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Exploration of the Sea

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

Copenhagen, 19-29 March 1985

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1 INTRODUCTION

1.1 Participants

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1.2 Terms of Reference

The Herring Assessment Working Group for the Area South of 62^0N met at ICES headquarters from 19-29 March 1985 in accordance with C.Res.1984/2:4:6 to

i) Assess the state of the herring stocks in Division IIIa, Sub-area IV (and, if possible separately for Divisions IVa, IVb, and Divisions IVc-VIId), Divisions Va and VIa and Sub-area VII to provide catch options inside safe biological limits for 1986

ii) Evaluate the biological justification for assessing the Clyde herring as a separate unit

iii) Provide data on the stock composition of the herring catches in Division IIIa.

In accordance with C.Res.1984/4:13, the Working Group was also required to

i) Provide quarterly catch at age and mean weight at age data as input for the Multispecies VPA for the period 1974 to 1984 and, as far as possible, for earlier years back to 1963 for the North Sea stocks

ii) Evaluate the evidence of natural mortality for the oldest age groups

iii) Assess the effects of applying the estimates of total natural mortality calculated by the Multispecies Working Group.

In addition to the above terms of reference, the following requests were referred to the Working Group by the ACFM:

i) In relation to a request from the Norwegian Ministry of Fisheries (on behalf of the three parties to the consultations on fishery regulations in the Skagerrak and Kattegat) both the Industrial Fisheries and Herring Assessment Working Groups were asked to provide as detailed data as possible on the species composition of catches taken in the sprat fishery (i.e., the industrial small- meshed fishery for sprat and other species) in Division IIIa broken down as far as possible by time and area, to enable the ACFM "to provide an early opinion on technical regulatory measures in the sprat fishery".

ii) In relation to a request from the Commission of the European Communities, the Working Group was asked:

a) to consider the need for the present extent and duration of the annual closure of the herring fishery in the northern Irish Sea designed to protect the spawning shoals, and

b) to consider the possibility of recommending alternative management measures which would not discriminate against small vessels, but which would achieve the same conservation effects as the existing regulations controlling fishing for herring and sprat in a number of coastal areas in the North Sea.

The new terms of reference and additional requests are addressed in appropriate sections of this report.

2 NORTH SEA HERRING

2.1 The Fishery

2.1.1 ACFM advice in 1984

At its 1984 meeting ACFM made the following recommendations in relation to North Sea herring.

a) In 1984 and 1985 the North Sea herring should be treated as two management units - the Downs stock and the herring in Divisions IVa and IVb.

b) At the proposed level of fishing mortality rate ($F_{0.1}$) TACs should be set as follows:

	1984	1985
Divisions IVa,b	95,000 t	166,000 t
Divisions IVc & VIId,e	49,000 t	62,000 t

c) Since Downs herring are present in Division IVb outside their spawning season, transference of up to 20% of the Divisions IVc - VIId,e TAC to Division IVb would be acceptable in both 1984 and 1985.

d) A closure of the spawning area within the 6-12 mile limit off the east coast of England should be implemented:

$54^0 10'$ - $54^0 45'$N during the period 15 August-30 September;
$55^0 30'$ - $55^0 45'$N during the period 15 August-15 September.

e) To protect juvenile herring, no herring or sprat fishery should be allowed in the area from the Danish coast to 7^0E and between $55^0 30'$ and 57^0N during the period 1 July-31 October.

2.1.2 Catches in 1984

The 1984 landings, 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 1984 is estimated at 317,263 tonnes, whilst the revised catch for 1983 is now 317,124 tonnes. The proportion of unallocated catch in 1984 was 22%, an improvement on the previous two years (58% in 1983 and 48% in 1982).

Adult herring catches

The approximate catch breakdown for adult herring (2-ring and older), based on information supplied by Working Group members, is presented by ICES Divisions and quarters in the text table below (in tonnes):

Divisions	Quarters (1984) I	II	III	IV	Total
IVa (W of 2^{0}E)	6,768	48,442	49,703	23,779	128,692
IVa (E of 2^{0}E)	-	31,329	11,597	1,143	44,429
IVb	15,040	6,599	23,688	8,451	53 778
IVc + VIId	10,009	715	59	35,119	45,902
Total	31,817	87,085	85,407	68,492	272,801

The total catch for Divisions IVa W and IVa E amounts to 173,121 tonnes which combined with that of Division IVb produces 226,899 tonnes of adult herring. This considerably exceeds the TAC recommended by ACFM (95,000 tonnes) for these two Divisions. The catch from Divisions IVc and VIId (45,900 tonnes) was 3,100 tonnes less than the TAC recommended by ACFM.

Juvenile Herring Catches (O + 1-group)

A similar catch breakdown for juvenile herring based on information supplied by Working Group members is presented in the following text table (in tonnes):

Divisions	Quarters (1984) I	II	III	IV	Total
IVa (W of 2^{0}E)	-	25	327	463	815
IVa (E of 2^{0}E)	-	771	3,281	844	4,896
IVb	1,767	2,349	17,509	17,677	39,302
IVc + VIId	5	1	12	107	125
Total	1,772	3,146	21,129	19,091	45,138

The total catch of juvenile herring (45,138 tonnes) represents a dramatic decrease compared with the 160,000 tonnes recorded in 1983 and 153,000 tonnes in 1982, and appears to have been largely due to improved enforcement of catch control regulations in Division IVb.

2.1.3 Catch in number

The numbers of herring caught by age and area are given in Tables 2.3 and 2.4. Table 2.5 provides a more detailed breakdown for 1984 by areas and quarters from information supplied by Working Group members. Most countries furnished sampling data for their catches and all the major fisheries were covered.

The text table below summarises the numbers caught at age for the most recent six years:

Millions of herring caught by age group (winter rings)

Year	0	1	2	3	4	5 and older	Total
1979	542	159	34	10	10	4	759
1980	792	161	108	92	32	26	1,211
1981	7,889	447	264	57	40	77	8,774
1982	9,557	840	268	230	34	34	10,963
1983	10,030	1,147	545	216	105	85	12,128
1984	2,189	561	976	421	191	152	4,490

The percentage contribution by number of 0- and 1-ring fish to the catch was 61% in 1984, which compares with values of 92-95% in the preceding three years (1981-83). The recruiting 1981 year class (2-ringers) contributed 56.1% by number to the adult catch (excluding 0- and 1-ringers). It was well represented in the catches of most divisions from the second quarter on, and contributed most strongly (70%) to the catches from Division IVb (Table 2.5).

The catch distribution given in Table 2.5 shows that practically all the 0-group and a large part of the 1-group were taken in Division IVb during the third and fourth quarters. These catches were mainly taken from the eastern half of this division in the industrial fishery. 1-group fish also appear in significant amounts in the Division IVa catches, particularly during the third quarter.

2.2 Recruitment

2.2.1 Relationship between IYFS indices and VPA estimates

At its meeting in January 1985 the Working Group on International Young Fish Surveys updated the regression between IYFS-indices and VPA estimates by including the more recent year classes up to 1980 (Doc. C.M.1985/H:2). The regression equation calculated by this Working Group was

$$y = 0.0029\ x - 0.12$$

where y = VPA estimate of 1-ringers in numbers x 10^{-9} and x = IYFS abundance of 1-ringers in no/hour for the standard area.

Since the intercept of the regression line on the y-axis was not significantly different from zero, the International Young Fish Survey Working Group considered it justifiable to force the regression line through the origin. The regression equation then becomes

$$y = 0.0028\ x$$

During the present meeting, new estimates of 1-group herring were available from a VPA based on a value of M = 0.8 for 1-ringers (Section 2.7.5).If the year classes 1968-80 in the IYFS (Section 2.2.4) are regressed against these new VPA estimates (Section 2.7.5), the regression equation becomes

$$y = 0.0045\ x + 0.03\ (r = 0.91)$$

As the intercept on the y-axis again is not significant, the regression can be forced through the origin, and the equation becomes

$$y = 0.0046\ x$$

In the following paragraphs, predictions of new year classes are calculated on the basis of both the old regression (y = 0.0028 x) and the new one (y = 0.0046 x).

2.2.2 Year class 1981

It was shown in the previous section that year class 1981 recruited in high numbers to all North Sea populations in 1984. The predictions for this year class given in the 1983 and 1984 reports of this Working Group thus turned out to be correct.

2.2.3 Year class 1982

A final IYFS-index for this year class is not yet available owing to technical problems in computer handling of the data. The Working Group was provided with some age/length data for the 1984 IYFS, which indicated that the provisional estimate based on the length group <20 cm was fairly accurate. Consequently, the Working Group decided to keep for the time being the IYFS index of 2,473 fish/hour given in last year's report.

Using the two different regression equations based on M = 0.1 and M = 0.8 on 1-ringers, the following estimates of the size of year class 1982 as 1- and 2-ringers are obtained.

Assumed M on 1-ringers	0.1	0.8
Stock as 1-ringers (1 Jan.)	6.92×10^9	11.38×10^9
Catch of 1-ringers	561×10^6	561×10^6
F on 1-ringers	0.09	0.07
Stock as 2-ringers (1 Jan.)	5.67×10^9	4.7×10^9

2.2.4 Year class 1983

The first results from the IYFS in 1985 give a preliminary index of 3,768 1-ringed herring for the standard herring area. This year for the first time some age/length information was available for the herring catches during the recent IYFS at the Working Group meeting, so the preliminary index should be more accurate than the ones used in previous meetings of this Working Group.

The index obtained this year is the highest on record; it is 40% higher than the previous highest one (year class 1969):

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
1983	3 768

Major concentrations of 1-ringed herring were found off the Jutland coast and in the entrance to the Skagerrak. There was in fact a continuous distribution of 1-ringed herring from the eastern North Sea, through the Skagerrak, into the Kattegat.

Using the regression equations based on M = 0.1 and M = 0.8 on 1-ringers, the following estimates of stock size as 1-ringers are obtained:

Assumed M on 1-ringers	0.1	0.8
Stock as 1-ringers (1 Jan.)	10.55×10^9	17.33×10^9

These estimates should be treated with some caution because the survey index in this case lies outside the range of values that were used in calculating the regression equation. The conclusion remains, however, that year class 1983 must be a very strong one - stronger probably than any year class that has been sampled during the history of the IYFS.

2.2.5 Year class 1984

This year class was sampled in the late larval stage by IKMT during the IYFS in February 1985. The results of this sampling are shown in Figure 2.1 together with similar data for the preceding two year classes. The new year class appears to be very abundant in the North Sea, with the main concentration in the central North Sea, and lower densities in the eastern North Sea and Skagerrak/Kattegat. Comparison of the distributions of year classes 1982-84 again illustrates the large variability in transport of larvae from year to year.

Experience with year class 1983 has again strengthened the hypothesis that the abundance of larvae at the time of IYFS is related to abundance of 1-group herring the next year, and thus to the final year class strength. The high abundance of larvae of year class 1984 should therefore be considered as a first optimistic indication of the strength of this year class.

The Working Group made a first attempt to quantify the relationship between IKMT abundance and VPA estimates of year class strength as 0-group. In order to calculate an IKMT-index, the North Sea was divided into four areas (Figure 2.2) and the mean value for all rectangles sampled within each area was weighted by the surface of the area (here approximated by the maximum number of rectangles that had been sampled within the area in any year). The sum of the weighted area indices for the four North Sea areas plus Skagerrak/Kattegat resulted in a total index for the whole North Sea area.

The index was regressed against estimates of VPA stock size as 0-group, derived from the total North Sea VPA (Section 2.7). The data used are presented in Table 2.6 and plotted in Figure 2.3. The correlation is almost significant ($r = 0.75$) and the regression equation obtained is

$$y = 0.0066x - 3.42$$

in which y = stock size of 0-ringers from VPA total North Sea x 10^{-9}

x = IKMT-index North Sea + Skagerrak/Kattegat.

It should be mentioned that larvae from the southern North Sea are under-represented in the results of the IKMT surveys in February both because of their small size and because of their distribution partly outside the survey area. However, the Working Group had no means to correct the IKMT-index for incomplete sampling of the Downs component, and it was decided for the time being to treat the IKMT-index as representative of 0-group abundance for the total North Sea stock.

2.2.6 Length frequency distributions from the International Young Fish Surveys

Prediction of recruitment to the North Sea spawning stocks

Almost all countries had submitted computer-readable data from the February 1985 IYFS. The Danish Fisheries Institute provided summaries of the length distributions in half-centimetre intervals for all the herring sampling areas. A limited amount of information was available for age/length keys, and with this coverage it indicated that few fish below 20 cm were likely to be 2-group. The preliminary abundance indices of fish below 20 cm for each sampling area have been used in establishing the abundances of the component length groups. Unfortunately comparable data for the 1983 and 1984 surveys did not become available until the end of the meeting.

The percentage length distributions were analysed using the method of Cassie as described by Burd and Hulme (1984). Table 2.7 gives the mean lengths and abundances of the components extracted in each area and the overall abundance of each component in the total area surveyed.These data are shown by herring sampling area in Figure 2.4. The small components shown in Figure 2.4 (a), which may contain elements of Downs herring, are seen to be very limited in distribution. Relatively high numbers occurred in the Southern and German Bights. Fish at the upper end of the length range of this first component occurred in increasing abundance northwards along the Jutland coastal areas. The 13 cm group is seen to be highly abundant in these regions, but relatively scarce in the south.

These distributions may be contrasted with those of larger fish in Figure 2.4 (b). These fish made up 73% of the total 1-group catch in 1985. They were abundant in the areas adjacent to the Dogger Bank particularly to the southwest.

It is clear from the above that the major part of the recruitment of the 1983 year class is likely to be destined for the central and northern North Sea spawning stocks. Quantification of the expected recruitment to the Downs stock is particularly difficult, however. Taking the smallest component in the southern areas (Herring Areas 51, 63-66) these amount to no more than 6% of the total year class strength. If one suppposed that the second component in these same areas is ascribable to the Downs stock this would add a further 14% to the year class strength. These give estimates (based on M on 1-group = 0.1) of the partition of recruitment as follows:

	Abundance x 10^9		
	Downs	Non-Downs	Total (para.2.2.4)
Low estimate 6%	0.62	9.92	)
Downs			) 10.55
High estimate 20%	2.11	8.44	)

Recruitment to the Downs stock is also monitored by an English survey for O-group herring.

Wood (1983) described a relationship between the abundance of 2-ringed fish of the Downs stock and indices of abundance of O-group on the East Anglian coast. This regression successfully predicted the 1980, and appears also to have estimated the 1981 year class. These data have been further refined and the new estimates are given in Table 2.8.

The results of the 1984 English O-group survey are totally anomalous when compared with the survey data from 1977. The 1984 values for the northern area (Dunstanburgh Head - Flamborough) are consistent in terms of meristic characters with the data for earlier years. The mean VS and K_2 for the 1983 year class are lower than any in the time series for the Bank herring (catches Flamborough to Cromer), which is also the most abundant component. Fish with the same VS and K_2 characteristics were predominant in the East Anglian area and Thames Estuary in 1984. Over the standard stations used in all other years the abundance was 0.193 x 10^3 per hour, with a mean VS of 56.260 and K_2 of 13,400. Fish with characertistic Downs vertebral counts, however, occurred in only one location in the Thames estuary.

English sampling in rectangle 38F7 in the German Bight during the 1985 IYFS gave a bimodal length distribution of 1-group. Fish below 12 cm had a VS of 56.571 characteristic of Downs herring while 12-15 cm fish gave a mean of 56.271 which is very similar to the values for the O-group in the English coastal samples. It is unfortunate that little other meristic material was available for analysis from the relevant areas.

Because of the difficulty of clearly identifying the Downs component in 1985, the means of the two estimates given in the text table above were taken as input values of recruitment of 1-ringers in 1985 for prediction purposes, the values being rounded as given below:

Estimates of 1-ringers at 1 January 1985	
Downs component	1×10^9
Non-Downs component	9×10^9

To estimate recruitment of 2-ringers to the Downs stock in 1985 and 1986, estimates taken from the current VPA for Divisions IVc/VIId (Section 2.7) have been regressed on indices of Downs herring abundance in the English O-group index and on the 1-group index from the IYFS estimate for Downs herring (Figure 2.5) using the data in Table 2.9. The value of L_1 = 10 cm for the Downs component in the IYFS is based on the two smallest length components in Table 2.7, that is those for which there is strong evidence of their identity. The regressions have been calculated including all year classes up to the 1980 year class. Assuming the spawning stock biomass in 1984 is 200,000 tonnes as indicated by both the acoustic and larval surveys the estimate of the 1981 year class is indicated on the figure. The abundances of the 1982 and 1983 year classes in the two independent series are indicated on the x-axes. The estimates of 2-ringer recruits from these regressions are given below :

Estimated no. of 2-ringer recruits (x 10^{-6})

Year class	Based on indices of 0-group	1-group	Year of recruitment to SSB
1982	750	1,070	1985
1983	270	120	1986

In 1984, an input recruitment of 1,000 x 10^6 2-ringers had been estimated for the Downs stock at 1 January 1985 from the previous regression on the English 0-group index. From new data available from the 1984 IYFS an index of 1,070 was obtained for this year class. Though a lower value is indicated above by the new 0-group regression, the value of 1 x 10_9 used previously has been used for this year class in the prediction in Section 2.8.

For 1986, a value of 200 x 10^6 was taken as the estimate of 2-ringers at 1 January, this being intermediate between the two estimates given in the text table above.

2.2.7 Use of IYFS data

Some progress has now been made in supplying preliminary exchange tapes with length frequency distributions to the ICES data base. This enables the Working Group to calculate more precisely an index of 1-ringed herring, and may be compared to the previous situation in which the preliminary index was calculated as the abundance of all herring less than 20 cm. The availability of LFD's at the time of the meeting also allows a study of the length composition of 1-ringed herring, which may provide indications of the racial composition of this age group (cf. para 2.2.6).

In order to make optimum use of the length data, however, it is necessary for age/length keys for most parts of the survey area to be available at the time of the Working Group meeting. During the present meeting, a limited amount of age/length data from the 1985 survey were already available, but there is clearly much room for improvement. It is desirable, therefore, that in future all participants make an effort to read herring otoliths during the survey or immediately afterwards, and make these results available to the Working Group meeting.

The availability of age/length data at the time of the Working Group meeting will also provide information on 2-group catches during the IYFS.

The use of 1985 IYFS data

Length distributions from the 1985 IYFS survey were available from five of the seven countries taking part in the IYFS in the North Sea. Only two contries did not submit the "quick-exchange" tapes because of technical problems. Age-length data were available from three countries and this information enabled the Working Group to make extensive use of the IYFS data only 1 1/2 months after the survey had finished.

The available length distributions were averaged within each statistical rectangle and the age/length key was used to separate the distribution into 1-group, 2-group and 3-group and older herring.

During the survey a preliminary catch of 1-group herring, estimated as herring less than 20cm, is reported by all participating countries. For each rectangle these preliminary estimates were corrected using the ratio between the number of 1-group herring (estimated using age-length keys) and the number of herring less than 20cm. It appeared from the calculations that only minor corrections were necessary,the preliminary catch per hour being reduced by only 2-3%. In several areas the length group approximately separating the 1 and 2-group was lower than 20 cm. In these areas, however, the main part of the length distribution was well below 20cm.

2.3 Acoustic Surveys

2.3.1 Northern North Sea (Div.IVa and Buchan area)

An acoustic survey of the northern North Sea was carried out in July 1984 by vessels from Norway and the United Kingdom, and the area covered was extended compared with previous years to cover most of the northern North Sea south to 57^0N, i.e., almost the whole of Division IVa.

The survey and analysis procedures were the same as in previous years and the echo-integrator values were converted to estimates of the number of herring per unit area using the target strength/length relationship recommended by the acoustic survey planning group (Doc. C.M.1983/H:12).

$$\text{TS per fish} = 20 \log_{10} L - 71.2 \text{ dB, where } L \text{ is in cm}$$

For purposes of comparison, the survey area has been divided into sub-areas shown in Figure 2.6. and the estimated numbers at age and biomass of herring in each sub-area are given in Table 2.10. The estimate for the total survey area consists of

a) Orkney-Shetland area - mean of Scottish and Norwegian estimates
b) Moray Firth - Scottish estimate
c) Buchan area - mean of Scottish and Norwegian estimates
d) Fladen area - Norwegian estimate
e) Aberdeen area - Scottish estimate

f) Eastern area - Norwegian estimate

The estimates of total stock biomass include 1- and 2-ringers; those of spawning stock biomass exclude 1-ringers and the estimated proportion of 2-ringers that were immature (stages 1 and 2), which was 10% and 28% on the Norwegian and Scottish surveys respectively.

The results of the survey indicate a total population of 354,000 tonnes (320,000 tonnes maturing) in the Orkney-Shetland area in 1984, that is the area covered in previous years. If the estimates for additional areas surveyed in 1984 are added, the total for the entire survey area in IVa (and IVb south to 57^{0}N) is 534,000 tonnes, of which 466,000 tonnes were maturing.

A comparison with acoustic stock size estimates from the previous two years is given below (in thousand tonnes)

	Spawning Stock Biomass		
	1982	1983	1984
Orkney Shetland	224	250	320
Buchan (incl. Moray Firth and Aberdeen)	?	(50 assumed)	57
Fladen	?	?	76
Eastern Area	?	?	13
Total	?	?	466

The results therefore indicate a considerable increase in population size in the Orkney-Shetland area between 1983 and 1984 which is due to a large extent to an increment of approximately 160,000 tonnes of 2-ringers.

2.3.2 Division IVb (Bank stock)

The annual survey for spawning herring was undertaken from 24 August to 4 September and covered an area off the Yorkshire coast up to 15 miles offshore, between Skinningrove and Flamborough Head. The main part of the survey was concentrated within an area off Robin Hood's Bay where in previous years major herring concentrations had developed. Insufficient time was available to cover the Longstone area effectively.

Early in the survey (24-28 August) no localised aggregations were evident and the herring were difficult to catch. The first signs of denser aggregations appeared on 29-30 August off Robin Hood's Bay and on 30-31 August a more clearly defined patch became evident about 9 miles east of the Bay. This patch then progressively contracted and increased in density up to the last day the area was surveyed (3 September). The size of individual shoals became very large during the latter part of the survey, up to 200-300m in diameter and 30-50m in vertical thickness. The area between Whitby and Skinningrove was covered on 25 August and the area off Flamborough Head on 26 August and 4 September, but few echotraces were recorded in these areas. Local fishermen reported herring spawn present in their demersal trawls early in September when fishing about 9 miles northeast of Flamborough Head.

On 3 September the majority of fish sampled were in maturity stages 5-6. Recruiting 2-ring fish (1981 year class) made up 75% by weight of the advanced maturity stage fish (5 and above). Very few spents were caught and overall only 13% of those sampled during the survey were in stage 6.

A limited high speed townet survey was carried out on 31 August-1 September and the results showed a very high density patch of small (<10mm) larvae, many in the yolk sac stage, centered about 7 miles NE of Whitby, with fairly high densities extending in a coastal band south to Flamborough Head. It was thus evident that there had been an earlier spawning, probably around 15 August.

Dutch trawlers had caught about 8,700 tonnes of herring in this region during the first half of August.

The acoustic survey results are summarised in Table 2.11, which shows the rapid build-up of the herring concentration over the space of a few days, attaining a peak estimate of around 228,000 tonnes at the end. The final survey on 3 September covered only the central area of the main patch. About 90% of the population sampled were in maturity stage 5 or above, and accepting these as "Banks" herring likely to spawn in this region, gives a peak biomass estimate of just over 200,000 tonnes. The age structure of the population together with a breakdown of the acoustic biomass into equivalent numbers and weight is presented in Table 2.12.

The estimate of 208,000 tonnes respresents a considerable increase over that recorded in the same general area in the 1983 survey, which was some 40,000 tonnes, although this was considered an underestimate. The 1984 survey did not cover the Longstone spawning area and some fish had also spawned off Whitby prior to the survey, so that an additional but unknown quantity of herring could be added to the 1984 estimate.

2.3.3 Divisions IVc and VIId

Two surveys were undertaken, the first by R/V Thalassa in November 1984 and the second by R/V "Clione" in February 1985. The November survey covered the southern North Sea south of 52^0N and the English Channel east of 0^0. A second grid covering the eastern Channel was completed in late November.

The first survey in the eastern Channel produced an estimate of 36,400 tonnes, whilst the second survey about two weeks later showed a major increase to 110,500 tonnes, associated with the appearance of dense spawning aggregations. The Southern Bight estimate for the area south of 52^0N amounted to 35,635 tonnes of which 75% derived from the Dutch and Belgian coastal areas.

The distribution of commercial fishing at the time of the survey suggested that herring were also present in shallow water near the continental coast, not effectively covered by the survey. If some allowance is made for these areas then a further 30,000 tonnes could be added to the Channel total and 10,000 tonnes to that from the Southern Bight. This would produce totals of 140,500 tonnes for the eastern Channel and 45,600 tonnes for the Southern Bight, i.e. a total of 186,000 tonnes.

These estimates indicate a considerable reduction in spawning biomass compared to that in November 1983, when the eastern Channel component was 104,000 tonnes and that from the Southern Bight 178,000 tonnes (total 282,000 tonnes). The latter figure could have been overestimated since some broad assumptions had to be made about the proportion of herring contributing to the total acoustic biomass in this area, owing to inadequate sampling.

The 1984 spawning stock estimate was apportioned into age groups using age distributions of samples from the Dutch and French fisheries during the last quarter in Divisions IVc and VIId. The estimated percentage age composition is given below.

Age composition of Dutch and French herring catches during the last quarter of 1984 in Divisions IVc and VIId (Excluding 1-ring fish)

(Winter rings)	2	3	4	5	>5
(Year class)	(1981)	(1980)	(1979)	(1978)	
% No.	57.4	28.5	8.1	5.2	0.7

The survey in February 1985 covered the Channel east of $0^0$15'W and the southern North Sea south of $52^0$20'N. Pelagic traces were scarce within the French sector of the Channel, and in the southern North Sea acoustic densities were low. The maximum densities were found over the central part where Dutch pair -

trawlers were catching spent herring. The survey of the Southern Bight was not completed owing to bad weather. The herring biomass estimate of 28,000 tonnes can thus only be a minimal one. 72% of this total derived from areas where the spent herring fishery was taking place. The age composition of the Dutch pair-trawl catches during February was as follows:

<u>Age composition of spent herring in Division IVc taken by Dutch pair-trawlers during February 1985 (Excluding 2-ring fish)</u>

(Winter Rings)	3	4	5	6	$\geq$6
(Year class)	(1981)	(1980)	(1979)	(1978)	
%No.	63.4	24.1	6.0	5.6	0.9

2.4 Herring Larval Surveys

The sampling intensity in all areas in 1984 was at an acceptable level, being broadly comparable to that in the preceding years. At its meeting in February 1985 the Herring Larval Working Group for the Area South of 62^0North revised all indices of larval abundance in the North Sea spawning areas over the period 1972-83, in some cases by modifying the standard sampling areas, and by laying down new rules governing how abundance should be estimated in areas which had not been sampled. These new larval abundance indices are given in Anon.,1985.

2.4.1 Division IVa

Surveys in this area were carried out by the Federal Republic of Germany, Netherlands and Scotland resulting in satisfactory coverage of the standard sampling area in both the first and second halves of the month. The indices of abundance for the smallest size category of larvae were 1617 x 10^9 for the first half of the month and 1813 x 10^9 for the second half. The total index for the Orkney-Shetland area in 1984 is only slightly higher than in 1983.

As in the immediately preceding years, the larval indices for the Buchan area have been added to those for the Orkney-Shetland area to get the indices appropriate to the Division IVa spawning stock. In the Buchan area surveys by Danish and Scottish research vessels gave satisfactory coverage of the standard sampling area in both halves of September. The 1984 index for the Buchan area was very similar to that of 1983.

The combined annual index for 1984 is 7667 x 10^9 larvae. This is slightly lower than in 1983. The interpretation of this larval index in relation to spawning biomass is commented on in Section 2.7.1.

2.4.2 Division IVb

In the area off the northeast English coast surveys were done throughout September and October by English and Netherlands research vessels. The abundance estimates for small larvae were 472 in early September, 2132 in late September, 756 in early October and 424 in late October. The abundance estimate for the first period is very much lower than in 1983 but in all other periods it is much higher. The mean annual index for 1984 is accordingly 946 x 10^9 which is about 50% higher than in 1983. If this annual index is used in the regression equation between spawning stock biomass and larval abundance produced by the February 1985 meeting of the Herring Larval Working Group: $Y= .070X + 20.82$, it would estimate the 1984 spawning stock biomass in Division IVb as 87,000 tonnes. It should be pointed out, however, that the larval abunbdance index is now very considerably greater than in any year on which the regression is based and must, therefore, be treated with some caution.

2.4.3 Divisions IVc and VIId

In these Divisions the larval data had not been received in adequate time to finalise the estimation of the abundance indices. The results quoted here should accordingly be considered as preliminary, although it is not likely that they will be very different from the final values. Surveys in these Divisions were done by the Netherlands in December and by England and the Federal Republic of Germany in January. The December Surveys gave an index of larvae less than 17 mm of 1129 x 10^9.

The estimate from the first half of January 1985, based on a survey by England, was 740 x 10^9 In the second half of January surveys were carried out by both England and the Federal Republic of Germany.Unfortunately the Federal Republic of Germany vessel had some problems with her sampler depth monitoring system which cast some doubts on the validity of her results. Accordingly these were not used from Division VIId, which was also sampled at this time by England, but the Federal Republic of Germany results were used in Division IVc where there was no other sampling. The resulting index for this period is 514 x 10^9.

The annual index for 1984/85 in Divisions IVc + VIId is 2383 x 10^9.The Herring Larval Working Group at its meeting in February 1985 made a regression between larval indices and spawning stock biomass in this area of $\ln Y=0.75\ln X-9.222$ where Y is stock in tonnes and X is larvae as individuals. If one inserts the 1984/85 index into this equation the spawning stock estimate is 222,000 tonnes.As in Division IVb, however, it should be noted that the most recent larval index is very much larger than the highest value used in estimating the regression and should accordingly be interpreted with caution.

2.5 Tagging Experiment

In 1983 and 1984 a herring tagging experiment was carried out by participants from Scotland, the Netherlands and Norway in the Shetland area (Division IVa) using a magnetic microtagging system earlier described by Morrison (1982). In this experiment approximately 48,000 herring were tagged in 1983 and of these 32 were recovered in a monitoring operation in 1984. The preliminary results from this experiment were available to the Working Group and the first indications are that the results are likely to be of considerable use for stock assessment when they have been more fully analysed, and particularly if tagging and monitoring of the tagged population are continued.

2.6 Natural Mortality

2.6.1 Predation Mortality on O-and 1-group Herring

In last year's report, the Working Group considered the first results from the 1981 ICES Stomach Sampling Project. It was decided to amend the numbers of herring by age groups consumed by whiting because it was suspected that an incorrect age/length key for herring had been used for the 3rd quarter of the year. Using these amended estimates of the amount of herring consumed by whiting, the Working Group arrived at a first tentative estimate of M = 1.0 for O-group (for the last 6 months of the year) and M = 0.8 for 1-group herring.

During the present meeting, new reports were available from the meeting of the coordinators of ahe stomach sampling project (Doc.C.M.1984/G:37) and of the Ad hoc Multispecies Assessment Working Group (Doc.C.M.1984/Assess:20). From the first report, it appears that all herring found in whiting stomachs during the 3rd quarter of 1981 have now been correctly classified as O-group (Table 5.4.1 in that report). These corrected data from the

Stomach Sampling Project were used by the Multispecies Assessment Working Group to calculate predation rates by all predators on all prey species over the period 1974-83, assuming that results from the 1981 sampling project in 1981 were representative for all other years. This was done by means of a Multi Species Virtual Population Analysis (MSVPA).

At the time of the present meeting, some doubts had arisen concerning the computer programme used for the MSVPA. Some members of the Multispecies Assessment Working Group (Sparre, pers.comm.) suspected that the programme used by their Working Group had not done what it was supposed to do, and they advised the Herring Assessment Working Group not to use the results from the present MSVPA, but to wait for the next report of the Multispecies Assessment Working Group.

Consequently the present Working Group decided for the time being to retain the values of M adopted in last year's report, i.e. M = 1.0 for 0-group (last half of the year), and M = 0.8 for 1-group.

2.6.2 Evaluation of the evidence of natural mortality for the oldest age groups

The relevant literature and the reports of all previous Herring Working Groups have been reviewed with reference to the problem of estimating natural mortality on fully recruited age groups.

All these analyses reflect the intense discussion of this problem in the years between the end of the 1950s and the beginning of the 1970s.

In general, two approaches have been applied in estimating natural mortality:

i) Estimates of total mortality rate (Z) for the war period, when fishing mortality was very low, were taken to be close approximations to the natural mortality rate. In this approach both analyses of cpue data and catch curve analyses have been applied.

ii) Regression of total mortalities against effort, the intercept (no fishing) being an estimate of M. This method, however, is very dependent on the nature of the respective fishery to which the effort data refer. Effort data from purse-seine and trawl fisheries are expected to be biassed since the increase in efficiency over a period sufficiently long for a regression analysis is difficult, if not impossible, to evaluate. It is thought that data from drift-net fisheries are not biassed in this way and that they are therefore more suitable for this type of analysis.

A variety of estimates was found ranging from 0.08 to 0.26. These estimates are of different quality and were associated with qualifying comments by the respective authors.

At a meeting of the Herring Working Group in 1964 a natural mortality rate of 0.2 was used (Anon., 1964). This was largely based on Cushing and Bridger (1966, in press at the time of the meeting), who estimated M from catch curves from the 1945 and 1946 fishery of Boulogne-based vessels as 0.17 for the Fladen Ground and 0.22 for the Channel. This value was used up to 1970 in all Herring assessments for the North Sea, the Celtic Sea and for the herring stocks to the west of Scotland and Ireland.

At the meeting of the Herring Working Group in 1971 the discussion on natural mortality was revived following a method presented to the Working Group to calculate M by a least square method resulting in an estimate of 0.08 (Anon., 1971).

Although the method was eventually withdrawn by the authors after the 1971 Working Group meeting (pers.comm.), the discussion continued and the effect of using a lower M-value was evaluated. The argument justifying the use of M = 0.1 can be seen in the following quotation from the 1972 Working Group meeting report

30 Herring Assessment Working Group for the Area South of 62^0N (Anon., 1972):

"The reliability of the stock sizes and fishing mortality estimates derived from the VPA analysis are to some extent dependent on the initial values of F and M chosen. In the past the natural mortality M for North Sea herring has often been quoted as a value of about M = 0.2. There is, however, evidence from mortality on effort studies which suggests a much lower value, less than 0.1 for adult herring /this refers to Postuma (1963)/. From the total North Sea adult catch per effort data presented here, a rather similar figure could also be derived. The effect of applying M =0.2 instead of 0.1 will be to decrease fishing mortality estimates and to increase those of stock size."

In the following Working Group reports no further discussion of natural mortality values could be found and M =0.1 was used.

Comparison of estimates of the size of herring stocks from acoustic surveys in subsequent years and taking into account the catches in the period between the surveys indicates that M might be higher than 0.1. There is, however, at present no firm basis on which to estimate the appropriate value and, in view of the fact that 0.1 lies within the range of published estimates, the Working Group would advise retaining this value until further analysis has been possible.

A change in M has consequences for the assessments as well as for the formulation of management advice. It will change the nature of the yield per recruit curve and thus the reference points $F_{(0.1)}$ and $F_{(max)}$ on which management advice is based.

In the assessments M is applied as a single value constant over a long period and over the whole range of adult age groups. In reality, however, natural mortality is a parameter which is likely to be variable between age groups and also between years during the time period.

2.7 State of the Stocks

2.7.1 Division IVa

Catches in numbers at age in Division IVa were used to run a VPA. To obtain Fs for each age group these catches were divided into those taken prior to and subsequent to the acoustic survey carried out in this Division. Annual Fs were estimated from the catches in number in each half of the year and the acoustic estimates of numbers at age in the population at the time of the survey. The catch in number data, the resulting Fs and the stock size in number are given in Tables 2.13-2.15.

The mean weights at age in the spawning stock used in previous reports to calculate the spawning stock biomass were the same as those in the catch and would not appear really appropriate for that purpose. New values were therefore estimated as weighted means of catches and mean weights at age from all national data taken in August in the appropriate areas. These values are given in Table 2.16 and were used in calculating the spawning stock biomass given in Table 2.15. Using these spawning stock biomasses over the period 1972-77 a new regression was calculated against the larval indices for the Orkney-Shetland plus Buchan areas. The relationship is $Y = 0.0274X + 69.0$ where Y is in 1,000 tonne units (Figure 2.7). This regression is significant at the 0.1 probability level. Putting the 1984 index into this equation estimates the 1984 spawning stock biomass as 280,000 tonnes.

There was some indication from the mean size of the 2-group herring caught in part of the area surveyed during the acoustic survey that a considerable proportion of this age group might be recruits to the Division IVb spawning population rather than to that spawning in Division IVa. This would find some support from the marked discrepancy between the estimates of spawning stock biomass in 1984 given in Table 2.15 (579,000 tonnes) and the one given above from the larval data.

To test the credibility of this hypothesis some adjustments first need to be made to the spawning stock biomass in 1984 estimated by the VPA, for two reasons: (a) it assumes that 0.67 of the F was generated prior to spawning whilst the catch data in 1984 indicate that this value should be 0.8; (b) the sampling done during the acoustic survey showed that only 72% of the 2-group were likely to spawn in 1984 whilst the VPA assumes all of this age group were mature. Applying these corrections the spawning stock biomass is reduced to 458,000 tonnes. Assuming then that the discrepancy between this value and the estimate from the larval data is due to 2-ringers from the Division IVb spawning stock in Division IVa at the time of the acoustic survey one gets an estimate of Division IVb 2-group in Division IVa at that time of 1300 million. This estimate is not incompatible with the estimate given for this age group in 1984 by the Division IVb VPA. It would imply that about 80% of the Division IVb recruit spawners were in Division IVa prior to spawning in 1984.

2.7.2 Division IVb (Bank stock)

The results of the 1984 acoustic survey off northeast England (Section 2.3.2) indicate that a minimum of just over 200,000 tonnes of herring were spawning in the main area of concentration in early September. To this must be added a further quantity to account for spawning at Longstone and spawning off Whitby prior to the survey. From the ratio of the total larval index in this area to the index in late September when the spawning in early September contributed to the index (Section 2.4.2) the total stock spawning in Division IVb (excluding Buchan) is likely to have been around 300,000 tonnes.

From the age composition of fish sampled during the survey, the total biomass was composed of an estimated 1,374 x 10^6 2-ringers and 343 x 10^6 3-ringers and older at 1 September.

The calculations of F values in 1984 from this stock estimate and from catches in number are given in Table 2.17.The catches in number are those for the whole of Division IVb (that part of Buchan in Div. IVb included) reduced by 30% in the first half of the year to account for a contribution of Downs stock caught in Division IVb (Section 2.7.3).

A VPA carried out using these values of F is given in Tables 2.18-2.20. Table 2.16 gives new mean weights at age at spawning time estimated from samples taken during the 1984 acoustic survey,and these were used in the VPA to calculate spawning stock biomass.

Because of the low catches prior to 1982, the VPA can be used to estimate F and stock size only in the most recent years. This indicates that F increased in 1983 and remained roughly constant in 1984. The spawning stock biomass increased in 1983 and even more dramatically in 1984 as a result of the high recruitment of the 1981 year class.

2.7.3 Divisions IVc and VIId

The index of larval abundance from the 1984-85 winter surveys suggested a biomass of 220,000 tonnes (Section 2.4.3). Doubts have been expressed concerning the method of derivation of the larval indices for 1981 and 1982, which may have led to overestimation of the biomasses in those years.

Two acoustic surveys were also conducted, one in November 1984 and the other in February 1985. For reasons explained in Section 2.3.3 the November estimate was accepted as the more appropriate and this amounted to 200,000 tonnes.

The spawning stock biomass from the acoustic survey (see Section 2.3.3) was converted into numbers at age using the fourth quarter age distributions and mean weight at age provided by the French and Dutch catch data. The mean weights at age averaged over the years 1981-84 are given in Table 2.16.

The fishing mortality in 1984 was estimated using the total catch over the year in Divisions IVc-VIId with the addition of 30% of the catches from Division IVb over the first half of the year to allow for a component of Downs fish caught in that division. F was determined for each age group 2-8 and a weighted mean F over age groups 3-6 was used as an input for the oldest age and the VPA run back to 1980. The data used in the estimation of F in 1984 are given in the text table below.

Estimation of F in 1984 for the Downs Herring
using a spawning stock biomass of 200,000 tonnes

Age	1984* Catch in No. (x 10^{-6})	No.x10^{-6} in SSB at end of year	1984 F	
2	200.1	781.6	0.218	
3	130.4	387.7	0.277	
4	40.4	110.2	0.298	
5	23.6	70.7	0.275	
6	2.6	5.4	0.376	
7	1.0	1.4	0.517	
8	0.5	0.0	-	0.426
9+	0.8	2.7	0.248	

(*Includes 30% of catch taken in Division IVb during first half of year)

The results of the VPA are given in Tables 2.21-2.23. These show a progressive increase in spawning stock since 1980, with a major increase over the last two years. The fishing mortality decreased from a very high level of 1.36 in 1980 to a relatively low level of 0.28 in 1984.

The recruitment (1.1×10^9) of the 1981 year class at 1 January 1984 was very close to that (1.0×10^9) estimated from a regression between the abundance of 1-group 'Downs' fish in the February IYFS (discriminated by length component analysis) and subsequent 2-group recruitment derived from VPA (see Section 2.3.5 in Doc. C.M.1984/Assess:12).

The 1981 year class contributed 49% by weight to the spawning stock biomass in 1984.

The Working Group had great difficulties in reconciling the results of this VPA with direct stock estimates and with information on the development of fishing effort. Both the larval surveys and acoustic surveys indicate that the spawning stock has remained fairly constant over recent years, instead of showing a three-fold increase as estimated by VPA. There may have been some reduction in F in 1984 due to limited outlets for herring in France, but no reduction in fishing effort was reported from the Dutch fishery.

One explanation for the discrepancy between the VPA and other information on this stock could be the assumption that catches in Divisions IVa and IVb contain a much larger proportion of Division IVc herring than is commonly assumed. If this were true, the F on Downs herring could be much higher than is presently assumed, possibly by a factor of 2. An analysis of catch curves in recent years indicates a Z of 0.7-0.8, corresponding to an F of 0.6-0.7.This explanation seemed unlikely to some members of the Working Group. The general opinion was that the apparent inconsistencies in the assessment of the Downs stock should be reason for extra caution in choosing TACs for future years.

2.7.4 VPA of Divisions IVa and IVb combined

As in last year's report a VPA was done for Divisions IVa and IVb combined to provide the necessary outputs for management advice. As inputs for the VPA, means of the weight in the stock were estimated from the values used in the separate Division IVa and IVb VPAs, weighted by these stock estimates. The values are given in Table 2.16. The maturity ogive for the combined stock was estimated similarly and gave 82% of 2-ringers and 100% of older fish. To obtain input Fs for the combined stock, for all age groups greater or equal to 3-ringers, weighted mean Fs were calculated from the separate VPA outputs. This procedure was not considered appropriate for the 2-ringers, because of the mixing of the two components during much of the year. Accordingly, an input F was estimated for the 2-group to produce a spawning stock biomass equal to the combined Divisions IVa and IVb spawning stock biomasses, after correcting for the overestimate produced in the VPA by using 0.67 instead of 0.8 for the F generated prior to spawning.

The outputs from this VPA given in Tables 2.24-2.26 would suggest that the mean F on this population in 1984, of 0.35, was higher than would be considered desirable on management criteria. The spawning stock biomass increased by over 50% between 1983 and 1984, but this was largely due to the recruitment of the strong 1981 year class. It should be noted that the strength of this year class given in the combined VPA, at 2900 million, is very close to the 3100 million predicted in last year's report, based on the IYFS survey and the split made between Division IVa + IVb and IVc on length criteria.

2.7.5 Total North Sea VPA

A VPA for the total North Sea was carried out using the catches in number at age for the entire North Sea and the combined estimated stock size in number at age at 1 January 1984 used in the VPAs for individual areas of the North Sea. The estimated F values in 1984 together with the values of M used on each age are given in the text table below:

Age(rings)	Catch in no. x 10^{-6} 1984	Stock in no. x 10^{-6} 1 Jan. 1984	F in 1984	M
			See:	
0	-	-	0.07(Sec.2.2.4)	1.0
1	-	-	0.07(" 2.2.3)	0.8
2	976	3,943	0.30	0.1
3	422	1,572	0.33	0.1
4	192	639	0.38	0.1
5	78	257	0.38	0.1
6	22	69	0.41	0.1
7	24	71	0.44	0.1
8	11	42	0.32	0.1
$\geq$ 9	18	70	-	-

In the calculations of spawning stock biomass mean weights at age in the stock are means of those used in the Division IVa + IVb, and Divisions IVc, VIId VPAs weighted by stock in number at 1 January (Table 2.16). The proportions of M and F before spawning in 1984 were 0.73 and 0.84 respectively, being the means of those on Division IVa + IVb and Divisions IVc, VIId weighted by the stock in number. For previous years, the proportion was assumed to be 0.67 for both F and M.

The results of the VPA given in Tables 2.27-2.29 indicate that average F on the fully exploited age groups has remained roughly constant since 1980 and that the spawning stock biomass increased from its lowest level of 59,000 tonnes in 1977 to 837,000 tonnes in 1984.

2.8 Projection of Catch and Stock Size for 1986 and 1987

2.8.1 Divisions IVa and IVb combined

To estimate the catches and stock sizes in 1986 in the combined Division IVa + IVb population, the stock size of 3-ringers and older in 1985 was taken from the outputs of the VPA for this area. Recruitment of the 1982 year class to this population was input as 4300 million, taken from the estimate given in last year's report based on the IYFS index and the split between the southern North Sea and northern plus central North Sea populations. Estimating the catch likely to be taken in this area in 1985 presents some problem because of the lack of agreement between the relevant management bodies. To resolve this, the TAC agreed within the EC zone (228,650 tonnes) was used and approximately 75,000 tonnes added for the catch in the Norwegian zone. The latter figure is close to the catch taken in the Norwegian zone in 1984. This resulted in an estimated 1985 catch of 300,000 tonnes in Division IVa + IVb which was used in the projections. This catch is assumed to be entirely of 2-ringers and older.

The recruitment in 1986 to this population, as 2-group, was set at 7369 million (9000 million 1-ringers at 1 January 1985 reduced by a Z of 0.2), as explained in Sections 2.2.4 and 2.2.6. The recruitment of 2-ringers in 1987 was assumed to be 5000 million as 1-ringers, reduced by an F of 0.1 on this age group, giving an estimate as 2-ringers of 4094 million. This has little real basis, but the estimate of this year class has no effect on the projections apart from the spawning stock biomass in 1987. The results of the projections for the herring stocks in Division IVa + IVb combined are given in Figure 2.8 and some management options are given in the text table below.

HERRING Divs.IVa+IVb combined

1985			
Stock biomass (2+)*	Spawn. stock biom. **	$\bar{F}$	Catch (2+) ***
1,380	942	0.324	300

Management option for 1986	1986				1987	
	Stock biom.(2+) *	Spawn. stock biom. **	$\bar{F}$	Catch (2+)	Stock biom. (2+) *	Sp.Stock biom. **
F=0.1	2.280	1.742	0.15	248	2.761	2.232
F_{86}= 0.8 x F_{84}		1.597	0.28	436	2.507	1.849
F_{86}= F_{84}		1.524	0.35	527	2.384	1.672

Weights in '000 tonnes.

* Stock biomass calculated at 1 January.

** SSB calculated at spawning time,i.e. 1 September.

*** The assumed catch in 1985 corresponds to a TAC of 300,000 tonnes.

The spawning stock biomass will increase considerably in 1985 despite the high F required to take the assumed catch in that year, and will increase further in 1986 even if the 1985 F is maintained in 1986. This is due to the high recruitment levels estimated for these years.

The prediction given above is based entirely on 2-ringers and older. The assumption of an F in 1985 of 0.1 (M =0.1) on 9000 million 1-ringers implies a catch of 816 million 1-ringers in 1985. At an assumed mean weight of 50 g this implies a catch of 41,000 tonnes. There is no basis on which to predict the catch of 1-ringers in 1986 or that of 0-ringers in any years.

2.8.2 Downs stock

Recruitment levels for 2-group fish in 1985-86 were estimated from the regressions described in Section 2.2.6. The expected numbers of recruits are 1.0×10^9 in 1985 (1982 year class) and 0.2×10^9 in 1986 (1983 year class). The same recruitment of 0.2×10^9 was assumed for 1987.

These values were used in the prediction programme (Table 2.30) and the results appear in the text table below.

HERRING Divs. IVc and VIId

1985			
Stock biomass (2+)*	Spawn. stock biom. **	$\bar{F}$	Catch (2+) ***
368	238	0.34	90

Management option for 1986	1986				1987	
	Stock biom.(2+) *	Spawn. stock biom. **	$\bar{F}$	Catch (2+)	Stock biom. (2+)*	Sp.Stock biom. **
F=0.1	308	240	0.15	37	298	232
F_{86}= 0.8 x F_{84}		217	0.25	58	272	192
F_{86}= F_{84}		205	0.31	70	258	171

Weights in '000 tonnes.

* Stock biomass calculated at 1 January.

** SSB calculated at spawning time,i.e. the end of the year.

*** The assumed catch in 1985 corresponds to a TAC of 90,000 tonnes.

The EEC-recommended TAC for 1985 in Divisions IVc + VIId is 90,000 tonnes and this value was used for the catch in 1985. This results in a spawning stock biomass of 238,000 tonnes for 1985. The options for 1986 show that the spawning stock biomass can be maintained at this level with $F_{0.1}$ (catch of 37,000 tonnes), but with an F of 0.25 (80% of the 1984 F) the spawning stock biomass declines to 217,000 tonnes (catch of 58,000 tonnes), and when equal to that of 1984 reduces further to 205,000 tonnes (catch of 70,000 tonnes). The 1987 projection suggests that if the spawning stock biomass is to be maintained F should not exceed $F_{0.1}$ (i.e. 0.15). Recent trends in yield, fishing mortality, spawning stock biomass and recruitment together with the short-term yield and spawning stock biomass are given in Figure 2.9.

There are negligible catches of 0- and 1-ringers in Divisions IVc and VIId.

2.9 Management Considerations

2.9.1 Adult fisheries

As in 1985, it is considered appropriate that the North Sea herring should be managed as two management units in 1986 - Divisions IVa and IVb combined, and Divisions IVc and VIId,e. No estimates of the catches of Downs stock in Divisions IVa and IVb in 1984 are available, but it would once again be appropriate for part of the TAC in Divisions IVc, VIId,e to be transferred to Division IVb (but not IVa).

In Division IVb there are currently closures of the spawning areas at spawning time. No further discussion on this subject took place at the Working Group meeting.

The Working Group considered the need for additional conservation measures for the southern North Sea stock. The latest assessment of the stock in Divisions IVc,VIId indicates that fishing mortality may have been considerably underestimated in former years, and that it may already be far above $F_{0.1}$. In addition, the recruitment forecast for this stock for year class 1983 is not very optimistic (cf. para. 2.2.6).

There is also evidence of considerable discarding of fish when too large a catch is taken in the spawning area. Because of the density of the spawning shoals, the fishermen cannot accurately estimate the quantity of fish taken in the net and this results in an estimated 10-20% of the total catch being lost as a result of torn codends.

For these reasons the Working Group advises extreme caution in setting TACs for this area in the coming year.

2.9.2 Catches of juvenile herring

In 1984 some inshore areas along the Danish and UK coast were closed to small-meshed fisheries during certain months of the year. This was done following the advice from ACFM to reduce in this way the catches of 0- and 1-group herring. The closed areas, or so-called "sprat boxes", are shown in Figure 2.10.

In the western part of the North Sea the sprat box off the northeast English coast has been superfluous since no sprat have occurred in this area for several years. In both this area and the Moray Firth and Firth of Forth existing by-catch regulations were already effective in reducing the by-catch of herring. Nonetheless the closures were introduced into the legislation to prevent fishing for sprat completely in areas where a high herring by-catch could potentially be taken when nominally fishing for sprat if the by-catch regulations were not strictly enforced. For these reasons it is not now considered necessary to maintain these closures.

However, the closed box in the eastern North Sea appears to have had a considerable effect on the catches of juvenile herring, particularly 0-group in 1984. The text table below summarises catches of juvenile herring taken in the North Sea in recent years, and the estimated fishing mortalities generated by them.

Year	1980	1981	1982	1983	1984
Catch of 0-group (Nos$\times 10^6$)	792	7,889	9,557	10,030	2,189
Catch of 1-group (Nos$\times 10^6$)	161	447	840	1,147	561
F on 0-group	0.12	0.57	0.49	0.40	0.07*
F on 1-group	0.10	0.20	0.23	0.21	0.07**

* from stock estimate in para. 2.2.4
** from stock estimate in para. 2.2.3

The high abundance of year class 1983 as 1-group as measured during the 1985 IYFS is likely to be partly the result of the restriction on 0-group catches in 1984.

Request from EEC

The EEC Commission has asked ICES to consider alternative measures to the existing sprat boxes, which would result in the same conservation effect, but at the same time create fewer problems for small vessels that cannot fish further offshore.

Small vessels in this context are boats below 40 BRT that work off the coast of Jutland. They are "day boats", i.e. they leave the harbour in the morning and return at night. Thus their range of action hardly reaches beyond the border of the Box and there are no real alternative fishing possibilities within the Box during the period of closure. The total catch within the Box fluctuated in the period 1979-82 between 60-100,000 tonnes over the whole year, of which vessels below 40 BRT are estimated to have taken 35-40%. The herring component in the catches within the Box increased from 8-9% in 1979-80 to 60-65% in 1981-82 which led to the introduction of the closed season.

One alternative to the present sprat box in the eastern North Sea would be an extension of the area of the box, in combination with a derogation for small boat fisheries. At the moment, a certain amount of mixed sprat and O-group herring is taken north and south of the existing box along the Jutland coast during the period of closure and within the box outside the closure period. If the present box were replaced by a zone about 20 nautical miles wide along the entire coastal area from 57^{0}10' - 54^{0}30'N (Figure 2.10) for the whole year, the amount of mixed sprat and O-group herring previously taken outside the box and closure period could be allocated to a fishery inside the box by the small boats that normally fished in this area without changing the present effect of the box on the level of catches.

As about 80% of the catch was taken in the present box during the present closed period, the level of derogation would be about 15-25,000 tonnes according to historic catches.

The Working Group appreciates that the closure of certain inshore areas for sprat fisheries may create special problems for local fisheries, and that there is a political pressure to accommodate the interests of these small boat fisheries. However, it was pointed out in last year's report that any allowance for catches of O- and 1- group herring will result in a disproportionate reduction of the adult catches. Figure 2.11 here reproduced from last year's report, shows long-term catch options for different combinations of fisheries on juvenile and adult herring. A catch of 1 tonne of O-group herring results in a loss of 4 tonnes of adult herring, and a catch of 1 tonne of 1-ringed herring creates a loss of 2 tonnes of adult herring. These estimates of course depend heavily on the present assumptions about M on juvenile herring, which are still rather uncertain but at the same time are the best ones presently available.

Another possibility would be to increase the maximum by-catch percentage for the small vessels. In practice, however, a maximum by-catch rule under the present relative levels of abundance of herring and sprat will be as restrictive for small vessels as a closed area system unless the by-catch level is set so high that it achieves no conservation effect.

2.10 Quarterly catch in number and weight at age, 1963-84

Data brought to the Working Group meeting to comply with the request regarding the Multispecies Working Group are summarised in Table 2.31. No data were provided for the period 1963-73, but for the period 1974-84 about 70% of the total catch is covered by appropriate data. Since further data will be available in due course, it was agreed that Working Group members would send their data to Mr N A Nielsen, Denmark, in good time for the November 1985 meeting of the Multispecies Working Group.

3 DIVISION IIIa HERRING

3.1 Stock Composition

As described in earlier reports Division IIIa contains a mixture of herring stocks. Young herring, 0 and 1-ringed fish, contain both indigeneous spring spawners and immigrant autumn spawners of predominantly North Sea origin. These autumn spawners emigrate while they are still 1-ringed fish. The spring spawners thus completely predominate among adult herring.

Using the methods outlined in last year's report and in the report from the Workshop on Stock Components in Division IIIa (Doc. C.M.1983/Assess:5), an attempt was made to split the catches of 0- and 1-ringed herring into stock components.

The general picture seen in previous years with one spring-spawning component (characterized by low mean length and a mean number of vertebrae around 56.0) and one component of larger fish with mean VS values above 56.30 assumed to be autumn spawners, is this year complicated by the appearance of a third component.

This component appeared in the first quarter of the year in both the IYFS and in the Danish catches from the northwestern part of the Kattegat. It showed a very low mean length (10-12 cm) and high numbers of vertebrae, 56.2-56.6. The origin of this component is uncertain.

Results from sampling spawning herring along the Norwegian Skagerrak coast in March-April 1984 showed a mean VS of the dominating year class in the range 56.00-56.70. This could indicate a mixture of spring-spawning components containing a varying proportion of the Skagerrak spring spawners with their high number of vertebrae (about 57.0). If the Skagerrak spring spawners increase it will seriously hamper our ability to split the Division IIIa herring into spawning components.

The characteristics of the unknown component in Division IIIa are also very close to those of the Downs herring. It is, however, considered to be very unlikely that this stock could penetrate into the Division IIIa.

The data presented allowed a split of part of the 1-group catches (60%). According to this, 26% of the 1-group were autumn spawners, 17% spring spawners and as many as 57% belonged to the component of unknown origin.

The scanty data presented on stock identity for the 0-group indicated that the proportion of spring spawners (with low VS values) in the catches was very small. It was not possible to distinguish between autumn spawners and the component of unknown origin.

3.2 The Fishery

3.2.1 Catch data

In 1984, the catches of herring in Division IIIa were estimated to be about 205,000 tonnes this being a slight increase over the estimate in 1983. It should be stressed, however, that both estimates were provided by Working Group members and have no official standing. The catch data in both 1983 and 1984 (Table 3.1) may undergo substantial revision and are to be regarded as provisional only.

The main difficulty in providing reliable catch data in Division IIIa is the distribution of industrial landings over a comparatively large number of small landing places, especially along the Danish coast of the Kattegat. Industrial landings in these harbours are often erratic, comprise vessels of very different sizes and fishing habits, all of which makes large-scale representative sampling very time-consuming.

As an example, the present estimate of Danish industrial landings in the northern Kattegat is based mainly on sampling the small vessels in one landing place. Applying this to the total industrial landings in the Kattegat gives a herring catch of about 61,000 tonnes. Another estimate based on reports from the industry amounts to about 12,000 tonnes. While the first figure is most likely to be an overestimate, the latter is certainly an underestimate. Having no additional data available at the meeting, the Working Group could not indicate the most likely level of catch within these extremes and decided to retain the higher estimate (61,000 tonnes) for the time being.

3.2.2 Catch in numbers at age

Table 3.2 shows the catch in numbers at age from 1975 to 1984. In the case of the two most recent years the same reservations as made in the previous section are, of course, valid and affect mainly total estimated numbers of 0- and 1-groups caught. The most conspicuous feature is the increase in the catch of 2-ringers, being the highest on record. Of the almost 5000 million 0-group shown in the table, only 8% derive from the Skagerrak, while 92% are referred to the Kattegat, mainly taken in July and August.

3.3 Biomass Estimates from Acoustic Survey

The annual acoustic survey in Division IIIa was carried out in August-September 1984. Owing to the difficulties of separating the spring-spawned components in this area, it was recommended that the survey should cover the whole of the expected distribution of the western Baltic Herring in late summer. As a result of this recommendation the survey was extended to cover Sub-Divisions 22, 23, and 24.

The integration was carried out by R/V "Dana" and R/V "Argos", both vessels using 38 khz echosounders and Simrad QD and Nord 10 computer integrator systems, respectively. Both systems were calibrated on standard copper spheres before the survey. An intercalibration between the two vessels gave a good regression with a correlation coefficient of .96 and a difference of .17 dB.

A new type of stratification was introduced in the 1984 survey. The former stratification based on statistical rectangles was abandoned in favour of one based on 6 depth strata within eight large geographical units. The stratum 0-20 m was only sparsely covered and the resulting bias is expected to be large with the vessels used, even though R/V"Dana" used a towed body in shallow water. Consequently the results from this stratum were not used.

The results are based on 2,500 nautical miles of track and the species composition in 51 pelagic trawl hauls were used to allocate the biomass to species. The following length-dependent TS-regressions were used:

Herring and Sprat

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

(Haldorsson & Reynisson 1983)

Gadoids

$$TS_{ind} = 21.8 \log L - 72.7 \text{ dB}$$

(Anon. 1984)

The blue whiting TS was applied because this species constitutes the major part of the gadoid biomass in this area. For mackerel, spurdogs and other species without a swim bladder a TS 6 dB below that of herring was used.

The numbers of herring we allocated to age according to the age composition in the trawl samples.

The estimates of the herring stocks in Division IIIa and Sub-Divisions 22-24 are given in Table 3.3 together with the estimates back to 1981. It should be noted that the estimates from 1981-83 are not raised to the area used in 1984.

The estimates show a decrease of the stock in number since 1982. However, the decrease is solely due to lower estimates of the 0- and 1-groups which are usually distributed in shallow water not adequately covered by the survey. The trend in the acoustic estimate is not consistent with the catch trend or with the IYFS indices for these year classes.

The older age groups have increased in number since 1982 and the adult stocks have increased from 123,000 tonnes in 1982 to 390,000 tonnes in 1984.

The increase is due not only to an increased adult stock in numbers but also to a shift in distribution to the Skagerrak where herring have substantially higher mean weights at age at this time of year. The estimated stock in number at age and the weighted mean weights at age in different areas are given in Table 3.4.

3.4 Recruitment

The 1985 Young Fish Survey in February was carried out under temperatures in the Kattegat and eastern part of the Skagerrak. The ice cover was the most extensive observ ed during the IYFS series and could be compared only with the very cold winter during the second world war.

In spite of the ice most of the standard trawl stations were worked and a total of 32 hauls were made in 14 rectangles. However, some trawl stations in the eastern part of the Kattegat which normally give high catches of 1-group herring could not be worked.

The index of 1-group herring, calculated as the geometric mean of the average catch in seven standard rectangles, was 4,721, which is the highest recorded and slightly higher than the 1984 index. The 1985 index is, however, likely to be too low due to missing trawl stations in the Kattegat. The abundance indices for 1972-85 are given in the text table below.

Year	Indices of 1-group herring
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
1985	4,721

The distribution of the 1-group herring has changed during the last three years and high numbers have also been caught in the western part of the Skagerrak. Owing to the change in distribution, the highest catches of 1-group herring both in the Kattegat and the Skagerrak were recorded outside the standard area. No attempt was made to extend the standard area, however, as the indices based on the new strata used to split spring-spawned and autumn-spawned components include all catches as well as all areas where 1-group herring are likely to appear.

An attempt to split the 1-group herring into spring- and autumn-spawned components was carried out using the same method as last year (Doc. C.M.1984/Assess:12). The resulting mean lengths and proportions are given in Table 3.5. The indices for the period when the GOV trawl was used are given in the text table below.

Year	Index Total	Index Spring spawners	Index Autumn spawners
1985	7.994	3.947*	4.047*
1984	6.035	2.793	3.242
1983	5.419	1.522	3.897
1982	2.560	1.408	1.152
1981	3.246	996	2.250
1980	2.311	1.607	704

* Preliminary result

The total index using this method is highly correlated with the catch in numbers of the same year class as 1-group (Table 3.2). The regression equation is $y = 0.649x - 963.7$ with $r = 0.99$.

The total index for 1985 is more than 30% higher than the 1984 index. This supports the idea that the index for the standard area is too low as a result of the missing trawl stations mentioned above.

The split gave as the best fit to the observed length frequency distribution two groups of components with mean lengths of 14.1-15.3 cm and 16.2-17.8 cm, respectively. The two groups have mean lengths within the range of spring- and autumn-spawned herring observed in previous years. However, the mean vertebral count in each length group indicated that all components had a rather high mean VS (Figure 3.1). To verify this, the mean VSs in each half-centimetre group were used to calculate a weighted VS for each component. The mean length, VS, and number of each component are shown in the text table below.

Mean length	Mean VS	Number
14.1	56.24	14.457
14.7	56.29	28.783
14.8	56.30	106.712
14.8	56.32	6.284
15.3	56.34	98.452
16.2	56.39	55.874
16.9	56.40	3.174
17.8	56.48	10.554

The component with a mean length of more than 16 cm has VS values comparable with VS data for this year class in the North Sea. These components were abundant in the entrance to the Skagerrak, whereas the components with a mean length of 14.7-15.3 cm were not (see Section 2.2.6).

The separation of components in previous years has not indicated any North Sea component with a mean length less than 15 cm in Division IIIa and the preliminary split has been made on this assumption. However, the VS values indicate that this split could still include the autumn spawners in the spring-spawner index or an increased recruitment of the Skagerrak spring spawners with high VS values.

The situation in 1985 is different from that in previous years, and it was concluded that the data should be analysed on the basis of smaller geographical areas to see if a further split of the components with mean length of about 15 cm could be carried out.

3.5 Virtual Population Analysis

In last year's report of this Working Group it was shown that a combined VPA for Division IIIa and the Western Baltic herring of age group 2 and older made a much better approximation to acoustic data than the separate VPAs. It was shown that a separate VPA for the Skagerrak and Kattegat resulted in unrealistically high Fs as they included fishing on a major part of the stock during the first half of the year in the Western Baltic.

At the present meeting the Working Group had no information on catches in the Western Baltic in 1984. A separate VPA for Division IIIa could be run by including an assumed Baltic F value in the M value applied, but the Working Group saw no point in running such a VPA a few weeks prior to the meeting of the Working Group on Assessment of Pelagic Stocks in the Baltic which should have all the catch data at its disposal.

3.6 Management Considerations

3.6.1 General

In previous reports the Working Group has demonstrated the close connections between the numerous spring-spawning stocks - or stocklets - in Division IIIa and the Western Baltic. From a biological point of view this makes it most convenient to regard and treat the spring-spawning herring in both areas as belonging to one management unit. This implies a combined assessment and a prognosis with TAC options for the two areas in common.

The Working Group is well aware that such a procedure may create certain management difficulties as the TAC options provided by ACFM will have to be treated by two different management bodies. The present Working Group could not, however, suggest any biological basis for a division of the catches.

Another difficulty is a logistic one within the ICES in that the same stock has hitherto been handled by two different Working Groups. Even though there is some overlap in membership, it is still difficult to coordinate data collection, assessments and any special research needed.

The present Working Group would, therefore, suggest that a workshop be held with the following items:

a) The possibilities of giving individual advice to the two management bodies in question.

b) How to coordinate the effort of Working Groups in doing a combined assessment.

3.6.2 Management of sprat/young herring fisheries

Even though the catch in weight and catch at age data presented in Tables 3.1 and 3.2 are rather uncertain, and in the case of immature herring in 1983-84 may be overestimates for reasons set out in Section 3.2, there is no doubt that the catch especially of 0-group herring is very substantial and that the fishing pattern on herring in Division IIIa is far from optimal.

The present problems derive from the fact that a substantial increase in recruitment to the North Sea autumn-spawning herring stock has occurred at the same time as a decline in the sprat stock in Division IIIa (and elsewhere). In the 1970s sprat was the main object of the industrial fishery but it is now vastly outweighed by the influx of North Sea 0-group herring. At the same time, the economic importance of the Danish industrial landings, especially in the Kattegat, has increased because of the decline in consumption species such as plaice and cod.

The Working Group has been asked to give an opinion on the merits of various technical measures which may be applied to the sprat-herring fishery in order to reduce the catch of small herring.

In recent years, the following measures have been introduced:

i) Herring may only be fished with a minimum mesh size of 32 mm in a directed fishery.

ii) By-catch of herring when fishing for sprat with a minimum mesh size of 16 mm must not exceed 10% of the individual landing.

iii) Ban on directed fishery on herring for industrial purposes.

iv) A minimum landing size of 18 cm. Herring below this length must not exceed 10% in landings from directed herring fisheries.

If all of these regulations were rigorously enforced the problem of catching young herring would certainly be solved but it would also result in severe difficulties in the pelagic fisheries in Division IIIa, especially in the Kattegat, taking the present composition of the pelagic stocks into consideration.

In relation to the measures listed above:

i) The 32 mm minimum mesh size is probably the largest mesh size that can be used in practice. Swedish trials have shown that, particularly in pelagic trawls, larger mesh sizes create serious meshing problems. The 32 mm mesh cannot be applied in fishing for sprat and its use appears to reduce the by-catch of O-group herring effectively.

ii) The by-catch limit of 10% was introduced when sprat was the predominant species in the sprat fishery. With an almost total reversal of the herring-sprat ratio, by-catch limits on herring have become meaningless unless the aim is to bring the industrial fishery to a stop.

iii) The ban on a directed herring fishery for industrial purposes does not seem very logical at a time when consumption markets are nearly saturated and prices are low. The most likely result of such a ban is that only the largest herring are landed and the non-marketable size categories will be discarded. This is clearly an economic waste, and discards at sea introduce a serious uncertainty about the actual catches.

iv) With the increasing amounts of juvenile herring entering into Division IIIa, rigorous enforcement of the minimum landing size would lead to discarding at sea.

From the above considerations the Working Group found that one reason for the apparent lack of enforcement in Division IIIa and the persistent high catches of juvenile herring was to be found in the radical change in the species composition. This has made measures like by-catch percentages and minimum sizes, introduced under quite different circumstances, inappropriate if small-meshed trawl fisheries are to continue. It, therefore, seems preferable to aim at a more gradual reduction in the juvenile catches by introducing measures which are easier to enforce and which do not make an entire section of the fishery illegal.

The Working Group concluded that the minimum mesh size of 32 mm was useful in reducing the mixed herring-sprat catches and is at the same time a measure controllable both at sea and on shore. If it is thought necessary to allow some fishery for "sprat" with a mesh size of 16 mm, this should be restricted to periods when O-group herring are less abundant in shallow waters and landings from such a fishery could furthermore be restricted by a catch limit. If a catch limit comprising the total landings taken with 16 mm meshes irrespective of the species composition were put forward, this would facilitate enforcement.

The Working Group further considered the most appropriate periods for regulating the sprat-herring fishery. From catch in number statistics it appears that the overwhelming part of the 0-group catch (more than 90%) takes place in the 3rd quarter and that July is the most critical month when more than 40% in numbers of the yearly catch in the Kattegat is taken. It thus appears that the introduction of a minimum mesh size of 32 mm in the 3rd quarter in the trawl fishery for herring and sprat would be an important step in reducing the catch of small herring, the most important months being July and August.

However, the catch of sprat is also at a maximum in these months, in which more than 50% of the yearly catch is taken. An additional regulation in the form of a combined quota for sprat and herring could be envisaged in order to relieve some of the difficulties for those small vessels working in inshore waters in what appears to be the main season of this fishery.

Such a quota ought to be enforceable, should make control of the sprat-herring fishery possible and could allow an extended use of the 32 mm mesh.

However, industrial fisheries for other species (Norway pout, sandeels) are carried out in Division IIIa using trawls with mesh sizes below 32 mm. Setting an appropriate quota level for such a fishery is extremely complex and in the absence of appropriate data is not a subject that could be adequately dealt with by this Working Group. It is therefore suggested that the subject should be considered in more detail by a workshop set up specifically for this purpose.

4 CELTIC SEA AND DIVISION VIIj HERRING

4.1 Introduction

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

4.2 The Fishery in 1984/85

4.2.1 Catch data

The total catches from the combined areas both by year and by season (1 April - 31 March) are given in Tables 4.1 and 4.2. The total provisional catch taken during the 1984/85 season was approximately 22,500 tonnes which was slightly higher than the 1984/85 total of over 21,000 tonnes. In 1984 ACFM recommended that catches both in 1984/85 and in 1985/86 should not exceed 13,000 tonnes for this area and the TAC adopted for 1985 was 13,000 tonnes. As in recent years the major portion of the catch which could be attributed to specific countries was taken by Ireland, and approximately 80% of the total catch was taken during the 3rd and 4th quarters of the season (i.e., October-March) by boats fishing the spawning concentrations.

Catches throughout most of the 3rd and 4th quarters were restricted as a result of marketing and the Irish fleet during this part of the season was fishing under small nightly quotas. This imposition of catch quotas undoubtedly resulted in some underestimation of the total catch because boats which took more than their nightly quota frequently "slipped" the excess amounts, particularly if the catch appeared to contain small fish. However, it has not been possible to obtain any estimate of the total amount discarded in this manner.

4.2.2 Catch in numbers per age group

The total seasonal catches in numbers per age group for autumn spawners are shown in Table 4.3 and for winter spawners in Table 4.4. These are based mainly on Irish samples but also include some French and Dutch data. Over 86% of the total catch was composed of either 1, 2, or 3 winter ring herring.The 1981/82 year class (2 winter ring fish) made up 53% of the catches compared with 68% for the 2 winter ring fish in 1983/84. There is a considerable difference between the distribution of 2 winter ring fish in the catches taken from the winter spawning population in the eastern part of the Celtic Sea and in the catches taken from the autumn spawners in the western part of the Celtic Sea and in Division VIIj. In 1984/85 the 2 winter ring fish constituted over 80% of the winter spawning component compared with 30% of the autumn spawners.

This difference was equally apparent in the 1983/84 seasons when the percentages were 83% for winter spawners and 47% for autumn spawners. In 1982/83, however, the percentage distributions were very similar and were 50% for winter spawners and 51% for autumn spawners. It is therefore concluded that recruitment of 2 winter ring fish to the winter spawning component of the overall stock was considerably higher in 1983/84 and 1984/85 than it was to the autumn spawning component.

4.2.3 Weight at Age

The mean weights at age for the combined areas were calculated by the 1982 Working Group. It was concluded then that as the major portion of the fishery takes place during the spawning time it would be realistic to use the weights at age in the catches as those for the stock at spawning time (i.e., October). However, the weights-at-age for 1984/85 were found to be consistently lower than those used in the 1982 Working Group report. In the younger age groups (1-3 winter ringers) the 1984/85 values were approximately 16% lower than in previous years. It has not been possible to explain the sudden drop in mean weights although it may be linked with the fact that the three year classes which show the biggest decrease are all comparatively strong ones; in addition there may have been some change in the spawning pattern during the main season which resulted in more spent fish in the catches. However, the 1984/85 mean weights at age have been used for the latest year in the VPAs while the previous values have been used for all preceding years.The old and new values are given below.

Winter rings	1	2	3	4	5	6	7	8	>8
Old values									
(all spawners)	115	174	211	229	244	257	260	263	266
New values									
(Autumn spawn.)	93	142	185	213	213	245	246	263	262
(Winter spawn.)	95	137	180	217	224	237	262	264	266

4.3 Larval Surveys

Larval surveys were conducted during 1984/85 for the seventh successive season, those during the early part of the season covered the spawning ground in Div. VIIj as well as the Celtic Sea. A total of eleven surveys were carried out in this area from October 1984 to March 1985, and coverage during 1984/85, as in recent seasons, was very good. The index for the whole season was calculated for the standard area by the method used by the 1983 Working Group (Doc. C.M.1983/Assess:9). The index (87.5×10^9) is approximately 1.5 times higher than the 1983/84 index which was the previous highest. Values of the indices for the last seven seasons for the standard area are given in the following text table (number of cruises in brackets):

Year	Autumn	Winter (x 1,465)	Total
1978/79	7.2(3)	1(3)	7.3*
1979/80	9.5(5)	3.4(5)	12.9
1980/81	7.6(4)	8.9(4)	16.5
1981/82	16.3(5)	1.5(5)	17.8
1982/83	14.6(5)	5.2(6)	19.7
1983/84	42.4(5)	15.6(5)	58.0
1984/85	34.2(5)	53.4(5)	87.6

* Monthly cruises - inefficient estimates

The index increased from 1983 to 1985 from the comparatively low levels of previous years. The increase in 1984/85 was particularly marked in the winter spawning component, and is considered to be the result of the very much higher recruitment of 2 winter ring fish which took place in 1983/84 and 1984/85 in this component. The index for the autumn spawners, however, was, slightly lower in 1984 than in 1983.

Spawning in early 1985 continued much later than in recent years and because of this an additional survey was carried out in March. However, no recently hatched larvae were caught in March and it was concluded that the larvae had not hatched before the survey was completed. The main spawning areas were the traditional ones - i.e., off Cork Harbour and in Baginbun Bay. It is also demonstrated by inspection of the larval abundance over the whole spawning period that two main spawning times occur - one in early October to mid- November and another from mid-January to mid-February. Little spawning appears to have taken place in recent years in December.

Although the indices above have been calculated for the standard area, the surveys in 1983/84 and 1984/85 covered a part of Div. VIIj as well as the standard Celtic Sea area. This larger survey area contains additional spawning grounds of autumn spawning fish that were adequately covered in both 1983 and 1984. The ratios of the autumn larval production in the "total area" (including Division VIIj), the "standard area" were 1.38 in 1983 and 1.65 in 1984. As these ratios were similar in both years it was decided to raise the larval index for the autumn spawners in the standard area by a factor of 1.50 for the years 1978 to 1982 to give a new autumn spawning index. This index is shown below:

Year	Original Index	New Index
1978	7,163	10,816
1979	9,503	14,350
1980	7,601	11,478
1981	16,285	24,590
1982	14,557	21,981
1983	-	58,537
1984	-	56,278

This new index shows that the autumn-spawning component was rather stable from 1978-80, increased considerably in 1981 and 1982 and increased further to a much higher level in 1983 and 1984.

4.4 Estimates of Fishing Mortality

In the past the Working Group has selected values of F in the final year of VPAs by comparing the overall larval index with the spawning stock biomasses derived from trial VPA runs. However, as shown above, the larval surveys demonstrate different trends in the autumn and in the winter spawning components. Using a similar method to that used by previous Working Groups does not now seem realistic. Its application would indicate that the F in 1984/85 was below 0.2, and this would generate stock sizes and year class strengths far in excess of those observed over the time series since 1958, mainly because of the rapid increase in the winter spawning index.

4.4.1 Autumn-spawning component

It was therefore decided to compare the recalculated autumn spawning larval index with the spawning stock biomasses calculated from trial VPA runs from which the catches of winter spawners had been removed. The data to allow this split to be accurately made were not available at this meeting. The separation was therefore based on the assumption

a) that only those catches taken by the Irish fleet fishing during December to February were winter spawners.

b) that the catches of winter spawners during the period 1978-81 were very small. That this is reasonable is indicated by the fact that the larval index of winter spawners indicated that the winter spawning population was small over this period in comparison with the autumn spawners. Moreover the Celtic Sea, where the winter spawning grounds are found, was closed during this period and most of the catches were taken from that part of the Celtic Sea and Division VIIj that included the autumn spawning component.

Trial VPAs were therefore run using the data for the autumn spawners only and with F values in 1984 varying between 0.3 and 1.2. The value of F that most closely corresponded to the larval index was 0.30, and this corresponded to a spawning stock in 1984 of about 47,000 tonnes. A value of 0.30 would also reflect the decreased effort which was a noticeable feature of fishery during 1984.

4.4.2 Winter-spawning component

Only three years' data (1982/83 to 1984/85) on catches in numbers at age were available for the winter spawning component and the catches (because of high recruitment in 1983/84 and 1984/85) were composed mainly of young fish. Even so,different values of F were applied to the catch in number data to generate different values of spawning stock which could then be compared with the larval indices. It was recognized that this was a somewhat qualitative approach but it appeared to be the only method available.

Table 4.5 lists the data. For the autumn spawners, the ratio SSB/Larval Abundance Index (LAI) is calculated for F values of 0.3 and 0.35. For the winter spawners the larval abundance index was adjusted upwards by a factor of 1.465 to allow for the difference in fecundity (Herring Working Group report 1984, p.28) before calculating SSB/LAI for the three levels of F. The SSB/LAI ratios are plotted in Figure 4.1 for the autumn spawners (1978-84) for an F in 1984 = 0.3, and for the winter spawners at the three 1984 F levels of 0.1, 0.2 and 0.3. Inspection of the figure suggests that the correspondence between the two sets of larval abundance data is best for the F value of 0.2 for the winter spawners. This would imply an SSB for winter spawners of about 50,000 tonnes. This analysis assumes that conditions for the two groups of larvae were similar over the period and that therefore the decline of the SSB/LAI ratio has a similar biological explanation, thus justifying the comparison.

4.4.3 Results from VPA

The results from a VPA on autumn spawners using an F in 1984 = 0.30 are given in Tables 4.6 and 4.7. Because of catch separation between autumn- and winter-spawners, the proportion of F applied before spawning has been changed from 0.20 to 0.33 in the years 1982-84. The value of F on 1-ringed fish in 1984 is the same as that used in previous years, i.e. 40% of that on adults.

The spawning stock biomass in 1983 and 1984 is estimated at about 47,000 tonnes which is approximately twice the level recorded when the stock was at its lowest level during the period 1976-81. This increase in spawning stock is mainly caused by the good recruitment of the 1979, 1980 and 1981 year classes which averaged about 159 million fish. Fishing mortality decreased in 1982 and 1983 from the very high value of 0.90 recorded in 1981 when the catches were very high, and the stock was still at a very low level. The value of F in 1983 was 0.40 which is the same as that selected by the previous Working Group for that year (Figure 4.2, A and B).

No VPA was carried out on winter spawners.

4.5 Recruitment

4.5.1 Autumn spawners

Results from the VPA suggest that recruitment to the autumn-spawning component has improved considerably in recent years and that from 1981-83 it averaged about 159 million fish compared with 63 million during the period 1975-80.

As separate assessments have been carried out for the autumn and winter spawning components it is not possible to use the results of the young herring surveys carried out in the Irish Sea to give an indication of recruitment to the Celtic Sea as a whole.

This had been calculated as a total of 122 million fish for both components for the 1982 year class. It is difficult to estimate the appropriate value to use in predictions for 1986 for the autumn component separately. However, the results from the VPA show a considerable improvement by the 1979, 1980, and 1981 year classes which average about 160 million fish. The geometric mean of all year classes from 1975 to 1982 is about 77 million fish and because of the uncertainties surrounding the basis for the assessment in general, and because recruitment to the autumn spawning component appears lower than that to the winter spawning component, it was considered more realistic to use this figure for predictions.

4.5.2 Winter spawners

The rapid increase in the winter spawning population has been caused by very high recruitment of the 1980/81 and 1981/82 year classes. These are estimated to have been about 161 million and 280 million fish respectively. The only indication of the strength of the 1983/84 year class is from the young herring surveys in the Irish Sea which would suggest that this year class is larger than either of the two previous ones. However, because of the lack of reliable data and because of the rapid development of this component in recent years it was decided to select a conservative level of recruitment of 100 million fish.

4.6 Stock Prediction and Management Considerations

The assessments of the Celtic Sea and Division VIIj herring stocks have been carried out on the separate components, and spawning stock sizes calculated for the spawning times in 1984. Predictions have also been carried out for each component, separately and the input parameters and results are shown in Tables 4.8-4.11 and Figures 4.2-4.3. Predictions have been carried out for three levels of F in 1986, $F_{0.1}$, F_{max} and $F_{86} = F_{84}$ all with a TAC constraint in 1985 of about 13,000 tonnes which is that set by the EC. This TAC has been apportioned into catches of autumn and winter spawners, allowing for catches already taken in the period January to March 1985 and the best estimates of catches for the remainder of the year. The estimated catch of winter spawners in 1985 is 7,900 tonnes and the estimated catch of autumn spawners is 5,100 tonnes.

The spawning stock of the autumn component is estimated to be about 50,900 tonnes in 1985 and if fishing is regulated in 1986 at $F_{0.1}$ = 0.16 then catches will be around 8,300 tonnes, and the resultant spawning stock biomass in 1986 will be 57,400 tonnes (Figure 4.2,D).

The spawning stock of the winter component is estimated to be about 69,000 tonnes in 1985, and if fishing in 1986 is regulated at $F_{0.1}$ then catches will be about 9,600 tonnes and the resultant spawning stock biomass in 1986 will be 70,300 tonnes (Figure 4.3,D).

Because of the rapid development of the winter spawning component since 1982, the fishery requires careful management in the immediate future. It is possible that the fishery may be reverting to the state it was in during the 1958-70 period when it was dominated by winter spawners. The age distribution of these winter spawners is at present made up almost entirely of young fish, generated by three good year classes. It should be emphasized that any future reduction in recruitment, if associated with an excessive exploitation rate could lead to an equally rapid decrease in the stock. In adjacent stocks in the Irish Sea it has taken a considerable number of years of relatively low exploitation for the age distribution of the stock to re-establish a state in which it could be considered to contain a 'buffer' stock.

A fishery on both components in 1986 at $F_{0.1}$ would yield an overall catch of about 18,000 tonnes. It would therefore be realistic to divide this catch so that the fishery does not overexploit either component. Because of the lack of information about the level of recruitment to the winter component it is not realistic to predict likely catches and stock sizes beyond 1986. However, in the autumn component, catches of over 12,000 tonnes in 1986 would cause a decrease in stock size by 1987. The main fisheries in recent years have tended to co-incide with the peak of the spawning seasons and there has been a sharp division between catches of autumn and winter spawners. The fishery exploiting mainly the winter component is carried out during December and January to March, and it is suggested that the catches in 1986 in these months should not exceed 9,000 tonnes. This would then allow catches of about 9,000 tonnes of the autumn spawners to be taken during the period April-November.

It must be emphasized that these measures are suggested for 1986 only. A better understanding of the development of both components will be available after the 1985/86 season.

5 WEST OF SCOTLAND HERRING

5.1 Assessment Procedure

The assessments in this area were done on the same Sub-divisions as in 1984. The limits of these are given in Figure 5.1

5.2 Division VIa North

5.2.1 Catch data

The catches reported by each country from this area in 1975-83 and the preliminary catches in 1984 are given in Table 5.1. There has been no change in the preliminary total catch for 1983 given in last year's report. The preliminary total catch reported for 1984 is 74,300 tonnes. This is about 10,000 tonnes more than the agreed TAC, and about 20,000 tonnes more than the TAC recommended by ACFM, for this area in that year. It will be noted that catches unallocated to country represent about 22% of the total.

5.2.2 Catch in numbers at age

The estimated numbers at age caught in Division VIa North, in each of the years 1975-84, are given in Table 5.2. In 1984, sampling data were available from the Federal Republic of Germany, Netherlands, Norway and Scotland. Faroese catches were converted to numbers at age using sampling data from Scottish purse-seine fishing in the same area at the same time. The 1981 year class constituted a high proportion of the catch, giving some support to the prediction in last year's report, based on the Scottish recruit survey, that this would be a strong year class. The 1982 year class was very poorly represented in the catches in 1984, but this is not necessarily symptomatic of a poor year class since there has in 1984 been a major change in the geographical distribution of the Scottish fishery, which has in the past taken the major part of the 1-group catches. This is commented further in Section 5.2.4.

5.2.3 Larval surveys

Larval surveys were carried out in Division VIa North in September and October by the Federal Republic of Germany and Scotland. Sampling coverage both in space and time was satisfactory. New larval abundance indices for this area were estimated by the Herring Larval Working Group for the Area South of 62^{0}N, for the period 1972-83, at its meeting in Aberdeen in February 1985 (Anon.,1985).These are based on rather different standard areas from the indices given in last year's report, and on a more satisfactory system for correcting for unsampled blocks. These revised larval indices are given in Table 5.4, together with the index for 1984 estimated on the same basis. The 1984 index is very much higher than that for 1983, which, as commented on last year, was very low compared with the two preceding years. It now appears even more likely that the 1983 index was biased downwards, although how this happened cannot be explained. The 1984 index is, however, of a similar size to those of 1981 and 1982.

5.2.4 Mean weight at age

The mean weights at age, in the catch and in the stock, for this population have not been revised since 1976. A sum of products check, run at the start of the assessment procedure, showed evidence of an increasing discrepancy between SOP and the actual catch since 1981, culminating in 1984 in a SOP only 81% of the reported catch. Accordingly it was decided to re-estimate mean weight at age in the catch, using weighted means for those countries which had supplied mean weights at age and catch in numbers data for all months of this fishery in 1984. These data accounted for over 80% of the reported catch.

These new estimates of mean weights at age in the catch were then smoothed by fitting a von Bertalanffy curve. The resulting estimates are given in Table 5.3. New SOP checks, using these values for the years 1982-84 and the previous ones for the period 1970-81, gave a satisfactory fit to the reported catches over the entire time period. The new mean weights at age in the catch are appreciably higher than the old ones in all age groups greater than 1-ringers. This is likely to be due to a change in the seasonal and geographic distribution of the fishery rather than to a real change in the weight of the fish since 1981 in the population. Saville et al. (1984) were unable to demonstrate any change in the mean length at age, or in the growth rate, of this herring population in the period under consideration. There has, however, been a real change in the seasonal and geographic distribution of the Scottish fishery, which has in all years taken in excess of 50% of the catch. Since 1982, an increasing proportion of the Scottish catch has been taken on offshore grounds, rather than in the Minch, and in the summer period rather than in winter.

In previous assessments, the mean weights at age used in estimating spawning stock biomass were the same as those used for the catch. These were obviously not realistic in relation to the true mean weight at spawning time, but it was considered that this was not of great relevance as the spawning stock biomasses were used only to explain relative changes from year to year rather than in any absolute sense.

Historic time series of spawning stock biomasses estimated from VPA are now used to estimate the spawning stock biomass in the most recent year from larval surveys. Therefore, it was considered necessary to estimate new mean weights at age at spawning time to be applied over the entire time period. This approach is legitimate since there is no evidence that there has been a change in the weight at age at spawning time during the period under consideration.

The new values were estimated from weighted means of reported weights at age of catches taken in August and September. These estimates were smoothed by fitting a power curve using least squares. The results are given in Table 5.3.

5.2.5 Fishing mortality in 1984

Inspection of the F at age array from a preliminary VPA showed that the difference of the F values between the older age groups and the 2-, 3- and 4-ringers was not sufficient to justify the change in exploitation pattern made in last year's assessment. Therefore, the exploitation pattern has been changed back to the one previously used, i.e. uniform over the age groups 2 to 8+.

The spawning stock biomass at spawning time in 1984 (1 September) has been estimated from the 1984 larval index as 262,000 tonnes. This estimate was based on a regression of the revised larval indices for the period 1973-80 against spawning stock size estimated from an initial VPA and using the revised exploitation pattern and the revised mean weights at spawning time given in Table 5.3. The scatter diagram and regression line with confidence limits are shown in Figure 5.2.

A VPA with F = 0.28 resulted in an estimate of the spawning stock biomass of 265,000 tonnes. This was considered to be sufficiently close to the target level. The regression of SSB estimates from the initial VPA on larval indices and from the final VPA estimates gave almost identical results and indicated an acceptable F value of 0.28 for 1984. The data used in the final regression are given in Table 5.4.

5.2.6 VPA results

The summarised results of the assessment are shown in Figure 5.3.

The fishing mortality estimates from the VPA (Table 5.5) are very similar to the results of last year's assessment except for the year 1983. The present estimate for that year is about 1/3 below the previous one which is thought to have been an overestimate due to the biased larval indices which had to be used.

Only two years after the re-opening of the fishery, fishing mortality increased to the relatively high level of 0.47 followed by a decrease to 0.37 in 1983 and to 0.28 in 1984. The 1984 value is still twice the $F_{0.1}$ level. The reduction of F from 1983 to 1984 is consistent with the reduction in effort in 1984 due to diversion of fishing activity to the Shetland area resulting in a lower catch.

The spawning stock biomasses in the VPA (Table 5.6) 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.

The increase of the spawning stock biomass in 1984 is due to the recruitment to the spawning stock of the good 1981 year class as predicted from the high catches of 1-ringers in 1983 and from the results of the research vessel recruitment survey given in last year's report.

5.3 Recruitment

As in previous years, the recruitment as 2-group at 1 January 1985 was based on Scottish surveys in the beginning of the year carried out since 1980. Although the surveys have covered a much wider area, in practice 2-group fish have in all years been almost entirely confined to the North Minch and the area around North Rona. In last year's report indices of abundance for 2-ringed fish were given for the years 1980-84 based on these two areas. It was suggested that these indices give some indication of the strength of the year class recruiting as 2-ringers in that year. In Table 5.7 these abundance indices are given for the period 1980-85, together with the corresponding VPA estimates of the strength of these year classes at this age. The 1985 index is low and would suggest that the 1982 year class is a weak one. In an attempt to quantify it more closely, a regression has been run between these parameters over the period 1980-84. The number of observations available is still very small and the VPA estimates of the strength of the year classes are, in all cases, still dependent, to some extent, on the estimates of F in the most recent year. The correlation coefficient is, under these circumstances, reasonably high and the regression equation given in Table 5.7 and shown in Figure 5.4 has been used to predict recruitment as 2-group to the stock in 1985. This gives a value of 349×10^6.This value is identical to the geometric mean of the VPA estimates of this age group in the years 1973-82 and the same value has been used in the prediction for recruitment as 2-group in 1986.

5.4 Management considerations

The 1984 assessment was based on a regression of spawning stock biomass on the old larval indices with a correlation coefficient of 0.63 indicating a high variance of the spawning/larval abundance relationship. In addition, the larval index from the 1983 survey appears now to be biased downwards. This resulted in high estimates of fishing mortality and very low estimates of both total biomass and spawning stock biomass with the consequence of relatively low levels of projected catches for 1985. This assessment was not accepted by ACFM.

The present assessment is based on a revised larval index (see Section 5.2.3) with reduced variability of the spawning stock/larval abundance relationship as indicated by the high correlation coefficient of 0.94.

The results of the assessment were used to project yields in 1986 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 1987 have been made by applying 2/3 of both the natural and fishing mortality of the previous year in 1987. The 1-ringers have not been included in the projection since they do not contribute significantly to the total catch (in 1984 less than 300 tonnes). Only very abundant year classes make significant contributions to the catch as 1-ringers. In view of the low recruitment level estimated for 1986/87 this will not be the case in these years.

The projections are made on the assumption that the agreed TAC for 1985 of 56,500 tonnes will be taken.

The parameters used in the prediction are given in Table 5.8 and the results are shown in Figure 5.5. Selected management options are given in the text table below.

HERRING			Div. VIa (N)
1985			
Stock biomass (2+) *	Spawning stock biom. **	$\bar{F}_{(2-7)}$	Catch (2+)***
332	276	0.23	56.5

	1986				1987	
Management Option for 1986	Stock biom. (2+) *	Spawning stock biom. **	$\bar{F}_{(2-7)}$	Catch (2+)	Stock biom. (2+) *	Spawn. Stock biom. **
$F_{(0.1)} = 0.5 \times F_{(84)}$	325	276	0.143	37	336	286
$F_{(86)} = 0.8 \times F_{(84)}$		261	0.224	56	315	253
$F_{(86)} = F_{(84)}$		252	0.280	68	300	233

Weights in thousand tonnes.

* Stock biomass calculated at 1 January.

** SSB calculated at spawning time, i.e. 1 September.

*** The assumed catch in 1985 corresponds to the agreed TAC.

It is clear from the 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 at least the $F_{0.1}$ level and maintained there. Maintaining the level of spawning stock biomass estimated for 1985 would require a reduction of the 1984 level of fishing mortality by about 40% to 0.17. This option is associated with a TAC of 45,000 tonnes in 1986.

Continued fishing at the present level of exploitation would reduce the size of the spawning stock. In this context it has to be remembered that the present estimate of the spawning stock biomass is largely dependent on the abundant 1981 year class and that the available abundance estimate of the 1982 year class indicates poor recruitment to the spawning stock in 1985.

5.5 Clyde Herring

5.5.1 Biological justification for separate assessment

At a meeting in September 1978, the Herring Assessment Working Group advised (C.M.1978/H:67 revised) that the population of herring in the Firth of Clyde should be treated as a separate unit for management purposes on the following grounds. Although the autumn-spawning herring, which made up the largest component of the landings in the Clyde, are known to belong to a stock or stocks spawning in other areas, they could not be identified as belonging to any one of the adjacent stocks in particular for the following reasons:

a) Recaptures of herring tagged in the Clyde were made in several of the surrounding areas;

b) the biological characteristics of Clyde herring (mean length and mean weight at age) were not consistent with those of any of the adjacent populations.

In the subsequent few years, recoveries of fish tagged in the Clyde were mostly from the Clyde itself indicating a very low net emigration rate. On this basis the Working Group has for the past few years made a separate assessment of the Clyde herring population, as well as treating it as separate for management purposes.

At the present meeting the biological justification for making a separate assessment of Clyde herring was re-evaluated in the light of new evidence.

During the late 1960s and early 1970s the composition of the Clyde herring catches changed from being predominantly spring-spawners to being predominantly autumn-spawners. The evidence for this was a change in mean vertebral count. Vertebral counts available up to and including 1982 (Table 5.9) show no evidence of any trend or sudden change in the years since the previous analysis. Surveys for herring larvae in March 1983 and March 1984, moreover, have provided no evidence of any recovery of the spring-spawning population.

The results from tagging experiments carried out in the years 1976-82 are summarised in Table 5.10. Most of the recoveries have come from the Clyde itself and the main areas of recapture outside the Clyde have been the Irish Sea and northwest Ireland. The small amount of tagging in 1982 took place outside the fishing season at a time when the proportion of autumn-spawners is likely to be lower.

Mean lengths at age in 1984 have been examined for comparison with the earlier period, this being the only recent year in which adequate sampling of discards has been carried out (see Sections 5.5.2 and 5.5.3). The mean lengths at age in the months May-October 1984 are given in Table 5.11. What this indicates is that in 1984 there was no evidence in the catches of a component of herring of very high length at age which was observed in the earlier analysis (C.M.1978/H:67, revised). The mean length at age is thus close to that in adjacent stocks. This provides no basis for allocation to any stock in particular, however, partly because the mean lengths at age in the different adjacent stocks are not grossly different and partly because in any case herring in the Clyde might grow at a different rate from their congeners in other areas.

From these analyses there is no evidence to suppose that Clyde herring belong to any stock other than those in adjacent areas. There is, however, no basis on which to identify the stock composition; what few additional tag returns there are support the earlier conclusion that herring from at least two adjacent stocks occur in the catches in the Firth of Clyde.

As pointed out in earlier reports, the tag returns indicate a considerable measure of continuity in the Clyde herring population. The corollary of this is that although the autumn-spawners leave the Clyde to spawn a high proportion of them return before or during the fishery of the following year. Since few tag recoveries have been made in other fisheries, a high proportion of the fishing mortality on Clyde herring is due to exploitation in the Clyde itself. Despite the probable mixed origin, assessment of the Clyde herring as a separate unit would therefore appear to be justified. Also, since these herring do not form a significant component of any other fisheries, exploitation in the Clyde will not have any significant direct effect on the quantity of fish available to other fisheries.

Clyde herring nevertheless contribute to the spawning potential of the stock or stocks of which they are a component and it is therefore appropriate for them to be managed at a level of fishing mortality rate consistent with that in adjacent areas. It is for this reason necessary to continue making assessments of the Clyde herring population on an annual basis.

5.5.2 The fishery in 1984

The preliminary reported landings from the Firth of Clyde in Scottish ports in 1984 were 2,991 tonnes, almost exactly the same as the TAC of 3,000 tonnes set by the management body (Table 5.12). In addition, approximately 247 tonnes were landed at Irish Sea ports during the months of June and July. An estimated 13 tonnes were landed as by-catch in the sprat fishery. Boxes of herring sampled weighed rather more than the nominal weight.

In 1984 sampling was carried out on a number of vessels in each of the months May, June, July and October to record the proportion of the catch discarded and to sample the discarded and landed portions. The estimated proportion discarded over the entire season was almost 40% of the total catch. On the basis of this sampling the total catch in the Clyde in 1984 including discards is estimated to have been 5,770 tonnes.

5.5.3 Catch in numbers at age

Catch in numbers at age in 1984 was estimated from samples of both landings (corrected for the percentage that boxes were overweight) and discards. The age composition in the landings and discards in each month is given in Table 5.13. In 1984 most of the fish discarded were in age groups 1 and 2. The total age composition for 1984 indicates a relatively strong contribution of 1-ringers but this could be due to the introduction of discard sampling. As in most previous years the catch was predominated by 2-ringers.

5.5.4 Virtual population analysis

No data independent of the fishery are available to assess the size of the population in the Clyde. To estimate the input value of F for a VPA, the number of days' absence from port by pair trawlers each year was examined for the years 1974-84 inclusive, a period during which almost the entire catch was taken by this method. The effort data are given in Table 5.14.

A trial run pf a VPA using an F of 0.3 on 2-9 ringers in 1984 indicated no correlation between mean F and effort in the years 1974-79 when the estimates of F are not significantly affected by the assumption of F in 1984,but this is not entirely surprising because effort varied by only 50% in these years. Since 1980, nominal effort has been considerably lower as a result of the introduction of restrictive TACs, and some correlation between F and effort over the period 1974-83 is found over a wide range of estimated F values in 1984. To establish the value of F in 1984 that gives the best fit to the effort data, VPAs were run with input F values ranging from 0.1 to 0.5.

The correlation coefficients between F and nominal effort and the intercepts on the y axis (F) are given in the text table below, and the scatter diagram for an F in 1984 of 0.2 is given in Figure 5.6.

Input F_{2-9}	Correlation coefficient r	Intercept an F axis
0.10	0.73	- 0.09
0.20	0.72	+ 0.04
0.25	0.69	+ 0.09
0.30	0.66	+ 0.14
0.40	0.58	+ 0.21
0.50	0.49	+ 0.27

From this it is clear that the lower values of F in 1984 produce a historic series that best fits the effort data. Accordingly, a value of 0.2 was chosen for the final VPA.

Because of adequate discard sampling in 1984 the estimated catches of 1-ringers are likely to be fairly reliable in that year. In earlier years, however, the catches in number of 1-ringers are likely to be underestimates of what was caught. Accordingly, the VPA is limited to 2-ringers and older.

The results of the VPA, given in Tables 5.15 - 5.17, indicate a considerable increase in biomass in 1984 which is a direct corollary of the high catches in that year combined with the low value of fishing effort.

5.5.5 Recruitment

In view of the doubt about the level of catches of 1-ringers over the last few years, it is not possible to estimate a reliable recruitment series for 0- and 1-ringers. From 1970-82 the number of 2-ringer recruits estimated by VPA varied between 7,300 and 42,000 thousand (Table 5.17). No independent recruitment indices are available for the Clyde, and for catch and stock prediction a value has to be chosen from this series. The modal recruitment lies in the range 15-20,000 x 10^3 and the median value is 17,100 x 10^3. A value of 17,000 x 10^3 2-ringers has accordingly been used in the predictions for both 1985 and 1986.

5.5.6 Predictions and management considerations

The estimated stock in numbers at age and biomass at 1 January 1984 and 1985 are given in Table 5.18. The value of F in 1985 is constrained by the level of catch that corresponds to the TAC, which has been set at 3,000 tonnes. In the past two or three years, however, discarding has taken place in this fishery. If one assumes that it will occur on the same scale in 1985 as it did in 1984 then approximately 2,000 tonnes will be discarded distributed mainly over the 1- and 2-ringers. Of these 2,000 tonnes a proportion will be 1-group which is not included in the catch prediction. If the proportion of this age group by weight in the discards is the same as in 1984, then it will account for about 460 tonnes in 1985. The catch of 2-ringers and older in 1985 is therefore likely to be 3,000 tonnes of landings and 1,540 tonnes of discards - a total of 4,540 tonnes. This is estimated to generate an F of 0.152 on 2-ringers and older in 1985.

Since full exploitation is reached in the 2-group, F is assumed to be evenly distributed over all age groups. In 1984, around 80% of the catch was taken before the end of August, so this is taken as the proportion of F before spawning time.

The results of a prediction for 1986 are given below for a range of values of F in 1986.

1984	1985			
Adult biomass (>2) at spawning time in 1984	F	landings	discards	Adult biomass (>2) at spawning time in 1985
28,700 t	0.152	3,000 t	1,540 t	27,700 t

1986			
F		Catch	Adult biomass (>2) at spawning time in 1986
$F_{86}=F_{85}$	0.152	4,300	26,350 t
$F_{0.1}$	0.165	4,650	26,100 t
$F_{86}=F_{84}$	0.2	5,550	25,350 t

The catch corresponding to $F_{0.1}$ would be 4,650 tonnes in 1986. At all levels of catch there would be a small decrease in the adult biomass at spawning time (assumed to be 1 October) in 1986 which is entirely due to the low value of recruitment assumed.

To calculate an appropriate TAC in 1986 from the above options, some prediction is needed about the likely level of discarding. At levels of TAC that impose a real restraint on the fishery, discarding of small fish is carried out to maximize earnings. At the other extreme a high level of TAC would remove the need for discarding so long as markets existed for all sizes of fish. At intermediate levels one might therefore expect the proportion of fish discarded to decrease as the TAC increases. With only one year's discard data to go on the form of the relationship between TAC and discards cannot be predicted. However, because of the likelihood that some discarding will continue even if the TAC is raised to the levels given in the catch options above, it would be inadvisable to use them directly as TAC options without making an allowance for discarding. On the basis of the argument above, a level of discarding of about 30% of the total catch might be associated with landings of over 3,000 tonnes. The catch option at $F_{0.1}$ in 1986 might then result in 3,250 tonnes of landings and 1,400 tonnes of discards.

This prediction, however, is based on a relatively low assumed level of recruitment in 1986. If this is correct, then the catches would contain a smaller proportion of 2-ringers than in 1984. Since these contribute mainly to the small component of the catch, this would be likely to reduce the proportion of catch discarded.

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

6.1 Catch Data

The catches by each country fishing in this area from 1975-83 and the preliminary catches for 1984 are given in Table 6.1. The preliminary catch for 1984 decreased to about 27,500 tonnes compared with 33,000 tonnes in 1983. No changes were made to the 1983 data. The main catches taken from the area were taken by Ireland. The proportion of "unallocated" catches in 1984 was 40%.

The TAC recommended by ACFM for 1984 was 12,000 tonnes and this figure was adopted by the EC.

In 1984 the main catches were taken,as in recent years, along the Irish coast, mainly in the 2nd and 3rd quarters. The catches taken were restricted because of marketing difficulties and because the Irish and Dutch fleets which previously fished herring during the winter months now concentrate on mackerel during the first and fourth quarters.

6.2 Catch in Numbers at Age

The catches in numbers per year class taken from this area are shown in Table 6.2. No changes have been made to the 1983 data. The 1984 figures are based on Irish and Dutch sampling data. The 1981 year class (2 winter ring fish) constituted about 50% of the catches in the area and was distributed evenly throughout the catches in both Divisions VIa (south) and VIIb. This is the highest percentage contribution by any recruiting year class since before 1970.

6.3 Larval Surveys

Larval surveys were carried out in this area by Scottish and Irish vessels in the period October-November 1984. The indices of larval abundance, however, are based only on surveys carried out in September and October as only for these months is the time series yet long enough to be used in a regression. Unfortunately no survey was carried out in September 1984 so an abundance index for that period had to be estimated from the mean ratio of abundance in these two months in previous years when surveys were done in both of them. The resulting index for 1984 is 268×10^9 which is a considerable increase over the values for the preceding three years.

A new regression between larval abundance and spawning stock biomass had to be calculated because of the changes in mean weight at age in the spawning stock. The input data for the regression are given in Table 6.3.

The regression over the period 1973-80 ($y = 0.104\ x + 65.93$ where y is in thousand tonne units and x is larvae x 10^{-9}. and this is shown in Figure 6.1 and is significant at the .01 probability level. The intercept is the major contribution to the predicted spawning stock biomass but this was also a feature of the previous regression.

Inserting the 1984 larval index in this equation indicates the 1984 spawning stock biomass to be 104,000 tonnes.

6.4 Mean Weight at Age

In previous VPAs the mean weights at age in the stock at spawning time were taken to be the same as the mean weights in the catches. As the seasonal distribution of the fishery has changed considerably in recent years these mean weights are no longer realistic. Therefore, a new set of mean weights, based on Irish and Dutch data collected in September-October 1982-84,was used to calculate the spawning stocks at 1 October. As there has not been any evidence of changes in growth parameters in this stock this set of mean weights was therefore used throughout the VPA series. The mean weights at age in the catches in 1983 and 1984 were also updated and these data used in the most recent years in the sum of products check (see Table 6.2). The calculation of the new mean weights at age in the stock at spawning time means that the new spawning stock biomasses are considerably higher than previously calculated.

6.5 Virtual Population Analysis

The procedure adopted by previous Working Groups was used to estimate an appropriate value of F for 1984. Trial VPAs were therefore run in order to reproduce a spawning stock biomass in 1984 of about 104,000 tonnes which was that calculated from the larval index in Section 6.3. The value of F = 0.28 gave a spawning stock of about 103,000 tonnes and was considered to be the most realistic. The results from the VPA using this value are shown in Tables 6.4 and 6.5.

As reported by the 1984 Working Group values of F for this stock have been fairly constant varying between .22 and .42 over the period 1973-84 (Table 6.4). The value of F = .28 in 1984 results in an F of 0.42 in 1983 compared with a value of 0.40 selected by the 1984 Working Group as most realistic.

The spawning stock biomass was at its highest level of about 166,000 tonnes in 1973. After this it declined to about 80,000 tonnes in 1977 and has subsequently increased slowly to about 104,000 tonnes.

Recruitment of 1 winter ring fish appears to have been very stable since 1973, apart from the 1976 and 1977 year classes which were considerably larger than the average (Table 6.5). Preliminary indications of the 1981 year class based solely on the 1984 catches would suggest that this year class may be the highest to enter the fishery for some time.

6.6 Recruitment

There are no satisfactory data available which give a fishery-independent index of recruitment to this stock. The Irish young herring surveys have not yet been carried out over a sufficiently long time series, while the Scottish young herring surveys are confined to the northern parts of Division VIa. Furthermore, the abundance of 1 winter ring fish (i.e. the 1982 year class) in the 1984 catches does not give any realistic estimate of recruitment because in recent years boats have tended to avoid areas where young fish are caught as a result of marketing difficulties. It appears, however, as stated in Section 6.2, that the 1981 year class is above average strength. Using a similar method to that used by the 1984 Working Group, i.e, the geometric mean over the period 1973-82, gives an average recruitment level of 202 million fish. Because of the stable state of the stock in recent years, this level has therefore been used in the prediction tables.

6.7 Catch Prediction and Management Considerations

Catch and stock size predictions have been carried out for this stock for 1986 and 1987, assuming a recruitment of 202 million fish in 1984 to 1987 and a TAC restraint of 14,000 tonnes in 1985. The input parameters are shown in Table 6.6 and the results are shown in the text table below and in Figure 6.2.

The spawning stock in 1985 is estimated to be about 117,000 tonnes. Catches of 14,000 tonnes in 1985 will generate a level of 0.14 and spawning stock of 125,500 tonnes in 1986. Fishing at $F_{0.1}$= 0.155 will result in catches of 17,200 tonnes in 1986 and a further increase in spawning stock. Fishing in 1986 at about the same level as that in 1984, i.e. F = .28, will create catches of 30,000 tonnes and a decrease in spawning stock to a slightly lower level than in 1985.

HERRING Div.VIaS and VIIb

1985			
Stock biom.(2+) *	Spawning stock biom. **	$\bar{F}_{(2-7)}$	Catch (2+) ***
165,600	117,000	.14	14,000

Management Option for 1986	1986 Stock biom. (2+)*	1986 Spawning stock biom.**	1986 $\bar{F}_{(2-7)}$	1986 Catch (2+)	1987 Stock biom. (2+)*	1987 Spawn. stock biom.**
$F_{0.10}$=.15	177,300	125,500	.15	17,200	186,200	132,800
$F_{86}=F_{84}$	177,300	112,200	.28	30,000	169,200	106,300

*) Stock biomass calculated at 1 January.

**) SSB calculated at spawning time, i.e. 1 October.

***) The assumed catch in 1985 corresponds to the agreed TAC.

7 IRISH SEA HERRING (DIVISION VIIa)

7.1 The Fishery in 1984

This section of the Working Group report refers to herring caught in the North Irish Sea, irrespective of stock, as in the 1984 report (C.M.1984/Assess:12). Allocation of catches to Manx and Mourne stocks was made only to examine whether the fishery was making a disproportionate impact on either stock. The Working Group accept that a joint assessment is more appropriate for management purposes, as explained in the 1984 report. The TAC recommended by ACFM for herring in Division VIIa for 1984 was 4,000 tonnes; this was subsequently adopted by the EC.

The reported catch from the North Irish Sea in 1984 was 4,066 tonnes, including 430 tonnes taken by selective fishing on the Mourne spawning ground (Table 7.1). The actual catch was greater than the declared catch because many small fish were sorted and discarded at sea, and test weighings showed that some boxes of herrings landed were overweight.The catch in weight of Manx stock and Mourne stock herring was roughly equal (Table 7.2)

The summer fishery opened on 4 June 1984; the pattern of fishing by the UK fleet was determined by fortnightly quotas per boat. Catchers reported quantities of herring caught each day or night to a control vessel of the United Kingdom Fisheries Protection Service. The number of boats taking part in the UK fishery is given in the text table below, together with the number of landings made in recent years.

	Year					
	1979	1980	1981	1982	1983	1984
No. of UK vessels	150	115	67	49	35	50
No. of UK landings	2,652	1,904	918	389	513	486

Nearly all that proportion of the TAC allocated to the summer fishery was taken by 16 August. The trawl fishery was closed from 31 August to 19 November to protect the spawning concentrations.

A small winter fishery took 508 tonnes of herring in the areas west and southwest of the Isle of Man and near the Irish coast.

7.2 Catch in Numbers at Age

The catch in numbers of fish per age group for the years 1975 to 1984 is given in Table 7.3. This has been estimated from sample data and declared landings in the Republic of Ireland, Northern Ireland and U.K. Isle of Man, and the results summed. The estimate for 1-ring fish is unreliable because of discarding of unquantified amounts of small fish.

7.3 Mean Weight at Age

Mean weights at age for 1984 were estimated from Northern Irish, Irish and Manx data derived from samples of the catch. Data for the years earlier than 1984 were re-examined and a new set of mean weights was derived. The sums of products from VPA with the new set is acceptably close to the declared catch in weight. The mean weights at age in the catch given in the text table below were used to calculate biomass at 1 January and at spawning time (1 October).

Mean Weight Kg

	Age							
Year	1	2	3	4	5	6	7	8+
1984	.076	.142	.187	.213	.221	.243	.240	.273
1975-83	.074	.155	.195	.219	.232	.251	.258	.278

7.4 Maturity at Age

Proportions of each age group likely to reach maturity, as indicated by gonad stages of sampled fish, were very similar to those found in 1983. The same proportions were used to estimate spawning stock size in all years; they are given in the text table below.

Age 1 .... 0.08
Age 2 .... 0.85
Age 3 and over . 1.00

7.5 Estimation of Fishing Mortality

7.5.1 Fishing effort

There are no data independent of the fishery from which stock size and fishing mortality can be estimated. In 1984 the Working Group used effort data available from trawler landings in Northern Ireland and the Isle of Man to select an appropriate F in 1983 for the VPA; a similar procedure has been applied now.

Trial VPAs were run with a range of values of F in 1984. The proportion of total fishing mortality generated by the UK catch was compared with UK effort. The correlation was between r = 0.87 and 0.82 for a range of 1984 F values between 0.1 and 0.2 (Table 7.4). As explained in the 1984 Working Group report (Doc. C.M.1984/Assess:12) there was a major change in the fishery in 1981; catch, effort and fishing mortality all showed a marked fall as a result of the management measures introduced. Trends in UK effort, and estimated F generated by the United Kingdom from trial VPAs with values of F in 1984 of 0.1, 0.15 and 0.2 were compared over the two periods 1979-80 and 1981-84. The F in 1984 which produced a trend in mean F_{age2-7} which corresponded most closely to the effort data was F = 0.15. It was decided to adopt F = 0.15 on 2-ring fish and older as value of F in 1984 for the VPA.

The Working Group recognises the limitations of the use of nominal fishing effort data expressed as number of landings and re-emphasises the need for fishery-independent estimates of stock size.

7.5.2 Virtual population analysis

No firm data are available to correct the nominal catch of 1-ring fish to account for discards. The Working Group considered that it was unrealistic to estimate a stock size for 1-ring herring from the nominal catch of this age group and an assumed value of F on 1-ringers in 1984 based on the recent exploitation pattern. For the purpose of prediction an estimate of the stock of 1-ring fish in 1984 was derived from the stock/recruitment relationship given in Figure 7.1.

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

Results from a VPA with $F_{(2-7)}$ 1984 = 0.15 are summarised in Tables 7.5 and 7.6 which give the fishing mortality rate at age, stock in numbers at age, and spawning stock biomass at spawning time. The VPA indicates that there has been a steady recovery of the stock from the very low level in 1980. The results of the VPA are shown in Figure 7.2.

Trial VPAs with a range of 1984 F values from 0.1 to 0.35 also indicated an increase of estimated spawning stock biomass from 1980 to 1984;a 1984 F = 0.4 gave estimates of SSB increasing from 1980-83 with equal estimates for 1983 and 1984.

7.6 Recruitment

Figure 7.1 shows the relationship between the number of recruits and the parent stock biomass as given by the results of VPA discussed in Section 7.5.2. A 'Shepherd' curve was fitted to the points in order to estimate recruitment in 1984 and 1985. A spawning stock biomass of 12,000 tonnes in 1982 indicates a stock of 80 million 1-ring herring in 1984, and an estimated SSB of 19,000 tonnes in 1983 indicates a stock of 108 million 1-ring herring in 1985.

The mean recruitment from 1980-83 indicated by VPA was 72 million 1-ring herrings from a mean SSB of 7,900 tonnes. Use of the mean value for the purposes of prediction would appear to be ultra cautious since there are strong indications that the SSB has been rising steadily since 1980. The VPA value for SSB in 1983, from which the 1985 recruitment is derived, is, however, heavily dependent on the input F for 1984. It is therefore suggested that input recruitment for the purposes of prediction should be 80×10^6 for both 1984 and 1985.

7.7 Management Considerations

7.7.1 Catch and stock predictions

The text table below gives projections of catch and stock based on a recruitment of 80×10^6 1-ring fish in 1985 and in 1986. The history of the fishery indicated by VPA (Table 7.6) suggests that these are conservative estimates of recruitment. The projection for 1985 is based on the agreed TAC of 5,000 tonnes.

1984				1985				1986			
Stock biom. 1 Jan	SSB spawn. time	F age 2-7	Catch	TAC 5,000 tonnes	Stock biom. 1 Jan	SSB spawn. time	Catch	Option	Stock biom. 1 Jan	SSB spawn. time	Ca
37.2	24.5	0.15	4.1	F=0.14	45.9	31.9	5.0	F^hd,(0.1); = 0.15	52.4	36.	
								F^hd,1986; = F^hd,1985;	52.4	37.2	

Catch and biomass in tonnes x 10^{-3}
Stock biomass = Σ weight of stock at age 1 to 8+
SSB = Spawning stock biomass
= Σ weight of stock age 1 to 8+ at spawning time x maturity ogive
Weight at age 1985 and 1986 = mean weight at age 1972-84

The predictions indicate that a fishery in 1985 with a TAC of 5,000 tonnes and a TAC for 1986 based on a fishing mortality F = 0.15 = $F_{(0.1)}$ would allow a continuing increase in spawning stock biomass, assuming moderate recruitment and an exploitation pattern similar to that observed in the years 1981 to 1984. The exploitation pattern was strongly affected by closure to directed fishing on the spawning areas except for a small selective fishery in the Mourne area. The results of the predictions are shown in Figure 7.2.

7.7.2 Other conservation measures

Spawning area closures

ACFM referred to the Working Group a letter from the EC which quoted legislation for 1985 and stated:

> "Taking into account the limitation which identical legislation for 1984 had on the ability of the fleets to catch the TACs recommended by ICES for the herring stocks in the northern Irish Sea, the Commission wishes to be advised whether the objective of the recommendation could be achieved:
>
> - by reducing the size of the closed area (for example, by limiting it to the actual spawning zones), or
>
> - by reducing the period during which the closure applies, or
>
> - a combination of both.
>
> If so, ICES is requested to recommend the boundaries of the revised closed area and/or the revised dates."

The 1984 legislation prohibited herring fishing in the North Irish Sea from 22 September to 15 November. There was, in fact, no difficulty in taking the quantity of herring allowed by the TAC. The declared catch was 4,066 tonnes against a TAC of 4,000 tonnes. The UK fishery was closed early because the quantity of herring allocated was caught by the end of August.

The limitation imposed by the legislation was that very few spawning and spent herring were available to the fishery.

The full extent of the Manx spawning area has not been determined. Fig. 7.3 shows the location of large numbers of newly hatched larvae in the years 1974-84. Centres of larval concentration varied from year to year. The presence of high concentrations of larvae indicates spawning near the point of capture. Mazey (running) herrings were taken as far east as $3^0$30'W in the years when fishing on the spawning grounds was permitted. It is likely that the spawning area extends beyond the limits of the area sampled for larvae and eggs.

The spawning grounds of Mourne herring are located approximately 2 miles offshore between Annalong and Kilkeel on the east coast of Northern Ireland (Figure 7.3). Small concentrations of Mourne herring overwinter in inshore waters south of Carlingford Lough and it is on these aggregations that previous winter fisheries depended.

Trawling on the spawning grounds generates a high F because the shoals are concentrated in an area which is relatively small. Spawning shoals are easily identified by the fishing fleet which directs its effort onto the highest concentration of fish. Accordingly, a ban on trawling over the spawning grounds is considered to be essential.

So long as a smaller area of closure could be effectively enforced, the objective of the present regulations could be achieved by reducing the closures to the following areas:

a) To the east of the Isle of Man within a zone bounded by the line of latitude $54^0$20'N running from the east coast of Isle of Man to $3^0$40'W; a line from $54^0$20'N, $3^0$40'W to $53^0$50'N, $3^0$50'W, along the line of latitude from $53^0$50'N, $3^0$50'W to $53^0$50'N, $4^0$50'W; and from $53^0$50'N, $4^0$50'W to the most westerly point of the Calf of Man.

b) To the east of Northern Ireland and the Republic of Ireland a zone bounded by the line of latitude $54^0$15'N, running from the east coast of Northern Ireland, to $5^0$15'W, a line from $54^0$15'N, $5^0$15'W to $53^0$50'N, $5^0$50'W, and from $53^0$50'N, $5^0$50'W to the east coast of the Republic of Ireland.

These two areas are shown in Figure 7.3.

Herring spawning east of the Isle of Man starts in the first week of September and continues into November. Peak spawning occurs in late September and early October. The time between spawning and hatching averages 10 days (Bowers, 1969).

The Mourne spawning season extends from mid-September to late October, with scattered spawnings as early as August and as late as January. In general peak spawning activity is from late September to early October.

The Working Group consider that the period of closure from 21 September to 16 November should not be reduced. Selective fishing by gill net on the Mourne spawning ground for a catch of adult herring not exceeding 600 tonnes should be allowed within this period as it was in 1984.

Nursery area closures

In 1984 the Working Group recommended that more detailed information on the distribution of juvenile and adult herring in the North Western Irish Sea be collected and that nursery area closures be re-assessed in 1985. To this end, a trawl and echo survey was conducted in the area between St. Johns Point ($54^0$15'N) and Belfast Lough ($54^0$45'N) inside the 12-mile limit during the period June - December 1984.

During the study eight surveys were conducted and 22 trawl hauls were made.The occurrence of herring within the survey area showed notable differences. With the exception of the spawning ground, the fish in the southern area ($53^0$50'N - $54^0$15'N) were sparse and more or less evenly spread out. In the northern area ($54^0$15'N - $54^0$40'N),a large concentration of herring was found in an area north of the South Rock Lightship (an area known as the "Rigg"). The highest catch rates (10-15 tonnes/1/2 hr tow) of the survey were made in this area.

The age composition of the catches is given in Table 7.7 and is compared with samples taken at the same time from the commercial trawl fishery further offshore. The 1981 (2 w.ring fish) and 1980 (3 w.ring fish) year classes dominated the catches from the commercial trawl fishery. Likewise, these year classes were the predominant component of the catches taken in the northern part of the survey area. The 1982 year class (1 w.ring fish) made up a higher proportion of catches in the southern area.

In addition, young herring surveys have been conducted in the northwestern Irish Sea since 1979. Data from these surveys indicate that 1-ring herring in the North Western Irish Sea are not confined to within the 12-mile limit. Juvenile herring are mainly distributed in the mid-channel area between the Isle of Man and the Irish coast (Molloy, 1980).

As stated above (Section 7.2), the percentage of 1-ring fish tabulated for the commercial fishery probably greatly underestimates the proportion of 1-ring herring in the catch (taken outside the 12-mile limit), for here was extensive sorting and dumping of small fish at sea.

On the basis of the above surveys, the present ban on herring fishing within 12 miles of the coasts of the Republic of Ireland and Northern Ireland between $53^0$50'N and 55^0N excludes fishing from an important adult distribution area off the North Co. Down coast.

Furthermore, since juvenile herring are not concentrated within the 12 mile limit, it does not seem necessary to continue the present prohibition of fishing for herring in this zone.

No information was available to the Working Group on the distribution of adults and juveniles in the eastern half of the Irish Sea.

8 ICELANDIC SPRING AND SUMMER SPAWNING HERRING

8.1 The Fishery in 1984

No signs of recovery of the Icelandic spring spawning herring were observed, and the fishery in 1984 was entirely (99.5%) based on Icelandic summer spawning herring.

The landings of summer spawning herring from 1969-1984 are given in Table 8.1. The 1984 landings were about 50,000 tonnes. Of these about 39,000 tonnes were taken by purse seiners, 10,400 tonnes in drift-nets and about 600 tonnes by set nets. The main fishery started on 30 September and was finished by 17 December. The text table below gives the catches, the TACs set and the TACs recommended during the last few years for this fishery.

Landings and TACs (in tonnes x 10^{-3}) of Icelandic summer spawning herring in 1981-1984

Year	Landings	TACs	Recommended TACs
1981	39.5	42.5	40.0
1982	56.5	50.0	50.0
1983	58.7	52.5	50.0
1984	50.0	50.0	50.0

8.2 Catch in Number, Weight at Age and Age Distribution

The catches in numbers at age for the Icelandic summer spawners for the period 1969-1984 are given in Table 8.1. During the period 1975-1977 the catches were dominated by the 1971 year class. During the period 1979-1982 the 1974 and 1975 year classes predominated in the catches. A complete change occurred in the age distribution in 1983 when the catch was dominated by the strong 1979 year class, then as 3-ringed herring. In 1983 this age distribution led to an unusually high proportion of immatures in the catch (30%). In 1984 the catch was still dominated by the 1979 year class which made up 61% of the total catch in number. As the entire 1979 year class was mature in 1984 the proportion of immatures in the catches dropped considerably compared to 1983 (10%). The weights at age for each year as well as the maturity at age are given in Tables 8.2 and 8.3 respectively.

8.3 Acoustic Surveys

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

In December 1984 a survey for this purpose was carried out, but owing to bad weather and short available survey time, it was not possible to survey the entire distribution area of the herring. Another survey was therefore carried out in January 1985. During that survey the herring was distributed in almost all the fjords in eastern Iceland, but the main concentrations were found in two fjords. Based on σ_{bs} values reported by Haldórsson and Reynisson (1983) as well as the mean weight of herring, it was estimated that about 200,000 tonnes of herring were in the fjords. As shown in Table 8.4, the total estimate is dominated by the strong 1979 year class. It was not possible to survey the total area of distribution of the 0- and 1-ringed herring. However, it was possible to survey one fjord at North-Iceland in February 1985. As this was the only area surveyed it is impossible to draw any conclusions about the total strength of the 1982 and 1983 year classes. Nevertheless, these year classes were found there in considerable quantity which gives rise to some optimism about recruitment in the next two years.

8.4 Virtual Population Analysis

The acoustic survey estimates from January 1985 and catches in numbers at age in 1984 were used to estimate the fishing mortality rate on each age group in 1984 and the stock size in numbers at age at 1 January 1984 and 1 January 1985 (Table 8.4). For comparison, the estimates from the acoustic survey in December 1983 are also given.

The calculated F on 4-ringers in 1984 (F = 0.25) is considerably higher than that on older age groups. The average calculated F for 5-10 ringers is 0.17 while for the oldest age groups it is even lower (0.04). These differences in fishing mortality rate between age groups can be explained by supposing that the fishery concentrated on the strong 1979 year class in 1984 rather than on the less abundant older age groups. For age groups 4 and older there is reasonable correspondence between the estimated stock in number at 1 January 1984 and the acoustic estimates of the corresponding year classes in December 1983.

The calculated F on 3-ringed herring (0.29) is even higher than that on 4-ringers. If this is accepted, then the number of the 1980 year class at 1 January 1984 is very much lower than the acoustic estimate in December 1983 (Table 8.4). If one uses the 1983 acoustic survey estimate and the catch in 1984, this gives an estimated F for this year class in 1984 of 0.09. From Table 8.5 it can be seen that in the period 1975-83 the values of F on 3-ringers have ranged between 31 and 92% of the mean F on the fully recruited year classes (F_{4-14}). The average F_3 value for the period is 0.15. Because of the discrepancy between calculated F values based on the two acoustic surveys, an F of 0.15, i.e. 60% of that on 4-ringers was chosen for 1984. Owing to the lack of estimates of the two youngest age groups it was decided to use F = 0.05 for 2-ringers and F = 0.001 for 1-ringed herring.

Using the catch at age data given in Table 8.1 and the 1984 F-values described above, a VPA was run using a natural mortality of 0.1. The outputs of fishing mortality at age, stock in numbers at age and spawning stock biomass at 1 July are given in Tables 8.5 and 8.6, respectively. The results of this assessment, i.e fishing mortalities and spawning stock size, are in good agreement with last year's assessment. This means that the fishing mortalities in the period 1978-1982 are considerably higher, and the spawning stock size correspondingly smaller, than in the assessments made prior to 1983. However, the recruitment of the strong 1979 year class has resulted in a sharp increase in the spawning stock size in 1984 and 1985. The most plausible explanation for the high F-values in 1978-1983 is that the acoustic surveys in January 1985 did not cover the total distribution of the herring and the estimated stock size must be looked upon as a minimum one. In January 1985 the herring were distributed in all the fjords at eastern Iceland, and bearing in mind that a very large concentration of over 200,000 tonnes of herring was assembled in an area of only 1.5 nm^2, one could easily overlook considerable concentrations of herring. That would be most likely to happen in areas which are not previously known as wintering grounds.

According to the present assessment the spawning stock biomass increased from about 11,000 tonnes in 1972 to about 180,000 tonnes in 1980. Some decline occurred in 1981 and 1982 but owing to the 1979 year class the spawning stock is estimated to be about 260,000 tonnes in 1985.

8.5 Management Considerations

Catches have been calculated over a range of Fs for 1985, 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 of predictions. Weights at age in the catch are rounded mean weights from recent years. The exploitation pattern is assumed to be similar to that experienced in the last few years. Resulting catches and spawning stock biomasses over a range of Fs are illustrated in Figure 8.1. For this population the Y/R and spawning stock biomass per recruit are also shown in Figure 8.1.

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

1984		1985			1986
Catch	F_{4+}	SSB at 1 July	F_{4+}	Catch	SSB at 1 July
50	0.22	262	0.15	35	294
			$0.22=F_{0.1}$	50	277
			$0.30=F_{83}$	66	263

During the last five years (1978-1983) the fishing mortality rate in the adult component of this stock has been about 0.3. This is well in excess of the $F_{0.1}$ level, which has been the target exploitation rate and corresponds to F=0.22. In 1984, however, the calculated average F for 4-ringers and older is 0.22. Despite the high fishing mortality levels in recent years, the spawning stock is increasing as a result of the 1979 year class. The Working Group points out that the exploitation rate of this stock can be held at the $F_{0.1}$ level in 1985 without any reduction in catches compared to those in 1984. For the 1986 season exploitation at the $F_{0.1}$ level would result in a preliminary TAC of 50,000 tonnes. Any projections for 1986, however, should be revised when new revised data become available late in 1985 or early 1986.

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