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Exploration of the Sea

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

Copenhagen, 20 - 30 March 1984

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

1. INTRODUCTION

1.1 Participants

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Mr Kjartan Hoydal, ICES Statistician, assisted in part of the meeting.

1.2 Terms of Reference

The Herring Assessment Working Group for the Area South of 62°N met at ICES headquarters from 20-30 March 1984 in accordance with C.Res.1984/2:8:5 in order to:

(i) assess the state of the herring stocks in Division IIIa, Sub-area IV, Divisions Va and VIa and Sub-area VII and to provide management options for 1984 and/or 1985 as appropriate inside safe biological limits,

(ii) evaluate any new data available on stock components in Division IIIa herring,

(iii) examine the possibility of making a seasonal assessment of Divisions IVc and VIId,e herring,

(iv) take into account the levels of predation mortality implied by the results of the stomach sampling project,

(v) analyse the effect of changes in the data sets of weight at age and age at first maturity on the time series of stock and spawning stock biomass.

2. NORTH SEA HERRING

2.1 The Fishery

2.1.1 ACFM advice and management of the fishery in 1983

At its 1983 meeting, ACFM made the following recommendations for the North Sea herring fisheries in 1983:

Division	TAC (tonnes)	Restrictions
IVa	35 000	
IVb	27 000	To be taken west of 3°E outside the period 15 Aug. - 30 Sep.
IVc - VIId	36 000	To be taken from 1 Oct. 1983 to 31 Mar. 1984
Total	98 000	

In addition, they recommended that there should be no directed fishery for herring and sprat in the area between the Danish coast and 7°E, and between 55°30' and 57°N during the period 1 Jul. - 31 Oct.

Subsequent to the ACFM meeting, agreements were reached between the European Community and Norway and interim quotas were allocated to fisheries in Divisions IVa and IVb. Later in the year, these quotas were increased, and the final agreement for 1983 was as follows:

Division IVa	42 850 tonnes
Division IVb	29 210 tonnes.

The total for Divisions IVa and IVb, including allocation to countries other than the EC and Norway, was 72 760 tonnes.

The Divisions IVc + VIId TAC was a "roll-over" from 1982 (increased by 1 000 tonnes) to be taken from 1 October 1983 to 31 March 1984.

Divisions IVc+VIId	73 000 tonnes
Total North Sea	145 760 tonnes

The total TAC agreed for the entire North Sea by Norway and the EC was approximately 50% higher than that advised by ACFM. In the event, however, agreement within the EC was reached so late in the year that national quotas by Division were not in all cases reached.

In addition to the above TAC agreements, the ban on directed fisheries for herring for industrial purposes was continued in 1983. A by-catch derogation of 10% herring was allowed in landings of sprat, and a 5% by-catch of herring in small-mesh fisheries for other species of fish.

2.1.2 Catches in 1983

The landings in 1983, including both officially reported national catches and unallocated catches (the sum of unreported catches supplied by Working Group members) are given in Table 2.1 for the total North Sea and for each Division in Tables 2.2.1 to 2.2.4. The total North Sea catch in 1983 is estimated to be 308 169 tonnes, and the revised total catch in 1982 is 235 569 tonnes. In both 1982 and 1983, approximately half the catches were not officially reported (48% in 1982 and 57% in 1983). The Working Group again stresses that the lack of accurate catch statistics is reflected in the reliability of the assessments done for the various stocks.

The approximate division of catches in the adult fisheries by Division and by periods of the year is given in the text table below, based on information supplied by Working Group members.

Division IVa	Jun.-Jul.	41 800 tonnes	total 62 000 t
	Oct.-Dec.	14 600 tonnes	
	Other periods and unknown	5 600 tonnes	
Division IVb	Sep.-Oct.	13 800 tonnes	total 21 500 t
	Other periods and unknown	7 700 tonnes	
Divisions IVc+VIId	Jan.-Mar.	6 400 tonnes	total 64 400 t
	Oct.-Dec.	57 800 tonnes	
	Other periods and unknown	<1 000 tonnes	

The catches in Division IVa were thus 80% higher than that advised by ACFM, and 45% higher than that agreed by the management bodies. In Division IVc, the catch was 80% higher than that advised by ACFM, although strict comparison is not possible because the TAC was advised for the period October 1983 to March 1984. In Division IVb, by contrast, the catch of adults was significantly lower than either the TAC advised by ACFM or the TAC agreed by the management bodies.

Catches of juvenile herring as revised increased very significantly from 78 000 tonnes in 1981 to 153 000 tonnes in 1982. In 1983, they increased again to 160 000 tonnes, which is close to the maximum level recorded in 1972.

2.1.3 Catch in number

Number of herring caught by age and area are given in Tables 2.3 and 2.4. Nearly all countries furnished sampling data for their catches, and some sampling was done on almost all fisheries. The sampling levels, however, were grossly inadequate in some areas and seasons and thus seriously undermined the reliability of the assessments.

Number at age for the most recent six years are summarised in the text table below.

Millions of herring caught by age group (winter rings)

Year	0	1	2	3	4	5 and older	Total
1978	130	169	5	6	5	1	316
1979	542	159	34	10	10	4	759
1980	792	161	108	92	32	26	1211
1981	7889	447	264	57	40	77	8774
1982	9557	840	268	230	34	34	10963
1983	10030	1147	545	216	105	85	12128

The contribution of 0- and 1-ringed fish as a proportion of the total catch in number remained at the unprecedented level of 1981 (1981: 95%, 1982: 95%, 1983: 92%).

2.2 Age Composition

Age composition data were available from the commercial catches and research vessel samples taken during the acoustic surveys. The main features are shown in the text table below, which gives percentage age compositions of 2-ringers and older, with the relative abundance of 1-ringers shown in brackets.

Year class	Age (w.r.)	Division IVa (west): Acoustic survey July	Commercial landings: Jun-Jul Nether-lands	Commercial landings: Jun-Jul Other countries	Commercial landings: Jun-Jul Total	Commercial landings: Oct-Dec Norway Scotland	Commercial landings: Moray Firth Dec Scotland	Commercial landings: Total
1982	0	-	-	-	-	-	-	-
1981	1	(71.8)*)	(2.0)	(0.1)	(1.2)	(1.8)	(999.6)	(96.5)
1980	2	41.0	68.0	8.8	44.8	35.4	75.4	39.2
1979	3	28.8	23.4	23.0	23.3	33.6	15.9	31.9
1978	4	6.5	5.4	15.9	9.5	8.4	2.8	7.9
1977	5	4.9	0.6	10.8	4.6	5.1	1.5	4.8
1976	6	6.6	0.7	14.6	6.2	6.0	3.1	5.8
1975	7	5.1	0.4	10.1	4.2	4.5	0.1	4.1
1974	8	4.8	0.1	8.9	3.6	3.8	0.9	3.5
1973+ earlier	≥9	2.3	1.3	7.9	3.9	3.2	0.2	2.9

*) Proportions of 1-ringers are shown in brackets, expressed as a percentage of the total number of 2-ringers and older.

Year class	Age (w.r.)	Division IVb(west) adult fisheries: Acoustic survey August (spawning grounds)	Commercial landings: France all year	Commercial landings: Netherlands Jun-Jul	Commercial landings: Norway Sep-Oct	Division IVb(east) adult fishery
1982	0	-	-	-	-	-
1981	1	(?)	(7.2)	(66.3)	(86.9)	(139.4)
1980	2	55.1	58.4	67.2	41.9	92.8
1979	3	31.6	29.2	20.5	37.8	4.6
1978	4	8.2	10.8	6.3	16.3	2.3
1977	5	2.8	1.4	2.3	2.1	0.2
1976	6	0.9	0.1	3.4	2.1	+
1975	7	0.1	0.2	-	-	0.1
1974	8	1.2	-	-	-	-
1973+ earlier	≥9	0.1	-	0.3	-	-

Year class	Division IVc						
	Age (w.r.)	Acoustic survey Nov. 1983		Commercial landings Oct-Dec 1983		Acoustic survey Feb. 1984*)	
		Div.IVc	Div.VIId	Div.IVc Netherlands	Div.VIId France	Div.IVc	Div.VIId
1982	0	-	-	-	-	-	-
1981	1	(28.2)	-	(6.3)	(0.7)	(27.5)	(2.0)
1980	2	50.3	62.6	63.6	57.3	62.1	17.9
1979	3	22.1	20.9	17.8	30.9	21.4	23.3
1978	4	24.4	14.6	14.8	10.0	14.0	44.6
1977	5	2.3	0.8	3.0	1.1	1.8	10.0
1976	6	0.9	0.9	0.6	0.7	0.4	4.2
1975	7	-	0.2	0.1	0.1	0.3	-

*) Listed under respective year classes

In Division IVa, the 1979 year class was reasonably well represented in the acoustic survey and commercial vessel samples. The 1980 year class (2-ringers) was the most abundant age group in the Dutch catches in the summer, whereas in other catches they were less abundant. Weighting by the size of catches made in the summer fishery, their percentage contribution (45%) was very close to that in the acoustic survey (41%). In the Moray Firth and its approaches, 1-ringers were abundant in samples from the acoustic survey in July and in Scottish commercial catches in December.

In the Division IVb (west) adult fisheries, 2-ringers were rather more abundant than in Division IVa. One-ringers were also abundant in this area and in the catches of adults in Division IVb (east).

In Divisions IVc and VIId, the 1980 year class was the predominant one, although 4-ringers (1978 year class) were reasonably well represented in some acoustic survey samples. 1-ringers were not a predominant feature in these areas and occurred in a significant proportion only in research vessel samples from Division IVc.

Overall, samples from all areas of the North Sea demonstrate a clear predominance of 2- and 3-ringers (when 1-ringers are excluded from consideration), thus confirming the good recruitment by these two year classes.

2.3 Recruitment

2.3.1 Year class 1980

From the commercial catches in 1983 it appears that the 1980 year class contained an important component of southern North Sea herring. The prediction given in last year's report (Section 2.3.3) thus turned out to be correct, and it seems that the length distribution of 1-group herring during the IYFS can indeed be used to detect the presence of a strong southern component (see also para. 2.3.5).

2.3.2 Year class 1981

No final index for this year class from the 1983 IYFS has yet become available due to technical difficulties in the exchange and processing of age/length data. The preliminary index of 1 910 fish per hour used in last year's report has now been updated to 1 918, which hardly makes any difference.

Substituting the value of 1 918 into the usual formula

$$Y = 0.0031\ x - 0.21$$

results in a year class strength of 5 740 x 10^6 as 1-ringers. Taking into account a catch of 1 147 x 10^6 1-ringers in 1983, the stock size of 2-ringers in 1984 is estimated at 4 086 x 10^6, and the fishing mortality on 1-ringers in 1983 at 0.24.

The length distributions for this year class during the 1983 IYFS have now become available. These distributions have been used in para. 2.3.5 to split the total North Sea recruitment into a IVc + VIId component, and a IVb + IVa component. The combined frequency distributions for the total North Sea are shown in Figure 2.1.

2.3.3 Year class 1982

During the IYFS in February 1984 a preliminary index of 2 473 fish per hour was obtained for the herring standard area. This index is considerably higher than any other index found in recent years (see text table below).

Year class	Abundance index IYFS
1968	822
1969	2 647
1970	1 629
1971	827
1972	1 195
1973	1 592
1974	452
1975	342
1976	575
1977	139
1978	535
1979	551
1980	1 293
1981	1 910
1982	2 473

Substituting the index of 2 473 into the regression formula given above, the strength of this year class as 1-ringers is estimated at 7 456 x 10^6. Assuming that fishing mortality on this year class as 1-ringers will be the same as for the preceding year classes (i.e., 0.24), then the stock size as 2-ringers in 1985 should be 5 307 x 10^6.

The regression formula used above to estimate recruitment in absolute numbers from IYFS indices is based on VPA, using a natural mortality of 0.1 on 1-ringed herring. In Section 2.9 of this report, it is concluded that this natural mortality must be very much higher, and for the time being the Working Group has adopted a value of 0.8 as natural mortality for 1-group herring.

The Working Group, however, considered that there was still too much uncertainty about this value to use it for a new VPA on the total North Sea stock, and thus produce new VPA estimates of 1-group herring which could be regressed against IYFS indices.

The Working Group was also aware of the fact that the present regression formula is based on the 1958, 1959 and 1968-74 year classes, and that it might be advisable to update the regression formula by including some of the more recent year classes, and leaving out the oldest ones. Because og shortage of time, it was decided to postpone this analysis until next year's meeting. Preliminary calculations, however, showed that these amendments would not result in major changes in the regression formula used until now.

2.3.4 Year class 1983

This year class, still in its larval stage (25-40 mm), was sampled by IKMT during the 1984 IYFS. Figure 2.2 shows its distribution and abundance, in comparison with results for the two preceding year classes.

Larval herring were more abundant in the North Sea in 1984 than in the previous year. The two main concentrations occurred east of the Dogger Bank and off the entrance of the Skagerrak. There was also a concentration of very small larvae (20 mm) off the Dutch coast. These must have been larvae from the southern North Sea spawning grounds, and it is the first time that they have been recorded in large numbers during the IYFS.

There was also a concentration of larvae at the border between the Skagerrak and Kattegat, indicating that a considerable part of the North Sea recruitment has again been transported into Division IIIa.

Of the 7 year classes that have been sampled by IKMT, 5 have now recruited to the adult stock in the North Sea. The first 3 of these (1976-1978) were very scarce in the IKMT survey, and recruited also in very low numbers to the adult stock in the central and northern North Sea. The following two year classes (1979-1980) were abundant in the IKMT survey, and they were also the first two year classes to recruit in reasonable numbers to the central and northern North Sea (despite large catches of these year classes as 0-group in the industrial fishery). The abundance of larvae in the IKMT survey thus seems to give a first indication of recruitment to the central and northern North Sea stocks. On the basis of the IKMT surveys, there is some optimistic indication of the recruitment to the central and northern North Sea stocks for 1986.

2.3.5 Length frequency distributions from the International Young Herring Survey

Prediction of recruitment to the North Sea spawning stocks

Wood (1983) described a relationship between the recruitment of 2-ringed fish to the southern North Sea spawning stock (Downs) and estimates of indices of year class abundance as 0-group fish on the East Anglian coast. This regression predicted major recruitment of the 1980 year class to the Downs stock, as has indeed occurred. Figure 2.3 gives the new regression based on the VPA developed from the 1983 (Table 2.5) catch data. The 1981 and 1982 year classes in the 0-group surveys indicate continued strong potential recruitment to the Downs stock and have been estimated at 1.189×10^9 and 1.077×10^9, respectively.

At this meeting, a working document was presented which subjected the area length distributions from the IYFS to analysis by the Cassie method (Burd, in press) in order to obtain estimates of recruitment to Divisions IVa,b and c, respectively.

The components extracted by this method and given in Table 2.6 have been regressed with the VPA estimates of 2-ringers derived for Divisions IVa, IVb and IVc/VIId.

It was decided that only the lower length group (13.0 cm) associated with the Downs regression would be accepted. This gave an index of 18.3 x 10^3 equivalent to a VPA 2-ringer estimate of 738 x 10^6 from the regression. This has been taken as confirmation of the order of magnitude of the 1981 year class as recruiting fish to the Downs stock as given in the 1st para. of this section. For prediction purposes, a recruitment of 1 x 10^9 has been chosen.

Because of the failure to quantify recruitments to the stocks in Divisions IVa and IVb, the Working Group was forced to combine the two areas for prediction, and the estimate of the 1981 year class was set at 3.1 x 10^9 by subtraction of the Downs estimate from that for the total North Sea as given in Section 2.3.2.

2.4 Acoustic Surveys

2.4.1 The 1983 acoustic survey in the northwestern North Sea (Division IVa)

The results of the ICES-coordinated survey in the Orkney-Shetland area carried out in July 1983 by Dutch, Norwegian and Scottish research vessels were presented at the 1983 Statutory Meeting (ICES, Doc. C.M.1983/H:52). The survey and analysis methods were the same as those used in the previous two years with the exception that the estimated numbers of fish were converted to biomass using weight data obtained during the survey.

The estimates of herring biomass obtained are given in the text table below:

	Ship	Dates	No. of quarter statistical rectangles surveyed	Estimated herring biomass (t) Immature	Spawning
a.	"G.O.Sars"	18-30/7	44	27 000	223 000
b.	"	18-30/7	Raised to 62 rectangles*	68 000	302 000
c.	"Scotia"	7-25/7	62	45 000	198 000
		Mean of b and c		56 500	250 000

* Raised by proportion of stock in additional area of the "Scotia" survey.

The estimate of spawning stock biomass in 1983 of 250 000 tonnes compares with a figure of 224 450 tonnes at the same time in 1982.

The estimated numbers of herring in each quarter statistical rectangle on the Scottish survey were allocated to age using length compositions and age/length keys provided by the participants (Table 2.7). In 1982 and 1983, the 1979 year class was well represented in the catches. A major difference, however, was the abundance of 1-ringers (1981 year class) in 1983, a feature not previously encountered in any year of the surveys which began in 1979. This age group was predominantly distributed to the east Orkney and in the approaches to the Moray Firth.

2.4.2 Division IVb stock (Bank)

The annual survey of spawning herring by echo-integration was carried out in the second half of August between the Farne Islands and Flamborough Head. Only one vessel was available in 1983, and, as a consequence, relatively little time could be spent in the Longstone area.

On arrival on 19 August on the Yorkshire coast grounds an area of some 60 km^2 was detected containing small plume traces. No integration was made, but trawl hauls indicated adult herring in maturity stage V. On 20 August, a further small area some 20 km^2 in extent was detected. Again, no integration was made, but a trawl haul of 16 baskets of herring showed that 30% were ripe and running in stage VI, and 4% were already spent.

An intensive survey on the Longstone spawning ground of 1982 gave few traces. The ship proceeded to the Buchan area, where survey grid lines were set at 5 miles and no concentrations of adult herring were detected.

Returning to the Longstone on 24-25 August, an acoustic biomass of 2 500 tonnes was detected of spawning herring. A 30 basket catch included 63% 2-ring recruits of the 1980 year class.

From 25/26 August to 29/30 August the ship surveyed the Yorkshire coast area. More spawning localities, frequented in earlier years of high stock abundance, were detected than in the years 1979-82. The maximum biomass estimate for the 5 patches integrated amounted to about 40 000 tonnes.

This must be a minimum estimate of the stock spawning off the English northeast coast, as no integration could be made for one important spawning concentration, and it is probable that some spawning at the Longstone was also missed.

The acoustic biomass estimates for the comparable area off the Yorkshire coast are as follows:

25-28 August 1979	12 000 tonnes
22-23 August 1981	10 000 tonnes
26-27 August 1982	32 000 tonnes
25-29 August 1983	40 000 tonnes (underestimate)

2.4.3 Divisions IVc and VIId

Two surveys were undertaken, one in November 1983 in excellent weather, the other in February 1984 disrupted by bad weather. In November, herring were widely distributed over the Southern Bight between 51° - 52°30'N as shown by the distribution of herring fishing vessels. The herring were generally in small shoals and intermingled with a number of other pelagic species. Only limited sampling was possible in Division IVc, and some broad assumption had to be made concerning the likely proportion of herring within the total acoustic biomass recorded in this region. A 75% assumption gave a total biomass of 178 x 10^3 tonnes for the Southern Bight.

In the eastern Channel, three major spawning concentrations were located, off Dieppe, Pointe d'Ailly and in the Bullock Bank - Bassurelle region. The French commercial catches contained about 95% herring at this time (G Biais, pers.comm.).

The eastern Channel component was thus estimated at 104 x 10^3 tonnes, which produced a combined estimate of 282 x 10^3 for Divisions IVc and VIId. The results are summarised in the text table below.

Herring in Divisions IVc and VIId - Estimates of herring biomass

November 1983

Division	Survey area (km^2)	Total biomass ($t \times 10^{-3}$)
IVc	20 073	178
VIId	6 834	104
Total	26 907	282

Age Distribution of Research Vessel Samples (% Number)

Year class :	1	2	3	4	5	6	7	8
	1981	1980	1979	1978	1977	1976	1975	1974
IVc (1 sample)	22.0	39.3	17.2	19.0	1.8	0.7	-	-
VIId (2 samples)	-	62.6	20.9	14.6	0.8	0.9	0.1	0.1

Conversion to numbers ($x 10^{-6}$) using commercial landings

Age composition for November 1983

IVc+VIId	68.3	988.2	485.8	204.7	37.0	9.7	2.3	-
%	3.8	55.0	27.1	11.4	2.1	0.5	0.1	-

2.5 Herring Larval Surveys

The sampling intensity achieved in all areas in 1983 was comparable to that in the preceding two years.

2.5.1 Division IVa

Surveys in this area were carried out by the Netherlands and the Federal Republic of Germany in early September, by Scotland in mid-September and by Denmark in late September. The indices of abundance of larvae less than 10 mm are: 1st half of September: 2 532; 2nd half of September: 973. Both of these indices are similar to, but slightly lower than, those for 1982. The mean for 1983 of 1 752, if inserted in the regression equation given in the 1982 report, would estimate the spawning stock biomass in 1983 in the Orkney-Shetland area as 189 000 tonnes.

However, since 1981 the Working Group has added the larval index from surveys in the Buchan area to those from the surveys in the area off the northeast coast of England to produce the regression between spawning stock biomass and larval abundance for Division IVb. As the larval indices in the Buchan area in those years were low, this probably had little influence on the regression for that Division. In 1982 and 1983, however, the larval indices in the Buchan area increased markedly from those of the immediately preceding years and would have a major effect on the estimates of spawning stock biomass in Division IVa or Division IVb, depending to which stock they are allocated. Since Buchan spawners have always been considered as part of the northern North Sea stock (Coop.Res.Rep., No. 4, 1965), and since they form a component of the catches in Division IVa, the Working Group decided that they would be more appropriately allocated to the Division IVa spawning stock. A new predictive regression was, therefore, estimated for the years 1972-82, by adding the Orkney-Shetland and Buchan indices and relating them to the spawning stock biomasses in the Division IVa VPA given in Table 2.8. The data points are shown in Figure 2.5. It is clear that the larval indices for 1978 and 1979 are much too high in relation to the estimated spawning stock biomasses in these years. The reasons for this are not clear at present, but are perhaps related to the undue effect on the indices for these years of 1-2 stations with extremely high larval catches. The regression equation for the combined larval indices against the Division IVa stock was estimated disregarding these two years. Under these circumstances, it has a correlation coefficient of 0.85, and the index for 1983 of 3 527 inserted in the equation estimates the 1983 spawning stock biomass as 217 000 tonnes compared with the 239 000 tonnes used in running this VPA.

2.5.2 Division IVb

Surveys in the Buchan area in September by Scotland and Denmark gave abundance indices of small larvae of 2 515 and 1 088 x 10^9 respectively, resulting in a mean index of 1 802 x 10^9. As stated above, these were combined with the index for the Orkney-Shetland area in estimating the Division IVa spawning stock biomass.

In the area off the northeast England coast, surveys by the Netherlands in early and late September and by England in early October gave abundance indices of small larvae of 1 575, 382 and 102 respectively. The estimates for the September surveys are very high compared with 1982, but the October one was very much lower. Because the area was not surveyed in late October, the same factor was used to convert the early October index to a late October index as in last year's report. The resulting index for the 1983 season is 523 x 10^9 early larvae. This index, inserted in the same regression equation as used in the 1982 and 1983 reports, gives an estimated spawning stock biomass in 1983 in the northeast England coast area of 62 000 tonnes.

2.5.3 Divisions IVc and VIId

Surveys were carried out by the Netherlands in December and by England and the Federal Republic of Germany in January. These gave estimates of abundance of all age categories of larvae of 2 351 x 10^9 in December and of 1 357 x 10^9 in January. The resulting mean of 1 854 x 10^9 for the entire spawning season is the highest yet recorded and almost twice the 1982/83 estimate. As in the preceding two years, however, it is far beyond the level for which the only regression available is useable to estimate spawning stock biomass. It can only be used in a non-quantitative way to indicate that this spawning stock is continuing to increase.

2.6 State of the Stocks

2.6.1 Division IVa

Catches in number of herring in Division IVa have been used in a VPA to assess the recent history of the stock. To estimate values of input F for 1983, the numbers at age were estimated from the mean of the acoustic survey estimates in July. Since catches in Division IVa are likely to include fish from the populations spawning in both the Orkney-Shetland and

Buchan areas, the numbers at age in the population given in Table 2.7 were increased by an arbitrary 20% to allow for fish known to be in the Buchan area (the northern part of Division IVb west) at the time of the acoustic survey. It was assumed that the resulting numbers were the estimate of stock size at 15 July 1983, approximately the mid-point of the acoustic survey (Table 2.8).

To estimate the values of F at age in that part of the year prior to 15 July, catches were as far as possible allocated to month and half the catches in July were assumed to have been taken before 15 July. These are given together with total catches for the year in Table 2.8. Catches up to 15 July and the acoustic estimates were used to calculate F at age and stock in number at 1 January 1983, assuming an M of 0.054 (13/24 of 0.1).

The results of the VPA using the input F values in Table 2.8 are given in Tables 2.9, 2.10 and 2.11. The VPA results are compared with other indices of abundance in Table 2.12. The small increase from 1982 to 1983 is seen in both the VPA and the acoustic survey results. The larval index is not easy to interpret: the index for Orkney-Shetland dropped slightly from 1982 to 1983, but if the increase in the Buchan index is taken into account, there may have been little change or an increase. There is thus no major discrepancy between the results from the three methods.

The discrepancy between the results from VPA, acoustic and larval surveys in explaining the change from 1981 to 1982 is not entirely resolved, although the increase measured by VPA is not as marked as indicated in last year's assessment. The results of the VPA thus indicate that a progressive growth has taken place in the Division IVa stock due to increments from the 1979 and 1980 year classes (see Table 2.12).

In considering the spawning stock biomass,it is necessary to point out that the estimates from the VPA given in Table 2.11 are not directly comparable with those estimated on the acoustic survey. This is because those in the VPA are calculated using long-term mean weights at age over the year as a whole, whereas those estimated from the acoustic survey used the higher mean weights at age of maturing fish obtained during the survey. The VPA was matched in 1983 to the numbers of fish estimated on the acoustic survey, so this explains any discrepancies between the results given in Tables 2.9 - 2.12.

2.6.2 Division IVb stock (Bank)

The estimate of spawning stock size from the central North Sea larval survey gives an estimate of 62 000 tonnes. The acoustic survey on the spawning shoals gave a stock of about 40 000 tonnes. This is bound to be an underestimate as the survey is restricted both in time and area. The percentage age composition of the spawning fish is given below:

Rings	2	3	4	5	6	7	8	>8
Year class	1980	1979	1978	1977	1976	1975	1974	
%	55.1	31.6	8.2	2.8	0.9	0.1	1.2	0.1

The larval abundances for Division IVb in previous Working Group reports have included production from the Buchan area. Confining these indices to the central North Sea spawning grounds, the recent larval indices are:

	No. x 10^{11}
1979	5.17
1980	0.06
1981	3.35
1982	3.84
1983	5.23

Comparing the larval indices for 1982 and 1983, there is an increment in 1983 of 36%. The acoustic biomass for the Yorkshire coast grounds indicated a minimum increment of 25% in 1983.

The total catch to 1 September of adult herring taken in Division IVb was about 12 000 tonnes. Age compositions for each country's catches have been summed and applied to the spawning stock as at 1 September assuming it to be 65 000 tonnes. The relevant data appear below:

Age	Stock x 10^6 1/9 1983	Catch x 10^6 to 1/9 1983	Stock x 10^6 at 1/1 1983
2	230.80	155.1	406.70
3	132.73	28.4	171.26
4	34.28	12.2	49.25
5	11.82	1.7	14.40
6	3.56	1.4	5.25
7	0.29		0.31
8	5.28		5.65
>8	0.21		0.23

Results from VPA

Applying the catches in numbers for 1983 for ages 2 and older (Table 2.13) to the stock size at 1 January 1983 given above, coefficients of fishing mortality were derived and used to initiate the VPA. Tables 2.14 and 2.15 give the outputs of F values and stock for 1974-83. The stock sizes differ between this assessment and that made in 1983. The SSB for 1982 was calculated as 100 000 tonnes based on adjustment to the central North Sea stock size to account for larval production on the Buchan grounds. With the removal of the Buchan element, the VPA reflects the central North Sea spawning stock and the 1982 stock sizes are markedly changed.

The spawning stock biomasses calculated by VPA and from acoustic surveys are compared below:

Tonnes x 10^3	Spawning stock biomass VPA	Spawning stock biomass Acoustic
Year		
1979	9.9	12.0
1980	14.9	-
1981	18.1	10.0
1982	37.0	32.0
1983	63.7	40.0x)

x) underestimate

2.6.3 Divisions IVc and VIId

Although larval surveys were carried out in the winter 1983-84, larval indices were not used to estimate stock size for the reasons indicated previously (see Section 2.5.3).

Biomass estimates from English acoustic surveys were available for November 1983 and February 1984. The Working Group accepted the November 1983 survey as the best estimate of the stock (see Section 2.4.3), which was used to estimate fishing mortality in 1983.

2.6.3.1 Estimation of fishing mortality in 1983 (Table 2.16)

The acoustic biomass estimate provided by the November 1983 survey was converted to an equivalent age distribution in number using the average age composition of samples from commercial catches taken in that month.

A comparison between the age structure of the catches taken in Divisions IVc and VIId and those provided by the three samples taken during the research vessel survey in November showed that although the Division VIId samples were comparable, the single one taken in Division IVc appeared anomalous, and in view of the high raising factor required for this single sample, it was felt that the commercial samples provided a better estimate for the overall age structure in November.

The stock sizes at the end of the year were then derived by subtracting the December catches together with a corresponding correction for natural mortality.

The fishing mortality for each age group in 1983 was thus calculated using the total catch taken during the whole year.

The weighted mean over age groups 2-8 (i.e., 0.24) was then used as an input for the VPA.

2.6.3.2 Results of the VPA

The results of the VPA are given in Tables 2.17-2.19 and summarised in Figure 2.6. The input fishing mortality used for the oldest age group was the unweighted mean over ages 2-6. Using the fishing mortality estimated for the year 1983, the spawning stock biomass attains 211 000 tonnes at the end of 1983.

The recruitment of the 1980 year class has resulted in an increase of spawning stock by a factor of x 1.7. This is approximately matched by the increase in the larval indices between those two years. Since 1980, the continuous growth of the stock has been associated with a decrease in the fishing mortality (Figure 2.6.A).

Seasonal VPA

The use of annual catch data in the VPA for this fishery arbitrarily divides the main fishing season into two periods. In order to estimate the effect of this split relative to the annual assessment, the Divisions IVc and VIId catches were regrouped on a seasonal basis. Catches in the second half of a year were added to those in the first half of the following year.

It was accepted in the 1982 Working Group report that catches taken in Division IVb contained a significant proportion of Downs stock fish. A correction was thus applied to the annual Divisions IVc-VIId catches in each year to allow for this component in the Division IVb catch. A similar adjustment was made to the seasonal catches; the IVc-VIId components taken in Division IVb were all added to the catches taken in the second half of each year for the years 1971-76.

The seasonal catches for Divisions IVc-VIId are presented in Table 2.20.

A VPA was then run, using an input fishing mortality derived from the November 1983 acoustic survey estimate of biomass (Tables 2.21-2.22). The stock was back-calculated at the 1st July taking into account catches over the intervening period and a natural mortality coefficient of 0.042 (5/12 of annual M = 0.1).

The fishing mortality for 1983/84 was then estimated using preliminary catches for the first part of 1984 (8 500 tonnes) and the unweighted mean value over the 2-6 age groups used as an input F for the VPA.

2.6.3.3 Comparison of results between the annual and seasonal VPAs

The results from the seasonal VPA are presented in Figure 2.6 (B and D) and can be compared with those from the annual VPA (Figure 2.6 (A and C)). In calculating the spawning biomass estimate, it was assumed that 0.5 of F and M had occurred prior to spawning.

The principal difference relates to variations in $\bar{F}$ before 1977, whereas yield, spawning stock and recruitment are very similar.

In monitoring the effects of fishing on recruiting year classes, there is some advantage in the use of seasonal VPA if important catches are taken in the first three months of a calendar year. While this fishing pattern occurred in earlier years, there is no such fishery at present. If such a fishery develops, it might be necessary to re-examine the need for a seasonal assessment.

2.7 VPA Combined Areas of the North Sea

2.7.1 Divisions IVa and IVb combined

The allocation of catches in Divisions IVa and IVb to their respective stocks is subject to some error. There are also difficulties in allocating recruitment to the Divisions IVa and IVb stocks. For these reasons, the Working Group decided to carry out an assessment of the two areas combined in addition to the separate assessments described in Section 2.6.

To obtain input F values for a VPA, the catches in the combined area and the summed estimates of stock in number at 1 January 1983 from the individual VPAs were used; the relevant data are given in Table 2.24. The results of the VPA are given in Tables 2.25-2.27. These indicate considerable growth in spawning stock size in both 1982 and 1983 as the 1979 and 1980 year classes recruited.

For comparative purposes, the summed results of the separate VPAs are given in Table 2.28 together with the results from the combined VPA.

2.7.2 Total North Sea

A VPA for the whole North Sea was carried out in the way described for the combinations of Divisions IVa and IVb, and the data used to calculate input F values are given in Table 2.24. The results are given in Tables 2.29-2.31. The comparison of the results with the sum of the results for the separate stock VPAs is given in Table 2.32.

The combined VPA indicates that the total spawning stock has grown progressively since 1977 to almost 600 000 tonnes in 1983.

2.8 Projection of Catch and Stock Size for 1984 and 1985

For both the suggested management areas, i.e., Divisions IVa and IVb combined and Divisions IVc + VIId catches for 1984 and 1985 as well as the corresponding stock sizes for 1985 and 1986 have been calculated for different levels of fishing mortality in 1984 and 1985. The data used are given in Tables 2.33 and 2.34. The detailed result for the year 1984, i.e., catches in 1984 and the resulting biomass estimates for 1985, are shown in Figures 2.7 and 2.8. Summarised results for Divisions IVa+IVb and Divisions IVc+VIId are given in the text tables in Section 2.10.

For the interpretation of these tables it has to be noted that the spawning stock biomass has been calculated at spawning time. Annual mortality has been applied in the year for which the estimate has been made. The effect of any annual catch can be assessed by comparing the biomasses at 1 January and not by comparison of the spawning stock biomasses given.

The estimate of spawning stock biomasses in 1986 assumes that the 1985 exploitation rate will be maintained in 1986.

2.9 Predation Mortality on 0- and 1-group Herring

The first results of the ICES Stomach Sampling Project in 1981 have now become available, and it is possible to compare number of juvenile fish consumed by predators, with assumptions about natural mortality used hitherto.

The number of juvenile herring removed by predators from the North Sea in 1981 are given in the text table below. Also shown is the number of juvenile herring taken in the same year as (by-) catch in the fishery.

Predators	Numbers of juvenile herring (millions) removed from the North Sea in 1981		
	0-group 1980 year class	1-group 1979 year class	2-group 1978 year class
Mackerel[1]	125	2	-
Whiting[2]	17316	2618	27
Cod[3]	12	866	219
Saithe[4]	23	66	12
Total removed by predators	17476	3552	258
Total catch of all fisheries[5]	7889	447	264

1) From Mehl and Westgård, 1983, Table 9, assuming all herring 5-14 cm were 0-group with w = 15 g, and all herring 15-19 cm were 1-group with w = 50 g.

2) Adapted from Hislop et al., 1983.

3) Daan (pers.comm.).

4) From Gislason, 1983.

5) This report, Table 2.3.

The numbers of 0- and 1-group herring eaten by whiting in 1981, as reported by Hislop et al. (1983), have been amended in this report (Appendix 1). It was concluded that the above authors used a wrong age/length key for juvenile herring in the 3rd quarter of the year, and a substantial number of herring given in their tables has now been shifted from 1-group to 0-group. It is possible that the erroneous age/length keys for herring have also been applied to the cod stomach contents, but the Working Group was not able to check this during the meeting. The numbers of 1-group herring eaten by cod are, therefore, possibly an overestimate.

The figures in the above table can be used to estimate fishing mortality and predation mortality on the 1979 year class as 1-group, and on the 1980 year class as 0-group.

2.9.1 Mortality on the 1979 year class as 1-group

The best estimate for the strength of the 1979 year class now is 1 400 x 10^6 2-ringers at the beginning of 1982 (Table 2.31). Assuming that the numbers removed by predators in 1981 represent the total natural mortality for that year, it is possible to calculate the following parameters for the year 1981.

Stock size of 1-ringers at beginning of year = 5 699 x 10^6

M on 1-ringers = 1.20 (largely generated in 1st quarter of the year)

F on 1-ringers = 0.15.

2.9.2 Mortality on the 1980 year class as 0-group

The best estimate at present for the strength of the 1980 year class is 2 500 x 10^6 2-ringers at the beginning of 1983 (Table 2.31). It is not possible to work back from here to obtain the stock size at the end of 1981 without making some assumptions about M in 1982.

The Working Group assumed that the number of herring consumed per 1 000 whiting in 1982 had been the same as in 1981. Using stock estimates for whiting in 1982, the total consumption of 1-group herring by the whiting stock in 1982 was estimated at 2 557 x 10^6 (Appendix 1). It was assumed that the numbers of 1-group herring consumed by other predators in 1982 were equal to that in 1981, i.e., 934 x 10^6 individuals. The total number of 1-group herring removed by predators in 1982 then becomes 3 491 x 10^6. The number of 1-ringers caught by the fisheries in 1982 was 840 x 10^6 (Table 2.3). Starting from these figures, the following parameters can be calculated for 1982:

Stock size 1-ringers at 1.1.1982 = 6 831 x 10^6

M on 1-ringers in 1982 = 0.81

F on 1-ringers in 1982 = 0.20.

The number of 0-group removed by predators in 1981 was 17 476 x 10^6 (see text table on p.16), and the number caught by the fisheries was 7889 x 10^6. This leads to the following population parameters for 1981:

Stock size on 0-ringers at 1.1.1981 = 32 196 x 10^6

M on 0-ringers in 1981 = 1.07

F on 0-ringers in 1981 = 0.48.

2.9.3 Conclusions

The calculation for the 1980 year class presented above is based on the assumption that the quantity of juvenile herring consumed is directly proportional to the number of predators present in the sea. Although this will certainly be an important factor, it is likely that the abundance of the prey species itself will affect the quantity of prey consumed. Given a certain stock size of whiting, the number of juvenile herring consumed can be expected to depend on the ratio of herring to other prey species available to the whiting. This ratio will not only depend on the absolute abundance of herring and other prey species in the sea, but also upon their distribution in relation to whiting.

The natural mortality inflicted by whiting and other predators upon the herring can thus be expected to vary rather widely from one year to another, depending upon all the variables mentioned above. It would be unwise, therefore, to treat the values of M calculated for 1981 as very accurate estimates of the average natural mortality on 0- and 1-group herring. Instead, they should be treated with some caution, more as an indication of the order of magnitude than as accurate point estimates.

It is beyond doubt, however, that the value of M = 0.1 used for 0- and 1-group herring until now is completely unrealistic, and should be replaced by values more in line with the outcome of the stomach sampling project.

From the calculations presented above, there are in fact two estimates of M on 1-ringers available (1.20 for year class 1979, and 0.81 for year class 1980). The Working Group decided to adopt the lower of the two estimates on the basis of the possible overestimation of the numbers of 1-ringed herring eaten by the cod stock in 1981.

It was therefore decided to adopt as a first approximation a value of M = 1.0 for 0-group herring, and a value of M = 0.8 for 1-group herring.

It should be borne in mind that the M on 0-group in 1981 is based mainly on stomach contents in the 2nd half of the year. For the first half of the year, low numbers of 0-group herring were found in the stomachs of predators. For this reason, the estimate of M on 0-group given above (1.0) is applicable to the 2nd half of the year (i.e., a 6 month period).

2.10 Management Considerations

2.10.1 Management of adult fisheries

In last year's report it was stated that if the recruiting 1980 year class was not fished in 1983 before it spawned, the spawning stock in that year would reach the target of 800 000 tonnes. In this assessment, the total North Sea spawning stock at spawning time is estimated at about 500 000 tonnes. This discrepancy is due to several factors. The major one is that in 1982 the estimated size of the total North Sea spawning stock in 1982 was 450 000 tonnes. The current estimates infer that it was only 310 000 tonnes in that year.

The second factor is that the prediction of a total North Sea spawning stock in 1983 of 800 000 tonnes stated that this was dependent on the 1980 year class adding about 400 000 tonnes to it, if it was not fished prior to spawning in that year. The present estimates suggest that it added only about 240 000 tonnes. The short-fall is due to the fact that there was some fishery on this year class in 1983 prior to spawning which resulted in a reduction of its contribution of about 60 000 tonnes. The strength of this year class in 1983 was also overestimated due to the catches taken from it as 1-ringers in 1982 being underestimated by about 400 million. This would introduce a discrepancy of about 70 000 tonnes. The aggregated effect of these factors accounts for all but about 10% of the discrepancy.

The present assessment shows that large increases are expected in the North Sea herring stock in 1984 and 1985 due to the recruiting two strong year classes, i.e., the 1981 and 1982 year classes. As explained in Section 2.3, the Working Group estimated that about 1×10^9 2-ringed herring (about 120 000 tonnes) would recruit to the Downs herring stock in 1984. In 1985, the recruitment would also be on the same level assuming an F = 0.24 on 1-ringers in 1984. The Working Group was not able to split the remainder of the recruitment of the 1981 and 1982 year classes between the herring stocks in the central and northern North Sea. A combined assessment had, therefore, to be carried out for the herring in Divisions IVa and IVb. The estimated recruitment of 2-ringers to these stocks combined in 1984 is 3.1×10^9 herring (about 400 000 tonnes).

Assuming that fishing mortality on 1-ringers in 1984 is the same as in 1983, the Working Group estimated that the number of 2-ringers recruiting to these stocks in 1985 would be 4.2×10^9 herring, i.e., about half a million tonnes.

By limiting the juvenile herring fishery, the rate of recruitment could be increased even further as explained in the following Section 2.10.2. This high level of recruitment in 1984 and 1985 provides an excellent opportunity to rebuild the North Sea herring stocks, by exploiting them at only low levels of fishing mortalities.

The results of the catch projections for the herring stocks in the central and northern North Sea combined as well as for the Downs stock are given in the text tables below and shown in Figures 2.8 and 2.9.

HERRING IN ICES DIVISIONS IVa AND IVb

1983			1984				1985				1986
$\bar{F}_{(2+)}$	Catch	SSB*)	Biomass (2+)**)	$\bar{F}_{(2+)}$	Catch	SSB*)	Biomass (2+)**)	$\bar{F}_{(2+)}$	Catch	SSB*)	Biomass (3+)**)
0.265	84	294	714	0.05	33	646	1 329	0.05	62	1 202	1 434
				0.10	65	625	1 291	0.10	117	1 129	1 326
			$F_{0.1}$ >	0.15	95	604	1 254	0.15	166	1 061	1 231
				0.20	123	584	1 219	0.20	211	997	1 141
				0.25	150	565	1 186	0.25	250	936	1 058
				0.30	177	546	1 155	0.30	286	883	982

Weights in thousand tonnes.
*) Spawning stock biomass is calculated for the time of spawning, i.e. 1 September.
**) Biomass is calculated for 1 January.

HERRING IN ICES DIVISIONS IVc AND VIId

1983			1984				1985				1986
$\bar{F}_{(2+)}$	Catch	SSB*)	Biomass (2+)**)	$\bar{F}_{(2+)}$	Catch	SSB*)	Biomass (2+)**)	$\bar{F}_{(2+)}$	Catch	SSB*)	Biomass (3+)**)
0.240	64	211	374	0.05	17	322	499	0.05	23	430	499
				0.10	34	306	481	0.10	44	394	457
			$F_{0.1}$>	0.15	49	291	463	0.15	62	361	420
				0.20	65	277	447	0.20	77	331	385
				0.25	79	263	431	0.25	91	304	354
				0.30	92	251	416	0.30	.103	279	325

Weights in thousand tonnes.
*) Spawning stock biomass is calculated for the time of spawning, i.e. 31 December.
**) Biomass is calculated for 1 January.

On the basis of these predictions, it is suggested that in 1984 and 1985 the North Sea herring should be treated as two management units, i.e., the Downs stock on the one hand and the herring in Divisions IVa,b on the other. The Working Group is, however, aware of the fact that Downs herring are present in Division IVb outside their spawning season. Therefore, fishing in Division IVb will cause some additional fishing mortalities on the Downs stock to that estimated on the basis of Divisions IVc-VIId catches alone.

Since the Working Group was not able to anticipate the level of the catch during summer in Division IVb, it was not able to estimate the likely increase in F on the Downs herring due to such a fishery. It was felt, however, that a transfer of up to a fifth of the Division IVc TAC to only Division IVb would be acceptable.

Since the herring stocks in Divisions IVa and IVb do not migrate to Division IVc, no transfers of the Divisions IVa,b TAC are suggested.

In order to prevent herring fishing on the spawning herring and to encourage a continued recovery of the Bank stock for the reasons given in the 1983 ACFM report, para. D.1.1.11, it is advised that a closure of herring fishing be implemented in the 6-12 mile zone between 54°10'N and 54°45'N during the period 15 August to 30 September and in the area of the 6-12 mile zone between 55°30'N and 55°45'N during the period 15 August to 15 September.

The Working Group does stress that the rate of recovery of the stock components in the North Sea has varied considerably. The spawning component at Orkney/Shetland has probably not increased to any appreciable extent in the last four years. It is, therefore, suggested that in the case of very heavy concentrations of fishing on a particular component, steps should be taken to make it possible to close areas on a real time basis.

2.10.2 Management Consideration regarding Catches of Juvenile Herring

In last year's report, the Working Group expressed its concern about the catches of 0-group herring taken in the eastern part of the North Sea and Division IIIa. It was stated that the large catches of juvenile herring were a threat to the recruitment of North Sea herring, and that they were contrary to a rational exploitation of this resource. Consequently, the Working Group advised a closure of the industrial (sprat) fishery in the area between 55°30'N and 57°00'N and between 7°E and the Danish coast, from 1 July to 31 October.

Catch data presented at this year's meeting show that catches of 0-group herring in 1982 have been even higher ($9\ 557 \times 10^6$) than they were assumed to be during the previous meeting, and that there was a further increase to $10\ 030 \times 10^6$ in 1983. This shows that the protection measures advised by the Working Group last year have either not been enforced, or alternatively applied to a too small area and/or period.

Attention is also drawn to the catches in Division IIIa, which appear to have contained large numbers of 0- and 1-group herring in recent years (Table 3.2) also mainly from North Sea origin.

In the light of these catch figures, it is surprising to note that recruitment of the 1981 and 1982 year classes, measured as 1-ringers during the IYFS, was still above average. This can only be explained by assuming that both year classes must originally have been of very large size.

The estimates of natural mortality on 0- and 1-group herring, derived from the Stomach Sampling Project (Section 2.9), provide us with the possibility of a first approximation of the effect of the young herring catches upon recruitment to the adult stocks in the North Sea. In the following calculation it has been assumed that M on 0- and 1-group herring in Division IIIa is the same as the M adopted for North Sea herring.

Numbers in million	North Sea			Division IIIa		
Year class	1980	1981	1982	1980/81	1981/82	1982/83
Catch as 0-group	7 889	9 557	10 030	3 624	3 334	4 876
Catch as 1-group	840	1 147		985	2 603	
Additional recruitment as 2-group if no catch of 0- and 1-group had been taken	1 681	2 095	1 658*	1 042	1 721	806*
Actual recruitment as 2-group	2 574	4 086	5 307			

* Only based on no 0-group catch

It should be noted that most of the gain from saving 0-group herring in Division IIIa should go to recruitment in North Sea Divisions IVa,b, and not to Division IIIa as suggested in the above table. A much smaller proportion of the gain from saving 1-group herring in Division IIIa would recruit to the North Sea(see Section 3.1). Despite the increased values of M used in the above calculation, it is obvious that a large proportion of potential recruitment to the adult stocks was lost due to catches of juvenile herring.

In the present situation of greatly increased recruitment, a limited catch of juvenile herring would not constitute a threat to the spawning stocks. It is clear, however, that the level of these catches in recent years has greatly reduced the potential harvest of adult herring and delayed the recovery of the spawning stock. The Working Group considers that there remains an urgent need for the effective implementation of the measures advised in last year's report if the management objective is to maximise the yield of North Sea herring. In relation to the high catches of 0- and 1-group herring in Division IIIa, see Section 3.6.

If management authorities consider it necessary to allow a certain catch of 0-group herring to be taken, the potential catch of 1-group and adult herring will be reduced. Appendix 2 demonstrates how the effect of taking different catches of 0- and 1-group could be quantified by a calculation of equilibrium yield at constant recruitment. It should be stressed that present estimates of M in juvenile herring are still uncertain, and that the quantitative effects calculated in Appendix 2 should therefore be considered as a first approximation.

3. DIVISION IIIa HERRING

3.1 Stock Composition

In late January 1983, a Workshop on Stock Components in Division IIIa reached the following opinion: for the time being, the broad outlines indicate that the major proportions of the catches of 0-group in July-December and of 1-group in January-March are referable to autumn spawners (North Sea).

An attempt at splitting the 1-group index obtained from IYFS into spring- and autumn spawners is described in Section 3.4. In connection with the commercial landings of 0- and 1-groups in 1983, an attempt using a somewhat different method is described below.

The analysis was only carried out on landings from the industrial fisheries which are responsible for almost the entire catch of 0-group and a major part of the 1-group. A split of Danish length frequencies by month was made using material of length-VS relations accumulated over the period 1979-82. Figure 3.1 shows a line drawn through the lengths beneath which all samples showed mean vertebral counts characteristic for the spring spawners in Division IIIa and the Western Baltic (VS < 56). In the same figure are plotted the monthly mean lengths for 0- and 1-group herring in 1983 for the Skagerrak and Kattegat, respectively. The monthly length frequencies were split according to the dividing line shown in Figure 3.1, so that length groups above the dividing line were assigned as autumn spawners, those below as spring spawners.

This somewhat rough approach seems permissible because the overlap between stock components is small, as illustrated by the sample shown below:

cm	12.5	13.0	13.5	14.0	14.5	15.0	15.5	16.0	16.5	17.0	17.5
VS	55.89	55.70	55.80	55.79	56.24	56.32	56.58	56.48	56.45	56.43	56.46

The VS values indicate that in this month (January 1983) a split made at 14.5 cm gives a good separation between spring- and autumn spawners.

Applied to the Danish industrial by-catches, the following results were obtained:

	Non spring-spawning component in Nos. (10^{-6})				Total in nos. (10^{-6})		Non-spring spawn. component in %	
	Skagerrak		Kattegat		Division IIIa		Division IIIa	
w.r.	0	1	0	1	0	1	0	1
Quarter								
1	-	95	-	178	-	1 104	-	25
2	-	60	172	32	172	273	100	34
3	953	25	1 575	10	3 054	196	83	18
4	241	11	103	1	1 330	93	26	13
Total	1 194	191	1 850	221	4 556	1 666	67	25

It should be noted that the percentage of non spring-spawning fish amongst the 1-group is not applicable to the total number caught at this age. A certain number are caught in the consumption fisheries and being appreciably larger than the 1-group in industrial landings could contain a higher percentage of autumn spawners.

3.2 The Fishery

3.2.1 Catch data

The landings of herring since 1973 are shown in Table 3.1. The preliminary figures for 1983 indicate a total catch of 198 000 tonnes or an increase of about 30% compared with 1982. The landings in 1983 were all allocated to countries and areas except in case of 5 000 tonnes, which were thought to be misreported and consequently subtracted from the total. The main increase took place in the Kattegat and may, to some extent, be due to more efficient sampling in this area, i.e., that previous years' landings have been underestimated. Even though the Danish Kattegat sampling in 1983 was intensified, the level is far from satisfactory in parts of the year. Thus, about 16 000 tonnes were calculated on the basis of 7 samples only.

3.2.2 Catch in numbers at age

Catch in numbers at age data were available for all major fisheries. The preliminary data are given in Table 3.2 and show a further increase in the number of 0- and 1-groups caught.

3.3 Biomass Estimates from Acoustic Surveys

Two acoustic surveys of herring biomass were carried out in 1983: one in August-September by R/V "Dana" and R/V "Argos", and one in December by R/V "Eldjarn". Preliminary results from the first survey were presented to the ACFM meeting in October 1983.

Both surveys were carried out using 38 Khz echo-sounders which were calibrated against standard copper spheres. Integrator output was corrected according to actual sound velocity and sound attenuation.

Recorded echo levels from both surveys were split on species according to composition in trawl catches, and a length-dependent target strength relation was used.

For herring and sprat, the relation published by Haldorsson and Reynisson (1982):

$$TS_{ind} = 21.7 \log l - 75.5 \text{ dB}$$

was used.

For gadoids, a TS_{ind} length regression as well as a TS_{kg} regression were calculated using data presented by Godo _et al._ (1982):

$$TS_{ind} = 21.8 \log l - 72.5 \text{ dB}$$

$$TS_{kg} = -10 \log l - 19.3 \text{ dB.}$$

Numbers of herring from both surveys were split at age according to the composition in the trawl catches. The two estimates of herring stock and biomass are:

W/R	No. x 10^{-6} Aug-Sep 1983	Dec. 1983
0	1 424	5 089
1	3 526	1 393
2	1 160	22
3	413	
4	122	
5	13	
6		
Total	6 658	6 504
Biomass (t)	325 000	153 000

The difference between the two sets of data is in conformity with observations from earlier years. The decline in 1-group and older herring from September to December reflects a migration out of the area surveyed, the older to the overwintering areas in the Sound and shallow waters.

The estimate of herring in numbers at age in September and November-December are given in the text table below. The 1979 and 1980 estimates are based on integration with 120 Khz system and the 1981 and onward with 38 Khz system.

Winter rings	Numbers at age (millions)						
	1979	1980	1981	Sep.1982	Nov. 1982	Sep.1983	Dec.1983
0	577	482	1840	6171	2530	1424	5089
1	611	477	698	2349	1060	3526	1393
2	1065	434	1260	999	380	1160	22
3	93	473	44	221	40	413	-
4	13	84	22	31	5	122	-
5	4	28	2	8	-	13	-
6	-	3	0.6	0.8	-	-	-
7	-	-	-	0.1	-	-	-

3.4 Recruitment

The annual Young Fish Survey was carried out in Division IIIa during February. A total of 35 hauls, covering 15 rectangles, were made with the GOV trawl.

The index of 1-group herring, calculated as the geometric mean of the arithmetic means of seven standard rectangles, was 4 690, which is the highest on record. The 1-group herring were evenly distributed over the surveyed area, and high numbers were also caught in the western part of the Skagerrak.

The abundance indices for 1972-84 are given in the text table below.

Year	Indices of 1-group
1972	78
1973	181
1974	726
1975	455
1976	1 339
1977	204
1978	575
1979	3
1980	504
1981	544
1982	1 647
1983	3 255
1984	4 690

The IKMT sampling during the survey covered 13 rectangles and 53 hauls were made. The abundance of autumn-spawned larvae, mean 32, was lower than in 1983 but higher than in the preceding 5 years.

To test the validity of the 1-group index, two regressions were carried out: the IYFS index on the catches of the same year class as 0-group and the catches of 1-group on the IYFS index the same year. The regressions are shown in Figures 3.2 and 3.3. Both regressions gave very high correlation coefficients of about 0.9 and low intercept.

An attempt at splitting the 1-group index from IYFS into spring- and autumn spawners was presented (Hagström, in prep.). The separation was based on the assumption that the length frequency distribution (LFD) of the components are normally distributed. The basic data, LFDs in number per hour from individual hauls, were grouped in depth strata. The summed LFDs per strata were separated by a two-step analysis in which the Bhattacharya method (1967) was used to estimate the start point for the final analysis described by Macdonald-Pitcher 1979.

The results of the separation are shown in Table 3.3. The small length component, mean 13-15 cm, and the large length component, mean 16-19 cm, were found to have VS within the meristic characteristics of spring- and autumn spawners, respectively.

The proportion of the components applied on the stratas and weighted together by the area proportion of the stratas to an overall indices are shown in Table 3.4.

In the text table below, the resulting 1-group indices are given.

Year	Index Spring spawners		Index Autumn spawners	
1981	996	.29	2 250	.69
1982	1 408	.55	1 152	.45
1983	1 522	.28	3 897	.72
1984	2 793	.46	3 242	.54

3.5 Virtual Population Analysis

As has been pointed out in earlier reports of this Working Group, a separate VPA and a separate assessment in general of the Division IIIa herring is probably meaningless due to the mixture of stocks in the area.

A combined assessment of Kattegat-Skagerrak and Western Baltic herring of age group 2 and older has been discussed in earlier reports of this Working Group, and in the 1983 report of the Working Group on Assessment of Pelagic Stocks in the Baltic (Doc. C.M.1983/Assess:13), and a combined assessment in 1984 was recommended by the last-mentioned Working Group. The main reason for running a combined assessment for the older fish in the two areas is that tagging experiments and Anisakis infestations indicate that a considerable but unknown proportion of the age group 2 and older fish is migrating between the two areas and separate VPAs for the two areas may overestimate the stock. To compensate for migration, an M of 0.3 has been used for some time in the separate assessment of Western Baltic stocks.

The Division IIIa assessment has been tuned on the basis of acoustic surveys, whereas the Western Baltic VPA has been tuned to fit Young Fish Survey indices. In its 1983 report (Doc. C.M.1983/Assess:13), the Baltic Pelagic Working Group presented a table of a VPA based on added catches from the two areas and an M of 0.1. This was tuned to fit the added acoustic estimates, which are both made in the period late August - early October. In order to provide a better allowance for the migratory pattern of the stock and seasonality in catches, an approach has been made at the present meeting in which the catches in the Western Baltic are considered to be taken in the first half of the year and catches in Division IIIa are from the second half of the year. The VPA was run on a half-yearly basis, and the input fishing mortalities chosen to make a fit between stock size and acoustic surveys for the years 1979-82 inclusive.

A comparison of the three VPA approaches and yearly acoustic stock estimates are shown in Table 3.5.

It is clear that any of the combined VPAs will make a better approximation to acoustic data than the separate VPAs. This is partly due to the lower natural mortality used in the combined runs.

A comparison between the combined and the single VPA for the Western Baltic and Division IIIa (Table 3.6) shows that average Fs for the Western Baltic are similar in the two cases indicating that the higher natural mortality used in the Baltic VPA compensates for the fishing of the Western Baltic stock taking place in Division IIIa.

The large difference between the resulting Fs in Division IIIa stresses the difficulties arising from a separate assessment for Division IIIa, when the major part of the common stock is fished outside the area.

The combined seasonal VPA split also indicates that while the Baltic separate VPA is useful in its present form, also a Division IIIa separate VPA could perhaps be used for assessment in that area by including the Baltic F values in the Division IIIa M value applied.

3.6 Management Considerations

3.6.1 General

The difficulties mentioned in last year's report and indeed in several earlier reports dealing with Division IIIa herring fisheries have made it impossible to make an assessment from which a meaningful prognosis can be obtained. Once again the Working Group draws the attention to the continuing increasing catches of young herring which infers lack of enforcement of existing regulations.

3.6.2 The catch of 0- and 1-group herring

According to the catch at age figures presented in Table 3.2, the catch of 0-group herring reached the highest level on record in 1983. As referred to in Sections 3.1 and 3.4, the proportions of autumn-spawned herring of the North Sea spawning stocks in the catches of 0- and 1-group fish were in the order of 2/3 and 1/4, respectively, in 1983. The present high catches of juvenile herring in the Skagerrak and Kattegat, therefore, reduce considerably the recruitment both to the adult stocks in the North Sea and to Division IIIa itself.

ACFM has in the past proposed a number of restrictions and the management bodies concerned have agreed on several numbers of regulatory measures to reduce the catch of juvenile herring, but without effective enforcement no improvement can be expected.

In order to achieve a possible improvement based upon the existing mesh regulation in Division IIIa, the Working Group recommends the following measure: fishing by trawl for herring and sprat with mesh sizes less than 32 mm should be prohibited in the whole of Division IIIa from 1 July to 30 September for all vessel categories.

3.6.3 Management of adult herring

In last year's report, it was proposed to make a combined assessment of the indigenous herring stocks in Division IIIa and the Sub-divisions 22-24 in the Baltic. However, at the time of the Working Group meeting no data on the herring catches in 1983 in the Sub-divisions in the Baltic were available and consequently no prognosis could be made.

4. CELTIC SEA AND DIVISION VIIj HERRING

4.1 Introduction

The herring fisheries in the Celtic Sea and Division VIIj are now considered to exploit the same stock. The assessments and management of the fisheries in both areas have therefore been combined since 1982.

4.2 The Fishery in 1983/84

4.2.1 Catch data

The total catches from the combined areas per year and per season (1 April - 31 March) are shown in Tables 4.1 and 4.2. The total catch taken during the 1983/84 season was about 21 000 tonnes, which was the highest catch recorded since 1973/74, and represented an increase of over 8 000 tonnes on the 1982/83 figure. ACFM recommended in May 1983 that the TAC for 1983 should not exceed 6 000 tonnes and the permitted catch subsequently agreed by the EEC was 8 100 tonnes for the period 1 October 1983 to 31 March 1984. The major portion of the catch, which could be attributed to specific countries, was taken by Ireland. Over 9 000 tonnes, i.e., about 43% of the total catch, could not be attributed to any country. Approximately 70% of the total catch was taken in the 3rd and 4th quarters (i.e., 1 October - 31 March) by fleets fishing during the main spawning period in the Celtic Sea.

Difficulties in marketing throughout the season restricted the fishery and undoubtedly prevented an even larger catch being taken.

4.2.2 Catch in numbers per age group

The total catches in numbers per age group are shown in Table 4.3. These are based mainly on Irish samples but also on some Dutch and French data. Over 68% of the total catches were composed of 2 winter-ring herring (i.e., 1980/81 year class), while the 1979/80 year class constituted about 18%. About 95% of the total catch was composed of 1, 2 and 3 winter-ring fish, while older fish appeared to be relatively scarce throughout the season.

4.3 Spawning Stock

4.3.1 Larval surveys

Larval surveys were conducted for the 6th successive season. The surveys during the early part of the season were extended to cover Division VIIj as well as the Celtic Sea.

For the purpose of calculating the larval index, only those stations in the standard area as used in the previous assessment (i.e., east of 9°30'W, west of 6°00'W and south of 52°20'N) were used. Coverage within this area was good in both 1982/83 and 1983/84. Small larvae (<10 mm) were much more abundant than in previous years and showed a major peak in the autumn and a secondary peak in the winter. In all, five of the ten cruises showed abundances which exceeded those in corresponding periods in previous years.

The main spawning area seemed to be off Cork Harbour, from where the larvae drifted westwards, and in Baginbun Bay, from where larvae drifted eastwards towards the Irish Sea.

The index for the whole season was calculated for the standard area by the method used by the 1983 Working Group (Anon., 1983). The index is 58 x 10^9, which is almost three times the 1982/83 value (the previous maximum). Values of the index for the last six seasons are given in the following text table (number of cruises in brackets):

	Autumn	Winter x 1.465	Total
1978/79	7 163 (3)	122 (3)	7 284*)
1979/80	9 503 (5)	3 374 (5)	12 877
1980/81	7 601 (4)	8 932 (4)	16 533
1981/82	16 285 (5)	1 510 (5)	17 795
1982/83	14 557 (5)	5 164 (6)	19 721
1983/84	42 393 (5)	15 608 (5)	58 001

*) Monthly cruises - inefficient estimate

4.4 Estimates of Fishing Mortality

As has been the situation in recent years, the cpue data cannot be used to obtain estimates of F for this fishery. In general, the fishery during 1983/84 was in a very depressed state because of marketing difficulties, and the major portion of the catch, which was taken by the Irish fleet, was taken under severe nightly quota restrictions, which lasted throughout the season. The number of boats partaking in the fishery remained about the same as in the previous season. The increased catches were probably mainly the results of an increased abundance of shoals during the season and not because of any increase in effort.

The same method of selecting F in 1983/84 was adopted as that used by the 1983 Working Group (i.e., a comparison between the average spawning stock biomasses, obtained from different input F values, and the average larval indices). The appropriate F value for 1983/84 would be about 0.40.

4.5 Results from VPA

The results from VPA, using F adult = 0.4 in 1983/84, are shown in Figure 4.1 (A and B) and in Tables 4.5 and 4.6. The exploitation pattern used was that F on 1 winter-ring fish was 40% of that on adults and the mean weights per age class are the same as those used in the previous assessment. The value of F declined from 0.7 in 1972/73 to less than 0.4 from 1977-79 during which time the fishery was closed. Subsequently, they increased again to over 0.8 in 1981/82, and then decreased again to 0.5 in 1982/83. The high F in 1981/82 appears to have coincided with a rise in catch to over 17 000 tonnes at a time when the spawning stock biomass was only about 24 000 tonnes and had not yet benefitted from the increased recruitment of the 1979/80 and 1980/81 year classes. The spawning stock biomass has increased rapidly from 1979 and is estimated to be about 64 000 tonnes at spawning time in 1983.

Results from the VPA indicate that recruitment has improved considerably in recent years, and the 1979/80 and 1980/81 year classes are considerably stronger than any since the 1969 year class recruited in 1971. This year class was the last strong one to enter the fishery before the stock collapsed in the mid-1970s and was calculated to be about 303 million fish. Recruitment in the 10 years prior to 1971 - when the stock was at a high level - averaged about 197 million fish. At the present time, when the stock appears to be recovering, the strength of the 1979/80 and 1980/81 year classes have been estimated to be about 179 and 322 million fish respectively.

4.6 Recruitment

The recruitment used for prediction by the 1982 Working Group was 50 million fish for 1983 and 1984. This low figure, which corresponded to the lowest observed level of recruitment since 1958, was justified because there was no real evidence that the spawning stock size had increased substantially, and it was felt unlikely that a low stock size would produce two successive strong year classes.

There are no direct methods of estimating recruitment for the Celtic Sea Division VIIj area. It has been established, however, that a proportion of the larvae from the spawning grounds in the Celtic Sea is carried into the Irish Sea,and the nursery areas in the Irish Sea have always been considered to contain quantities of Celtic Sea recruits. Young herring surveys have been carried out in this area since 1980, and the results obtained (catches of 1 winter-ring herring/hr) during February have been compared with the numbers of 1 winter-ring fish from the Celtic Sea stock at 1 April from VPA (1983). The comparisons are as follows:

5.2.5 VPA results

The fishing mortality results from the VPA (Table 5.3) show that in all years since 1977, the values are appreciably higher than in previous assessments. This is particularly so in the years since the re-opening of the fishery when instead of being close to the $F_{0.1}$ level, it is now very much in excess of it.

The spawning stock biomasses in the VPA (Table 5.4) show that there was a rapid recovery of the stock once the fishery was closed in mid-1978. This recovery was, however, halted with the re-opening of the fishery in 1981 and subsequently declined again rapidly. The recruitment of the weak 1980 year class to the spawning stock in 1983 certainly was a contributing factor to the marked decline in spawning stock biomass from 1982 to 1983. But the high exploitation rate in these two years has accentuated this effect. Based on catches of 1-ringers in 1983 and the input F used in the VPA, the 1981 year class will be a strong one, and this is supported by the research vessel recruit survey. The effect of this year class in increasing the spawning stock in 1984 will, however, be largely dissipated by the high TAC agreed for that year. The summarised results of the assessments are shown in Figure 5.4.

5.3 Recruitment

As in previous years, the estimate of recruitment as 2-group in 1984 was based on the Scottish survey undertaken in February of each year since 1980. In the years prior to 1984, the whole of Division VIa had been sampled with 25 GOV trawl hauls distributed over the area.

In practice, the 2-group fish were in all years almost completely confined to the area off the north coast of Scotland and in the North Minch. In 1984, due to a defect on the research ship used for these surveys, only one week was available for the survey, and, accordingly, it was decided to confine the sampling to these two areas. For this reason, indices of abundance of the 2-group herring were estimated for all years based on these two areas. These indices are shown in Figure 5.3 as the weighted mean catch per hour's fishing plotted against the VPA estimates of stock size at this age given in Table 5.6. With only four points, all of which are to an extent dependent on the input F used in the VPA, calculating a regression equation has no justification. However, it would appear that these indices do give some indication of the likely strength of the year class recruiting as 2-ringers in that year. The index for 1984 is 13 578, the highest value ever recorded during the time-series. Based on this, recruitment as 2-group in 1984 has been taken as 600 million, which is a conservative value in relation to the high research vessel index. It will be noted that this value is appreciably less than that estimated from the catch of 1-group in 1983 and the input F used in the VPA for that age group.

For recruitment as 2-group in 1985 in the prediction, a value of 330 million has been used, estimated from the geometric mean of this age group in the years 1973-82.

5.4 Management Considerations

It is clear from this assessment that the spawning stock biomasses estimated in the assessments done in 1982 and 1983 were much higher than the values for these years derived from the current one. The main reason for this would appear to be the high variance about the spawning stock/larval abundance relationship, on which these estimates of stock size were and are based. These overestimates of stock size, in association with catches in 1982 and 1983 appreciably above the levels recommended by ACFM, appear to have resulted in reducing the spawning stock biomass in 1983 to a very low level.

It is true that the present estimate of the spawning stock biomass in 1983 is subject to the same high variance as previous estimates. But that the stock in 1983 is much lower than had been previously estimated finds some support from fishermen's statements that herring are scarce in the area, and from an acoustic biomass estimate bade by a Scottish research vessel in November 1983. This did not cover the total distribution of the stock, but making some allowance for this, it is compatible with the stock size estimate given above.

The results of the assessments given above were used to project yields in 1985 and stock biomasses for adult (2+) herring at the beginning of the year as well as at spawning time (spawning stock biomass). Estimates of spawning stock biomass in 1986 have been made by applying 2/3 of both the natural and fishing mortality of the previous year in 1986. The parameters used are given in Table 5.7 and the results are shown in Figure 5.5.

The agreed TAC for 1984 is 64 020 tonnes. This is about 20% higher than the TAC of 53 000 tonnes recommended by ACFM. This recommendation was made to restrict the 1984 exploitation to the $F_{0.1}$ level. Based on the present assessment, the appropriate recommendation to achieve this would have been 23 000 tonnes.

One of the projections for 1985 is based on the assumption that the agreed TAC of 64 020 tonnes in 1984 will be taken, despite the fact that this will require an exploitation rate in that year which is about the same as in 1983 and much above any desirable biological level.

The yields in 1985 on this option, at various reference levels of fishing mortality rate, are given in the text table below, together with biomass estimates for 1986.

<u>Management options for 1985</u>

Species: Herring Area: ICES Div. VIa North

1984				Management option for 1985	1985				1986	
Stock biom. (2+) 1)	Spawn. stock biom. 2)	$\bar{F}_{(2-7)}$	Catch (2+) 3)		Stock biom. (2+) 1)	Spawn. stock biom. 2)	$\bar{F}_{(2-7)}$	Catch (2+)	Stock biom. (2+) 1)	Spawn. stock biom. 2)
144	88	0.575	64	$F_{0.1}$	121	100	0.165	19	145	120
				$F_{85}=0.5xF_{83}$		92	0.275	30	133	102
				$F_{85}=0.8 \times F_{83}$		82	0.44	44	118	79
				$F_{85} = F_{83}$		76	0.55	53	109	63

Weights in thousand tonnes.
1) Stock biomass calculated at 1 January
2) SSB calculated at spawning time, i.e., 1 September
3) The assumed catch in 1984 corresponds to the agreed TAC.

It is clear from these projections that, if the main aim is to increase the spawning stock biomass to a higher level to reduce the risk of recruitment failure, the exploitation rate will have to be reduced to the $F_{0.1}$ level and maintained there to at least 1986. Continued fishing at the present high level of exploitation until 1986 would reduce the spawning stock biomass to the level at which the fishery was closed in 1978.

The second option for 1984 is to reduce the exploitation rate in that year to the $F_{0.1}$ level. A projection has been made based on this assumption. The results are shown in Figure 5.6 and are summarised in the text table below.

Management options for 1985

Species: Herring   Area: ICES Div. VIa North

1984				Management option for 1985	1985				1986	
Stock biom. (2+) 1)	Spawn. stock biom. 2)	$\bar{F}_{(2-7)}$	Catch (2+) 3)		Stock biom. (2+) 1)	Spawn. stock biom. 2)	$\bar{F}_{(2-7)}$	Catch (2+)	Stock biom. (2+) 1)	Spawn. stock biom. 2)
144	119	0.165	23	$F_{0.1}$	168	139	0.165	26	183	152
				$F_{85} = 0.5 \times F_{83}$		128	0.275	41	167	128
				$F_{85} = 0.8 \times F_{83}$		114	0.44	61	146	100
				$F_{85} = F_{83}$		104	0.55	72	134	84

Weights in thousand tonnes
1) Stock biomass calculated at 1 January
2) SSB calculated at the spawning time, i.e. 1 September
3) The assumed catch in 1984 corresponds to the agreed TAC.

This would result in a spawning stock biomass in 1984 of 119 000 tonnes, which would be a less dangerous level than the 88 000 tonnes resulting from the first option. If the exploitation rate was maintained at the $F_{0.1}$ level in subsequent years, the spawning stock biomass in 1986 would be close to the 1974 level, when the stock was already rather heavily depleted. This would suggest that fishing at the $F_{0.1}$ level would have to be maintained for several years to take the stock out of danger.

5.5 Clyde Herring

5.5.1 The fishery in 1983

The reported landings from the Firth of Clyde in Scottish ports in 1983 were 2 530 tonnes, slightly in excess of the TAC of 2 500 tonnes (Table 5.8). In addition, an estimated 273 tonnes were landed in Northern Ireland and the Isle of Man during July and August. The fishery in 1983 was limited by nightly quotas and extended over a longer season than in the previous three years.

In addition to the reported landings, an estimated 13 tonnes were caught as by-catch in the Clyde sprat fishery. There was also some evidence to suggest additional landings took place illegally but these cannot be quantified. In addition, significant discarding of 'small' and 'medium' herring (defined approximately as fish weighing less than 250 g) took place. These are estimated to have amounted to approximately 50% of the recorded landings. Boxes of herring sampled also weighed about 10% more than the nominal weight. The total catch of herring in the Clyde in 1983 is, therefore, estimated on these bases to be about 4 400 tonnes, excluding illegal landings. Reports from the fishery indicate that fishermen found no difficulty in catching their quotas at any time during the season.

5.5.2 Catch in numbers at age

Catch in numbers at age in 1983 was estimated from samples of landings at Scottish ports corrected for the percentage that boxes were overweight. The catch landed at Irish Sea ports was allocated using samples obtained in the Irish Republic. The quantity estimated to have been discarded was allocated to number at age in the following way:

From mean weights at age of fish landed in each month, discarded fish would have been spread over age groups 2-4 in May-July and October, and over age groups 2-3 in August and September. The mean weights and numbers landed of these age groups were used to estimate the landings in weight of 'small' and 'medium' fish. The estimated weight of discards was allocated over these age groups to produce the reported excess of catch over the reported landings.

The estimated numbers at age (x 10^{-3}) from each component of the catch are given in the text table below

Age	Landed at Scottish ports (corrected for overweight boxes)	Discards	Total
2	5 048.5	4 369.6	10 109.0
3	2 602.5	2 404.6	5 232.4
4	1 130.1	514.1	1 747.4
≥5	2 108.4	-	2 108.4

Minor corrections were also made to the numbers at age landed in 1982 (given in last year's report). Since discarding of 'small' and 'medium' herring was also reported to have taken place on a similar scale in that year, the numbers at age discarded (assuming that the weight of discards was 50% of the reported landings) were estimated by applying the proportions of 2-4 ringers given in the text table above to the overall numbers at age in the landings. Corrected totals for 1982 and numbers at age for 1983 are given in Table 5.9. In the years prior to 1982, there is no evidence to suggest significant discarding of fish of 2 years old and older, so no corrections have been made to the catch at age previously reported for these years.

5.5.3 Tagging experiments

Small numbers of tag recoveries were made in 1983 from earlier tagging experiments, all from within the Firth of Clyde.

5.5.4 Virtual Population Analysis

As in previous years, there are no fishery-independent data for this population to provide a basis for estimating an input F for the final year of a VPA. VPAs were, therefore, run on a trial basis, with input Fs of 0.1 - 0.5 to get measures of the resulting mean Fs on the fully recruited age groups over the years 1980-83, when the fishing effort had been stable. On this basis, an F of 0.3 on fully recruited age groups would appear to be the most appropriate value for 1983. With this value, the mean Fs for 1980-82 only vary by -17% to +20% of the 1983 value used. For all other input Fs, the percentage variation is much higher. The VPA with an input F of 0.3 in 1983 was therefore chosen as the best one.

From this VPA, the mean Fs at age over the period 1979-82 showed no significant variation within age groups 2-7 and an F of about 5% of the mean of these on age group 1. This exploitation pattern was used in subsequent estimations. The resulting outputs from this final VPA are given in Tables 5.10 and 5.11. The results of this VPA would suggest that the mean F on the fully recruited age groups declined appreciably in 1980 from the values which applied in preceding years. More striking is the decline which appears to have taken place in the 1-group since 1979. The total and adult stock biomasses appear to have increased progressively in each successive year since their low points in 1979 and the recruitment as 2-group in 1982 and 1983 are appreciably higher than in previous years.

5.5.5 Recruitment

There is no firm basis on which to predict recruitment to this population. These have been taken as the mean of the years 1978-82, as 0-group and 1-group from the VPA for substitution in the stock size in 1984.

5.6 *Management Considerations*

The results of the assessments given above were used to predict yields and stock biomasses in 1984 and 1985. The parameters used in doing so are given in Table 5.12. In doing a prediction of yield and stock size in 1985, it is necessary to make an estimate of the catch which will be taken from the stock in 1984. In the light of the evidence mentioned above that the catch was about 50% higher than the landings, due to discarding of fish in age groups 2-4, the prediction for 1985 was run initially on the assumption that the catch in 1984 would be 50% higher than the TAC of 2 500 tonnes agreed for this area for that year. This would require an F of about 0.2 in 1984.

The proportion of the total weight caught which is discarded is, however, a function of the proportion of the catch taken as 2-4 group, and the initial run had to be modified slightly to produce landings of 2 500 tonnes in 1984. An F of 0.21 on fully exploited age groups achieved this. Predictions have been run for 1985 at the $F_{0.1}$ level, 0.165 for this population and at F = 0.21. The results are given in the text table below, together with the estimated weight discarded on the assumption that discarding will continue in 1984 and 1985 at the 1983 pattern.

1983				1984			
Landings	Discards	F	Adult biomass 1 Jan.	Landings	Discards	F	Adult biomass 1 Jan.
2 800	1 265	.30	19 913	2 537	1 427	.21	21 716

1985				1986
Landings	Discards	F	Adult biomass 1 Jan.	Adult biomass 1 Jan.
2 397	1 081	.165	23 764	26 308
2 990	1 347	.210	23 764	25 412

It seems clear from these results that the current low TAC of 2 500 tonnes, under current market conditions in which small and medium fish fetch much lower prices than the large fish, is resulting in a large-scale discarding of adult marketable fish and is likely to continue doing so unless the market improves or the TAC is increased. Increasing the TAC somewhat, for example to 3 000 tonnes, might well decrease discarding, and in that case might even result in some increase in the stock. The predictions given above at two levels of F for 1985, moreover, show that even on the assumption of maintenance of current discarding practice in that year, maintaining the 1984 F in 1985 would result in a difference in the adult stock in 1986 of only 3% compared with fishing at the $F_{0.1}$ level. On this basis, an increase of the TAC in 1985 to 3 000 tonnes might be considered a justifiable experiment.

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

6.1 Catch Data

The catches of each country fishing in this area in the years 1974-82 and the preliminary catches for 1983 are given in Table 6.1. Some revisions have been made to the 1982 catches, which had been given as preliminary in the 1983 report. This revision caused an increase in the catch for that year of about 1 000 tonnes. The preliminary total catch for 1983 is about 33 000 tonnes, which is the highest catch recorded since 1976. The TAC recommended by ACFM for this area for 1983 was 12 000 tonnes. As in recent years, the largest catches from this area are taken by Ireland (75% of the allocated catches), although the catch taken by the Netherlands fleet also increased in 1983. Considerable catches, approximately 13 000 tonnes, were placed in the unallocated category. Most of the catches were taken from along the northwest Irish coast and are distributed fairly evenly throughout the year.

The fishery was again restricted by lack of demand throughout the year, and a large number of boats formerly engaged in herring fishery now partake mainly in the mackerel fishery and take herring only as a by-catch.

6.2 Catch in Numbers at Age

The estimated numbers of herring per age class taken from this area are shown in Table 6.2. The 1982 catches at age have been revised slightly because of the changes mentioned above. The 1983 catch at age data is based on Irish and Dutch samples. The catches taken from Division VIa South were composed mainly of herring belonging to the 1979 and 1980 year classes (20% and 26%, respectively), while the 1977 year class represented about 20% of the catch. The 1979 year class represented about 30% of the Dutch catch taken in the northern part of Division VIIb, while 34% of the Irish catch taken from this Division was composed of the 1980 year class. The 1977 year class dominated the catches from this area up to 1982. However, the presence of considerable numbers of 2- and 3-winter-ring fish (over 50% of the total catch) may indicate some improvement in recruitment in the area.

6.3 Larval Surveys

Larval surveys were carried out in this area by Scottish and Irish vessels in the period September - November 1983. The Irish surveys, initiated in 1981, cover the whole spawning areas and spawning period in this area. However, the time-series is not yet long enough to enable spawning biomass to be estimated each year. Accordingly, the index of abundance for the smallest size group of larvae was calculated as in preceding years for the same standard area as covered by Scottish and Irish surveys. This gave an index for 1983 of 196.89×10^9, about 25% lower than that for 1982. In last year's report, comment was made that Irish sampling gave appreciably lower catches of the smallest size category of larvae than Scottish sampling, and an adjustment was made to the 1982 index to correct for this. Comparison of measurements made in 1983 suggested that this anomaly no longer existed and accordingly no correction was made in that year. The index for 1983 substituted in the regression equation $y = 56658.204 + 81.1770x$ ($r = .8576$) given in Table 6.5 of last year's report gives a spawning stock biomass estimate of 72 600 tonnes. The resulting larval indices are given in Table 6.3.

The standard size area used for calculating the larval index was selected on the basis that it was jointly covered by the Irish and Scottish surveys from 1981-83. It is, however, situated in the southern part of Division VIa South and does not cover the time or the areas from where the greatest number of small class larvae are taken by the Irish surveys. A comparison of the indices calculated from the main spawning area along the Irish coasts indicates an increase of larval production from 1982 to 1983.

6.4 VPA

The input $F = 0.4$ was calculated from the spawning stock estimate of about 73 000 tonnes, and the catches taken in 1983. A VPA with this input F was run, and the results are shown in Tables 6.4 and 6.5., Fig. 6.1.

Values of F appear to have been very constant in recent years, varying from 0.27 in 1977 to 0.19 in 1982. The spawning stock biomass also appears to have been very constant during this period and has since 1976 ranged between 66 000 tonnes and 89 000 tonnes. This is, however, considerably lower than the level of 136 000 tonnes recorded in 1973. Recruitment of 1-winter-ring fish has been very stable since 1973 and, apart from the 1976 and 1977 year classes which appear to have been somewhat stronger, has averaged about 184 million fish over this period.

6.5 Recruitment

There are still no satisfactory data available to give a fishery-independent index of recruitment to the stock. Young herring surveys carried out by Ireland have not yet been carried out over a sufficiently long time-series, and the Scottish young fish survey in 1984 was confined to the northern part of Division VIa. The 1983 Working Group examined the catches of 1-winter-ring fish in an attempt to get some indication of the strength of recruitment but concluded that this method gave an unrealistically low estimate (42 million). In 1982 and 1983, catches of 1-winter-ring fish have been considerably reduced because of poor markets, and their abundance in the overall age distributions cannot be taken to give any index of recruitment.

The spawning stock in the area appears to be in a stable condition since 1976, and recruitment has been more or less constant since 1973 apart from the higher 1976 and 1977 year classes. An average recruitment level of 182 million fish, which is the geometric mean from 1973-82 (excluding the 1976 and 1977 year classes), was used in the predictions.

6.6 Management Considerations

The results of the assessments given above have been used to predict yields in 1984 and 1985. A TAC of 12 000 tonnes has been agreed for 1984. Recruitment of the 1982 and 1983 year classes has been taken as 182 million 1-winter-ring fish. The results of the predictions for various values of F are shown in Figure 6.1. Y/R and spawning stock biomass per recruit are also shown in Figure 6.1.

1983			1984			1985		
Catch	$\bar{F}_{2-7}$	Spawn. stock	Catch	$\bar{F}_{2-7}$	Spawn. stock	Catch	$\bar{F}_{2-7}$	Spawn. stock
33 000	0.40	74 300	28 700	0.40	63 800	25 800	0.40	57 900
			12 400	0.155 $= F_{0.1}$	75 200	13 600	0.155	82 900
			11 000	0.122	76 100	11 000	0.122	86 000

In the previous years, TACs have had no restraint on the fishery, and a continuation of the 1983 level of fishing will result in a decline of the spawning stock in 1984, and in 1985 the stock will be at the lowest level recorded. Fishing at $F_{0.1}$ in 1984 and 1985 will yield catches of between 12 000 ~ 14 000 tonnes and will allow the spawning stock to increase.

6.7 Occurrence of Winter- and Spring-Spawning Herring

The assessment of the herring stock in this area is based on the assumption that the herring stock spawns in the autumn. Catches are, therefore, assumed to belong to an autumn-spawning component and the subsequent stock sizes, calculated from VPAs, are then compared with the larval indices which are derived from surveys on the autumn-spawning population. However, it has become clear that in recent years at least (Molloy, 1983), non-autumn spawning fish constitute an important part of the catches. Herring are now known to spawn along the west and northwest Irish coast from December to March using the same spawning grounds as the autumn-spawning components, and these winter/spring spawners may constitute about 25% of the total annual catches. The inclusion of winter- and spring-spawners in the VPA may have considerable effect on the relationship between the larval indices and stock size. This effect may become more important, if these non-autumn spawners continue to increase in the catches. Information should therefore be collected about larval abundances during December to March and the racial composition of the catches throughout the year.

7. IRISH SEA HERRING (DIVISION VIIa)

7.1 Introduction

The TAC recommended by ACFM for herring in Division VIIa for 1983 was 3 000 tonnes. The TAC actually applied by EEC was a roll-over from the 1982 recommendation of 3 800 tonnes. The reported catch from the North Irish Sea was 3 881 tonnes, including 561 tonnes taken in September by selective (gill-net) fishing on the Mourne spawning ground (Table 7.1). The actual catch was greater than 3 881 tonnes because many small fish were sorted and dumped.

As in previous years, the 1983 catches were allocated to Manx or Mourne stocks, on the basis of vertebral counts, gonad condition and location of capture as described in Doc. C.M.1979/H:6. 2 103 tonnes were allocated to Manx stock, and 1 778 tonnes to Mourne stock (Table 7.1). However, the Working Group has always recognised that this method may not be accurate, but it is a necessary step to consideration of Manx and Mourne spawning aggregations as separate management units. At their 1983 meeting, ACFM recommended that the Working Group should consider the possibility of making a combined assessment of the Manx and Mourne herring (Doc. C.M.1983/Assess:22).

Despite the evidence for some long-standing anatomical differentiation among N.Irish Sea spawning components, population dynamic variables and biochemical characters fail to support the recognition within the N.Irish Sea of more than one unit stock (King, 1983). In addition, the location of the fishery has changed considerably in recent years, and at present little fishing takes place on the actual spawning grounds. The major portion of the catches is taken in the months prior to spawning when fish from both components are mixed on the feeding grounds to the west of the Isle of Man.

The Working Group decided, therefore, to combine the catches for both components and present a joint assessment. It was considered that this would produce a more meaningful and accurate estimate of the total stock biomass in the N.Irish Sea. As the catches at present are taken mainly from the mixed fishery, the recommended TAC can be set to cover this fishery and still allow limited catches on the Mourne spawning grounds.

7.2 The Fishery in 1983

Apart from the selective fishery in September on the Mourne spawning ground, nearly all the fish were caught west and southwest of the Isle of Man, off the Mull of Galloway, or Mid-Channel between N.Ireland and the Isle of Man. The level of fishing activity was agreed by a representative port committee. The fishery opened on 6 June 1983 and weekly quotas/boat operated up to 4 July; thereafter weekly quotas were recommended, but a 'carry over' was allowed for individual boats so that they could economise on effort if they wished. Catchers reported quantities of herring caught to a control boat of the United Kingdom Fisheries Protection Service. Only 35 vessels took part in the United Kingdom fishery in 1983 compared to 115 in 1980, 67 in 1981, and 49 in 1982. Nevertheless, the United Kingdom quota was taken early by 23 August. There was no fishing reported from east of the Isle of Man on the Manx spawning ground. The selective directed herring fishery opened on the Mourne spawning ground on 13 September and closed within 10 days, the quota having been reached.

7.3 Catch in Numbers at Age

The total catch in numbers of fish per age group from 1974-83 is shown in Table 7.3. This has been estimated from data from samples of landings in N.Ireland, the Republic of Ireland and the Isle of Man.

The total catches in the years prior to 1983 for the separate Manx and Mourne fisheries have been combined, using the data present at the 1982 Working Group meeting.

As in 1982, there were persistent reports and some sampling evidence of considerable discarding of young herring from the catches made by Northern Ireland and Manx fleets in June and July. It was, therefore, considered impossible to make a reliable estimate of numbers caught at age 1. The figure for this age given in Table 7.3 is that representing 1-ring fish in the declared catch only, as in previous years.

7.4 Mean Weights at Age

For the purpose of the combined assessment, a set of mean weights at age was estimated, based on N.Irish, Irish and Manx data. For age groups 2 to 8+, these were derived from a straight mean between data sets for Manx and Mourne stocks and are consistent with those used in previous assessments. There was a reduction of about 30% in the mean weight of 1-ring herring in 1983 compared with previous years; fewer 1-ring fish than usual were taken in the latter part of the season when some of them are at stage IV and V. The weights used are given in the text table below:

Age (w.r.)	1	2	3	4	5	6	7	8+
Weight (g)	72	168	203	225	243	260	276	284.

7.5 Maturity at Age

The division between immatures and the adult components of the Mourne and Manx stocks was based on maturity ogives, which have been calculated from Northern Ireland samples of herring taken during the 1983 fishing season by pelagic trawl and gill net. These estimates, together with the previous Working Group estimates, are given in the text table below

Age	1983 estimates			Previous WG estimates	
	Mourne	Manx	Combined	Mourne	Manx
1	0.11	0	0.08	0.33	0
2	0.84	0.85	0.85	1.00	1.00
3 and older	1.00	1.00	1.00	1.00	1.00

The 1983 maturity ogives are somewhat different from those adopted by the 1977 Working Group. The current estimates are now considered to be the best available data on maturity proportions at age. Consequently, the 1983 maturity ogive for the total N.Irish Sea herring stock was used for all subsequent calculations.

7.6 Estimation of Fishing Mortality

There are no data independent of the fishery from which stock size and fishing mortality can be estimated. The Working Group considered that effort data could be used to estimate F in 1983 in order to initiate a VPA.

The only effort data available are the numbers of landings by trawlers in N.Ireland and the Isle of Man. From 1979 to 1981 boats worked to daily quotas, for 1982 to weekly quotas and for 1983 to weekly quotas with a roll-over to the following week (see Section 7.2). The effect of the change in the quota system is unknown, but the major change in the number of landings occurred before 1981 when the system changed, indicating a major decline in effort. The effort data are shown plotted in Figure 7.1, together with weighted mean F_{2-7} for the period 1979-83 derived from trial VPAs assuming input F_{2-8} of 0.15, 0.2 and 0.3. All plots show a declining trend with the major drop between 1980 and 1981. The mean value for 1979 and 1980 was considered in relation to the mean value for 1981-83 for all plots and is given in the text table below.

		Mean 1979-80 (A)	Mean 1981-83 (B)	A/B
Effort (no. of landings)		2 278	617	3.69
Trends in F assuming input	0.15	0.99	0.29	3.41
$F_{(2-8+)}$	0.20	1.04	0.35	2.94
	0.30	1.09	0.46	2.36

The input F which produces a trend in mean F_{2-7} over the period which corresponds most closely to the effort data is F = 0.15. Because of a possible effect on the effort data by the change in quota system, it was decided to adopt F = 0.2 on 2-ring fish and older as the input values for assessment.

The exploitation pattern derived from a trial VPA indicated that full exploitation is reached at 2-rings, while F on 1-ringers was approximately 15% of that on older fish in the years 1980-82. It was not possible to determine the proportional F on this age group for 1983, because of the problems raised by discards. The Working Group considered it unrealistic to compute a stock size for 1-ring fish from catch data adjusted for discards and an assumed F. For the purposes of prediction, an estimate of the stock of 1-ring fish was derived from the stock/recruit relationship shown in Figure 7.2.

Terminal F values in 1983 and earlier years were taken from the mean weighted values of F for age groups 2-7 derived from the trial VPA.

7.7 Results from VPA

The results from a final VPA, with the input values discussed above, are summarised in Tables 7.4 and 7.5, which give mortality at age, stock in numbers at age and spawning stock biomass at spawning time. The spawning stock biomass at spawning time in 1981 was estimated at 7 000 tonnes, in 1982 at 11 000 tonnes and in 1983 at 17 000 tonnes. The figure for 1983 excludes the small contribution to the spawning stock biomass made by 1-ring spawners. The VPA indicates that the spawning stock biomass was very low in 1980 and that it has increased each year since then.

7.8 Recruitment

As explained in Section 7.3, the catch in numbers of 1-ring herring in 1983 derived from reported catches and aged samples of landed herring is not a reliable basis for estimating recruitment in 1983. A 'Shepherd' stock/recruitment curve was calculated from the results of VPA (Figure 7.2). Recruitment of 1-ring fish in 1983 and 1984 was estimated from the equation to the curve, and the figures rounded to the nearest million. There are as yet insufficient data to make an estimate of recruitment in 1985 from spawning stock biomass in 1983; for the purpose of projection, this has been assumed equal to recruitment in 1984. The text table below gives the estimates for 1983 and 1984, together with those for earlier years derived from VPA.

Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Recruits No.$\times 10^{-6}$	158	253	142	145	109	125	94	53	54	63	83	50	74
Parent stock biomass t $\times 10^{-3}$	x	x	32	31	22	15	12	8	10	9	5	7	11

x = VPA commences 1972.

7.9 State of the Stock

Figure 7.3 shows that the decline in stock biomass which was characteristic of the 1970s has been halted. The total biomass at 1 January each year appears to have been increasing modestly from the low value in 1980; spawning stock biomass at spawning time has increased more; catches since 1980 have been relatively low as a result of low TACs. Estimates from VPA of stock size in 1982 and 1983 must be treated with caution, but it appears that the stock is recovering. Continued cautious management should result in increasing spawning stock biomass and increasing recruitment. The text table below gives projections based on a recruitment in 1983 of 50 x 10^6 1-ring fish, and 74 x 10^6 in 1984 and 1985.

1983				1984				1985			
Stock biom. 1 Jan.	Spawn. stock biom. at sp. time	F	Catch	Option	Stock biom. 1 Jan.	Spawn. stock biom. at sp. time	Catch	F	Stock biom. 1 Jan.	Spawn. stock biom. at sp. time	Catch
27.3	17.1	0.2	3.9	TAC 1984 =3 000 t F =0.117	33.1	22.4	3.0	$F_{0.1}$=0.15	41.4	27.9	4.9
								0.2	"	26.5	6.4
								0.3	"	24.1	9.1
				$F_{0.1}$ F=0.15	33.1	21.7	3.8	$F_{0.1}$=0.15	40.6	27.2	4.8
								0.2	"	25.9	6.2
								0.3	"	23.5	8.9

Catch and biomass in tonnes x 10^{-3}.
Stock biomass = Σ weight of stock at age 1 to 8+.
Spawning stock biomass = Σ weight of stock at age 1 to 8+ at spawning time x maturity ogive.
Weight at age from text table in Section 7.4.

Yield per recruit and long-term biomass per recruit curves based on the mean weight at age and exploitation pattern used in the VPA are shown in Figure 7.3. The Y/R curve is virtually asymptotic and has an $F_{0.1}$ point at F = 0.15.

7.10 Management Considerations

7.10.1 TAC

The Working Group accepts that a single N.Irish Sea assessment is more appropriate to the fishery than separate assessments for Manx and Mourne stocks. The Working Group, therefore, recommends that a single TAC be set for herring in the North Irish Sea.

The 1983 Working Group reported that it would be prudent to examine data from the 1983 fishery before considering management for 1984. ACFM, therefore, made a provisional recommendation for a TAC in 1984 of 3 000 tonnes. This is lower than the catch derived from exploitation at the management reference F of $F_{0.1} = 0.15$ (see text table in Section 7.9). Predictions to 1984 and 1985 indicate that $F_{0.1}$ would result in a catch in 1984 of 3 800 tonnes, in 1985 of 4 800 tonnes, and allow a continued increase in spawning stock biomass. Accordingly, the Working Group suggests that ACFM amends the recommendation for 1984 to 3 800 tonnes for the North Irish Sea.

Catches of 4 000 - 5 000 tonnes taken in each of the last three years appear to have allowed an increase in spawning stock despite low recruitment.

Both Manx and Mourne stocks appear to be increasing steadily and maintaining their relative strengths with a ratio Manx/Mourne of 3:1. So long as the major part of the single TAC is not taken on either of the main spawning grounds, there should be no danger of a disproportionate effort on one stock.

7.10.2 Other Conservation Measures

Management of the North Irish Sea fishery in the past has included measures to limit fishing mortality on the spawning stock by closure of the fishery from the Saturday nearest to 21 September until the Monday nearest to 16 November, except for a small, selective gill-net fishery on the Mourne spawning ground, prohibition of directed herring fishery in the nursery areas, and a minimum size regulation of 20 cm. These measures should be continued in 1984. Gill-net catches on the Mourne spawning ground should not exceed 600 tonnes. The catch taken should count against the total TAC for the N.Irish Sea.

Re-definition of nursery areas

In 1977, the Working Group recommended the closure of defined nursery areas (Doc. C.M.1977/H:3). In recent years, there have been numerous reports from N.Irish fishermen of substantial shoals of adult herring inside the 12-mile Irish coast limit between Belfast Lough (54°40'N) and St. John's Point (54°10'N). However, because of the absence of any reliable data on the stock composition in this area, the Working Group could not evaluate the above reports. The Working Group, therefore recommends that more detailed information on the distribution of juvenile and adult herring in that area be collected during 1984 and that the situation should be re-assessed in 1985.

8. THE ICELANDIC SPRING- AND SUMMER-SPAWNING HERRING

8.1 The Fishery

No signs of recovery of the Icelandic spring-spawning herring were observed, and the fishery in 1983 was entirely based (99.7%) on Icelandic summer spawners.

The landings of summer-spawning herring from 1969-83 are given in Table 8.1. The 1983 landings were about 58 700 tonnes. Of these, about 18 300 tonnes were taken in drift-nets, 900 tonnes by set-nets and 39 500 by purse-seines. The fishery took place during the last four months of the year. The text table below gives the catches, the TACs set and the TACs recommended during the last four years for this fishery.

Landings and TACs (in tonnes x 10^{-3}) of Icelandic summer-spawning herring in 1980-1983

Year	Landings	TACs	Rec. TACs
1980	53.3	50.5	45.0
1981	39.5	42.5	40.0
1982	56.5	50.0	50.0
1983	58.7	52.5	50.0

8.2 Catch in Number, Weight at Age and Age Distribution

The catch in numbers by age for the Icelandic summer-spawners are given in Table 8.1 for the period 1969-83. During the period 1975-77 the catches were predominated by one year class, i.e., the 1971 year class. During the period 1979-82 the year classes from 1974 and 1975 predominated in the age distribution. In 1983, this is completely changed, because the age distribution is very much predominated by the strong 1979 year class. Out of 280 million herring caught in 1983, 80 million were immature or about 30% by numbers. This is the highest proportion of immature herring in this fishery for several years and is associated with the recruitment of the very strong 1979 year class. The weight at age for each year as well as the maturity at age is given in Tables 8.2 and 8.3, respectively.

8.3 Acoustic Abundance Surveys in December 1983 and January 1984

The state of the Icelandic summer-spawning herring has been monitored by acoustic abundance surveys since 1973. It has been shown (Jakobsson, 1982) that the acoustic estimates are correlated with the subsequent VPA outputs.

During the period December 1983 - January 1984 large concentrations of herring were assembled at the head of one fjord at East Iceland. In addition, some concentrations had also assembled at the western south coast of Iceland. Repeated acoustic estimates were obtained on these concentrations in December 1983 and January 1984. Based on the mean weights at age from the sampling of these wintering concentrations and values for back-scattering cross section (Haldórsson and Reynisson, 1982) the biomass of the wintering grounds was about 310 000 tonnes of herring. Of these, about 250 000 tonnes were assembled at the head of one east coast fjord. Based on 6 trawl hauls about 90% of the herring in that fjord belonged to 1-, 2- and 3-ringers with very few older herring in the samples. In the trawl samples taken at the south coast, the proportion of older herring was considerably higher, as is shown in Table 8.4. The acoustic estimates thus obtained and the catches in 1983 (also given in Table 8.4) were used to calculate the fishing mortalities in 1983. On this basis, the fishing mortality for the adult herring was $F_{4+} = 0.3$. For the 3-ringers it was F = 0.14. The acoustic estimate of the 3-ringers (1979 year class) was 940 x 10^6 herring. This is a much higher estimate than obtained for any other year class in this stock. It was, therefore, considered justifiable to use a higher input F of 0.2 for this assessment. This is 2/3 of the adult F instead of the usual half of the adult F for the 3-ringers. The fishing mortality for the 2-ringers was $F_2 = 0.05$ and the F for 1-ringers was $F_1 = 0.005$. The data used for these calculations are given in Table 8.4.

8.4 VPA Outputs

Using the catch at age data given in Table 8.1, and input Fs as described above, a VPA was run. The outputs of fishing mortality at age, stock in numbers at age and spawning stock biomass at 1st of July are given in Tables 8.5 and 8.6, respectively. The results of this assessment indicate that the fishing mortalities during the period 1978-82 have been considerably higher than assessed previously, and the spawning stock has correspondingly been about 25% lower than previously assessed for that period. With the recruitment of the strong 1979 year class there is, however, a sharp increase in the stock abundance in 1983 and 1984.

There may be several reasons for the difference between this assessment and the previous ones. During the acoustic surveys in the winter 1983/84, the major part of the herring was concentrated at the head of one narrow fjord. Sampling with pelagic trawl under these circumstances can be very difficult, and it is possible that the younger year classes have been overestimated with the corresponding underestimate of the older year classes. In the VPA, this would result in higher fishing mortalities on these year classes during the last four years or so. It is also possible that the older year classes were not present in the east coast fjords when the survey was carried out in December 1983. At the end of January 1984, the main herring concentrations had started to leave the innermost part of the fjord, and a sample (catch of 10 tonnes) taken then contained a higher proportion of 4-ringers and older herring than obtained in December. The low catches of the 4-ringers and older herring during the 1983 season are most likely explained by a concentration of fishing effort on the very strong recruiting 1979 year class.

According to the present assessment the spawning stock biomass increased from about 11 000 tonnes in 1972 to about 170 000 tonnes in 1978. During the period 1979-82 it has remained between 170 000 and 200 000 tonnes. IN 1984, the spawning stock is expected to increase sharply to about 260 000 tonnes.

8.5 Management Considerations

Catches have been calculated over a range of Fs for 1984, using the starting parameters given in Table 8.7. The stock in numbers data are derived from Table 8.6, apart from the 1-ringers which are assumed to be 400 million. This age group is practically absent from the catch and has no effect on the results. Weight at age for the catch are rounded mean weights from the previous few years. The exploitation pattern is similar to that experienced in the last few years. Resulting catches and spawning stock biomass over a range of Fs are illustrated in Figure 8.1. For this population the Y/R and spawning stock biomass recruit are also shown in Figure 8.1

Projections of stock abundance and catches in thousand of tonnes for a range of values of Fs are given in the text table below.

1983		1984			1985
Catch	F_{4+}	Spawn. stock at 1 July	F_{4+}	Catch	Spawning stock at 1 July
59	0.3	260	0.15	36	290
			0.20	47	280
			0.22= $F_{0.1}$	51	275
			0.30= F_{83}	68	260

During the last five years (1979-83), the fishing mortality in the adult component of this stock has been about 0.3. This is well in excess of the $F_{0.1}$ level (i.e., the target exploitation rate), which for this stock is $F_{0.1} = 0.22$. Despite this, the spawning stock abundance is increasing at present due to the recruitment of the strong 1979 year class. The Working Group recommends that the exploitation rate of this stock should be reduced to the $F_{0.1}$ level in 1984. This can be done without severe reduction in catches because of the relatively high level of recruitment at present.

9. DENSITY-DEPENDENT GROWTH

The 1983 Working Group was asked to extract from their data files information relevant to density-dependent population parameters and present the result in working papers to the 1984 Working Group meeting.

Working documents were presented on Manx, Celtic Sea, central and southern North Sea stocks, and Icelandic summer-spawning herring. Length for age and stock size both increased in the Celtic Sea and Manx herring over a long period of years. Therefore, there is no evidence for compensatory growth in either Manx or Celtic Sea herring. In both Downs and Bank herring, the high mean lengths recorded in the late 1970s correspond with year classes derived from the period of lowest spawning stock biomasses. Furthermore, with the increased spawning stock biomasses of recent years, reduction in mean length has occurred for both Downs and Bank herring. Icelandic summer-spawning herring show clear evidence of density-dependent growth. In this stock, the mean weight at age increased and the age at first maturity decreased during the early 1970s when stock abundance was low. A reduction in growth and in the proportion of 2-ringers that spawned paralleled the increase of spawning stock sizes of the mid- and late 1970s. From the Icelandic data it was clear that failure to take account of change in these population parameters can seriously bias the estimates of the spawning stock.

Detailed reports of the above investigations will be presented at the 1984 Statutory Meeting of ICES, where density-dependent growth has been designated a special topic.

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Table 2.1 HERRING. Catch in tonnes 1973-1983 North Sea (Subarea IV and Division VIId) by country.
(National catches as officially reported. Unallocated catches provided by W.G. members).

Country \ Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983*
Belgium	2 160	603	2 451	2 451	57	-	-	-	-	9 700	5 969
Denmark	174 254 a)	61 728	115 616	34 841	12 769	4 359	10 546	4 431	21 146	67 851	10 468
Faroe Islands	54 935 b)	26 161 b)	25 854	14 378	8 070	40	10	-	-	-	-
Finland	-	-	-	1 034	-	-	-	-	-	-	-
France	22 235	12 548	20 391	14 468	1 613	2 119	2 560	5 527	15 099	15 310	16 353
German Dem. Rep.	1 728	3 268	2 689	2 624	2	-	-	-	-	-	-
Germany, Fed. Rep.	10 634 c)	12 470	6 953	1 654	221	24	10	147	2 300 c)	349 c)	1 837
Iceland	23 742 d)	29 017	16 286	9 412	-	-	-	-	-	-	
Netherlands	34 070	35 106	38 416	20 146	4 134	18	-	509	7 700	22 656	49 000
Norway	99 739	40 975	34 183	27 386	4 065	1 189	3 617	2 165	70	680	32 512
Poland	5 738	9 850	7 069	7 072	2	-	-	-	-	-	-
Sweden	4 222 e)	3 561	6 858	4 777	3 616	-	-	-	-	-	284
U.K. (England) f)	2 268	5 699	6 475	9 662	3 224	2 843	2 253	77	303	3 730	111
U.K. (Scotland) f)	16 012	15 034	8 904	15 015	8 159	437	-	610	45	1 780	17 260
USSR	30 735	18 096	20 653	10 935	78	4	162	-	-	-	-
Total North Sea	484 012	275 116	312 798	174 834	46 010	11 033	19 158	13 466	46 663	122 056	133 794
Total including unallocated catches							25 148	60 994	140 972	235 569	308 169

*)Preliminary
a) Total includes 2 107 t for human consumption unspecified to area
b) Supplied by Fiskirannsóknarstovan
c) From Federal Republic of Germany national statistics compiled by Federal Research Board for Fisheries, Hamburg
d) Excludes 15 938 t caught on Skagerrak border and allocated to that area on the basis of age analysis
e) Swedish catches in Danish ports reported by area (North Sea, Skagerrak) used for area allocation of Swedish landings reported as Skagerrak and North Sea in Swedish Statistics
f) Catches from Moray Firth not included

Table 2.2.1 HERRING, catch in tonnes in Division IVa West

Year / Country	1979	1980	1981	1982	1983
Belgium	-	-	-	-	-
Denmark	437	687	11 357	3 155	4 282
France	493	651	1 851	1 970	680
Fed.Rep. Germany	10	-	-	48	1 542
Netherlands	-	-	-	-	19 700
Norway	-	-	-	-	16 971
UK (England)	-	-	-	-	-
UK (Scotland)	6	18	2	1 706	16 136
Sweden	-	-	-	-	213
Unallocated	0	1 762	6 492	300	2 213
Total	946	3 118	19 702	7 179	61 738

Table 2.2.2 HERRING, catch in tonnes in Division IVa East

Year / Country	1979	1980	1981	1982	1983
Belgium	-	-	-	-	-
Denmark	-	-	-	491	-
France	68	-	-	-	-
Fed.Rep. Germany	-	-	-	-	-
Netherlands	-	-	-	-	-
Norway	1 250	21	70	680	-
UK (England)	-	-	-	-	-
UK (Scotland	-	-	-	-	257
Unallocated	0	2 476	937	0	431
Total	1 318	2 497	1 007	1 171	688

Table 2.2.3 HERRING, catch in tonnes in Division IVb

Country \ Year	1979 Juv.	1979 Adult	1980 Juv.	1980 Adult	1981 Juv.	1981 Adult	1982 Juv.	1982 Adult	1983 Juv.	1983 Adult
Belgium	-	-	-	-	-	-	-	-	-	-
Denmark	10 107	-	3 733	-	9 689	-	64 205	-	-	6 050
France	-	448	-	176	-	524	-	561	-	705
Germany, Fed.Rep.	-	-	147	-	2 300	-	118	-	-	-
Netherlands	-	-	35	-	-	-	-	-	-	300
Norway	2 367	-	1 607	-	-	-	-	-	5 688	8 468
UK (England)	2 252	-	76	-	-	13	-	3 128	-	40
UK (Scotland)	156	-	592	-	33	10	74	-	867	-
Sweden	-	-	-	-	-	-	-	-	-	71
Unallocated	1 030		9 258		65 811	0	88 544	1 937	153 254	5 870
Total	16 360		15 624		77 833	547	152 941	5 626	159 809	21 504

Table 2.2.4 HERRING, catch in tonnes in Divisions IVc and VIId

Country \ Year	1979	1980	1981	1982	1983
Belgium	-	-	-	9 700	5 969
Denmark	-	11	100	-	135
France	1 551	4 700	12 724	12 799	14 968
Germany, Fed.Rep.	-	-	-	183	295
Netherlands	-	474	7 700	22 656	29 000
Norway	-	482	-	-	1 385
UK (England)	1	1	290	602	71
UK (Scotland)	-	-	-	-	-
Unallocated	5 000	37 418	21 069	22 732	12 606
Total	6 552	43 086	41 883	68 652	64 430

Table 2.3. HERRING. North Sea catch in millions of fish by age.

Year	Area	Age in winter rings 0	1	2	3	4	5	6	7	8	>8	Total
1973	IVaW of 2°E	-	52.5	742.1	452.6	58.0	39.5	20.3	2.6	0.5	0.6	1 368.7
	IVaE of 2°E	-	0.3	16.2	23.1	6.3	7.2	1.0	0.3	0.8	-	55.2
	IVb	-	242.5	180.1	39.0	28.3	4.7	7.2	-	-	-	501.8
	IVbYH	289.4	2 070.5	362.5	29.4	2.6	0.5	0.2	0.3	-	-	2 755.4
	IVc+VIId,e	-	2.2	43.3	115.1	55.0	7.4	1.9	0.5	0.1	0.0	225.5
	Total NS	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	IVaW of 2°E	65.3	162.9	98.5	112.9	97.1	36.0	18.6	4.5	1.5	1.0	598.3
	IVaE of 2°E	5.7	131.8	24.2	10.8	1.0	-	-	-	0.1	-	173.6
	IVb (adult)	-	54.0	493.7	212.3	19.5	18.9	3.6	0.3	0.4	0.1	802.8
	IVbYH	925.1	493.5	132.1	5.7	-	-	-	-	-	-	1 556.4
	IVc+VIId		3.9	24.1	20.3	8.4	1.2	0.1	0.2	-	-	58.2
	Total NS	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3 189.3
1975	IVaW of 2°E	-	267.0	120.0	69.0	49.0	40.2	9.8	6.3	2.9	1.1	565.3
	IVaE of 2°E	-	82.5	8.2	7.0	2.4	0.4	0.1	0.1	-	-	100.7
	IVb (adult)		268.8	147.1	124.2	81.2	14.8	5.8	2.7	0.5	0.3	645.4
	IVbYH	262.8	1 818.1	139.2	19.8	2.6	-	0.4				2 242.9
	IVc+VIId	1.0	24.1	127.2	39.6	5.3	1.8					199.0
	Total NS	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	IVaW of 2°E	-	19.4	572.9	56.3	17.9	13.2	3.6	2.6	0.5	0.3	686.7
	IVaE of 2°E	-	-	10.6	1.1	0.5	0.5	0.4	-	-	-	13.1
	IVb (adult)	0.9	35.5	205.9	17.6	28.4	20.3	1.8	1.8	0.5	0.1	312.8
	IVbYH	237.3	49.5	17.7	0.5	1.7	-	-	-	-	-	306.7
	IVc+VIId	-	22.2	94.4	41.8	3.5	0.5	0.3	-	-	-	162.7
	Total NS	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1 482.0
1977	IVaW of 2°E	2.6	2.7	9.3	171.7	8.6	3.8	2.1	0.9	0.2		201.9
	IVaE of 2°E	0.4	3.3	+	4.9	1.2	1.1	1.0	0.6	0.5	+	13.0
	IVb (adult)	-	1.1	25.9	6.8	0.3	1.9	1.0	-	+	-	37.0
	IVbYH	253.8	136.3	3.1	-	-	-	-	-	-	-	393.2
	IVc+VIId	-	0.9	6.4	3.0	0.7	0.2	+	+	-	-	11.2
	Total NS	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7		656.3
1978	IVaW of 2°E			0.1	0.1	1.5	0.2	0.1	+	+	+	2.0
	IVaE of 2°E				0.2	1.2	-	+	0.2	0.2	0.3	2.1
	IVb (adult)		0.2	0.6	1.4	1.1	0.1	0.1	+			3.5
	IVb (indust.)	130.0	168.0	1.4								299.4
	IVc+VIId		0.4	2.8	4.0	1.2	+	+				8.4
	Total NS	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	IVaW of 2°E		1.9	0.4	0.3	2.2	0.5	+	+	+		5.3
	IVaE of 2°E		-	2.4	0.3	+	+	+				2.7
	IVb (adult)		0.5	2.1	0.4	2.2	0.9	0.1	0.4	0.3		6.9
	IVb (indust.)	542.0	156.4	7.6	-	0.1	0.1	+	0.4	0.3	0.1	707.0
	IVc+VIId		0.4	21.6	9.0	5.6	0.6	0.1				37.3
	Total NS	542.0	159.2	34.1	10.0	10.1	2.1	0.2	0.8	0.6	0.1	759.2
1980	IVaW of 2°E		+	2.2	6.5	1.2	2.7	0.6	0.8	0.4	0.1	14.5
	IVaE of 2°E	166.8	-	+	0.1	0.1	0.1	+	+	+		167.1
	IVb (adult)		0.4	0.7	0.4	0.1	0.2	+	+	+	+	1.8
	IVb (indust.)	624.9	137.3	6.0	1.0	0.6	0.3	+	0.1	+		770.2
	IVc+VIId	+	23.4	99.1	83.8	30.2	18.4	1.7	0.5	+	+	257.1
	Total NS	791.7	161.1	108.0	91.8	32.2	21.7	2.3	1.4	0.4	0.1	1 210.7
1981	IVaW of 2°E	20.0	3.7	0.7	7.6	17.7	20.1	17.9	18.0	5.4	1.1	112.1
	IVaE of 2°E	-	0.1	0.1	0.4	1.1	1.5	1.1	0.1	-	-	4.5
	IVb (adult)	-	-	0.8	0.4	0.3	0.3	0.4	+	+	+	2.4
	IVb (indust.)	7 868.7	435.9	40.0	8.0	1.0	-	-	-	-	-	8 353.6
	IVc+VIId	-	7.3	222.6	40.4	19.3	6.7	3.3	0.6	-	-	300.4
	Total NS	7 888.7	447.0	264.3	56.9	39.5	28.5	22.7	18.7	5.5	1.1	8 773.1
1982	IVaW of 2°E	0.3	-	0.9	2.6	5.6	6.9	4.3	5.9	3.0	0.9	30.4
	IVaE of 2°E	-	4.3	7.0	-	-	-	-	-	-	-	11.3
	IVb (adult)	0.1	28.6	12.6	4.3	1.6	0.7	0.3	0.4	0.1	0.1	48.8
	IVb (indust.)	9 552.4	786.6	46.7	1.8	-	-	-	-	-	-	10 387.5
	IVc+VIId	3.9	20.9	201.2	221.4	26.5	6.8	2.2	1.5	0.5	0.1	485.0
	Total NS	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	IVaW of 2°E	-	51.9	126.8	74.9	27.5	13.5	18.4	12.3	10.9	12.1	348.3
	IVaE of 2°E	-	0.9	4.6	0.5	0.1	-	-	-	-	-	6.1
	IVb (adult)	-	98.2	60.2	29.7	12.7	1.6	1.4	-	-	-	203.8
	IVb (indust.)	10 029.1	970.5	101.5	6.2	0.3	-	-	-	-	-	11 107.6
	IVc+VIId	0.8	25.1	251.7	105.1	64.5	11.1	3.0	0.5	0.5	0.1	462.4
	Total NS	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

Table 2.4 Millions of HERRING caught annually per age group (winter rings) in the North Sea 1970-1983

Year \ Winter rings	0	1	2	3	4	5	6	7	8	> 8	Total
1970	898.1	1 196.2	2 002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5 249.3
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	7888.7	447.0	264.3	56.9	39.5	28.5	22.7	18.7	5.5	1.1	8 772.9
1982	9556.7	840.4	268.4	230.1	33.7	14.4	6.8	7.8	3.6	1.1	10 963.0
1983	10029.9	1 146.6	544.8	216.4	105.1	26.2	22.8	12.8	11.4	12.2	12 128.2

Table 2.5 O-group abundance indices and estimated numbers of 2-ringed Downs HERRING.

Year Class	No./hour	VPA 2-ringers x 10^6
1975	24	69
1976	31	176
1977	70	258
1978	2 153	877
1979	159	782
1980	524	1 237
1981	1 474	1 189 (estimates)
1982	972	1 077 (")

Table 2.6 Abundance indices (a) in thousand/hour, mean length ($\bar{l}$ cm) and standard deviation (s.d.) for year class components.

Year class		COMPONENT 1	2	3	4
1970	a	4.70	45.67	33.11	
	l	12.8	15.0	18.0	
	s.d.	0.59	0.74	0.85	
1971	a	5.80	14.76	26.85	
	l	14.9	15.9	16.7	
	s.d.	0.77	0.85	0.84	
1972	a	9.58	12.52	25.38	
	l	13.7	15.6	18.4	
	s.d.	1.02	0.91	0.75	
1973	a	4.31	19.65	47.58	
	l	12.9	14.9	18.0	
	s.d.	1.15	1.02	0.85	
1974	a	5.07	13.11	11.40	
	l	13.3	14.9	17.6	
	s.d.	0.76	1.13	0.91	
1975	a	3.39	5.27	13.21	
	l	13.1	14.4	17.2	
	s.d.	0.95	1.05	0.90	
1976	a	4.11	11.47	12.32	
	l	14.0	15.3	17.9	
	s.d.	0.85	1.48	0.94	
1977	a	1.95	1.84	2.83	
	l	12.4	14.9	17.1	
	s.d.	0.75	1.11	0.88	
1978	a	13.11	5.05	14.39	
	l	11.10	13.5	16.2	
	s.d.	0.71	0.91	1.32	
1979	a	8.83	10.67	16.33	
	l	13.1	14.9	17.1	
	s.d.	0.98	.87	1.16	
1980	a	35.12	12.74	7.04	
	l	12.1	14.9	18.1	
	s.d.	0.89	0.98	1.08	
1981	a	46.55	38.08	20.67	9.48
	l	13.4	15.4	17.0	10.8
	s.d.	0.70	0.90	1.0	0.6

Table 2.7 Estimated numbers at age ($x\ 10^{-6}$) from acoustic surveys in July 1982 and 1983 in the northwestern North Sea.

1982*			1983				
Age	Year Class	"Scotia"	Year Class	"Scotia" A	"G O Sars" (1)	"G O Sars" (2)B	Mean of A&B
0	1981	-	1982	-	-	-	-
1	1980	22.7	1981	769.4	379.2	925.2	847.3
2	1979	589.2	1980	396.9	307.0	571.0	484.0
3	1978	178.1	1979	378.4	192.6	300.5	339.4
4	1977	49.0	1978	67.4	66.9	87.0	77.2
5	1976	111.1	1977	58.9	47.8	57.4	58.2
6	1975	27.5	1976	58.5	97.3	97.3	77.9
7	1974	44.2	1975	42.4	78.1	78.1	60.2
8	1973	92.0	1974	49.6	62.3	62.3	56.0
9	pre 1973	6.0	pre 1974	5.7	48.5	48.5	27.1
Biomass (t)		233 000		198 000	223 000	302 000	250 000

* From 1983 report (Doc. C.M.1983/Assess:9)

(1) Estimate from 44 rectangles surveyed

(2) Each age group raised to total survey area covered by "Scotia"

Table 2.8 Input parameters for VPA - Division IVa, including the Buchan area. (Nos.at age x 10^{-6})

Age	Estimated no at 15 July 1983 (acoustic s.)	Catch in no. age to 15 July	F in period up to 15 July	No. in stock at 1 Jan 1983	Catch in no. whole year	F over 1983
0	-	-	-	-	-	-
1	1 016.8	1.4	0.00134	1 074	52.8	0.053
2	580.8	83.8		701	131.4	
3	407.3	39.2		468	75.4	
4	92.6	16.0		114	27.6	
5	69.8	7.3		82	13.5	
6	93.5	10.1		109	18.4	
7	72.2	7.1		83	12.3	
8	67.2	5.8		77	10.9	
9	32.5	6.0		40	12.1	
≥ 2	1 415.9	175.3	0.114	1 671	301.6	0.21

Table 2.9 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN NORTH SEA (FISHING AREA IVA)

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	294.7	349.5	19.4	6.0	0.0	1.9	0.0	4.8	4.3	52.8
2	122.7	128.2	583.5	9.3	0.1	2.8	2.2	0.3	17.9	131.4
3	123.7	76.0	57.4	176.6	0.3	0.6	6.6	8.0	2.6	75.4
4	98.1	51.4	18.4	9.8	2.7	2.2	1.3	18.8	5.6	27.6
5	36.0	40.6	13.7	4.9	0.2	0.5	2.8	21.6	6.9	13.5
6	18.6	9.9	4.0	3.1	0.1	0.0	0.6	19.0	4.3	18.4
7	4.5	6.4	2.6	1.5	0.2	0.0	0.8	16.1	5.9	12.3
8	1.6	2.9	0.5	0.7	0.2	0.0	0.4	5.4	3.0	10.9
9+	1.0	1.1	0.3	0.0	0.3	0.0	0.1	1.1	0.9	12.1
TOTAL	700.9	666.0	699.8	211.9	4.1	8.0	14.8	97.6	51.4	354.4

Table 2.10 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN NORTH SEA (FISHING AREA IVA)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.706	0.300	0.105	0.037	0.000	0.015	0.000	0.009	0.006	0.053
2	0.563	0.680	1.028	0.060	0.001	0.015	0.019	0.004	0.040	0.210
3	0.847	0.727	0.658	0.919	0.002	0.005	0.040	0.082	0.016	0.210
4	0.993	0.944	0.338	0.194	0.026	0.018	0.011	0.139	0.069	0.210
5	1.106	1.197	0.623	0.126	0.005	0.005	0.026	0.229	0.062	0.210
6	1.168	0.955	0.251	0.245	0.003	0.000	0.007	0.221	0.058	0.210
7	0.724	1.821	0.625	0.126	0.020	0.000	0.024	0.276	0.089	0.210
8	1.000	1.400	0.600	0.300	0.020	0.000	0.015	0.200	0.060	0.210
9+	1.000	1.400	0.600	0.300	0.020	0.000	0.015	0.200	0.060	0.210
(4- 7)U	0.975	1.207	0.459	0.173	0.013	0.006	0.017	0.216	0.070	0.210
(2- 8)W	0.731	0.802	0.926	0.519	0.008	0.010	0.023	0.138	0.047	0.210

Table 2.11 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN NORTH SEA (FISHING AREA IVA)

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: 0.670
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.670

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	608	1412	205	174	217	134	211	536	809	1074	********
2	298	271	947	167	152	197	120	191	480	728	922
3	226	154	124	306	142	138	175	106	172	418	534
4	172	88	67	58	111	128	124	152	89	153	306
5	56	63	31	43	43	97	114	111	120	75	112
6	28	17	19	15	35	39	88	101	80	102	55
7	9	8	6	13	11	31	35	79	73	68	75
8	3	4	1	3	11	0	28	31	54	60	50
9+	2	2	1	0	16	0	7	6	16	67	93
TOTAL NO	1402	2019	1400	780	737	764	902	1313	1892	2745	
SPS NO	443	333	608	415	483	585	637	663	982	1357	
TOT.BIOM	137941	102924	169652	105843	96755	117862	140770	158209	197069	293886	
SPS BIOM	74796	55059	89398	71888	89892	109535	129734	132945	178148	238768	

Table 2.12 Herring larval indices - North Sea 1972-83.

Spawning stock biomass t x 10^{-3}

Year	VPA	Acoustic Survey*	Larval indices		
			Orkney-Shetland	Buchan	North coast England
1972	183.1	-	2 128	3	104
1973	125.0	-	945	4	446
1974	74.8	-	403	272	112
1975	55.1	-	152	116	54
1976	89.4	-	314	1	43
1977	71.9	-	909	59	121
1978	89.9	-	3 345	119	104
1979	109.5	-	3 325	79	147
1980	129.7	-	2 074	8	51
1981	132.9	191	2 341	9	335
1982	178.1	202	1 926	232	385
1983	238.8	251	1 725	1 802	523

*Excluding Buchan area; immature 2-ringers excluded

Table 2.13 VIRTUAL POPULATION ANALYSIS

HERRING IN THE CENTRAL NORTH SEA (FISHING AREA IVB)

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	427.7	268.7	176.2	22.5	1.8	9.2	6.6	40.9	58.3	161.7
3	152.2	129.1	14.1	5.1	1.0	0.3	1.3	8.5	6.1	35.9
4	13.5	74.1	23.6	0.2	0.8	1.7	0.7	1.4	1.6	13.0
5	13.0	13.0	15.6	1.4	0.1	0.8	0.4	0.2	0.7	1.6
6	2.8	4.5	1.4	0.7	0.1	0.1	0.0	0.4	0.3	1.4
7	0.2	1.9	1.5	0.0	0.0	0.7	0.1	0.0	0.4	0.0
8	0.3	0.4	0.4	0.0	0.0	0.5	0.0	0.1	0.1	0.0
9+	0.1	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
TOTAL	609.8	492.0	232.9	29.9	3.8	13.3	9.1	51.5	67.6	213.6

Table 2.14 VIRTUAL POPULATION ANALYSIS

HERRING IN THE CENTRAL NORTH SEA (FISHING AREA IVB)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	1.168	2.434	2.421	1.453	0.409	0.584	0.200	0.493	0.280	0.538
3	0.886	1.339	0.941	0.405	0.177	0.098	0.133	0.377	0.111	0.248
4	0.361	1.442	0.846	0.025	0.091	0.453	0.308	0.185	0.100	0.324
5	0.493	0.619	1.391	0.092	0.014	0.111	0.162	0.121	0.119	0.124
6	0.674	0.280	0.108	0.164	0.008	0.016	0.000	0.215	0.240	0.328
7	0.282	1.265	0.127	0.000	0.000	0.061	0.018	0.000	0.308	0.000
8	0.900	1.250	0.900	0.000	0.000	0.169	0.000	0.020	0.020	0.000
9+	0.900	1.250	0.900	0.000	0.000	0.169	0.000	0.020	0.020	0.000
(2- 6)U	0.716	1.223	1.141	0.428	0.140	0.252	0.160	0.278	0.170	0.312
(3- 6)U	0.603	0.920	0.822	0.171	0.072	0.169	0.151	0.225	0.143	0.256

Table 2.15 VIRTUAL POPULATION ANALYSIS

HERRING IN THE CENTRAL NORTH SEA (FISHING AREA 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: 0.667
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.667

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	646	304	200	31	6	22	58	110	251	407	********
3	270	122	24	16	6	3	11	28	61	171	215
4	47	101	43	9	10	5	5	9	18	49	121
5	35	29	22	17	8	8	5	2	7	14	32
6	6	19	14	5	14	7	6	2	1	5	12
7	1	3	13	12	4	12	6	6	2	1	3
8	1	1	1	11	11	3	11	5	5	1	1
9+	0	0	0	11	11	0	11	0	5	1	2
TOTAL NO	1005	639	317	109	68	66	88	162	349	650	
SPS NO	489	196	104	79	61	47	76	116	244	408	
TOT.BIOM	149207	104551	51061	22529	15855	12204	10955	24681	51241	97443	
SPS BIOM	75719	35513	19342	17848	14411	9942	14943	18103	37042	65068	

Table 2.16 . HERRING Divisions IVc and VIId - Calculation of fishing mortality in 1983.

HERRING Divisions IVc and VIId Catches by France, Netherlands and Belgium combined 1983

Numbers (x 10^{-6})	1 (1981)	2 (1980)	3 (1979)	4 (1978)	5 (1977)	6 (1976)	7 (1975)	8 (1974)	Total (x10^{-6})	Tonnes
NOV	6.90	99.93	49.13	20.71	3.75	0.98	0.23	-	181.63	28 536
(%)	(3.80)	(55.02)	(27.05)	(11.40)	(2.06)	(0.54)	(0.13)			
DEC	7.05	110.81	32.08	21.10	3.72	1.10		0.35	176.21	23 368
(%)	(4.00)	(62.89)	(18.21)	(11.97)	(2.11)	(0.62)		(0.20)		
November 1983 Acoustic Biomass Estimate Converted by NOV. Catch/Age Distribution:										
(No. x 10^{-6})	68.25	988.16	485.82	204.74	37.00	9.70	2.33	-	1,796.0	282x10^3
No. at 31 Dec (Adjusted by 'M' for one month)	67.68	979.96	481.79	203.04	36.69	9.62	2.31	-	1,781.1	279.7x10^3
Minus Dec Catch	60.63	869.15	449.71	181.94	32.97	8.52	2.31	-	1,605.23	256x10^3
1983 Annual Catch	25.1	251.7	105.1	64.5	11.1	3.0	0.5	0.5	461.9	64 430
F_{83}	0,331	0,243	0,200	0,290	0,277	0,288	0,187	(0,187)		

Table 2.17 VIRTUAL POPULATION ANALYSIS

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

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	177.2	144.8	141.8	12.9	3.0	22.1	99.3	222.6	201.2	251.7
3	36.1	54.5	45.8	4.7	4.4	9.1	83.9	40.4	221.4	105.1
4	14.4	15.0	10.0	0.8	1.5	6.2	30.2	19.3	26.5	64.5
5	7.1	3.6	5.2	0.7	0.0	0.8	13.5	6.7	6.8	11.1
6	0.9	1.7	0.7	0.3	0.0	0.1	1.7	3.3	2.2	3.0
7	0.3	0.8	0.3	0.0	0.0	0.1	0.5	0.6	1.5	0.5
8	0.1	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.5	0.5
9+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1
TOTAL	286.1	220.6	203.9	19.4	8.9	38.5	234.1	292.9	460.2	436.5

Table 2-18 VIRTUAL POPULATION ANALYSIS

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

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	1.229	1.331	2.382	0.234	0.047	0.141	0.515	0.309	0.314	0.240
3	1.508	1.709	3.255	0.455	0.105	0.175	1.000	0.361	0.508	0.240
4	1.355	1.136	2.443	0.672	0.227	0.189	1.184	0.577	0.379	0.240
5	1.419	1.576	1.647	1.700	0.013	0.163	1.140	0.816	0.363	0.240
6	0.644	1.757	1.732	0.315	0.074	0.161	0.536	0.547	0.614	0.240
7	0.902	2.109	2.649	0.077	0.014	1.831	2.949	0.325	0.456	0.240
8	1.231	1.502	2.293	0.675	0.093	0.166	0.875	0.522	0.435	0.240
9+	1.231	1.502	2.293	0.675	0.093	0.166	0.875	0.522	0.435	0.240
(2- 6)U	1.231	1.502	2.292	0.675	0.093	0.166	0.875	0.522	0.435	0.240

Table 2.19 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

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	261	205	161	65	69	176	258	877	782	1237	********
3	115	69	49	13	46	60	138	140	582	517	881
4	20	23	11	2	3	38	45	46	88	317	368
5	10	5	7	1	1	6	23	13	23	55	226
6	2	2	1	1	0	1	4	8	5	15	39
7	1	1	0	0	1	0	1	2	4	2	10
8	0	0	0	0	0	1	0	0	1	2	2
9+	0	0	0	0	0	0	0	0	0	0	2
TOTAL NO	408	305	229	82	125	281	475	1085	1486	2145	
SPS NO	100	68	17	56	105	217	209	704	909	1527	
TOT.BIOM	56	41	31	11	17	39	68	142	194	297	
SPS BIOM	13	9	2	7	14	30	29	91	117	211	

Table 2.20 VIRTUAL POPULATION ANALYSIS - SEASONAL

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

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	173.9	158.5	120.0	5.8	0.4	38.6	118.9	245.6	157.9	285.0
3	82.0	51.0	33.9	2.6	2.6	15.9	91.0	34.9	186.2	98.5
4	15.3	14.8	8.8	0.5	3.7	9.3	28.9	13.3	24.1	56.5
5	6.9	3.7	5.1	0.0	0.7	0.2	13.0	3.3	5.7	8.5
6	1.0	1.7	0.7	0.0	0.0	0.0	1.1	2.9	2.4	2.6
7	0.4	0.8	0.3	0.0	0.0	0.0	0.1	0.6	1.9	0.3
8	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.6	0.3
9+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
TOTAL	279.6	230.7	168.8	9.1	7.4	64.0	253.1	300.6	378.8	451.8

Table 2.21 VIRTUAL POPULATION ANALYSIS - SEASONAL

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

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	1.282	1.623	2.300	0.130	0.006	0.243	0.695	0.395	0.287	0.260
3	1.535	1.836	3.064	0.251	0.071	0.328	1.241	0.394	0.520	0.260
4	1.410	1.302	5.021	0.424	0.577	0.349	1.497	0.509	0.460	0.260
5	1.411	1.745	4.751	0.863	1.819	0.046	1.011	0.580	0.381	0.260
6	0.680	1.834	2.796	6.176	0.001	0.000	0.350	0.569	0.961	0.260
7	1.063	2.184	9.948	7.222	0.147	0.001	8.309	0.318	0.794	0.260
8	1.264	1.668	3.586	1.569	0.495	0.193	0.959	0.489	0.522	0.260
9+	1.264	1.663	3.586	1.569	0.495	0.193	0.959	0.489	0.522	0.260
(2- 6)U	1.264	1.668	3.586	1.569	0.495	0.193	0.959	0.489	0.522	0.260
(2- 8)U	1.235	1.742	4.495	2.377	0.445	0.166	2.009	0.465	0.561	0.260

Table 2.22 VIRTUAL POPULATION ANALYSIS - SEASONAL

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: 0.500
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.500

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	250	205	138	50	66	188	248	789	664	1305	********
3	109	63	37	12	39	59	133	112	481	451	911
4	21	21	9	2	9	33	39	35	68	259	315
5	9	5	5	0	1	4	21	8	19	39	181
6	2	2	1	0	0	0	4	7	4	12	27
7	1	1	0	0	0	0	0	2	4	1	8
8	0	0	0	0	0	0	0	0	2	1	1
9+	0	0	0	0	0	0	0	0	0	1	1
TOTAL NO	392	297	190	64	115	285	445	953	1241	2069	
SPS NO	190	124	50	56	106	237	268	742	973	1728	
TOT.BIOM	53	40	25	8	16	39	63	124	161	281	
SPS BIOM	26	17	6	7	14	32	37	96	125	235	

Table 2.24. Calculation of input parameters for VPA of A) Divisions IVa and IVb combined and B) total North Sea.

A

Age	No. at 1 January 1983 from individual stock VPA x 10^{-6}			Catch in number in 1983	F
	IVa	IVb	Sum	IVa + IVb combined	
2	728	407	1 135	293	
3	418	171	589	111	
4	153	49	202	41	
5	75	14	89	15	0.265
6	102	5	107	20	
7	68	1	69	12	
8	60	1	61	11	
≥ 9	67	1	68	12	
Σ	1 671	649	2 320	515	

B

Age	No.at 1 January 1983 from individual stock VPAs x 10^{-6}				Catch in number in 1983	F
	IVa	IVb	IVc	Sum	IVa,b,c combined	
0					10 030	0.82*)
1					1 147	0.235*)
2	728	407	1 237	2 372	545	
3	418	171	517	1 106	216	
4	153	49	317	519	105	
5	75	14	55	144	26	0.251
6	102	5	15	122	23	
7	68	1	2	71	13	
8	60	1	2	63	11	
≥9	67	1	1	69	12	
Σ 2+	1 671	649	2 146	4 466	951	

*) Matched to IYFS results for 1981 and 1982 year classes

VPA

Table 2.25 HERRING IN THE NORTHERN AND CENTRAL NORTH SEA (Fishing areas IVa and IVb)

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	748.5	414.5	807.1	38.3	2.1	12.5	8.9	41.6	67.2	293.1
3	341.7	220.0	75.5	183.4	1.7	1.0	8.0	16.4	8.7	111.3
4	117.6	135.2	48.5	10.1	3.8	4.5	2.0	20.1	7.2	40.6
5	54.9	55.4	34.0	6.8	0.3	1.5	3.3	21.9	7.6	15.1
6	22.2	16.1	5.8	4.1	0.2	0.1	0.6	19.4	4.6	19.8
7	4.8	9.1	4.4	1.5	0.2	0.8	0.9	18.1	6.3	12.3
8	2.0	3.4	1.0	0.7	0.2	0.6	0.4	5.4	3.1	10.9
9+	1.1	1.4	0.4	0.0	0.3	0.1	0.1	1.1	1.0	12.1
TOTAL	1292.8	855.1	976.7	244.9	8.8	21.1	24.2	144.0	105.7	515.2

Table 2.26 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN AND CENTRAL NORTH SEA (Fishing areas IVa and IVb)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	1.143	1.389	1.219	0.247	0.016	0.071	0.075	0.171	0.120	0.265
3	0.955	1.183	0.937	0.916	0.014	0.009	0.053	0.172	0.044	0.265
4	0.902	1.198	0.805	0.262	0.035	0.042	0.020	0.165	0.096	0.265
5	1.141	1.425	1.032	0.214	0.010	0.016	0.035	0.273	0.078	0.265
6	1.061	1.171	0.459	0.277	0.008	0.004	0.007	0.264	0.076	0.265
7	0.680	1.898	1.115	0.183	0.017	0.035	0.037	0.268	0.115	0.265
8	0.880	1.420	1.180	0.450	0.030	0.060	0.020	0.290	0.060	0.265
9+	0.880	1.420	1.180	0.450	0.030	0.060	0.020	0.290	0.060	0.265
(4- 7)U	0.946	1.423	0.853	0.234	0.018	0.024	0.025	0.243	0.091	0.265
(2- 7)W	1.062	1.304	1.153	0.594	0.020	0.038	0.042	0.203	0.098	0.265

Table 2.27 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN AND CENTRAL NORTH SEA (Fishing areas IVa and 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: 0.670
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.670

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
2	1144	574	1192	183	135	192	129	277	625	1320	********
3	579	330	129	319	130	121	162	109	211	501	916
4	206	202	92	46	116	116	108	139	83	183	348
5	84	76	55	37	32	101	100	96	107	68	127
6	35	24	16	18	27	29	90	88	66	89	47
7	10	11	7	9	12	24	26	81	61	55	62
8	4	5	2	2	7	11	21	22	56	49	38
9+	2	2	1	0	11	2	5	5	18	54	72
TOTAL NO	2065	1223	1494	614	469	595	642	816	1226	2320	
SPS NO	950	479	648	396	433	542	584	665	1076	1817	
TOT.BIOM	323129	202186	212239	105438	86861	111415	128624	157541	212090	374928	
SPS BIOM	150553	79743	94168	67541	80123	101877	117449	127462	186771	293590	

Table 2.28 Comparison of summed VPA results and combined VPAs Divisions IVa and IVb combined.

Year	Spawning stock size				Recruitment of 2-ringers			
	IVa	IVb	Sum	IVa,b combined	IVa	IVb	Sum	IVa,b combined
1972	183.1	43.8	226.9	230.9	1 718	504	2 222	2 239
1973	125.0	74.8	199.8	207.3	1 038	765	1 803	1 994
1974	74.8	73.7	148.5	150.6	298	646	944	1 144
1975	55.1	35.5	90.6	79.7	271	304	575	574
1976	89.4	19.8	109.2	94.2	947	200	1 147	1 192
1977	71.9	17.8	89.7	67.5	167	31	198	183
1978	89.9	14.4	104.3	80.1	152	6	158	135
1979	109.5	9.9	119.4	101.9	197	22	219	192
1980	129.7	14.9	144.6	117.4	120	38	158	129
1981	132.9	18.1	151.0	127.5	191	110	301	277
1982	178.1	37.0	215.1	186.8	480	251	731	625
1983	238.8	63.7	302.5	293.6	728	407	1 135	1 320

Table 2.29 VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	996.1	263.8	238.2	256.8	130.0	542.0	791.7	7888.7	9556.7	10029.9
1	846.1	2460.5	126.6	144.3	168.6	159.2	161.1	447.0	840.4	1146.6
2	772.6	541.7	901.5	44.7	4.9	34.1	108.0	264.3	268.4	544.8
3	362.0	259.6	117.3	186.4	5.7	10.0	91.8	56.9	230.1	216.4
4	126.0	140.5	52.0	10.8	5.0	10.1	32.2	39.5	33.7	105.1
5	56.1	57.2	34.5	7.0	0.3	2.1	21.7	28.5	14.4	26.2
6	22.3	16.1	6.1	4.1	0.2	0.2	2.3	22.7	6.8	22.8
7	5.0	9.1	4.4	1.5	0.2	0.8	1.4	18.7	7.8	12.8
8	2.0	3.4	1.0	0.7	0.2	0.6	0.4	5.5	5.6	11.0
9+	1.1	1.4	0.4	0.0	0.3	0.1	0.1	1.1	1.1	12.1
TOTAL	3189.3	3753.3	1482.0	656.3	315.4	759.2	1210.7	8772.9	10963.0	12127.7

Table 2.30 VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.214	0.486	0.464	0.346	0.188	0.305	0.315	1.097	0.944	0.820
1	0.710	1.045	0.404	0.504	0.356	0.328	0.125	0.263	0.270	0.235
2	1.129	1.303	1.366	0.216	0.025	0.101	0.343	0.276	0.222	0.251
3	0.949	1.492	1.030	1.105	0.035	0.059	0.378	0.273	0.364	0.251
4	0.800	1.135	1.441	0.204	0.062	0.072	0.242	0.246	0.230	0.251
5	1.083	0.952	0.854	0.659	0.007	0.030	0.194	0.311	0.120	0.251
6	1.038	0.969	0.209	0.196	0.030	0.005	0.038	0.284	0.102	0.251
7	0.676	1.705	0.683	0.065	0.012	0.145	0.041	0.425	0.133	0.251
8	0.940	1.280	0.800	0.190	0.010	0.040	0.090	0.200	0.120	0.251
9+	0.940	1.280	0.800	0.190	0.010	0.040	0.090	0.200	0.120	0.251
(4- 7)U	0.899	1.190	0.797	0.281	0.028	0.063	0.129	0.317	0.146	0.251
(2- 7)W	1.037	1.297	1.282	0.612	0.032	0.075	0.292	0.279	0.254	0.251

Table 2.31 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: 0.667
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.667

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0	5414	717	671	921	796	2160	3072	12333	16311	18709	********
1	1739	3953	399	382	590	597	1440	2028	3726	5742	7456
2	1189	773	1258	241	209	374	389	1150	1411	2574	4107
3	616	348	190	290	176	184	306	250	790	1022	1812
4	239	216	71	61	87	153	157	190	172	497	720
5	88	97	63	15	45	74	129	112	134	124	350
6	36	27	34	24	7	41	65	96	74	108	87
7	11	12	9	25	18	6	37	57	66	60	76
8	3	5	2	4	21	16	5	32	33	52	43
9+	2	2	1	0	32	3	1	6	10	57	77
TOTAL NO	9336	6150	2697	1963	1980	3608	5601	16254	22727	28944	
SPS NO	1027	586	656	430	545	758	841	1471	2131	3556	
TOT.BIOM	511478	447913	263816	144828	148861	209050	313228	592062	864602	1279530	
SPS BIOM	163916	96101	97588	72134	98531	131260	153077	237311	344193	563304	

Table 2.32 Comparison of summed VPA results with combined VPA for total North Sea.

Year	Spawning stock size					Recruitment of 2-ringers				
	IVa	IVb	IVc	Sum	Combined	IVa	IVb	IVc	Sum	Combined
1972	183.1	43.8	36.5	263.4	273.0	1 718	504	328	2 550	2 552
1973	125.0	74.8	19.5	219.3	227.8	1 038	761	276	2 075	2 080
1974	74.8	73.7	13.5	162.0	163.9	298	646	261	1 205	1 189
1975	55.1	35.5	9.2	99.8	96.1	271	304	205	780	773
1976	89.4	19.8	2.4	111.6	97.6	947	200	161	1 308	1 258
1977	71.9	17.8	7.2	96.9	72.1	167	31	65	263	241
1978	89.9	14.4	14.4	118.7	98.5	152	6	69	227	209
1979	109.5	9.9	30.0	149.4	131.3	197	22	176	395	374
1980	129.7	14.9	28.5	173.1	153.1	120	38	258	416	389
1981	132.9	18.1	91.4	242.4	237.3	191	110	877	1 178	1 150
1982	178.1	37.0	125.3	340.4	344.2	480	251	782	1 513	1 411
1983	238.8	63.7	215.1	517.6	563.3	728	407	1 237	2 372	2 574

LIST OF INPUT VARIABLES FOR THE ICES PREDICTION PROGRAM

Table 2.33

HERRING IN DIVISIONS IVA AND IVB COMBINED

FIRST YEAR: 1984
LAST YEAR: 1986

YEAR	RECRUITMENT millions
1984	3100.
1985	4300.
1986	4300.

PROPORTION OF F (fishing mortality) BEFORE THE SPAWNING SEASON: 0.67
PROPORTION OF M (natural mortality) BEFORE THE SPAWNING SEASON: 0.67

AGE	STOCK SIZE millions	F AT AGE	M	MATURITY OGIVE	WEIGHT IN THE CATCH gram	WEIGHT IN THE STOCK JJJJJ
2	3100.0	0.265	0.10	1.000	126.000	126.000
3	916.0	0.265	0.10	1.000	176.000	176.000
4	348.0	0.265	0.10	1.000	211.000	211.000
5	127.0	0.265	0.10	1.000	243.000	243.000
6	47.0	0.265	0.10	1.000	251.000	251.000
7	62.0	0.265	0.10	1.000	267.000	267.000
8	38.0	0.265	0.10	1.000	271.000	271.000
9+	72.0	0.265	0.10	1.000	271.000	271.000

LIST OF INPUT VARIABLES FOR THE ICES PREDICTION PROGRAM

Table 2.34

HERRING IN DIVISIONS IVC AND VIID

FIRST YEAR: 1984
LAST YEAR: 1986

YEAR	RECRUITMENT millions
1984	1000.
1985	1000.
1986	1000.

PROPORTION OF F (fishing mortality) BEFORE THE SPAWNING SEASON: 1.00
PROPORTION OF M (natural mortality) BEFORE THE SPAWNING SEASON: 1.00

AGE	STOCK SIZE millions	F AT AGE	M	MATURITY OGIVE	WEIGHT IN THE CATCH kilogram	WEIGHT IN THE STOCK kilogram
2	1000.0	0.260	0.10	1.000	0.120	0.120
3	380.5	0.260	0.10	1.000	0.151	0.151
4	367.7	0.260	0.10	1.000	0.173	0.173
5	225.6	0.260	0.10	1.000	0.200	0.200
6	38.8	0.260	0.10	1.000	0.230	0.230
7	10.5	0.260	0.10	1.000	0.230	0.230
8	1.7	0.260	0.10	1.000	0.230	0.230
9+	2.1	0.260	0.10	1.000	0.230	0.230

Table 3.1 HERRING in Division IIIa. Landings in tonnes 1973-1983
(Data mainly provided by Working Group members)

	Country/Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983*
Skagerrak	Denmark	42 098	35 732	29 997	7 326	19 889	6 425	5 153	5 180	18 001	22 881	54 102
	Faroe Islands	5 265	7 132	8 053	1 553	10 064	1 041	817	526	990	715	1 980
	Germany Fed.Rep.	-	36	108	6	32	28	181	-	199	43	40
	Iceland	15 938	231	1 209	123	-	-	-	-	-	-	-
	Norway (Open Sea)	836	698	196	-	-	1 860	2 460	1 350	6 330	10 140	5 300
	Norway (Fjords)	1 680	1 720	1 459	2 304	1 837	2 271	2 259	2 795	950	1 560	2 834
	Sweden	20 429	11 683	12 348	6 505	8 109	11 551	8 104	10 701	30 274	24 859	35 176
	Total	86 246	57 232	53 370	17 817	39 931	23 176	18 974	20 552	56 744	60 198	99 432
Kattegat	Denmark	78 125	54 540	48 974	41 749	38 205	29 241	21 337	25 380	18 721	12 366	62 901
	Sweden	40 418	39 779	23 769	30 263	37 160	35 193	25 272	18 260	38 871	38 892	40 463
	Total	118 543	94 319	72 743	72 012	75 365	64 434	46 609	43 640	57 592	51 258	103 364
Division IIIa Total		204 789	151 551	126 113	89 829	115 296	87 610	65 583	64 192	114 336	111 456	202 796
Unallocated								8 117	20 053	57 000	35 344	-4 800
GRAND TOTAL								73 700	84 245	171 336	146 800	197 996

* Preliminary

Table 3.2

HERRING IN FISHING AREA IIIA (KATTEGAT AND SKAGERRAK)

CATCH IN NUMBERS UNIT: MILLIONS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	2499	2006	433	934	147	457	682	3624	3334	4876
1	910	1471	1474	1437	876	168	467	966	965	2603
2	375	149	325	329	455	583	233	656	314	490
3	135	60	26	61	65	70	185	178	241	122
4	47	57	4	12	10	13	30	68	26	56
5	26	15	3	5	1	4	4	8	16	5
6	9	6	1	4	1	0	1	2	3	2
7	3	1	1	2	0	0	0	0	1	0
8+	1	1	1	0	0	0	0	0	0	0
TOTAL	4006	3766	2270	2784	1555	1296	1603	5502	4920	8154

Table 3.3 Length components of 1-group herring in Division IIIa from 1980-1984. Mean lengths

Year	Strata	Length components							
		l(cm)	p	l(cm)	p	l(cm)	p	l(cm)	p
1980	1	14.0	.73			17.0	.27		
	2	14.6	.14			16.2	.86		
	3	15.1	.09					18.01	.91
	4					16.2	.45	18.2	.55
1981	1	12.9	.34			16.9	.66		
	2					15.6	.47	18.0	.53
	3					16.3	.24	19.1	.76
	4					17.4	.81	19.6	.19
1982	1	13.9	.15	15.5	.85				
	2			15.5	.60			18.0	.40
	3					17.2	1.0		
	4					17.4	.80	19.6	.20
1983	1	14.3	.27			17.0	.73		
	2	14.4	.11			17.5	.89		
	3	13.8	.58			17.3	.42		
	4	14.0	.65			17.5	.35		
1984	1	13.5	.55			16.3	.45		
	2	13.3	.50			16.4	.50		
	3	13.9	.26			15.4	.74		
	4	14.2	.57			16.4	.43		

Table 3.4 Split of 1-group HERRING in spring-spawned and autumn-spawned indexes in Division IIIa.

Year	Strata	No/1hr hauls	Hauls	C_{spr}	C_{aut}
1984	1	54 619	6	3 755	3 072
	2	30 121	4	3 765	3 765
	3	61 913	8	2 012	5 727
	4	33 278	15	-	2 219
		Weighted mean		2 793	3 242
1983	1	57 643	9	1 729	4 675
	2	35 020	4	964	7 798
	3	52 045	6	3 773	2 732
	4	4 171	13	209	112
		Weighted mean		1 522	3 897
1982	1	5 906	4	1 476	0
	2	39 387	5	4 726	3 151
	3	6 293	5	-	1 259
	4	18 507	6	-	3 084
		Weighted mean		1 408	1 152
1981	1	30 823	6	1 747	3 391
	2	7 528	4	-	1 882
	3	6 058	9	-	673
	4	1 044	9	-	116
		Weighted mean		996	2 250

Table 3.5 Div. IIIa HERRING and western Baltic combined VPA

Year Class (spring spawners)	VPA 1 Jan.			Acoust. Oct.	VPA 1. Jan			Acoust. Oct.	VPA 1 Jan.			Acoust. Oct.	VPA 1 Jan.			Acoust. Oct.	VPA 1 Jan.		
	SA	Seas	Add		SA	Seas	Add		SA	Seas	Add		SA	Seas	Add		SA	Seas	Add.
1975	213	166	169	38	76	57	58	28	35	26	27	1	11	6	8	2	4	1	4
1976	864	685	707	1 288	321	244	256	84	121	85	95	3	41	21	29	6	16	3	10
1977	3 327	2 506	2 557	1 338	1 646	1 285	1 339	474	572	404	448	24	202	104	142	19	82	14	47
1978					1 740	1 205	1 278	404	958	681	750	62	349	185	247	53	141	28	82
1979									3 954	2 175	2 343	1 396	2 206	1 049	1 214	344	1 091	256	404
1980													230	2 116	1 487	1 550	783	1 382	816
1981																			

SA: Separate VPA, stocks added after run

Seas: 22 & 24 catches allocated to 1. half year, Div. IIIa catches allocated to 2. half year

Add: Catches added on annual basis

Add: $F_2 = 0.5$ $F_{3-8} = 1.0$ $M = 0.1$

Seas: $F_2 = 0.4$ $F_{3-4} = 1.3$ $F_{5-8} = 1.5$ $M = 0.1$

SA: 22-24 : $F_2 = 0.22$ $F_3 = 0.45$ $F_{4-8} = 0.70$ $M = 0.3$

Div IIIa : $F_{2-8} = 0.8$

Table 3.6 Div. IIIa HERRING

	Areas 22 + 24		Div. IIIa	
W.R.	Combined VPA	Single VPA	Combined VPA	Single VPA
2	0.22	0.29	0.42	1.20
3	0.67	0.72	0.30	1.21
4	0.87	0.88	0.26	1.19
5	0.76	0.76	0.18	1.14
6	0.71	0.73	0.20	1.27
7	0.77	0.76	0.07	(1.12)
$\bar{UF}$	0.67	0.69	0.24	1.19

Calculated fishing mortalities averaged for 1975-80. Comparison between a combined VPA for Div. IIIa and Sub-areas 22+24 (Belt Seas - western Baltic) and VPAs done for each area separately. The combined VPA was run on half-yearly basis assuming all 22-24 catches taken in 1. half year and all Div. IIIa catches being attributable to the 2. half year.

M assumed = 0.1

Single SA 22+24 VPA assumed M = 0.3

Single Div. IIIa VPA assumed M = 0.1

Table 4.1 Annual Celtic Sea and Division VIIj HERRING, 1974-83. (Data provided by Working Group members.)

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	United Kingdom	USSR	Unallocated	Total
1974	2 261	-	433	16 276	2 105	954	-	-	-	22 029
1975	1 924	-	361	10 587	2 825	512	24	1 054	-	17 287
1976	1 919	147	28	5 986	1 627	324	-	826	-	10 857
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

Table 4.2 Celtic Sea and Division VIIj HERRING by season (1 April to 31 March) (Data provided by Working Group members).

Season	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	United Kingdom	USSR	Unallocated	Total
1974/75	2 150	-	435	13 939	2 462	954	-	-	-	19 940
1975/76	2 451	-	399	8 640	2 441	579	24	1 054	-	15 588
1976/77	1 317	147	36	5 864	1 324	257	-	826	-	9 771
1977/78	95	-	96	6 264	1 378	-	-	-	-	7 833
1978/79	8	-	220	8 239	1 002	-	-	-	-	7 559
1979/80	584	-	20	7 932	850	-	-	-	935	10 321
1980/81	9	-	2	9 024	292	-	-	-	3 803	13 130
1981/82	123	-	-	15 830	1 150	-	-	-	-	17 103
1982/83	+	-	-	13 042	-	-	-	-	-	13 042
1983/84*	495	-	-	10 000	1 500	-	-	-	9 186	21 181

*Provisional

Table 4.3 VIRTUAL POPULATION ANALYSIS

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

CATCH IN NUMBERS UNIT: THOUSANDS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	5507	12768	13317	8159	2800	11335	7162	39361	15339	11484
2	42808	15429	11113	12516	13385	13913	30093	21285	42725	87253
3	17184	17783	7286	8610	11948	12399	11726	21861	8728	22895
4	22530	7333	7011	5280	5583	8636	6535	5505	4817	2735
5	4225	9006	2872	1585	1540	2889	2812	4438	1497	1579
6	3737	3520	4785	1898	1476	1316	2204	3436	1891	277
7	2978	1644	1980	1043	547	1283	1184	795	1670	315
8	903	1136	1243	383	658	551	1262	513	355	790
9+	827	1194	1769	470	482	635	565	866	596	261
TOTAL	100699	69813	51376	39944	38652	52957	63595	97860	77598	127589

Table 4.4 VIRTUAL POPULATION ANALYSIS

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

MEAN WEIGHT AT AGE OF THE STOCK UNIT: KILOGRAM

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.115	0.115
2	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.174	0.174
3	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.211	0.211
4	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.198	0.229	0.229
5	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.209	0.244	0.244
6	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.222	0.257	0.257
7	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.218	0.260	0.260
8	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.232	0.263	0.263
9+	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.238	0.266	0.266

Table 4.5 VIRTUAL POPULATION ANALYSIS

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

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1974-80
1	0.13	0.27	0.21	0.15	0.07	0.14	0.15	0.26	0.05	0.16	0.16
2	0.73	0.54	0.35	0.27	0.55	0.48	0.60	0.73	0.44	0.40	0.47
3	0.69	0.68	0.47	0.44	0.40	0.56	0.83	1.08	0.67	0.40	0.58
4	0.72	0.63	0.55	0.65	0.51	0.51	0.57	1.11	0.65	0.40	0.59
5	0.43	0.63	0.48	0.21	0.36	0.47	0.27	0.86	0.96	0.40	0.41
6	0.50	0.67	0.73	0.59	0.27	0.51	0.71	0.54	1.02	0.40	0.57
7	0.73	0.36	0.89	0.30	0.30	0.35	1.07	0.53	0.49	0.40	0.57
8	0.69	0.61	0.48	0.37	0.38	0.49	0.60	0.82	0.40	0.40	0.52
9+	0.69	0.61	0.48	0.37	0.38	0.49	0.60	0.82	0.40	0.40	0.52
(1- 7)W	0.58	0.50	0.36	0.29	0.29	0.34	0.47	0.48	0.20	0.36	
(2- 7)W	0.69	0.61	0.48	0.36	0.38	0.50	0.62	0.87	0.50	0.40	

Table 4.6 VIRTUAL POPULATION ANALYSIS

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

STOCK SIZE IN NUMBERS UNIT: THOUSANDS

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: 0.200
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.500

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1974-80
1	48548	57120	74519	61183	45499	88764	54957	179547	322456	81510	********	61513
2	86307	38697	39571	54787	47612	38508	69552	42926	125116	277191	62848	53576
3	36077	37635	20409	25269	37700	30390	21667	34462	18724	72734	168125	29878
4	45762	16397	17239	11566	14707	22789	15763	8532	10579	8689	44116	20603
5	12764	20112	7900	8963	5472	8021	12443	8031	2553	5016	5270	10811
6	9962	7546	9679	4429	6606	3453	4522	8591	3077	880	3043	6602
7	5985	5494	3499	4235	2211	4577	1879	2008	4521	1001	534	3983
8	1893	2601	3413	1297	2843	1489	2925	584	1064	2510	607	2351
9+	1734	2734	4857	1592	1597	1716	1309	1615	1893	829	2025	2220
TOTAL NO	249052	188335	161087	173320	164246	199707	185017	286297	489964	450360		
SPS NO	188705	136270	126187	127514	126011	136520	134810	166497	296036	363432		
TOT.BIOM	41090	30554	27830	26381	26109	29825	28064	38745	68594	77532		
SPS BIOM	32149	23264	20667	20470	20943	21781	21834	24111	44526	64168		

LIST OF INPUT VARIABLES FOR THE ICES PREDICTION PROGRAM

Table 4.7

CELTIC SEA HERRING DIVISIONS VIIG-J

FIRST YEAR: 1984
LAST YEAR: 1986

YEAR	RECRUITMENT thousands
1984	122000.
1985	93000.
1986	93000.

PROPORTION OF F (fishing mortality) BEFORE THE SPAWNING SEASON: 0.20
PROPORTION OF M (natural mortality) BEFORE THE SPAWNING SEASON: 0.50

AGE	STOCK SIZE thousands	F AT AGE	M	MATURITY OGIVE	WEIGHT IN THE CATCH kilogram	WEIGHT IN THE STOCK kilogram
1	122000.0	0.160	0.10	0.500	0.115	0.115
2	62846.0	0.400	0.10	1.000	0.174	0.174
3	168125.0	0.400	0.10	1.000	0.211	0.211
4	44116.0	0.400	0.10	1.000	0.229	0.229
5	5270.0	0.400	0.10	1.000	0.244	0.244
6	3043.0	0.400	0.10	1.000	0.257	0.257
7	534.0	0.400	0.10	1.000	0.260	0.260
8	607.0	0.400	0.10	1.000	0.263	0.263
9+	2025.0	0.400	0.10	1.000	0.266	0.266

Table 5.1 Catch in weight, Division VIa (North) 1973-1983

Country	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983*
Denmark	932	-	374	249	626	128	-	-	1 580	-	-
Faroes	10 003	5 371	3 895	4 017	3 564	-	-	-	-	74	834
France	2 441	411	1 244	1 481	1 548	1 435	3	2	1 243	2 069	1 313
German Dem.Rep.	251	200	600	279	-	-	-	-	-	-	-
Germany Fed.Rep.	9 663	8 687	5 582	4 084	-	26	-	256	3 029	8 453	6 283
Iceland	2 532	9 566	2 633	3 273	-	-	-	-	-	-	-
Netherlands	27 892	17 461	12 024	16 573	8 705	5 874	-		5 602	11 317	20 200
Norway	32 557	26 218	509	5 183	1 098	4 462	-		3 850	13 018	7 336
Poland	2 062	334	376	390	-	-	-		-	-	-
Sweden	-	-	-	2 206	261	-	-		-	-	-
UK(England)	-	45	125	20	301	134	54	33	1 094	90	-
UK(Scotland)	120 800	107 475	85 395	53 351	25 238	10 097	3	15	30 389	38 381	31 616
USSR	1 137	2 392	1 244	2 536	-	-	-	-	-	-	-
Unallocated	-	-	-	-	-	-	-	-	4 633	18 958	-4 059
TOTAL	208 270	178 164	114 001	93 642	41 341	22 176	60	306	51 420	92 360	63 523

* Preliminary

Table 5.2 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN PART OF VIA

CATCH IN NUMBERS UNIT: THOUSANDS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	536119	82676	8225	11508	108199	1614	0	3003	219	144
1	309016	172879	69053	34836	22525	392	12867	56740	13504	81923
2	124944	202087	319604	47739	46284	225	1535	77961	250010	77810
3	151025	89066	101548	95834	20567	122	452	105600	72179	92743
4	519178	63701	35502	22117	40692	31	246	61341	93544	29262
5	82466	188202	25195	10083	6679	21	62	21473	58452	42535
6	49633	30601	76289	12211	3833	12	43	12623	23580	27318
7	34629	12297	10918	20992	2100	7	40	11583	11516	14709
8	22470	13121	3914	2758	6278	2	3	1309	13814	8437
9+	21042	13698	12014	1486	1544	0	1	1326	4027	8484
TOTAL	1850572	868328	662262	259564	258921	2426	15049	332959	540645	383365

Table 5.3 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN PART OF VIA

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.470	0.276	0.032	0.032	0.205	0.005	0.000	0.015	0.009	0.023
1	0.573	0.241	0.347	0.163	0.074	0.001	0.048	0.070	0.074	0.072
2	0.561	0.817	0.809	0.380	0.302	0.001	0.003	0.598	0.774	0.684
3	0.797	0.893	1.201	0.534	0.250	0.001	0.002	0.357	0.693	0.653
4	0.892	0.838	1.009	0.623	0.403	0.000	0.002	0.331	0.543	0.594
5	0.915	0.861	0.852	0.793	0.530	0.000	0.001	0.250	0.531	0.450
6	1.215	0.950	0.944	1.265	0.712	0.002	0.001	0.268	0.422	0.450
7	0.854	1.023	0.980	0.652	0.665	0.002	0.006	0.212	0.370	0.450
8	0.879	0.855	0.985	0.628	0.363	0.001	0.001	0.228	0.373	0.450
9+	0.879	0.855	0.985	0.628	0.363	0.001	0.001	0.228	0.373	0.450
(2- 7)U	0.872	0.897	0.966	0.741	0.465	0.001	0.002	0.303	0.556	0.547

Table 5.4 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN PART OF VIA

STOCK SIZE IN NUMBERS UNIT: THOUSANDS

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: 0.670
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.670

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0	1490004	359684	276552	379699	613617	320085	634365	219051	1368957	6654	********
1	740947	845854	247023	242416	332626	452518	288090	573997	195350	1238476	5884
2	304508	377999	601309	158045	166268	279568	409063	248445	484461	164118	1042771
3	287136	157278	151158	242211	97756	124644	252749	368884	150919	202147	74932
4	917648	117148	58240	41154	128441	68919	112606	228267	233609	68518	95201
5	143522	340259	45847	19219	16350	77656	62331	101711	148379	122887	34130
6	73615	52038	130189	17695	7865	8264	70246	56340	71657	78924	70899
7	62461	20011	18214	45820	4519	3493	7434	63520	39003	42495	45535
8	40086	23823	6512	6183	21606	2103	5154	6734	46462	24375	24518
9+	37539	24871	19988	3331	5314	0	1051	6322	13559	24511	28205
TOTAL NO	4103666	2318963	1555032	1155772	1414362	1337269	1841221	1873772	2752427	1972905	
SPS NO	1991674	587436	528443	346254	348722	577797	857788	897495	730278	464850	
TOT.BIOM	397352	260090	177084	109549	108210	126893	170060	229551	218938	234612	
SPS BIOM	167190	94819	77025	55530	53306	77549	128657	132085	117726	79581	

Table 5.5 Predictive regression between larval indices (numbers x 10^{-9}) and spawning stock biomass (t x 10^{-3} age 2 and older) in Division VIa (North). Regression based on data from 1972-82.

Year	larval index	Spawning stock biomass
1972	2 871	447
1973	1 913	315
1974	1 095	167
1975	1 039	95
1976	375	77
1977	1 040	54
1978	649	53
1979	1 290	78
1980	2 185	129
1981	2 484	132
1982	2 533	118
1983	834	82*

*Predicted from regression equation

$$Y = 5.456 + 0.092\ x \quad (r = 0.63)$$

Table 5.6 HERRING, Division VIa North.
Mean number of 2-ringers per hour fishing in the Scottish Young Fish Survey and VPA estimates of 2-ringers in the stock.

Year	Survey estimate	VPA (millions)
1980	6 768	409
1981	1 157	248
1982	2 173	484
1983	14	164
1984	13 578	[1043]

LIST OF INPUT VARIABLES FOR THE ICES PREDICTION PROGRAM

Table 5.7

HERRING IN DIVISION VIA(NORTH)

FIRST YEAR: 1984
LAST YEAR: 1986

YEAR	RECRUITMENT thousands
1984	600000.
1985	330000.
1986	330000.

PROPORTION OF F (fishing mortality) BEFORE THE SPAWNING SEASON: 0.67
PROPORTION OF M (natural mortality) BEFORE THE SPAWNING SEASON: 0.67

AGE	STOCK SIZE thousands	F AT AGE	M	MATURITY OGIVE	WEIGHT IN THE CATCH kilogram	WEIGHT IN THE STOCK kilogram
2	600000.0	0.684	0.10	1.000	0.121	0.121
3	74932.0	0.653	0.10	1.000	0.158	0.158
4	95201.0	0.594	0.10	1.000	0.175	0.175
5	34130.0	0.450	0.10	1.000	0.186	0.186
6	70899.0	0.450	0.10	1.000	0.206	0.206
7	45535.0	0.450	0.10	1.000	0.218	0.218
8	24518.0	0.450	0.10	1.000	0.224	0.224
9+	28205.0	0.450	0.10	1.000	0.224	0.224

Table 5.8 Monthly landings (tonnes) of HERRING from the Firth of Clyde (all fishing methods combined). (Data provided by the Working Group.)

Month	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
January	*	*	*	*	4*	4*	6*	15*	2*	+ *
February	91*	68*	7*	*	6*	8*	3*	15*	16*	1*
March	168*	85	69*	*	7*	13*	8*	14*	1*	1*
April	398	369	521	530	246	12*	4*	32*	2*	-*
May	280	283	436	544	245	4*	2*	25*	615	1*
June	607	203	281	640	238	336	114	429	850	265
July	690	354	332	494	376	466	656	982	757	519
August	543	240	473	601	587	450	645	511	262	681
September	310	515	541	559	581	374	559	106	-*	604
October	451	811	598	556	653	263	79	-*	-*	457
November	245	571	595	560	647	1*	3*	2*	-*	1*
December	91	120	236	328	272	-*	2*	4*	1*	-*
Not known	189	44	50	35						273 1)
Total	4 053	3 663	4 139	4 847	3 862	1 951	2 081	2 135	2 506	2 803

* Subject to closure of directed fishery.

1) Landed in Northern Ireland and Isle of Man during July and August.

Table 5.9 VIRTUAL POPULATION ANALYSIS

CLYDE HERRING

CATCH IN NUMBERS UNIT: THOUSANDS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	86	0	0	0	0	0	380	0	427	479
1	5308	12694	6194	1041	14123	507	333	312	220	314
2	3841	1876	10480	7524	1796	4859	5633	2372	11311	10109
3	2817	2483	913	6976	2259	807	1592	2785	4079	5232
4	2559	1024	1049	1062	2724	930	567	1622	2440	1747
5	1140	1072	526	1112	634	888	341	1158	1028	963
6	494	451	638	574	606	341	204	433	663	555
7	700	175	261	489	330	289	125	486	145	415
8	253	356	138	251	298	156	48	407	222	189
9	87	130	178	146	174	119	56	74	63	85
10+	59	67	100	192	236	154	68	18	53	38
TOTAL	22344	20328	20477	19367	23180	9050	9347	9667	20651	20126

Table 5.10 VIRTUAL POPULATION ANALYSIS

CLYDE HERRING

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.002	0.000	0.000	0.000	0.000	0.000	0.009	0.000	0.012	0.001
1	0.533	0.380	0.341	0.104	0.677	0.027	0.020	0.008	0.005	0.010
2	0.787	0.322	0.547	0.784	0.235	0.459	0.411	0.171	0.410	0.300
3	0.583	0.466	0.229	0.765	0.533	0.141	0.238	0.326	0.436	0.300
4	0.541	0.383	0.325	0.401	0.686	0.354	0.125	0.359	0.466	0.300
5	0.437	0.404	0.308	0.595	0.394	0.440	0.189	0.358	0.361	0.300
6	0.453	0.321	0.397	0.570	0.672	0.338	0.151	0.345	0.318	0.300
7	0.554	0.254	0.277	0.531	0.669	0.703	0.178	0.560	0.166	0.300
8	0.526	0.538	0.291	0.415	0.637	0.688	0.208	1.190	0.477	0.300
9	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.300
10+	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.300
(2- 7)U	0.567	0.358	0.347	0.608	0.527	0.406	0.215	0.353	0.359	0.300

Table 5.11 VIRTUAL POPULATION ANALYSIS

CLYDE HERRING

STOCK SIZE IN NUMBERS UNIT: THOUSANDS

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: 0.750
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.750

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0	46566	24837	12186	33178	21965	19732	43793	50191	37095	505597	********
1	13442	42053	22474	11027	30020	19875	17854	39264	45415	33159	455218
2	16946	7138	26019	14462	8988	13810	17502	15839	35231	40684	29705
3	6670	6931	4680	13623	5978	6429	7893	10498	12079	21160	27405
4	6411	3369	3965	3368	5735	3270	5050	5631	6858	7065	14184
5	3095	3379	2078	2593	2041	2614	2077	4031	3558	3895	4736
6	1421	1721	2041	1332	1294	1246	1524	1555	2550	2245	2611
7	1722	818	1129	1242	707	598	604	1185	997	1678	1505
8	647	896	574	774	661	326	266	609	612	764	1125
9	231	346	473	388	463	316	149	197	168	344	512
10+	157	178	266	511	628	410	181	48	141	154	333
TOTAL NO	97308	91716	75886	82547	78480	68627	97095	129049	144704	614944	
SPS NO	21315	17200	27242	21137	17561	20381	26331	29628	42395	57924	
TOT.BIOM	12459	13827	14140	12266	12230	10958	12453	17274	23412	30254	
SPS BIOM	5700	4734	6965	5667	4706	5336	6876	7757	10766	14752	

Table 5.12 Input parameters for Clyde HERRING catch prediction.

Age	Stock in winter at 1 Jan 1984 x 10^{-3}	$\bar{w}$ (g)	Exploitation pattern
0	34 555	10	.015
1	30 486	160	.045
2	29 705	225	1
3	27 405	270	1
4	14 184	290	1
5	4 736	310	1
6	2 611	328	1
7	1 505	340	1
8	1 125	345	1
9	512	350	1
≥10	333	350	1

Recruitment of 0-ringers in 1985 and 1986 = 34 555 x 10^3

Table 6.1. Estimated catches in weight in Divisions VIa (south) and VIIb,c, 1974-83.

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983*)
Belgium	-	-	12	-	-	-	-	-	-	-
France	145	68	47	-	-	-	-	-	353	19
German Dem.Rep.	1 833	1 394	890	-	-	-	-	-	-	-
Germany, Fed.Rep.	5 667	4 431	924	221	100	5	-	2 687	265	-
Ireland	16 395	12 465	10 895	15 916	19 128	18 910	27 499	19 443	16 856	15 000
Netherlands	2 225	15 208	16 546	4 423	481	1 939	1 514	2 790	1 735	5 000
Poland	6 034	2 558	2 778	6	-	-	-	-	-	-
United Kingdom (N. Ireland)	28	6	1	1	6	2	1	2	-	-
USSR	4 262	2 634	674	-	-	-	-	-	-	-
Unallocated	-	-	-	-	-	1 752	1 110	-	-	13 000
Total	36 589	38 764	32 767	20 567	19 715	22 608	30 124	24 922	19 209	33 019

*) Provisional data

Table 6.2 VIRTUAL POPULATION ANALYSIS

HERRING IN FISHING AREAS VIIB,C AND LOWER VIA (W. COAST OF IRELAND, PORCUPINE BANK)

CATCH IN NUMBERS UNIT: THOUSANDS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0	194	823	0	82	4	0	0	0	0
1	3374	7360	16613	4485	10170	5919	2656	1620	748	1517
2	29406	41308	29011	44512	40320	50071	40058	22265	18136	43688
3	41116	25117	37512	13396	27079	19161	64946	41794	17004	49534
4	44579	29192	26544	17176	13308	19969	25140	31460	28220	25316
5	17857	23718	25317	12209	10635	9349	22126	12812	18280	31782
6	8882	10703	15000	9924	5556	8422	7748	12746	8121	18320
7	10991	5909	5298	5534	4270	5443	6946	3461	4089	6695
8	10272	9378	3596	1360	3638	4423	4344	2735	3249	3329
9+	30549	32029	15703	4150	3524	4090	5334	5220	2675	4251
TOTAL	196936	184908	175327	112746	118232	126851	179498	134113	100722	184432

Table 6.3 VIRTUAL POPULATION ANALYSIS

HERRING IN FISHING AREAS VIIB,C AND LOWER VIA (W. COAST OF IRELAND, PORCUPINE BANK)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.02	0.05	0.08	0.03	0.03	0.02	0.02	0.01	0.01	0.01
2	0.20	0.29	0.27	0.30	0.30	0.21	0.17	0.18	0.10	0.40
3	0.30	0.23	0.41	0.18	0.27	0.20	0.40	0.25	0.18	0.40
4	0.46	0.32	0.36	0.30	0.24	0.29	0.40	0.31	0.24	0.40
5	0.52	0.42	0.45	0.25	0.27	0.23	0.52	0.32	0.26	0.40
6	0.36	0.60	0.45	0.29	0.15	0.32	0.27	0.56	0.31	0.40
7	0.25	0.39	0.58	0.27	0.17	0.20	0.42	0.17	0.31	0.40
8	0.32	0.32	0.38	0.26	0.25	0.24	0.22	0.26	0.21	0.40
9+	0.32	0.32	0.38	0.26	0.25	0.24	0.22	0.26	0.21	0.40
(1- 9)W	0.26	0.27	0.29	0.20	0.17	0.16	0.25	0.20	0.15	0.32
(2- 9)W	0.32	0.32	0.38	0.27	0.26	0.23	0.31	0.26	0.19	0.40

Table 6.4 VIRTUAL POPULATION ANALYSIS

HERRING IN FISHING AREAS VIIB,C AND LOWER VIA (W. COAST OF IRELAND, PORCUPINE BANK)

STOCK SIZE IN NUMBERS UNIT: THOUSANDS

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: 0.670
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.670

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0	163818	240664	204587	354626	328082	175919	237556	170388	177044	0	********
1	193430	148229	217577	184336	320879	296785	159174	214950	154174	160196	0
2	171053	171815	127128	181087	162530	280676	262913	141312	192954	138791	143509
3	165853	126861	116282	87508	121634	108822	206439	199660	106725	157363	84181
4	126861	111073	99953	69671	66461	84367	80278	125245	141183	80426	95445
5	46113	72561	72620	57135	46750	47508	57396	48813	83489	100967	48781
6	30700	24818	43182	41908	40113	32164	34114	30986	32018	58200	61240
7	51096	19358	12330	24663	28506	31210	21117	23517	15974	21269	35300
8	39311	35890	11915	6229	17247	21739	23073	12526	17993	10576	12900
9+	116913	122577	52032	19007	15758	20103	28331	23907	15922	13505	14606
TOTAL NO	1195148	1073847	948608	1026369	1147962	1099291	1110392	991504	937477	741293	
SPS NO	565269	517851	382382	381546	392664	503522	544942	475827	498966	415681	
TOT.BIOM	162326	146217	121955	107974	125454	138958	139939	131720	124545	118345	
SPS BIOM	104626	95905	69178	65949	68730	83754	90782	82963	86510	74343	

Table 6.5 Parameters predicting yield at spawning stock biomass in Div. VI south and VIIb in 1984 and 1985.

Age	Stock Size 1984	F-pattern	Weight in Catch and stock
1	182 000	0.10	0.090
2	143 509	1.00	0.129
3	84 181	1.00	0.165
4	95 445	1.00	0.191
5	48 781	1.00	0.209
6	61 240	1.00	0.222
7	35 300	1.00	0.231
8	12 900	1.00	0.237
9+	14 606	1.00	0.241

Recruitment in 1984 and 1985 (1 w. ringers) = 182 million

Table 7.1 HERRING. Total catches (tonnes) in North Irish Sea (Division VIIa), 1974-83.

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983*
France	3 194	813	651	85	174	455 3)	1	-	-	48 3)
Ireland	5 894	4 790	3 205	3 331	2 371	1 805	1 340	283	300	860
Netherlands	1 116	630	989	500	98	-	-	-	-	-
U.K.	27 489	18 244	16 401	11 498	8 432 2)	10 078 4)	9 272	4 094	3 375	3 025
Other	945 1)	26 1)	-	-	-	-	-	-	1 180 5)	-
Total	38 638	24 503	21 246	15 414	11 075	12 338	10 613	4 377	4 855	3 933

1) USSR 2) Includes 68.5 tonnes of spring-spawned herring

3) No data basis for allocation to stock 4) Additional unrecorded catch of 106 tonnes estimated

5) Unallocated *) Preliminary

Table 7.2 HERRING. Total catch by stock in North Irish Sea, 1974 - 1983.

Country	1974		1975		1976		1977		1978		1979		1980		1981		1982		1983*	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
France	5 194	-	813	-	651	-	85	-	87	87	-	-	1	-	-	-	-	-	-	-
Ireland	1 783	4 111	2 406	2 384	1 816	1 389	2 009	1 322	610	1 761	748	1 054	762	578	100	183	198	102	346	514
Netherlands	1 116	-	630	-	989	-	500	-	98	-	-	-	-	-	-	-	-	-	-	-
U.K.	23 639	3 850	15 408	2 836	12 831	3 570	9 837	1 661	7 663	700	9 382	696	7 897	1 375	2 837	1 257	2 120	1 255	1 759	1 266
Unallocated	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	779	401	-	-
Total Manx	30 677		19 283		16 287		12 431		8 458		10 130		8 660		2 937		3 097		2 105	
Total Mourne	7 961		5 220		4 959		2 983		2 548		1 753		1 953		1 440		1 758		1 780	

1 - Manx stock; 2 - Mourne stock

*) Preliminary

Table 7.3 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN IRISH SEA (MANX PLUS MOURNE HERRING)

CATCH IN NUMBERS UNIT: THOUSANDS

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	43250	33330	34740	30280	15540	11770	5840	5050	5100	1305
2	109550	48240	56160	39040	36950	38270	25760	15790	16050	12162
3	39750	39410	20780	22690	13410	23490	19510	3200	5670	5598
4	24510	10840	15220	6750	6730	4250	8520	2790	2150	2820
5	10650	7870	4530	4520	1740	2200	1980	2300	330	445
6	4990	4210	2810	1460	1340	1050	910	330	1110	434
7	5150	2090	2420	910	670	400	360	290	140	255
8+	1630	1640	1270	1120	550	290	230	240	380	59
TOTAL	239480	147630	137980	106770	76780	81720	65110	29990	30910	23128

Table 7.4 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN IRISH SEA (MANX PLUS MOURNE HERRING)

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = 0.10

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.38	0.28	0.41	0.29	0.19	0.27	0.12	0.09	0.07	0.03
2	0.93	0.85	0.89	0.97	0.62	0.83	1.31	0.48	0.38	0.20
3	1.05	0.94	1.02	1.03	0.96	0.91	1.32	0.47	0.28	0.20
4	1.01	0.82	1.10	1.00	0.91	0.84	0.90	0.57	0.58	0.20
5	0.75	0.96	0.89	1.08	0.68	0.77	1.14	0.58	0.11	0.20
6	0.32	0.68	1.01	0.70	1.01	1.05	0.75	0.50	0.54	0.20
7	0.95	0.86	0.95	0.99	0.72	0.86	1.22	0.50	0.36	0.20
8+	0.95	0.88	0.95	0.99	0.72	0.86	1.22	0.50	0.36	0.20
(2- 7)W	0.95	0.88	0.95	0.99	0.72	0.86	1.22	0.50	0.36	0.20

Table 7.5 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN IRISH SEA (MANX PLUS MOURNE HERRING)

STOCK SIZE IN NUMBERS UNIT: THOUSANDS

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: 1.000
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.750

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	142366	144514	108959	124551	94294	52911	53686	63431	83146	46389	********
2	188653	87825	99143	65668	83977	70568	36709	43029	52597	70387	40734
3	63849	67328	33920	36098	22591	41030	27714	8980	23981	32598	52144
4	40227	20299	23736	11098	11813	7790	14956	6722	5095	16321	24001
5	21010	13285	8129	7135	3676	4290	5036	5491	3442	2575	12091
6	9326	8947	4597	3032	2196	1681	1803	882	2792	2801	1908
7	8756	3726	4115	1509	1364	724	531	771	465	1476	2075
8+	2771	2924	2159	1853	712	525	540	638	1317	341	1346
TOTAL NO	476958	348848	284757	251551	220623	179520	138775	129946	172855	172688	
SPS NO	117445	81857	62972	47268	57336	48495	25812	38121	58935	91255	
TOT.BIOM	74690	50808	41647	33413	30184	27575	20473	17089	22908	27272	
SPS BIOM	22038	15325	11502	8347	9908	8816	4727	6723	10570	17072	

Table 8.1 Catch in numbers, millions and catch in weight, tonnes, Icelandic summer spawning herring.

AGE	1969	1970	1971	1972	1973	1974	1975
1	4.520	2.003	8.774	0.147	0.001	0.001	1.518
2	78.410	22.344	13.071	0.322	0.159	3.760	2.049
3	8.274	33.965	5.439	0.131	0.678	0.832	31.975
4	5.178	4.500	13.688	0.163	0.104	0.993	6.493
5	10.015	2.734	3.040	0.264	0.017	0.092	7.905
6	2.841	4.419	1.563	0.047	0.013	0.046	0.863
7	1.389	1.145	3.276	0.028	0.006	0.002	0.442
8	1.179	0.531	0.748	0.024	0.006	0.001	0.345
9	0.609	0.604	0.250	0.013	0.003	0.001	0.114
10	0.424	0.195	0.103	0.009	0.003	0.001	0.004
11	0.286	0.103	0.120	0.003	0.001	0.001	0.001
12	0.139	0.076	0.001	0.001	0.001	0.001	0.001
13	0.109	0.061	0.001	0.003	0.001	0.001	0.001
14	0.074	0.051	0.001	0.001	0.001	0.001	0.001
JUVENILE	78.943	23.167	16.899	0.376	0.065	3.285	3.973
ADULT	34.504	49.564	33.176	0.780	0.929	2.448	47.739
TOTAL CATCH	20.913	15.779	10.975	0.310	0.255	1.274	13.280

AGE	1976	1977	1978	1979	1980	1981	1982
1	0.614	0.705	2.634	0.929	3.147	2.283	0.454
2	9.848	18.853	22.551	15.098	14.347	4.629	19.187
3	3.908	24.152	50.995	47.561	20.761	16.771	28.109
4	34.144	10.404	13.846	69.735	60.728	12.126	38.280
5	7.009	46.357	8.738	16.451	65.329	36.871	16.623
6	5.481	6.735	39.492	8.003	11.541	41.917	38.308
7	1.045	5.421	7.253	26.040	9.285	7.299	43.770
8	0.438	1.395	6.354	3.050	19.442	4.863	6.813
9	0.296	0.524	1.616	1.869	1.796	13.416	6.633
10	0.134	0.362	0.926	0.494	1.464	1.032	10.457
11	0.092	0.027	0.400	0.439	0.698	0.884	2.354
12	0.001	0.128	0.017	0.032	0.001	0.760	0.594
13	0.001	0.001	0.025	0.054	0.110	0.101	0.075
14	0.001	0.001	0.051	0.006	0.079	0.062	0.211
JUVENILE	9.573	22.321	35.502	33.011	18.438	12.764	22.889
ADULT	53.439	92.744	119.396	156.750	190.290	130.250	188.979
TOTAL CATCH	17.168	28.924	37.333	45.072	53.269	39.544	56.528

AGE	1983
1	1.470
2	22.422
3	151.198
4	30.181
5	21.525
6	8.637
7	14.017
8	13.666
9	3.715
10	2.373
11	3.424
12	0.552
13	0.100
14	0.003
JUVENILE	78.323
ADULT	194.960
TOTAL CATCH	58.665

Table 8.2 Weight at age, in grammes. Icelandic summer spawners

AGE	1969	1970	1971	1972	1973	1974	1975
1	82.0	85.0	88.0	96.0	90.0	80.0	110.0
2	157.0	169.0	165.0	177.0	199.0	189.0	179.0
3	195.0	216.0	237.0	278.0	257.0	262.0	241.0
4	264.0	263.0	273.0	332.0	278.0	297.0	291.0
5	284.0	312.0	301.0	358.0	337.0	340.0	319.0
6	304.0	329.0	324.0	379.0	381.0	332.0	339.0
7	339.0	338.0	346.0	410.0	380.0	379.0	365.0
8	372.0	357.0	368.0	419.0	397.0	356.0	364.0
9	379.0	378.0	390.0	470.0	385.0	407.0	407.0
10	390.0	396.0	409.0	500.0	450.0	410.0	389.0
11	376.0	408.0	412.0	500.0	450.0	410.0	430.0
12	401.0	425.0	420.0	500.0	450.0	423.0	416.0
13	409.0	430.0	442.0	500.0	450.0	423.0	416.0
14	414.0	450.0	450.0	500.0	450.0	423.0	416.0
AGE	1976	1977	1978	1979	1980	1981	1982
1	103.0	84.0	73.0	75.3	68.9	60.8	65.0
2	189.0	157.0	128.0	145.3	115.3	140.9	141.0
3	243.0	217.0	196.0	182.4	202.0	190.5	186.1
4	281.0	261.0	247.0	230.9	232.5	245.5	217.3
5	305.0	285.0	295.0	284.7	268.9	268.6	273.7
6	335.0	313.0	314.0	315.7	316.7	297.6	293.3
7	351.0	326.0	339.0	333.7	351.6	329.8	323.0
8	355.0	347.0	359.0	350.4	360.4	355.7	353.8
9	395.0	364.0	360.0	366.7	379.9	368.3	384.6
10	363.0	362.0	376.0	368.3	382.9	405.4	388.7
11	396.0	358.0	380.0	370.6	392.7	381.5	400.4
12	396.0	355.0	425.0	350.0	390.0	400.0	393.5
13	396.0	400.0	425.0	350.0	390.0	400.0	390.3
14	396.0	420.0	425.0	450.0	390.0	400.0	419.5

AGE	1983
1	59.3
2	131.7
3	179.7
4	218.1
5	259.9
6	308.6
7	328.7
8	356.5
9	370.2
10	406.9
11	436.6
12	458.6
13	429.9
14	471.5

Table 8.3.

Proportion of mature herring in each group. Based on samples taken in Sept.-Dec. by purse seine and pelagic trawls. The number of herring analysed are given in the brackets.

Rings	1960	1961	1962	1963	1964	1965
2	0.28 (254)	0.13 (128)	0.04 (78)	0.54 (13)	0 (90)	0.05 (141)
3	0.79 (179)	0.79 (229)	0.46 (82)	0.96 (45)	0.85 (114)	0.75 (177)
4	0.99 (81)	0.97 (179)	0.83 (117)	0.97 (69)	0.99 (78)	1.0 (122)
5			0.96 (85)		0.98 (58)	
Rings	**1966**	**1967**	**1968**	**1969**	**1970**	**1971**
2	0.05 (279)	0.02 (121)	0.02 (139)	0.08 (1595)	0.22 (970)	0.38 (436)
3	0.52 (195)	0.41 (472)	0.67 (141)	0.73 (165)	0.89 (1271)	0.98 (318)
4	0.95 (170)	0.84 (136)	0.97 (328)	0.99 (104)	1	1
Rings	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**
2	0.29 (157)	0.64 (74)	0.14 (662)	0.27 (163)	0.13 (611)	0.02 (948)
3	1.0 (5)	0.99 (132)	0.94 (86)	0.97 (2053)	0.90 (143)	0.87 (263)
4	1	1	1	1	1 (1018)	1 (121)
Rings	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
2	0.04 (714)	0.07 (366)	0.05 (417)	0.03 (185)	0.05 (718)	0.0 (302)
3	0.78 (1012)	0.65 (835)	0.92 (290)	0.65 (390)	0.85 (342)	0.64 (1471)
4	1.0 (174)	0.90 (907)	1.0 (808)	0.99 (178)	1.00 (466)	1.0 (218)

Table 8.4 Stock abundance and catches by age groups x 10^{-6} 1983.

Year classes	Rings	Acoustic estimates			Catches 1983	F_{83}
		E-coast Dec '83	S-coast Jan '84	Total		
1981	1	223	12	235	1.5	0.006
1980	2	402	8	410	22.4	0.05
1979	3	894	46	940	151.2	0.14 (0.2)
1978	4	92	10	102	30.2	0.25
1977	5	39	10	49	21.5	0.35
1976	6	12	7	19	8.6	0.36
1975	7	21	13	34	14.0	0.33
1974	8	19	14	33	13.7	0.33
1973	9	7	5	12	3.7	0.26
1972	10	3	3	6	2.4	0.32
	10+	11	4	15	4.1	0.23
N_{4+} = 270		C_{4+} = 98.2		F_{4+} = 0.3		

Table 8.5. Icelandic summer spawners. Fishing mortalities.

AGE	1969	1970	1971	1972	1973	1974	1975
1	0.107	0.064	0.138	0.002	0.000	0.000	0.009
2	0.849	0.947	0.647	0.006	0.003	0.010	0.021
3	0.591	1.020	0.554	0.010	0.014	0.015	0.104
4	0.657	0.661	1.542	0.025	0.009	0.023	0.136
5	0.722	0.779	1.193	0.083	0.003	0.009	0.233
6	0.829	0.726	1.354	0.040	0.005	0.009	0.097
7	0.920	0.855	2.009	0.059	0.006	0.001	0.098
8	0.899	1.014	3.213	0.055	0.015	0.001	0.165
9	0.857	1.717	2.353	0.628	0.008	0.003	0.146
10	0.943	0.655	1.963	0.485	0.253	0.003	0.012
11	1.219	0.548	0.989	0.223	0.080	0.112	0.003
12	1.110	1.204	0.008	0.016	0.097	0.097	0.141
13	0.799	3.564	0.035	0.027	0.018	0.119	0.119
14	0.700	1.000	1.000	0.040	0.010	0.020	0.150
AVERAGE WEIGHTED BY STOCK IN NUMBERS							
AVE 4-14	0.751	0.765	1.578	0.047	0.007	0.018	0.165

AGE	1976	1977	1978	1979	1980	1981	1982
1	0.001	0.002	0.019	0.004	0.016	0.002	0.001
2	0.070	0.040	0.068	0.129	0.078	0.026	0.021
3	0.045	0.218	0.131	0.178	0.234	0.111	0.198
4	0.138	0.145	0.168	0.237	0.321	0.187	0.348
5	0.191	0.250	0.156	0.274	0.324	0.293	0.372
6	0.225	0.253	0.312	0.188	0.280	0.316	0.495
7	0.147	0.322	0.418	0.310	0.307	0.256	0.559
8	0.120	0.266	0.676	0.276	0.356	0.233	0.358
9	0.187	0.184	0.492	0.378	0.232	0.395	0.503
10	0.228	0.325	0.501	0.242	0.506	0.181	0.539
11	0.367	0.059	0.632	0.417	0.557	0.579	0.692
12	0.004	1.130	0.043	0.081	0.001	2.175	0.870
13	0.183	0.004	0.605	0.168	0.388	0.158	1.915
14	0.150	0.250	0.250	0.250	0.350	0.350	0.500
AVERAGE WEIGHTED BY STOCK IN NUMBERS							
AVE 4-14	0.151	0.231	0.270	0.253	0.322	0.291	0.452

AGE	1983
1	0.005
2	0.050
3	0.200
4	0.300
5	0.300
6	0.300
7	0.300
8	0.300
9	0.300
10	0.300
11	0.300
12	0.300
13	0.300
14	0.300
AVERAGE WEIGHTED BY STOCK IN NUMBERS	
AVE 4-14	0.300

Table 8.6. Icelandic summer spawners, VPA stock size in number ($x 10^{-6}$) and spawning stock biomass at 1 July.

AGE	1969	1970	1971	1972	1973	1974	1975
1	46.823	33.785	71.274	73.748	421.017	116.756	171.019
2	143.018	38.074	28.666	56.159	66.590	381.014	105.608
3	19.396	55.372	13.369	13.576	50.508	60.102	341.181
4	11.242	9.721	18.075	6.949	12.160	45.057	53.592
5	20.344	5.275	4.541	3.499	6.133	10.904	39.825
6	5.263	8.942	2.190	1.246	2.916	5.533	9.779
7	2.409	2.079	3.914	0.512	1.083	2.626	4.963
8	2.073	0.869	0.800	0.475	0.436	0.974	2.374
9	1.104	0.763	0.285	0.029	0.407	0.389	0.880
10	0.724	0.424	0.124	0.025	0.014	0.366	0.351
11	0.422	0.255	0.199	0.016	0.014	0.010	0.330
12	0.216	0.113	0.134	0.067	0.011	0.011	0.008
13	0.207	0.064	0.031	0.120	0.060	0.009	0.009
14	0.154	0.084	0.002	0.027	0.106	0.053	0.008
JUVENILE	183.749	69.573	88.602	113.621	445.495	448.034	258.348
Sp. stock biomass	16 699	19 873	13 259	10 690	27 322	43 276	113 956

AGE	1976	1977	1978	1979	1980	1981	1982
1	555.929	400.835	147.621	223.144	209.466	1093.471	534.180
2	153.301	502.440	362.020	131.069	201.026	186.541	987.239
3	93.610	129.354	436.706	306.139	104.256	168.264	164.389
4	278.337	80.987	94.122	346.713	231.851	74.633	136.319
5	42.325	219.422	63.400	72.018	247.543	152.199	56.019
6	28.534	31.643	154.555	49.069	49.558	162.036	102.742
7	8.028	20.617	22.242	102.394	36.802	33.894	106.865
8	4.070	6.272	13.514	13.253	67.954	24.493	23.743
9	1.820	3.267	4.351	6.220	9.098	43.056	17.548
10	0.688	1.366	2.459	2.407	3.857	6.528	26.244
11	0.314	0.496	0.893	1.348	1.709	2.103	4.927
12	0.298	0.197	0.423	0.430	0.804	0.886	1.067
13	0.006	0.268	0.058	0.366	0.358	0.726	0.091
14	0.008	0.005	0.242	0.028	0.280	0.220	0.561
JUVENILE	698.662	910.041	591.236	459.122	408.781	1334.053	1486.032
Sp. stock biomass	124 039	124 148	166 110	185 346	190 527	160 563	162 925

AGE	1983
1	309.705
2	482.914
3	875.050
4	122.062
5	87.054
6	34.931
7	56.689
8	55.270
9	15.025
10	9.597
11	13.848
12	2.232
13	0.404
14	0.012
JUVENILE	1107.637
Sp. stock biomass	205 197

Table 8.7 Input parameters used in catch prediction for the Icelandic summer-spawning (Div. Va) HERRING.

Rings	Stock in number (in'000) at 1/1 1984	Proportional F	Mean weight in catch and in spawning stock
1	400 000	0.005	60
2	278 835	0.15	135
3	415 648	0.5	175
4	648 253	1.0	220
5	81 820	-	260
6	58 354	-	310
7	23 415	-	330
8	38 000	-	360
9	37 048	-	375
10	10 071	-	390
11	6 433	-	-
12	9 282	-	-
13	1 496	-	-
14	0 277	-	-

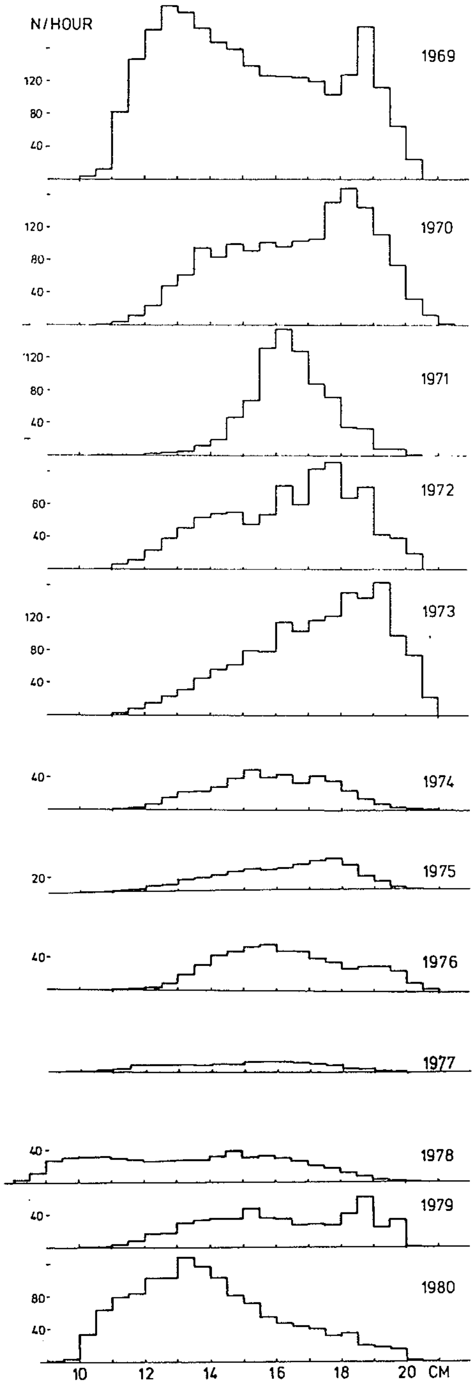

Figure 2.1.

Length distributions in number per hour of one year old HERRING in the North Sea without Moray Firth and Skagerrak.

Data from IYFS.

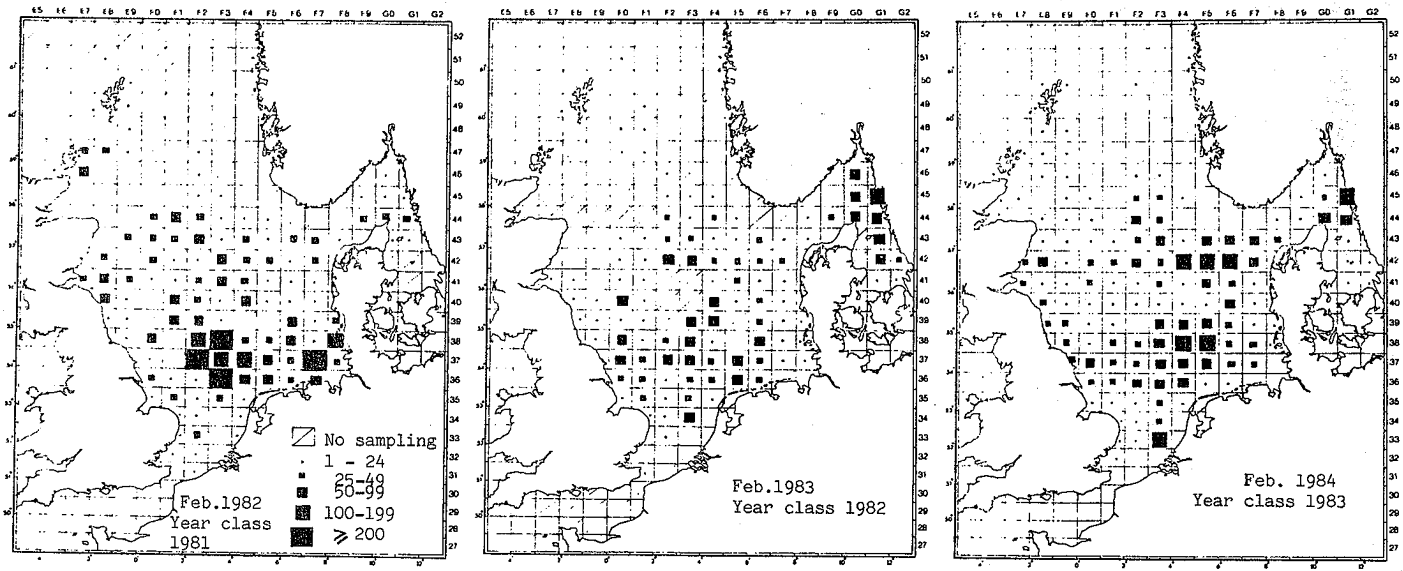

Figure 2.2 Herring larvae sampled by IKMT during the International Young Fish Surveys 1982-1984

Figure 2.3. Recruitment of 2-ringers from VPA vs indices of 0-group HERRING on the East Anglian coast.

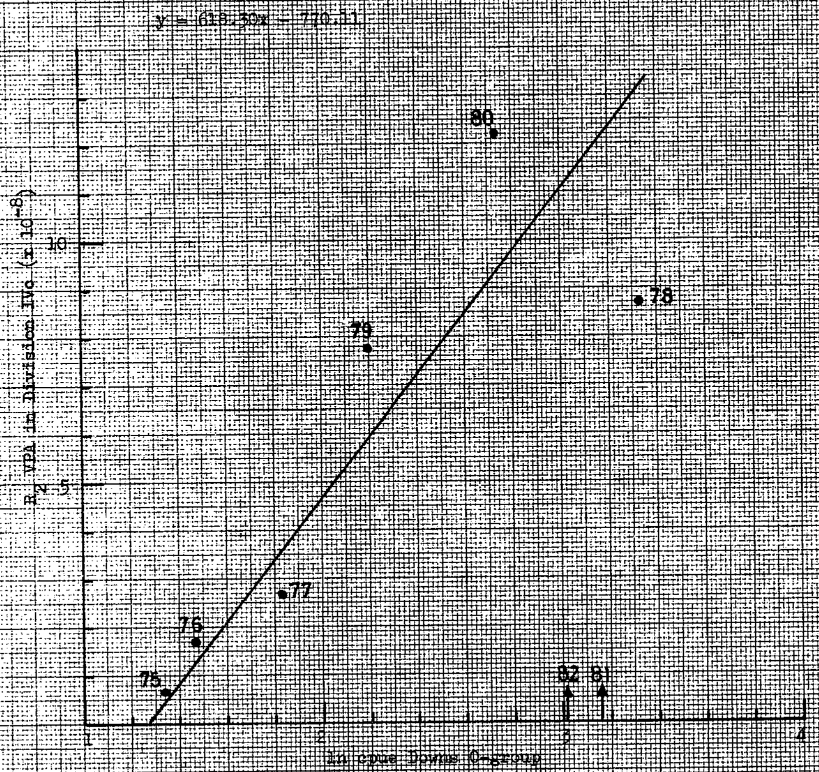

Figure 2.4. HERRING in the southern North Sea.
Recruitment from VPA vs calculated IYFS index.

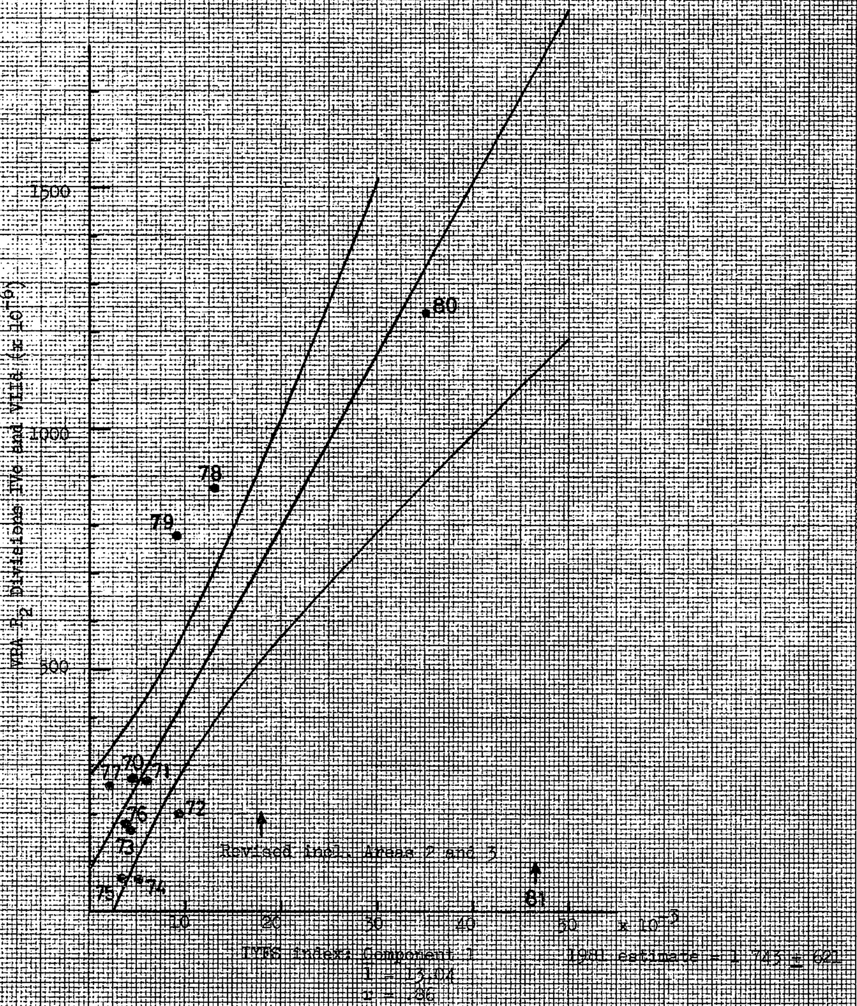

Figure 2.5. Spawning stock biomass from VPA vs larval index. HERRING in Division IVa, northern North Sea.

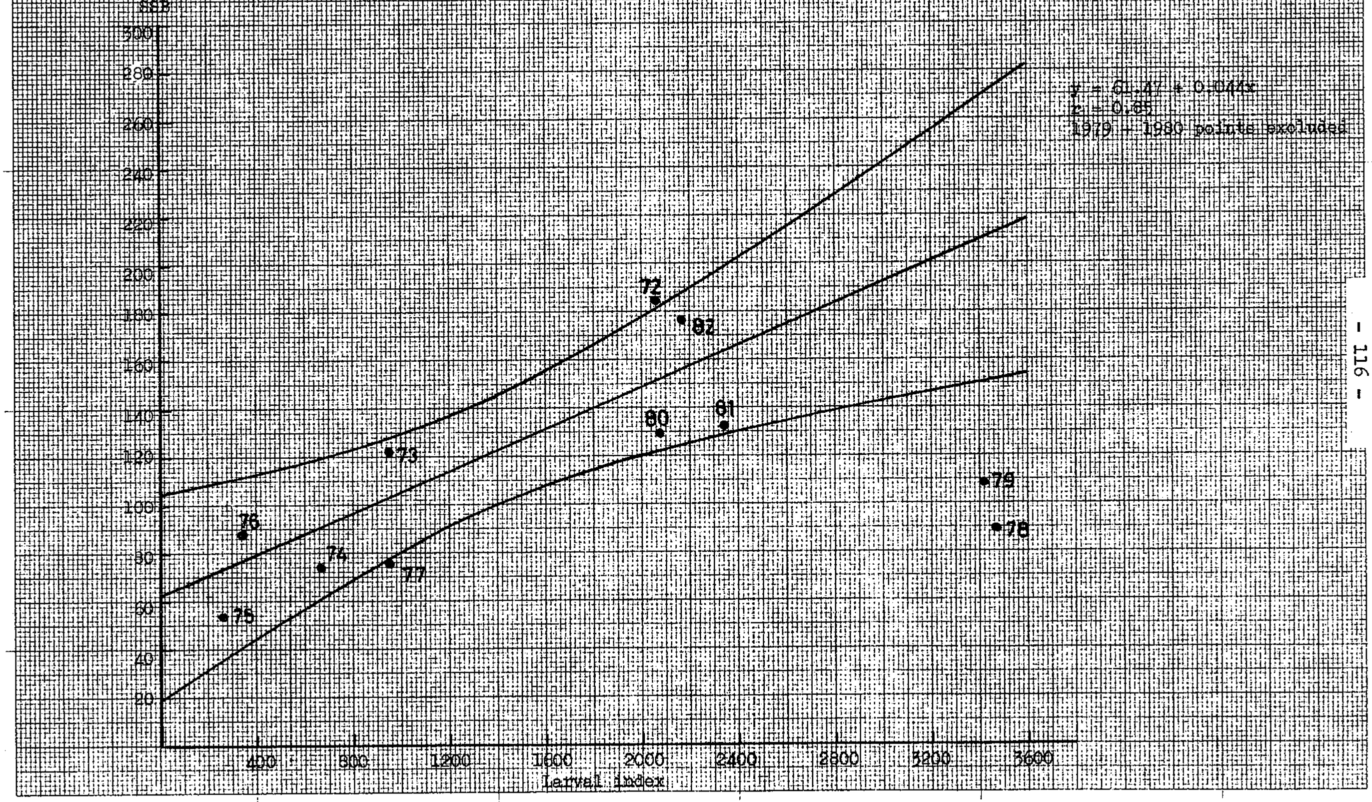

Figure 2.6. HERRING in Divisions IVc and VIId.

A Trends in yield and fishing mortality (annual)

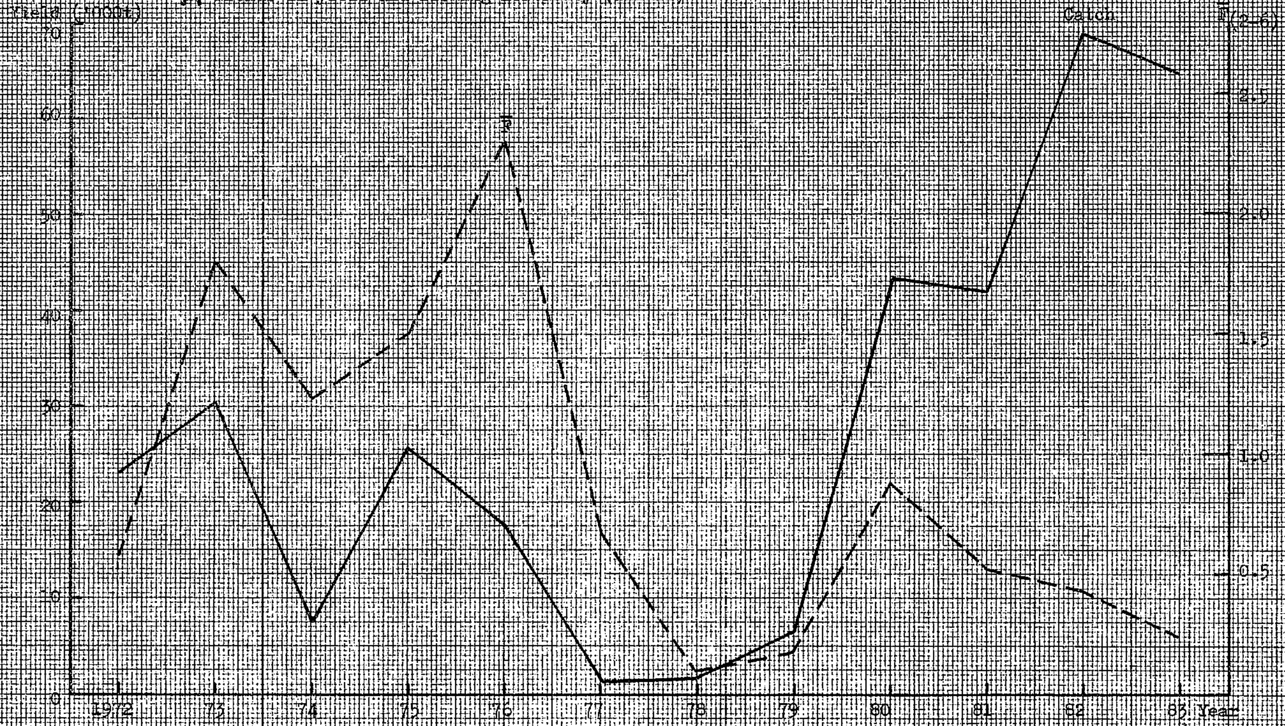

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Figure 3.6 (Continued)

B Trends in yield and fishing mortality (seasonal)

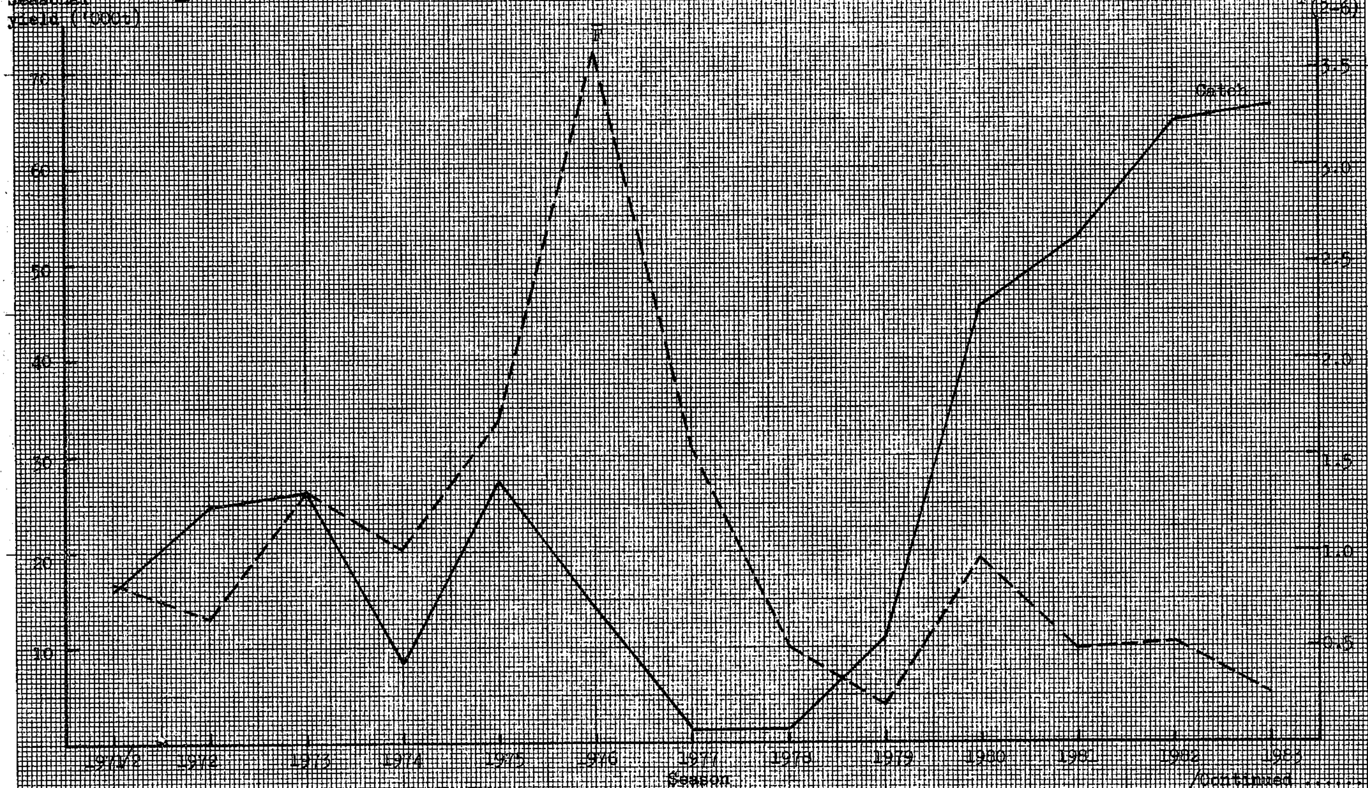

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Figure 2.6. (Continued)

C Trends in spawning stock biomass and recruitment (annual)

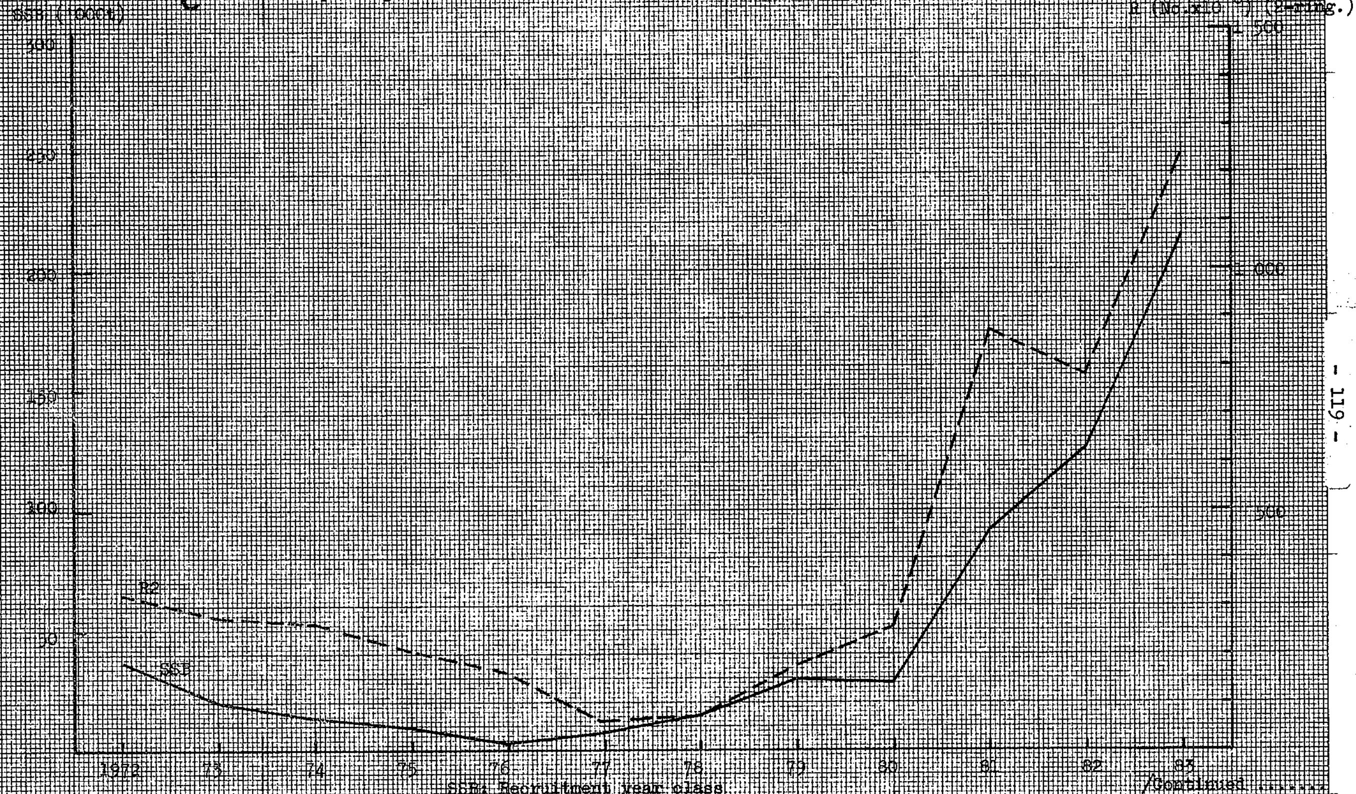

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Figure 2.6. (Continued)

D Trends in spawning stock biomass and recruitment (seasonal)

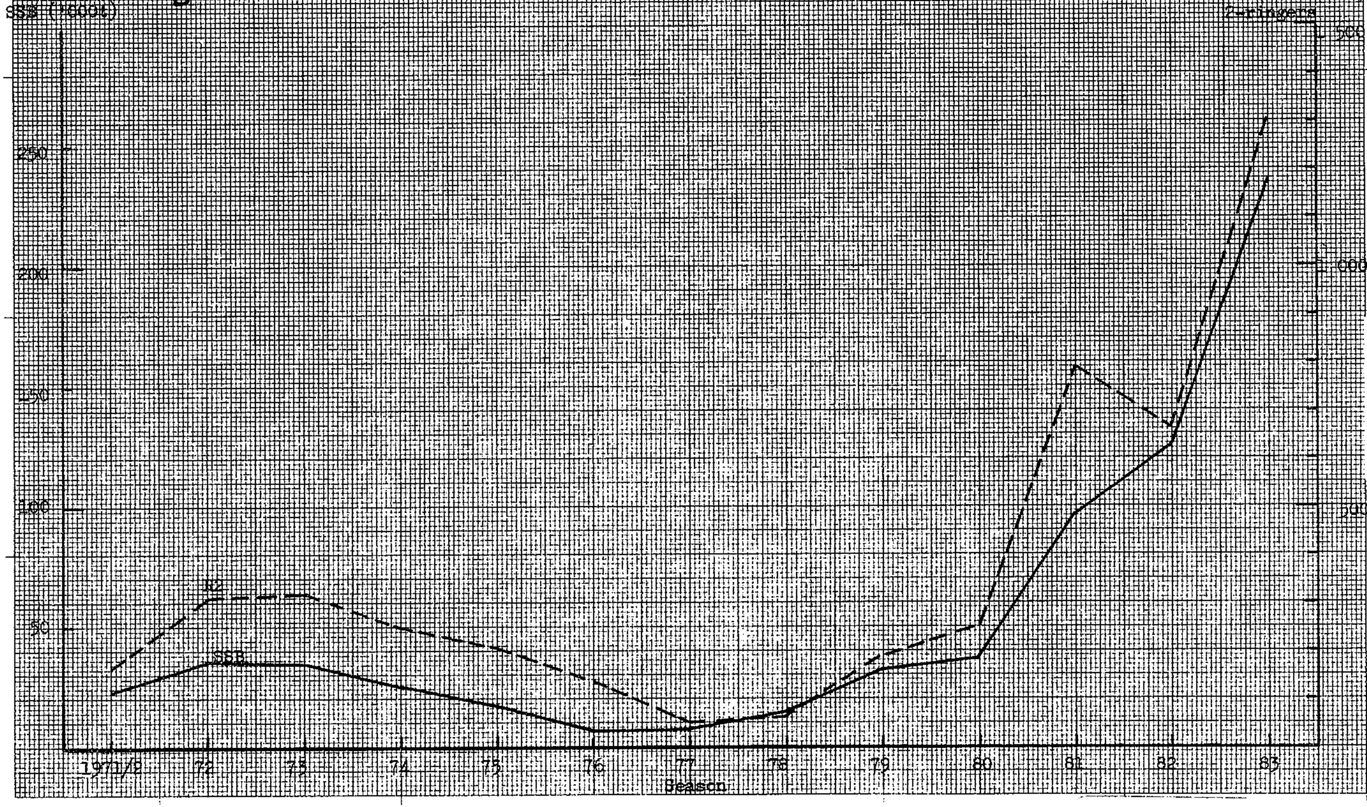

Figure 2.7. HERRING in Divisions IVa and IVb combined.

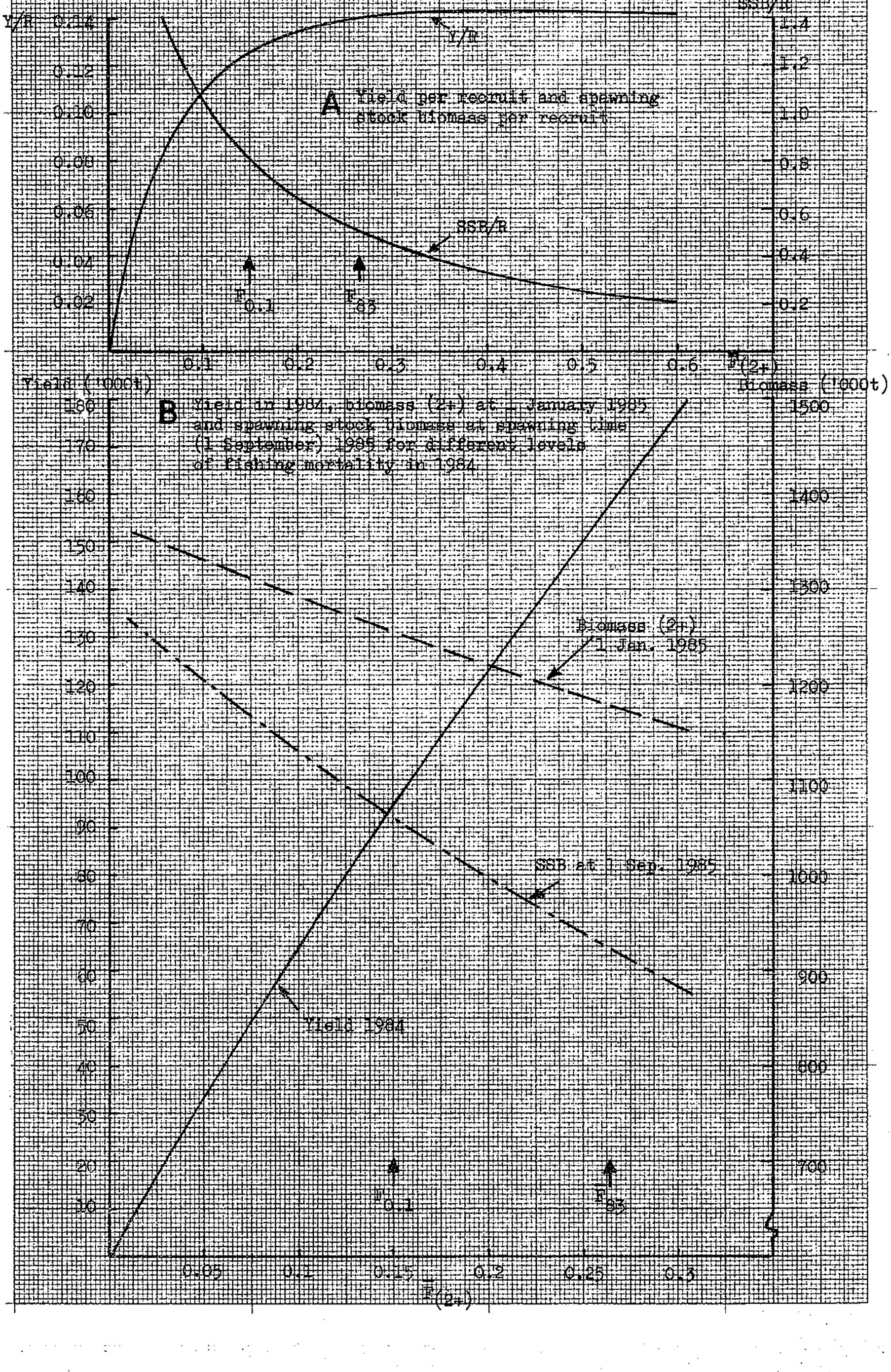

Figure 2.8. HERRING in Divisions IVc and VIId.

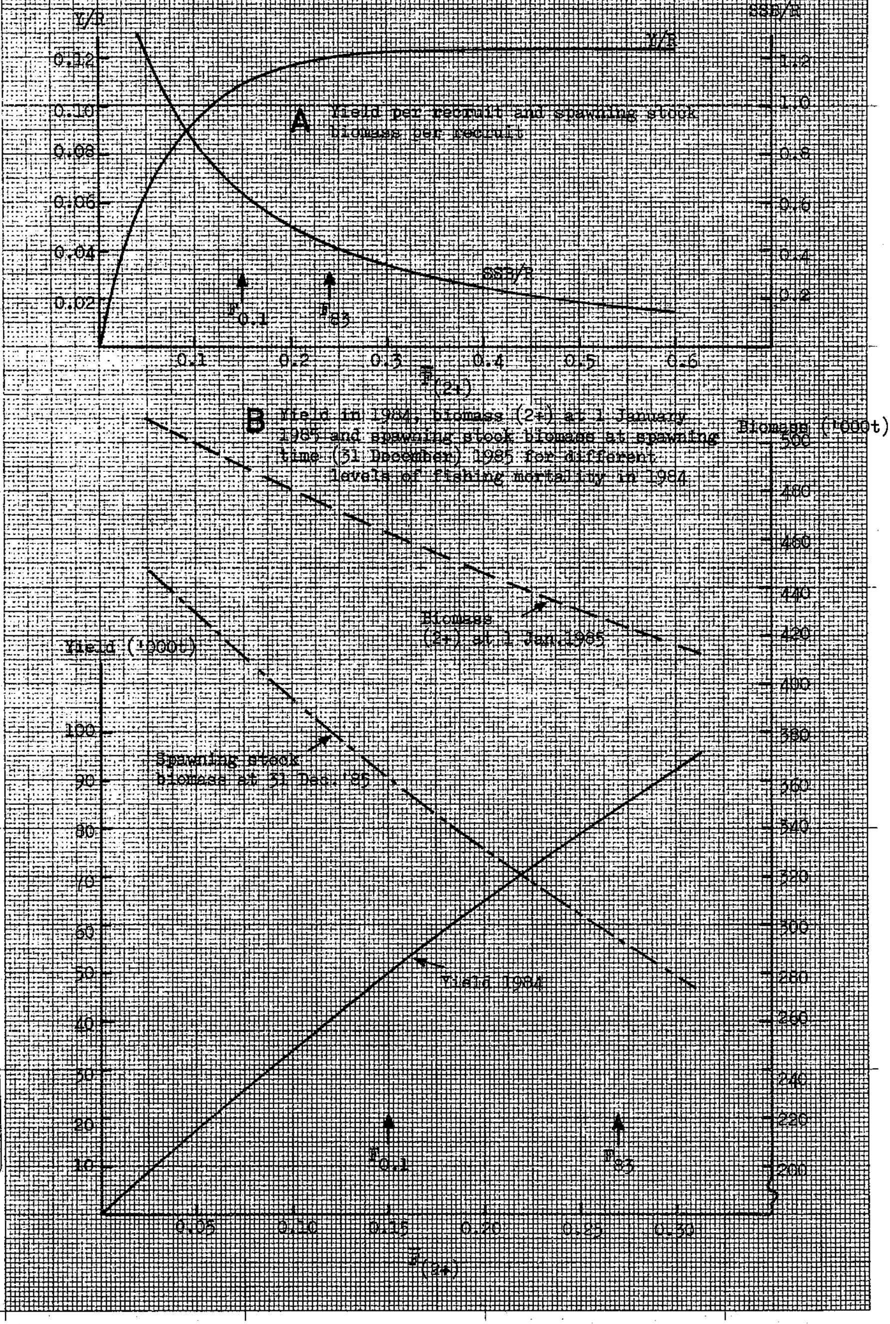

Figure 2.9. Long-term yield. North Sea HERRING.
Corresponding yield of 1-group and adult herring (≥ 2-group) for 3 levels of 0-group yields.

A = 0-group yield = 0 tonnes
B = 0-group yield = 37 000 tonnes
C = 0-group yield = 82 000 tonnes

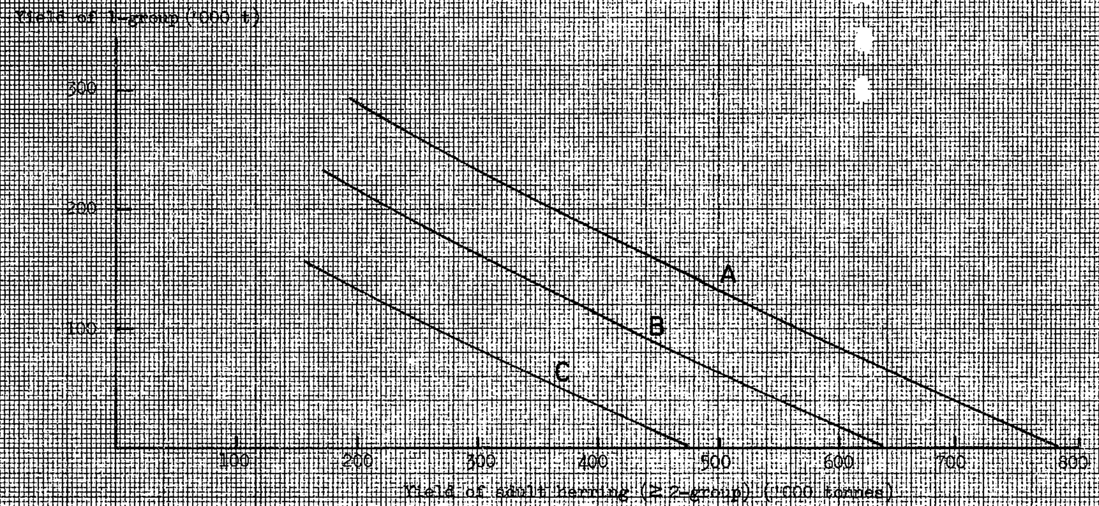

Figure 3.1. Division IIIa HERRING, 1983.
Mean length of 0 and 1-group herring in industrial landings per month plotted with lengths beneath which no samples in 1979-82 contained components of exogene herring according to meristic characters (full drawn line). For further explanation, see text in Section 3.

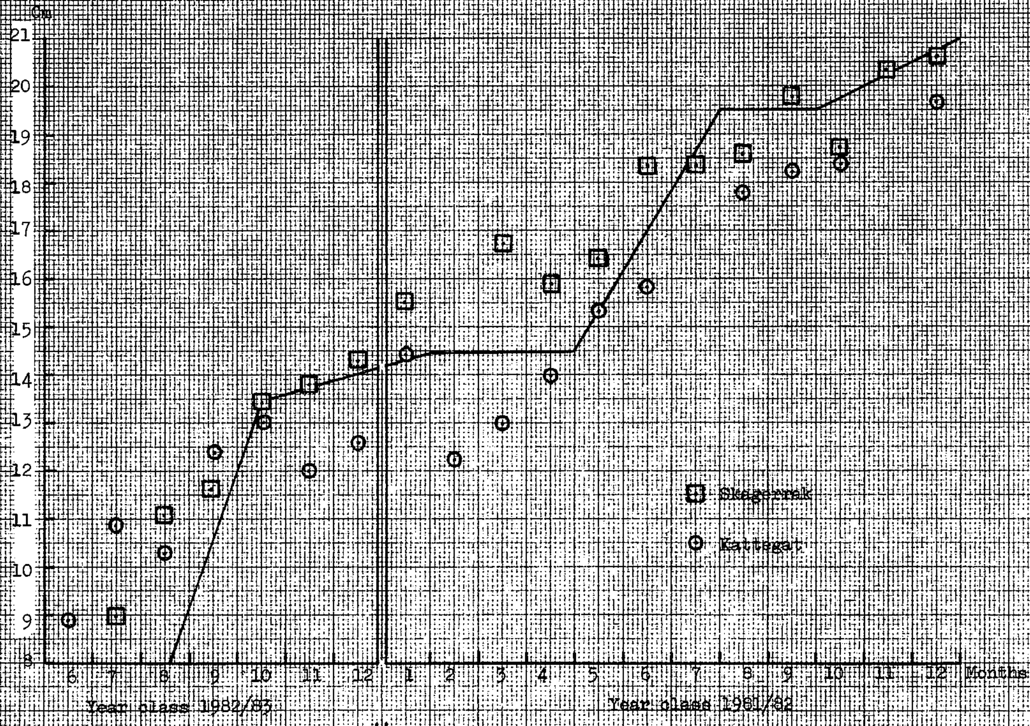

Figure 3.2. Regression of catch in number x 10^{-6} of 1-group HERRING on IYFS index the same year. Division IIIa (year classes shown).

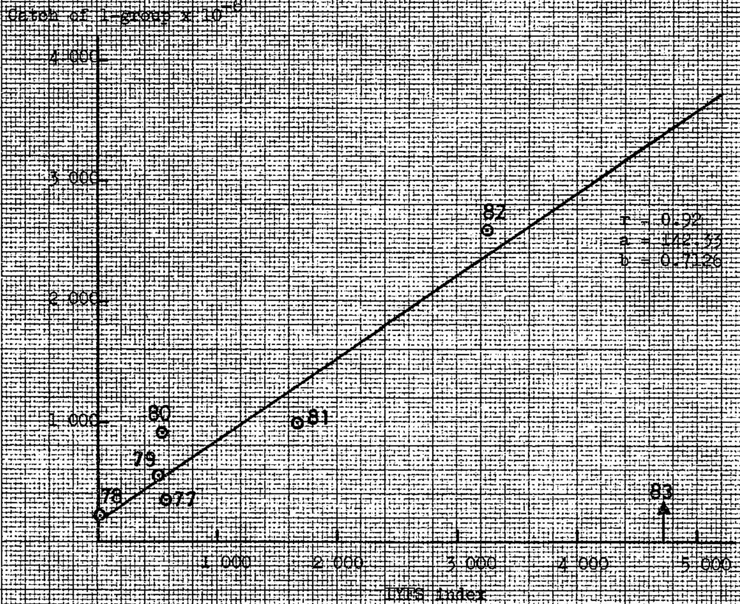

Figure 5.5. Regression of the 1-group IYFS index for HERRING on the catch of the same year class as 0-group. Division IIIa.

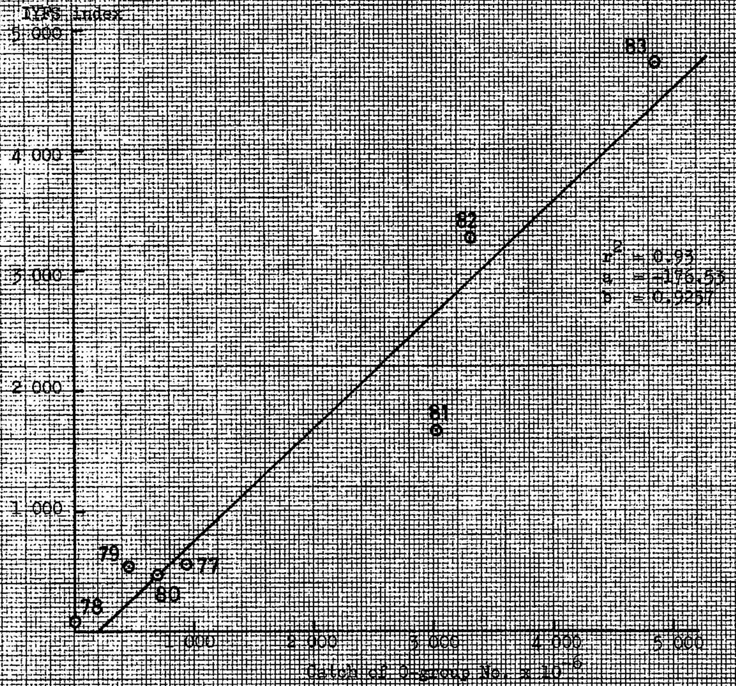

Figure 4.1. Celtic Sea HERRING in Division VIIj.

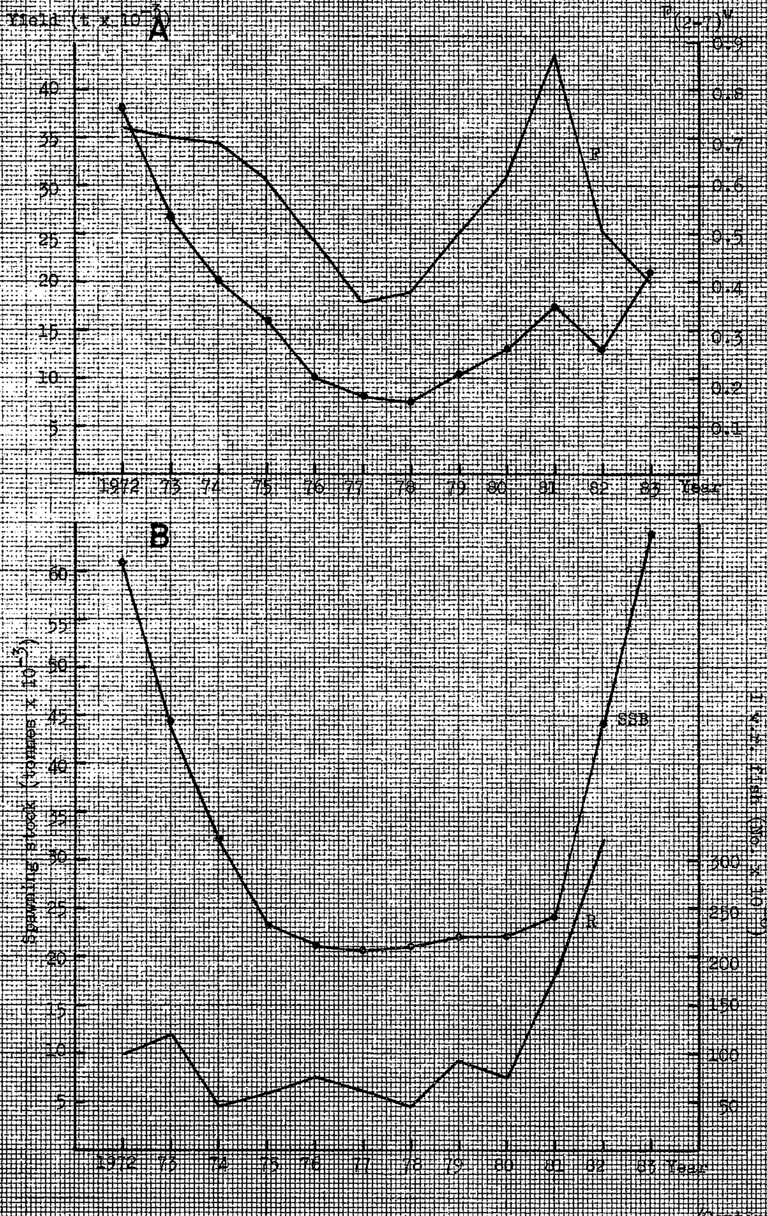

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Figure 4.__ (Continued)

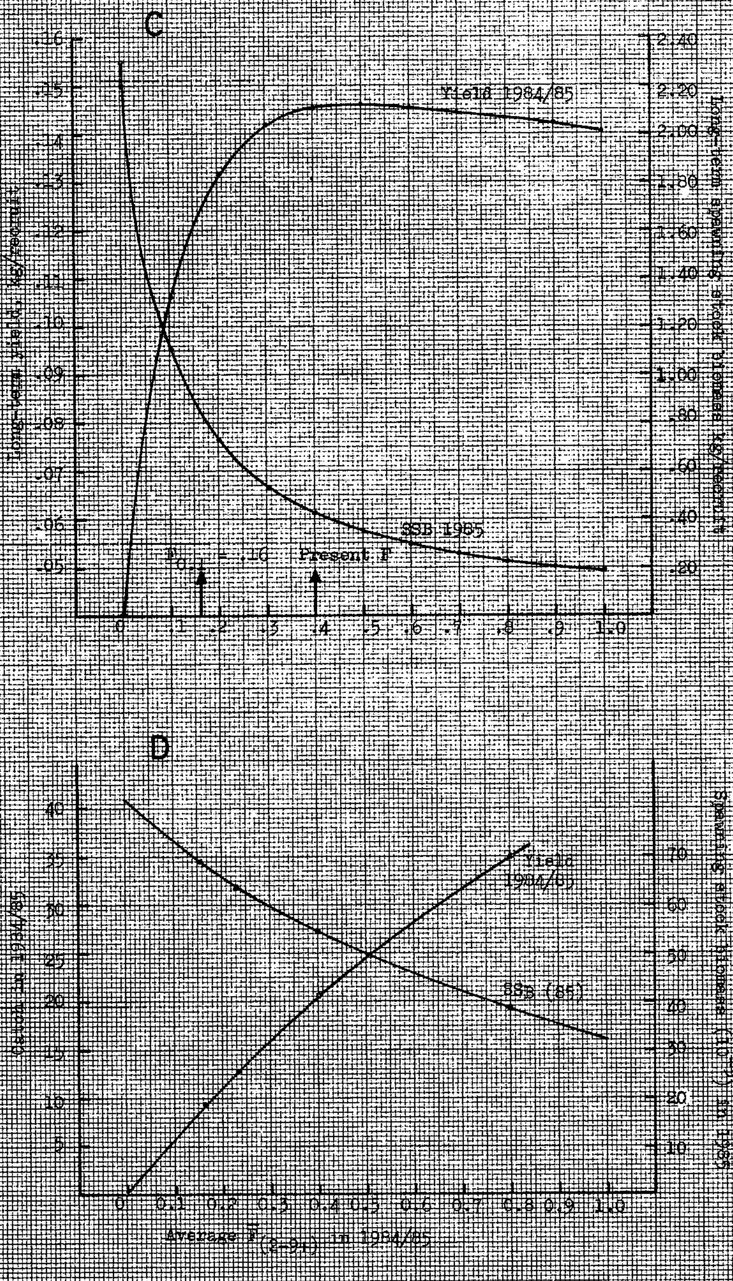


Figure 5.1. Boundaries of new HERRING unit stocks west of Scotland and Ireland.

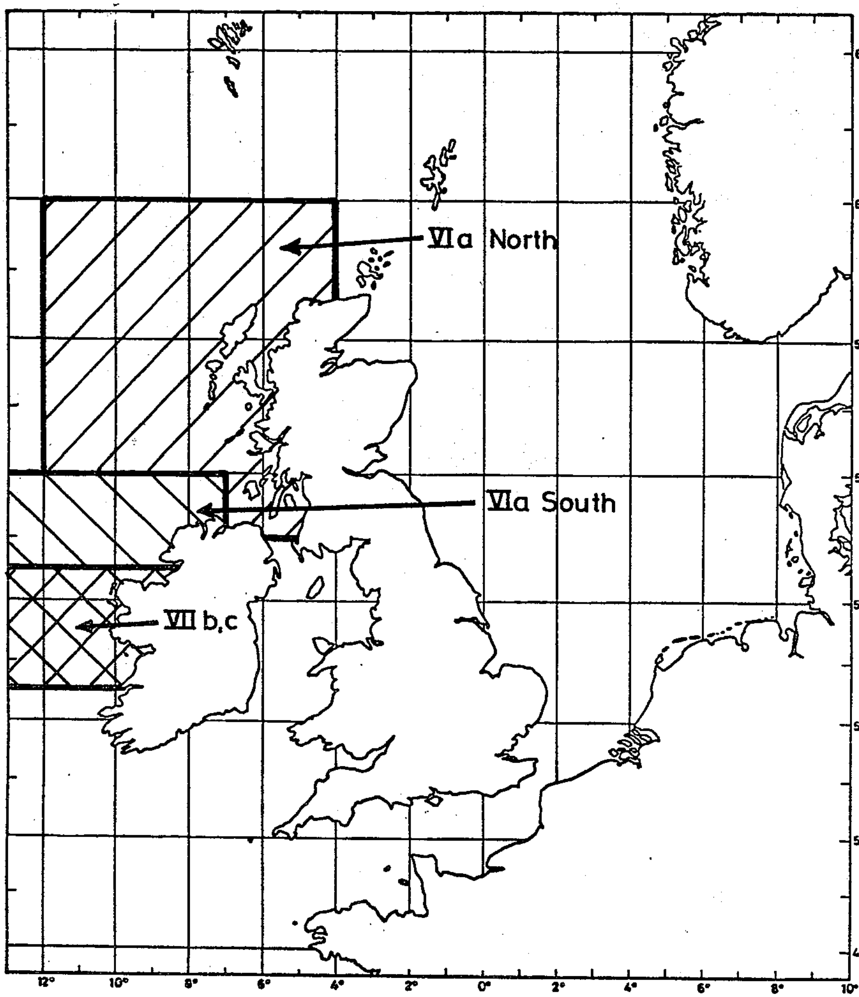


Figure 5.2. Larval abundance indices and spawning stock biomasses in Division VIa North. Points are labelled by years.

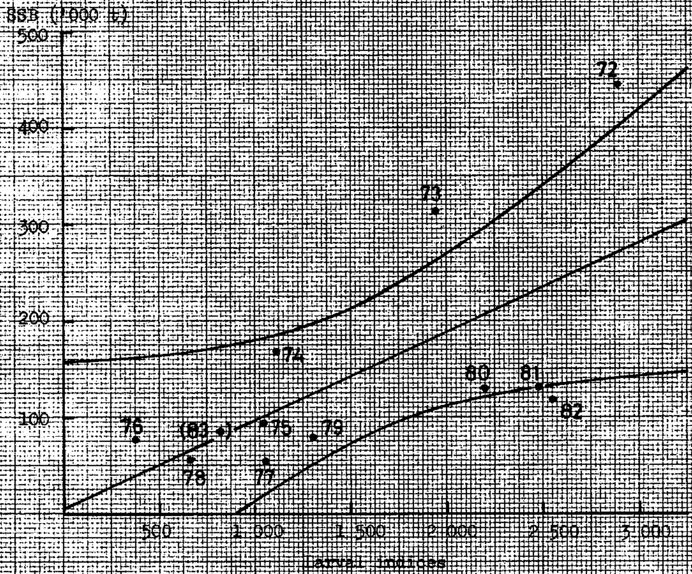


Figure 5.3. HERRING in Division VIa North.
Mean number of 2-ringers per hour fishing in the Scottish Young Fish Survey/VPA estimates of 2-ringers.

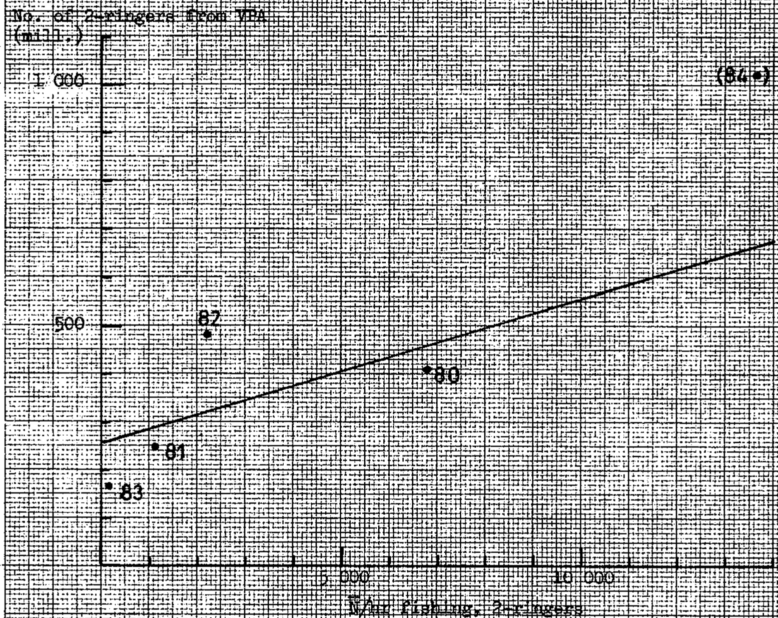


Figure 5.4. HERRING in Division VIa North.

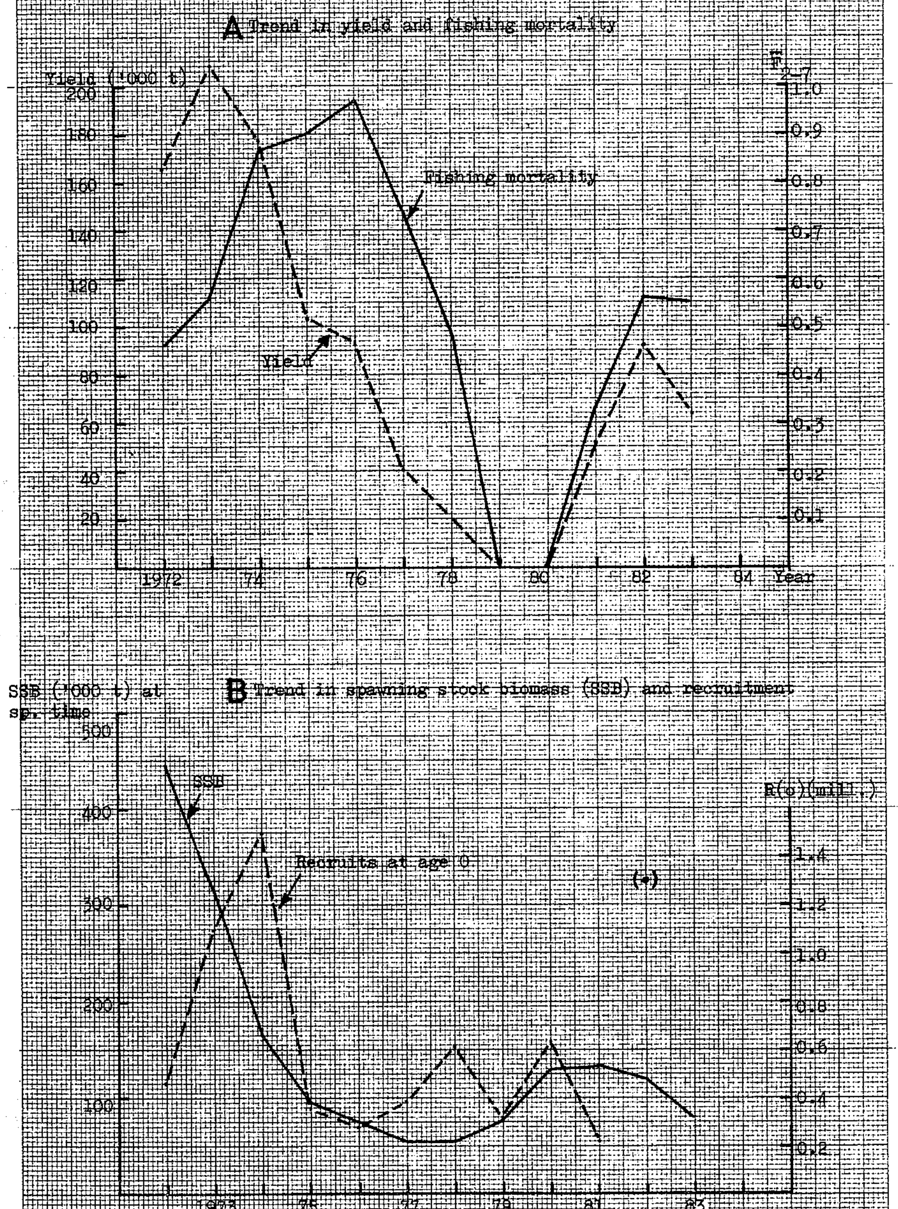
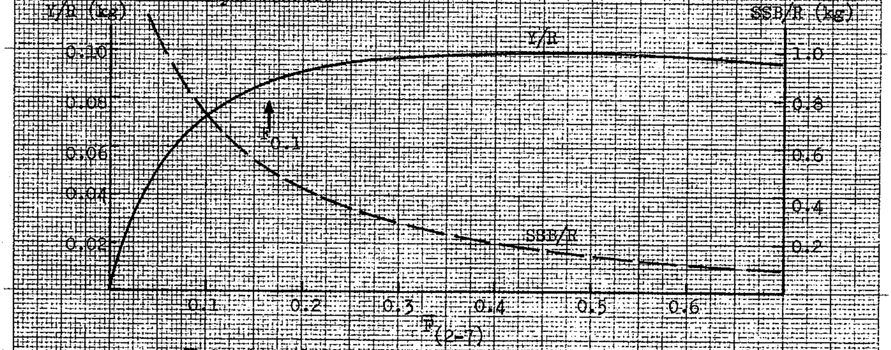


Figure 5.5. HERRING in Division VIa North.

A Yield per recruit and spawning stock biomass (at spawning time) per recruit



B Catch in 1985, adult biomass at the beginning of 1986 and spawning stock biomass at spawning time in 1986 for different levels of fishing mortality in 1985. ASSUMING A CATCH OF 64 020 TONNES IN 1984 (AGREED TAC FOR 1984).

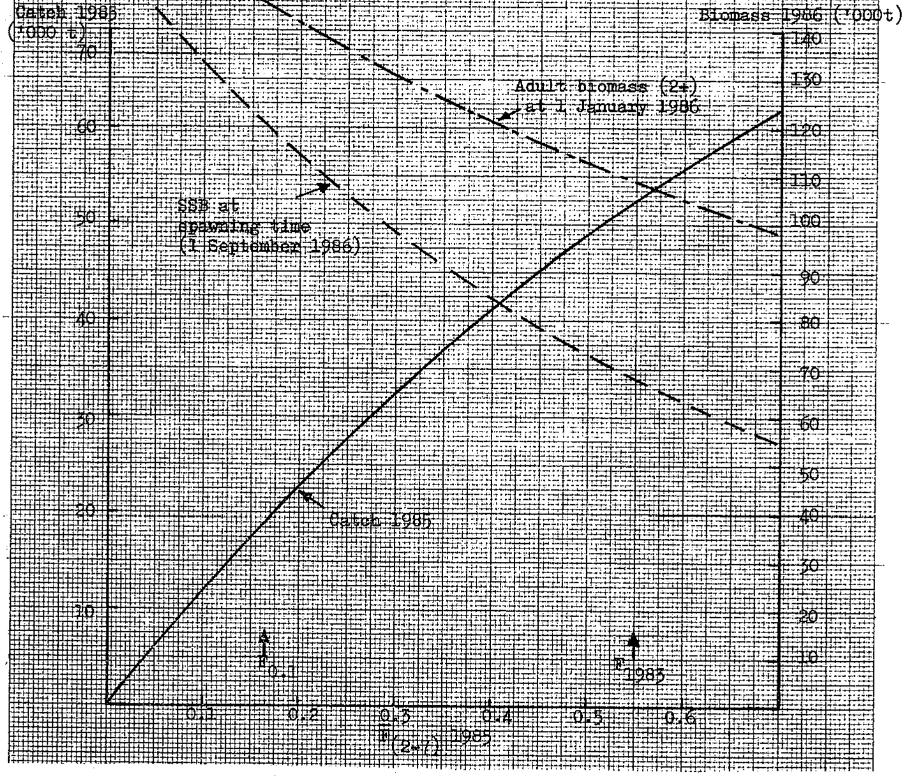


Figure 5.6. HERRING in Division VIa North.
Catch in 1985, adult biomass at the beginning of 1986 and spawning stock biomass at spawning time in 1986 for different levels of fishing mortality in 1985.
ASSUMING A CATCH OF 23 000 TONNES IN 1984 ($F_{0.1}$ LEVEL)

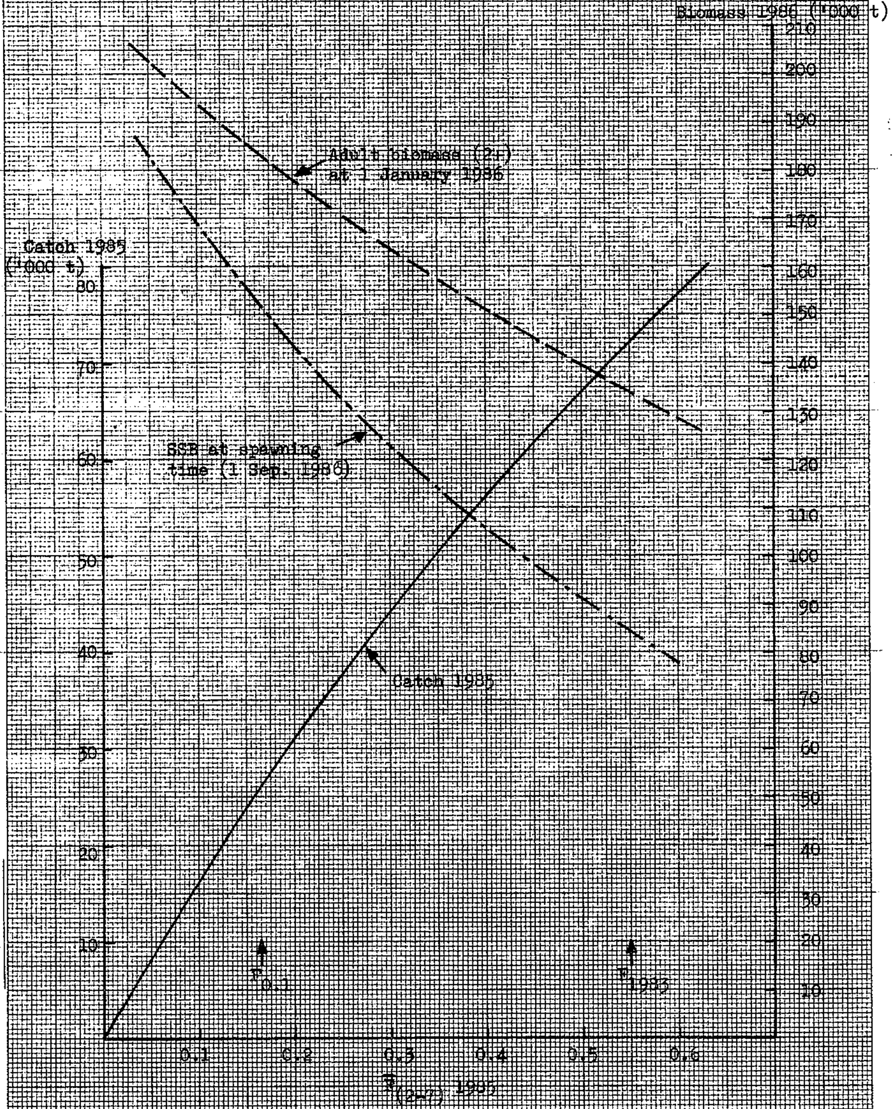
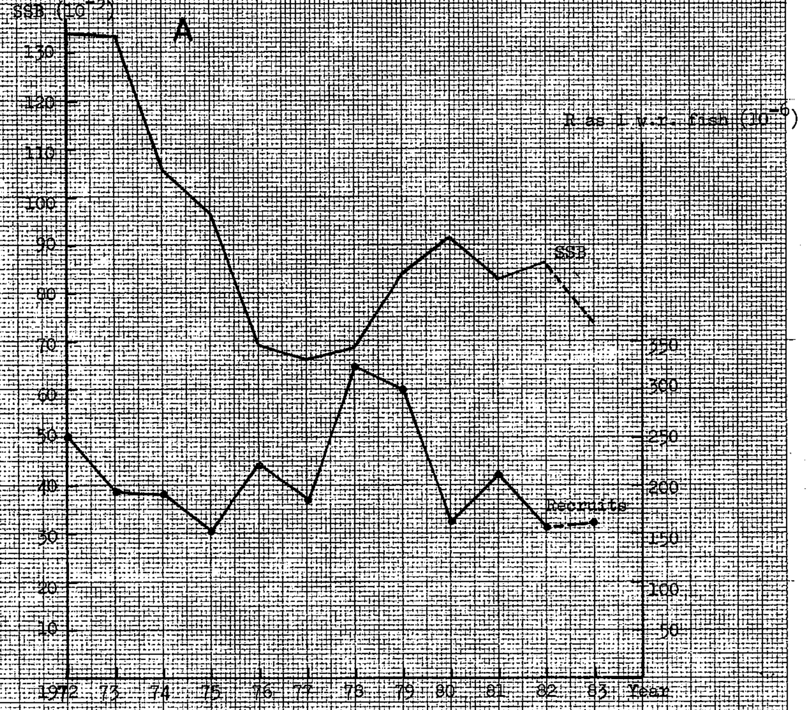


Figure 6.1. HERRING in Divisions VIa South and VIIb-c.
Results from VPA (input F = 0.4) in 1983.



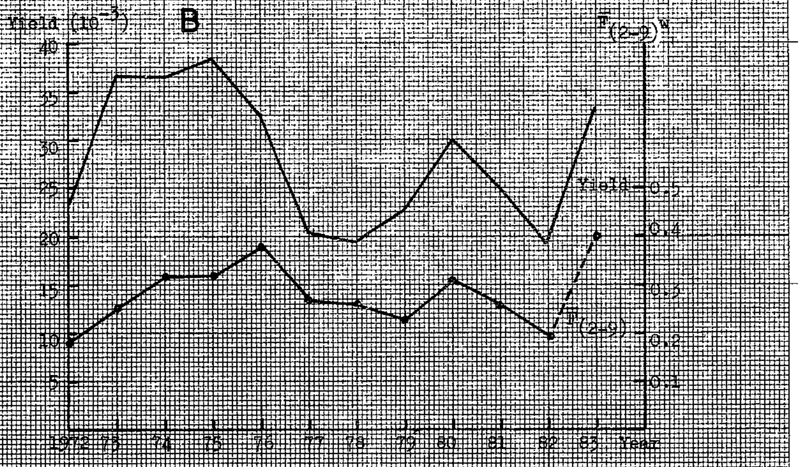


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Figure 6.1. (Continued)

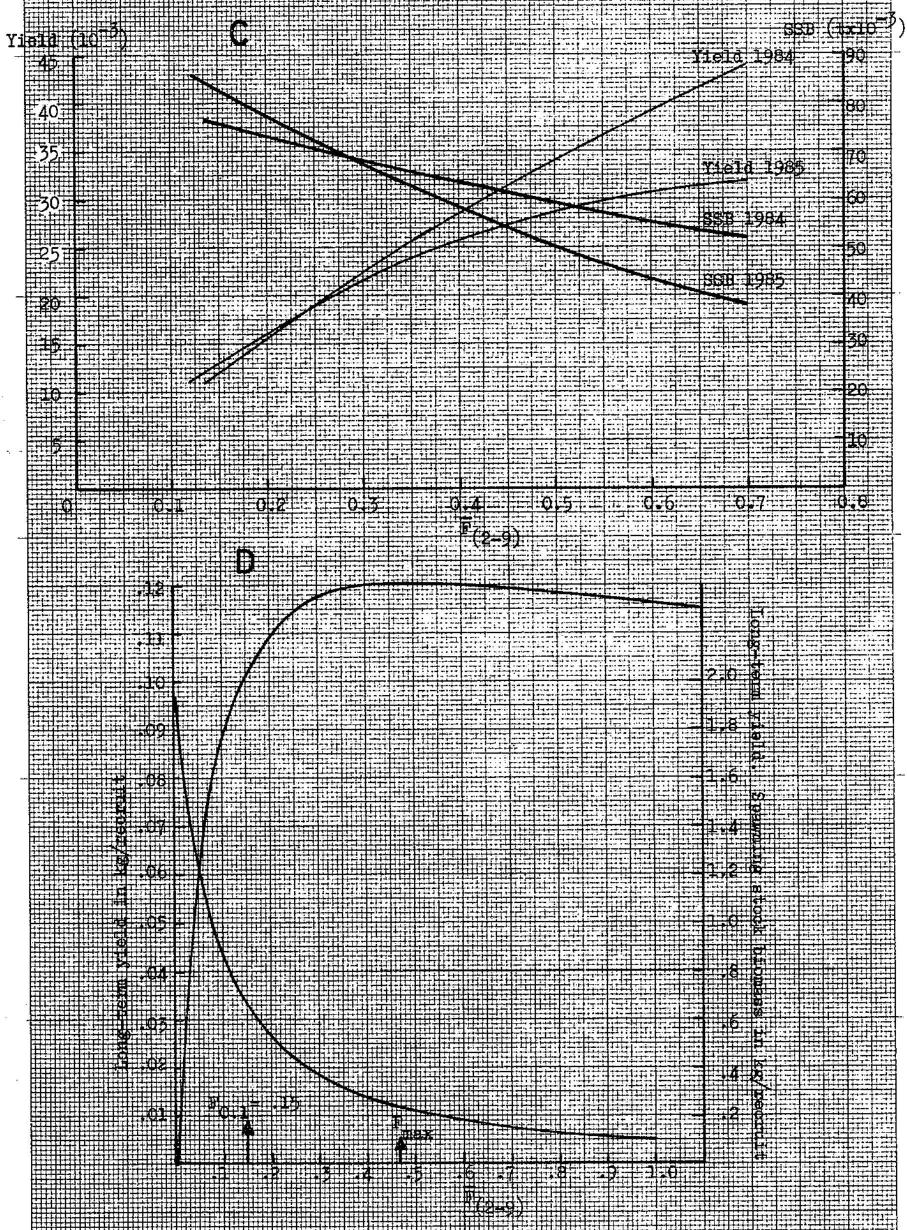
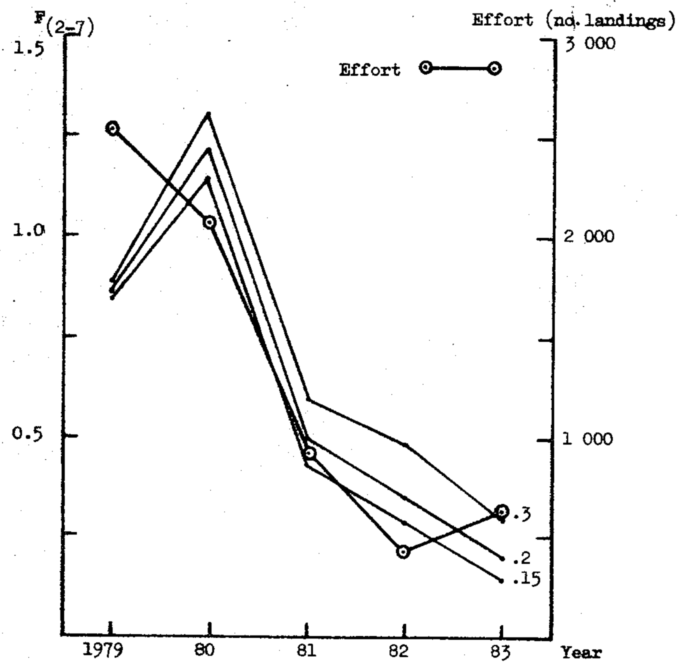


Figure 7.1. Relation between weighted mean values of $F_{(2-7)}$ using different values of input F and effort. Northern Irish Sea HERRING.



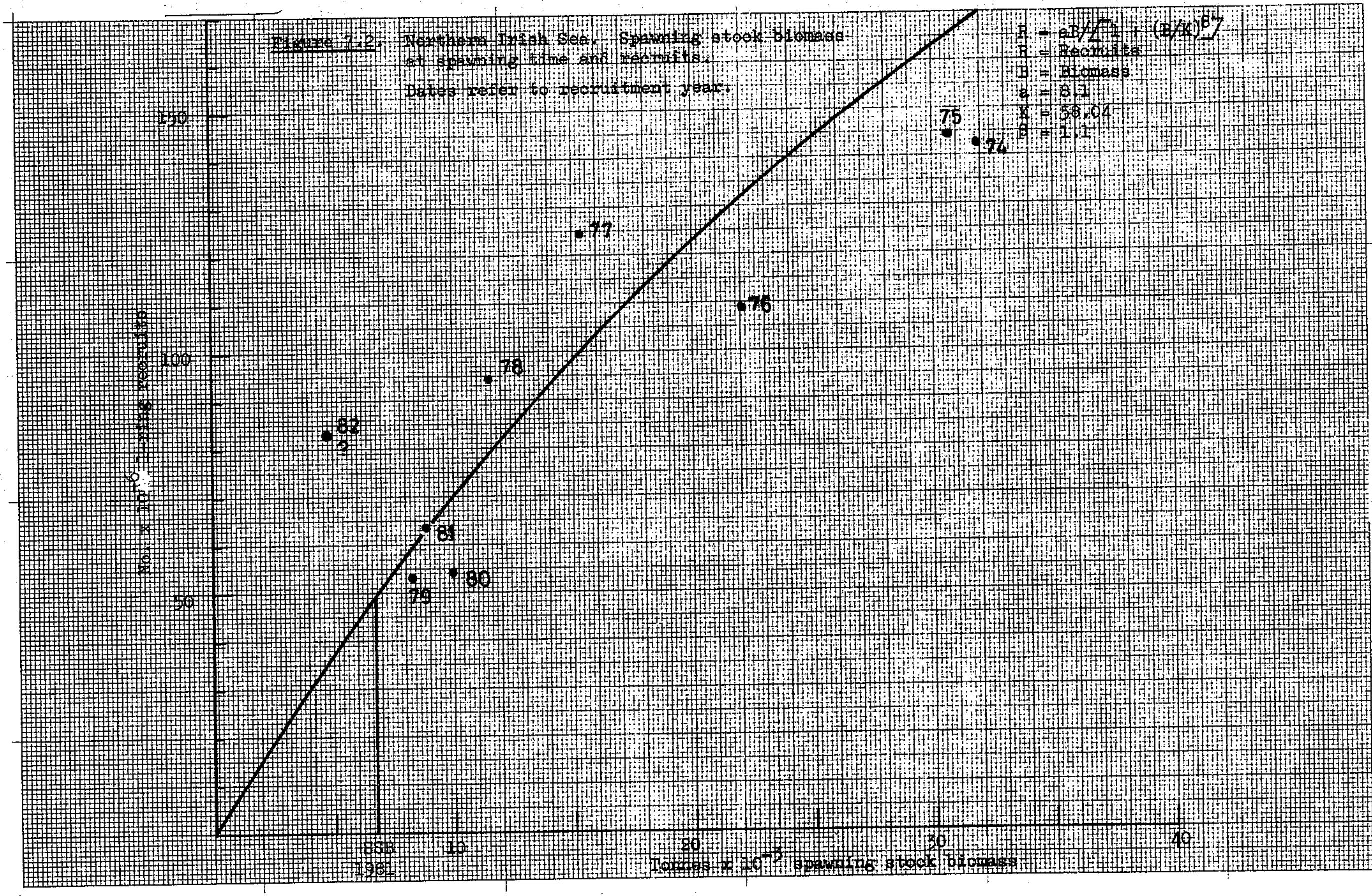


Figure 7.2. Northern Irish Sea. Spawning stock biomass at spawning time and recruits.

Dates refer to recruitment year.

Irish Sea HERRING.

Figure 7.3. Fish stock summary.

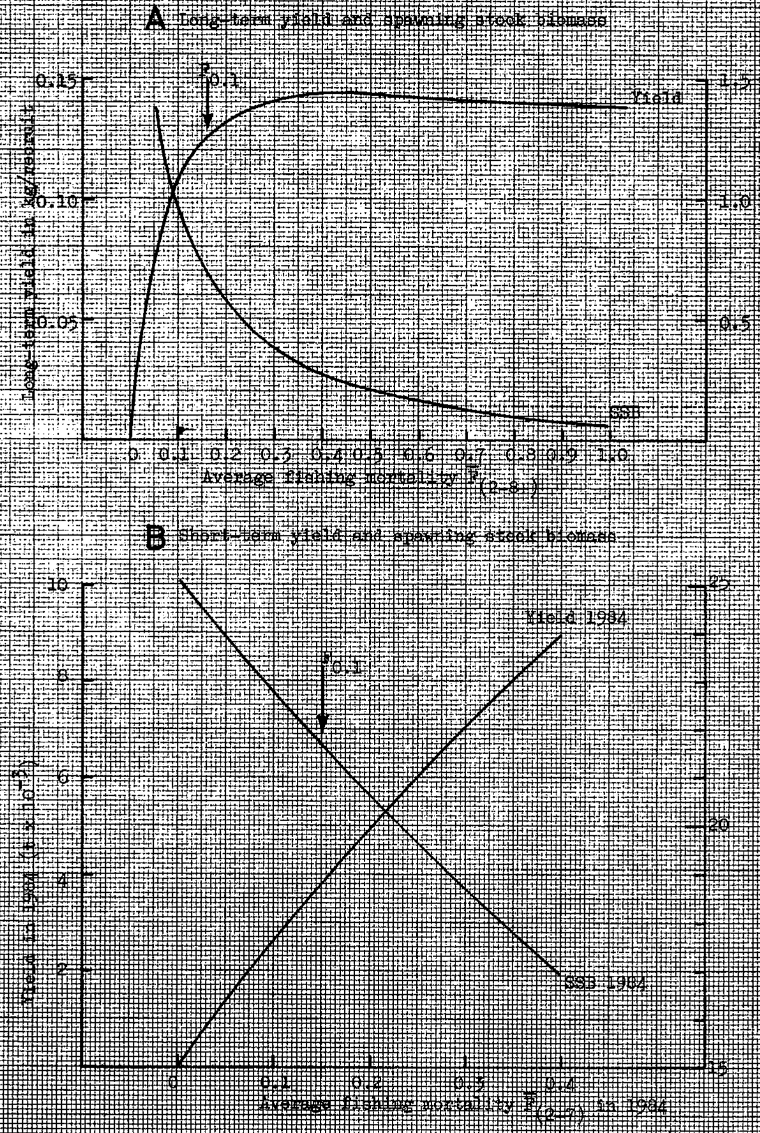


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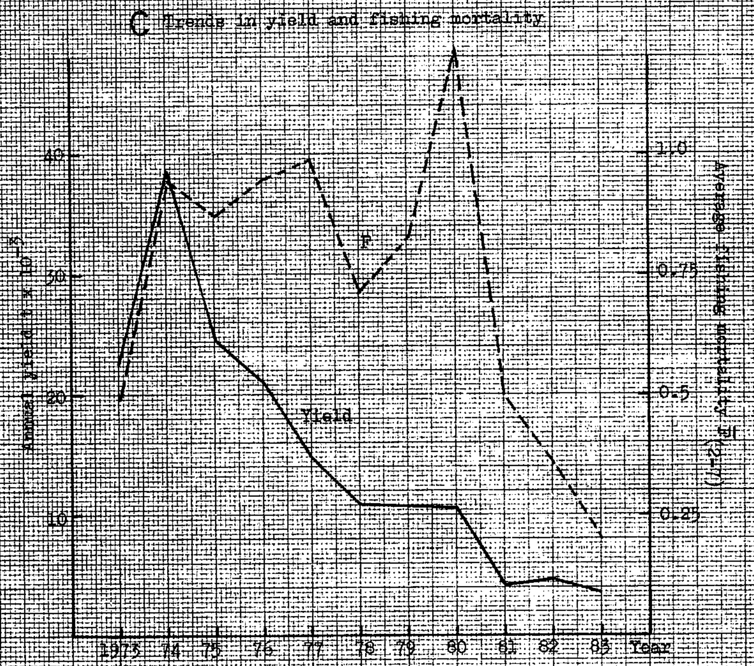
Figure 1.3. (Continued)



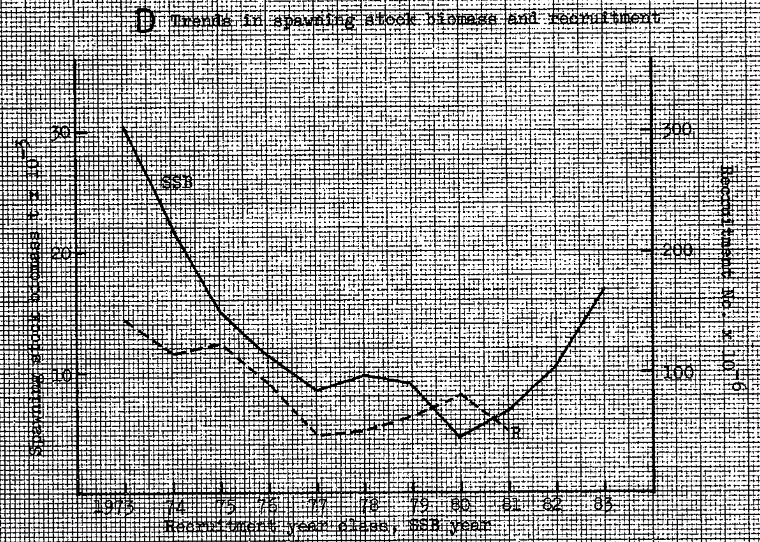


Figure 8.1. Icelandic summer-spawning HERRING.

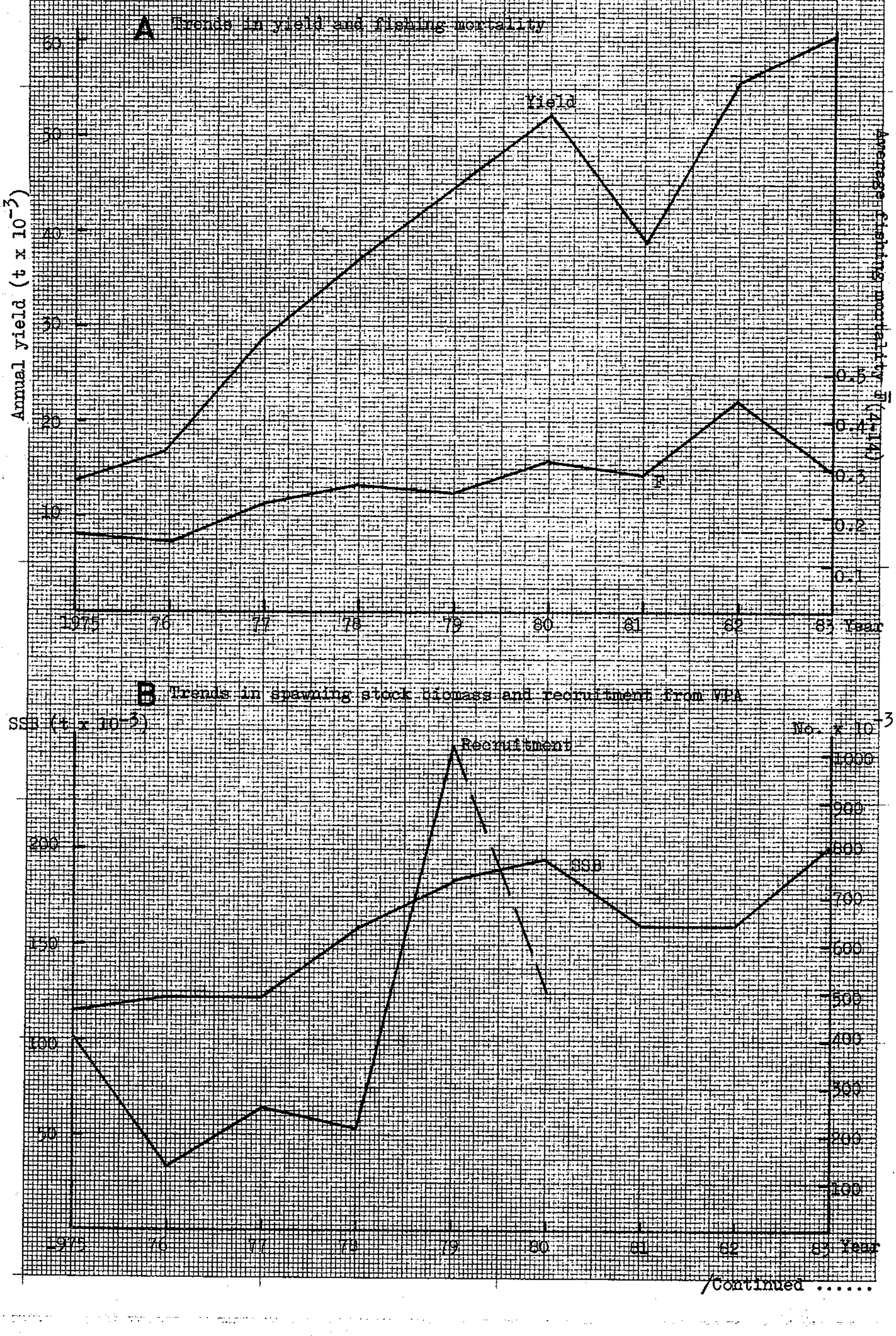


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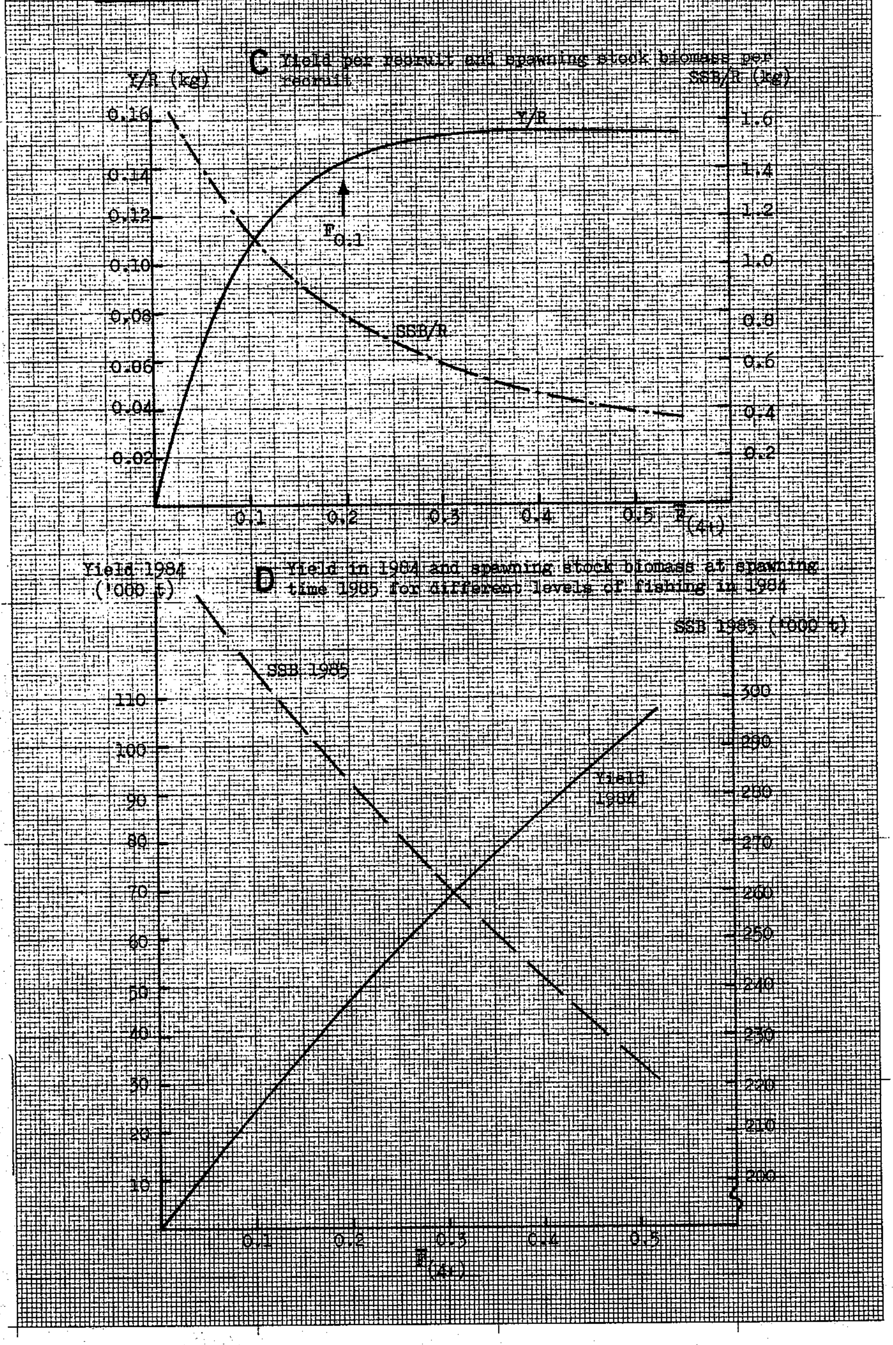
Figure 8.1 (Continued)



APPENDIX 1

Calculation of the Number of Juvenile Herring consumed by the Whiting Stock in 1981 and 1982

Data on predation by whiting on herring, derived from the 1981 ICES stomach sampling project were presented by Hislop *et al.* (1983). Since whiting appears to be by far the most important predator on juvenile herring, the Working Group decided to look at the results of this study in some more detail.

The above authors presented mean quantities of prey, split into length categories, per stomach of whiting of different age groups and per quarter (Table 5 of the above report). To arrive at an estimate of total predation, the mean quantities of prey per stomach have to be multiplied by the total number of whiting in each age group in the relevant quarter. The present Working Group has done this by taking the most recent stock estimate for whiting on 11.1.1981 (Anon.1984) and by calculating the average stock size in each quarter of the year, assuming that Z was equally divided over the 4 quarters. The following stock sizes are obtained this way:

Quarter	North Sea Whiting in 1981						
	Number per age group in millions						
	0	1	2	3	4	5	6+
1	1 396	647	987	430	128	30	15
2	1 172	559	839	329	92	22	10
3	984	484	713	252	67	16	7
4	826	419	606	193	48	11	5

When the mean quantities of herring per whiting stomach are multiplied with the total number of whiting in each quarter, the following total quantities of herring in whiting stomachs are obtained.

	Mean quantitites of herring (tonnes) in all whiting stomachs		
	Length of prey in cm		
Quart.	<10	10 - 14	15 - 19
1	15	231	12
2	26	0	0
3	153	730	0
4	143	10	2

There is a remarkable difference in herring consumption by whiting between the different quarters, with very little predation in the second quarter, and a very large predation in the third quarter of the year. Most likely, the increased predation in the third quarter is due to the availability of a new herring year class as 0-group fish.

Hislop et al. (1983) have converted their data on average weight of prey per stomach into estimates of total consumption of herring by whiting of different age groups. This was done by using certain assumptions about digestion rate, converting weights of prey into length, and finally length into age. The table below is a summary of their Table 6.

Estimated numbers of herring of each age group consumed per 1 000 whiting of each age in 1981

Quarter	Age of herring (rings)	Age of whiting (years) 0	1	2	3	4	5	6+
1	1			594	2 659	4 796	5 363	6 439
	2			2	27	73	80	90
2	0	338	1 065	1 569	2 635	1 484	1 186	1 001
3	0		1 001	4 150	7 343	9 935	11 756	9 528
	1		482	3 322	3 491	3 106	2 716	2 197
4	0	55	639	3 045	6 390	9 483	10 559	8 462
	1		24	3	11	37	88	123

The remarkable feature of the above table is the very high number of 1-ringed herring consumed by whiting in the third quarter of the year, especially in view of the fact that no 1-ringed herring at all was consumed in the second quarter. There are some reasons to suspect that the split in age groups for the third quarter is incorrect, and that most of the herring classified as 1-ringers must have been in fact 0-group herring.

a) All of the herring consumed were either below 10 cm, or in the length class 10-14 cm. It is likely that the herring in the length class 10-14 cm were mainly in the lower range of this length class. This is supported by the fact that a relatively large number of this length class was eaten by small whiting of 1 and 2 years old.

b) In the third quarter of 1981, very large numbers of the 1980 year class were taken as 0-group herring by the industrial fishery. This indicated that 0-group herring must have been very abundant at that time of the year, and also must have played a relatively important role in the diet of whiting.

c) Age/length data referring to by-catches of juvenile herring in the sprat fishery (text table below) show that all 1-group herring in the third quarter of the year were over 15 cm long.

Age/length distributions of juvenile herring in 1981						
Length in cm	IVa West, July Norwegian samples		IVb, August Danish samples		IVb, September Danish samples	
	0-group	1-group	0-group	1-group	0-group	1-group
8.0			1			
9.0			18		6	
10.0			19		4	
11.0			21		28	
12.0			60		47	
13.0			44		32	
14.0			17		21	
15.0		2	1	3	4	
16.0		30		28	2	6
17.0		36		30		18
18.0		19		32		13
19.0		14		32		9
20.0		63		41		9
21.0		60		14		7
22.0		17		4		3
23.0		1		1		
24.0+		3		1		

On the basis of this information, it was decided to reject the age-split used by Hislop et al. and to classify all herring less than 15 cm in the 3rd quarter of the year as 0-group herring. The estimated numbers of herring eaten by the whiting in 1981 are then revised as follows

Revised estimates of herring of each age group consumed per 1 000 whiting of each age in 1981								
Quarter	Age of herring (rings)	Age of whiting (years)						
		0	1	2	3	4	5	6+
1	1			594	2 659	4 796	5 363	6 439
	2			2	27	73	80	90
2	0	338	1 065	1 569	2 635	1 484	1 186	1 101
3	0		1 483	7 472	10 834	13 041	14 472	11 725
4	0	55	639	3 045	6 390	9 483	10 559	8 462
	1		24	3	11	37	88	123

The total numbers of herring in each age group consumed by the whiting stock in 1981 can be calculated from the figures given in the above table, and the quarterly stock estimates of whiting given earlier:

Total numbers of herring (x 10^6) eaten by the whiting stock in 1981			
Quarter	0-group	1-group	2-group
1	-	2 601	27
2	3 348	-	-
3	9 963	-	-
4	4 005	17	-
Total	17 316	2 618	27

For the year 1982, no data are available from stomach sampling. Estimates of the consumption of juvenile herring by the whiting stock can only be made assuming that the mean consumption per whiting in 1982 has been the same as in 1981.

The numbers of whiting in each quarter of the year have been calculated the same way as for 1981, i.e. taking the stock estimate for 1.1.1982 from Anon 1984, and calculating the average stock sizes in each quarter. The following stock sizes are thus obtained:

Quarter	North Sea Whiting in 1982						
	Number per age group in millions						
	0	1	2	3	4	5	6+
1	977	698	361	504	150	35	12
2	902	589	308	412	118	26	8
3	833	497	262	337	93	19	6
4	769	419	223	275	73	14	4

If we multiply the numbers of whiting in 1982 by the revised estimates of herring consumption per 1 000 whiting (in 1981), we get the following estimate for total herring consumption in 1982:

Total numbers of herring (millions) eaten by the whiting stock in 1982			
Quarter	0-group	1-group	2-group
1	-	2 539	29
2	2 716	-	-
3	7 903	-	-
4	3 620	18	-
Total	14 239	2 557	29

APPENDIX 2

Yields from the North Sea Stock for Various Levels of Juvenile Fishery

Assuming a constant recruitment, the yield of the 0-group, 1-group and adult ($\geq$2-group) is calculated for various levels of fishing mortality on these age groups.

The weight at age used are the ones given in C.M.1978/H:3, apart from the weight of the 0-group. The average catch weight of this age group is lower than the weight previously used. Samples from the catch showed a catch weight of 0-group of 9 g.

The analysis of the stomach sampling data indicated a large predation on the 1-group herring in the 1st half of the year, chiefly caused by whiting predation. The fishery on the 1-group takes place mainly in the second half of the year and a calculation on an annual basis could introduce a bias in the calculated effect. Therefore, the natural mortality was split in the ratio 7:3 between the 1st half and 2nd half of the year.

The fishing mortality was split in the ratio 2:8 between the 1st and 2nd halves of the year, based on historic catch data.

The input data are summarized in the text table below:

W.R.	0	1	2	3	4	5	6	7	8+
Av. weight (g)	9	50	126	176	211	243	251	267	271
M	1.0	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	0.56	0.24							

The recruitment was assumed to be 35 x 10^9 measured as 0-group. In section 2.9.2 the recruitment of the 1980 year class is estimated to 32 x 10^9. This year class is slightly lower than an average year class measured as 1-group in the IYFS. It was therefore decided to use 35 x 10^9 as the recruitment estimate as 0-group in this example.

The fishing mortality on the adult herring was $F = 0.2$ in all the runs.

Results

The results are given in Figure 2.9, showing corresponding yield of 1-group and adult herring for three levels of fishing mortality on the 0-group.

Example A: This example assumes no catches of 0-group herring ($F_0 = 0$)

Example B: A catch of 37 000 tonnes of 0-group is assumed corresponding to $F_0 = 0.2$

Example C: A catch of 82 000 tonnes of 0-group is assumed corresponding to $F_0 = 0.5$

Some examples, together with the calculated spawning stock estimate, are given in the text table below:

0-group	0	0	0	37	37	37	82	82
1-group	0	34	120	0	54	120	58	145
Adult	780	705	520	640	520	390	350	174
SSB (1/9)	3 083	2 790	2 067	2 524	2 067	1 531	1 385	688

The calculations are based on an assumed recruitment of 35 x 10^9 measured as 0-group. The absolute levels of catches should therefore only be considered as examples of the relative effect. The present level of the juvenile fishery must be interpreted in terms of fishing mortality. In the following text-table, the fishing mortality and corresponding catches in the above examples are shown:

Example A		Example B		Example C	
F_1	Catch 1-group	F_1	Catch 1-group	F_1	Catch 1-group
0	0	0	0	0	0
.1	34	.1	28	.1	21
.2	66	.2	54	.2	40
.3	95	.3	78	.3	58
.4	121	.4	99	.4	74
.5	145	.5	119	.5	88
.6	168	.6	137	.6	102
.7	188	.7	154	.7	114
.8	207	.8	169	.8	125
.9	224	.9	183	.9	136

The spawning stock has been calculated for the examples given above. In all examples an F = 0.2 is used on the age groups-2 and older. Thus, there is a one-to-one correspondance between the catch of adult herring and the spawning stock in each example.