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REPORT OF THE HERRING ASSESSMENT WORKING GROUP

FOR THE AREA SOUTH OF 62°N

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1 INTRODUCTION

1.1 Participants

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Dr E.D. Anderson, ICES Statistician, attended the meeting when necessary and provided statistical assistance.

1.2 Terms of Reference

In accordance with C.Res.1987/2:3:10, the Herring Assessment Working Group for the Area South of 62°N met at ICES Headquarters from 5-15 April 1988 to:

a) assess the status of and provide catch options for 1989 within safe biological limits for the herring stocks in Division IIIa, Sub-area IV (and, if possible, separately for Divisions IVa and IVb, and IVc and VIId), Divisions Va and VIa, and Sub-area VII;

b) 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 1987 as input for the multispecies VPA;

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

1.3 General Considerations

1.3.1 Natural mortality

In the light of comments made by ACFM about the validity of applying values of natural mortality rate (M) estimated for the North Sea to adjacent areas, the Working Group considered whether any revision should be made to the values of M used in the assessments made in 1987. Since this subject is to be addressed by the Multispecies Working Group at its meeting in June 1988, the Herring Working Group decided to make no changes in its present assessments. The values of M used in this report are as follows:

Age (rings)	Icelandic summer-spawning herring	All other stocks
0	-	1.0 (per half year)
1	0.1	1.0
2	0.1	0.3
3	0.1	0.2
>4	0.1	0.1

1.3.2 Use of more up-to-date information for management

The present procedure for providing management advice relies on information that is collected two years ahead of the season to which the advice is applicable. This procedure is convenient for managers because it gives them ample time to consider the biological advice, and to take management decisions well ahead of the fishing season.

However, the accuracy of the biological advice resulting from this procedure is inevitably fairly low. The Working Group has to make assumptions on the F that will be generated in the intermediate year (between the last year for which data are available and the year for which stock estimates have to be made). New stock estimates that become available half way during the intermediate year cannot be used to correct stock predictions and the TAC advice based on them. In the case of North Sea herring, acoustic surveys are carried out during summer, and the new acoustic estimates which become available in September are not used in management decisions for the following year.

It seems, therefore, that the present procedure for providing management advice is rather inefficient, in that it does not make optimum use of existing information. The Working Group, therefore, suggests that ACFM consider the possibility of shifting the time of the Working Group meeting towards the end of the year, at which time both new acoustic estimates and first estimates from larvae surveys will be available.

1.4 Biological Reference Points and Management Strategies for Herring Stocks

At the request of ACFM, the Working Group considered the subject of consistency in the management of the herring stocks included in its terms of reference.

The biological reference points $F_{0.1}$, F_{med}, and F_{SQ} (*status quo* fishing mortality) as estimated in 1987 are given in Table 1.4.1, together with the F options and F values advised by ACFM. This shows that the F values advised by ACFM in 1987, based on assessments carried out by the Working Group, ranged from 0.15 to 0.39.

The stated objectives of the advice varied between stocks and included:

a) rebuilding or maintaining the stock towards or at a target spawning stock biomass;

b) managing at $F_{0.1}$ to maintain stability of TAC;

c) stabililizing F at status quo level;

d) keeping F consistent with that in adjacent areas.

In the view of the Working Group, the advice given on each stock should take into account:

a) the present stock size in relation to a target stock size defined by the long-term historic potential of the stock;

b) the need for stability of catch levels, taking into account expected recruitment variability;

c) the need for consistency of advice between management units in those cases where a stock is exploited in more than one management area;

d) the need to prevent the fishing mortality rate from rising to unsustainable levels, taking into account the susceptibility of pelagic stocks to collapse under heavy exploitation combined with recruitment failure.

Finally, the type of advice given must take into account the reliability that can be placed on the assessment of the stock in question.

In the light of these considerations, it is entirely expected and appropriate that the form of the advice will vary from stock to stock. In the present report, the Working Group has, wherever possible, indicated a range of options together with the factors that might be considered in advising TACs.

2 NORTH SEA HERRING

2.1 The Fishery

2.1.1 ACFM advice applicable to 1987

At its 1986 meeting, ACFM advised the following TACS for 1987:

Divisions IVa,b: 600,000 t (including an estimated 69,000 t of 1-ringers)

Divisions IVc, VIId: 11,000 t for the period 1 January - 30 June

The final advice for Divisions IVc, VIId given at the 1987 ACFM meeting was for a TAC of 10,000 t for the whole year. The TACs adopted by the management bodies were:

Divisions IVa,b: 560,000 t

Divisions IVc, VIId: 40,000 t

In addition, ACFM advised:

a) that the closure of the "sprat box" off the west coast of Denmark should be maintained to protect juvenile herring;

b) that the spawning area closures in the western part of Division IVb should be maintained to protect the dense spawning shoals.

2.1.2 Catches in 1987

Official and unofficially reported landings for 1987 are presented in Table 2.1.1 for the total North Sea and for each division in Tables 2.1.2 - 2.1.5. The total provisional catch was 621,820 t, an increase of 78,068 t from 1986.

Unallocated catches amounted to 35,000 t (5.6% of the total), compared with 21,089 t (3.9%) in 1986. The Netherlands catches included an estimate for discards amounting to around 10% of their total.

Adult herring catches (2-ring and older)

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

	Quarter - 1987				
Division	I	II	III	IV	Total
IVa (W of 2^0E)	37.9	46.4	104.2	48.9	237.4
IVa_2 (E of 2^0E)[1]	24.3	23.3	14.1	51.7	113.4
IVb[2]	20.1	4.0	22.5	29.2	75.8
IVc + VIId	8.3	0.7	0.1	33.4	42.5
Total	90.6	74.4	140.9	163.2	469.1

[1]Excluding 8.5 t transferred to Division IIIa from second and third quarters.
[2]Excluding 5.2 t transferred to Division IIIa from second and third quarters.
Weights in '000 t.

The table excludes catches of 13,700 t from the second and third quarters in Divisions IVaE and IVb which were transferred to Division IIIa. This allowed for the estimated proportion of migrant spring spawners from that division which were identified by vertebral count (see Section 3.1).

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

The total catch of 2-ringers and older in Divisions IVa and IVb was thus estimated at 426,600 t and including a similarly estimated catch of 121,500 t of 1-ring fish (see following section) gives a total of 548,100 t. This compares with the ACFM recommended TAC of 600,000 t (including 69,000 t of 1-ringers) and the agreed TAC of 560,000 t.

In Divisions IVc and VIId, the estimated catch of adult herring was 42,500 t compared with the agreed TAC of 40,000 t and the TAC of 10,000 t advised by ACFM.

Juvenile herring catches (0- and 1-ring)

The following text table presents a catch breakdown for 0- and 1-ring juvenile herring obtained from sums of products supplied by Working Group members.

		Quarter - 1987				
Division	Age group	I	II	III	IV	Total
IVa (W of 2^0E)	0	-	-	-	-	-
	1	-	-	1.3	10.7	12.0
IVa (E of 2^0E)	0	-	-	3.2	2.3	5.5
	1	0.1	0.4	4.4	22.0	26.9
IVb	0	-	-	1.4	12.1	13.5
	1	23.4	2.8	10.4[1]	46.0[1]	82.6
IVc + VIId	0	-	-	-[1]	-	-
	1	-	-	-[1]	1.9	1.9
Total	0	-	-	4.6	14.4	19.0
	1	23.5	3.2	16.1	80.6	123.4

[1]Less than 30 t.
Weights in '000 t.

The total catch of juvenile herring amounted to about 142,400 t, which represents an increase of 20,500 t from 1986. The catch of 0-ring herring increased from 3,800 t in 1986 to around 19,000 t in 1987, whilst 1-ring catches showed a relatively smaller increase from 118,100 t in 1986 to 123,400 t in 1987, an increase of 51%. The majority of the juvenile catch was taken in the eastern halves of Divisions IVa and IVb, where 0- and smaller 1-ring fish were taken in shallow water coastal fisheries by vessels using 16-mm mesh bottom trawls. Larger 1-ring fish were exploited in deeper water areas in the third and fourth quarters by larger industrial trawlers using both 32-mm and smaller mesh trawls and purse seiners. Most of the juvenile catches were taken for reduction purposes.

Some catches of larger 1-ring fish were also taken during the fourth quarter in the western half of Division IVa.

2.1.3 Catch in number

Quarterly age compositions by number caught and mean weights at age were submitted for each division by the main countries fishing herring in the North Sea during 1987. For countries which only submitted catch, conversions to equivalent age distributions were made using data supplied by other countries with similar fisheries in the appropriate quarter and division. A detailed breakdown of numbers caught by age for each division, quarter, and total year is provided in Table 2.1.6, including summed totals for the whole North Sea.

In 1987, data were also made available on the estimated quantity of North Sea herring taken in Division IIIa in 1987 (see Section 3.1).

Total North Sea age compositions for the years 1970-1987 are provided by Table 2.1.7.

The contribution of 0- and 1-ring fish to the catch amounted to 60% by number (23.3% by weight), compared with 48% by number (23.3% by weight) in 1986. Table 2.1.8 provides the percentage age compositions of 2-ring and older herring for 1987. The recruit year class (1984) contributed 56.7% by number (42.4% by weight to the adult catch) (2-ring and older).

2.2 Natural Mortality

No changes were made in M at age in this year's assessment. The values are listed in Section 1.3.1.

2.3 Recruitment

2.3.1 IYFS indices

Slight revisions were made to the IYFS indices of 1-ringed herring for the 1982-1985 year classes using new outputs from the IYFS data base. The revised series of indices is given in Table 2.3.1.

The regression of IYFS indices of 1-ringed herring on estimates of the same age group from VPA was updated, including one more recent year class (1983), and leaving out the year classes prior to 1974. Because of the introduction of a new standard gear for the survey in 1976, it is suspected that average fishing power of the ships before 1976 may not be completely comparable to that for later years. The first year class sampled with the new GOV-trawl was the 1974 year class.

Results of the calculation are presented in Figure 2.3.1. The new regression again has an intercept which is not significantly different from zero. For predictive purposes, the regression was, therefore, forced through the origin, and the resulting equation is:

$$y = 0.0053\ x$$

in which y = VPA estimate of 1-ringers in numbers (billions) and x = IYFS abundance in no/hour for the standard area.

The new 1984 and 1985 year classes were also plotted in the graph, although they were not used in calculating the regression (VPA estimates still uncertain). It appears that the most recent VPA estimates for those year classes are in good agreement with the results from the IYFS.

In recent years, large numbers of 2-ringed herring have been taken in the IYFS. Indices for 2-ringed herring from the 1980 year class onward were included in Table 2.3.1. For earlier years, data on 2-ringed herring are not yet available from the IYFS data base.

The 2-ringed herring are distributed mainly outside the standard area used for calculating indices for 1-ringers. Hence, the 2-ringer index was calculated as the mean of all rectangle means in the total North Sea.

The data series is too short yet to judge the value of the IYFS 2-ringer index as an independent estimator of year-class strength.

2.3.2 IKMT indices

A new series of IKMT indices was calculated, based on the numbers per haul corrected for tow duration and water depth (Table 2.3.2). The areas used in calculating the new indices are shown in Figure 2.3.2. These indices are inherently more accurate than the former series based on the uncorrected numbers per haul.

A comparison between the new and old (uncorrected) indices is made in Table 2.3.3, and the new regression is shown in Figure 2.3.3. The regression of the new indices on VPA has a higher correlation and a lower intercept (almost zero) than the regression of the old indices on VPA.

Because of the increasing trend in both recruitment and stock size over the years of observations, there is a chance that the IKMT index for the North Sea and Division IIIa merely reflects larval production by the adult stock and not subsequent recruitment. This problem cannot be resolved until one or more weak year classes are observed at high spawning stock size.

As a consequence, the Working Group could not, at the present time, recommend the use of the IKMT index for predictive purposes. However, it seems that the IKMT index can be used in a qualitative way as an indicator for either strong or poor year classes.

2.3.3 Recruitment forecast 1985 year class

Last year's report estimated the strength of the 1985 year class as 1-ringers at 37.20 billion using a preliminary index of 6,000 from the IYFS.

Using the revised index of 5,717 from the 1987 IYFS, and the updated predictive regression presented above, the latest estimate for the 1985 year class based on the IYFS is 30.30 billion as 1-ringers.

The provisional index from the 1988 IYFS shows that this year class was also very abundant as 2-ringers (Table 2.3.1). Although the 2-ringer index from the IYFS was not considered to give an accurate estimate of the abundance, the high value obtained during the 1988 survey can presumably be taken as a qualitative indication of a strong year class.

The acoustic summer survey estimated the year class to be 13.7 billion in June-July, which back-calculated to 1 January 1987 gives 25.0 billion.

2.3.4 Recruitment forecast 1986 year class

An index for 1-ringers from the 1988 IYFS was calculated using length data from all participating countries and age/length keys from five out of the eight participating countries. The preliminary index calculated in this way was 4,178 fish/hour, which was again very high (Table 2.3.1).

Large numbers of this year class were sampled during the IYFS in Division IIIa (Table 2.3.4). The total number of 1-ringers in Division IIIa was estimated to be twice the number in the North Sea. From length distributions and meristic characters (Section 3.4.2), it appears that the large majority of 1-ringed herring sampled in Division IIIa were of North Sea origin.

It should be noted that Division IIIa is not included in the standard area for calculating the IYFS index for 1-ringers. The occurrence of a major part of the year class outside the standard area might, therefore, possibly result in an underestimate from the IYFS.

From Table 2.3.4, it appears that the number of 1-ringed herring in Division IIIa relative to the number in the North Sea has tended to increase in recent years.

The mean length (cm) of 1-ringed herring for the most recent year classes calculated for the whole North Sea and Division IIIa was as follows:

Year class	1981	1982	1983	1984	1985	1986
Mean length	15.1	14.6	14.7	14.0	14.2	13.6[1]

[1]Not including Division IIIa.

From this, it can be seen that the 1986 year class was very low. The predicted strength of the 1986 year class on the basis of the IYFS index for the 1-ringer standard area is 22.14 billion.

2.3.5 Recruitment forecast 1987 year class

The IKMT sampling during the 1988 IYFS produced an overall index for the North Sea and Division IIIa of 16,415. This index is lower than the one for the preceding year class, but it is at the same level as the indices for the 1984 and 1985 year classes (Table 2.3.2, Figure 2.3.3). Bearing in mind what was said in Section 2.3.2 about the prediction value of the IKMT index, it is likely that the 1987 year class will be a relatively strong one.

Figure 2.3.4 shows the distribution of O-group herring during the 1988 IYFS. It is seen that there was a large gap in sampling coverage in the northwestern North Sea and that the O-group herring were relatively abundant in the Skagerrak.

2.3.6 Trends in recruitment

Examination of the recent trend in recruitment indicates that recruitment has now returned to the level prevailing in the post-war period up to 1970 (Figure 2.3.5).

2.3.7 Recruitment to individual stocks

In last year's report, it was concluded that separate recruitment forecasts for Divisions IVc, VIId could no longer be made on the basis of IYFS results. In previous years, the 1-ringer index from the IYFS was split into a Divisions IVc, VIId component and a Divisions IVa,b component using differences in length distribution between the two components. In those years, the recruits from Divisions IVc, VIId tended to be smaller than the ones from Divisions IVa,b.

In 1987, this split could no longer be made because of a reduction in length of the Divisions IVa,b recruits. This year, the mean length of 1-ringed fish taken during the IYFS was reduced even further, and it was not possible to distinguish a separate Divisions IVc, VIId component in the length distributions for the various sampling areas.

Last year's report also commented upon the usefulness of two series of O-group surveys in the Southern North Sea aimed at obtaining recruitment forecasts for the Divisions IVc, VIId stock. These surveys are the English O-group survey in July along the northeast and east coasts of England, and the Dutch survey of pre-metamorphosis larvae in the Wadden Sea in April. Both surveys produce indices that are loosely correlated with recruitment in Divisions IVc, VIId (as estimated from VPA), but the indices from the English and Dutch surveys often give conflicting indications. This is probably due to anomalous distributions of the larvae in some years and incomplete sampling of the distribution area. A time series of the abundance indices is given in Table 2.3.5 together with estimates of 2-ring recruitment from VPA (Section 2.8.3).

A combined index from the English and Dutch series was calculated, using Shepherd's RCRTINX2 analysis (Table 2.3.5). However, there are only a few years of overlap between the VPA series and the combined index series, and it was not possible to calculate a predictive regression.

Even if a correlation between 0-group abundance and year-class strength exists, one has to be cautious in using this relationship for predictive purposes. As with the IKMT index for the total North Sea, it is still possible that the 0-group abundance merely reflects spawning stock size, and that the correlation between 0-group abundance and recruitment is due to the simultaneous trends in both stock size and recruitment.

2.4 Acoustic Surveys

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

An acoustic survey was carried out in the North Sea between 53°30' and 62°N in late June, July, and early August by vessels from Norway and the UK. The survey analysis procedures and target strength/length relationship were the same as those used in previous years.

Estimated numbers of herring in each statistical rectangle are shown in Figures 2.4.1 and 2.4.2 for total herring and mature herring, respectively. The maturing part of the stock was found predominantly west of 0° with the exception of a concentration in the Egersund Bank area. The percentages of 2- and 3-ringers expected to spawn in 1987 (i.e., at maturity stages 3 or above) were 63% and 96%, respectively. This compares with an estimated 80% of 2-ringers mature in 1986. The mature biomass was estimated to be 817,000 t for the whole North Sea, of which 487,000 t was found in Division IVa and 330,000 t in Division IVb. A comparison with previous surveys is given below:

Area	Spawning biomass ('000 t)					
	1982	1983	1984	1985	1986	1987
Orkney/Shetland	224	250	320	285	374	367
Moray Firth/Buchan	?	?	57	13	40	60
Fladen	?	?	76	73	100	60
Eastern area	?	?	13	43	10	47
Egersund Bank	?	?	?	20	10	19
Total	≥224	≥250	≥466	434	534	553

The estimated total numbers at age in the above areas from 1984-1987 are given in Table 2.4.1, and the estimated numbers at age for the total area covered in 1987 are given in Table 2.4.2.

2.4.2 Eastern part (E of 2°E) of Northern and Central North Sea

R/V "Dana" covered the area east of 2°E and between 54° and 60° north during August. The estimated number of fish by age is shown in Table 2.4.3 together with the results from "Eldjarn" during

June-July in approximately the same area. "Dana" estimated a high abundance of 0-group (25.8 billion) mainly in the area close to the Danish coast. The estimate from Eldjarn was just 6% of that value. Normally the 0-group is concentrated closer to the coast during June than during August, so "Eldjarn" might have missed the main 0-group areas. The estimates for 1-ringers were about equal while the estimate of older fish from "Dana" was more than twice the estimate from "Eldjarn". There is a possibility that differences in sampling might have caused some of the discrepancy in estimated numbers at age between the surveys.

Meristic samples taken on board "Dana" (Section 3.1) indicate that virtually all 3-ringers and older and about 50% of the 2-ringers in the area shown in Figure 3.1.1 belonged to the Division IIIa/Baltic spring spawners. Nearly all the adult fish recorded by "Dana" were in that area. On this basis, the estimates from "Dana" were split into Division IIIa spawners and North Sea spawners. There were no indications of Division IIIa fish among the 0- and 1-ringers. Too few old fish were sampled for vertebral counts to make a similar split of the estimates from "Eldjarn".

2.4.3 Western Central North Sea (Division IVb West)

The English northeast coast acoustic survey for spawning herring was undertaken from 28 August - 6 September. It concentrated on the spawning ground areas off the Yorkshire coast between Whitby and Flamborough Head (54°42'N - 53°58'N) up to 14-15 nautical miles off the coast.

A maximum total biomass of around 133,600 t was found from 28-31 August, a high proportion of this concentrated in an area off Flamborough Head where Dutch and German trawlers were operating. About 30,000 t of this total were estimated to be immature 1-ring fish of the 1985 year class which, unusually for this age group in this region, was quite strongly represented in most of the samples taken. About 6% of the 2-ring fish sampled were also immature.

The first spawning fish were not located until 2 September, when a patch was found about 12 miles NE of Flamborough Head. In the Whitby - Robin Hoods Bay area, spawning fish were not found until 5-6 September, when a peak spawning biomass estimate of around 51,000 t was made.

The majority of mature fish sampled were in stages 4-5 until near the end of the survey, and the minimum length group showing stage 5 maturity was 22 cm.

The age composition of combined samples taken on the survey is shown in Table 2.4.4, with the 1986 values for comparison. A notable feature is the marked reductions in mean lengths and weights for age in 1987 (see Section 2.7).

2.4.4 Estimates of mortality rates from acoustic surveys

The estimated numbers at age in the area north of 57^0N covered in each of the years 1984-1987 are given in Table 2.4.1 together with total mortality rates derived from them. In addition, estimates of mortality rates for the combined North Sea stocks are given in Table 2.4.2, based on:

a) for 1984-1986, the sum from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc and VIId winter surveys;

b) for 1987, the numbers at age from the summer survey of Divisions IVa,b.

Estimates of Z on 2-ringers and older over the period ranged from 0.57-1.02 with a mean of 0.84.

2.5 Herring Larvae Surveys

2.5.1 Herring larvae surveys in 1987/1988

The sampling intensity in all areas in 1987/1988 was at an acceptable level, being broadly comparable to that in the preceding years.

The Orkney-Shetland area was surveyed once by the Federal Republic of Germany in the first half of September and once by Scotland in the second half of September. In addition, the Netherlands sampled the central part of the area in the first half of September. Most of the small larvae were caught in the area between Orkney and Shetland and east of Orkney. Hatching is estimated to have peaked in early September.

In the Buchan area, Scotland surveyed once in the first half of September, while Denmark made two coverages in the second half of September. The main spawnings took place around Turbot Bank. In addition, some small larvae were found outside Peterhead. Hatching mainly took place between mid-August and early September, with a peak around 1 September.

The Central North Sea was surveyed six times in September and October. The Netherlands sampled once in the first half of September, twice in the second half, and once in the second half of October. The two remaining coverages were by England in the second half of September and in the first half of October. The main concentrations of small larvae were found at Longstone and Whitby/Flamborough. Smaller concentrations were found at the N.E. Bank and in the Outer Dowsing. Hatching mainly took place through September and early October, with a peak in the second half of September.

The Southern Bight and Eastern Channel were surveyed by the Netherlands, once in the first and once in the second half of December. England covered the first half of January, and the Federal Republic of Germany covered the second half of February. Significant recordings of larvae were found in December off Dieppe and in January at North Hinder. Hatching is estimated to have peaked in early December and in late December/early January.

2.5.2 Larvae production estimates (LPE)

Calculations of LPEs were made available to the Working Group by DIFMAR, Hirtshals. The estimates were calculated as described in last year's report of the Working Group (Anon., 1987).

The production estimates are based on estimates of mortality rates (z/k) calculated from the larvae data. In Table 2.5.1, the results for the years since 1980 are given for the four standard areas in Sub-area IV. For each area, the average mortality rate over the years 1980-1987 was used as the area-specific mortality rate for all years from 1972-1987. As can be seen from Table 2.5.1, only very slight changes have been made to the area-specific mortality rates due to the new 1987 data.

The LPE values for the four standard areas are shown in Table 2.5.2. The most striking feature of the results is the major decrease in the Buchan area from 1986 to 1987 (1986 = 831; 1987 = 200). The decrease is not due to insufficient survey coverage, but is a result of either a decrease in early spawning or of increased egg and yolk sac larvae mortality rates.

The LPE estimates were corrected for differences in fecundity in Table 2.5.3. No new fecundity data were available to the Working Group this year.

2.5.3 Indices based on small larvae (LAI)

Calculations of LAIs were made available to the Working Group by the DAFS Marine Laboratory, Aberdeen. The estimates were calculated as described by Saville and Rankine (1985). The LAIs for the time period 1972-1987 are given in Table 2.5.2 together with the LPE results.

The LAI results show an increase from 1986 to 1987 only in the Orkney-Shetland area, while the three other standard areas all show a decrease. The apparent decrease in the Buchan area cannot be explained by early hatching prior to the first surveys because in 1987, fewer medium-sized larvae were observed in the first survey period than in 1986 (an estimated 821 billion in 1987 compared with 3,050 billion in 1986).

The LAI values for Divisions IVa,b combined and for the total North Sea were calculated as follows. The sum of the Orkney-Shetland LAI and the Buchan LAI was added to four times the LAI for the Central North Sea to give the LAI for Divisions IVa,b. The LAI for the Central North Sea was multiplied by 4 as it is reported as the mean of the four half-month periods that are included. The LAI for Divisions IVc, VIId was added to the LAI for Divisions IVa,b to give the LAI for the total North Sea.

2.5.4 Regressions between larvae and VPA SSB

The two series of larvae indices (LAI and LPE) for the total North Sea give conflicting results over the past 3-4 years (Figure 2.5.1) and it was, therefore, not possible to use them to tune a VPA for this area. Instead, the North Sea VPA was tuned using the series of acoustic survey estimates, and the larvae surveys were used in a more qualitative way to evaluate the reliability of the resulting assessment. In addition, they provided the only indication of developments in the individual spawning components in the North Sea and Channel.

Based on an input F of 0.55 for age groups 3+ in 1987, regressions were made between LAI and SSB from the VPA and between LPE and SSB from the VPA. For both regressions, the intercepts were not significantly different from zero. Therefore, two new regressions with zero intercept were calculated. The regressions are given on the scatterplots in Figures 2.5.2 and 2.5.3 for LPE and LAI, respectively. From the regressions, the SSBs for 1987 were estimated to be 559,000 t and 777,000 t from LPE and LAI, respectively.

In Figures 2.5.2 and 2.5.3, estimates from the period before the closure of the herring fishery all tend to lie above the regression lines, while the estimates from the years under and just after the closure lie below the regression lines. It is not possible to tell if this is due to better survival of the larvae since 1978, inadequate sampling techniques in the first years of the IHLS surveys, an artifact in the VPA (e.g., unreported catches in the period since the closure), or a combination of these factors.

For comparison with SSB from the VPA, Figure 2.5.1 gives the predicted estimates of SSB from the LPE and LAI regressions with the VPA over the years 1972-1987.

There is no evidence from the larvae surveys of any increase in SSB in the three most recent years.

2.6 Tagging

Norwegian experiments using internal steel tags have been carried out. In total, 25,000 tags were released in the area north of $56^{0}30'$ in November 1986 (9,000) and March 1987 (16,000). At the end of 1987, 218 tags were returned, of which 105 can be associated with a known catch (56,500 t). The returns indicate quite variable survival of tagged fish from the different experiments. The results were, therefore, not used for calculation of fishing mortality or size of the stocks exploited by the Norwegian fishery.

Scottish tagging experiments using external tags continued in the western part of Division IVa in June 1987, and an experiment was carried out in the Moray Firth in January.

2.7 Mean Weight and Maturity at Age

2.7.1 Mean weight at age in the catch and stock

Mean weights at age (weighted by numbers caught) in 1987 are presented by divisions and quarters in Table 2.7.1. The 1986 Working Group report first drew attention to a decrease in mean weights at age in the catch, when a comparison was made between the values in 1985 and those used prior to 1985 for the ICES stock prediction program. This downward trend continued in 1986, and the 1987 data are presented in Table 2.7.2 with earlier years for comparison. It is evident there has been a further marked reduction in mean weights of 2-ring fish (18% overall) and a small decrease in 3-ringers in 1987. Older fish, however, if anything, registered an overall increase, with values close to those recorded in 1985.

It has also become evident in recent years that 1-ring fish taken during the February IYFS have shown decreased mean lengths (see text table, Section 2.3.4).

However, care must be taken in interpreting changes in annual catch-weighted mean values, since much will depend on the quarterly distribution of catches. A comparison between third quarter mean weights at age in 1986 and 1987, when most of the adult fish caught are in advanced maturity stages, shows a less dramatic decrease in mean weight of 2-ring fish, as shown in the following text table:

	Third quarter mean weights (g) at age in the catch		
Age (w.r.)	1986	1987	% reduction
1	78	53	32.0
2	146	133	8.9
3	190	183	3.7
4	224	220	1.8
5	248	247	0.4
6	281	263	6.4
7	287	285	0.7
8	328	310	5.5
9+	364	342	6.0

The mean weights at age in the summer acoustic survey in 1987 are very close to those in the third quarter catches (Table 2.7.3). On this basis, mean weights in the stock were revised for the years 1985-1987 (see Table 2.8.3) using third quarter values in the catch as the best estimates.

2.7.2 Maturity ogive

Estimates of the percentage of 2- and 3-ringers that were mature in 1987 were available from research vessels samples taken on the July acoustic survey and from commercial samples (Table 2.7.4). In almost all areas, the percentage of mature 3-ringers was very high, with overall values of 96% during the acoustic survey and 90% in Norwegian catches taken during the fourth quarter.

The percentage of mature 2-ringers was more variable. It was high (80%-100%) in Scottish and Norwegian catches from western areas taken in the third and fourth quarters, respectively, and much lower (50-70%) in samples from the eastern half of the North Sea. The overall percentage from both the Norwegian fourth quarter catches and acoustic survey amounted to 63-65%. Because of a possibility that the commercial fisheries in spawning areas may have been biased towards larger mature fish, the Working Group used values of 63% and 100% as the proportions of 2- and 3-ringers, respectively, mature in the VPA.

2.8 State of the Stocks

2.8.1 Total North Sea (Sub-area IV and Division VIId)

ICES was requested by the EC and Norway to provide its best quantitative estimate of the spawning stock in the total North Sea. For the reasons given in Section 2.8.3, the Working Group could not make any separate assessment for the southern North Sea. As a result, it was not possible to base the total North Sea assessment on assessments for the separate divisions. Instead, it was based on survey indices and a VPA for the total North Sea.

Larvae surveys were conducted in all the known spawning areas (Section 2.5). The larvae abundance estimate summed for all areas was slightly higher than in 1986, while the summed larvae production estimate was considerably (46%) lower than in 1986.

As discussed in Section 2.5.4, it was not possible to tune the VPA using the larvae surveys. Instead, the North Sea VPA was tuned using the series of acoustic survey estimates, and the larvae surveys were used in a qualitative way to evaluate the reliability of the resulting assessment.

Acoustic surveys were conducted in the whole Northern and Central North Sea in the period late June - early August (Section 2.4). The acoustic estimate was considered to be an estimate for the total North Sea as the southern stock is likely to be in the areas surveyed at the time of the survey. Acoustic estimates for the years 1981-1986 were obtained by summing estimates from the annual summer survey in the Northern North Sea, the autumn survey in the Western Central North Sea and the winter survey in the Southern North Sea. The possibility of double counting parts of the stock by this procedure was discussed, but not considered as a major source of overestimation.

To estimate the level of F in 1987, the time series of total acoustic estimates was compared with estimates of SSB from runs of a VPA using different input F values. The exploitation pattern used in the VPA was obtained from an analysis of catches in numbers at age in the first and second halves of the year and the estimates of numbers at age on the acoustic survey (Table 2.8.1). The table also gives the exploitation pattern derived from a separable VPA based on the years 1983-1987. From this, unit selection was assumed to occur over the age groups 3 and older, while the relative F on younger age groups was 0.76 on 2-ringers, 0.34 on 1-ringers, and 0.25 on 0-ringers. The output of the separable VPA is shown in Table 2.8.2.

As shown in Table 2.7.3, the mean weights at age of spawners observed during the acoustic survey were quite close to those in the catches in the third quarter including immatures. Therefore, the mean weights at age in the third quarter catches were used for the stock at spawning time for the years 1985-1987 (Table 2.8.3). For the earlier years, the values calculated for 1984 by the 1985 Working Group were used. A proportion of mature 2-ringers of 63% in 1987 was used on the basis of the acoustic survey. This is a decrease compared to earlier years (Table 2.8.3).

The text table below shows the regression parameters for the regressions between the acoustic estimates and the VPA estimates for different values of F in 1987.

F_{3+}	0.45	0.50	0.55	0.60	0.65	0.70
Slope	1.26	1.13	1.03	0.94	0.87	0.81
Intercept	-139	-93	-57	-26	-1	21
r	0.937	0.947	0.952	0.951	0.944	0.934

The highest correlation coefficient (r) was obtained for the regression based on an input F = 0.55, which also gave a nearly 1:1 relationship. This was then considered to be the one giving the best fit. The points and the regression line are shown compared to the line in Figure 2.8.1.

The time series of acoustic estimates and VPA estimates for three three different values of input F are shown in Figure 2.8.2. The results of the final VPA run (F_{3+} = 0.55) are given in Tables 2.8.4 - 2.8.6. Table 2.8.6 also shows the age 2+ stock biomass at the time of spawning.

In spite of improved recruitment, the growth of the spawning stock in the period 1985-1987 is considerably reduced compared to the years 1983 and 1984, which means that the fishery in recent years has nearly balanced the contribution from the recruiting year classes. The estimate of the spawning stock in 1987 is 860,000 t.

The VPA results compared to last year's projection are discussed for Divisions IVa,b in Section 2.8.2. That discussion is generally applicable to the total North Sea.

During the last day of the Working Group meeting, it was observed that, in 1987, the proportion of F before the acoustic survey was not 0.67 (as implicitly assumed when tuning the VPA to the time series of acoustic surveys), but only in the order of 0.37 (Table 2.8.1).

This means that the spawning stock biomass from the VPA is not directly comparable with the acoustic estimate. Thus, the tuning procedure used was not completely correct. This may explain at least a part of the discrepancy between the fishing mortality (F_{3-8} = 0.73) from Table 2.8.1 and the terminal fishing mortality (0.55) obtained by tuning the VPA to the acoustic estimate of spawning stock biomass.

The proper way of dealing with this problem seems to be to run a new VPA with a new value of the proportion of F before spawning, and to tune this to the acoustic estimate of spawning stock projected to the time of spawning.

As the VPA is tuned to the whole series of acoustic surveys, this revision is not likely to make a large impact on the VPA estimate of spawning stock in 1987, but it is likely to increase the average F for 1987, coming closer to the one estimated in Table 2.8.1. This will reduce the projected stock at 1 January 1988 which is the input for the 3-ringers and older for the projection. This has to be remembered when interpreting the projections given in Section 2.9.

2.8.2 Divisions IVa and IVb

The larvae surveys show that the contribution from Divisions IVa, b both to the total North Sea larvae production and to the larvae abundance has been between 75 and 90% without any trend since 1983. The Working Group was not able to determine the stock composition of the 1987 acoustic estimates. In the years 1984-1986, the Divisions IVa,b acoustic estimate made up about 85% of the total North Sea estimate. There was no evidence in 1987 that the herring spawning in Divisions IVa,b did not represent the major part of the total North Sea stock. Therefore, what is said about the state of the total North Sea stock is also applicable to the Divisions IVa,b combined stock.

A VPA for this area was run by using the same input F by age for 1987 as for the total North Sea VPA. Except for mean weights at age, the other input parameters are also the same. The mean weights at age in the stock for the years 1985-1987 were based on third quarter catches, while the values for earlier years are the same as used by last year's Working Group (Table 2.8.7). The proportions of maturity used in each year are also given in Table 2.8.7. The catch at age and the results of the VPA are given in Tables 2.8.8-2.8.10. When compared to the total North Sea VPA, it appears strange that the years 1973-1980 show a larger spawning stock in Divisions IVa,b than in the total North Sea. This might be caused by the very low and presumably uncertain catches during that period. In addition, there might be unrealistic differences in mean weights at age in the stock and in F on the oldest true age groups.

The Divisions IVa,b spawning stock estimate for 1987 of 775,000 t is 138,000 t (15%) below the projection made by the 1987 Working Group. This is explained by the decrease (20% for the most dominant age group) in the applied mean weights at age in the stock numbers and the change in proportion of mature 2-ringers. The estimated number of 2-ringers at 1 January 1987 is 30% higher than the estimate from the 1987 Working Group, but the contribution from that year class to the spawning stock is 4% below the projection due to decreased individual weight, decreased proportion of maturity, and increased fishing.

2.8.3 Problems in separate assessments for Divisions IVc, VIId

Over the past years, the Working Group has run into problems when trying to do a separate assessment for Divisions IVc, VIId. These problems can be summarized as follows:

a. Discrepancies between VPA and direct stock estimates for earlier years

For any value of terminal F in 1987, a VPA for Divisions IVc, VIId will produce F values for the years 1980-1985 in the order of 1.00 and spawning stock sizes in the order of 50,000 t. Tables 2.8.14 and 2.8.15 show the results of a VPA using an input F of 0.65 for 1987. Results from acoustic surveys in the years 1981-1985 indicate a spawning stock size between 96,000 - 150,000 t (Table 2.8.11).

The explanation for this discrepancy, given already in last year's report, is that the stock is not only exploited in Divisions IVc, VIId in autumn and winter, but also in Divisions IVa,b in spring and summer. Catches of Southern North Sea herring taken in Divisions IVa,b will not be included in a VPA for Divisions IVc, VIId, and this will lead to a bias in the results of the VPA. The omission of part of the catches from the VPA will lead to an underestimate of stock sizes. The estimated F for earlier years, however, is expected to be close to the true value, as it mainly reflects the catch curves.

b. No separate recruitment forecasts

As stated in Section 2.3.8, recruitment forecasts for the Southern North Sea can no longer be made from the IYFS data. The results from the English and Dutch 0-group surveys are not considered to be adequate for recruitment prediction.

c. Catches taken in Divisions IVa,b unpredictable

It is not possible to make a reliable prediction of the proportion of the Divisions IVc, VIId stock that will be taken in Divisions IVa,b during spring and summer. At present, the Divisions IVc, VIId stock is very small in relation to the Divisions IVa,b stock, and it is probably not randomly distributed throughout Divisions IVa,b. The actual fishing mortality experienced by the southern fish in Divisions IVa,b will depend on the distribution of these fish in relation to the major fishing fleets. This distribution is probably quite variable from one year to another, and so will be the fishing mortality. The Working Group considers it unrealistic to assume that the F on southern fish in the summer will always be a fixed proportion of the F on Divisions IVa,b herring.

Considering the problems in predicting recruitment and also in predicting catches taken in Divisions IVa,b, the Working Group decided not to make a separate stock assessment or prediction for Divisions IVc, VIId. Instead, the Southern North Sea stock was included in the stock prediction for the total North Sea.

2.8.4 Divisions IVc, VIId

Although no analytical assessment was carried out for Divisions IVc, VIId, the Working Group examined available survey indices and carried out a VPA to evaluate recent trends. The survey indices for Divisions IVc, VIId are shown in Table 2.8.11.

The larvae abundance index for 1987 was 28% below the 1986 value, and the larvae production estimate was 51% below the 1986 value. The southern stock component of the total North Sea acoustic estimate could not be calculated. All the survey indices indicate a rather stable but low stock in the period 1982-1986.

A VPA using an arbitrary input F of 0.65 was run for this area. An unknown but quite important proportion of the exploitation on this stock is going on outside Divisions IVc, VIId. Therefore, the VPA did not give realistic estimates of the stock size. The fishing mortalities resulting from the converged part of the VPA were considered to be realistic, however (see Section 2.8.3).

Tables 2.8.12 - 2.8.15 show the input and results of a VPA. The results show a quite high F (in the order of 1.0) since 1982. The results for the latest three or four years are uncertain, but the surveys indicate that the stock in 1987 was still low, and the catches in the area were at the same level as in previous years. This then implies that the fishing mortality was in the same order of magnitude in 1987 as in the 1982-1984 period.

2.8.5 Stock-recruitment

Figure 2.8.3 gives the scatterplot of stock size and resulting recruitment as 1-ringers from the VPA. The figure also gives the line corresponding to a value of F of 0.35 chosen by ACFM for advising a 1988 TAC.

The value of F of 0.35 coincides with the value of F_{med} when only spawning stock sizes in the range of 1.0-2.5 million t are included in the estimation of F_{med}.

2.9 Projection of Catch and Stock Size - Total North Sea

The input data for the prediction are given in Table 2.9.1. The input exploitation pattern, maturity ogive, and proportion of F and M before spawning were the same as used for the year 1987 in the VPA. The mean weights at age both in the catch and stock were also equal to the 1987 values in the VPA except the value for 1-ringers. This was reduced by 10% compared to 1987 corresponding to the decrease estimated from the IYFS data in 1988. The input recruitment of 1-ringers in 1988 was the figure estimated from the IYFS 1988 (22.14 billion). For the 2-ringers, a value of 8 billion was chosen as an average between a projected estimate of 1-ringers from the 1987 IYFS (9.1 billion) and a projected estimate of 1-ringers from the acoustic summer survey (7.1 billion). For the older age groups, the values were taken from the VPA. The input recruitment of 1-ringers in 1989 and 1990 was 15.1 billion which is an average of the 1981-1984 year classes as 1-ringers. The recruitment of 15.1 billion 1-ringers lies very close to a

15.8 billion geometric mean of 1-ringer recruitment over the years 1947-1970 and 1981-1985.

Using these data, an F_{3+} of 0.42 is required to reach the TAC of 530,000 t in 1988. The catch will then include 58,000 t 1-ringers. This represents a 24% reduction in F_{3+} compared to 1987. A yield-per-recruit calculation gives $F_{0.1}$ = 0.13 and F_{max} = 0.30 (Figure 2.9.1). For the prediction for 1989 and 1990, these F values were used. In addition, an F of 0.35 suggested by the Working Group and ACFM in May 1987, F_{87} (0.55), and F_{88}(0.42) were used. The resulting catches and spawning stocks for each option are shown in Table 2.9.2. An identical prediction was made showing the biomass of 2-ringers and older at the time of spawning (Table 2.9.3).

To obtain a catch of 500,000 t in 1989, which is the expected long-term average yield from the stock, a fishing mortality of 0.35 is required. Table 2.9.4 gives a detailed output for this option.

In interpreting the biomass of spawners and of the age 2+ stock at the time of spawning in 1990, it has to be remembered that they also reflect the effect of fishing during two-thirds of the year at the same level of F as in the preceding year.

2.10 Management Considerations

2.10.1 TAC advice for 1989 for Divisions IVa,b

The Working Group discussed the management of North Sea herring at considerable length in its 1987 report, stressing the desirability of managing the level of catches to allow the spawning stock (in Divisions IVa,b) to grow to a level of 1.5 - 2.0 million t which would provide a buffer against a short-term decrease in recruitment. The stated aim of the management bodies regulating fisheries on the North Sea stocks is to allow recovery of the total North Sea spawning stock to a level of 2.2 million t (record of consultations between the EC and Norway in 1986 and 1987). To achieve either of these objectives, it is necessary to control the fishing mortality rate at a level that will permit continued recovery. The value of F of 0.35 chosen by ACFM for advising a 1988 TAC, and which coincides with the value of F_{med}, is predicted to allow further growth of the spawning stock biomass to 1.47 million t in 1989 and, if projected further (assuming mean recruitment), to 1.56 million t in 1990. According to the prediction (Table 2.9.2), a recovery to the management bodies' objective by 1990 could be achieved by reducing the fishing mortality rate in 1989 and 1990 to the $F_{0.1}$ level.

As a result of the possible overestimation of the stock in number at 1 January 1988 (see Section 2.8.1), it should be noted that the advice given above may be too optimistic.

The division of a TAC for 1989 between Divisions IVa,b and Divisions IVc, VIId is discussed in more detail in Section 2.10.2. The TAC for Divisions IVa,b, however, is most appropriately calculated by subtracting the TAC chosen for Divisions IVc, VIId from the overall TAC chosen for the total North Sea.

2.10.2 Management of the Divisions IVc, VIId stock

Although a separate stock prediction for the Divisions IVc, VIId stock is no longer possible, the herring in the Southern North Sea should still be considered as a separate management unit. Both in the 1950-1960s and in the early 1980s, the F on this stock rose above the F for other North Sea stocks (Burd, 1978, and Section 2.8.3), probably as a result of the extra exploitation of this stock on its spawning grounds. This led to the depletion of this stock in the early 1960s and to the lack of further recovery after the re-opening of the fishery in 1981.

The high vulnerability of the southern stock compared to other North Sea stocks requires additional management measures for this stock. Two specific protection measures may be considered: a closure of the fishery during part of the winter season, and a catch restriction by a separate TAC for Divisions IVc, VIId.

A closure of the fishery in Divisions IVc, VIId during the spawning season (15 November - 31 December) would provide additional protection for this stock. However, it is not certain whether this measure would be acceptable to the fishing industry as a major part of the catch is now taken for the roe.

Whether a closure of spawning grounds is introduced or not, the catches in Divisions IVc, VIId will have to be restricted by a special TAC for this area. This TAC will be of a precautionary nature, adjusted upward or downward in response to changes in F or spawning stock size. Because mortality rates on this stock can only be estimated as an average over a number of years, the Working Group last year advised keeping the precautionary TAC constant over a number of years before adjusting it. The Working Group advised reducing the TAC for 1988 and subsequent years below the average catch level for the previous six years (57,000 t).

This advice was followed by management bodies who set a TAC of 30,000 t for 1988. This TAC is higher than the advice given by ACFM (15,000 t), but considerably below the catch level in the previous years. Recent estimates of stock size from larvae surveys indicate that the stock in 1987 may have declined from its 1986 level (Section 2.5). However, as the results from the larvae surveys are known to be rather variable from year to year, the Working Group considered the results of the 1987/1988 larvae surveys as insufficient evidence for a major change in spawning stock size from 1986/1987 - 1987/1988. The Working Group, therefore, considered a continuation of the 1988 TAC (30,000 t) in 1989 as an appropriate management measure.

The Working Group noted that a TAC of 30,000 t for 1989 contains a risk of stock depletion. This danger is inherent in a situation where precautionary TACs have to be based on data from two years earlier. This risk can only be reduced by either setting the precautionary TAC at a really cautious level (e.g., 15,000 t as advised by ACFM), or by postponing the final decision on the TAC until after the results of the 1988/1989 larvae surveys have become available.

The precautionary TAC for Divisions IVc, VIId is part of the TAC for the total North Sea. It should be deducted from the total North Sea TAC in order to derive the TAC for Divisions IVa,b.

2.10.3 Management of juvenile fisheries

The existing conservation measures for juvenile herring in the North Sea (closed areas and 20-cm minimum landing size) seem to have been reasonably well enforced in 1987. The fact that the reported catch of juvenile herring increased by 20,500 t from 1986 was primarily due to the occurrence of the strong 1985 and 1986 year classes as juveniles, and probably also to improved catch reporting and sampling.

The emphasis of the industrial fishery in the North Sea has now clearly shifted to 1-ringed herring that have reached the legal minimum size and that are mainly caught in the second half of the year.

The main exploitaton on juvenile North Sea herring in terms of numbers caught is now formed by the industrial fishery in Division IIIa. Catches of juvenile herring in Division IIIa remained very high in 1987 and amounted to an estimated 162,000 t. These fish were nearly all 0-group and small 1-ringers with a mean weight of 33 g (Table 3.2.4). There can be no doubt that this fishery is causing a considerable loss of recruitment to the North Sea stock.

Part of the juvenile catches in Division IIIa are landed under the TAC for mixed small clupeoids. The TAC for these catches in 1987 was 80,000 t, and the same TAC has been adopted for 1988.

The Working Group considers that existing management measures have been ineffective in controlling catches of juvenile herring in Division IIIa. A continuation of these catches will reduce the total yield of the North Sea stocks and may contribute to the risk of severe TAC reduction in the North Sea in the future.

The existence of a legalized fishery for juvenile herring in Division IIIa is inconsistent with the policy of juvenile conservation followed in the North Sea. Furthermore, as long as catches of juvenile herring are permitted in Division IIIa, there is a possibility of misreporting catches of juvenile herring taken in the North Sea.

2.11 Requests from the Multispecies Working Group

2.11.1 Historic quarterly data base (numbers and mean weights at age

Quarterly catches in number and mean weights at age for the entire North Sea for 1987, excluding spring spawners transferred to the Division IIIa assessment, are given in Table 2.11.1.

The historic data back to and including 1974 are in an advanced state of preparation and should be available for the Multispecies Working Group in June 1988.

2.11.2 Geographical distribution of the catches in the North Sea in 1987

Data on the geographical distribution of catches in the North Sea in 1987 were available from Denmark, the Netherlands, Norway, the UK (England), and the UK (Scotland). The data were derived from logbooks or market sampling programmes. For all countries, the geographical data were scaled to the national catches in each month. The available data represent about 82% of the total catch of herring in 1987.

Figures 2.11.1 - 2.11.12 show the catch of the four countries by ICES rectangles for each month in 1987 and include both juvenile and adult catches.

The geographical distribution of total herring and mature herring, based upon acoustic surveys in June-August 1987, are shown in Figures 2.4.1 and 2.4.2, respectively.

3 DIVISION IIIa HERRING

3.1 Stock Composition

3.1.1 Baltic and Division IIIa spring spawners in the North Sea

It was shown in last year's report that spring-spawning herring migrate from Division IIIa into the adjacent parts of Divisions IVaE and IVb where they constitute parts of the catches in the second and third quarters. From an assessment point of view, these catches should be referred to the Divisions IIIa,b,c herring stocks and included in their assessment.

Danish and Norwegian samples from the North Sea together with data on vertebral counts formed the basis for a definition of the North Sea area invaded by Division IIIa spring spawners.

Figure 3.1.1 shows mean vertebral counts (VS) at age in Danish samples from the commercial fishery in the eastern part of the North Sea. It appears that in all samples, except the earliest taken on 22 May, herring of age 3 and older are typical spring spawners of the coastal type dominating the Division IIIa and Baltic stocks. The 2-ringers, however, are more or less mixed with herring of North Sea origin, presumably the smaller immatures of a year class which otherwise consist of recruit spawners which have moved into the Western North Sea.

In some cases, the length distribution of the 2-group is bimodal - the lower mode showing VS of spring spawners while the larger fish have characters typical of autumn spawners (see sample from 26 May in Figure 3.1.1).

Some Norwegian samples from May-August (Figure 3.1.2) corroborate the pattern shown by the Danish samples. They also show that the VS of herring in the Western North Sea are in the range 56.3 - 56.6, which is typical for autumn spawners.

A further confirmation of the presence of Division IIIa spring spawners in the North Sea is provided by Danish samples from research hauls during the acoustic survey in August 1987 as shown in Figure 3.1.3. In these samples, all 0- and 1-ringers are autumn spawners, all 3-ringers and older are spring spawners, while the 2-ringers are either pure spring spawners or contain a mixture of spring- and autumn-spawned origin.

On this basis, the Working Group decided to transfer all 3-group and older herring caught east of 3°E and between 56°30' - 59°N in May-August inclusive to the Division IIIa herring assessment. The transfer area is indicated in Figure 3.1.2.

The 2-ringers were split into the two spawning components according to the proportions of their numbers in the samples. This gave approximately a 50:50 division, and the resulting estimate of the herring in numbers at age which should be referred to Division IIIa is shown in Table 3.1.1.

It is noted that the transfer cuts through a large area of catches in May-June but isolates a patch of catches in July-August as shown in Figures 2.11.5 - 2.11.8. Transfer of catches made in September (Figure 2.11.9) in the same area has not been considered due to lack of meristic data from this month even though spring spawners could still be expected to occur in these catches.

The present separation is, therefore, uncertain and it is not possible, based on available data, to judge if the present transfer is an over- or underestimate of the real catches of spring spawners in the North Sea.

The Working Group, therefore, reiterates its recommendation given in the 1987 report that increased biological sampling is needed in the eastern part of the North Sea to be able to separate the catches properly.

3.1.2 Stock composition in Division IIIa

An attempt was made to separate the catches of herring in Division IIIa in 1987 into Division IIIa/Baltic spring spawners and autumn spawners from the North Sea. The approach chosen involved meristic character calculations on aggregated length frequencies by quarter for the Skagerrak and Kattegat, respectively. Where the mean vertebral count indicated a mixture of components, a modal length analysis was applied to separate the different components. The resulting components were checked against a record of VS per length group by area and by quarter.

In the case of 1-group and 2-group herring, aggregate length frequencies were only available from the Swedish catches, and the results of the split of these catches were applied also to the Danish catches of these age groups.

Vertebral counts of the 0-group in all quarters and over the whole area showed a total predominance of North Sea autumn spawners, and the catches of this age group were assigned to the North Sea stock. The results of the analysis of 1-group and 2-group herring are summarized below:

1-Group Herring

	Skagerrak			Kattegat		
		Proportion			Proportion	
Quarter	Mean VS	NS	SSP	Mean VS	NS	SSP
1	56.41	1.00	-	56.35	1.00	-
2	56.64	1.00	-	56.27	1.00	-
3	56.31	1.00	-	56.00	0.04	0.96
4	56.31	1.00	-	56.09	0.12	0.88

2-Group Herring

	Skagerrak			Kattegat		
		Proportion			Proportion	
Quarter	Mean VS	NS	SSP	Mean VS	NS	SSP
1	56.10	0.24	0.76	55.91	-	1.00
2	56.18	0.54	0.46	55.80	-	1.00
3	55.78	-	1.00	55.75	-	1.00
4	55.98	-	1.00	55.84	-	1.00

NS = North Sea autumn spawners.
SSP = Division IIIa spring spawners.

The mean vertebral count indicates an area separation of the two components of herring with a dominance of North Sea autumn spawners in the Skagerrak and spring spawners in the Kattegat. A proportion less than 1.0 in the table indicates where a modal length analysis was applied. The separation gave components that could be assigned to either stock based on the criteria that spring spawners should have a mean VS of 56.0 or less and autumn spawners VS values in the range of 56.3-56.5. The proportion of the different components of 2-group herring found in the first quarter in the Skagerrak was corroborated by the estimated proportions in the IYFS in the same year.

The results of the separation of the total international catch presented in Section 3.2 still have some uncertainties, since it is assumed that the different fleets taking part in the herring fishery in Division IIIa exploit the stock mixture in the same way.

3.2 The Fishery

3.2.1 Landings

Table 3.2.1 shows the landings from Division IIIa by countries. The Skagerrak landings increased about 13% from 139,000 t in 1986 to 157,000 t in 1987. In the Kattegat, landings remained at the same level as in 1986 (about 77,000 t). The total yield in Division IIIa of 234,000 t was thus somewhat higher than in the previous year, but at the same level as in 1984-1985.

A major part of the landings went for industrial purposes either as "by-catch" in the 16-mm mesh fishery or as unmarketed fish from the fishery for human consumption carried out with a 32-mm mesh. The consumption fishery amounted to about 20% of the total landings. It was not possible, however, to give any reasonably accurate estimate of how much of the industrial landings originated from 16- and 32-mm mesh, respectively.

3.2.2 Catch in numbers at age

Sampling of the Danish industrial landings recommenced in the second half of 1987. For the first half year, the Working Group used age compositions and numbers per kg from 1984. The possible errors introduced in this way are, however, not likely to be very significant as the landings so treated only amounted to about 12% of the yearly total. The Danish consumption fishery in the Skagerrak was not covered by sufficient sampling.

There was no Danish fishery in the first quarter, and in the two following quarters, the fishing in the Skagerrak extended into the North Sea as described above. The samples from the latter fishery were, therefore, applied to the catch in the Skagerrak as well. In the fourth quarter, age compositions were taken from samples of the Swedish landings which overlapped the Danish fishery in area during that part of the year. Danish industrial landings in the first two quarters in the Kattegat were not sampled, and the Danish consumption landings were not covered in the fourth quarter. Data on industrial landings in 1984 were again used on the Danish industrial landings in the first and second quarters amounting to about 26% of the total herring catch in the Kattegat. The consumption herring were treated according to Swedish data. The catch in numbers, mean weights, SOP, and catches (t) so obtained are shown in Table 3.2.2 by quarters and by the Skagerrak and the Kattegat separately. The table represents only the catches made in Division IIIa and does not include spring-spawning herring caught in the North Sea. It does include the North Sea immatures caught within Division IIIa, however.

In order to split the catches into the two management groups, the catches in numbers at age were assigned to spring and autumn spawners, respectively, as described in Section 3.1. The result is shown in Table 3.2.3 which may be considered as being an underestimate of the catch of indigenous Division IIIa/Baltic herring, even thought it includes the landings made in the adjacent parts of the North Sea. It seems unlikely, for example, that no 0-group and very few 1-group herring of Division IIIa/Baltic origin should be caught within the area. A scrutiny of the variable mean weights for these age groups in the Skagerrak and Kattegat also gives the impression that the results should be treated with some caution.

The amounts of herring allocated to the North Sea autumn spawners are shown in Table 3.2.4. Even though the figures may represent an overestimate, there is no doubt that a very substantial amount of young immature North Sea herring was caught in Division IIIa in 1987.

3.2.3 Advice and management applicable to 1987 and 1988

As in 1985 and 1986, there was a TAC in 1987 for the mixed sprat/juvenile herring fishery with small-meshed gears for industrial purposes in Division IIIa. The TAC for this fishery was 80,000 t in 1987 as in 1986. Before 1985, it was prohibited to catch herring with small-mesh gear. Nevertheless, large amounts of herring caught as by-catch in the sprat fishery were landed in the first half of the 1980s, when the dominance of sprat was replaced by a dominance of herring.

The TAC for 1988 for the mixed sprat/juvenile herring fishery was set at 80,000 t.

An agreed TAC for the catch of herring was set at 138,000 t for human consumption in Division IIIa in 1987. For 1988, a TAC was again set at 138,000 t.

Even if one takes the mixed TAC to be a herring TAC only, the total herring TAC in Division IIIa in 1987 becomes 218,000 t. As the total catch of herring in Division IIIa in 1987 was 233,960 t (Table 3.2.1), the TAC agreed was exceeded by 15,960 t.

3.3 Biomass Estimates from Acoustic Surveys

Three acoustic surveys of herring abundance were carried out in Division IIIa and the eastern part of the North Sea which is known to be the summer/autumn distribution area of the spawners.

In August, the eastern part of Divisions IVa,b was surveyed by "Dana". By the end of the same month and in early September, "Dana" continued the survey and covered Division IIIa. A third survey was carried out by "G.O. Sars" in December. This survey covered a large part of Divisions IVa,b and IIIa inclusive.

Previous acoustic estimates of herring in Division IIIa were based on an Icelandic target strength regression (Halldorsson and Reynisson, 1983) for clupeoids and a blue whiting regression for gadoids. For species without a swim bladder such as mackerel, spurdogs, and others, a TS 6 dB below that of herring has been used.

In the 1987 estimates, a new set of target strength regressions was used, and the results are not comparable to previous estimates of the herring stock in this area.

The target strength regressions used in previous years (old) and in 1987 (new) are:

New	Old
Clupeoids and horse mackerel:	
TS = 20.0 log L - 71.2 dB	TS = 21.7 log L - 75.5 dB
Mackerel:	
TS = 20.0 log L - 88.1 dB	TS = 21.7 log L - 81.5 dB
Gadoids:	
TS = 20.0 log L - 67.5 dB	TS = 21.8 log L - 72.7 dB

The new set of TS regressions applied in Division IIIa means that the same regressions are now used in the North Sea, Division IIIa, and the Baltic area. Without evaluating the appropriateness of a unique set of regressions for this large area, the new regressions at least give a possibility to make direct comparisons and combination of different survey estimates.

The change in TS regressions in the Division IIIa estimates means that previous estimates of the herring stock in this area should be revised.

The results of the different surveys in 1987 are given in the text table below. The August - early September surveys are synoptic and the estimates are summed.

Acoustic estimates of Division IIIa herring[1]

Age group	North Sea[2] August	Division IIIa August-September	Σ[3]	Division IIIa December
0	-	11,548	-	10,192
1	-	5,745	-	3,619
2	459	693	958	312
3	372	784	665	7
4	154	236	310	5
5	41	90	114	-
6	10	40	43	-
7	-	3	3	-
Total	1,036	18,839	2,093	14,135
Biomass (t)	134,137	527,525	252,459	311,000

[1] Numbers in millions.
[2] Separated based on meristic characters (see Section 3.1).
[3] Corrected for overlapping coverage.

The present estimate indicates a spawning stock defined as 2-group and older of 2.09 billion individuals or about 250,000 t and very high abundance of 0-group and 1-group herring in Division IIIa.

During the three latest years, the Norwegian November-December survey has covered both the eastern part of Division IVb and Division IIIa. The text table below compares the estimates of 0- and 1-ringers for those areas (all the estimates are referred to

TS = 20 log L - 71.2 dB). The proportion in Division IIIa is generally high. The summed estimate of the 0-ringers in 1987 is about 40% higher than in previous years.

Survey year	Division IVb (E of 2^0E)		Division IIIa		Sum	
	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

Numbers in millions.

3.4 Recruitment

3.4.1 General remarks on the 1988 IYFS survey

The 1988 IYFS survey was carried out in February without any problems with ice cover, and almost all standard stations were worked in the area. In total, 38 valid herring hauls were carried out. The bad weather influenced all stations in the eastern part of the Skagerrak, and the estimate might be too low.

3.4.2 Abundance of 1-group herring

Extremely large catches of 1-group herring were obtained in the Kattegat area, and large catches were also made along the Danish coast in the Skagerrak. The total index in 1988 was 67,753, which is more than 3 times higher than any previous index on record (1980-1988).

Division IIIa is known to be an important nursery area for both local spring spawners and autumn spawners from the North Sea.

Normally, both stocks occur mixed in the area, and attempts have been made to split the components by differences in length frequency. The modal length analysis used is described in Anon., (1984).

It has not been possible, however, to use this method for separation since 1984 when the growth of the North Sea herring started to decrease.

It is clear from the results of the 1988 survey that the decrease in growth has continued. The vertebral counts of the aggregated 1-group components per depth stratum show that all the 1-group herring could be assigned to the North Sea stock, as shown in the text table below:

Stratum (m)	Mean length (cm)	Mean VS
10-34	11.8	56.37
35-44	13.2	56.49
45-65	13.6	56.43
66-150	12.5	56.51

The total indices for the period 1980-1988 and indices for spring spawners and autumn spawners separately in 1980-1984 are given in the text table below:

	Index					
	Total		Spring spawners		Autumn-spawners	
Year	1-gr.	2-gr.	1-gr.	2-gr.	1-gr.	2-gr.
1980	2,311	387	1,607	307	704	80
1981	3,246	1,393	966	1,318	2,250	75
1982	2,560	549	1,408	445	1,152	104
1983	5,419	1,063	1,522	946	3,897	117
1984	6,035	1,947	2,793	1,419	3,242	528
1985	7,994	2,473	-[1]	1,867	-[1]	606
1986	21,489	2,738	-[1]	1,562	-[1]	1,176
1987	11,733	3,671	-[1]	2,921	-[1]	949
1988	67,753	10,095	-[1]	7.834	-[1]	2,161

[1] Separation not valid.

3.4.3 Abundance of 2-group herring

The 2-group herring index in 1988 was 10,095 which is more than 2.5 times higher than the 1987 index and the highest on record (1980-1988). The total index is a mixture of North Sea herring and Division IIIa/Baltic herring. In the case of 2-group herring, the modal length analysis method described above could still be used.

The split gave components with mean lengths in the range 16.0-21.6 cm and mean VS of 55.90-56.48. The mean length, proportion, and vertebral counts of each component found in the four strata are shown in the text table below:

Stratum (m)	Spring spawners			Autumn spawners		
	Mean length	Prop.	Mean VS	Mean length	Prop.	Mean VS
10-34	16.9	0.78	55.90	21.6	0.22	56.39
35-44	17.0	0.94	55.97			
	19.2	0.06	56.10			
45-65	17.4	0.89	56.07	21.3	0.11	56.32
66-150	16.0	0.10	55.95	21.4	0.58	56.41
	18.3	0.32	56.03			

The spring-spawner and autumn-spawner indices are totally dominated by the components that have a mean VS of 55.90-55.97 and 56.39-56.41, respectively. The estimated proportion of spring spawners in 1988 (about 78%) is very close to the long-term mean of 74%.

3.5 State of Stock and Management Considerations

3.5.1 General remarks

The assessment of the combined Division IIIa and Southwestern Baltic herring stock has, since 1985, been the task of the Working Group on Assessment of Pelagic Stocks in the Baltic. The results of the 1988 assessment, management considerations, predictions, and state of the stock will be given by that working group.

3.5.2 Exploitation of the adult stock

The migration pattern of the adult spring-spawning stock in Division IIIa - Southwestern Baltic has given rise to the result that the adult stock is at present exploited in three separate management units which represent two different assessment areas: the North Sea and Division IIIa - Southwestern Baltic inclusive. Inherent in the present management situation is the danger that the adult stock could be overfished within the advice given, since the catches in the North Sea are counted against the TAC for the much larger stock in this area.

The Working Group is aware of the problems involved in changing the present management regime, but an appropriate management of the Division IIIa stock can only be achieved when the catches of spring spawners in the eastern part of the North Sea are counted against the recommended TAC for this stock. The Working Group cannot at present give a firm recommendation of the appropriate time period and area, but as a precautionary step, the 1987 transfer area indicated in Figure 3.1.2 and the period indicated in Section 3.1 could be used.

3.5.3 Management of juvenile fisheries

The juvenile fisheries in Division IIIa are known to exploit mainly autumn spawners from the North Sea stock, and management of this problem is discussed in Section 2.10.3.

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 assessment and management, those areas have been have been combined since 1982. The area for which the assessment is now made together with the area for which the TAC is set by the EC is shown in Figure 4.1.1. It should be noted that, although the management unit covers all of Divisions VIIg,h,j,k and the southern part of Division VIIa, all of the catches in recent years have come from the southern part of Division VIIa and from Divisions VIIg,j.

4.2 The fishery in 1987-1988

4.2.1 Catch data

The total 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 total catch taken during 1987-1988 was 22,200 t, which was over 7,000 t higher than the previous season. The total catch included considerable quantities of herring which were caught in the northern part of Division VIIj, but misreported as having been taken in Division VIIb. However, the total catch does not include what are believed to be substantial quantities of fish which were caught but later "slipped" and discarded at sea. This practice arose because vessels were not allowed to land in excess of their nightly quotas.

Most of the catch from this fishery in recent years has been taken by Irish boats which fish the spawning concentrations along the Irish coast during the autumn and winter. Over 4,400 t (20% of the total catch) was placed in the "unallocated" category. The fishery, as in recent seasons, is almost completely dependent on the Japanese roe market. No revisions were made to the 1986 and 1986/1987 catch data.

4.2.2 Advice and management applicable to 1987

The TAC recommended for this area for the 1987/1988 season was 18,000 t. This figure was subsequently adopted by the EC for the calendar year 1987. The total landings for the year were 23,000 t, i.e., 28% above the agreed TAC. The overshooting of the TAC took place in spite of increased monitoring of the catches of the Irish fleet and the closure of the fishery on a number of occasions. In line with suggestions to protect the spawning stock made by the 1987 Working Group and subsequently endorsed by ACFM, the Irish fishery was completely closed from 7-31 November, 23

December - 4 January, and 24 January - 22 February. In addition to these closures during the spawning season, the entire Irish fishery remained closed during the period 1 April - 11 October, and all boats were required, as in recent years, to carry licenses. Boats fished throughout the season subject to nightly quotas determined by local management committees in accordance with market demands. Despite these precautions, however, it was disappointing to note the amount of fish which was taken in excess of the recommended level. The number of boats (54) fishing consistently throughout the season was about the same as in 1986/1987.

4.2.3 Catches in numbers at age

The total seasonal catches in numbers at age are shown in Table 4.2.3. These data are based entirely on Irish samples. Catches by France and the Netherlands were allocated age distributions according to Irish samples in the relevant period. No changes were made in the age distributions of the 1986/1987 catches.

The overall age distribution was dominated by the 2-winter-ring herring (i.e., 1984/1985 year class). This year class, together with the two preceding ones, constituted 84% of the total catch. Catches of 1-winter-ring (i.e., the 1985/1986 year class) only constituted 3.8% of the catch. In 1986/1987, catches of 1-winter-ring fish were also very low (2.8%), and this was taken as a possible indication of low recruitment. However, this year class appears to be quite strong in the present age distribution. In contrast to 1986/1987, there are relatively more old fish (>5-winter-rings) in the 1987/1988 catches.

The decrease which has taken place in the amount of 1-winter-ring fish in the catches during recent seasons did not arise because of any changes in fishing pattern, either in the timing of the fishery, the gear used, or in the fishing areas. There is evidence that a considerable decrease has occurred in the mean lengths of fish from this area (Molloy, working document), and this may have affected the recruitment mechanism whereby fish are recruiting at a later age. No allowances were made for the amounts of fish which were "slipped" and discarded at sea because it was not possible to quantify the amount.

4.3 Larval Surveys

The larval surveys, which were carried out in the area from 1978-1985, have not been resumed. The possibility of carrying out some surveys during 1988/1989 is discussed in Section 4.5.

4.4 Mean Weights At Age

As the major part of the catch is taken during the spawning period, the mean weights at age at spawning time (1 October) are taken to be the same as the mean weights at age of the catch.

The mean weights in 1987/1988 were generally lower than in 1986/1987 and are shown below.

Season	Winter rings								
	1	2	3	4	5	6	7	8	>8
1984/1985	104	152	189	201	230	250	254	262	264
1986/1987	112	155	172	187	215	248	236	284	332
1987/1988	96	138	186	192	204	231	255	267	283

4.5 Stock Assessment

Since the larval surveys in this area were discontinued in 1984/1985, there has been no independent method of monitoring changes in stock abundance. During the period of the larval surveys, the changes in larval indices were used to suggest the most likely trends in spawning stock biomass derived from different VPA runs, using various values of F. In the absence of survey data in 1986 and 1987, the VPA was tuned to produce a spawning stock biomass of 100,000-110,000 t in 1985 estimated by the last calibrated VPA and considered as the most realistic value for that year. This spawning stock level was considered to be the highest recorded since the late 1950s and was the result of a recovery of the stock following the closure of the Celtic Sea fishery from 1977-1982. In 1987, however, the Working Group pointed out that the VPA carried out in that year could not be considered as the basis for any analytical assessment because of the lack of any appropriate information to choose an input F. However, in May 1987, ACFM did, in fact, carry out a stock projection based on a spawning stock biomass calculated by the Working Group and assuming a catch in 1987/1988 of 18,000 t and a very low level of recruitment. The low level of recruitment was assumed because of the poor abundance of the 1-winter-ring fish in the catches during 1986/1987. The resultant spawning stock was calculated at 87,000 t.

The present Working Group concluded that, because of the absence of any survey data since 1984/1985 and the doubts about the amount of fish slipped in the 1987/1988 season, it was impossible to carry out any analytical assessment for this stock. A VPA to estimate the current stock situation was, therefore, not carried out and stock projections were not made.

It should, therefore, be pointed out that it will not be possible to do stock assessments and provide management advice for this area until up-to-date information about the stock size is obtained. The Working Group considered the type of data which would be required in order to resume assessment (Section 9).

In order to determine whether a relationship existed between the abundance indices obtained from the larval surveys carried out from 1978-1985, a VPA was run to obtain coverged values of spawning biomass for the relevant years. The resulting SSB and larval indices are shown in Table 4.5.1, and the relationship is shown in Figure 4.5.1. This would seem to indicate that useful information could be obtained from a resumption of the larval surveys.

It was concluded that:

1) Information about stock abundance could be obtained either from acoustic surveys carried out during the spawning season or from a resumption of the larval surveys. An examination of the results of the larval surveys carried out in 1984/1985 indicated that there are two main spawning times and that it might be possible to obtain useful information by examining the larval abundance immediately after each of the spawning peaks.

2) Accurate information is required about the catches from the area in relation to the level of discards and also misreporting of catches to other areas. Information about discards could be obtained by placing observers on board vessels during the spawning season, and information about the correct origin of catches could be obtained from the inspection of logbooks.

4.6 Stock Projection

As stated in the previous section, stock projections were not carried out for this stock due to lack of data.

4.7 Recruitment

The young fish surveys carried out in the Irish Sea have not provided any estimate of recruitment to the Celtic Sea stock. As has been pointed out in Section 4.2.3, catches of 1-winter-ring fish may not give a valid indication of recruitment because of changes that have occurred in the age of recruitment to the fishery.

4.8 Management Considerations

It is difficult to provide management advice because of the lack of knowledge about the present level of the stock. However, it is important to consider the following factors. When the stock was last assessed in 1985/1986, it was considered to be at about 100,000 t. The 1986 Working Group examined in detail long-term yields and safe biological limits. It was concluded that, at stock levels of about 100,000 t, catches of 15,000-20,000 t could be maintained under conditions of average recruitment. This level of catch was based on historical yield/biomass ratios and estimates of maximum sustainable yield. Catches in 1986/1987 were below the advised level, while catches during 1987/1988, excluding discards, exceeded the recommended level. Enforcement measures were introduced in 1987 which restricted fishing on the spawning grounds, in line with advice from the 1987 Working Group and ACFM.

The Working Group, therefore, would suggest that catches should be maintained at 15,000-20,000 t. Restrictions on fishing on the spawning grounds should be continued, and efforts should be made to prevent slipping and discarding of catches at sea. The quality of advice for this fishery cannot be improved until surveys are resumed.

5 WEST OF SCOTLAND HERRING

5.1 Division VIa (North)

5.1.1 The fishery

The catches reported for each country for this area are given in Table 5.1.1. The preliminary total catch reported for 1987 is 63,007 t, compared with a reported catch of 81,699 t in 1986. The reduction in catch is accounted for by a reduction in unallocated catches from 37,840 t in 1986 to 18,038 t in 1987.

5.1.2 Catch in numbers at age

The estimated numbers at age caught in Division VIa (North) in each of the years 1970-1987 are given in Table 5.1.2. For 1987, age composition data were available from Scotland, Norway, and the Netherlands. Landings by the Federal Republic of Germany and France were converted to numbers at age using the Norwegian and Dutch catch-at-age data, the Scottish data being excluded because of the high level of fishing activity in the Minch. Catches of 1-ringers in the Moray Firth were previously included in the catch in numbers for Division VIa (North), but, since 1985, these have been negligible.

5.1.3 Larval surveys

The survey coverage in 1987 was at an acceptable level. The complete standard areas were surveyed by Scotland and the Federal Republic of Germany in mid-September and by Scotland again in mid-October. The main concentration of small larvae was recorded west of Uist, off the Flannans, and off the north coast of Scotland in mid-September. Hatching is estimated to have taken place from late August - early October, with peaks in early September and around 1 October.

As last year, two sets of results from the surveys were available to the Working Group (Table 5.1.3). First, the larval abundance index (LAI) giving an index of the abundance of small larvae (<10 mm); secondly, the larvae production estimate (LPE) giving an index of the production of 8-mm larvae, based on back-calculation from the abundance of 8-16 mm, corrected for larval mortality using area-specific mortality rates, estimated from the surveys. Both sets of indices were calculated as in last year's Working Group report (Anon., 1987). The LPE was converted to estimates of SSB using the mean fecundity/kg as last year. No attempt was made to account for egg mortality. The LAI value for 1987 is the highest on record, while the LPE value is half the record high 1986 value and comparable to the 1985 value.

It should be noted that the use of the LPE index in this area seems to be problematic. This may be due to differences in larval transport between years. The dominant feature of the circulation in this area is a density-driven coastal current, flowing strongly up the west side of the Hebrides and eastwards along the Scottish north coast, being steered by the bottom topography (Heath et al., 1987).

The very high LPE value for 1986 may be caused by less transport of larvae out of the standard areas. Thus, the estimated mortality rate for 1986 (0.24) is the lowest observed and falls outside the mean minus 2 times the standard deviation for the years 1980-1987, excluding 1986 (0.42 - 2 x 0.08 = 0.26). Nevertheless, the mean mortality rate was applied to 1986 for the estimation of the LPE. This may be causing the high 1986 LPE value.

It might be reasonable to use area- and year-specific mortality rates. However, using the z/k ratio at face value gives far too variable LPE values. It is recommended that this problem should be considered in more detail.

5.1.4 Acoustic survey

An acoustic survey of Division VIa (North) was carried out by R/V "Scotia" during November 1987, repeating similar surveys in 1983, 1985, and 1986 (Hopkins, Working Document).

Mean target strength per fish was calculated using the relationship:

$$TS/fish = 20 \log L - 71.2 \text{ dB}$$

where L = length in cm.

Mean weight per fish (grammes) was calculated from the relationship:

$$W = 0.0235 \times L^{2.682}$$

determined at the time of the survey.

The results indicated a total population size of 383,000 t during the survey. The biomass of 2-ringers and older was estimated at 364,000 t. This is considerably higher than the 1986 survey estimate of 273,000 t of mature fish. However, coverage in 1986 was poor due to bad weather conditions during the survey, and, therefore, the 1986 figure is likely to be an underestimate.

The number of 1-ringed fish during the survey was estimated at 249 million. This must be considered a minimum estimate of the abundance of the 1985 year class, because the arrival of recruits from the North Sea may not have been complete at the time of the survey.

5.1.5 Recruitment

As in previous years, the catch rates of 2-ringers from Scottish bottom trawl surveys carried out in Division VIa (North) during March were used to provide an estimate of recruitment. Only data from hauls off the northern coast of Scotland (Statistical Rectangles 46E4-E6, 47E4-E6) and in the North Minch (Statistical Rectangles 44E3-E4, 45E3-E4) were used for the calculation. The abundance index for 2-ringers was calculated as follows:

i) catch rates were standardized to catch rates per hour,

ii) mean catch rates were calculated for each of the two sub-areas,

iii) the unweighted mean of the catch rates in the two sub-areas was used as the abundance index.

The results, along with the number of hauls used in the estimates, are shown in Table 5.1.4. For the 1988 survey, age composition was estimated using age/length data from the North Sea IYFS. The 1988 index is, therefore, preliminary.

The index for 1988 is the highest in the series and is comparable to that for the very strong 1981 year class. However, the indices are based on a small number of hauls each year and are highly variable, so they cannot be used to provide quantitative estimates of recruitment. The qualitative indication is that the 1985 year class is likely to be of at least average strength. This is supported by the acoustic survey estimate of 1-ringers in November 1987 in comparison with the estimates in earlier years (Table 5.1.4). For the purposes of projecting catches and stock sizes in 1989 and 1990, the likely level of recruitment of 2-ringers in 1988 and 1989 was assumed to be the geometric mean of the number of 2-ringers from the VPA over the years 1973-1985 (506 million).

5.1.6 Mean weight at age

Weight-at-age data from the 1987 fishery were available from Scotland, the Netherlands, and Norway and are shown in Table 5.1.5. The SOP for 1987 is 2.8% less than the reported catch.

Mean weights at age in the stock are as used in previous years (Table 5.1.5).

5.1.7 Spawning stock biomass and fishing mortality in 1987

Last year's assessment was based on SSB estimates derived by tuning the VPA to larval abundance indices (LAI). However, the LAIs have increased progressively since 1984 and are now well outside the previously observed range. Tuning the VPA to this series of LAIs could, therefore, be very misleading because of the extrapolation beyond the range of the converged SSB estimates. Since the coverage of the 1987 acoustic survey was reasonable, the SSB estimate from this survey of 364,000 t was considered to be the best available. This corresponds to a fishing mortality in 1987 of 0.17.

The resulting SSB estimates in each year are plotted against the LAIs in Figure 5.1.1. The trends in the LAIs are consistent with the VPA estimates of SSB up to and including 1986. It is not possible at this time to determine whether the point for 1987 is outlying because of inherent variability in the LAI or because the LAI for 1987 is outside the range of linearity with SSB.

Figure 5.1.2 shows the LPE values plotted against the VPA estimates of SSB. The scatter is greater than that for the LAI regression, with the 1986 point outlying. However, the 1987 point is consistent with the estimate of SSB from the VPA.

5.1.8 Results of the assessment

As a consequence of the high year-to-year variability in the catch of 1-ringers, which does not necessarily reflect year-class strength, converged VPA estimates of this age group could not be used as an indication of recruitment. This age group was, therefore, excluded from the analysis.

The catch-at-age data were examined using separable VPA. Using S values of 1 at ages 3 and 8, the analysis indicated a dip in the exploitation pattern at age 7, highlighting an apparent sampling or ageing problem in 1986 where the catches in numbers of 7- and 8-ringers are anomalous (Table 5.1.2). Downweighting years 1985/1986 and re-running the SVPA indicated an approximately flat exploitation pattern over the range of ages used (Table 5.1.6), but the matrix of residuals indicated that this is rather variable from year to year. The separable fishing mortalities were not, therefore, used to begin a VPA. Instead, a flat exploitation pattern for 2-ringers and older with F = 0.17 was used for 1987, and input Fs for the oldest ages were taken as the unweighted means over ages 3-6.

The results of the assessment are given in Tables 5.1.7 and 5.1.8 and in Figure 5.1.3. The SSB estimates and fishing mortalities are in good agreement with those obtained in previous years. The decrease in F in 1987 reflects the lower catch and continuing increase in stock size.

5.1.9 Projection

The projections were made on the assumption that the catch in 1988 will be the agreed TAC of approximately 50,000 t. The parameters used in the projections are given in Table 5.1.9, and the results are shown in Figure 5.1.3. $F_{0.1}$ was estimated to be 0.17, which is equivalent to the fishing mortality in 1987. F_{high} and F_{med} are unchanged from last year's assessment at 0.8 and 0.28, respectively (Figure 5.1.4). Selected management options are given in the text table below.

1988				1989					1990	
Stock biom. (2+)	SSB	F	Catch (2+)	Management option	Stock biom. (2+)	SSB	F	Catch	Stock biom. (2+)	SSB
445	365	0.14	50	$F_{0.1}$	443	357	0.17	58	433	349
				F_{med}		332	0.28	91	396	296

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 that fishing mortalities at around $F_{0.1}$ = F_{87} would result in a slight reduction in SSB by 1989. However, in the absence of any reliable indication of recruitment, the projections are consistant with a stabilization of stock size at an exploitation rate at around $F_{0.1}$. The detailed prediction assuming $F_{0.1}$ in 1989 is given in Table 5.1.10.

5.1.10 Management considerations

No convincing stock and recruitment relationship can be established for the Division VIa (North) herring stock, so considerations of this type cannot be used to identify safe biological limits in terms of spawning stock biomass.

Inspection of the historic fishing mortality data of the stable period prior to 1965 indicated that an F not exceeding 0.35 was sustainable (Anon., 1987). Fishing mortalities rose to around 1.0 following the peak catches corresponding with the introduction of purse seine fishing in the area in the early 1970s. Catches declined very rapidly thereafter and by 1978, the spawning stock had reached an all-time minimum of 70,000 t. At this point, the fishery was closed.

Since then, the stock has recovered rapidly and is now of comparable size to that in the early stable period prior to 1965. Present levels of exploitation are near $F_{0.1}$ and considerably less than F_{med}. The indications are, therefore, that continued fishing at or around $F_{0.1}$ is unlikely to exceed safe biological limits.

5.1.11 Research and data requirements

Catch and biological data for this stock are generally of a high quality and are well documented.

The larvae surveys have so far provided a good record of trends in stock size and should be continued. New fecundity data should be collected to improve the performance of the larvae production estimates.

The acoustic surveys in Division VIa (North) are providing useful estimates of stock size and recruitment and should be continued. The survey in 1988 will be carried out in December instead of

November, and this might improve the estimate of recruitment.

5.2 Clyde Herring

5.2.1 The fishery

The reported landings from the Firth of Clyde in 1987 were 2,895 t (Table 5.2.1) compared with a TAC of 3,500 t. Allowing for overweight boxes, the total landings were estimated to be 3,173 t. No quantitative information was available on discarding in 1987, and reports from the fishery indicate that it may have varied at different times during the season and between different parts of the fleet.

Monthly landings in numbers at age are given in Table 5.2.2, together with an estimated catch in number for the whole year assuming the percentage of each age discarded was the same as in 1986. On this assumption, the main age groups in the fishery in 1987 were 3-6-ringers. The catch of 2-ringers appears to have been at a low level, but it is not clear to what extent this age group may have been discarded.

The number of days absent from port by pair trawlers (850 days) was significantly lower than in any previous year in the period 1974-1986 (Table 5.2.3). In 1987, however, a higher proportion of the landings (352 t) was taken as a by-catch by vessels fishing for other species - mainly roundfish and Nephrops trawlers. The effort was thus raised by the ratio of total to pair trawl landings. The estimated effort in pair trawl units (998 days) nevertheless indicates a 27% decrease from 1986. This can at least partly be explained by low market prices in 1987.

5.2.2 Weight at age and stock composition

Monthly weights at age for 1987 are given in Table 5.2.4, with data for 1985 and 1986 for comparison. Although the data are for landings in 1987 and catch in the previous two years, there was clearly a major decrease in mean weight at age in 1987. This was primarily due to a change in condition factor, individual herring being up to 30% lighter than fish of equivalent length in previous years.

To examine this further, samples were collected by research vessel for meristic and maturity analysis in July 1987. Of the adult fish (2-ringers and older) sampled, 54% were still in maturity stage VIII, indicative of spring spawners that had not yet begun to mature. The vertebral counts (VS) are given below:

Sample	Maturity stage	Mean VS	Number sampled
1	III-IV	56.39	21
	VIII	57.10	21
2	III-IV	56.32	25
	VIII	56.92	24

These support the view that the herring in maturity stage VIII were local spring spawners with a high VS, while the maturing fish were immigrant autumn spawners. The proportion of fish at different maturity stages in the commercial landings is given in Table 5.2.5. If one assumes that stage VIII fish from May-July were spring spawners, an estimated 53% of the catch was of this type over this period. Similarly, the relatively high proportion of herring at stage III in August-September and stages III-IV in October-November indicates that spring spawners formed a rather high proportion of the total catch in 1987.

5.2.3 Acoustic surveys

Exploratory acoustic surveys were carried out in the Clyde in May-June 1985 and June 1986 and a more complete survey from 8-14 July 1987. Biomass estimates and estimates of numbers at age from the 1987 survey are given in Table 5.2.6. The estimated total biomass of 16,100 t may be an underestimate because of herring within 3 m of the sea bed not covered by the integrator.

The acoustic survey estimate was compared with that from the previous exploratory surveys and with VPA estimates tuned using effort data (Anon., 1987) in Table 5.2.7. The estimate of 2-ringers and older in 1987 of 8,700 t compares with the projected estimate from the most recent VPA of 19,800 t at 1 January. Even allowing for natural mortality and catches in the first half of the year and for lower mean weights at age in 1987, the estimate based on VPA was 14,500 t at 1 July 1987, i.e., 70% higher than the acoustic survey estimate. Previous acoustic surveys also gave lower estimates than VPA.

In making comparisons between acoustic survey and VPA estimates, it has to be borne in mind that the migrations of the various stock components that contribute to the exploitable population in the Clyde are not precisely known, and that they may vary from year to year. It is thus possible that the entire exploitable stock was not present in the Clyde in July 1987.

From analysis of maturity stages during the period of the 1987 survey, an estimated 54% of the 2-ringers and older were spent and, therefore, likely to be spring spawners. Comparable data from commercial landings in July 1987 indicate a lower percentage of spent fish (25%). From this, it seems likely that the biomass of local spring spawners present in the Clyde at the time of the survey lay in the range 2,200-4,700 t.

5.2.4 Stock assessment

A VPA on 2-ringers and older was tuned using pair trawl effort data. Separable VPA indicated rather constant selection on all age groups, and the separable mortalities on the oldest ages and in the last year were used as input F values. Values of F over the period 1974-1984 were correlated with effort (Figure 5.2.1). The F predicted in 1987 from a regression forced through the origin was 0.11. The separable VPA and VPA outputs are shown in Tables 5.2.8-5.2.11.

The results of the VPA tuned using effort data were very different from those obtained in the same way in 1987. They indicate a maturing stock in 1986 of 40,000 t compared with 17,000 t in the previous assessment, while F in 1986 is now estimated to be 0.11 compared with 0.24 in last year's assessment. This may indicate that the measure of fishing effort used (while being strongly correlated with estimated F in the past) is not giving a reliable index of fishing mortality rate.

The VPA estimate of population size in 1987 (30,000 t) and the acoustic estimate of the population present in the Clyde in July 1987 (8,700 t) are very different. While this might indicate that F in 1987 was considerably higher than estimated, it is also possible that a relatively small part of the population exploited in the Clyde was available to the fishery in 1987. Further light may be thrown on this after the July 1988 acoustic survey has been completed.

5.2.5 Recruitment

The VPA outputs in Table 5.2.11 indicate a low level of 2-ringer recruitment in 1987. This is, however, dependent on the assumed level of discarding which is generally highest on the younger age groups. A check on the relative proportion of 2-ringers in the Clyde in 1987 is provided by the results of the acoustic survey (Table 5.2.6). The relative proportion in the landings, estimated catches, VPA, and acoustic survey are given below:

2-ringers as percentage of 2-ringers and older

Category	Percentage
Landings	5.0
Estimated catch (assuming discard rate as in 1986)	7.9
VPA	9.0
Acoustic survey	29.6

This may indicate that the relative abundance of 2-ringers was underestimated by their proportion in the landings.

Recruitment of 2-ringers in 1988 was not shown by the level of 1-ringers in the landings in 1987 because the level of discarding of this age group was not known. Sampling in the acoustic survey, however, indicated rather large quantities of 1-ringers. The only sample of 1-ringers taken for meristic analysis had a mean length of 14.5 cm and a mean VS of 57.3, indicative of spring-spawned herring. This sample was taken in the inner reaches of the firth. In the outer firth, however, 1-ringers had a higher mean length (18 cm), but no meristic sampling was carried out.

The apparent high abundance of 1-ringers in 1987 might indicate good recruitment of 2-ringers in 1988. Since it is not yet clear, however, whether the acoustic survey provided a reliable prediction of recruitment, this needs to be re-evaluated when catch data and the acoustic survey results are available for 1988.

5.2.6 Management considerations

A number of features of the assessment of the Clyde herring population in 1987 makes a reliable forecast for 1988 and 1989 extremely difficult to make.

Using the same methodology as in 1987, there is a marked discrepancy between estimates of population size and fishing mortality rates in recent years. The results of the acoustic survey, moreover, give a rather different indication of the population size, but the results are difficult to evaluate because of the immigrant nature of the herring exploited in the Clyde. The lack of discard data in 1987 also reduces the reliability of the assessment and, in particular, makes it difficult to obtain indications of recruitment in either 1988 or 1989. Finally, it is not known whether the marked changes in condition factor (mean weight at age) will be perpetuated in 1988 and 1989. In view of all these difficulties, the Working Group suggests that only provisional advice be given for 1989 and that the advice be re-evaluated after the 1988 acoustic survey has taken place.

While no recent surveys have been carried out in the spawning area at Ballantrae Bank in the spring, there is no evidence of any significant recovery of the indigenous spring-spawning stock. Since the landings in 1987 appeared to contain a considerable proportion of spring spawners, management in the near future should be aimed at providing protection to this stock. If provisional advice is required for 1989, a stabilization at the level of recent catches would appear to be appropriate.

In addition, the Working Group reiterates the need to close the fishery during the pre-spawning and spawning period (January - mid-April inclusive).

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

6.1 The Fishery

6.1.1 Catch data

The catches by each country fishing in these areas from 1978-1986 and the preliminary catch for 1987 are shown in Table 6.1.1. No changes were found necessary to the catches reported as preliminary for 1986. The catch in 1987 increased from 28,700 t in 1986 to over 35,000 t in 1987. This was the highest recorded catch since 1975, when over 38,000 t were landed. Most of the allocated catch during 1987 was taken by Irish and Dutch fleets, while over 18,000 t (i.e., 53% of the total catch) was placed in the "unallocated" category.

The main catches by the Irish fleet, which came from along the Irish coast in the southern part of Division VIa and the northern part of Division VIIb, were fairly evenly distributed throughout the year. The catches from the Dutch fleet were mainly from the fourth quarter and were from offshore areas in both Division VIIb and Division VIa (South). As in recent years, the catches by the Irish fleet were restricted by marketing difficulties.

6.1.2 Advice and management applicable to 1987

The TAC recommended for this area for 1987 was 18,000 t, while the agreed TAC was in fact lower (17,000 t). The subsequent catch was 35,000 t. It should be pointed out that since Division VIa (South) and Divisions VIIb,c were combined in 1982 for assessment and management purposes, the total catch level in each subsequent year has been about double the recommended level.

6.1.3 Catches in numbers at age

The catches in numbers at age for this fishery are shown in Table 6.1.2. No changes were made in the 1986 data. The 1987 catch-at-age data were based on Irish and Dutch samples, and good coverage of the fishery was generally obtained.

The 1981 year class (5-winter-ring fish in 1987) still continued to dominate the catches throughout the year. It was very evenly distributed throughout the catches and overall constituted about 30% of the total number of fish landed. The 1983 year class constituted about 24% of the catches. This year class, which in 1987 was a strong one in the adjoining Division VIa (North) stock, increased in proportion throughout 1986 and, in that year, made up 18% of the total catches. One-winter-ring fish (1985 year class) constituted only 4% of the catch, but, as pointed out in the 1986 Working Group report, this age group is usually very poorly represented in this fishery.

6.2 Weight at Age

The mean weights at age were calculated from Irish and Dutch sampling data. The overall mean weights in the catch were considerably lower (17%) than in 1986 and reflect the increased catches which were made in the fourth quarter of the year. The mean weights at spawning time (1 October) were based on samples taken, as in previous years, in August and September. These mean weights were very similar to those obtained in 1986. The 1987 mean weights in the catches were used in the VPA for that year, while the mean weights in the stock at spawning time used for the predictions were based on the combined 1986 and 1987 data.

6.3 Larval Surveys

Larval surveys in this area were again carried out by Ireland in 1987. Scottish surveys of the southern part of Division VIa were discontinued in 1986. Three Irish surveys were carried out during 1987, and good coverage of the standard area was generally obtained. In line with some suggestions made by the 1987 Working Group, some additional stations were included to the north of the Irish coast and also in the southern part of Division VIIb. These northern stations were outside the standard area. The first survey (28 September - 4 October) indicated high concentrations of small larvae off the northwestern Irish coast. Medium-sized larvae found to the north of the Irish coast indicated that some spawning must have occurred before the survey commenced. The second survey (12-16 October) again indicated high concentrations of larvae off the northwestern Irish coast. Quantities of both small- and medium-sized larvae were found at the additional stations outside the standard area near the Scottish coast. The third survey (29 October - 5 November) indicated quantities of small larvae in the southern part of the standard area. Again, medium-sized larvae were found outside the standard area along the Scottish coast. Large larvae (>15 mm) were also found in this area during the third survey, but were generally scarce throughout the surveys. Some spawning undoubtedly took place after the surveys were completed as 25% of the fish sampled in Division VIa (South) during November-December were in stages V and VI.

The larval abundance indices (LAI) and the larval production estimates (LPE) are given in Table 6.3.1, together with estimates of fecundity and spawning stock biomass from the LPE. The LPEs were calculated using the same mean mortality rate (0.54) as last year. The LAI was underestimated because no survey was carried out in September and only half of the survey area was sampled in November and 28% of the index for the standard area was extrapolated.

6.4 Stock Assessment

The only fishery-independent method available to detect changes in stock size in this area is the larval surveys. As is shown in Table 6.3.1, these surveys indicate a sharp decline in stock size in 1984 and 1985 followed by a rapid increase in 1986. The results from the 1987 surveys show that the LPE is about the same as the 1986 value, while the LAI decreased by about a third. As explained in the previous paragraph, this value may be underestimated. The 1986 and 1987 Working Groups found extreme difficulty in matching the trend in spawning stock size indicated by the larval surveys with any trends in spawning stock sizes obtained from different VPA runs. The difficulties were mainly because the larval surveys indicated a halving of the spawning stock in 1984 and 1985 and a rapid increase in 1986. They also failed to show any increase which would have resulted from the recruitment of the very strong 1981 year class which boosted the stock when it first spawned in 1984. In spite of these difficulties, the 1986 and 1987 Working Groups tuned the VPAs to the larval surveys in both years. In order to do this in 1987, the Working Group had to ignore the high values obtained in that year and considered it unlikely to have indicated a realistic increase in stock size. This procedure by the 1986 and 1987 Working Groups meant that high input values of F = 0.4 and 0.6 had to be assumed. This gave a spawning stock in 1986 of only 50,000 t which was far lower than any recorded in the available time series. ACFM, in May 1987, expressed considerable doubts about this assessment and stated that it was difficult to reconcile the changes in stock size indicated by the larval surveys with those indicated by the catch data.

The present Working Group again examined the relationship between the larval survey results and the spawning stock biomasses estimated from different VPA runs. Again, there appears to be no relationship between the different sets of data, and it was not possible to select any input F value for 1987 which would give a sharp decline in stock in 1984 and 1985, followed by a rise in 1986 and 1987 as indicated by the larval surveys (Figure 6.4.1). The values of LAI and LPE obtained by the 1987 surveys support the 1986 values which were not considered realistic by the 1987 Working Group. In addition, in order to recreate the input F values used by the 1986 and 1987 Working Groups (0.4 and 0.6), would require an unrealistically high input F value in 1987 (F >2.0) and a subsequent stock size which would be below the likely catch level. It, therefore, appears that, at the moment, it is proving impossible to calibrate the survey results using the VPA.

The Working Group considered that the larval surveys are not giving a realistic estimate of spawning stock size for a number of possible reasons:

1) There is evidence that some important spawning areas are situated on the southern boundary of Division VIIj and Division VIIb (Molloy, Working Document), and, therefore, there may be an influx of herring into the area from Division VIIj.

2) The larval surveys have, in some years, missed part of the autumn-spawning production because of the timing of the surveys.

3) No account is taken of the existence of winter/spring-spawning herring in the area which can, in some years, make considerable contributions especially to the winter catches. The occurrence of this component was noted by the 1984 Working Group following a paper by Molloy (1983). It was suggested at that time that consideration should be given to carrying out additional larval surveys in this area in January and February.

Results from VPA

At its meeting in May 1987, ACFM noted some peculiarities in the exploitation pattern assumed for this stock in 1986 with respect to ages 2 and older (a flat-topped pattern). This could have influenced the inconsistency in the larval data. A separable VPA was, therefore, carried out on ages 2-8. A terminal F of 0.35 on age 3 and a terminal S of 1.0 were selected. F = 0.35 was selected because it represented the average F generated during the period 1973-1976 when catches exceeded 36,000 t per annum. The average catch in recent years (1983-1986) was 28,100 t. The results from the separable VPA are shown in Table 6.4.1. The exploitation pattern was flat-topped for 3-winter-ring fish and older, with 2-winter-ring fish being subjected to about half of the mortality on the older age groups.

An ordinary VPA was then carried out on fish of 2-winter rings and older, using input F = 0.35 and the exploitation pattern derived from the separable VPA. The results are shown in Tables 6.4.2 and 6.4.3. The spawning stocks now calculated are considerably higher for the recent years than those estimated by the 1986 and 1987 Working Groups. These now appear to have been unrealistically low because they were influenced by the low larval abundances in 1984 and 1985. The spawning stock remained very constant in the area from 1977-1983 and averaged about 112,000 t. In 1984, it was boosted to about 162,000 t by the recruitment of the very strong 1981 year class and subsequently declined to its present level of about 131,000 t. The trends in SSB indicated by this VPA since 1970 and the recent trends in the indices from the larval surveys are shown in Figure 6.4.2.

The highest levels of SSB recorded for this stock were those during the period 1970-1973 when the spawning stock averaged about 148,000 t. The values of F estimated from this VPA were very constant over the period 1977-1987, ranging from 0.23-0.40. If this VPA is correct, then the values of F calculated by the 1986 and 1987 Working Groups for input F values in those years of 0.4 and 0.6, respectively, were considerably overestimated. As has been pointed out in previous reports (Anon., 1984), one of the features of this stock is the low variation that occurs in the mortality rates. Recruitment of 2-winter-ring fish also appears to be very stable in this stock. The 1981 year class appears to be very strong and still dominates the age distributions, while the 1983 year class also appears to be reasonably abundant.

6.5 Recruitment

Irish trawl surveys have been carried out in this area since 1981. The results of these surveys were presented in a working document by Molloy, but so far, there appears to be very little relationship between the abundance indices obtained and the results from VPA. The 0-group indices from the trawl surveys did, however, pick up the strong 1981 year class and also the 1983 year class which appeared as reasonably abundant from the VPAs. The indices obtained from the surveys carried out in 1987 were the highest recorded for the 1-winter-ring fish (i.e., the 1985 year class) and were also quite high for the 0-group fish (1986 year class). The 1985 year class was also well represented in the Irish catches taken in the first quarter of 1988.

Previous Working Groups have used the geometric mean value of the abundance of either 1- or 2-winter-ring fish from the VPA as an estimate of recruitment for predictions. The 1987 Working Group calculated the geometric mean over the period 1980-1985, excluding the strong 1981 year class. The calculated mean was 171 million 2-winter-ring fish. A similar procedure this year over the period 1980-1986, again excluding the strong 1981 year class, gave a mean of 235 million fish. The mean calculated in 1987 included a very low value of 99 million fish for the 1982 year class, but the most recent value for this year class from the 1988 VPA indicates that it is about 200 million.

6.6 Stock and Catch Projections

Stock and catch projections were made using the stock at 1 January 1988 calculated from VPA. The level of recruitment for 1988-1990 was assumed to be 235 million 2-winter-ring fish. The predictions were based on two catch levels in 1988: a) the unlikely event of the 1988 TAC of 14,000 t being observed and b) catches at the same level as 1987 (about 35,000 t). The input parameters and the results of these predictions are shown in Tables 6.6.1 and 6.6.2 and Figure 6.6.1. Catches of 14,000 t in 1988 will generate an $F = 0.14$, which is below the level of $F_{0.1} = 0.169$. Catches of 35,000 t in 1988 will generate an $F = 0.39$, which is approximately the same as that assumed in 1987. The resultant spawning stocks in 1988 are 133,000 t and 112,000 t. On the assumption of catches in 1988 of about 35,000 t, predictions were made for three levels of fishing mortality in 1989: $F_{89} = F_{87}$, $F_{med} = 0.2$, and $F_{0.1} = 0.169$. Catches generated are 30,000 t, 17,000 t, and 15,000 t, respectively. Fishing at $F_{0.1}$ in 1989 will increase the spawning stock from 114,000 t to 121,000 t, while catches of about 30,000 t will reduce the spawning stock from 99,000 t to 90,000 t. Fishing at $F_{med} = 0.2$ in 1989 will generate catches of about 17,000 t and result in a spawning stock in that year at about the same level as that of 1987, i.e., 111,000 t. A continuation of fishing at this level will result in a slight increase in spawning stock to 116,000 t in 1990. It should be stressed that all these calculations depend on the validity of the stock estimates from VPA.

6.7 Management Considerations

As was pointed out in Section 6.4, this latest assessment of the stock in this area is considerably different from those carried out in 1986 and 1987. The levels of spawning stock biomass and fishing mortality calculated, however, seem to be much more in conformity with those evident over the time series available. A feature of this fishery noted in earlier Working Group reports was the stability of the stock, the fishing mortality, and also the general catch level. The Working Group would like to stress that, although the present assessment may not be considered a completely analytical one, more confidence is attached to it than to those carried out in 1986 and 1987. It must also be noted that the predictions are based on a conservative level of recruitment, although results for the young fish surveys indicate that the 1986 year class is a strong one.

The possibility of a continuous or sudden increase in fishing effort in this area does not appear likely because of more effective control of the TAC, the poor demand for herring at the moment, and because this fishery is not suitable for the Japanese roe market. In addition, the Irish fleet in 1988 will, for the first time, be restricted by a licensing system and individual boat quotas.

Fishing at $F_{0.1}$ = 0.169 generates catches of about 15,000 t in 1988, which would appear to be unnecessarily low. The spawning stock biomass/recruitment plot shown in Figure 6.7.1 indicates that F_{med} = 0.2 which is slightly lower than the level of 0.25 estimated from VPA for the years 1984-1986. It is suggested that consideration be given to regulating the catches at this level for 1989 and 1990, i.e., about 0.20 until a proper analytical assessment can be made. The detailed output from the prediction for this management option is shown in Table 6.6.3.

7 IRISH SEA HERRING (DIVISION VIIa)

7.1 The Fishery

7.1.1 The fishery in 1987

The catches reported by each country fishing in Division VIIa from 1978-1987 are given in Table 7.1.1. For 1987, the total catch of 5,823 t was in excess of the TAC of 4,500 t agreed by the EC and included 1,333 t (23%) unallocated to country. Discarding was probably quite high in June, but thereafter fell to a low level. Since this is impossible to quantify for the current or previous years, the catch figures were not adjusted.

Data were not available to split the catch into Manx and Mourne stock components, as was done prior to 1983, but based on the location of catches, it is unlikely that the fishery made a disproportionate impact on either stock. However, with the fishery extending well into September this year, catches from the Manx stock spawning grounds on Douglas Bank were higher than they have been for several years and amounted to more than 1,000 t.

7.1.2 Catches in number at age

The catches in numbers at age for the years 1972-1987 are given in Table 7.1.2. They were estimated from the age distribution of samples taken in Northern Ireland, the Republic of Ireland, and the Isle of Man, together with the quantities of herring landed. The 1984 year class (2-ring) was the dominant age group in the catch, while the 1983 and 1981 year classes were also well represented.

7.1.3 Advice and management applicable to 1987

While ACFM recommended a TAC of 4,300 t for 1987, the EC adopted a slightly higher figure of 4,500 t. The usual closed season on the spawning grounds from 21 September - 31 December and a prohibition of fishing in nursery areas were also in operation. The UK was allocated a quota of 3,300 t; of this, 300 t was set aside for the Mourne gillnet fishery, and a detailed management programme was introduced to control the uptake of the remainder of the allocation. This included the licensing of all vessels, controlling the dates of the opening and closing of the fishery, and the reporting and monitoring of all catches through a control vessel. For the first time in this fishery, the Northern Ireland

Producers' Organisation was given a sectional quota.

The Republic of Ireland was allocated a quota of 1,170 t and also introduced measures to control the fishery, including restricting herring fishing to the period 4 August - 7 September.

7.2 Mean Weight and Maturity at Age

Mean weights at age in the catch are given in the text table below. Weights at age have declined considerably over the last four years, and the values for 1987 were substantially below the long-term mean for this fishery.

	Age							
Year	1	2	3	4	5	6	7	8
1976-1983	0.074	0.155	0.195	0.219	0.232	0.251	0.258	0.278
1984	0.076	0.142	0.187	0.213	0.221	0.243	0.240	0.273
1985	0.087	0.125	0.157	0.186	0.202	0.209	0.222	0.258
1986	0.068	0.143	0.167	0.188	0.215	0.229	0.239	0.254
1987	0.058	0.130	0.160	0.175	0.194	0.210	0.218	0.229

Weights in kg.

Despite the change in mean weight at age, the maturity ogive was found to be the same as in previous years.

7.3 Stock Assessment

7.3.1 Estimation of fishing mortality rate

In the absence of data independent of the fishery, two methods were attempted in order to select an input F for the VPA. The first was based on effort data, as used for this fishery by the Working Group in previous years, while the second was a SHOT method (Anon., 1985; Shepherd, in prep.). However, because of the *status quo* assumption behind the SHOT method, the results of this analysis were not used for the assessment (Agnew, Working Document).

The effort data available were for trawler landings in Northern Ireland and the Isle of Man. The analysis used the method described in the 1987 Working Group report. This method attempts to determine the best fit to the relationship between $F_{(2-7,UK)}$ and UK effort for the period 1980-1986 inclusive for a range of input F values. The whole series of data available from 1972 was not used because of the major change in this fishery after 1980 (Anon., 1984). The effort data used in the analysis this year differed from that given in the 1987 report, in that catch and effort data for September 1980 and 1981 became available. These two years have a great impact on the regression of F on effort which explains the differences between the following analysis and that performed in 1987.

The analysis was performed using the UK proportion of F obtained from an iterated VPA run over a range of F values. The data for this analysis are given in Table 7.3.1. The input F_{87} value which corresponded most closely to the predicted F_{87} value was 0.38, while the maximum correlation coefficient and minimum sum of residuals squared from the last three years indicated an F_{87} of about 0.3, and this latter value was selected as the input F value for the VPA. It must be emphasized, however, that the correlation coefficients were high for a wide range of input F values, and the selection of an input F using the effort data is not very firmly based. For more reliable assessments in future years the Working Group strongly recommends that alternative data independent of the fishery are necessary for the Irish Sea.

7.3.2 Selection pattern

A series of separable VPAs was performed to investigate the selection pattern, the results of which are given in the text table below. It was not clear that the use of a selection pattern different from that generally assumed for this stock (0.08 on 1-year-olds and 1.0 on 2-year-olds and older) was indicated by this analysis. Thus, the selection pattern in the ensuing analyses was unchanged from previous years.

Separable VPA results (F = 0.30 at reference age)

Reference age	Terminal S	S at age 1	2	3	4	5	6	7
2	0.8	0.088	1.000	1.040	1.107	0.817	0.877	0.800
2	1.0	0.087	1.000	1.062	1.166	0.898	1.016	1.000
3	0.8	0.082	0.907	1.000	1.070	0.796	0.864	0.800
3	1.0	0.071	0.837	1.000	1.106	0.862	0.992	1.000

The results from separable VPA using F = 0.3 at age 2 and S = 1.0 at age 7 are given in Table 7.3.2

7.3.3 Results of VPA

A VPA was performed using input F_{87} = 0.30 and weight-at-age and catch-at-age data for the years 1972-1987. The natural mortalities used were the same as those used by the Working Group last year, as was the selection pattern.

The results of this VPA are shown in Tables 7.3.3 (fishing mortality) and 7.3.4 (stock size) and in Figure 7.3.1. They suggest that F_{86} was much higher than the value of 0.25 used in 1986 and that SSB has declined since 1985. The changes in the assessment from that performed in 1987 are explained by the higher mortalities used in the present assessment, which results from the use of the more complete effort data and the considerably lower weights at age observed in 1987.

The spawning stock biomass and recruitment data from the VPA are presented in Figure 7.3.2.

7.4 Recruitment

The results of the Irish young fish survey carried out in the spring off the Irish coast between Belfast and Dublin are given in the text table below, together with the corresponding number of Irish Sea recruits estimated from the VPA.

Year of survey	1980	1981	1982	1983	1984	1985	1986	1987	1988
Year class	1978	1979	1980	1981	1982	1983	1984	1985	1986
Index (fish/h)	121	725	1,078	474	409	723	923	975	563
VPA 1-ring (millions)	151	211	223	222	118	147	164	148	-

The VPA estimates of recruitment show very little correlation with the index, so the latter was not used to calculate recruitment for 1988. It is worth noting, however, that the index for 1988 recruits (1986 year class) is considerably less than those for the three preceding years.

According to the VPA, recruitment has been low and stable over the last four years. A mean of these years (144 million fish) was, therefore, used for predictions of future recruitment in 1988-1990.

7.5 Stock and Catch Projections

The results of yield-per-recruit and spawning stock biomass-per-recruit analyses are shown in Figure 7.3.1. There is no F_{max} and $F_{0.1}$ = 0.167. F_{high}, F_{med}, and F_{low} were calculated as detailed in the 1987 Working Group report (Anon., 1987) from the gradients of lines drawn on the stock-recruitment graph (Figure 7.3.2). These were found to be F_{high} = 0.78, F_{med} = 0.35, and F_{low} = 0.24.

Projections were performed for two levels of catch in 1988 using the input parameters given in Table 7.5.1. The first was that the catch would equal the TAC which has been set at 10,500 t. The second was that the fishery would operate at a similar level to the last two years and generate an F = 0.3. In each case, the projections were performed for two levels of fishing mortality in 1989: the *status quo* F (0.3) and $F_{0.1}$ (0.167). The management options associated with these projections are summarized in the text table below:

1988					1989				1990	
Stock biom.	SSB	F_{2-7}	Catch	Management option	Stock biom.	SSB	F_{2-7}	Catch	Stock biom.	SSB
Catch = TAC										
37	11	0.66	10.5	$F_{0.1}$	26	13	0.167	2.5	29	15
				F_{87}		11	0.300	4.3	27	12
Catch at status quo F = 0.3										
37	15	0.30	5.6	$F_{0.1}$	31	17	0.167	3.2	33	18
				F_{87}		15	0.300	5.5	31	15

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

Detailed outputs from the projection using F_{88} = 0.30 and F_{89} = 0.30 are given in Table 7.5.2.

7.6 Management Considerations

7.6.1 Catch limits

It must be stressed that the lack of data available for this fishery precludes a fully analytical assessment. The foregoing analysis is based on a best estimate of F_{87} and recruitment which have not been validated by independent means.

However, with the TAC for 1988 now set at more than twice that of 1987, it is appropriate to consider the implications of projections based on input levels of F derived from the amended effort data.

According to the management option table above, if the catch in 1988 equals the TAC, a continuation of the associated exploitation rate in 1989 will result in a considerable decrease in SSB. It is, therefore, likely that a considerable reduction in TAC will be needed in 1989 to ensure stock recovery.

However, to provide greater stability of catches and fishing mortality, some reduction in catch in 1988 would be necessary.

7.6.2 Spawning and nursey area closures

Since the collapse of the northern Irish Sea herring stocks in 1980, management of the fishery in this area has included closures to fishing of spawning and nursery areas. Given the present uncertainty about the state of the stock and with the increased TAC in 1988 likely to lead to a considerable increase in fishing on the spawning grounds, the Working Group considers that the closures applied by the EC to the 1987 fishery should continue.

8 ICELANDIC SPRING- AND SUMMER-SPAWNING HERRING

8.1 The Fishery

8.1.1 The fishery in 1987

No signs of recovery of the Icelandic spring-spawning herring were observed, and the fishery in 1987 was entirely (99.8%) based on Icelandic summer-spawning herring.

The landings of summer-spawning herring from 1969-1987 are given in Table 8.1.1. The 1987 landings amounted to about 73,000 t. In the last few years, the drift and setnet fishery has gradually decreased, and in 1987, all the herring were caught in the purse seine fishery which started on 8 October and finished by 17 December. Of the total catch of about 73,000 t, about 24,000 t went for reduction. In 1987, the fishery was entirely limited to the fjords at east Iceland. The text table below gives the landings and the TACs recommended during the last few years for this fishery:

Year	Landings	TACs	Recommended TACs
1984	50.3	50.0	50.0
1985	49.1	50.0	50.0
1986	65.5	65.0	65.0
1987	73.0	72.9	70.0

Weights in '000 t.

8.1.2 Catch in number and weight at age

The catches in numbers at age for the Icelandic summer spawners for the period 1969-1987 are given in Table 8.1.1. In the first years after the fishery was reopened in 1975, the 1971 year class was most abundant. During the period 1979-1982, the 1974 and 1975 year classes predominated in the catches. During the period 1983-1986, the fishery was dominated by the very strong 1979 year class. In 1987, the fishery was, on the other hand, based on a number of year classes ranging from 3- to 11-year-old herring. It is of interest to note that the older year classes, that is 6-ringers and older, are much better represented than in previous years. The weights at age for each year are given in Table 8.1.2. In 1987, the mean weights at age were close to the average weights for the period 1978-1985. Maturity at age is given in Table 8.1.3.

8.2 Acoustic Surveys

The Icelandic summer-spawning herring stock has been monitored by acoustic surveys annually since 1973. These surveys have been carried out in November-December or January after the fishery has been closed.

In November and December 1987 and in January 1988, two surveys were carried out for this purpose. The survey in November and

December was aimed at the 0- and 1-ringed herring in the fjords and shallow waters of west and north Iceland as well as at the recruiting year classes south of Iceland and the adult herring in the east coast fjords. The January survey was aimed at the adult concentrations at east Iceland. The results of this November-December survey form the basis for the present assessment of the stock. The results are given in Table 8.3.1. By January 1988, a considerable proportion of the adult herring had left the east coast fjords, and the results from the January survey could not be used for assessment purposes.

8.3 Stock Assessment

The results of the November-December acoustic survey together with the catch in numbers by age were used to calculate an exploitation pattern for the 1987 season. The results are given in Table 8.3.1. Usually it is considered that the Icelandic summer-spawning herring are fully recruited as 4-ringers. In 1987, it was clear, however, that the fishery was concentrated on the older component of the stock, that is 6-year-old and older herring which were concentrated in the east coast fjords. Large quantities of younger age groups were located off the southeast and southwest coasts of Iceland where no fishing took place.

Using this exploitation pattern, a series of VPAs was run using a range of terminal Fs. The best one-to-one relation between the eleven acoustic estimates and virtual population analysis was obtained with an input F of 0.36 (Figure 8.3.1). This is somewhat lower than using the latest survey results alone because that would give an input for the 6-year-old and older herring of 0.38.

Using the catch data given in Table 8.1.1 and the values of fishing mortalities given in the last column of Table 8.3.1, a VPA was run using a natural mortality rate of 0.1 on all age groups. Fishing mortality at age, stock in numbers at age, and spawning stock biomass on 1 July are given in Tables 8.3.2 and 8.3.3, respectively. In the assessments made in 1985 and 1986, fishing mortalities in the period 1978-1983 were higher than in the assessments made prior to 1983. In the present assessment, the mortalities during the above-mentioned period are much lower than in the 1985 and 1986 assessments and agree closely with those obtained prior to 1983. According to the present assessment, the spawning stock biomass increased from about 11,000 t in 1972 to about 230,000 t in 1980. Some decline occurred in 1981 and 1982, but owing to the strong 1979 and 1983 year classes, the spawning stock increased sharply in the most recent years (Figure 8.3.2) and was estimated to be about half a million t in 1987 and 1988. This is a higher level than was estimated for this stock before.

8.4 Catch and Stock Projections

Catches were calculated over a range of Fs for 1988 using the parameters given in Table 8.4.1. The stock-in-numbers data were derived from Table 8.3.3. Weights at age in the catch were obtained by using the relation:

$$W_{i+1} - W_i = -0.186W_i + 80.415 \text{ (g)}$$

where W_i and W_{i+1} are the mean weights of the same year class in years i and i+1, respectively, for the period 1978-1987. This relation was used to calculate the weight at age in the catch in 1988 for 1- to 8-ringed herring. For older herring, the mean weights at age from 1985-1987 were used.

Projections of spawning stock biomass and catches for a range of values of F are given in the text table below and in Figure 8.4.1.

1987		1988			1989
Catch	F_{4+}	SSB at 1 July	F_{4+}	Catch	SSB at 1 July
72	0.237	528	0.15	70	530
			0.22	100	500
			0.30	130	470

Weights in '000 t.

The details of one of the projections are given in Table 8.4.2.

During the period 1981-1984, the fishing mortality rate varied from 0.183 to 0.3 and averaged 0.226 or very close to the target level of fishing mortality for this stock of $F_{0.1}$ = 0.22. In 1985, fishing mortality appeared to have been below $F_{0.1}$, while in 1986, fishing mortality was somewhat higher. In 1987, the weighted average fishing mortality for 4-year-old and older herring was 0.237 which is very close to the $F_{0.1}$ level.

8.5 Management Considerations

The Working Group points out that the long-term optimum sustainable yield of this stock is considered to be about 75,000 t, but owing to the recent high level of recruitment, the yield can be increased during the coming 2-3 years. Exploiting this stock at the $F_{0.1}$ level in 1988 would thus result in a catch of about 100,000 t, which is an increase of 27% from 1987. The projection indicates that exploitation at the $F_{0.1}$ level in 1989 would result in a preliminary TAC of 95,000 t. An alternative management strategy would be to catch 90,000 t in 1988 and 100,000 t in 1989 and 1990. This would require a fishing mortality of 0.193, 0.224, and 0.246 in each of the years, respectively.

9 RESEARCH REQUIREMENTS

The Working Group reviewed the abundance indices available for each assessment. Four types of indices are in use: larval surveys [both larval abundance index (LAI) and larval production estimate (LPE)], acoustic estimates (of adult stock or of recruits), young fish surveys (YFS), and catch/effort data from the commercial fleet (CPUE) (Table 9.1).

Two assessments (North Sea and West of Scotland) have several fishery-independent indices. On the other hand, two assessments (Clyde and Irish Sea) have relied on commercial effort data, and one assessment (Celtic Sea) has no abundance index available. For these cases, an analytical assessment is difficult, if not impossible.

The Working Group summarized and discussed the application and performance of the various indices (Table 9.2). It recognized that stock status has changed markedly in the last few years (i.e., recovery of several stocks) and that there is a need to review the use of abundance indices.

Acoustic surveys are proving very valuable, particularly as stocks return to high abundance. These surveys have the advantage of providing estimates of absolute abundance and age composition. They are efficient in terms of data acquisition per unit survey time and are useful for several species simultaneously. The question of precision, mostly around target strength, remains unchanged.

Larval surveys provide two indices: LAI and LPE. Whereas these surveys were of primary importance in documenting recovery and in tuning VPAs in previous years, there are questions of the possible impact of density-dependent effects as stocks increase to higher levels. The Working Group noted that LAI and LPE have, in several cases, given conflicting indications and that some recent values are outside of the documented range of the established regressions. Larval surveys are very valuable for monitoring the relative importance of, and changes in, individual spawning units within the larger assessment area. Most stocks are still expanding, and the performance of larval indices in this situation is of interest.

Young fish surveys in conjunction with VPA have provided estimates of recruitment in some areas, and IKMT surveys of late larvae have given early indications of strong year classes.

The Working Group reiterated that commercial catch rates may not be a useful indicator of abundance because of changes in catchability.

The Working Group made the following specific observations and recommendations:

North Sea - While the summer acoustic surveys provide an estimate of the total North Sea herring stock size, larval surveys are valuable to monitor individual spawning unit performance. In the absence of acoustic data for the southern North Sea (since 1986), a continued larval survey is essential.

Celtic Sea - An assessment is not possible without an estimate of abundance and complete catch statistics. An acoustic survey of spawning aggregations and/or reinitiation of larval surveys are recommended.

West of Scotland - A more reliable recruitment index is needed. This may be achieved by conducting the acoustic survey in December rather than November.

Clyde - This assessment is hampered by the lack of a fishery-independent index and the problem of stock definition (i.e., degree of mixing with other areas). The egg bed survey and July acoustic survey initiated last year are designed to provide estimates of the size of the indigeneous stock and mixed stock, respectively.

West of Ireland - Results from larval surveys are inconsistent with trends in VPA in this assessment. It was noted that early spawning and a portion of the larval distribution were missed in recent larval surveys. Initiation of an acoustic survey is recommended.

Irish Sea - The effort series is unreliable, and an analytical assessment is not possible without some other abundance index. The Working Group recommends that an acoustic survey be initiated, and that previous larval survey data be examined to assess the potential value of such a survey.

Iceland - The acoustic surveys for both juveniles and adults have been very successful in providing, together with data from the fishery, the basis for the assessment of the stock. The continuation of these surveys is recommended.

10 REFERENCES

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11 WORKING DOCUMENTS

The following working documents were presented.

D.J. Agnew. Use of Shepherd's hang-over TAC method (SHOT) to estimate Irish Sea (Division VIIa) herring stock size.

P. Degnbol and E. Kirkegaard. Preliminary report on the Danish acoustic survey in the North Sea, August 1987.

M. Heath. Overwintering study of herring larvae.

P. Hopkins. Report of an acoustic survey in Division VIa (N) in November 1987.

J. Jakobsson. Icelandic spring- and summer-spawning herring.

J. Molloy. Young fish surveys on the west and northwest coasts of Ireland (Divs. VIa S and VIIb).

J. Molloy. Celtic Sea/VIIj. Density dependent growth.

J. Molloy. Irish herring larval surveys 1978-1987.

E.J. Simmonds and A. Aglen. Reports on acoustic herring surveys in IVa and IVb during summer 1987.

R. Stephenson. Two tables summarizing abundance indices used in ICES herring (south of 62^0N) assessments.

Table 1.4.1 Biological reference points and objectives of management advice on herring stocks in 1987.

Stock	Biological reference points			ACFM advice		
	F0.1	Fmed	F86	F option	F value	Objective
IVa,b	0.14	0.35	0.48	F_{med}	0.35	Rebuild and maintain SSB at 1.5-2.0 million t
IVc,VIId	No analytical assessment					
Celtic Sea	0.16	0.33	0.15	F_{SQ}	0.15	No increase in F
VIa (North)	0.17	0.28	0.26	$F_{0.1}$	0.17	Maintain SSB at current level
VIa Clyde	0.16	NA	0.24	F_{SQ}	0.24	F consistent with adjacent areas
VIa (South),VIIb,c	0.15	0.18	0.60	-	0.28-0.39	Reduce F to allow increase in SSB
VIIa	0.16	0.45	0.25	F_{SQ}	0.25	No increase in F
Va	0.22	NA	0.24	$F_{0.1}$	0.22	Manage at $F_{0.1}$

Table 2.1.1 HERRING. Catch in tonnes, 1978-1987, 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	1978	1979	1980	1981	1982
Belgium	-	-	-	-	9,700
Denmark	4,359	10,546	4,431	21,146	67,851
Faroe Islands	40	10	-	-	-
France	2,119	2,560	5,527	15,099	15,310
Germany, Fed.Rep.	24	10	147	2,300	349
Netherlands	18	-	509	7,700	22,300
Norway	1,189	3,617	2,165	70	680
Sweden	-	-	-	-	-
UK (England)	2,843	2,253	77	303	3,703
UK (Scotland)[2]	437	-	610	45	1,780
USSR	4	162	-	-	-
Total North Sea	11,033	19,158	13,466	46,663	122,056
Total including unallocated catches	-	-	60,994	140,972	235,925

Country	1983	1984	1985	1986	1987[1]
Belgium	5,969	5,080	3,482	414	39
Denmark	10,467	38,777	129,305[1]	121,631	138,596
Faroe Islands	-	-	-	623	2,228
France	16,353	20,320	14,400	9,729	7,266
Germany, Fed.Rep.	1,837	11,609	8,930	3,934	5,552
Netherlands	40,045	44,308	79,335[1]	85,998	115,450
Norway	32,512	98,714	161,279[1]	219,598	238,678
Sweden	284	886	2,442	1,872	1,725
UK (England)	111	1,689	5,564	1,404	873
UK (Scotland)[2]	17,260	31,393	55,795	77,459	76,413
USSR	-	-	-	-	-
Total North Sea	124,838	252,776	460,532	522,662	586,820
Total including unallocated catches	305,954	317,263	534,752	543,751	621,820

[1] Preliminary.
[2] Catches of juveniles from Moray Firth not included.

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	1985	1986	1987
Denmark	687	11,357	3,155	4,282	26,786	77,788	48,590	50,184
Faroe Islands	-	-	-	-	-	-	275	102
France	651	1,851	1,970	680	1,408	2,075	462	285
Germany, Fed.Rep.	-	-	-	1,542	12,092	4,790	2,510	3,250
Netherlands[2]	-	-	-	15,745	19,143	49,965	42,900	60,450
Norway	-	-	-	16,971	21,305	10,507	63,848	55,311
UK (Scotland)	18	2	1,706	16,136	24,634	52,100	71,285	66,774
Sweden	-	-	-	213	-[1]	-[1]	-[1]	768
Unallocated	1,762	6,492	300	3,955	24,030	4,249	-	-
Total	3,118	19,702	7,179	61,738	129,398	201,474	229,870	237,124

[1] Included in Division IVb.
[2] Netherlands catches include discard estimates.

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	1985	1986	1987
Denmark	-	-	491	-	126	-	4,540	7,101
Faroe Islands	-	-	-	-	-	-	-	2,126
France	-	-	-	-	-	-	-	159
Norway	21	70	680	-	49,125	111,307	115,068	143,256
Sweden	-	-	-	-	-	-	-	957
UK (Scotland)	-	-	-	257	74	-	-	-
Unallocated	2,476	937	-	431	-	-	-	-
Total	2,497	1,007	1,171	688	49,325	111,307	119,608	153,599

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	1985	1986	1987
Denmark	3,733	9,689	64,205	6,050	13,808	51,517	67,966	81,280
France	176	524	561	705	2,299	1,037	605	387
Faroe Islands	-	-	-	-	-	-	348	-
Germany, Fed.Rep.	147	2,300	118	-	2	4,139	1,424	2,302
Netherlands[4]	35	-	219	300	4,600	-[3]	21,101	17,200
Norway	1,607	-	-	14,156	25,820	39,465	40,682	40,111
UK (England)	76	13	3,128	40	1,956[1]	5,214	1,101[1]	329
UK (Scotland)	592	43	74	867	2,477	2,894	6,057	9,639
Sweden	-	-	-	71	884[2]	2,442[2]	1,872[2]	-
Unallocated	9,258	65,811	90,262	159,124	41,294	47,799	1,594	35,000
Total	15,624	78,380	158,567	181,313	93,140	154,507	142,750	186,248

[1] Includes catches misreported from Division IVc.
[2] Includes Division IVa catches.
[3] Included in Division IVa.
[4] Netherlands catches include discard estimates.

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	1985	1986	1987
Belgium	-	-	9,700	5,969	5,080	3,482	414	39
Denmark	11	100	-	135	53	-	535	31
France	4,700	12,724	12,799	14,968	16,613	11,288	8,662	6,435
Germany, Fed.Rep.	-	-	183	295	-	-	-	-
Netherlands	474	7,700	22,081	24,000	21,922	32,370	21,997[4]	37,800
Norway	482	-	-	1,385	-	-	-	-
UK (England)	1	290	602	71	571[1]	350	303[5]	544[6]
UK (Scotland)	-	-	-	-	-	799	117	-
Unallocated	37,418	21,069	23,307	17,606	1,788	21,595	19,495	-
Total	43,086	41,883	68,652	64,430	46,027	69,884[3]	51,523	44,849

[1] Includes 520 tonnes coastal spring-spawning herring.
[2] Includes 269 tonnes coastal spring-spawning herring.
[3] Includes 905 tonnes coastal spring-spawning herring.
[4] Includes 263 tonnes coastal spring-spawning herring.
[5] Includes 233 tonnes coastal spring spawning herring.
[6] Includes 250 tonnes coastal spring-spawning herring.

Table 2.1.6 North Sea HERRING, 1987, millions caught by year class, age group (winter rings), division, and quarter.

Division	Quarter	1986 0	1985 1	1984 2	1983 3	1982 4	1981 5	1980 6	1979 7	1978 8	<1977 9+	Total	0+1 ring
IVa	I	-	-	30.2	97.5	70.8	40.1	8.3	2.3	1.5	1.1	251.8	-
(W of 2^0E)	II	-	-	108.6	60.3	52.5	30.6	10.0	3.1	1.8	1.3	268.2	-
	III	-	20.5	268.5	109.2	84.3	61.7	16.6	8.8	1.7	3.2	574.5	20.5
	IV	-	148.1	283.4	52.9	29.3	14.4	2.9	2.0	0.9	0.1	534.0	148.1
	Total	-	168.6	690.7	319.9	236.9	146.8	37.8	16.2	5.9	5.7	1,628.5	168.6
IVa	I	-	8.4	5.7	52.6	54.8	31.9	6.4	2.1	0.6	0.8	163.3	8.4
(E of 2^0E)	II	-	20.2	77.7	31.8	33.1	15.8	6.1	1.9	0.5	0.3	187.4	20.2
	III	218.4	63.4	48.4	23.3	15.8	8.5	5.2	0.6	0.3	0.3	384.2	281.8
	IV	133.4	282.4	274.8	67.1	33.4	20.3	11.3	2.2	0.5	0.3	825.7	415.8
	Total	351.8	374.4	406.6	174.8	137.1	76.5	29.0	6.8	1.9	1.7	1,560.6	726.2
IVb	I	-	1,675.3	366.3	42.2	0.5	0.4	0.1	<0.1	<0.1	<0.1	2,085.2	1,675.3
	II	-	196.5	53.4	5.3	0.2	0.1	<0.1	<0.1	<0.1	<0.1	255.5	196.5
	III	237.2	217.0	95.4	41.5	9.9	6.8	2.1	0.4	<0.1	-	610.3	454.2
	IV	1,207.0	870.9	232.6	26.1	16.5	4.6	0.2	0.2	-	-	2,358.1	2,077.9
	Total	1,444.2	2,959.7	747.7	115.1	27.1	11.9	2.4	0.7	0.1	0.1	5,309.1	4,403.9
IVc + VIId	I	-	-	3.5	25.0	35.2	6.2	1.1	0.1	<0.1	-	71.1	-
	II	-	-	<0.1	0.7	2.8	0.9	0.2	0.1	-	-	4.7	-
	III	0.5	0.4	0.1	0.1	0.1	0.1	<0.1	<0.1	-	-	1.3	0.9
	IV	1.0	19.3	157.8	51.6	42.4	6.5	5.2	<0.1	<0.1	0.6	284.4	20.3
	Total	1.5	19.7	161.4	77.4	80.5	13.7	6.5	0.2	<0.1	0.6	361.5	21.2
Total North Sea		1,797.5	3,522.4	2,006.4	687.2	481.6	248.9	75.7	23.9	7.9	8.1	8,859.7	5,319.9

Catches made in the South Buchan Area of Division IVb are included in those for Division IVa (W of 2^0E).
Spring spawners transferred to Division IIIa not included.

Table 2.1.7 Millions of HERRING caught annually per age group (winter rings) in the North Sea, 1970-1987.

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

Table 2.1.8 Percentage age composition of North Sea HERRING (2-ring and older) in the catch in 1987.

Division	Quarter	2 (1984)	3 (1983)	Older	Total number (millions)
IVa (W of 2^0E)	I	12.0	38.7	49.3	251.8
	II	40.5	22.5	37.0	268.2
	III	48.5	19.7	31.8	554.0
	IV	73.4	13.7	12.9	385.9
	Total	47.3	21.9	30.8	1,459.9
IVa (E of 2^0E)	I	3.7	34.0	62.3	154.9
	II	46.5	19.0	34.5	167.2
	III	47.3	22.8	29.9	102.4
	IV	67.0	16.4	16.6	409.9
	Total	48.7	21.0	30.3	834.4
IVb	I	89.4	10.3	0.3	409.9
	II	90.5	9.0	0.5	59.0
	III	61.1	26.6	12.3	156.1
	IV	83.0	9.3	7.7	280.2
	Total	82.6	12.7	4.7	905.2
IVc + VIId	I	4.9	35.2	59.9	71.1
	II	-	14.9	85.1	4.7
	III	25.0	25.0	50.0	0.4
	IV	59.8	19.5	20.7	264.1
	Total	47.4	22.7	29.9	340.3
IVa + IVb	I	49.3	23.6	27.1	816.6
	II	48.5	19.7	31.8	494.4
	III	50.7	21.4	27.9	812.5
	IV	73.5	13.6	12.9	1,076.0
	Total	57.7	19.1	76.8	3,199.5
Total North Sea	I	45.7	24.5	29.8	887.7
	II	48.0	19.7	32.3	499.1
	III	50.7	21.4	27.9	812.9
	IV	70.8	14.8	14.4	1,340.1
	Total	56.7	19.4	23.9	3,539.8

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	1-ringers standard area	2-ringers total North Sea	VPA estimate 1-ringer (billions)
1974	452	-	1.00
1975	342	-	0.93
1976	575	-	1.50
1977	139	-	1.61
1978	535	-	3.40
1979	551	-	4.66
1980	1,293	106	8.11
1981	1,797	149	14.74
1982	2,663	712	13.35
1983	3,416	648	12.63
1984	3,667	853	(20.98)[2]
1985	5,717	(3,844)[1]	(31.71)[2]
1986	(4,178)[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

Table 2.3.3 Comparison of old and new series of IKMT indices. Old series is calculated from uncorrected numbers per haul; new series is calculated from numbers per haul x $\frac{\text{water depth}}{\text{tow duration}}$.

Year class	IKMT old index	IKMT new index	VPA 0-ringers (billions)
1976	1,237	1,658	4.48
1977	632	1,273	4.58
1978	2,460	5,061	10.10
1979	4,768	9,821	13.90
1980	3,423	7,455	34.09
1981	5,193	13,016	54.81
1982	3,904	9,818	51.72
1983	4,880	11,173	37.76
1984	5,829	17,617	59.06

Regression of old IKMT index on VPA: r^2 = 0.65
a = -5.38
b = 0.0099

Regression of new IKMT index on VPA: r^2 = 0.73
a = 0.33
b = 0.0036

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	73,710	32.5
1984	163,482	73,897	31.1
1985	250,805	104,189	29.4
1986	229,255	278,162	54.8
1987	446,615	285,269	39.0
1988	262,467	689,426	72.4

Table 2.3.5 Abundance indices of Downs recruits derived from English 0-group and Dutch larvae surveys.

Year class	IVc/VIId[1] VPA 2-ring (millions)	English 0-group (No./hr) July	Dutch larvae (No./m^3 (x 10^{-4}) April	Predicted[2] R2 (0-group)	Predicted[3] R2 (larvae)	Multiple[4] recruit 0-group/larvae
1975	87	26	11	150	131	-
1976	201	36	22	171	170	-
1977	247	65	57	217	243	-
1978	755	1,650	174	795	370	-
1979	484	157	796	309	654	-
1980	588	521	931	500	694	625
1981	579	1,596	609	784	592	788
1982	(935)	863	933	613	695	668
1983	(362)	33	1,697	165	870	374
1984	(476)	10,527	1,646	1,672	860	1,336
1985	-	3,580	2,435	1,085	996	1,204
1986	-	1,671	2,008	799	926	982

[1] Trial run using input VPA F = 0.65.
[2] Using Ln 2-ring/Ln 0-group (1975-1981) R = 0.903.
[3] Using Ln 2-ring/Ln Larvae (1975-1981) R = 0.877.
[4] Using Shepherd's multiple recruit survey program (RCRTINX2) (with tapered time weighting not applied and final estimates shrunk towards mean).

Table 2.4.1 Numbers (millions) per year class estimated in the approximate area north of 57°N for the years 1984-1987 and estimates of mortality (Z).

Year class	Survey year				Z_{84-85}	Z_{85-86}	Z_{86-87}
	1984	1985	1986	1987			
1985	-	-	-	2,425	-	-	-
1984	-	-	1,639	2,888	-	-	-
1983	-	726	2,156	501	-	-	1.46
1982	551	1,819	999	386	-	0.60	0.95
1981	1,718	836	310	258	0.72	0.99	0.18
1980	610	228	82	69	0.98	1.02	0.17
1979	264	81	19	34	1.18	1.44	-0.58
1978	82	29	7.5	11	1.05	0.34	0.38
1977	36	13	1.2	20	1.00	2.40	-1.61
1976	46	23	2.8	-	.68	2.72	-
1975	38	19	-	-	1.35	-	-
pre-1975	37	-	-	-	1.44	-	-
>2-ringers	2,830	3,048	3,577	4,137	-	-	-
>3-ringers	1,112	1,229	1,421	1,249	0.83	0.76	1.05

Table 2.4.2 Total North Sea estimates of numbers (millions) per year class estimated from acoustic surveys. For 1984-1986, the estimates are the sum of the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc,VIId winter survey. The 1987 estimates are from the summer survey in Divisions IVa,b (cf. Table 14 in the survey report: Working Document by Degnbol and Kirkegaard).

Year class	Survey year				Z_{84-85}	Z_{85-86}	Z_{86-87}	1/3 Z(84-87)
	1984	1985	1986	1987				
1985	-	-	-	13,736	-	-	-	-
1984	-	-	1,639	4,303	-	-	-	-
1983	-	726	3,206	955	-	-	1.21	-
1982	551	2,789	1,637	657	-	0.53	0.91	-
1981	3,194	1,433	833	368	0.80	0.54	0.82	0.72
1980	1,005	323	135	77	1.14	0.87	0.56	0.86
1979	394	113	36	38	1.25	1.14	-0.05	0.78
1978	158	41	24	11	1.35	0.54	0.78	0.89
1977	44	17	6	20	0.95	1.04	-0.36	0.72
1976	52	23	8	-	0.82	1.66	-	-
1975	39	19	-	-	1.44	-	-	-
pre-1975	41	-	-	-	-	-	-	-
>2-ringers	4,927	4,758	5,885	6,429	-	-	-	-
>3-ringers	1,733	1,969	2,679	2,126	0.92	0.57	1.02	-
SSB ('000 t)	807	697	942	817	-	-	-	-

Table 2.4.3 Comparison of acoustic estimates from "Eldjarn", June 1987 and "Dana", August 1987 in the area 2^0 - 7^0W and 54^0 - 60^0N. Numbers in millions.

Age w-r	Eldjarn - June	Dana - August	
		North Sea spawners	IIIa/Baltic spawners[1]
0	1,553	25,828	-
1	12,298	9,718	-
2	505	592	459
3	72	3	372
4	40	2	154
5	7	-	41
6	-	-	10

[1] Split based on vertebral counts.

Table 2.4.4 Age compositions of samples taken on NE coast acoustic survey CLIONE 11b/1987 (28 Aug - 5 Sep) Whitby - Flamborough survey.

Item	1 (1985)	2 (1984)	3 (1983)	4 (1982)	5 (1981)	6 (1980)	7 (1979)	8+ (<1979)	
$\bar{L}$ (cm)	21.0	24.9	26.6	28.4	29.8	30.8	31.2	32.8	
$\bar{W}$ (g)	60.6	124.1	154.9	192.2	224.6	252.7	263.0	308.7	
% no.	18.2	50.9	12.1	9.3	8.5	0.4	0.6	0.1	
% wt.	8.3	47.5	14.1	13.4	14.5	0.7	1.2	0.3	
Stage 4 and above maturity									
$\bar{L}$ (cm)	-	25.2	26.9	28.5	29.8	30.8	31.2	32.8	26.5 cm
$\bar{W}$ (g) (≡ Stage 5)	-	128.1	160.4	194.5	225.4	252.7	263.0	308.7	154.8 g
% no.	-	59.4	14.7	12.4	12.0	0.5	0.9	0.2	
% wt.	-	49.1	15.2	15.6	17.5	0.8	1.5	0.3	
1986 values of mean length, weight, and percentage number and weight (mature fish only)									
$\bar{L}$ (cm)	-	26.2	28.2	29.3	31.0	31.2	32.0	32.6	
$\bar{W}$ (g) (≡ Stage 5)	-	155.6	199.7	227.4	274.0	284.0	306.4	328.7	
% no.	-	51.3	15.6	28.0	2.8	0.7	0.9	0.7	
% wt.	-	42.4	16.5	33.7	4.0	1.1	1.5	1.0	
1986-1987 difference									
$\bar{L}$ (cm)	-	-1.0	-1.3	-0.8	-1.2	-0.4	-0.8	+0.2	
$\bar{W}$ (g)	-	-27.5	-39.3	-32.9	-48.6	-31.3	-43.4	-20.0	
% change wt.	-	-17.7	-19.7	-14.5	-17.7	-11.0	-14.2	-6.1	

Table 2.5.1 ICES International herring larvae surveys. Estimated mortality rates rates (z/k) per mm for the standard areas over the years 1980-1987. 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. The two bottom lines give mean and standard deviations of the estimates by area.

Year	Area							
	Orkney-Shetland		Buchan		Central North Sea		Divs. IVc + VIId	
	z/k	SE	z/k	SE	z/k	SE	z/k	SE
1980	-	-	-	-	-	-	0.33**	0.05**
1981	0.29	0.01	-	-	-	-	-	-
1982	0.25*	0.01*	-	-	0.40	0.02	0.80**	0.12**
1983	0.27*	0.01*	0.43	0.04	0.34	0.03	-	-
1984	0.20	0.02	0.42	0.01	-	-	0.54**	0.07**
1985	0.25*	0.01*	-	-	0.33*	0.02*	0.56**	0.03**
1986	0.28*	0.03*	0.27*	0.02*	-	-	0.48**	0.02**
1987	0.37*	0.02*	0.37*	0.02*	0.35*	0.01*	0.64**	0.03**
Mean	0.27		0.37		0.36		0.56	
Std. dev.	0.05		0.07		0.03		0.16	
Mean (1980-1986)	0.26		0.37		0.36		0.57	

Table 2.5.2 Larvae production estimates (LPE x 10^{11} larvae) calculated using area-specific natural mortality rates (z/k) compared to larvae abundance indices (LAI x 10^{9} larvae) from Saville and Rankine (1985).

Year	Orkney-Shetland		Buchan		Central North Sea		Divs. IVc + VIId	
	LPE	LAI	LPE	LAI	LPE	LAI	LPE	LAI
1972	147	5,779	-	7	25	112	18	171
1973	77	2,387	-	10	85	734	9	133
1974	58	1,284	-	379	48	(635)	1	25
1975	42	439	-	441	49	59	1	25
1976	16	655	-	1	11	76	1	18
1977	-	1,321	-	228	72	174	2	23
1978	88	3,705	-	363	78	462	3	111
1979	236	5,649	-	200	60	188	10	403
1980	256	3,982	-	18	111	214	114	1,193
1981	175	3,939	-	20	201	364	379	4,855
1982	263	3,795	92	1,002	80	338	177	3,709
1983	216	3,346	277	4,483	80	661	236	2,354
1984	166	3,538	433	4,296	560	1,055	161	2,267
1985	259	10,487	477	4,351	669	3,802	188	4,065
1986	173	5,500	831	3,780	485	2,027	321	4,780
1987	291	9,356	200	3,308	347	1,970	159	3,358

Table 2.5.3 The LPE index of SSB ('000 tonnes) estimated from larvae production estimates (LPE x 10^{11} larvae), and number of eggs (x 10^5) per kg SSB compared to LAI (x 10^9 larvae).

Year	Div. IVa (incl.Buchan)			Division IVb			Divs. IVa + IVb		Divs. IVc + VIId			North Sea	
	LPE	Eggs/kg	LPE/SSB	LPE	Eggs/kg	LPE/SSB	LPE/SSB	LAI	LPE	Eggs/kg	LPE/SSB	LPE/SSB	LAI
1972	147	(1.56)	94	25	(1.79)	14	108	6,234	18	0.94	19	127	6,405
1973	77	(1.56)	49	85	(1.79)	47	96	5,333	9	0.93	10	106	5,466
1974	58	(1.56)	37	48	(1.79)	27	64	4,203	1	0.87	1	65	4,228
1975	42	1.59	26	49	(1.79)	27	53	1,116	1	1.01	1	54	1,141
1976	16	1.52	11	11	(1.79)	6	17	960	1	0.74	1	18	978
1977	-	1.57	-	72	(1.79)	40	-	2,245	2	1.02	2	-	2,268
1978	88	1.57	56	78	(1.79)	44	100	5,916	3	1.18	3	103	6,027
1979	236	1.64	144	60	(1.79)	34	178	6,601	10	1.07	9	187	7,004
1980	256	1.69	151	111	(1.79)	62	213	4,856	114	1.14	100	313	6,049
1981	175	1.51	116	201	(1.79)	112	228	5,415	379	1.06	358	586	10,270
1982	355	1.60	222	80	(1.83)	44	266	6,149	177	1.11	159	425	9,858
1983	493	1.53	322	80	(1.82)	44	366	10,473	236	1.10	215	581	12,827
1984	599	1.67	359	560	1.67	335	694	12,054	161	1.04	155	849	14,321
1985	694	1.60	434	669	1.88	356	790	30,046	188	1.08	174	964	34,111
1986	1,004	(1.60)	628	485	(1.76)	276	904	17,388	321	(1.08)	297	1,201	22,168
1987	491	(1.60)	307	347	(1.76)	197	504	20,544	159	(1.08)	147	651	23,902

Table 2.7.1 North Sea HERRING 1987.
Mean weight (g) at age (w.r.) and year class weighted by numbers caught.

Division	Quarter	1986 0	1985 1	1984 2	1983 3	1982 4	1981 5	1980 6	1979 7	1978 8	1977< 9+
IVa	I	-	-	95	134	164	185	209	219	268	250
(W of 2^0E)	II	-	-	120	178	212	235	264	268	265	292
	III	-	62	143	196	233	258	283	291	322	349
	IV	-	72	111	152	173	207	221	240	261	271
	Total	-	71	124	167	200	228	257	270	281	315
IVa	I	-	14	80	136	158	182	209	245	279	267
(E of 2^0E)	II	-	21	109	141	161	190	214	237	278	283
	III	15	69	112	136	163	186	211	233	250	258
	IV	17	78	107	142	173	188	212	224	257	261
	Total	15	72	108	139	163	186	212	235	268	267
IVb	I	-	14	45	80	163	185	209	218	270	248
	II	-	14	64	106	146	174	191	171	214	214
	III	6	48	117	176	198	224	233	240	283	-
	IV	10	53	92	148	169	204	249	206	-	-
	Total	9	28	70	131	179	215	233	225	273	244
IVc + VIId	I	-	-	74	100	126	150	166	240	232	-
	II	-	-	82	109	136	157	171	184	-	-
	III	6	49	110	170	200	207	207	237	-	-
	IV	27	101	105	142	167	178	206	186	174	234
	Total	20	100	105	128	148	164	198	211	197	234
IVa	Total	15	72	118	157	186	214	237	260	278	304
IVa + IVb	Total	10	35	99	152	186	214	237	259	278	304
North Sea	Total	10	35	99	149	180	211	234	258	278	295

Table 2.7.2 Comparison between mean weights (g) at age (w.r) in catch of North Sea HERRING (adult) from earlier years and 1985-1987.

Age	IVa			IVb			IVa+IVb				IVc+VIId				Total North Sea			
	1985	1986	1987	1985	1986	1987	Pre-1985	1985	1986	1987	Pre-1985	1985	1986	1987	Pre-1985	1985	1986	1987
2	137	123	118	123	120	70	126	133	122	99	117	113	108	105	125	128	121	99
3	170	158	157	177	157	131	176	171	158	152	141	124	139	128	166	164	153	149
4	199	183	186	202	191	179	211	200	184	186	170	148	164	148	204	194	182	180
5	216	209	214	216	219	215	243	216	210	214	192	170	185	164	228	211	207	211
6	235	222	237	223	232	233	256	233	223	237	221	168	208	198	253	220	221	234
7	263	246	260	250	220	225	267	261	245	259	224	212	174	211	266	258	238	258
8	270	253	278	267	207	273	271	270	253	278	216	207	202	197	271	270	252	278
9+	293	263	304	291	237	244	271	293	263	304	208	193	232	234	270	292	262	295

Table 2.7.3 Mean weight at age, Sub-area IV, in third quarter catches and in the acoustic summer survey.

Year class	Age group (Winter rings)	Mean weights (g)		
		Acoustic (summer)		Catch (Q 3)
		Including immatures	Mature only	Including immatures
1984	2	105	136	133
1983	3	167	182	183
1982	4	220	220	220
1981	5	256	256	247
1980	6	281	281	263
1979	7	290	290	285
1978	8	305	305	310
1977<	9+	341	341	342

Table 2.7.4 North Sea herring. Percentages of 2- and 3-ringers mature in samples from the summer acoustic survey and commercial catches (maturities 3-6 in third quarter; 7-8 in fourth quarter).

Division	Summer acoustic survey (July)		Scottish catches		Norwegian catches 4th quarter	
			July	August		
	2	3	2	2	2	3
IVa W	55	98	82	94	80	99
IVa E	47	83	-	-	68	87
IVb W	87	100	100	100	-	-
IVb E	-	-	-	-	47	91
IVb (total)	80	97	-	-	-	-
Weighted means total North Sea	63	96	82	95	65	90

Table 2.8.1 Number at age in 1987 acoustic survey and in catches in first and second halves of year with estimates of F and exploitation pattern.

Age group	(No. in millions)			F			Exploitation pattern	S values (Separable VPA)
	Catch (Q I+II)	Acoustic survey (July)	Catch (Q III+IV)	I+II	III+IV	Annual		
1	1,900.0	13,736.0	1,620.0	0.10	0.16	0.26	0.36	0.34
2	639.2	4,322.3	1,360.3	0.13	0.38	0.51	0.70	0.76
3	312.2	948.8	371.5	0.26	0.47	0.73	1.00	1.00
4	247.5	687.0	231.4	0.30	0.41	0.71	0.97	0.96
5	124.2	391.9	122.8	0.27	0.38	0.65	0.89	0.81
6	31.9	84.3	43.3	0.31	0.72	1.03	1.41	0.83
7	9.4	42.9	14.2	0.19	0.40	0.59	0.81	0.96
8	4.4	12.2	3.5	0.30	0.34	0.64	0.88	1.00
9+	3.5	22.9	4.5	0.14	0.22	0.36	0.49	-
			$\bar{F}(3-8)$	0.27	0.45	0.73	1.00	

Table 2.8.2 NORTH SEA HERRING (FISHING AREA IV)
At 13.26.05 20 APRIL 1988
from 78 to 87 on ages 0 to 8
with Terminal F of .600 on age 3 and Terminal S of 1.000
Initial sum of squared residuals was 90.608 and
final sum of squared residuals is 42.430 after 85 iterations

Matrix of Residuals

Years	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87		WTS
Ages											
0/ 1	-.736	1.247	.295	.908	1.576	2.208	-.212	-1.244	-2.329	.000	.211
1/ 2	1.830	1.153	-.090	-.110	.595	.176	-.636	.063	-.201	.000	.402
2/ 3	-.607	-.374	.843	-.706	.187	.059	-.277	-.152	.183	.000	.646
3/ 4	-.694	-.782	.799	-.595	.508	-.337	-.213	.114	-.072	.000	.568
4/ 5	.683	-.428	.045	-.149	-.064	-.184	.064	.205	-.020	.000	1.000
5/ 6	.421	.446	.089	.505	-.563	-.077	.425	.092	.122	.000	.902
6/ 7	-1.256	-1.304	-1.869	.241	-.638	-.231	.006	.237	.630	.000	.361
7/ 8	-1.080	1.219	-1.273	.679	-.477	-.122	.405	-.277	.472	.000	.374
	.000	.000	.000	.000	.000	.000	.000	.000	.000	-.647	
WTS	.001	.001	.001	.001	1.000	1.000	1.000	1.000	1.000		

Fishing Mortalities (F)

	78	79	80	81	82	83	84	85	86	87
F-values	.1091	.1321	.2896	.4896	.2887	.3669	.4159	.5720	.5251	.6000

Selection-at-age (S)

	0	1	2	3	4	5	6	7	8
S-values	.2515	.3429	.7607	1.0000	.9574	.8076	.8260	.9559	1.0000
Smoothed S	.25	.34	.76	1.00	1.00	1.00	1.00	1.00	1.00

Table 2.8.3 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.

Age	Weight at age				Proportions of maturity					
	1947-1984	1985	1986	1987	1947-1955	1956-1971	1972-1984	1985	1986	1987
0	15	9	6	6	-	-	-	-	-	-
1	50	64	78	49	-	-	-	-	-	-
2	155	141	146	133	0.70	1.00	0.82	0.70	0.75	0.63
3	187	193	190	183	1.00	1.00	1.00	1.00	1.00	1.00
4	223	228	224	220	1.00	1.00	1.00	1.00	1.00	1.00
5	239	248	248	247	1.00	1.00	1.00	1.00	1.00	1.00
6	278	258	281	263	1.00	1.00	1.00	1.00	1.00	1.00
7	299	300	287	285	1.00	1.00	1.00	1.00	1.00	1.00
8	305	318	328	310	1.00	1.00	1.00	1.00	1.00	1.00
9+	312	316	364	342	1.00	1.00	1.00	1.00	1.00	1.00

Table 2.8.4 SUM OF PRODUCTS CHECK

NORTH SEA HERRING (FISHING AREA IV)
CATEGORY: TOTAL

CATCH IN NUMBERS UNIT: millions

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	195	1269	142	443	497	157	375	645	839	112	898	684
1	2393	336	2147	1262	2972	3209	1383	1674	2425	2503	1196	4379
2	1142	1889	270	2961	1548	2218	2570	1172	1795	1883	2003	1147
3	1967	480	797	177	2243	1325	741	1365	1494	296	884	663
4	166	1456	335	158	148	2039	450	372	621	133	125	208
5	168	124	1082	81	149	145	890	298	157	191	50	27
6	113	158	127	230	95	152	45	393	145	50	61	31
7	126	61	145	22	256	118	65	68	163	43	8	27
8	129	56	86	42	26	413	96	82	14	27	12	0
9+	142	88	87	51	58	78	236	173	92	25	12	12
TOTAL	6539	5917	5218	5427	7992	9854	6850	6241	7746	5264	5249	7177

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	750	289	996	264	238	257	130	542	792	7889	9557	10030
1	3341	2368	846	2461	127	144	169	159	161	447	840	1147
2	1441	1344	773	542	902	45	5	34	108	264	268	545
3	344	659	362	260	117	186	6	10	92	57	230	216
4	131	150	126	141	52	11	5	10	32	40	34	105
5	33	59	56	57	35	7	0	2	22	29	14	26
6	5	31	22	16	6	4	0	0	2	23	7	23
7	0	4	5	9	4	2	0	1	1	19	8	13
8	1	1	2	3	1	1	0	1	0	6	4	11
9+	0	1	1	1	0	0	0	0	0	1	1	12
TOTAL	6046	4907	3189	3753	1482	656	315	759	1211	8773	10963	12128

	1984	1985	1986	1987
0	2190	1293	704	1798
1	560	1620	1763	3522
2	976	1223	1155	2007
3	422	1173	827	687
4	193	366	458	482
5	78	124	128	249
6	22	43	61	76
7	24	20	20	24
8	11	13	13	8
9+	18	16	15	8
TOTAL	4492	5891	5145	8859

Table 2.8.5 VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)
FISHING MORTALITY COEFFICIENT UNIT: Year-1 VARIABLE NATURAL MORTALITY COEFFICIENT

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	.03	.02	.00	.01	.01	.01	.02	.03	.03	.01	.04	.03
1	.25	.13	.09	.12	.31	.25	.19	.30	.30	.33	.27	.60
2	.43	.61	.25	.30	.39	.77	.59	.42	1.33	.78	.97	.88
3	.32	.35	.62	.27	.41	.74	.70	.80	1.87	.91	1.26	1.21
4	.32	.39	.42	.22	.36	.77	.57	.91	1.07	.87	1.32	1.21
5	.26	.37	.49	.15	.30	.63	.82	.81	1.17	1.05	.87	1.06
6	.26	.37	.71	.16	.23	.49	.37	.98	1.12	1.53	1.08	2.43
7	.42	.19	.59	.23	.24	.44	.36	1.30	1.43	1.11	1.00	2.69
8	.30	.30	.40	.30	.40	.67	.69	.90	.90	.90	1.00	.00
9+	.30	.30	.40	.30	.40	.67	.69	.90	.90	.90	1.00	.00
(3-6)U	.29	.37	.56	.20	.33	.66	.61	.88	1.31	1.09	1.13	1.48
(4-7)U	.31	.33	.55	.19	.28	.59	.53	1.00	1.20	1.14	1.07	1.85

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.06	.05	.07	.14	.14	.09	.05	.09	.09	.44	.31	.35
1	.58	.67	.44	.68	.22	.27	.19	.17	.08	.16	.18	.13
2	.81	1.02	1.03	1.24	1.32	.19	.02	.09	.28	.30	.24	.29
3	.80	1.33	.96	1.50	1.17	1.34	.04	.06	.40	.25	.51	.33
4	.80	.99	.98	1.30	1.71	.27	.09	.08	.26	.28	.22	.43
5	.53	.94	1.18	1.79	1.27	1.14	.01	.05	.21	.35	.14	.24
6	.49	1.26	1.05	1.26	.89	.42	.07	.01	.06	.32	.12	.30
7	.08	.72	.61	1.82	1.42	.50	.03	.38	.06	.79	.15	.30
8	1.00	1.00	1.00	1.00	1.00	.80	.10	.10	.30	.30	.30	.30
9+	1.00	1.00	1.00	1.00	1.00	.80	.10	.10	.30	.30	.30	.30
(3-6)U	.65	1.13	1.04	1.46	1.26	.79	.05	.05	.23	.30	.25	.33
(4-7)U	.47	.98	.96	1.54	1.32	.58	.05	.13	.15	.44	.16	.32

	1984	1985	1986	1987
0	.10	.04	.01	.14
1	.07	.22	.14	.19
2	.27	.37	.44	.42
3	.40	.64	.48	.55
4	.51	.70	.53	.55
5	.58	.65	.50	.55
6	.28	.67	.69	.55
7	.53	.41	.68	.55
8	.38	.54	.47	.55
9+	.38	.54	.47	.55
(3-6)U	.45	.67	.55	.55
(4-7)U	.48	.61	.60	.55

Table 2.8.6 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

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
0	12211	109038	46365	47742	62789	34905	27868	40286	38705	21584	41093	32382
1	16517	4379	39375	16974	17306	22810	12750	10035	14446	13752	7875	14596
2	3718	4712	1418	13245	5517	4680	6561	3897	2740	3937	3641	2216
3	7963	1786	1895	820	7292	2773	1601	2689	1893	539	1333	1020
4	636	4752	1031	838	512	3957	1088	649	985	239	178	309
5	773	418	2920	615	608	323	1654	559	237	305	91	43
6	524	541	261	1618	480	409	155	656	224	66	96	35
7	382	367	339	116	1246	344	226	97	223	66	13	30
8	520	226	274	170	84	884	200	143	24	48	20	0
9+	574	354	276	206	183	168	495	304	161	44	20	0
TOTAL NO	43819	126573	94154	82345	96017	71253	52598	59315	59639	40581	54360	50631
SPS NO	10517	8671	5534	12414	10729	7308	6760	4993	2219	2526	2238	1559
TOT.BIOM	3998290	4517200	4509452	4702708	4873246	4406394	3336030	2840008	2544078	1915247	1927755	1847338
SPS BIOM	2111987	1802300	1217193	2255122	2101324	1509984	1299187	945204	436423	434313	380681	266093
BIOM 2+	2111987	1802300	1217193	2255122	2101324	1509984	1299187	945204	436423	434313	380681	266093

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	20864	10304	21776	3123	2910	4482	4583	10101	13897	34085	54810	51715
1	11516	7241	3623	7435	997	933	1501	1610	3403	4655	8107	14741
2	2942	2380	1358	858	1379	294	261	455	501	1159	1456	2500
3	679	968	639	360	185	273	180	189	308	279	633	850
4	248	250	210	201	66	47	59	142	146	170	177	313
5	84	101	84	71	50	11	32	48	119	102	116	129
6	14	44	36	23	11	13	3	29	42	87	65	92
7	3	8	11	11	6	4	8	3	26	36	57	52
8	2	2	3	6	2	1	2	7	2	22	15	44
9+	1	1	2	2	1	0	3	1	0	4	4	49
TOTAL NO	36352	21300	27742	12090	5606	6059	6632	12587	18444	40599	65441	70484
SPS NO	1697	1351	916	482	504	325	423	652	758	1153	1588	2481
TOT.BIOM	1552408	1162074	919568	692966	373889	228751	243572	392487	594874	1080936	1679888	2229436
SPS BIOM	289626	236016	164638	87608	84664	57924	78524	123041	148193	214470	292780	452411
BIOM 2+	328613	263529	180204	96155	97664	63832	84348	132823	157642	236041	321098	499499

	1984	1985	1986	1987	1988
0	37764	59060	87300	21519	0
1	13353	12628	20977	31707	6882
2	4763	4588	3720	6703	9646
3	1388	2697	2359	1776	3262
4	501	758	1159	1191	839
5	183	271	341	615	622
6	91	92	129	187	321
7	61	62	43	59	98
8	35	33	37	20	31
9+	59	40	41	20	21
TOTAL NO	58199	80230	116105	63795	
SPS NO	4221	4344	4333	5034	
TOT.BIOM	2460252	2812944	3570984	3391768	
SPS BIOM	741127	770098	805182	861993	
BIOM 2+	831907	894395	887909	1065598	

Table 2.8.7 Mean weight at age (g) in the stock at the time of spawning and proportions of maturity, Divisions IVa and IVb.

Age	Weight at age				Proportions of maturity				
	1964-1984	1985	1986	1987	1964-1971	1972-1984	1985	1986	1987
2	166	141	146	133	1.00	0.82	0.70	0.75	0.63
3	201	193	190	183	1.00	1.00	1.00	1.00	1.00
4	234	228	224	220	1.00	1.00	1.00	1.00	1.00
5	255	248	248	247	1.00	1.00	1.00	1.00	1.00
6	283	258	281	263	1.00	1.00	1.00	1.00	1.00
7	302	300	287	285	1.00	1.00	1.00	1.00	1.00
8	309	322	328	310	1.00	1.00	1.00	1.00	1.00
9+	315	316	364	342	1.00	1.00	1.00	1.00	1.00

Table 2.8.8 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN NORTH SEA (FISHING AREA IVA + IVB)
CATCH IN NUMBERS UNIT: millions

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
0	497	157	375	645	839	112	898	684	740	289	996	263
1	2950	3209	1380	1671	2419	2498	1192	4357	3336	2366	842	2436
2	1525	2192	2515	1129	1772	1721	1921	1016	1305	1301	749	415
3	2165	1264	731	1349	1474	288	800	621	315	544	342	220
4	148	2007	449	367	612	128	120	177	121	95	118	135
5	143	143	887	296	156	189	49	26	28	52	55	55
6	95	150	45	393	142	50	60	30	5	29	22	16
7	256	117	65	68	163	42	8	26	0	3	5	9
8	26	413	96	82	14	27	12	0	1	1	2	3
9+	58	78	236	173	92	25	12	12	0	1	1	1
TOTAL	7863	9730	6778	6172	7683	5079	5071	6949	5852	4681	3131	3554

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	238	257	130	542	792	7889	9553	10029	2187	1293	695	1796
1	104	143	168	159	138	440	820	1122	496	1607	1752	3503
2	807	38	2	13	9	42	67	293	776	909	1047	1845
3	76	183	2	1	8	16	9	111	291	1004	633	610
4	49	10	4	5	2	20	7	41	152	322	413	401
5	34	7	0	2	3	22	8	15	54	111	114	235
6	6	4	0	0	1	19	5	20	19	35	52	69
7	4	2	0	1	1	18	6	12	23	19	18	24
8	1	1	0	1	0	5	3	11	10	13	13	8
9+	0	0	0	0	0	1	1	12	17	16	14	7
TOTAL	1319	645	307	722	954	8472	10478	11666	4025	5329	4753	8498

Table 2.8.9 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN NORTH SEA (FISHING AREA IVA + IVB)
FISHING MORTALITY COEFFICIENT UNIT: Year-1 VARIABLE NATURAL MORTALITY COEFFICIENT

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
0	.01	.01	.02	.03	.04	.01	.04	.03	.06	.05	.07	.15
1	.31	.25	.19	.30	.33	.34	.30	.65	.58	.69	.53	.67
2	.39	.78	.59	.42	1.34	.79	.99	.91	.82	.98	1.05	1.18
3	.40	.71	.71	.81	1.89	.92	1.29	1.22	.89	1.14	.84	1.23
4	.36	.76	.57	.92	1.07	.86	1.31	1.16	.80	.72	.77	.93
5	.28	.62	.82	.81	1.24	1.06	.86	1.07	.49	.86	1.11	.94
6	.25	.47	.36	.97	1.08	1.92	1.07	2.48	.52	1.23	1.04	1.09
7	.27	.48	.33	1.24	1.38	1.03	5.94	2.54	.08	.65	.59	1.71
8	.80	.80	.80	.80	.80	.80	.80	.80	.80	1.00	1.00	1.00
9+	.80	.80	.80	.80	.80	.80	.80	.80	.80	1.00	1.00	1.00
(2-6)U	.34	.67	.61	.78	1.32	1.11	1.10	1.37	.70	.98	.96	1.07
(3-7)U	.31	.61	.56	.95	1.33	1.16	2.09	1.69	.56	.92	.87	1.18

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	.18	.15	.08	.21	.13	.52	.35	.43	.10	.04	.01	.14
1	.20	.38	.32	.31	.18	.23	.22	.14	.08	.24	.15	.19
2	1.05	.18	.01	.06	.04	.13	.08	.20	.24	.34	.45	.42
3	.76	.81	.01	.01	.05	.11	.04	.21	.33	.61	.45	.55
4	.98	.20	.03	.04	.02	.17	.06	.23	.46	.69	.51	.55
5	.55	.30	.01	.01	.03	.29	.08	.16	.49	.63	.49	.55
6	.20	.10	.01	.00	.01	.22	.08	.27	.27	.60	.61	.55
7	.90	.07	.01	.05	.03	.23	.09	.28	.52	.40	.64	.55
8	.80	.30	.01	.02	.03	.20	.05	.20	.35	.55	.50	.55
9+	.80	.30	.01	.02	.03	.20	.05	.20	.35	.55	.50	.55
(2-6)U	.71	.32	.01	.02	.03	.18	.07	.21	.36	.57	.50	.52
(3-7)U	.68	.29	.01	.02	.03	.20	.07	.23	.41	.59	.54	.55

Table 2.8.10 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN NORTH SEA (FISHING AREA IVA + IVB)
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

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
0	61984	34217	27473	37475	37314	19447	38801	32186	20391	8911	21818	2859
1	17090	22514	12496	9889	13412	13240	7089	13753	11444	7073	3111	7450
2	5395	4613	6452	3807	2689	3563	3457	1931	2652	2357	1299	675
3	7166	2702	1573	2655	1862	521	1192	953	578	867	657	337
4	512	3924	1083	635	971	231	171	268	230	194	228	233
5	615	323	1655	556	228	302	88	42	76	94	85	95
6	456	420	157	660	223	60	95	34	13	42	36	25
7	1134	323	239	99	226	68	8	29	3	7	11	12
8	50	783	181	155	26	52	22	0	2	2	3	6
9+	109	148	448	328	174	47	23	23	1	1	2	2
TOTAL NO	94511	69967	51758	56257	57125	37531	50946	49219	35389	19548	27250	11694
SPS NO	10368	7124	6640	4958	2187	2319	2078	1387	1496	1359	950	519
TOT.BIOM	5291846	5182862	3775832	3088184	2880605	2281665	1945200	2170807	1868881	1375513	935981	970729
SPS BIOM	2132066	1538047	1347278	1001071	457093	428314	377560	255844	272753	252814	184511	105206
2+ BIOM	2132066	1538047	1347278	1001071	457093	428314	377560	255844	310232	282735	200228	112707

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
0	2268	2951	2691	4363	10162	29357	50081	44153	34782	55026	86804	21501
1	901	698	938	915	1295	3282	6398	13019	10604	11534	19493	31529
2	1397	272	176	250	246	397	956	1885	4144	3614	3326	6164
3	154	361	169	128	174	175	259	651	1147	2409	1905	1576
4	81	59	132	136	104	135	128	204	433	677	1074	992
5	84	28	44	116	119	92	104	109	146	248	309	581
6	34	43	19	39	103	105	63	86	85	81	119	171
7	8	25	35	17	35	93	76	52	59	59	40	58
8	2	3	21	32	14	31	67	63	36	32	35	19
9+	1	0	32	5	4	6	22	70	60	39	38	18
TOTAL NO	4929	4439	4256	6001	12257	33675	58154	60294	51497	73719	113143	62609
SPS NO	669	477	524	590	658	761	1237	2075	3741	3739	3809	4541
TOT.BIOM	419667	251407	248810	282281	394327	814721	1412185	2214581	2431171	2484844	3276184	3217610
SPS BIOM	125407	98575	117573	131158	148717	169850	256222	410442	701716	671859	710177	775038
2+ BIOM	142254	104471	121829	137022	154571	178761	278308	450816	787804	771394	783771	962277

	1988
0	0
1	6876
2	9592
3	3000
4	744
5	518
6	303
7	89
8	30
9+	20

Table 2.8.11 HERRING in Divisions IVc and VIId. SSB indices.

Year	LAI (10^9)	LPE ('000 t)	Acoustic surveys ('000 t) Div.VIId Nov	Div.VIId Dec	Div.IVc Nov	Div.IVc Dec	Div.IVc Feb	Acoustic end of year	Divisions IVc + VIId catch ('000 t)
1972	171	19	-	-	-	-	-	-	23.0
1973	133	10	-	-	-	-	-	-	30.2
1974	25	1	-	-	-	-	-	-	7.4
1975	25	1	-	-	-	-	-	-	25.5
1976	18	1	-	-	-	-	-	-	17.5
1977	23	2	-	-	-	-	-	-	1.4
1978	111	3	-	-	-	-	-	-	-
1979	403	9	-	-	-	-	-	-	(5.0)
1980	1,193	100	-	-	-	-	-	-	43.1
1981	4,855	358	-	23	-	73	-	96	41.9
1982	3,709	159	-	-	-	-	143	146	68.7
1983	2,354	215	104	-	70	-	-	150	64.4
1984	2,267	155	111	-	36	-	-	133	46.0
1985	4,065	174	85	53	-	69	-	124	69.9
1986	4,780	297	101	-	-	-	-	127	51.5
1987	3,358	147	-	-	-	-	-	-	44.8

Table 2.8.12 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	0	4	4	6	6	4	22	5	2	4	24
2	22	26	55	42	23	162	82	131	135	43	24	127
3	79	61	10	15	20	9	84	42	29	115	20	40
4	1	33	1	5	10	5	5	31	9	55	8	5
5	6	2	3	2	2	2	2	1	5	7	1	2
6	0	2	0	0	3	0	1	0	0	2	0	0
7	0	1	0	0	1	0	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	0	0	0	0	0
TOTAL	129	124	73	69	64	184	178	227	184	226	58	198

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	22	1	0	0	23	7	21	25	14	13	11	20
2	94	6	3	22	99	223	201	252	173	314	108	161
3	42	3	4	9	84	40	221	105	117	169	194	77
4	4	1	1	6	30	19	27	65	33	44	46	81
5	1	0	0	1	18	7	7	11	23	12	14	14
6	0	0	0	0	2	3	2	3	2	8	9	7
7	0	0	0	0	1	1	2	1	1	1	2	0
8	0	0	0	0	0	0	1	1	0	0	0	0
9+	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	163	11	8	37	257	300	481	462	361	563	383	360

Table 2.8.13 Mean weight at age (g) in the stock at the time of spawning and proportion of maturity, Divisions IVc and VIId.

	Weight at age				Proportions of maturity
Age	1964-1984	1985	1986	1987	1964-1987
1	92	84	80	35	-
2	126	114	113	114	1.0
3	161	139	152	143	1.0
4	191	171	174	168	1.0
5	215	188	214	190	1.0
6	231	179	220	210	1.0
7	232	223	170	229	1.0
8	232	198	202	247	1.0
9+	232	223	232	263	1.0

Table 2.8.14 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	.19	.00	.02	.04	.01	.02	.01	.04	.03	.01	.01	.11
2	.12	.68	.82	.54	.67	.67	.69	.72	.60	.77	.35	1.16
3	1.01	.57	.68	.62	.56	.64	1.01	1.05	.37	2.18	1.21	1.99
4	.17	1.87	.02	.83	1.00	.27	1.03	1.44	.67	2.99	1.15	1.26
5	.90	.92	.88	.04	.58	.47	.11	.30	.85	1.78	.62	.72
6	.01	1.07	.01	.05	.06	.26	.42	.02	.01	.83	.08	.01
7	.01	.37	.01	.01	.43	.01	.09	.43	.00	.37	.17	.01
8	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
9+	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
(2-6)U	.44	1.02	.48	.41	.57	.46	.65	.71	.50	1.71	.68	1.03
(3-7)U	.42	.96	.32	.31	.53	.33	.53	.65	.38	1.63	.64	.80

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	.17	.01	.00	.00	.02	.01	.02	.02	.01	.02	.01	.08
2	2.11	.11	.04	.13	.61	.41	.64	.67	.42	.49	.42	.49
3	2.53	.37	.10	.17	1.18	.59	1.04	.93	.84	1.05	.68	.65
4	1.09	.26	.24	.19	1.33	.95	.95	.99	.84	.87	.89	.65
5	.31	.14	.00	.16	1.37	1.15	.97	1.30	1.07	.77	.64	.65
6	.22	.01	.01	.05	.77	.88	1.53	1.61	.77	1.52	3.02	.65
7	.01	.01	.01	.01	.37	.60	1.21	2.32	1.34	2.17	2.21	.65
8	.01	.01	.01	.01	.01	.01	1.37	1.97	.96	.97	.97	.65
9+	.01	.01	.01	.01	.01	.01	1.37	1.97	.96	.97	.97	.65
(2-6)U	1.25	.18	.08	.14	1.05	.80	1.03	1.10	.79	.94	1.13	.62
(3-7)U	.83	.16	.07	.12	1.00	.83	1.14	1.43	.97	1.28	1.49	.65

Table 2.8.15 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	192	303	323	151	1034	516	796	961	256	259	572	360
2	232	59	111	117	53	377	187	290	341	92	94	208
3	134	153	22	36	51	20	143	70	105	138	31	49
4	5	40	71	9	16	24	9	42	20	60	13	8
5	10	4	6	63	4	5	16	3	9	9	3	4
6	2	4	1	2	55	2	3	13	2	4	1	1
7	1	2	1	1	2	47	1	2	12	2	1	1
8	1	1	1	1	1	1	42	1	1	11	1	1
9+	1	3	1	1	1	2	11	32	1	1	1	1
TOTAL NO	579	568	537	382	1216	994	1207	1414	747	574	718	633
SPS NO	205	106	115	130	101	217	178	178	225	61	66	61
TOT.BIOM	73	71	63	51	127	116	138	156	93	75	74	71
SPS BIOM	28	17	20	23	19	34	31	28	33	10	9	9

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	224	238	548	672	2090	1326	1632	1613	2562	1004	1312	403
2	118	70	87	201	247	755	484	588	579	935	362	476
3	48	11	46	62	131	99	371	188	223	282	426	177
4	5	3	6	34	43	33	45	107	61	79	81	176
5	2	2	2	4	26	10	11	16	36	24	30	30
6	2	1	1	2	3	6	3	4	4	11	10	14
7	1	1	1	1	2	1	2	1	1	2	2	0
8	1	1	1	1	1	1	1	1	0	0	0	0
9+	1	1	1	1	1	1	0	0	1	0	1	1
TOTAL NO	403	328	694	979	2544	2233	2548	2517	3467	2337	2224	1278
SPS NO	21	60	107	207	152	435	316	325	398	550	398	397
TOT.BIOM	46	34	71	106	260	244	283	278	365	251	234	132
SPS BIOM	3	8	16	30	22	58	45	46	56	67	55	54

	1988
1	0
2	137
3	216
4	76
5	83
6	14
7	7
8	0
9+	1

Table 2.9.1
List of input variables for the ICES prediction program.

HERRING - TOTAL NORTH SEA
The reference F is the mean F for the age group range from 3 to 6

The number of recruits per year is as follows:

Year	Recruitment	(1-ringers)
1988	22140.0	IYFS as 1-ringers
1989	15100.0	] 1981-1984 mean
1990	15100.0	

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	22140.0	.34	1.00	.00	31.000	44.000
2	8000.0*	.76	.30	.63	99.000	133.000
3	3262.0	1.00	.20	1.00	150.000	185.000
4	839.0	1.00	.10	1.00	180.000	220.000
5	622.0	1.00	.10	1.00	211.000	247.000
6	321.0	1.00	.10	1.00	234.000	263.000
7	98.0	1.00	.10	1.00	258.000	285.000
8	31.0	1.00	.10	1.00	277.000	310.000
9+	21.0	1.00	.10	1.00	299.000	342.000

* IYFS and acoustic estimates of 1-ringers in 1987 projected to 1 January 1988.

Table 2.9.2

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

HERRING - TOTAL NORTH SEA (SSB as defined by the maturity ogive)

Year 1988					Year 1989					Year 1990	
factor	ref. F	stock biomass	sp.stock biomass	catch	mgt. opt.	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.4	.42	3109	1171	530	$F_{0.1}$	.13	3090	1685	206	3537	2152
					F_{max}	.30		1512	451	3184	1673
						.35		1466	514	3093	1559
					F_{88}	.42		1404	599	2970	1409
					F_{87}	.55		1294	745	2759	1170

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 1990 has been calculated with the same fishing mortality as for 1989.
The reference F is the mean F for the age group range from 3 to 6.

Table 2.9.3

Effects of different levels of fishing mortality on catch, stock biomass and 2+ stock biomass.

HERRING - TOTAL NORTH SEA (SSB defined as the 2+ stock)

Year 1988					Year 1989					Year 1990	
factor	ref. F	stock biomass	2+ stock biomass	catch	mgt. opt.	ref. F	stock biomass	2+ stock biomass	catch	stock biomass	2+ stock biomass
.4	.42	3109	1431	530	$F_{0.1}$	.13	3090	1951	206	3537	2352
					F_{max}	.30		1757	451	3184	1849
						.35		1704	514	3093	1725
					F_{88}	.42		1633	599	2970	1566
					F_{87}	.55		1509	745	2759	1311

The data unit of the biomass and the catch is 1000 tonnes.
The 2+ stock biomass is given for the time of spawning.
The 2+ stock biomass for 1990 has been calculated with the same fishing mortality as for 1989.
The reference F is the mean F for the age group range from 3 to 6.

Table 2.9.4 HERRING - TOTAL NORTH SEA

```
*******************************************************
* Year 1988. F-factor    .420 and reference F    .4198 *
*------------------------------------------------------*
* Run depending on a TAC value                          *
*******************************************************
```

						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	.1427	1883.31	58382	22140.0	974160	.0	0	.00	0
2	.3190	1902.93	188389	8000.0	1064000	5040.0	670320	3328.93	442747
3	.4198	1020.60	153090	3262.0	603470	3262.0	603470	2153.48	398393
4	.4198	274.66	49439	839.0	184580	839.0	184580	592.26	130298
5	.4198	203.62	42964	622.0	153634	622.0	153634	439.08	108452
6	.4198	105.09	24589	321.0	84423	321.0	84423	226.60	59595
7	.4198	32.08	8277	98.0	27930	98.0	27930	69.18	19716
8	.4198	10.15	2811	31.0	9610	31.0	9610	21.88	6783
9+	.4198	6.87	2055	21.0	7182	21.0	7182	14.82	5069
Total		5439.32	530000	35334.0	3108989	10234.0	1741149	6846.24	1171057

```
*******************************************************
* Year 1989. F-factor    .350 and reference F    .3500 *
*******************************************************
```

						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	.1190	1081.34	33521	15100.0	664400	.0	0	.00	0
2	.2660	1434.35	142000	7061.5	939180	4448.7	591683	3044.70	404945
3	.3500	1159.69	173953	4307.7	796924	4307.7	796924	2979.94	551289
4	.3500	494.68	89042	1755.1	386132	1755.1	386132	1298.30	285625
5	.3500	140.61	29669	498.9	123230	498.9	123230	369.05	91154
6	.3500	104.25	24393	369.9	97276	369.9	97276	273.60	71955
7	.3500	53.80	13880	190.9	54401	190.9	54401	141.20	40241
8	.3500	16.42	4549	58.3	18065	58.3	18065	43.11	13363
9+	.3500	8.72	2605	30.9	10575	30.9	10575	22.87	7822
Total		4493.86	513617	29373.2	3090186	11660.5	2078289	8172.76	1466397

```
*******************************************************
* Year 1990. F-factor    .350 and reference F    .3500 *
*******************************************************
```

						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	.1190	1081.34	33521	15100.0	664400	.0	0	.00	0
2	.2660	1001.75	99173	4931.8	655923	3107.0	413231	2126.42	282813
3	.3500	1079.40	161910	4009.5	741751	4009.5	741751	2773.63	513122
4	.3500	700.48	126085	2485.3	546771	2485.3	546771	1838.42	404451
5	.3500	315.42	66554	1119.1	276425	1119.1	276425	827.83	204474
6	.3500	89.66	20980	318.1	83665	318.1	83665	235.31	61887
7	.3500	66.47	17149	235.8	67214	235.8	67214	174.45	49719
8	.3500	34.30	9502	121.7	37730	121.7	37730	90.03	27909
9+	.3500	16.03	4792	56.9	19451	56.9	19451	42.07	14388
Total		4384.86	539670	28378.2	3093334	11453.5	2186242	8108.17	1558766

Table 2.11.1 HERRING Total North Sea 1987.
Numbers at age (millions) and weight at age (g) caught in each quarter year (excluding spring-spawner transfers to Division IIIa).

Quarter		1986 0	1985 1	1984 2	1983 3	1982 4	1981 5	1980 6	1979 6	1978 8	1977< 9+	Total	SOP ('000 t)
I	No.	-	1,683.7	405.7	217.3	161.3	78.6	15.9	4.5	2.1	1.9	2,571.0	114.2
	w	-	14	49	120	154	181	206	232	271	257		
II	No.		216.7	239.7	98.1	88.6	47.4	16.3	5.1	2.3	1.6	715.8	77.5
	w	-	15	104	162	190	218	244	255	268	290		
		-											
III	No.	456.1	301.3	412.4	174.1	110.1	77.1	23.9	9.8	2.0	3.5	1,570.3	161.6
	w	10	53	133	183	220	247	263	285	311	341		
IV	No.	1,341.4	1,320.7	946.6	197.7	121.6	45.8	19.6	4.5	1.5	1.1	4,002.5	258.2
	w	11	61	104	145	170	194	212	225	260	246		
Total	No.	1,797.5	3,522.4	2,006.4	687.2	481.6	248.9	75.7	23.9	7.9	8.1	8,859.6	611.5
	w	10	35	99	149	180	211	234	258	278	295		

Table 3.1.1 Catch in number (millions) and mean weight (g) at age of herring in Divisions IVa,b in 1987 which were transferred to the Division IIIa/Sub-divisions 22-24 herring stock.

Age	Quarter 2		Quarter 3		Grand total
	N	W	N	W	
2	20.8	83	14.7	102	35.5
3	18.1	122	16.9	126	35.0
4	14.7	150	10.3	143	25.0
5	4.8	181	4.1	171	8.9
6	1.9	196	0.9	191	2.8
7	0.5	237	0.2	164	0.7
8	0.1	278	+	-	0.1
9	0.1	283	+	-	0.1
Tonnes (SOP)	8,068		6,139		14,207

Table 3.2.1 HERRING in Division IIIa. Landings in tonnes, 1978-1987.(Data mainly provided by Working Group Members).

Country	1978	1979	1980	1981	1982
Skagerrak					
Denmark	7,753	8,729	22,811	45,525	43,328
Faroe Islands	1,041	817	526	900	715
Germany, Fed.Rep.	28	181	-	199	43
Norway (Open sea)	1,860	2,460	1,350	6,330	10,140
Norway (Fjords)	2,271	2,259	2,795	900	1,560
Sweden	11,551	8,140	10,701	30,274	24,859
Total	24,504	22,586	38,183	83,768	80,645
Kattegat					
Denmark	29,241	21,337	25,380	48,922	38,609
Sweden	35,193	25,272	18,260	38.871	38,892
Total	64,434	46,609	43,640	87,833	77,501
Division IIIa total	88,938	69,195	81,823	171,601	158,146

Country	1983	1984	1985	1986	1987[1]
Skagerrak					
Denmark	54,102	64,621	88,192	94,022	105,017
Faroe Islands	1,980	891	455	520	-
Germany, Fed.Rep.	40	-	-	11	-
Norway (Open sea)	500	-	2,752	677	-
Norway (Fjords)	2,834	1,494	1,673	860	1,209
Sweden	35,176	59,195	40,349	42,996	51,184
Total	94,632	126,201	133,421	139,086	157,410
Kattegat					
Denmark	62,901	71,359	69,235	41,669	46,706
Sweden	40,463	35,027	39,829	35,852	29,844
Total	103,364	106,386	109,064	77,521	76,550
Division IIIa total	197,996	232,587	242,485	216,607	233,960

[1] Preliminary.

Table 3.2.2 Herring. Division IIIa. Catch in numbers at age, mean weights, SOP, and catch by quarters and areas in 1987.

Age	Quarter I		Quarter II		Quarter III		Quarter IV		Total	
	N	W	N	W	N	W	N	W	N	W
Skagerrak										
0	-	-	-	-	1,661.2	8.4	932.1	10.6	2,593.3	9.19
1	258.9	16.4	301.4	21.7	889.8	51.0	491.2	61.4	1,941.3	44.47
2	144.5	60.6	152.1	63.4	137.5	70.9	67.4	75.1	501.5	66.22
3	19.1	61.1	38.0	73.1	25.9	92.5	5.9	101.9	88.9	78.09
4	1.9	88.0	12.9	85.6	9.4	89.6	4.4	95.2	28.6	88.55
5	0.4	173.3	1.9	115.8	3.9	166.9	0.3	178.7	6.5	152.90
6	0.1	173.5	0.9	128.5	1.1	182.0	1.0	124.0	3.1	147.48
7	0.1	206.8	+	165.9	0.2	217.0	+	-	0.3	179.53
Total	425.0	-	507.2	-	2,729.0	-	1,502.3	-	5,163.5	-
SOP	14,436		20,423		73,238		46,304		154,351	
Catch	14,774		20,389		74,299		47,948		157,410	
Kattegat										
0	-	-	8.9	5.0	2,415.3	5.8	1,220.5	9.9	3,644.7	7.17
1	848.1	12.5	315.8	14.5	201.5	26.0	196.4	36.5	1,561.8	17.66
2	109.1	39.4	119.4	31.8	27.1	48.0	91.2	56.8	346.8	41.03
3	17.9	63.6	15.1	47.4	3.1	103.8	7.2	104.2	43.3	67.58
4	16.8	82.4	3.7	58.4	1.0	125.3	7.8	105.2	29.3	86.90
5	6.9	121.4	1.4	98.0	-	-	4.0	121.3	12.3	118.70
6	2.5	125.0	0.4	124.9	-	-	0.5	147.1	3.4	128.24
7	0.3	161.5	0.1	157.1	-	-	-	-	0.4	160.40
Total	1,001.6	-	464.8	-	2,648.0	-	1,527.6	-	5,642.0	-
SOP	18,587		9,561		21,060		26,564		75,722	
Catch	18,587		9,517		21,431		27,015		76,550	

Table 3.2.3 Herring. Division IIIa. 1987 estimated catch in numbers at age (millions), mean weights at age, SOP, and catch in tonnes by quarters of spring-spawning herring caught in Division IIIa and adjacent parts of the North Sea.

Age	Quarter 1		2		3		4	
	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$	N	$\bar{W}$
2	218.9	50.03	210.2	47.39	179.3	69.98	158.6	64.58
3	37.0	62.57	71.2	80.08	45.9	105.60	13.1	103.16
4	18.7	82.97	31.3	112.63	20.7	117.89	12.2	101.59
5	7.3	124.24	8.1	151.36	8.0	169.00	4.3	125.30
6	2.6	126.87	3.2	168.13	2.0	186.05	1.5	131.70
7	0.4	172.83	0.6	223.68	0.2	190.50	+	-
8	-	-	0.1	278.00	-	-	-	-
9	-	-	0.1	283.00	-	-	-	-
SOP (tonnes)	16,124		21,190		21,621		13,570	

Table 3.2.4 Estimated numbers at age of North Sea herring caught in Division IIIa in 1987.

Age	N (millions)	w (gr)	SOP (tonnes)
0	6,238.0	8.01	49,966
1	3,136.9	33.11	103,863
2	103.1	82.02	8,456
Total	9,478.0	-	162,285

Table 4.2.1 Celtic Sea and Division VIIj HERRING landings by calendar year (t), 1977-1987. (Data provided by Working Group members.)

Year	France	Germany Fed.Rep.	Ireland	Netherlands	Unallocated	Total
1977	106	96	5,533	1,455	-	7,190
1978	8	220	6,249	1,002	850	15,519
1979	584	20	7,019	850	3,705	12,178
1980	9	2	8,849	393	-	9,253
1981	123	-	15,562	1,150	-	16,835
1982	+	-	9,501	-	-	9,501
1983	495	-	10,000	1,500	10,187	22,187
1984	680	-	7,000	890	11,148	19,718
1985	622	-	11,000	-	4,601	16,223
1986	-	-	13,338	+	-	13,338
1987[1]	820	-	15,500	1,453	5,310	23,083

[1] Provisional.

Table 4.2.2 Celtic Sea and Division VIIj HERRING landings (tonnes) by season (1 April-31 March). (Data provided by Working Group members.)

Year	France	Germany Fed.Rep.	Ireland	Netherlands	Unallocated	Total
1977/1978	95	96	6,264	1,378	-	7,833
1978/1979	8	220	8,239	1,002	-	7,559
1979/1980	584	20	7,932	850	935	10,321
1980/1981	9	2	9,024	292	3,803	13,130
1981/1982	123	-	15,830	1,150	-	17,103
1982/1983	+	-	13,042	-	-	13,042
1983/1984	495	-	10,000	1,500	9,186	21,181
1984/1985	680	-	7,000	890	14,009	22,579
1985/1986	622	-	11,995	-	4,509	17,126
1986/1987	-	-	14,725	1	-	14,726
1987/1988[1]	820	-	15,500	1,453	4,444	22,217

[1] Provisional.

Table 4.2.3 SUM OF PRODUCTS CHECK

HERRING SOUTH AND SOUTH WEST OF IRELAND (FISH AREAS VIIG-J)
CATEGORY: TOTAL

CATCH IN NUMBERS UNIT: thousands

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	8159	2800	11335	7162	39361	15339	11484	16456	15018	2451	5064
2	12516	13385	13913	30093	21285	42725	87253	78324	47824	33441	56780
3	8610	11948	12399	11726	21861	8728	22895	34672	30392	25270	36504
4	5280	5583	8636	6585	5505	4817	2735	13527	13438	19406	19503
5	1585	1580	2889	2812	4438	1497	1579	2066	1933	5180	12138
6	1898	1476	1316	2204	3436	1891	277	915	191	664	2302
7	1043	540	1283	1184	795	1670	315	317	71	58	996
8	383	858	551	1262	313	335	790	195	145	17	251
9+	470	482	635	565	866	596	261	152	111	7	393
TOTAL	39944	38652	52957	63593	97860	77598	127589	146624	109123	86494	133931
CATCH	7833	7559	10321	13130	17103	13042	21181	22579	17126	14726	22217
C/SOP(%)	104	98	103	109	103	95	93	99	102	100	100