32.8	32.5	47.0
	Total	57.5	41.8	0.7	518.8
IVc + VIId	I	35.6	36.6	27.8	648.3
	II	23.2	39.0	37.8	478.0
	III	24.5	41.5	34.0	1,227.4
	IV	26.5	36.3	37.2	677.0
	Total	28.4	40.8	30.8	2,891.1
Total North Sea	I	32.5	36.9	30.6	718.4
	II	23.2	38.9	37.9	479.9
	III	24.5	41.4	34.1	1,228.5
	IV	24.5	36.7	38.8	1,152.9
	Total	25.9	38.7	35.4	3,579.7

Table 2.2.5 HERRING NORTH SEA. Samples of commercial catches available to the Working Group.

Country	Catch in tonnes	No. of samples	No. of age-readings	No. of fish measured	Estimate discards
Belgium	434	0	0	0	no
Denmark	210,315	85	4,984	5,316	no
Faroe Islands	1,916	0	0	0	no
France	33,512	28	1,846	6,719	no
Germany, Fed.Rep.	38,707	24	593	9,723	no
Netherlands	84,178	74	1,862	11,348	yes
Norway	221,891	236	7,823[1]	24,600[1]	no
Sweden	5,586	0	0	0	yes
UK (England)	7,980	6	2,123[1]	9,721[1]	no
UK (Scotland)	68,106	102	n/a	12,422	no
Unallocated	22,322	24	588	3,681	yes

[1] Including research vessel samples.

Table 2.2.6 Comparison of the fraction of spring spawners estimated by discriminant analysis, mean vertebral count and vertebral count/length frequency analysis for 2-ringers (2) and for older fish (3+). n = number of samples.

Estimation method	Div. IVa E, July			Div. IVb E, August		
	2	3+	n	2	3+	n
Discriminant analysis	0.30	0.48	11	-	-	-
Mean vertebral count	0.25	0.51	16	0.45	0.91	1
Vertebral count/length frequency	-	-	-	0.38	1.00	1

Table 2.2.7 Transfer of Division IIIa spring spawners taken in the North Sea catches in 1986-1989. Catch in numbers ('000) and mean weight (g) at age with SOPs in tonnes.

Year		Quarters 2 and 3 Divisions IVa (e) and IVb								Total
		2	3	4	5	6	7	8	9+	
1986	No	-	52,782	42,013	14,617	2,751	1,938	602	651	115,354
	W	-	156.8	171.7	194.5	210.1	216.6	210.6	283.1	
	SOP	-	8,276	7,214	2,843	578	420	128	184	19,642
1987	No	35,500	35,000	25,000	8,900	2,800	700	100	100	108,100
	W	94	124	147	177	195	216	278	283	
	SOP									14,207
1988	No	44,561	108,915	19,532	8,168	2,203	391	-	-	183,770
	W	94	131	154	171	176	212	-	-	
	SOP	4,206	14,221	3,015	1,393	399	83	-	-	23,306
1989	No	27,313	52,687	38,325	11,615	8,651	3,811	1,700	224	144,326
	W	91	120	164	180	178	191	202	209	
	SOP	2,488	6,337	6,298	2,090	1,537	729	344	47	19,869

[1] Originally tabulated in millions and rounded off.

Table 2.3.1 Recruitment indices for 1- and 2-ringed herring from International Young Fish Surveys. Indices given are means of all rectangle means either in 1-ringer standard area or in total North Sea.

Year class	Standard area	Total North Sea	VPA estimate (billions)	
	1-ringers	2-ringers	1-ringers	2-ringers
1974	452	-	0.81	-
1975	342	-	0.81	-
1976	575	-	1.47	-
1977	139	-	1.57	-
1978	535	-	3.43	-
1979	551	-	4.74	-
1980	1,293	106	8.17	2.52
1981	1,797	149	14.75	4.77
1982	2,663	712	13.46	4.63
1983	3,416	648	13.58	4.07
1984	3,667	853	22.72	7.34
1985	5,717	3,962	26.35	7.68[2]
1986	4,192	816	15.46[2]	4.56[2]
1987	3,468	459[1]	19.43[2]	-
1988	2,111[1]	-	-	-

[1] Preliminary.
[2] Estimate still inaccurate.

Table 2.3.2 Abundance indices of 0-ringed herring from IKMT sampling during International Young Fish Surveys. Catches corrected for haul duration and water depth. Area divisions are shown in Figure 2.3.4.

Area	North west	North east	Central west	Central east	South west	South east	Division IIIa	Southern Bight	IKMT index
Area factor	27	11	28	33	12	30	10	10	
Year class									
1976	16.2	4.2	36.5	1.5	2.4	0.7	0.5	4.9	1,658
1977	7.1	7.1	15.1	4.4	16.7	3.8	1.8	10.2	1,273
1978	52.7	9.3	108.3	6.0	3.0	1.5	22.3	0.0	5,061
1979	18.4	58.4	78.7	122.4	67.7	43.0	29.8	16.0	9,821
1980	15.6	0.2	43.4	34.6	26.7	101.6	74.5	56.1	7,455
1981	59.1	0.1	86.8	59.6	64.4	193.5	32.7	10.7	13,016
1982	7.6	3.3	20.4	74.4	87.0	92.6	140.9	42.1	8,918
1983	5.7	2.0	34.3	80.4	81.2	142.0	101.7	113.2	11,173
1984	25.0	5.7	90.8	77.7	298.7	215.4	83.1	89.5	17,617
1985	34.8	17.2	126.3	103.1	139.2	233.2	25.5	25.3	17,242
1986	95.1	8.7	218.9	167.0	249.0	279.8	14.3	73.2	26,331
1987	23.3	9.3	125.0	94.3	47.8	185.5	144.9	148.4	16,415
1988	10.7	6.1	28.5	28.8	45.2	123.2	54.4	4.8	6,935
1989	24.9[1]	8.9[1]	11.9	28.1	4.0	10.6	12.3	0.0	2,520

[1] Estimated from other cruises.

Table 2.3.3 IKMT index and VPA estimates of 0-group, and parameters of fitted regression lines for assessments of North Sea and North Sea and Division IIIa combined.

Year class	IKMT new index	VPA 0-ringers (billions)	
		North Sea	North Sea + Div. IIIa
1976	1,658	4.40	4.39
1977	1,273	4.47	4.68
1978	5,061	10.19	10.69
1979	9,821	14.12	16.83
1980	7,455	24.25	37.96
1981	13,016	54.84	65.08
1982	8,918	52.02	62.80
1983	11,173	40.36	54.63
1984	17,617	63.79	81.70
1985	17,242	72.75	92.96
1986	26,331	44.85	97.05
1987	16,415	54.87[1]	49.87[1]
1988	6,935	99.00[1]	57.00[1]
1989	2,520	-	-

[1] Not used in regression.

Regression of VPA on IKMT index:

i) North Sea VPA
(regression forced through origin)

r^2 = 0.541
a = 9.831
b = 0.002408 (s.e. 0.000740, df 9)

ii) North Sea VPA

r^2 = 0.487
b = 0.00304 (s.e. 0.000406, df 10)

iii) North Sea and Division IIIa VPA

r^2 = 0.825
a = 1.575
b = 0.00428 (s.e. 0.000657, df 9)

iv) North Sea and Division IIIa VPA
(regression forced through origin)

r^2 = 0.824
b = 0.00438 (s.e. 0.000342, df 10)

Table 2.3.4 Relative proportions of 1-ringed herring in North Sea and Division IIIa. Number in each area calculated as (mean number per square) x (number of squares sampled).

Survey year	North Sea	Division IIIa	% in Division IIIa
1983	153,439	38,024	19.9
1984	163,482	31,633	16.2
1985	250,805	78,113	23.7
1986	229,255	224,370	49.5
1987	446,615	114,483	20.4
1988	259,193	661,089	71.8
1989	264,714	170,275	39.1
1990	129,486	34,583	21.1

Table 2.3.5 Relation between IYFS indices and VPA stock numbers of 1-group herring in the North Sea.

Year class	Standard index	GLM	GLM incl. Div. IIIa	VPA
1980	1,293	-	-	8,168
1981	1,797	6,756	2,504	14,754
1982	2,663	4,207	1,800	13,465
1983	3,416	5,645	2,347	13,581
1984	3,667	8,307	3,255	22,716
1985	5,717	13,948	5,166	26,353
1986	4,192	5,683	2,451	15,459
1987	3,468	5,067	1,996	19,434
1988	2,111[1]	2,463	1,182	-
Regressions (log scale) between indices and VPA (year classes 1981-1986):				
R^2		0.70	0.85	0.88
a		4.64	4.11	3.87
b		0.63	0.64	0.74
Predicted year-class strength in millions:				
1986		20,513	15,057	15,736
1987		17,094	14,071	13,470
1988		12,527	8,881	9,135

[1] Preliminary.

Table 2.4.1 Summer acoustic survey 1989. Estimated numbers of herring at age (millions) per spawning group and area.

N = numbers
B = biomass ('000 t)
I = immature
M = mature
Sp = Spring spawner
Au = Autumn spawner

Age	IVa W	IVa E		IVb W	IVb E		Skagerrak		Kattegat		Total	
		Au	Sp		Au	Sp	Au	Sp	Au	Sp	Au	Sp
0	1,227.5	0	0	142.8	703.0	-	975.0		82.7		3,131	0
1	2,492.0	104.0	0	249.7	1,616.0	-	1,040.0		830.8		6,333	0
2I	489.3	197.0	-	51.7	56.5	-		-		-	795	-
2M	2,473.5	169.0	155	288.9	0	31.5		581.0		337.8	2,931	1,105
3I	128.1	91.0	-	11.3	0	-		-		-	30	-
3M	2,983.2	320.0	462	217.6	0	11.0		151		90.3	3,521	714
4	1,231.1	341.0	280	40.1	0	3.0		22		12.2	1,612	317
5	397.2	101.0	78	8.0	0	0		2		0.7	488	81
6	207.2	74.0	50	0	0	0		1		0.4	281	54
7	86.7	33.0	16	0	0	0		0.3		0	120	16
8	33.0	11.0	4	0	0	0		0.2		0	44	4.2
9+	16.6	5.0	0	0	0	0		0		0	22	0
Total	11,747.4	1,446.0	1,045	1,010.1	2,375.5	45.5	2,015.0	757.5	913.5	414.4	19,508	2,289
Spwn.N	7,410.5	1,054.0	1,045	554.6	0	45.5	0	757.5	0	441.4	9,019	2,289
Spwn.B	1,350.0	209.9	156.6	76.7	0	5.0	0	64.9	0	29.0	1,637	255.5

Table 2.4.2 Acoustic summer survey 1989. Mean weight at age (g) per spawning group and area.

I = immature
M = mature
Sp = Spring spawners
Au = Autumn spawners

Age	IVa W	IVa E		IVb W	IVb E		Skagerrak		Kattegat		Total mean			
											1989		1988	
		Au	Sp		Au	Sp	Au	Sp	Au	Sp	Au	Sp	Au	Sp
0	3.8	-	-	5.1	14.9	-	21.3	-	11.3		12.0	-	7	-
1	59.2	69.4	-	49.7	47.0	-	48.7	-	35.7		51.1	-	43	-
2I	107.4	102.9	-	97.2	100.4	-	-	-			105.1	-	100	-
2M	141.8	137.4	109.0	125.0	-	100.4	-	79.1	-	59.9	139.9	78.0	134	65
3I	135.4	122.2	-	99.7	-	-	-	-		-	128.4	-	119	-
3M	179.9	177.8	128.7	151.1	-	121.4	-	103.3		81.9	177.9	117.3	168	118
4	213.2	210.3	177.5	155.0	-	157.3	-	126.8		104.9	211.1	171.0	215	160
5	259.5	237.8	199.2	186.0	-	-	-	174.2		107.8	253.8	197.8	239	166
6	286.8	272.4	212.6	-	-	-	-	156.8		124.3	283.0	210.8	270	181
7	291.8	279.2	215.8	-	-	-	-	179.8		-	288.3	215.1	277	241
8	326.4	285.1	227.3	-	-	-	-	195.0		-	316.1	225.8	297	175
9+	376.9	314.6	-	-	-	-	-	-		-	362.5	-	310	-

Table 2.4.3 Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1984-1989. 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 and 1989 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						$Z_{1988-1989}$
	1984	1985	1986	1987	1988	1989	
1	551	726	1,639	13,736	6,431	6,333	
2	3,194	2,789	3,206	4,303	4,202	3,726	0.55
3	1,005	1,433	1,637	955	1,732	3,751	0.11
4	394	323	833	657	528	1,612	0.07
5	158	113	135	368	349	488	0.08
6	44	41	36	77	174	281	0.22
7	52	17	24	38	43	120	0.37
8	39	23	6	11	23	44	-0.02
9+	41	19	8	20	14	22	0.52
Z(2+/3+)	0.92	0.57	1.02	0.81	0.11		
SSB ('000 t)	807	697	942	817	897	1,637	

SSB defined as all fish ≥ maturity stage III.

Table 2.5.1 ICES International herring larvae surveys. Estimated mortality rates rates (z/k) per mm for the standard areas over the years 1980-1989. Estimates marked with an asterix (*) are based on regression over the larval length range 10-16 mm. Estimates marked with a double asterix (**) are based on the length range 11-16 mm. Other estimates are based on the length range 8-16 mm.

Year	Orkney-Shetland	Div. VIa (N) + Ork./Shet.	Buchan	Central North Sea	Divs. IVc + VIId
1980	-	0.29*	-	-	0.33**
1981	0.29	0.34	-	-	-
1982	0.25*	0.26*	-	0.40	0.80**
1983	0.27*	0.26*	0.43	0.34	-
1984	0.20	0.24	0.42	-	0.54**
1985	0.25*	0.29*	-	0.33*	0.56**
1986	0.28*	0.22*	0.27*	-	0.48**
1987	0.37*	0.36	0.37*	0.35*	0.64**
1988	0.53*	0.56	0.38	0.31	0.71**
1989	0.39*	0.41	0.22	0.46	-
Mean	0.31	0.32	0.35	0.37	0.58
89z/k	0.31		0.37	0.35	
88z/k	0.27		0.37	0.36	0.56

89z/k: Mortality rates used in the 1989 HAWG Report (Anon., 1989d).
88z/k: Mortality rates used in the 1988 HAWG Report (Anon., 1988).

Table 2.5.2 Larvae production estimates (LPE x 10^{11} larvae) calculated using area-specific natural mortality rates (z/k). Division IVa is the sum of Orkney-Shetland and Buchan LPEs. Division VIa + Orkney/Shetland is combined LPEs for Orkney-Shetland and Division VIa(N). The 1989 value for Divisions IVc + VIId is provisional.

Year	Ork/Sh	Buchan	IVa	VIa(N)+Ork/Sh	Central North Sea	IVc+VIId
1972	174	-	174	-	23	20
1973	95	-	95	229	80	10
1974	78	-	78	153	45	2
1975	54	-	54	147	46	1
1976	20	-	20	55	10	1
1977	-	-	-	151	67	-
1978	102	-	102	198	73	3
1979	299	-	299	517	57	11
1980	332	-	332	586	103	127
1981	225	-	225	457	187	406
1982	336	92	428	554	76	190
1983	282	277	559	396	64	258
1984	213	433	646	391	523	178
1985	314	477	791	575	633	206
1986	218	831	1,049	789	451	359
1987	359	200	559	597	331	175
1988	413	727	1,140	803	568	231
1989	730	703	1,433	1,422	313	(230)

Table 2.5.3 The LPE index of SSB ('000 tonnes) estimated from larvae production estimates (LPE * 10E11 larvae), and Fec, i.e., number of eggs (* 10E5) per kg SSB. SSB is the index of spawning stock biomass estimated as the ratio between LPE and Fecundity. Fecundities marked with an asterix are estimated as the average of the three closest years where an estimate was available.

Year	IVa (incl.Buchan)			IVb			IVa + IVb	IVc + VIId			North Sea
	LPE	Fec.	SSB	LPE	Fec.	SSB	SSB	LPE	Fec.	SSB	SSB
1972	174	1.56*	112	23	1.79*	13	124	20	0.94	21	146
1973	95	1.56*	61	80	1.79*	45	106	10	0.93	11	116
1974	78	1.56*	50	45	1.79*	25	75	2	0.87	2	77
1975	54	1.59	34	46	1.79*	26	60	1	1.01	1	61
1976	20	1.52	13	10	1.79*	6	19	1	0.74	1	20
1977	-	1.57	0	67	1.79*	37	-	2	1.02	2	-
1978	102	1.57	65	73	1.79*	41	106	3	1.18	3	108
1979	299	1.64	182	57	1.79*	32	214	11	1.07	10	224
1980	332	1.69	196	103	1.79*	58	254	127	1.14	111	365
1981	225	1.51	149	187	1.79*	104	253	406	1.06	383	636
1982	428	1.60	268	76	1.83*	42	309	190	1.11	171	480
1983	559	1.53	365	64	1.82*	35	401	258	1.10	235	635
1984	646	1.67	387	523	1.67	313	700	178	1.04	171	871
1985	791	1.60*	494	633	1.88	337	831	206	1.08	191	1,022
1986	1,049	1.60*	656	451	1.76*	256	912	359	1.08*	332	1,244
1987	559	1.60*	349	331	1.76*	188	537	175	1.08*	162	699
1988	1,140	1.60*	713	568	1.76*	323	1,035	231	1.08*	214	1,249
1989	1,433	1.60*	896	313	1.76*	176	1,074	230	1.08*	213	1,287

Table 2.5.4 Larvae abundance indices (LAI) by area and for the total North Sea. The 1989 values for Divisions IVc + VIId and for the total North Sea are provisional.

Year	Ork-Shet.	Buchan	Central North Sea	IVc+VIId	North Sea
1972	5,779	7	112	171	6,405
1973	2,387	10	734	133	5,466
1974	1,284	379	635	25	4,228
1975	439	441	59	25	1,141
1976	655	1	76	18	978
1977	1,321	228	174	23	2,268
1978	3,705	363	462	111	6,027
1979	5,649	200	188	403	7,004
1980	3,982	18	214	1,193	6,049
1981	3,939	20	3,364	4,855	22,270
1982	3,795	1,002	338	3,709	9,858
1983	3,346	4,483	661	2,354	12,827
1984	3,538	4,296	1,055	2,267	14,321
1985	10,487	4,351	3,802	4,065	34,111
1986	5,500	3,780	2,027	4,780	22,168
1987	9,596	3,308	1,970	3,317	24,101
1988	16,502	12,319	2,946	3,907	44,512
1989	17,424	6,940	2,205	(7,523)	(40,707)

Table 2.6.1 NORTH SEA HERRING 1989. Mean weight (g) at age (winter rings) and year class in the catches. Weighted by numbers caught.

Division	Quarter	0 1988	1 1987	2 1986	3 1985	4 1984	5 1983	6 1982	7 1981	8 1980	9+ 1979
IVa (W of 2^0E)	I	-	95	114	132	146	175	170	186	-	-
	II	-	67	128	149	168	248	276	294	329	333
	III	-	70	145	187	217	258	281	293	302	350
	IV	-	85	130	158	174	192	218	201	209	-
	Total	-	81	132	171	198	241	269	274	271	349
IVa (E of 2^0E)	I	-	83	88	119	139	167	196	201	251	226
	II	-	81	126	156	169	197	202	249	275	228
	III	10	74	133	169	195	228	250	280	293	356
	IV	14	90	129	152	167	194	207	217	222	167
	Total	12	89	124	144	164	192	213	229	265	209
IVb	I	-	24	63	96	122	-	151	-	-	-
	II	-	33	79	108	147	151	172	152	172	-
	III	12	42	125	171	203	231	288	288	283	333
	IV	40	56	114	150	187	203	195	242	-	-
	Total	17	42	93	162	199	225	280	276	273	333
IVc + VIId	I	-	-	71	86	105	135	133	143	173	-
	II	-	79	98	120	139	160	167	164	172	179
	III	15	51	109	128	150	199	203	210	215	-
	IV	40	87	111	133	161	192	209	222	200	-
	Total	36	69	110	127	151	182	198	201	198	179
IVa	Total	12	85	129	157	175	210	233	246	268	256
IVa + IVb	Total	17	43	116	158	179	212	237	250	269	259
North Sea	Total	17	43	115	153	173	208	231	247	265	259

Spring spawners transferred to Division IIIa are not included.

Table 2.6.2 Mean weight of HERRING (g) by quarter and areas, 1986-1989. Spring spawners transferred to Division IIIa are not included.

Division	Year	Quarter	Winter rings									
			0	1	2	3	4	5	6	7	8	9+
IVa +IVb	1986	I	-	14	77	118	150	177	187	226	229	250
	1987	I	-	14	49	123	161	184	209	231	271	257
	1988	I	-	14	65	119	155	178	191	212	230	232
	1989	I	-	28	85	120	140	167	195	200	251	226
	1986	II	2	30	130	167	196	224	225	259	259	284
	1987	II	-	15	104	162	192	220	245	255	268	290
	1988	II	-	45	102	143	170	200	217	252	253	315
	1989	II	-	43	108	152	168	201	217	262	276	282
	1986	III	6	78	146	190	24	248	282	288	327	364
	1987	III	10	54	134	182	219	248	265	286	310	342
	1988	III	11	58	124	178	217	239	261	283	283	296
	1989	III	12	42	136	179	207	244	274	288	296	350
	1986	IV	20	79	129	167	183	198	216	227	271	262
	1987	IV	11	61	104	147	172	197	214	230	261	264
	1988	IV	12	69	117	141	166	194	191	212	213	243
	1989	IV	39	64	128	154	170	194	209	215	214	167
	1986	Total	6	67	122	158	184	210	223	245	253	263
	1987	Total	11	35	97	150	185	213	237	259	269	304
	1988	Total	11	55	112	147	176	199	217	238	257	263
	1989	Total	17	43	116	158	179	212	237	250	269	259
IVc + VIId	1986	I	12	18	70	95	118	145	167	200	202	-
	1987	I	-	-	74	100	126	150	166	240	232	-
	1988	I	-	-	98	96	118	134	181	145	160	-
	1989	I	-	-	71	86	105	135	133	143	173	-
	1986	II	2	25	83	104	129	153	163	198	202	-
	1987	II	-	-	82	109	136	157	171	184	-	-
	1988	II	-	-	102	142	176	192	201	197	206	-
	1989	II	-	79	98	120	139	160	167	164	172	179
	1986	III	20	80	113	152	174	214	220	170	-	232
	1987	III	6	49	110	170	200	207	207	237	-	-
	1988	III	-	-	131	184	208	220	227	238	234	-
	1989	III	15	51	109	128	150	199	203	210	215	-
	1986	IV	20	80	113	152	174	214	220	170	-	232
	1987	IV	27	101	105	142	167	178	206	186	174	234
	1988	IV	-	80	103	135	159	184	197	203	-	-
	1989	IV	40	87	111	133	161	192	209	222	200	179
	1986	Total	19	59	108	139	164	185	209	174	202	232
	1987	Total	20	100	104	128	148	164	198	210	197	234
	1988	Total	-	80	103	132	156	178	197	185	165	-
	1989	Total	36	69	110	127	151	182	198	201	198	179
Total North Sea	1986	Total	6	67	121	153	182	208	221	238	253	262
	1987	Total	11	35	98	147	179	210	234	258	269	299
	1988	Total	11	55	111	145	174	197	216	237	253	263
	1989	Total	17	43	115	153	173	208	231	247	265	259

Figure 2.7.1 Stock estimates by age for acoustic survey, IYFS and larval surveys (LPE) for the years 1984-1989.

```
Acoustic Survey, IYFS and LPE(age dist. as acoust.)  1984-1989
103
Acoustic Surv. 1 Jan, 2-8
1984 1989
1  1
2  8
1 4179.5  1315.4   513.7   207.5    54.7    65.4    44.3
1 3548.3  2233.8   556.1   194.7    68.4    29.6    32.7
1 4120.3  2060.4   951.2   176.4    49.9    33.7     6.3
1 5695.1  1387.0   946.9   516.1   114.1    50.0    16.4
1 5369.2  2321.8   751.0   515.8   254.7    68.0    31.2
1 4701    4620     1985     574     331     144.9    50.1
IYFS 1-4
1984 1989
1  1
1  4
1 1447  266   77  28
1 2152  805  295  39
1 2967  790  319  75
1 4382 1400  174  85
1 4957 3962  714  56
1 1917  821  391  86
LPE 2-7
1984 1989
1  1
2  7
1 3447 1085  425 171  47 56
1 4089 2101  474 166  60 25
1 4234 2162 1100 178  48 32
1 3334  742  511 286  60 30
1 5851 2412  735 486 242 60
1 2929 2949 1267 384 221 94
```

Table 2.7.2 VIRTUAL POPULATION ANALYSIS.

NORTH SEA HERRING (FISHING AREA IV)
CATEGORY: TOTAL

CATCH IN NUMBERS UNIT: millions

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	898.1	684.0	750.4	289.4	996.1	263.8	238.2	256.8	130.0	542.0	791.7	7888.7
1	1196.2	4378.5	3340.6	2368.0	846.1	2460.5	126.6	144.3	168.6	159.2	161.1	447.0
2	2002.8	1146.8	1440.5	1344.2	772.6	541.7	901.5	44.7	4.9	34.1	108.0	264.3
3	883.6	662.5	343.8	659.2	362.0	259.6	117.3	186.4	5.7	10.0	91.8	56.9
4	125.2	208.3	130.6	150.2	126.0	140.5	52.0	10.8	5.0	10.1	32.2	39.5
5	50.3	26.9	32.9	59.3	56.1	57.2	34.5	7.0	.3	2.1	21.7	28.5
6	61.0	30.5	5.0	30.6	22.3	16.1	6.1	4.1	.2	.2	2.3	22.7
7	7.9	26.8	.2	3.7	5.0	9.1	4.4	1.5	.2	.8	1.4	18.7
8	12.0	.0	1.1	1.4	2.0	3.4	1.0	.7	.2	.6	.4	5.5
9+	12.2	12.4	.4	.6	1.1	1.4	.4	.0	.3	.1	.1	1.1
TOTAL	5249.3	7176.7	6045.5	4906.6	3189.3	3753.3	1482.0	656.3	315.4	759.2	1210.7	8772.9

	1982	1983	1984	1985	1986	1987	1988	1989
0	9556.7	10029.9	2189.9	1292.9	704.0	1797.5	1292.9	1955.8
1	840.4	1146.6	560.2	1620.2	1763.2	3522.3	1970.8	1899.5
2	268.4	544.8	976.0	1223.2	1155.1	2006.7	1955.5	927.7
3	230.1	216.4	421.7	1173.4	827.1	687.1	1185.1	1383.6
4	33.7	105.1	192.5	365.7	458.3	481.5	398.1	828.1
5	14.4	26.2	77.5	123.6	127.7	248.8	260.6	218.3
6	6.8	22.8	21.6	43.3	61.1	75.7	128.6	129.4
7	7.8	12.8	24.1	20.0	20.2	23.7	37.9	63.3
8	3.6	11.0	10.6	13.0	13.4	7.9	15.1	20.7
9+	1.1	12.1	17.8	16.0	14.6	8.0	8.4	8.7
TOTAL	10963.0	12127.7	4491.9	5891.3	5144.7	8859.2	7253.0	7435.1

Table 2.7.3 Herring in the total North Sea (Sub-area IV). Weight at age (g) in the stock at time of spawning and proportions of maturity by years, applied in the VPA.

Age	Weight at age						Proportions of maturity							
	1947-1984	1985	1986	1987	1988	1989	1947-1955	1956-1971	1972-1984	1985	1986	1987	1988	1989
0	15	9	6	6	7	12	-	-	-	-	-	-	-	-
1	50	64	78	49	43	51	-	-	-	-	-	-	-	-
2	155	141	146	133	122	140	0.70	1.00	0.82	70	0.75	0.63	0.66	0.79
3	187	193	190	183	163	178	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.94
4	223	228	224	220	215	211	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5	239	248	248	247	239	254	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	278	258	281	263	270	283	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	299	300	287	285	271	288	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	305	318	328	310	297	316	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9+	312	316	364	342	310	362	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

(Values for 1985-1989 derived from acoustic survey data.)

Table 2.7.4

NORTH SEA HERRING (FISHING AREA IV)

MEAN WEIGHT AT AGE IN THE CATCH UNIT: gram

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	7.000
1	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	50.000	49.000
2	126.000	126.000	126.000	126.000	126.000	126.000	126.000	126.000	126.000	126.000	126.000	118.000
3	176.000	176.000	176.000	176.000	176.000	176.000	176.000	176.000	176.000	176.000	176.000	142.000
4	211.000	211.000	211.000	211.000	211.000	211.000	211.000	211.000	211.000	211.000	211.000	189.000
5	243.000	243.000	243.000	243.000	243.000	243.000	243.000	243.000	243.000	243.000	243.000	211.000
6	251.000	251.000	251.000	251.000	251.000	251.000	251.000	251.000	251.000	251.000	251.000	222.000
7	267.000	267.000	267.000	267.000	267.000	267.000	267.000	267.000	267.000	267.000	267.000	267.000
8	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000
9+	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000	271.000

	1982	1983	1984	1985	1986	1987	1988	1989
0	10.000	10.000	10.000	9.000	6.000	11.000	11.000	17.000
1	59.000	59.000	59.000	36.000	67.000	35.000	55.000	43.000
2	118.000	118.000	118.000	128.000	121.000	99.000	111.000	115.000
3	149.000	149.000	149.000	164.000	153.000	150.000	145.000	153.000
4	179.000	179.000	179.000	194.000	182.000	180.000	174.000	173.000
5	217.000	217.000	217.000	211.000	208.000	211.000	197.000	208.000
6	238.000	238.000	238.000	220.000	221.000	234.000	216.000	231.000
7	265.000	265.000	265.000	258.000	238.000	258.000	237.000	247.000
8	274.000	274.000	274.000	270.000	252.000	277.000	253.000	265.000
9+	275.000	275.000	275.000	292.000	262.000	299.000	263.000	259.000

Table 2.7.5

DISAGGREGATED Qs
LOG TRANSFORMATION
NO explanatory variate (Mean used)
Fleet 1 ,Acoustic Surv. 1 Jan, has terminal q estimated as the mean
Fleet 2 ,IYFS 1-4 , has terminal q estimated as the mean
Fleet 3 ,LPE 2-7 , has terminal q estimated as the mean
FLEETS COMBINED BY ** VARIANCE **

Regression weights
, 1.000, 1.000, 1.000, 1.000, 1.000, 1.000,
Oldest age F = 1.000*average of 5 younger ages. Fleets combined by variance of predictions
Fishing mortalities

Age,	84,	85,	86,	87,	88,	89,
0,	.086,	.033,	.013,	.060,	.056,	.100,
1,	.064,	.197,	.134,	.195,	.201,	.258,
2,	.267,	.335,	.372,	.392,	.274,	.236,
3,	.399,	.637,	.426,	.425,	.455,	.339,
4,	.490,	.683,	.523,	.448,	.443,	.633,
5,	.569,	.594,	.476,	.532,	.412,	.413,
6,	.299,	.641,	.586,	.509,	.512,	.329,
7,	.563,	.440,	.621,	.419,	.458,	.452,
8,	.464,	.599,	.527,	.467,	.456,	.433,

Log catchability estimates

Age 1 Fleet,	84,	85,	86,	87,	88,	89
1 , No data for this fleet at this age						
2 ,	-1.80,	-1.34,	-1.49,	-1.42,	-.68,	-1.35
3 , No data for this fleet at this age						

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised, F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 , No data for this fleet at this age								
2 ,	-1.35 ,	.397,	.2600 ,	.2577,	.000E+00,	.000E+00,	-1.347,	.150
3 , No data for this fleet at this age								

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.258	.397	0.000	.397	0.000

(cont'd)

Table 2.7.5 (cont'd)

Age 2

Fleet	84	85	86	87	88	89
1	.13	-.03	.28	.11	-.28	.18
2	-2.62	-1.51	-1.37	-1.30	-.59	-1.56
3	-.06	.11	.31	-.43	-.20	-.29

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	.07	.215	1.0677	.2107	.000E+00	.000E+00	.065	.081
2	-1.49	.709	.2250	.2543	.000E+00	.000E+00	-1.491	.268
3	-.09	.294	.9119	.2888	.000E+00	.000E+00	-.092	.111

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.236	.168	.104	.168	.381

Age 3

Fleet	84	85	86	87	88	89
1	.22	.19	.06	-.15	-.12	.13
2	-2.62	-1.83	-1.81	-2.23	-1.29	-2.34
3	.03	.13	.11	-.78	-.08	-.32

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	.05	.170	1.0560	.3162	.000E+00	.000E+00	.054	.064
2	-2.02	.510	.1325	.4690	.000E+00	.000E+00	-2.021	.193
3	-.15	.377	.8585	.4028	.000E+00	.000E+00	-.153	.142

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.339	.148	.925E-01	.148	.391

(cont'd)

Table 2.7.5 (cont'd)

Age 4

Fleet	84	85	86	87	88	89
1	.27	.04	.08	-.13	-.18	.42
2	-2.64	-2.62	-2.46	-2.54	-2.78	-2.72
3	.08	-.12	.23	-.74	-.20	-.03

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	.08	.247	1.0866	.4533	.000E+00	.000E+00	.083	.093
2	-2.63	.126	.0724	.6971	.000E+00	.000E+00	-2.626	.048
3	-.13	.362	.8762	.5727	.000E+00	.000E+00	-.132	.137

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.632	.107	.120	.120	1.249

Age 5

Fleet	84	85	86	87	88	89
1	.42	-.07	-.42	.10	-.20	.08
2	No data for this fleet at this age					
3	.23	-.23	-.41	-.49	-.26	-.32

SUMMARY STATISTICS

Fleet	Pred. q	SE(q)	Partial F	Raised F	SLOPE	SE Slope	INTRCPT	SE Intrcpt
1	-.01	.311	.9854	.3748	.000E+00	.000E+00	-.015	.117
2	No data for this fleet at this age							
3	-.25	.273	.7809	.4440	.000E+00	.000E+00	-.247	.103

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.412	.205	.840E-01	.205	.168

(cont'd)

Table 2.7.5 (cont'd)

Age 6

Fleet,	84,	85,	86,	87,	88,	89
1 ,	-.28,	.01,	-.74,	-.26,	.01,	-.17
2 ,	No data for this fleet at this age					
3 ,	-.43,	-.12,	-.78,	-.91,	-.04,	-.58

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 ,	-.24 ,	.298,	.7886 ,	.3083,	.000E+00,	.000E+00,	-.238,	.113
2 ,	No data for this fleet at this age							
3 ,	-.47 ,	.377,	.6224 ,	.3644,	.000E+00,	.000E+00,	-.474,	.142

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.329	.234	.815E-01	.234	.121

Age 7

Fleet,	84,	85,	86,	87,	88,	89
1 ,	.42,	-.43,	.04,	-.12,	-.20,	.04
2 ,	No data for this fleet at this age					
3 ,	.27,	-.60,	-.02,	-.63,	-.32,	-.40

SUMMARY STATISTICS

Fleet ,	Pred. q ,	SE(q),	Partial F ,	Raised F ,	SLOPE ,	SE Slope ,	INTRCPT,	SE Intrcpt
1 ,	-.04 ,	.309,	.9590 ,	.4187,	.000E+00,	.000E+00,	-.042,	.117
2 ,	No data for this fleet at this age							
3 ,	-.28 ,	.378,	.7538 ,	.5074,	.000E+00,	.000E+00,	-.283,	.143

Fbar	SIGMA(int.)	SIGMA(ext.)	SIGMA(overall)	Variance ratio
.452	.239	.941E-01	.239	.155

Table 2.7.6 VIRTUAL POPULATION ANALYSIS.

NORTH SEA HERRING (FISHING AREA IV)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 VARIABLE NATURAL MORTALITY COEFFICIENT

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.035	.034	.058	.046	.074	.145	.142	.095	.046	.088	.092	.433
1	.268	.601	.576	.673	.446	.681	.226	.285	.195	.170	.077	.159
2	.973	.882	.808	1.015	1.026	1.269	1.303	.199	.023	.092	.290	.302
3	1.265	1.214	.800	1.314	.955	1.489	1.270	1.276	.037	.063	.402	.260
4	1.318	1.221	.798	.984	.950	1.292	1.651	.328	.086	.081	.280	.286
5	.867	1.052	.543	.947	1.173	1.569	1.261	.993	.012	.042	.222	.380
6	1.055	2.454	.486	1.337	1.065	1.230	.600	.407	.056	.009	.054	.339
7	1.000	2.313	.082	.714	.713	1.913	1.311	.254	.028	.291	.072	.683
8	1.231	.000	.542	1.059	.971	1.498	1.219	.652	.044	.097	.207	.390
9+	1.231	.000	.542	1.059	.971	1.498	1.219	.652	.044	.097	.207	.390
(2- 6)U	1.096	1.365	.687	1.120	1.034	1.369	1.217	.641	.043	.057	.250	.313
(3- 6)U	1.126	1.485	.657	1.146	1.036	1.395	1.196	.751	.048	.049	.240	.316

	1982	1983	1984	1985	1986	1987	1988	1989
0	.312	.335	.086	.033	.013	.060	.056	.100
1	.175	.129	.064	.197	.134	.195	.201	.258
2	.233	.285	.267	.335	.372	.392	.274	.236
3	.502	.318	.399	.637	.426	.425	.454	.339
4	.229	.427	.490	.683	.523	.448	.443	.632
5	.144	.250	.569	.594	.476	.531	.412	.412
6	.130	.314	.299	.641	.586	.509	.512	.329
7	.166	.341	.563	.440	.621	.419	.458	.452
8	.235	.331	.464	.599	.527	.467	.456	.433
9+	.235	.331	.464	.599	.527	.467	.456	.433
(2- 6)U	.247	.319	.405	.578	.477	.461	.419	.390
(3- 6)U	.251	.327	.439	.639	.503	.478	.455	.428

Table 2.7.7 VIRTUAL POPULATION ANALYSIS.
NORTH SEA HERRING (FISHING AREA IV).
STOCK SIZE IN NUMBERS. UNIT: millions.
BIOMASS TOTALS. UNIT: tonnes.

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .670
PROPORTION OF ANNUAL M BEFORE SPAWNING: .670

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	41149	32385	20878	10218	21846	3058	2814	4437	4525	10151	14129	34257
1	7877	14617	11517	7246	3591	7461	973	898	1484	1589	3421	4741
2	3640	2217	2949	2381	1360	846	1389	286	248	449	493	1165
3	1331	1020	680	974	639	361	176	280	173	180	304	273
4	178	307	248	250	214	201	67	41	64	137	138	166
5	91	43	82	101	85	75	50	12	26	53	114	94
6	97	34	14	43	35	24	14	13	4	24	46	83
7	13	31	3	8	10	11	6	7	8	3	21	39
8	18	0	3	2	3	5	1	2	5	7	2	18
9+	18	0	1	1	2	2	1	0	7	1	1	4
TOTAL NO	54411	50654	36374	21223	27786	12043	5491	5974	6545	12594	18670	40841
SPS NO	2232	1559	1702	1355	920	478	508	323	415	635	737	1137
TOT.BIOM	1927214	1848389	1553856	1161719	919989	692237	372322	225931	240778	388156	594272	1083549
SPS BIOM	379190	266161	290480	236664	165544	87136	85452	58019	78095	119654	143869	210301

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	55033	54267	41779	61996	85246	48671	37250	32251	0
1	8170	14823	14283	14104	22057	30951	16864	12955	10735
2	1487	2523	4793	4930	4261	7099	9369	5076	3683
3	638	873	1405	2719	2612	2175	3555	5275	2969
4	173	317	520	772	1177	1397	1164	1848	3076
5	113	124	187	288	353	631	808	677	889
6	58	89	88	96	144	198	336	484	405
7	53	46	59	59	46	73	108	182	315
8	18	41	30	30	34	22	43	62	105
9+	6	45	50	37	37	22	24	26	51
TOTAL NO	65749	73148	63194	85032	115968	91241	69521	58834	
SPS NO	1601	2502	4258	4586	4935	5840	7998	8416	
TOT.BIOM	1688730	2274673	2573675	2991822	3779940	3701536	3292610	3477675	
SPS BIOM	293694	453917	746038	807249	906803	1010461	1255501	1526239	

Table 2.7.8 Time series of relative estimates of spawning stock, and the spawning stock for the converged part of the VPA ('000 t).

Year	SSB VPA	SSB LPE	SSB Acoustic	LAI	IYFS 2+ Total Area
1972	290	146	-	6,405	-
1973	236	116	-	5,466	-
1974	164	77	-	4,228	-
1975	88	61	-	1,141	-
1976	85	20	-	978	-
1977	58	-	-	2,268	-
1978	79	108	-	6,027	-
1979	123	224	-	7,004	-
1980	148	365	-	6,049	35.4
1981	214	636	305	22,270	863.0
1982	293	480	402	9,858	201.5
1983	451	635	440	12,827	270.8
1984	742	871	807	14,321	377.1
1985	799	1,022	697	34,111	1,166.5
1986	892	1,244	942	22,168	1,204.7
1987	-	699	667[1]	24,101	1,705.3
1988	-	1,249	801[2]	44,512	4,760.1
1989	-	1,287	1,490[3]	40,707	1,248.0

[1] Reduced by 150,000 t [catches of spawners between time of the survey (15 July) and 1 November].
[2] Reduced by 94,000 t [catches of spawners between time of the survey (15 July) and 1 September].
[3] Reduced by 147,000 t (catches of spawners between time of the survey and 1 Spetember).

Table 2.7.9

Analysis by RCRTINX2 of data from file sur-ind-3
Prediction of SSB from LPE, Acoustics, IYFS 2+, Total North Sea.

Data for 3 surveys over 18 years
REGRESSION TYPE = C
TAPERED TIME WEIGHTING APPLIED
POWER = 3 OVER 10 YEARS
PRIOR WEIGHTING NOT APPLIED
FINAL ESTIMATES NOT SHRUNK TOWARDS MEAN
ESTIMATES WITH S.E.'S GREATER THAN THAT OF MEAN INCLUDED
MINIMUM S.E. FOR ANY SURVEY TAKEN AS .20
MINIMUM OF 5 POINTS USED FOR REGRESSION

Yearclass = 1987

Survey/ Series	Index Value	Slope	Inter-cept	Rsquare	No. Pts	Predicted Value	Sigma	Standard Error	Weight
LPE SS	6.5511	1.461	-3.459	.8567	14	6.1121	.34064	.36686	.22173
ACOUST	6.5043	1.350	-2.316	.9295	6	6.4653	.17740	.19505	.74606
IYFS 2	7.4421	.871	.870	.4668	7	7.3539	.79205	.96248	.03221
MEAN						6.0729	.75833	.75833	.00000

Yearclass = 1988

Survey/ Series	Index Value	Slope	Inter-cept	Rsquare	No. Pts	Predicted Value	Sigma	Standard Error	Weight
LPE SS	7.1309	1.568	-4.178	.8536	14	7.0027	.31852	.38483	.22592
ACOUST	6.6871	1.337	-2.229	.9236	6	6.7093	.18383	.21115	.75043
IYFS 2	8.4682	.888	.762	.4645	7	8.2809	.77536	1.18943	.02365
MEAN						6.2178	.67349	.67349	.00000

Yearclass = 1989

Survey/ Series	Index Value	Slope	Inter-cept	Rsquare	No. Pts	Predicted Value	Sigma	Standard Error	Weight
LPE SS	7.1608	1.595	-4.368	.8462	14	7.0574	.29973	.37962	.37692
ACOUST	7.3072	1.314	-2.082	.9136	6	7.5197	.19491	.31243	.55646
IYFS 2	7.1693	.887	.763	.4649	7	7.1201	.74179	.90294	.06662
MEAN						6.3531	.58659	.58659	.00000

Yearclass		Weighted Average Prediction	Internal Standard Error	External Standard Error	Virtual Population Analysis	Ext.SE/ Int.SE
1987	6.42	611.33	.17	.16		.92
1988	6.81	909.36	.18	.18		1.00
1989	7.32	1508.45	.23	.16		.68

Table 2.7.10 NORTH SEA HEERING (FISHING AREA IV) from 1970-1989 on ages 0-7 with Terminal F of .500 on age 4 and Terminal S of 1.000. Initial sum of squared residuals was 204.788 and final sum of squared residuals is 86.532 after 111 iterations.

Matrix of Residuals

Years / Ages	70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79
0/ 1	-.869	-1.588	-.285	-.621	-.061	1.214	.736	-1.203	.474
1/ 2	-.456	-.078	.649	.388	.037	.095	-.111	.650	1.435
2/ 3	.373	-.232	.354	.355	.425	.238	.024	-.882	-.832
3/ 4	.430	-.114	.170	.419	-.013	-.074	.423	.389	-.779
4/ 5	.369	-.076	-.003	-.413	-.323	-.479	-.177	.152	.561
5/ 6	-.610	-.163	-.661	-.354	.190	.415	.016	.219	.176
6/ 7	-.413	3.032	-.548	.347	-.285	-.675	-.873	-.485	-1.722
	.000	.000	.000	.000	.000	.000	.000	.000	.000
WTS	.010	.010	.010	.010	.010	.010	.010	.010	.010

Years / Ages	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89		WTS
0/ 1	2.733	1.530	2.459	2.866	3.595	1.256	.129	-.901	.458	.191	.000	.175
1/ 2	1.031	-.481	-.212	.266	-.053	-.783	-.194	-.381	.175	.377	.000	.473
2/ 3	-.328	.623	-.622	.037	.023	-.228	-.201	.219	.062	-.073	.000	.616
3/ 4	-.609	.687	-.384	.479	-.248	-.046	.186	.090	-.074	-.209	.000	.668
4/ 5	-.301	-.144	-.020	-.161	-.171	.143	.175	.044	-.125	-.084	.000	1.000
5/ 6	.443	-.242	.480	-.799	-.210	.350	-.100	.026	-.007	.088	.000	.689
6/ 7	-1.514	-2.400	-.002	-1.082	-.569	-.263	-.158	.339	-.090	-.016	.000	.238
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	5.371	
WTS	.010	.010	.010	.010	.010	.010	1.000	1.000	1.000	1.000		

Fishing Mortalities (F)

	70	71	72	73	74	75	76	77	78	79
F-values	1.1824	1.5193	.8847	1.2596	1.1937	1.8132	2.0108	1.6856	.1764	.1740
	80	81	82	83	84	85	86	87	88	89
F-values	.4130	.5775	.3770	.4157	.4451	.6251	.5202	.5685	.5279	.5000

Selection-at-age (S)

	0	1	2	3	4	5	6	7
S-values	.0634	.3551	.6663	.8838	1.0000	.9813	1.0439	1.0000

Table 2.7.11 VIRTUAL POPULATION ANALYSIS.

NORTH SEA HERRING (FISHING AREA IV)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 VARIABLE NATURAL MORTALITY COEFFICIENT

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.035	.034	.058	.047	.075	.171	.155	.096	.047	.087	.092	.434
1	.268	.602	.579	.674	.458	.690	.276	.319	.197	.172	.077	.159
2	.973	.883	.813	1.026	1.029	1.362	1.350	.257	.026	.093	.295	.300
3	1.267	1.215	.803	1.338	.982	1.507	1.681	1.458	.050	.073	.409	.265
4	1.340	1.228	.800	.992	1.004	1.415	1.757	.650	.111	.111	.332	.293
5	.874	1.109	.551	.953	1.200	1.973	1.851	1.260	.029	.056	.325	.485
6	1.047	2.589	.544	1.387	1.083	1.327	1.321	1.231	.084	.022	.073	.585
7	1.000	2.207	.095	.889	.787	2.074	1.793	1.370	.142	.487	.185	1.109
8	1.330	.000	.464	1.451	1.892	2.210	1.871	2.106	.572	.697	.426	2.056
9+	1.330	.000	.464	1.451	1.892	2.210	1.871	2.106	.572	.697	.426	2.056
(2- 6)U	1.100	1.405	.702	1.139	1.059	1.517	1.592	.971	.060	.071	.287	.386
(3- 6)U	1.132	1.535	.674	1.167	1.067	1.555	1.653	1.150	.068	.065	.285	.407

	1982	1983	1984	1985	1986	1987	1988	1989
0	.313	.352	.089	.033	.015	.065	.038	.032
1	.175	.130	.068	.205	.130	.233	.221	.166
2	.233	.285	.268	.361	.394	.376	.345	.266
3	.498	.318	.399	.643	.476	.462	.427	.471
4	.235	.422	.491	.683	.532	.535	.506	.570
5	.148	.259	.558	.596	.476	.547	.550	.510
6	.180	.327	.313	.619	.589	.510	.538	.516
7	.361	.527	.598	.471	.583	.423	.460	.490
8	.569	1.116	1.003	.669	.588	.419	.463	.436
9+	.569	1.116	1.003	.669	.588	.419	.463	.436
(2- 6)U	.259	.322	.406	.581	.494	.486	.473	.467
(3- 6)U	.265	.331	.440	.635	.519	.514	.505	.517

Table 2.7.12 VIRTUAL POPULATION ANALYSIS.

NORTH SEA HERRING (FISHING AREA IV)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .670
PROPORTION OF ANNUAL M BEFORE SPAWNING: .670

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	41058	32274	20856	9991	21655	2619	2585	4395	4474	10187	14121	34252
1	7872	14583	11476	7238	3508	7390	812	814	1468	1571	3434	4737
2	3639	2215	2937	2366	1357	816	1364	227	218	444	486	1170
3	1330	1019	678	965	629	359	155	262	130	157	300	268
4	176	307	248	249	207	193	65	24	50	101	120	163
5	90	42	81	101	84	69	42	10	11	40	82	78
6	98	34	12	42	35	23	9	6	3	10	35	54
7	13	31	2	7	10	11	5	2	2	2	9	29
8	17	0	3	2	2	4	1	1	0	1	1	7
9+	17	0	1	1	1	2	0	0	1	0	0	1
TOTAL NO	54310	50505	36295	20961	27487	11485	5039	5740	6357	12513	18587	40759
SPS NO	2227	1554	1690	1332	898	434	450	236	311	546	657	1065
TOT.BIOM	1924537	1844156	1548805	1153008	907998	673069	348898	200954	213904	365481	573769	1062991
SPS BIOM	378100	265277	288388	232347	160744	78668	74028	41088	56144	99268	124401	190452
2+ BIOM[1]	378100	265277	327285	259520	176300	86167	86654	45480	61056	108731	133270	211741
TOT.BIOM[1]	854240	756635	680433	451732	400374	223191	121804	93866	127136	218050	318099	516837

(cont'd)

Table 2.7.12 (cont'd)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	54844	52023	40355	63790	72748	44851	54866	99001	0
1	8168	14754	13465	13581	22716	26353	15459	19434	35285
2	1486	2523	4767	4629	4069	7342	7683	4561	6059
3	642	872	1405	2700	2390	2033	3734	4029	2588
4	169	319	520	772	1162	1215	1049	1994	2059
5	110	121	190	288	353	618	644	572	1021
6	43	86	84	98	143	198	323	336	311
7	27	33	56	56	48	72	108	171	182
8	9	17	17	28	32	24	43	61	95
9+	3	19	29	34	34	24	24	26	51
TOTAL NO	65500	70766	60889	85976	103695	82731	83932	130186	
SPS NO	1545	2436	4205	4389	4599	5657	6944	6932	
TOT.BIOM	1668795	2216675	2495864	2926260	3681141	3417402	3111402	4275230	
SPS BIOM	277691	433840	732074	777337	846953	963764	1102257	1256053	
2+ BIOM[1]	305319	480010	821521	901506	938567	1791827	1348063	1376117	
TOT.BIOM[1]	854240	1141566	1442518	1576842	1990907	1889577	1832936	2418506	

[1]Refers to the time of spawning.

Table 2.7.13 VIRTUAL POPULATION ANALYSIS.

HERRING IN THE SOUTHERN NORTH SEA (FISHING AREAS IVC AND VIID)

CATCH IN NUMBERS UNIT: millions

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	21.30	.40	3.60	3.60	6.00	5.50	4.20	21.80	4.80	2.20	3.90	24.10
2	22.30	25.50	54.80	42.40	22.90	161.80	81.60	130.80	135.10	43.30	24.10	127.20
3	78.50	60.50	9.90	15.40	19.90	8.80	83.80	41.70	29.30	115.10	20.30	39.60
4	.70	32.60	1.20	4.90	9.70	5.30	5.40	31.10	9.30	55.00	8.40	5.30
5	5.90	2.10	3.10	2.20	1.50	1.90	1.60	.70	5.00	7.40	1.20	1.80
6	.01	2.40	.01	.10	3.00	.40	1.00	.30	.01	1.90	.10	.01
7	.01	.50	.01	.01	.60	.40	.10	.60	.01	.50	.20	.01
8	.01	.01	.01	.01	.01	.01	.40	.01	.01	.10	.01	.01
9+	.01	.03	.01	.01	.01	.02	.10	.30	.01	.01	.01	.01
TOTAL	128.74	124.04	72.64	68.63	63.62	184.13	178.20	227.31	183.54	225.51	58.22	198.04

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	22.20	.90	.40	.40	23.40	7.30	20.90	25.10	13.70	13.10	10.80	19.70	4.40	12.60
2	94.40	6.40	2.80	21.60	99.10	222.60	201.20	251.70	172.60	314.10	107.60	161.40	112.00	106.10
3	41.80	3.00	4.00	9.00	83.80	40.40	221.40	105.10	116.60	169.00	193.70	77.40	212.80	205.40
4	3.50	.70	1.20	5.60	30.20	19.30	26.50	64.50	33.00	44.10	45.70	80.50	45.30	182.00
5	.50	.20	.01	.60	18.40	6.70	6.80	11.10	22.60	12.30	13.50	13.80	32.50	31.50
6	.30	.01	.01	.10	1.70	3.30	2.20	3.00	2.00	8.40	9.20	6.50	5.80	19.50
7	.01	.01	.01	.01	.50	.60	1.50	.50	.50	1.40	1.90	.20	.80	3.40
8	.01	.01	.01	.01	.01	.01	.50	.50	.03	.10	.10	.10	.50	1.20
9+	.01	.01	.01	.01	.01	.01	.10	.10	.40	.20	.40	.60	.00	.04
TOTAL	162.73	11.24	8.45	37.33	257.12	300.22	481.10	461.60	361.43	562.70	382.90	360.20	414.10	561.74

Table 2.7.14 VIRTUAL POPULATION ANALYSIS.

HERRING IN THE SOUTHERN NORTH SEA (FISHING AREAS IVC AND VIID)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 VARIABLE NATURAL MORTALITY COEFFICIENT

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	.197	.002	.023	.040	.009	.017	.008	.037	.031	.014	.011	.111
2	.224	.731	.848	.762	.720	.678	.703	.729	.608	.806	.362	1.192
3	1.038	1.945	.778	.669	1.172	.742	1.039	1.108	.375	2.298	1.371	2.286
4	.265	2.132	.154	1.140	1.200	1.194	1.540	1.572	.760	3.716	1.506	2.267
5	1.172	3.957	1.533	.409	1.268	.701	1.453	.751	1.141	3.992	3.445	1.767
6	.017	4.160	.323	.140	1.410	1.392	.893	1.141	.018	2.187	1.635	.336
7	.599	3.081	.353	.547	3.705	.615	1.789	2.862	.082	3.676	2.506	.617
8	2.260	2.260	.630	.630	1.600	1.350	2.590	.810	.370	2.690	1.960	.990
9+	2.260	2.260	.630	.630	1.600	1.350	2.590	.810	.370	2.690	1.960	.990
(2- 6)U	.543	2.585	.727	.624	1.154	.942	1.125	1.060	.581	2.600	1.664	1.570
(3- 6)U	.623	3.049	.697	.590	1.262	1.007	1.231	1.143	.574	3.048	1.989	1.664

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
1	.167	.006	.001	.001	.018	.009	.021	.025	.008	.017	.006	.013	.005	.080
2	2.101	.111	.038	.132	.611	.411	.638	.679	.417	.484	.334	.181	.166	.300
3	3.103	.365	.100	.173	1.183	.588	1.040	.918	.868	1.043	.682	.457	.409	.550
4	2.558	.564	.231	.187	1.323	.952	.945	.981	.807	.947	.877	.645	.504	.700
5	2.323	1.418	.012	.155	1.348	1.129	.965	1.295	1.038	.716	.765	.633	.519	.700
6	2.214	.232	.192	.144	.739	.837	1.418	1.555	.755	1.373	1.948	.943	.529	.600
7	.580	.363	.339	.266	1.863	.557	1.070	1.536	1.170	1.998	1.337	.159	.241	.600
8	2.640	1.970	.660	.590	.410	.130	1.150	1.220	.280	.680	.710	.180	.640	.600
9+	2.640	1.970	.660	.590	.410	.130	1.150	1.220	.280	.680	.710	.180	.640	.600
(2- 6)U	2.460	.538	.114	.158	1.041	.783	1.001	1.085	.777	.913	.921	.572	.425	.570
(3- 6)U	2.549	.645	.134	.165	1.148	.876	1.092	1.187	.867	1.020	1.068	.670	.490	.638

Table 2.7.15 VIRTUAL POPULATION ANALYSIS.

HERRING IN THE SOUTHERN NORTH SEA (FISHING AREAS IVC AND VIID)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: thousand tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: 1.000
PROPORTION OF ANNUAL M BEFORE SPAWNING: 1.000

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	185	296	251	144	1026	509	788	953	249	251	565	360
2	128	56	109	90	51	374	184	287	338	89	91	205
3	132	76	20	34	31	18	141	67	103	136	29	47
4	3	38	9	8	14	8	7	41	18	58	11	6
5	9	2	4	7	2	4	2	1	8	8	1	2
6	1	2	0	1	4	1	2	0	1	2	0	0
7	0	1	0	0	1	1	0	1	0	1	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9+	0	0	0	0	0	0	0	1	0	0	0	0
TOTAL NO	457	471	393	284	1130	914	1124	1352	716	544	698	621
SPS NO	119	33	50	53	32	152	111	130	205	42	55	51
TOT.BIOM	57	55	43	33	110	100	121	143	87	70	71	68
SPS BIOM	17	5	7	8	5	20	16	18	29	6	7	7

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1	225	238	548	672	2093	1333	1614	1616	2566	1204	3071	2330	1285	258	0
2	119	70	87	201	247	757	486	582	580	936	435	1124	846	470	87
3	46	11	46	62	131	99	372	190	219	283	427	231	695	531	258
4	4	2	6	34	43	33	45	108	62	75	82	177	120	378	251
5	1	0	1	4	26	10	11	16	36	25	26	31	84	65	170
6	0	0	0	1	3	6	3	4	4	12	11	11	15	45	29
7	0	0	0	0	1	1	2	1	1	2	3	1	4	8	22
8	0	0	0	0	0	0	1	1	0	0	0	1	1	3	4
9+	0	0	0	0	0	0	0	0	2	0	1	4	0	0	1
TOTAL NO	395	321	689	976	2544	2239	2534	2517	3470	2537	4057	3909	3049	1758	
SPS NO	13	54	102	203	150	434	319	322	398	550	452	921	1030	736	
TOT.BIOM	44	33	70	105	259	244	282	278	366	267	383	282	320	230	
SPS BIOM	2	7	14	29	21	58	46	46	56	67	61	115	125	101	

Table 2.8.1

List of input variables for the ICES prediction program.

NORTH SEA HERRING (SSB CALCULATED USING MATURITY OGIVE FOR 1989)
The reference F is the mean F for the age group range from 2 to 6

The number of recruits per year is as follows:

Year	Recruitment
1990	10680.0
1991	2710.0
1992	17100.0

Proportion of F (fishing mortality) effective before spawning: .6700
Proportion of M (natural mortality) effective before spawning: .6700

Data are printed in the following units:

Number of fish:	millions
Weight by age group in the catch:	gram
Weight by age group in the stock:	gram
Stock biomass:	tonnes
Catch weight:	tonnes

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
1	10680.0	.17	1.00	.00	43.000	51.100
2	3945.0	.27	.30	.79	115.000	139.900
3	2588.0	.47	.20	.94	153.000	177.900
4	2059.0	.57	.10	1.00	173.000	211.100
5	1021.0	.51	.10	1.00	208.000	253.800
6	311.0	.52	.10	1.00	231.000	283.000
7	182.0	.49	.10	1.00	247.000	288.300
8	95.0	.44	.10	1.00	265.000	316.100
9+	51.0	.44	.10	1.00	259.000	362.500

(cont'd)

Table 2.8.1 (cont'd)

For data that can be entered by file or manually by screen the following table gives the method of input by age group. The identifiers in the table are to be interpreted as:

space: not defined or set by the program
M : manual input by screen
F : data read from a file

age	F at age	M at age	maturity ogive	weight in the catch	weight in the stock
1	F	F	F	F	F
2	F	F	F	F	F
3	F	F	F	F	F
4	F	F	F	F	F
5	F	F	F	F	F
6	F	F	F	F	F
7	F	F	F	F	F
8	F	F	F	F	F
9+	F	F	F	F	F
proportion of F before spawning: F					
proportion of M before spawning: F					

The data from the files were selected as follows:

F at age: year 1989 from file FNEWMOR
M at age: year 1989 from file NATMOR
Maturity ogive: year 1989 from file MORPROP
Catch weight: year 1989 from file WECA
Stock weight: year 1989 from file WEST
Proportions of F and M: from file MORPROP

Table 2.8.2

Effects of different levels of fishing mortality on
catch, stock biomass and spawning stock biomass.

NORTH SEA HERRING (SSB CALCULATED USING THE MATURITY OGIVE FOR 1989)

Year 1990					Year 1991					Year 1992	
fac-tor	ref. F	stock biomass	sp.stock biomass	catch	fac-tor	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.7	.33	2441	1262	415	.3	.15	2011	1417	191	2610	1385
					.6	.30		1282	363	2387	1080
					.9	.43		1181	487	2227	882
					1.0	.47		1150	524	2178	826
1.0	.47	2441	1152	559	.3	.15	1818	1263	170	2444	1248
					.6	.30		1144	323	2245	975
					.9	.43		1055	433	2102	798
					1.0	.47		1027	467	2059	747

The data unit of the biomass and the catch is 1000 tonnes.
The spawning stock biomass is given for the time of spawning.
The spawning stock biomass for 1992 has been calculated with the same fishing mortality as for 1991.
The reference F is the mean F for the age group range from 2 to 6

$F_{89}(2\text{-}6) = 0.467$

$F_{0.1} = 0.147$

$F_{max} = 0.426$

Table 2.8.3

Results

14.58.49 02 MAY 1990
NORTH SEA HERRING (SSB CALCULATED USING MATURITY OGIVE FOR 1989)

****
* Year 1990, F-factor .698 and reference F .3257 *
****

						at 1 January		at spawning time	
age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	sp.stock size	sp.stock biomass	sp.stock size	sp.stock biomass
1	.1159	745.64	32062	10680.0	545748	.00	0	.00	0
2	.1857	580.21	66723	3945.0	551905	3116.55	436005	2250.90	314900
3	.3288	660.80	101102	2588.0	460405	2432.72	432780	1707.01	303676
4	.3979	645.29	111634	2059.0	434654	2059.00	434654	1474.99	311371
5	.3560	291.87	60709	1021.0	259129	1021.00	259129	752.22	190913
6	.3602	89.78	20738	311.0	88013	311.00	88013	228.49	64661
7	.3420	50.31	12427	182.0	52470	182.00	52470	135.35	39020
8	.3043	23.78	6301	95.0	30029	95.00	30029	72.46	22903
9+	.3043	12.77	3306	51.0	18487	51.00	18487	38.90	14100
Total		3100.44	415006	20932.0	2440844	9268.27	1751571	6660.31	1261549

****
* Year 1991, F-factor .642 and reference F .2996 *
****

						at 1 January		at spawning time	
age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	sp.stock size	sp.stock biomass	sp.stock size	sp.stock biomass
1	.1066	174.69	7511	2710.0	138481	.00	0	.00	0
2	.1708	476.59	54808	3499.1	489523	2764.29	386723	2016.50	282108
3	.3024	576.96	88275	2427.3	431817	2281.67	405908	1629.56	289898
4	.3659	446.15	77184	1525.2	321970	1525.20	321970	1116.22	235633
5	.3274	333.45	69357	1251.5	317636	1251.52	317636	939.87	238539
6	.3313	174.14	40225	647.1	183139	647.14	183139	484.74	137180
7	.3146	50.55	12485	196.3	56592	196.30	56592	148.69	42867
8	.2799	27.24	7219	117.0	36976	116.98	36976	90.69	28667
9+	.2799	22.69	5877	97.4	35323	97.44	35323	75.55	27385
Total		2282.47	362944	12471.0	2011460	8880.53	1744270	6501.82	1282281

(cont'd)

Table 2.8.3 (cont'd)

```
*********************************************************
* Year 1992. F-factor    .642 and reference F    .2996 *
*********************************************************
```

						at 1 January		at spawning time	
age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	sp.stock size	sp.stock biomass	sp.stock size	sp.stock biomass
1	.1066	1102.27	47397	17100.0	873810	.00	0	.00	0
2	.1708	122.06	14037	896.2	125374	707.98	99045	516.46	72252
3	.3024	519.43	79472	2185.3	388757	2054.14	365431	1467.06	260990
4	.3659	429.63	74326	1468.7	310049	1468.73	310049	1074.89	226909
5	.3274	255.01	53043	957.1	242920	957.13	242920	718.79	182429
6	.3313	219.64	50736	816.2	230992	816.23	230992	611.40	173024
7	.3146	108.27	26742	420.4	121210	420.43	121210	318.47	91813
8	.2799	30.20	8002	129.7	40990	129.68	40990	100.53	31779
9+	.2799	34.15	8845	146.6	53159	146.65	53159	113.69	41213
Total		2820.66	362603	24120.3	2387266	6700.97	1463801	4921.29	1080412

Table 2.8.4

Effects of different levels of fishing mortality on
catch, stock biomass and spawning stock biomass.

NORTH SEA HERRING (SSB DEFINED AS 2+ STOCK)

Year 1990					Year 1991					Year 1992	
fac-tor	ref. F	stock biomass	sp.stock biomass	catch	fac-tor	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.7	.33	2441	1365	415	.3	.15	2011	1517	191	2610	1427
					.6	.30		1376	363	2387	1116
					.9	.43		1270	487	2227	914
					1.0	.47		1237	524	2178	856
1.0	.47	2441	1249	559	.3	.15	1818	1358	170	2444	1289
					.6	.30		1232	323	2245	1011
					.9	.43		1138	433	2102	829
					1.0	.47		1109	467	2059	777

The data unit of the biomass and the catch is 1000 tonnes.
The spawning stock biomass is given for the time of spawning.
The spawning stock biomass for 1992 has been calculated with the same fishing mortality as for 1991.
The reference F is the mean F for the age group range from 2 to 6

Table 2.9.1 NORTH SEA HERRING (FISHING AREA IV) from 1970-1989 on ages 0-8 with Terminal F of .500 on age 4 and Terminal S of 1.000. Initial sum of squared residuals was 243,398 and final sum of squared residuals is 112,948 after 123 iterations.

Matrix of Residuals.

Years / Ages	70/71	71/72	72/73	73/74	74/75	75/76	76/77	77/78	78/79
0/ 1	-1.542	-2.146	-.663	-1.081	-.576	.581	.089	-1.629	.242
1/ 2	-1.412	-.960	.075	-.333	-.689	-.825	-1.059	-.141	.944
2/ 3	.190	-.287	.489	.410	.472	.224	.025	-.841	-.771
3/ 4	.362	-.021	.428	.609	.163	.069	.607	.598	-.640
4/ 5	.305	.036	.269	-.205	-.131	-.314	.038	.394	.698
5/ 6	-.659	-.043	-.382	-.138	.394	.600	.249	.458	.307
6/ 7	-.446	3.173	-.256	.583	-.056	-.455	-.604	-.223	-1.603
7/ 8	4.883	1.533	-2.350	-.441	-.408	.647	.036	-1.020	-1.162
	.000	.000	.000	.000	.000	.000	.000	.000	.000
WTS	.010	.010	.010	.010	.010	.010	.010	.010	.010

Years / Ages	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89		WTS
0/ 1	1.991	1.007	1.928	2.038	2.406	1.183	-.068	-.377	.211	.195	.000	.185
1/ 2	.256	-.700	-.383	-.058	-.027	-.494	-.266	-.226	.013	.537	.000	.430
2/ 3	-.326	.876	-.649	.182	.054	-.272	-.176	.145	.083	-.050	.000	.550
3/ 4	-.529	.811	-.395	.597	-.190	-.127	.224	.021	-.025	-.244	.000	.582
4/ 5	-.223	-.017	-.030	-.043	-.114	.061	.213	-.026	-.075	-.120	.000	1.000
5/ 6	.518	-.116	.469	-.684	-.155	.269	-.062	-.043	.042	.052	.000	.657
6/ 7	-1.448	-2.276	-.016	-.971	-.517	-.346	-.119	.267	-.040	-.054	.000	.226
7/ 8	1.338	-1.398	.728	-.528	-.118	.348	-.318	.418	-.121	.000	.000	.165
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	-1.408	
WTS	.010	.010	.010	.010	.010	.010	1.000	1.000	1.000	1.000		

Fishing Mortalities (F)

	70	71	72	73	74	75	76	77	78	79
F-values	1.1702	1.2978	.6828	1.0581	1.0332	1.6266	1.7152	1.2674	.1286	.1414
	80	81	82	83	84	85	86	87	88	89
F-values	.3506	.5328	.3329	.4056	.4664	.6128	.5345	.5496	.5386	.5000

Selection-at-age (S)

	0	1	2	3	4	5	6	7	8
S-values	.1709	.6950	.7222	.8901	1.0000	.9691	1.0087	.9305	1.0000

Table 2.9.2 VIRTUAL POPULATION ANALYSIS.
North Sea + transfers from Division IIIa.

NORTH SEA HERRING (FISHING AREA IV)

CATCH IN NUMBERS UNIT: millions

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	898	684	750	289	996	264	238	257	130	542	1263	9520
1	1196	4379	3341	2368	846	2461	127	144	169	159	245	872
2	2003	1147	1441	1344	773	542	902	45	5	34	134	284
3	884	663	344	659	362	260	117	186	6	10	92	57
4	125	208	131	150	126	141	52	11	5	10	32	40
5	50	27	33	59	56	57	35	7	0	2	22	29
6	61	31	5	31	22	16	6	4	0	0	2	23
7	8	27	0	4	5	9	4	2	0	1	1	19
8	12	0	1	1	2	3	1	1	0	1	0	6
9+	12	12	0	1	1	1	0	0	0	0	0	1
TOTAL	5249	7177	6046	4907	3189	3753	1482	656	315	759	1792	10849

	1982	1983	1984	1985	1986	1987	1988	1989
0	11957	13297	6662	4179	3664	8036	3123	2959
1	1116	2449	1737	3228	4723	6675	7763	2938
2	299	574	1095	1316	1246	2124	2248	1490
3	230	216	422	1173	827	687	1185	1384
4	34	105	193	366	458	482	398	828
5	14	26	78	124	128	249	261	218
6	7	23	22	43	61	76	129	129
7	8	13	24	20	20	24	38	63
8	4	11	11	13	13	8	15	21
9+	1	12	18	16	15	8	8	9
TOTAL	13670	16726	10260	10478	11156	18367	15167	10039

Table 2.9.3 VIRTUAL POPULATION ANALYSIS.
North Sea + transfers from Division IIIa.

NORTH SEA HERRING (FISHING AREA IV)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 VARIABLE NATURAL MORTALITY COEFFICIENT

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.035	.034	.058	.047	.075	.170	.155	.096	.045	.083	.125	.481
1	.268	.602	.579	.674	.458	.689	.274	.318	.197	.164	.112	.283
2	.973	.883	.813	1.024	1.027	1.359	1.343	.255	.026	.093	.356	.321
3	1.266	1.214	.802	1.336	.979	1.498	1.664	1.430	.049	.073	.410	.267
4	1.332	1.222	.798	.990	1.000	1.400	1.700	.631	.107	.109	.330	.294
5	.866	1.088	.545	.947	1.194	1.934	1.756	1.104	.028	.054	.320	.482
6	1.020	2.441	.522	1.351	1.065	1.305	1.209	1.000	.066	.021	.069	.572
7	1.000	1.931	.081	.818	.732	1.914	1.661	1.020	.098	.360	.177	1.019
8	1.155	.000	.316	1.032	1.396	1.634	1.222	1.391	.305	.416	.274	1.774
9+	1.155	.000	.316	1.032	1.396	1.634	1.222	1.391	.305	.416	.274	1.774
(2- 6)U	1.091	1.370	.696	1.130	1.053	1.499	1.534	.884	.055	.070	.297	.387
(3- 6)U	1.121	1.491	.667	1.156	1.059	1.534	1.582	1.041	.062	.064	.282	.404

	1982	1983	1984	1985	1986	1987	1988	1989
0	.333	.392	.210	.084	.064	.139	.103	.085
1	.224	.250	.190	.363	.306	.384	.478	.320
2	.258	.301	.295	.383	.419	.393	.387	.277
3	.500	.320	.403	.639	.474	.463	.426	.469
4	.238	.425	.497	.696	.526	.532	.508	.568
5	.148	.262	.564	.609	.493	.537	.544	.513
6	.179	.328	.318	.630	.612	.540	.521	.506
7	.348	.521	.601	.483	.603	.450	.504	.465
8	.476	1.033	.976	.675	.615	.443	.512	.504
9+	.476	1.033	.976	.675	.615	.443	.512	.504
(2- 6)U	.265	.327	.416	.591	.505	.493	.477	.467
(3- 6)U	.266	.334	.446	.644	.526	.518	.500	.514

Table 2.9.4 VIRTUAL POPULATION ANALYSIS.
North Sea + transfers from Division IIIa.

NORTH SEA HERRING (FISHING AREA IV)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .670
PROPORTION OF ANNUAL M BEFORE SPAWNING: .670

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	41064	32286	20867	9998	21681	2633	2590	4392	4675	10692	16825	37961
1	7873	14586	11480	7242	3510	7400	817	816	1467	1645	3620	5462
2	3640	2215	2938	2368	1358	817	1367	229	218	443	514	1190
3	1330	1020	679	966	630	360	156	264	131	158	299	267
4	177	307	248	249	208	194	66	24	52	102	120	163
5	91	42	82	101	84	69	43	11	12	42	83	78
6	99	34	13	43	35	23	9	7	3	10	36	55
7	13	32	3	7	10	11	6	2	2	3	9	30
8	18	0	4	2	3	4	1	1	1	2	2	7
9+	19	0	2	1	2	2	1	0	1	0	0	1
TOTAL NO	54324	50522	36315	20976	27520	11513	5056	5745	6563	13097	21508	45214
SPS NO	2234	1558	1694	1336	902	438	456	242	317	550	664	1068
TOT.BIOM	1926403	1845391	1550317	1154231	909509	674745	350543	202393	218392	377963	628859	1158483
SPS BIOM$_1$	379868	266383	289441	233228	161694	79740	75319	42422	57540	100419	125933	191379
TOT.BIOM	856045	757875	681684	452796	401606	224616	123320	95287	130156	225257	339847	540026

(cont'd)

Table 2.9.4 (cont'd)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	65079	62797	54630	81679	92958	97051	49874	56979	0
1	8636	17168	15605	16286	27633	32076	31079	16546	19251
2	1513	2539	4919	4745	4167	7484	8034	7087	4421
3	640	866	1393	2712	2398	2030	3741	4043	3981
4	167	318	515	762	1172	1222	1046	2000	2070
5	110	119	188	283	344	626	650	569	1026
6	44	86	83	97	139	190	331	341	308
7	28	33	56	55	47	68	100	178	186
8	10	18	18	28	30	23	39	55	101
9+	3	20	30	34	33	23	22	23	42
TOTAL NO	76229	83963	77436	106681	128920	140794	94917	87820	
SPS NO	1546	2424	4223	4404	4612	5677	7004	8288	
TOT.BIOM	1850060	2500251	2836629	3274856	4199342	4028917	3791303	3980042	
SPS BIOM	278005	431934	734045	778358	847880	965780	1109318	1446231	
TOT.BIOM[1]	896943	1221439	1541801	1679201	2113567	2090408	2022806	2294941	

[1]At spawning time.
Total biomass estimated at 1 January is based on 3rd quarter mean weights.

Table 2.10.1 HERRING TOTAL NORTH SEA 1989.
Numbers (millions) and weights (g) at age (winter rings) and year class of herring caught in each quarter. (Spring spawner transfers to Division IIIa excluded.)

Quarter		0 1988	1 1987	2 1986	3 1985	4 1984	5 1983	6 1982	7 1981	8 1980	9+ ≤1979	Total No.	SOP ('000 t)
I	No.	-	47.5	233.8	264.8	149.5	36.7	18.8	11.0	2.1	1.9	766.1	84,393
	w	-	28	85	116	133	163	187	196	249	226		
II	No.	-	24.8	111.1	186.9	133.2	22.8	16.3	7.3	1.7	0.6	504.7	74,449
	w	-	43	108	152	168	200	216	260	274	280		
III	No.	1,615.6	1,620.4	300.5	509.1	246.5	81.9	50.8	25.6	10.9	3.4	4,464.7	316,099
	w	12	42	136	179	207	244	274	288	296	350		
IV	No.	340.2	206.8	282.3	422.8	298.9	77.0	43.5	19.5	6.1	2.8	1,699.9	201,846
	w	39	65	122	145	165	193	209	216	212	167		
Total year	No.	1,955.8	1,899.5	927.7	1,383.6	828.1	218.3	129.4	63.3	20.7	8.7	7,435.1	676,787
	w	17	43	115	153	173	208	231	247	265	259		
Stock wts.[1] (July)	$\bar{w}$	12	51	140	178	211	254	283	288	316	362		

[1] These stock wts. derive from the acoustic survey samples taken in July from Divisions IVa,b and used in the 1990 SSVPA.