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Exploration of the Sea

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Pelagic Fish Committee

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

ICES headquarters, 27 April - 5 May 1981

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

1. PARTICIPANTS AND TERMS OF REFERENCE

1.1 Participants

R S Bailey	United Kingdom (Scotland)
E Bakken	Norway
A B Bowers	United (Isle of Man)
A C Burd	United Kingdom (England)
A Corten	Netherlands
A Eltink	Netherlands
R Grainger	Ireland
O Hagström	Sweden
D P J King	United Kingdom (N. Ireland)
K Popp Madsen	Denmark
A Maucorps	France
J Massé	France
J Molloy	Ireland
N A Nielsen	Denmark
R Rosenberg	Sweden
A Saville	United Kingdom (Scotland)
A Schumacher	Federal Republic of Germany
B Sjöstrand	Sweden
Ø Ulltang, Chairman	Norway
R J Wood	United Kingdom (England)
O J Østvedt	Norway

1.2 Terms of Reference

The Herring Assessment Working Group for the Area South of 62°N met at ICES headquarters from 27 April to 5 May 1981, in accordance with C.Res.1980/2:6/9:

- (i) to re-assess the herring stocks in Sub-areas IV and VII, Divisions IIIa and VIa, and sprat stocks in Sub-area IV,
- (ii) to collate any new data available on herring by-catch in the sprat fisheries by small time and area sub-divisions,
- (iii) to assess the effects of a 40 mm maximum mesh size for trawl gears for herring in Sub-area IV.

2. NORTH SEA HERRING (Sub-area IV and Division VIIId)

Historically, catch figures in Divisions VIIId and VIIe were combined in Bulletin Statistique. In the catch table and in the assessment only the catches for Division VIIId have been regarded as referring to the North Sea stock. Small populations of herring (Plymouth stock) exist in Division VIIe and are taken as by-catches of other pelagic species, but should not be taken into account for assessment of the Downs stocks (Divisions IVc + VIIId).

2.1 The Fishery in 1980

2.1.1 Catch data

Catch data for the years 1971-79 are given in Table 2.1.1 with a preliminary estimate for the year 1980.

The ban on directed fishing for herring in the North Sea and the reduction of by-catches in other fisheries, as recommended by ACFM, were in principle enforced in 1980. The landing figures as reported by Working Group members include both by-catches and substantial catches taken by illegal directed fishing on herring. The latter were taken into account in the catch tables in weight without national allocation and in the calculation of catches in numbers.

Under these circumstances, the total North Sea catch is estimated at 60 994 tonnes, of which about 50 000 tonnes do not appear in the official statistics. Although the effort made by the Working Group members to report more realistic figures is very much appreciated, this situation is found unacceptable by the Working Group. The Working Group confirms its great concern regarding the efficiency of the control of landings and the reporting of them.

In Table 2.1.2 the catches resulting from directed herring fisheries are reported by Sub-divisions for the years 1972-80, with the exception of some herring by-catches in Division IVb where the split between the type of fishing was impossible to estimate.

The estimated by-catches in all fisheries are given by Sub-divisions in Tables 2.1.3-2.1.6.

In almost all areas directed catches and by-catches have increased, especially in Divisions IVc + VIId, where a major directed herring fishery has been carried out immediately prior to and during the spawning season with apparently no restrictions.

The catches of juvenile herring in the directed fishery and/or as by-catch in the industrial fishery reached a level of 14 944 tonnes, of which 12 021 tonnes were taken in Division IVb, 2 403 tonnes in Division IVa East of 2°E and 520 tonnes in the northern part of Division IVc,

2.1.2 Catch in number by age

Numbers of herring caught by age and area are given in Tables 2.1.7 and 2.1.8 and summarised in the text table below for the past five years (with the revised figures for 1979).

Millions of herring caught by age group (winter rings)

Year	0	1	2	3	4	5 and older	Total
1976	238	127	901	117	52	46	1 481
1977	257	144	45	186	11	13	656
1978	130	169	5	6	5	1	316
1979	542	159	34	10	10	4	759
1980	792	161	108	92	32	26	1 211

The catch of 0-ringed fish escalated further in 1980 and seems to be, with 792 million individuals, the second largest over the past 10 years. Although the reporting in earlier years was more inaccurate, the fact remains that the reported catch of this age group has increased by a factor of 6 in two years.

The percentages of 0- and 0+1-ringed fish in the total catch have slightly decreased in comparison to last year, being nevertheless 66% and 78% respectively. The decrease is mainly due to the increase in illegal fishing on adult herring.

2.2 Age Composition

The International Acoustic Survey carried out on herring around the Shetlands gave the opportunity of an intensive sampling, the results of which are summarised in the text table below. In this area the 1976 year class is predominating. The 1973, 1975 and 1977 year classes are contributing by about 15%, while the 1974 year class which was the predominant one in the 1979 survey is slight weaker.

Age group (w.r)	Year class	Div. IVa W	Div. IVb		Divs. IVc + VIId	
		Echo surveys July ¹⁾	May ¹⁾	August ¹⁾	Nov. ²⁾	Nov. + Dec. ²⁾
0	1979				0.41	
1	1978		1.01		32.24	1.12
2	1977	15.89	39.70	20.9	44.49	45.75
3	1976	41.47	32.66	9.7	12.65	35.30
4	1975	14.30	6.53	1.4	1.63	11.26
5	1974	10.22	15.58	53.2	6.94	6.01
6	1973	15.19	3.01	7.2	0.41	0.51
7	1972	1.71	0.50	0.6	0.41	5.09
8	1971	0.69	-	0.6	0.41	-
8+	<1971	0.53	1.01	6.4	0.41	-
No. of fish		1 143	645	3)	700	1 963

Percentage age compositions (autumn spawners)

- 1) Research ship sampling
- 2) Landings sampling
- 3) Number not available, catches approximately 8 tonnes.

In the central North Sea (Division IVb) another survey carried out in May shows the predominance of the 1977 year class, but the samples probably contained a high proportion of the Downs component since age compositions given for herring in spawning condition in August show a much lower proportion of recruits and of 3-ringed fish.

The predominance of the 1977 year class is observed in the catches sampled in the southern North Sea and English Channel (Divisions IVc + VIId). The sampling made in November off the Dutch coast shows in addition a fairly high proportion of the 1978 year class. This year class is almost absent in the sampling carried out in November and December 1980 of the illegal catches taken on the spawning grounds in the southwest of Division IVc and in Division VIId.

2.3 Recruitment

2.3.1 Year class 1977

In last year's report of the Working Group, the strength of year class 1977 as 1-ringers was estimated at 0.43×10^9 based on the results of the International Young Fish Survey. It was considered, however, that the 1979 IYFS might have underestimated this year class due to exceptional weather conditions at the time of the survey.

From the observations on the southern North Sea population referred to above, it is clear that the Downs component was very high in this year class and might suggest that this year class may indeed have been underestimated by IYFS (see para. 2.2).

2.3.2 Year class 1978

The final abundance index for this year class during the 1980 International Young Fish Survey (which became available only after the previous meeting of the Working Group) was 535 fish/hour. At the previous meeting the Working Group used a preliminary figure of 585 fish/hour.

Substituting the final figure for year class 1978 into the formula presently used for estimating year class size in absolute numbers from IYFS indices:

$$Y = 0.0031X - 0.21$$

the strength of the year class as 1-ringers is now estimated at 1.45×10^9 instead of 1.60×10^9 .

During the IYFS in February 1981, very high numbers of year class 1978 were caught in the Southern Bight. Dutch fishermen operating in the Southern Bight have also reported large concentrations of 2 year old herring in this area during the first months of 1981. The southern distribution of this year class as 2-ringers would suggest that it will recruit predominantly to the southern North Sea spawning stock. Other observations supporting this hypothesis are the low average size of 1-ringers during the 1980 IYFS, and the high percentage of very small otolith nuclei among this year class, both as 1-ringers and as 2-ringers.

In para. 2.3.5 it is shown that the high influx of southern North Sea larvae in Dutch coastal waters in April 1979, and the high abundance of 0-group herring in English east coast surveys in July 1979 could also indicate a good recruitment of year class 1978 to the southern North Sea.

2.3.3 Year class 1979

The IYFS in February 1981 has yielded a preliminary abundance index of 504 fish/hour for the herring standard area. This indicates that year class 1979 will be of the same magnitude as its predecessor, and only about 35% of an average year class from the period 1968-73.

Year class	Abundance index IYFS	Year class strength as 1-ringers ($\times 10^{-9}$) estimated from VPA	Year class strength as 1-ringers ($\times 10^{-9}$) predicted from regression formula
1968	822	3.55	
1969	2 647	7.35	
1970	1 629	5.79	
1971	827	3.82	
1972	1 195	1.75	
1973	1 592	4.39	
1974	452	0.73	
1975	342	-	0.85
1976	575	-	1.57
1977	139	-	0.43 ^{x)}
1978	535	-	1.45
1979	504	-	1.35

x) ignoring constant in regression formula.

Applying the usual regression formula

$$Y = 0.0031X - 0.21$$

the strength of the year class in absolute numbers as 1-ringers is estimated at 1.35×10^9 .

During the Young Fish Survey, an unusually large proportion of the 1-ringed herring was taken in the western part of the North Sea (Figure 2.1). It is not clear, however, how this distribution pattern has affected the survey mean, or how it should be interpreted in terms of recruitment to the individual sub-populations.

In last year's report of the Working Group attention was drawn to the very high numbers of pre-metamorphosis herring larvae, caught by IKMT during Young Fish Survey in February 1980. It was assumed that the high abundance of $\frac{1}{2}$ year old herring could be an indication of a strong year class 1979. Now that the results of the 1981 IYFS have become available, it is clear that year class 1979 has been drastically reduced in numbers between February 1980 and February 1981.

Using the IYFS value as a reference point, the fishing mortality on year class 1979 as 0-ringers is estimated at 0.44, and the stock size as 0-ringers at 2.313×10^6 . A comparison with values for $F_{0\text{-ringers}}$ in previous years is given in the following text table.

Year class	Catch 0-ringers $\times 10^{-6}$	Stock as 1-ringers $\times 10^{-6}$, estimated from IYFS	$F_{0\text{-ringers}}$ (assuming $M = 0.1$)
1975	238	850	0.24
1976	257	1 570	0.14
1977	130	430	0.27
1978	542	1 450	0.30
1979	792	1 350	0.44

Because of uncertainties about the assumed value of $M = 0.10$ for 0-ringers, the calculated fishing mortalities on this age group are subject to the same reservations as expressed in last year's report of the Working Group.

2.3.4 Year class 1980

At the time of the Working Group meeting most of the results from the IKMT sampling in February 1981 were available. These preliminary results indicate a high abundance of pre-metamorphosis larvae in the North Sea, and particularly in Division IIIa:

Year class	Number of squares fished by IKMT in the North Sea	Mean catch per square in the North Sea	Mean catch per square in Division IIIa
1976	68	5.8	0.2
1977	106	3.9	0.9
1978	90	10.5	7.9
1979	119	28.9	9.5
1980	93	19.8	35.9

Figure 2.2 shows the distribution of pre-metamorphosis herring larvae in February 1981. Compared with the previous year, there were slightly more larvae in the southern North Sea, and many more in Division IIIa. However, our experience with year class 1979 has shown that it is necessary to be very cautious in interpreting the results of the IKMT sampling. A high abundance of a year class in the pre-metamorphosis stage is not necessarily a guarantee that the year class will turn out to be a strong one.

2.3.5 Recruitment forecasts by sub-populations

Until now the International Young Fish Surveys have yielded recruitment estimates for all North Sea populations combined, and it has not been possible to further allocate the 1-ringed herring to various sub-populations. One possible exception is the southern North Sea population, the members of which have a significantly lower mean length and a higher percentage of very small or opaque otolith nuclei than herring from other populations. In last year's report of the Working Group, the low mean length of year class 1978 during the 1980 IYFS, combined with the high percentage of very small nuclei was considered to be a possible indication of a high proportion of southern North Sea recruits among this year class. In the 1981 IYFS, again a high percentage of opaque nuclei was found among the 1-ringed herring, which could again point to a high proportion of southern North Sea recruits.

There are two other sources of information which could possibly be used to forecast recruitment to the southern North Sea population. One is the English programme of midwater trawl surveys, that sample 0-group herring in July along the East Anglian coast and in the Thames estuary (Wood, 1971). The mean number of herring caught in this area in these surveys was high in the early 1970s, when the southern North Sea stock showed a revival, and has been low afterwards until year class 1978 (Table 2.3.1). The second source of information is the Dutch monitoring programme on the influx of pre-metamorphosis larvae into Dutch coastal waters in April each year. Details of the method are described by Corten and Van de Kamp (1979).

After a period of very low catches, the numbers of these larvae in Dutch coastal waters have increased sharply since 1978 (Table 2.3.1).

Looking at the data in Table 2.3.1, it is seen that the English 0-group surveys would indicate a strong recruitment in the southern North Sea for year class 1978, and a moderate recruitment for year class 1979. The Dutch sampling programme would suggest a strong recruitment in the southern North Sea for year classes 1979 and 1980.

2.4 The 1980 Acoustic Survey

In June-July 1980, an ICES coordinated acoustic survey was carried out to estimate the size of the herring population in the Orkney-Shetland region of the northwestern North Sea. To evaluate the results of the survey, the Planning Group coordinating the surveys met in Aberdeen in February 1981 and their report was made available to the Working Group.

The report of the Planning Group indicated that there is considerable doubt about the target strength of herring and that intership variability is a major problem. The reasons for this are not known and as a result the Working Group did not feel in a position to use the results of the survey in their assessment of the North Sea herring. Nevertheless, they felt that these surveys should be continued and made the following recommendations for the 1981 survey:

- a) the major effort in 1981 should be put on resolving the reasons for the intership variability, by conducting intensive surveys of small areas with more than one ship, and by comparing all stages of the process, including calibration, species partitioning, threshold levels, survey design, etc., by making extensive intercalibration exercises;
- b) part of the effort should be devoted to an evaluation of carrying out a survey during the spawning season in August-September, when the herring might be expected to be concentrated in smaller areas. It was noted that the Scottish survey in 1981 was planned for August.

2.5 Herring Larval Surveys

2.5.1 Use of larval data for assessment purposes

At the 1980 Statutory Meeting of ICES it was recommended that the Working Group on Herring Larval Surveys South of 62°N meet in 1981, prior to the meeting of the Herring Assessment Working Group, to re-examine the statistical requirements for deriving reliable indices of larval abundances from these surveys, re-calculate these indices for the period during which suitable survey data are available, and re-calculate the regression equations relating these indices to spawning stock size. The report of this meeting (C.M.1981/H:3) was circulated to members of the Herring Assessment Working Group in advance of its 1981 meeting.

This resolution from ICES originated from the importance which larval survey data have in the assessment of stocks on which directed fishery is currently prohibited, and a realisation that a number of discrepancies and inconsistencies have in recent years been noticed in the utilisation of these data for estimating the parental stock sizes.

One of the major problems in the past utilisation of the data from these surveys has arisen from the fact that in some areas, and in particular in Divisions IVa and VIa, the area sampled and the distribution of sampling in time during a year have varied considerably from year to year. Such inconsistencies in sampling distributions cannot be completely corrected for, but the Herring Larval Survey Working Group found it necessary to re-calculate the larval indices for these two areas on a completely new basis to reduce to the minimum the inconsistencies arising from these sources. Full details of the procedures adopted to re-calculate the indices for these two stocks can be found in the report of this Working Group (C.M.1981/H:3), but essentially what was done was to divide all sampling data into standard time periods and uniform strata and re-calculate indices based on these.

The resulting, rather different, larval abundance indices for these divisions necessitated the recalculation of the regression equations for these stocks. These were calculated as functional regressions using the same measures of spawning stock derived from VPA as in the past.

The Herring Assessment Working Group discussed the report from the Herring Larval Survey Working Group and agreed that, despite some limitations of the data available, the indices and the resulting regression equations were an improvement on those previously used, and were the best that could be made with the available data. It also endorsed the Herring Larval Survey Working Group's recommendations on future research activities aimed at clarifying some areas of uncertainty which still remain in the utilisation of these data. The estimates of spawning stock sizes in recent years derived from these indices and regression equations and the limitations of them are discussed in the sections of this report dealing with the individual stocks.

When this report was discussed Mr Corten drew the attention of the Assessment Working Group to a different method of using the North Sea larval data which he had devised, and which he considered preferable (Corten, 1980). This method had also been discussed during the Herring Larval Survey Working Group's meeting and is commented on in the report of that Working Group. This method has the advantage that it produces an estimate of the larval production for the North Sea population as a whole, rather than indices for the individual spawning stocks, but also demands a number of assumptions which the majority of the Herring Larval Working Group found it difficult to accept and which makes greater demands on the completeness of the coverage of larval sampling both in space and time. The method, when used in conjunction with stock projections for the total North Sea, produces larger stock estimates for the northern and central North Sea populations than the ones given in the report of the Herring Larval Working Group and a smaller estimate for the southern North Sea population.

Reservations were also expressed about continuing to use the relationships between larval abundance and spawning stock size to estimate stock size at values of larval abundance beyond those used when estimating the regression equations. This limitation of the method was accepted as valid by the Herring Assessment Working Group, and it was pointed out that this point had been reached in Divisions IVa and IVc-VIIId.

2.5.2 Estimates of spawning stock sizes from the larval survey data in the North Sea

2.5.2.1 Division IVa

The Herring Larval Survey Working Group calculated indices of larval abundance for this division by using only samples taken within the area between 4°W and 1°W and between 58°N and 60°N, as this is the only area which has been consistently sampled in all years. For the same reason of consistency, only samples taken in September were utilised. These samples were then allocated to area strata of 1 statistical rectangle, and time strata of 1-15 September and 16-30 September. Mean values within these strata were estimated. These mean values of numbers of larvae $< 10 \text{ mm}^2$ for each stratum were then multiplied by the sea area in square metres within these statistical rectangles and summed over all statistical rectangles within the time stratum. The annual index was then taken as the mean for the two time strata. These indices are more consistent between years than the procedure previously used in estimating indices and more fully utilise all the available sampling data in their derivation.

To calculate spawning stock sizes to relate to these larval indices, a VPA was done using catch in number data for Division IVa given in previous reports of the Herring Assessment Working Group, and using 2/3 of the combined Z to calculate the spawning stocks at 1 September. The resulting functional regression equation is $\bar{y} = 0.0725x + 50.839$ and the corresponding predictive regression is significant at the 5% level.

Applying the larval indices to this equation gives estimates of the spawning stock in this division of:

<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
> 100 000 tonnes ¹⁾	> 295 000 tonnes ¹⁾	278 000 tonnes	203 000 tonnes

1) These are minimal values because of some inadequacies in the sampling in the second time strata in these years.

These values must be interpreted with some caution, because the confidence limits of the estimates are wide. Two other features of these estimates must also be taken into consideration in evaluating them; firstly, that the regression equation has a positive intercept on the y-axis which would mean that with a zero larval index one would still estimate a spawning stock size of about 51 000 tonnes and, secondly, that the larval indices for 1978 and 1979 are higher than the highest value encountered during the years used in calculating the regression equation. These factors must result in great caution in placing too much reliance on the absolute values of the spawning stock estimates. It should also be borne in mind that the spawning stock in this division had already been very sharply reduced from its level in earlier years by the time of the values used in estimating the regression.

As in other areas, these are the only quantifiable data which can be used in estimating the spawning stock size in this division. However little reliance one places in the reliability of the estimates of the absolute values of stock size derived from these larval indices, they would clearly point to an appreciable increase in it from 1977 to 1978, but no demonstrable subsequent increase. This, taken in conjunction with other data pointing to low recruitment to the stock in this area, must suggest great caution in proposing any relaxation of the current prohibition on fishing in this area. However, every effort should be made to get a new independent estimate of stock size, since the larval regression equation cannot be improved before a new VPA can be carried out.

2.5.2.2 Division IVb

In this division larval sampling during the period 1971-80 were more consistent both in the sampling coverage and in the timing of sampling than in Division IVa, and the Larval Survey Working Group were able to use the larval indices previously utilised by the Herring Assessment Working Group in its previous report without modification. The estimates of spawning stock size used in calculating the regression equation were also then used in that report resulting in a functional regression equation of $\hat{y} = 10.2115x + 7.557$. The corresponding predictive regression is significant at the 1% level. It should be noted, however, that these spawning stock estimates for the period used in calculating the regression were estimated by deducting from the Division IVb catch in number fish which, on maturity considerations, were thought to be Downs spawners and that these were then added to the Division IVc and VIId catches in estimating the spawning stock sizes used in the regression for that area. Some members of the Herring Assessment Working Group expressed their reservations about this procedure and it was agreed that the data used in making these assessments of spawning stock size should be examined at the next meeting of the Herring Assessment Working Group.

The spawning stock sizes for this division since the time of closure of the directed herring fishery, estimated from this regression equation, are:

<u>1978</u>	<u>1979</u>	<u>1980</u>
30 000 tonnes	31 000 tonnes	14 000 tonnes

The estimate for 1980 raised some additional problems in that there were some inadequacies in the larval sampling in the latter part of the time period used in estimating the larval index. These deficiencies were, however, corrected as far as the data would permit and other evidence would support the great scarcity of spawning fish in this division in 1980, which this estimate implies.

Clearly, the larval indices in this division would suggest that there has been no appreciable recovery of the spawning stock since the directed fishery was prohibited and might even suggest that it declined to a still lower level in 1980. This in conjunction with other evidence of herring scarcity and low recruitment would clearly suggest that no relaxation of the ban on directed herring fishery should be considered in this division.

2.5.2.3 Divisions IVc and VIIId

The Herring Larval Survey Working Group calculated indices of larval abundance for these divisions for each year from 1957/58 to 1980/81 and calculated a regression equation for the period 1957/58 to 1975/76 during which VPA-derived estimates of spawning stock size were also available. Using this regression equation and the larval abundance indices for later years, they estimated spawning stock sizes of 12 000 - 15 000 tonnes in the period 1976/77 - 1978/79, 63 000 tonnes in 1979/80 and 142 000 tonnes in 1980/81. That Working Group, however, expressed severe reservations about this regression equation and the resulting stock size estimates, because the relationship is not significant, and because the larval data over this entire period were available only as larvae of all size categories and there are serious objections to using these as indicators of the size of the parental stock which produced them. In the period 1969/70 - 1975/76 when the larval data are available by size categories, the indices of the smallest category fluctuated very widely from spawning season to spawning season in a way which was quite unrelated to the size of the parental stock. These reservations were also increased by the fact that by 1979/80 and 1980/81 the larval indices were outside the range used in estimating the regression equation.

The Herring Assessment Working Group fully accepts these reservations about the use of this relationship to predict spawning stock sizes from larval abundance data. But in the current circumstances there is no other way of getting a quantitative estimate on which to base stock management advice. Moreover, the very rapid increase in larval abundances in this area in 1979/80 and 1980/81, to a level in the latter season considerably higher than has been seen in this area since 1951/52, must give some confidence that although the estimate may not be very precise there must have been a very major increase in spawning stock size.

2.6 By-Catch of Herring in the Sprat Fisheries

By-catches of herring have mainly been associated with the sprat fisheries. An analysis based on about 230 samples from these fisheries collected in 1979 and 1980 is shown in Figure 2.3. In each statistical rectangle the average percentage of herring is shown by the lower figure while the upper figure indicates the number of samples from which the average is calculated.

These samples indicate that the overall by-catch is low except in some restricted areas. These higher by-catch levels occur in shallow waters and close inshore in nursery areas, e.g. along parts of the Danish and British coasts.

The catches in inshore waters are responsible for the high numbers of 0-group herring taken. At this stage of life the herring are found in dense concentrations in very restricted areas and consequently they are very vulnerable to trawl fisheries with small-meshed gear. Even though the actual catch in weight may not seem very impressive (perhaps 3 000 - 5 000 tonnes), the resulting catches in numbers are very large (vide para. 2.1.2) because of the large number of fish per kg.

The natural mortality of 0-group herring may be appreciably higher than $M = 0.1$ which is used in assessments on North Sea herring and the direct effect of the removal of 0-group is therefore difficult to quantify at present. As the numbers caught in the last two years, however, amount to about half the total year class strength for 1-group herring calculated as at 1 January, i.e. about 2-4 months after the 0-group reduction took place, the effect must be appreciable and perhaps even a major responsible agent in the delay observed in the rebuilding of the adult stocks, especially in Division IVb.

The Working Group therefore strongly recommends that every effort should be made in order to reduce or eliminate the by-catch of 0-group herring. The most effective way would be to close the areas of high concentrations in those months where high by-catches take place.

From the present material this would appear to be statistical rectangles 42 F 7 and 41 F 7. The percentage monthly distribution of herring caught from these rectangles are shown below:

Year	Month							
	I-V	VI	VII	VIII	IX	X	XI	XII
1979	nil	0	0	4	59	35	1	nil
1980	nil	4	25	56	7	5	3	nil

The period is apparently not the same in the two years. A closure from mid-July to mid-October should, however, reduce the by-catch by about 80% on average.

As indicated in Figure 2.3 and noted in the previous report, high by-catch levels occurred in coastal areas of the United Kingdom in 1979.

Additional data will be available at the ACFM meeting in July.

The average by-catch level, taking the North Sea as a whole, was shown by ACFM to have been of the order of 3.6% of the total catches in 1979. Its subsequent recommendation applied this level to individual catches. The Working Group considers that ACFM should reconsider this recommendation in the light of its practicability. It also wishes to point out that the effectiveness of any percentage by-catch regulation is not dependent on the level set but on proper enforcement and control.

2.7 State of the Stock and Management Advice

2.7.1 Criteria for re-opening the fisheries

At its 1980 meeting the Herring Assessment Working Group for the Area South of 62°N discussed criteria for re-opening fisheries on herring stocks which are currently subject to bans on directed fishing. It was stressed in the report that before a limited fishery could be allowed, there should be evidence of a recovery of the spawning stock, and of improved recruitment. A re-opening of the fishery should not be based only on expected increases in the spawning stock compared to an estimated level in a past year, and/or expected improved recruitment from an increasing spawning stock. Because of errors involved when

projecting the stock forwards from a given, but uncertain, starting value and the uncertainties about the actual form of the relation between spawning stock and recruitment it could have disastrous consequences to replace evidence with expectations.

Since that meeting Dr J Beddington, acting as a consultant to the EEC Commission, has submitted a report to that body, entitled "Harvesting Strategies for North Sea Herring and the Effects of Random Variations in Recruitment". The document was made available to the Working Group. Since Beddington's approach and conclusions were very different from the approach and conclusions of the 1980 Working Group meeting, the Working Group had a rather thorough discussion of Beddington's report.

Beddington investigated by simulation techniques the effect of various harvesting strategies on the North Sea herring. He took the stock size previously calculated by the Working Group at 1 January 1976 and projected it forward using a Shepherd 1979 type stock/recruitment relationship to estimate subsequent recruitments to the population. Recruitments were generated from a probability distribution around the stock/recruitment curve.

Given the low spawning stock size at the starting point of the projections, the validity of the subsequent outputs is very dependent on the stock/recruitment relationship used. Estimated strength of recent year classes from LYHS indicates that recruitments predicted from the stock/recruitment curve used by Dr Beddington are heavily biased upwards at spawning stock sizes as observed during the most recent years. In his model this will then generate a much too high spawning stock size. Although Dr Beddington started with the 1976 stock size, he scaled down his extrapolations so that the spawning stock biomass in 1979 was 230 000 tonnes, the value given in the Working Group report for that year.

The following example illustrates that this scaling down must have been very large. By starting the model with the 1976 adult stock size, estimate all year classes from 1974 onwards from the model and not scaling down the extrapolations, the resulting stock sizes were calculated. In the text table below are shown the resulting spawning stock sizes for 1977-80, together with spawning stock sizes estimated as estimated by the larval surveys (1 000 tonnes). (The figures are taken from a working paper by A Saville.)

Year	Predicted spawning stock from Beddington's model (M = 0.1)	Larval survey estimates of spawning stock size
1977	334	158
1978	523	344
1979	831	372
1980	1 415	359

This shows that the predicted spawning stock in 1979 from Beddington's model of 831 000 tonnes is at a much higher level than both that of 230 000 tonnes, to which the population is scaled in 1979 in the Beddington approach and the revised larval survey estimate of 372 000 tonnes. The text table shows further that the prediction for 1980, when the stock is not scaled down, would be 1.4 million tonnes. This

reflects the large growth potential of the stock under the assumed stock/recruitment relationship. The estimates from the larval surveys show a much more slow recovery of the North Sea stock. This indicates that, either the stock/recruitment relationship is valid, but by chance we have had low recruitment in the years 1977-80, or the assumed stock/recruitment relationship is biased at stock levels as observed in recent years. The Working Group tends to believe that the slow recovery of the stock is due to the assumed stock/recruitment relationship being unrealistic at these low stock sizes.

The above-mentioned discrepancy between predicted and observed spawning stock size shows the danger of relying on estimated stock/recruitment relationships based on experience in former periods and using these in predictions, without taking direct observations into account. That Beddington scaled down his projection to 230 000 tonnes in 1979 presents no appreciable safeguard, since the subsequent projections are subject to the same bias. That one starts afresh from a more realistic base in 1979 has only a very short-term effect.

It is of course true that Beddington would not in fact have worked with the values given above, as he incorporated a stochastic element into his projections. This does not, however, alter the fact that on average his values should have been close to those given above. Incorporation of a stochastic element does not remove the bias.

It is also true that Beddington himself took into account that the stock/recruitment curve might overestimate recruitment at low stock sizes and did an alternative analysis based on a depensatory curve, assuming zero recruitment below a certain level of the spawning stock, a linear relationship for stock sizes between this level and an intermediate level and constant recruitment for higher stock sizes. At very low spawning stock sizes this presents a safeguard. If one repeated the exercise described above with his depensatory relationship would in fact get a bias in projected stock sizes in the opposite direction for the period 1977-80. However, at stock sizes as estimated from the larval surveys in 1978 and 1979 his depensation equation would give even higher recruitments than the Shepherd type curve, as illustrated in the text table below (from the working paper by A Saville).

Year class	Estimated recruitment from Shepherd type curve	Estimated recruitment from depensation equation	IYHS estimate
1978	5.62	7.87	2.36
1979	5.92	8.93	2.05

On this basis it would appear that neither of these stock/recruitment relationships provide an adequate basis on which to formulate a long-term management strategy. The depensation equation presents a safeguard only at very low values of spawning stock sizes. At present intermediate stock sizes it seems to heavily overestimate recruitment.

Although the Working Group would not use simulated predictions as a basis for opening the fishery, the simulation method might well show useful for evaluation of different management strategies.

Taking into account the criticisms of the Beddington model given above, simulations based on a new stochastic model were presented to the Working Group (working document by A Laurec and A Maucorps). These consider a range of Shepherd stock/recruitment relationships and a Ricker relationship modified to include an inflexion point to take into account the likelihood of very poor recruitment at low spawning stock sizes and the possibility that the stock/recruitment curve may be different when the stock is increasing.

If stock/recruitment relationships can be established, preferably for the different stock components, this method is likely to provide a more realistic approach.

The Working Group concluded, however, that at present no stock/recruitment relationship, which is likely to predict realistic recruitment values, can be defined. The Group will again stress the need for having evidence from direct observations of a recovery of the spawning stock, and of improved recruitment, before a fishery is allowed. Basing management decisions on a Beddington type model could have disastrous consequences as explained in last year's reports of both the Working Group and ACFM

The Working Group, in making these examinations of Beddington's model, used the natural mortality of $M = 0.1$ on which all its former advice is based. Postuma (1963) analysed the wartime data from Belgium and gave a value of 0.08. The Working Group in its discussions in 1972 agreed that a value of $M = 0.10$ was consistent with observations from a variety of fisheries. The use of $M = 0.2$ has the effect of increasing stock sizes and decreasing the fishing mortality estimate. But provided that one of these estimates is consistently used, it has little effect on management decisions. The Working Group chose to examine the Beddington model in terms of $M = 0.1$.

Since the collapse of all herring populations in the North Sea, the Working Group and ACFM have consistently recommended that until the total spawning biomass had reached 800 000 tonnes no directed herring fishery should be permitted. It was considered that at this level the risk of recruitment failure due to low spawning stock biomass was relatively low.

ACFM has commented: "Since the stock components of the North Sea herring may be recovering at different rates, and since the level of recruitment to these components may differ, re-opening of the total North Sea herring fishery may prevent one stock from recovering while another may remain lightly fished, depending on the distribution of fishing effort". (ICES Coop.Res.Rep., No.102, para. C.2.24).

2.7.2 The state of the North Sea stock components

The characteristics of the exploitation of herring in the North Sea in 1980 and the results of research vessel investigations indicate that the stock is not responding as a homogeneous unit to the closure of the total North Sea. Applying the criteria previously adopted for the total North Sea would result in maintaining the recommendation that no directed fishery should be allowed in 1981.

Following the ACFM recommendations the Working Group has considered the evidence from the individual North Sea component stocks to assess the feasibility of re-opening fisheries on different individual components.

2.7.2.1 Divisions IVc and VIIId stocks (Downs)

The magnitude of the unauthorised catches from the Southern Bight and Channel spawning grounds of the Downs herring in the 1980/81 winter has indicated that the 1977 year class, which formed an important part of the catch (40%), may have been more abundant in the total North Sea than expected. It appears that the predominant part of the recruitment has occurred to the Downs stock.

In 1979/80 the larval abundances in this area had already reached the levels observed at the time of the earlier recovery of the Downs stock in the 1960s. The 1980/81 larval surveys indicate a further major increment in spawning stock as shown in the text table below:

Year class	1957/8	1958/9	1960/1	1961/2	1962/3	1963/4	1965/6	1967/8	1969/70	
Larval abundance indices	36	139	147	187	30	22	13	26	108	
Year class	1970/1	1971/2	1972/3	1974/5	1975/6	1976/7	1977/8	1978/9	1979/80	1980/1
Larval abundance indices	126	7	67	13	8	7	9.8	16.4	147.3	363.7

The 1978 year class which will recruit to the spawning stock in 1981 has been shown by the IYFS not to be strong for the total North Sea. However, other information from the English 0-group survey, biological characteristics of the fish in the IYFS and observations on catches of this year class in the summer of 1980 indicate that the Downs proportion of the total recruitment could be high. Sampling of catches off the Dutch coast in November 1980 would also suggest that this year class will recruit strongly to this stock. There is thus reason to expect a further increment in the spawning stock biomass in 1981/82, the magnitude of which cannot be assessed at present.

2.7.2.2 Division IVb stock (Bank)

Age compositions from the spawning stock in the central North Sea are given in the text table below.

Division IVb age distributions (1977: from Ass. Working Group Rep.;
(1978-80: from English samples of spawning herring - Longstone and Whitby areas)

Winter rings

Year	2	3	4	5	6	7	≥ 8	%
1977	<u>72.4</u>	19.0	0.7	5.4	2.5	-	-	100
1978	15.7	<u>52.8</u>	17.0	2.2	5.6	6.4	0.3	100
1979	12.8	4.3	<u>40.4</u>	28.7	2.1	5.3	6.4	100
1980	20.9	9.7	1.4	<u>53.2</u>	7.2	0.6	7.0	100

It is seen from the text table on p.15 that the dominant year class is still that of 1974 which are now 5-ringers in 1980. No new good year classes have recruited to this stock. The larval surveys have shown a major fall in larval abundance in 1980:-

Larval abundance index x 10⁻¹¹

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
2.54	1.07	5.00	3.84	1.70	0.44	?	2.23	2.26	0.59

(Table 3, C.M.1981/H:3).

Thus, it would appear that little or no recovery has taken place in the central North Sea stock as explained in Section 2.5.2.2 and this is partly consequential on the lack of recruitment.

2.7.2.3 Division IVa stock component

During the ICES Coordinated Acoustic Surveys in 1979 and 1980 and compositions of the catches in the vicinity of the Orkneys Shetlands have been derived.

In 1978 some Scottish research vessel hauls were made in August in the area. The last commercial fishery data were obtained in 1977. All those data have been tabulated as percentages below:-

% age composition of Division IVa stock component

Winter rings	1	2	3	4	5	6	7	8+	Σ
1977	1.4	4.7	<u>86.2</u>	4.3	1.9	1.0	.4	.1	100.0
1978	-	42.6	21.8	<u>30.9</u>	1.6	1.9	1.0	.3	100.1
1979	27.4	16.6	7.9	28.7	<u>18.6</u>	.6	.2	-	100.0
1980	-	15.9	41.5	14.3	10.2	<u>15.2</u>	1.7	1.2	100.0

The 1973 year class remains an important part of the stock in contrast to its spawning abundance in Division IVb; in 1980 the 1976 year class was dominant.

The larval surveys in the area indicate that the larval abundance has recovered from the low levels of 1973-76 in 1978, but that there has been no further increase in 1979 and 1980 (see Section 2.5.2.1).

Larval abundance index (No. x 10⁻⁹)

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Larval abundance	390	2 128	945	403	152	314	(698) ¹⁾	(3385) ¹⁾	3 132	2 026

1) Underestimates

2.7.3

Management advice

It is clear from the above sections that the recovery of the North Sea herring stock is not taking place in all areas at the same rate. As a consequence the management advice could be different in different areas.

The Working Group investigated the possibilities of allowing a TAC in Divisions IVc and VIId as a consequence of the improvement in stock detected. Age data were available from the unauthorised catches and a stock size for 1981 was calculated on the basis of the estimate of spawning stock size derived from the larval abundances. The resulting fishing mortality in 1980 was estimated to be 0.23, Table 2.7.1.

As the 1978 year class will be an important part of the spawning stock in 1981/82, an input value of half the total North Sea estimate for IYFS has been used.

In the text table below and in Figure 2.5 the expected catches for various levels of fishing mortality are shown:

F_{1981}	C_{1981}	SSB 31.12.81	% Change in SSB from 1980
.0	0	221	56
.1	22	200	41
.2	42	181	28
.3($F_{0.1}$)	60	164	16
.4	77	148	5
.5	92	134	-6
.55 (F_{max})	99	127	-11
.6	106	121	-15
.7	118	110	-23

The unauthorized fishery has reduced the possible gains in stock size in 1980. Fishing has already taken place in January of this year and this should be deducted from those predicted annual catches in the text table above.

In the present situation when management is aiming at rebuilding the spawning stock, it is apparent that even taking the criterion of $F_{0.1}$ would seriously reduce the rate of recovery, and considerably lower F -values are required to ensure a further stock recovery, taking into account the uncertainties in the various assumptions.

Unlike in the other North Sea divisions, Division IVc south of 53°N and in Division VIId, the open sea catch consists only of Downs herring. While Downs herring are also caught in the feeding areas in Divisions IVa and IVb, the converse is not true as the other stocks after spawning do not migrate into the Southern Bight. The Downs stock is thus solely exploited in Division IVc south of

53°N from October (when they are moving to the spawning grounds in both Division IVc and Division VIIId) to March (when they are returning northwards as spent). The Working Group recommends that any TAC allowed should only be taken in the area south of 53°N in Divisions IVc and VIIId and within the time period October to March.

The situation of the stocks in both Division IVa and Division IVb gives rise for disquiet in their response to the North Sea ban. In one case the spawning stock biomass appears to have remained at a stable level for three years and in the other case has decreased. There is also little sign of an increment in recruitment. For the most recent year classes, if it is true that an important part of the total stock of 1-ringers are Downs recruits, then recruitment to the other components must be low. In the light of this evidence the Working Group does not recommend any directed herring fishery for 1981 in Divisions IVa and IVb.

In the North Sea, appreciable quantities of 0- and 1-group fish have continued to be taken as by-catches. In Section 2.6, it has been shown that closure for sprat fishing of a limited area of the eastern North Sea for three months each year would reduce the catches of 0-group herring considerably. Appreciable catches of 0- and 1-group are also taken in Division IIIa, and a component of these probably also originates from North Sea spawners. The Working Group recommends that action should be taken to close these areas as soon as possible.

The catches of North Sea 0-group, the VPA estimates and the IYHS predictions of 1-ringers' abundances and the catch of 1-ringers in Division IIIa shown in Table 2.7.2 for each year class. (See p.56).

Because of the low state of the Downs stock in 1971-77 the contribution to the total North Sea recruitment must have been low. It may be assumed that the major part of the 1973-76 year classes as 1-ringers were derived from Divisions IVa and IVb.

Rosenberg and Palmén have recently shown in the IYFS catches in Division IIIa that about 40% of the 1-ringers in February 1980 could be ascribed as North Sea autumn spawners. The catch of 1-ringers in that year can be seen to be about three times that in the North Sea. While it is not known at present how applicable this percentage of North Sea recruits is to the annual catch, there may well be a large proportion taken. The potential recruitment to the North Sea spawning stocks is thus further reduced by an unquantified component in Division IIIa. Such loss would be likely to be suffered by the Division IVa and IVb stocks, particularly in the 1974-76 year classes, which entered the spawning stock in 1977, 1978 and 1979.

The Working Group considers that urgent action is needed to reduce the catches of 0- and 1-ringed herring for the general benefit of the North Sea and Division IIIa and perhaps even the Baltic stocks. In the case of the North Sea, a specific measure has been suggested in Section 2.6 and recommended above.

2.7.4 Projection of stock size for the total North Sea

A projection of stock sizes from 1.1.1979 to the spawning stock at 1.9.1981 has been presented to the Working Group. This is a continuation, and partly a revision, of a projection made at the 1980 Working Group meeting (Doc. C.M.1980/H:4), which was initially based on a stock size estimate for 1977 derived from a VPA with assumed values of fishing mortality for 1976, the last year in which a directed herring fishery was permitted throughout the year.

Catch figures in numbers per age group have been used to estimate from the initial stock size the fishing mortality for that year and the stock size in the following year. These calculations have been continued up to 1981. For 1981, it was assumed that no catch would be taken. The spawning stock estimate was derived from the stock size at the beginning of the year by applying $2/3$ of the total mortality.

The year classes present in the stock in 1977 have almost completely disappeared in the stock projection at the beginning of 1981. Thus, the projected stock sizes for the years 1979 to 1981 are increasingly dependent on the input of 1-ringed recruits as estimated from the IYFS.

The spawning stock estimates from the projection are generally higher than those derived from larval surveys. This could be due to the basic assumption made in the projection that the recruits as estimated from the IYFS remain in the North Sea throughout their lives. This means that no account has been taken of the Division VIa recruits, which are known to occur in the juvenile fishery and in the survey area, and which are expected to withdraw from the North Sea before they spawn. Thus, the spawning biomass estimate in the prediction contains a component of herring which does not contribute to the actual spawning in the North Sea, but the quantities cannot be assessed at present, and may vary from year class to year class. It is clear, however, that considering any emigration out of the North Sea in the projection would further reduce the estimated spawning biomass towards the level indicated by the larval surveys.

Furthermore, a general problem in herring assessments is expected to add further reservations to the results of the stock projections, i.e. the uncertainties about the natural mortality, particularly on the 0- and 1-ringers.

In the light of these reservations the Working Group decided that the projections should not be incorporated in the report in order to avoid misinterpretation.

3. HERRING IN THE SKAGERRAK AND THE KATTEGAT (Division IIIa)

3.1 Stock Composition

Samples of adult herring in pre-spawning condition from the Skagerrak, the Kattegat, and the North Sea and its adjacent waters were characterised by their mean values of VS, K_2 , and O_1 ; where O_1 is the distance between the outer margins of the first winter ring along the axis of the otolith (rostrum - post rostrum) (Rosenberg and Palmén, in MS). The autumn spawners were shown to have higher mean values of O_1 than the spring spawners. Today, no autumn spawning component of any importance to the fisheries is spawning in Division IIIa.

With the spawning herring as a reference it could be shown that the vast majority of 2-group and older herring in the Skagerrak and the Kattegat belonged to the spring spawning component. The spring spawned and autumn spawned 1-group herring could be separated by length measurements during the first part of the year. Such a separation showed that the proportion of spring spawned herring caught during the 1980 International Young Fish Survey in February was approximately 60%. The majority of the rest could originate from the North Sea and its adjacent waters judged by their means of VS. In a scientific trawl survey in September 1980 in Division IIIa approximately 80% of the 1-group herring were spring spawners

according to separation by otolith measurements. The Skagerrak area was, however, less adequately covered by these surveys and the major part of the samples of immature herring from the Kattegat was taken in the deeper, eastern part. The results from the material collected during the two surveys are, therefore, not directly applicable to the commercial landings, but should be supplemented with data extracted from the commercial samples which hitherto have not been treated in this respect.

In the case of 0-group herring, the measurements are not feasible but a distinction between spawning components can be obtained from the multimodal length distributions which are often observed.

3.2 The Fishery

3.2.1 Catch data

The landings of herring during the last decade are given in Table 3.1. The preliminary total landings based on official figures in 1980 for Division IIIa amounted to approximately 64 000 tonnes, i.e. about the same as in the previous year. However, estimates made by the Working Group indicated that at least 20 000 tonnes should be added as unallocated landings. These include mainly misreported and unreported landings, but also some by-catches in other fisheries and landings of undersized herring (minimum landing size is 18 cm) from directed fishery for human consumption herring. The unallocated landings were divided almost equally between the Skagerrak and the Kattegat, so that the assumed landings amounted to about 30 800 tonnes and 53 400 tonnes, respectively.

The figure of the total landings should be regarded as an underestimate of the catches as the discards at sea of small herring are not included. As no information was available, the Working Group suggested last year that the discards were between 4% and 10% of the landings. The Working Group agreed that an addition of 7%, giving a total catch of approximately 90 000 tonnes, could still be an underestimate but closer to the actual catch.

3.2.2 Catch in numbers at age

As in earlier years the different herring fisheries in Division IIIa were not all covered by adequate sampling for age distribution and numbers per unit weight landed. Danish trawl landings from the Kattegat were thus apartioned according to Swedish samples, and the Faroese landings from the Skagerrak according to Norwegian purse seine samples from the open sea.

The results are shown in Table 3.2 and as input figures for a VPA in Table 3.3. The latter permits a comparison with 1979 and indicates an increase in the numbers caught of all age groups except the 2-ringers (year class 1978).

Because no age data were available, the discards were assumed to have the same age compositions as estimated for by-catch herring. Table 3.2 shows that this assumption led to an increase of 30% in the estimated catch of 0-group herring. This is probably an overestimate, partly because the 0-groups are only available in the second half of the year and partly because such small herring have a distribution which is different from that of the older herring caught for human consumption. The Working Group preferred, however, to choose an assumption for which the direction of a possible bias was known.

Compared with previous years, the number caught at age in 1980 appear to reflect the two features shown already in last year's report, i.e. the rather strong 1977 year class and the rather weak 1978 year class.

3.3 Biomass Estimates from Acoustic Surveys

Two acoustic estimates of herring stock were reported to the Working Group from surveys carried out in September and November 1980. Preliminary results from the September survey have already been reported to the ACFM by an ad hoc Group.

The reported estimate has been revised, as an inadequate method of splitting the biomass on species was used.

The estimate from the September survey is based on a length-dependent conversion factor. The target strength value used was -38.3 dB per kg for herring with a mean length of 23.7 cm. This value was established in 1980 by TS-measurement on herring in a cage (Aglen et al., in prep.).

The transducer broke down after one week of the survey in September and a new one was installed and calibrated. The integration in the first week was, therefore, corrected by comparing integrated values in the same areas in the following weeks. This gave a correction factor of 2.44.

Fishing was carried out using a single boat pelagic trawl, mainly during day-time, and both the participating research vessels found shoals of herring more difficult to catch compared to the previous survey in 1979. This avoidance would lead to an underestimate of the herring biomass and also give a biased age composition. More details on the survey and the methods used are presented in the report of the Working Group on Division IIIa Stocks 1981: sprat section. A full report will be presented at the ICES Statutory Meeting in 1981.

A total herring biomass of 230×10^3 tonnes was estimated in the area surveyed, which was about 75% of the total Division IIIa area. The herring biomass was converted into number per age group according to the age composition in the trawl catches. The result is compared with the revised estimate from the 1979 survey (C.M.1980/H:54) and presented in the text table below, where also the estimate from November is included.

Year	1979 Sept.	1980 Sept.	1980 Nov.
Biomass x 10^{-3} tonnes	201.4	238.1	175.0
Surveyed area in miles ²	6 170	10 977	15 200
Total No. x 10^{-6}	2 364.9	1 981.4	4 541
Age group	1979	1980	1980
0	577.4	481.9	1 709
1	610.7	476.9	2 787
2	1 067.4	434.2	34
3	92.8	473.4	11
4	12.7	84.0	
5	3.9	27.9	
6		3.1	

The ad hoc Group concluded in its report that the September estimates of 0- and 1-groups were inaccurate, because the areas sampled do not coincide with the proper distribution area of young fish. The catch data from the hauls may underestimate the older components of the herring stock in Division IIIa because of age-dependent avoidance differentials. However, the 1977 year class appears to be strong also in September 1980.

In November a second acoustic survey was carried out in Division IIIa by R/V "Johan Hjort". Details concerning equipment and method applied are described in the report of the Working Group on Division IIIa Stocks (C.M.1981/G:12). Herring were observed in the whole of the area investigated in the Kattegat. The shallow area in the western part was not covered. In the Skagerrak, herring were observed along the Swedish coast and in a smaller area west of Skagen.

The biomass estimates given in the table above were based on length-dependent target strength. The length-dependent target strength used in the November 1980 survey is based on measurements made by Nakken and Olsen (1977) and applied to the formula by Aglen:

$$TS_{kg} = -10 \log_{10} L - 25.4$$

where L is fish length in cm.

This formula fits very well with measurements made last year by Aglen et al. (in prep.). They found a target strength per kg as -38dB for engaged herring of 23.7 cm.

The biomass is transferred to numbers per age group according to combined data from trawl hauls made by the research vessel during the survey as shown in the text table above.

The 0- and 1-group could be overestimated due to problems of catching herring with trawl. The acoustic values were split into different species and age groups according to trawl catches. If older herring avoid the trawl, the acoustic values of these will then be designated to younger age groups. The age distributions in samples from the Swedish fishery in the fourth quarter in 1980 show that about 60% in numbers were younger than 2 years (0- and 1-group). However, the age distribution in Swedish samples from by-catches in the fourth quarter of 1980 shows that about 99% were younger than 2 years. This is the same age distribution as that obtained in the Norwegian survey.

The adult stock is normally found close to the coast and in its overwintering areas, the Sound and the Belt.

Alternative estimates of the herring stock were calculated using target strength per log of -31dB for herring as proposed for the North Sea by ICES Planning Group on Acoustic Surveys (C.M.1981/H:5).

These new TS values reduced the estimate for September and November to 39 000 tonnes and 27 000 tonnes respectively. Compared to the landings these estimates are rather low.

3.4

Recruitment

The annual young fish survey was carried out during 2-10 February 1981 with R/V "Argos".

Sampling with the GOV bottom trawl was made on 32 stations, 17 in the Skagerrak and 15 in the Kattegat. The abundance index of 1-group herring calculated as the geometric mean of the arithmetic means of seven standard squares was 544. This is slightly higher than the index from the previous year and somewhat higher than the mean of all years. Thus, the index indicates that the 1-group is of average strength.

It must be kept in mind, however, that no separation has so far been made between spring and autumn spawned components in 1981. The greatest numbers were also this year found in the Kattegat, with higher concentrations along the Swedish coast than in the central parts. Although the abundances were comparatively lower in the Skagerrak, 1-group herring were found in all the squares in numbers of between 6 and 385 per trawl hour.

Abundance indices for 1972-81 (year classes 1970/71 - 1979/80) are shown in the text table below.

Year	1-group index
1972	78
1973	181
1974	726
1975	455
1976	1 339
1977	204
1978	575
1979	3
1980	504
1981	544

3.5 State of the Stock and Management Advice

3.5.1 Stock size

Estimates of stock size in Division IIIa may be derived from two sources: catch figures and acoustic surveys.

The catch in numbers at age for 1974-80 (incl.) were used in a VPA as shown in Tables 3.3 - 3.5. The critical choice of input Fs in 1980 were governed by the following considerations:

- (i) the 0-group Fs were set at 0.2 which gives year class 1980 at about average strength as indicated by the abundance index in IYFS in 1981;
- (ii) the fishing mortality for the 1-group was assumed to be 0.25, which generated a 1979 year class strength also close to the average as indicated by the IYFS 1980;
- (iii) for 2-groups and older an F value of 0.7 was assumed. This was also applied as input for the older fish in last year's assessment, except for the 2-group where $F = 0.44$ was adopted considering the strength of year class 1977 in the 1979 acoustic survey. The Working Group found, however, that there was no reason to assume that this age group should not be subject to the same effort as the 3 years old and older;
- (iv) the same differential natural mortalities at age which were used in earlier assessments were applied also in the present exercise.

The results of the VPA are shown in Tables 3.4 and 3.5. The latter shows, amongst other things, the estimated stock sizes in numbers at age as at 1 January 1979 and 1980. In order to compare the VPA estimates with those derived from the acoustic surveys, $2/3$ of the total mortality (Z) were applied to the former to get the stock at 1 September. The results are shown (in numbers $\times 10^{-6}$) in the following text table:

	1 Sep.1979 Acoustic survey	1 Sep. 1979 VPA	1 Sep. 1980 Acoustic survey	1 Sep.1980 VPA	Nov. 1980 Acoustic survey
0	577	(2 760)	482	(3 115)	1 709
1	611	594	477	1 707	2 787
2	1 067	548	434	276	34
3	93	82	473	225	11
4	13	12	84	36	
5	4	4	28	5	
6			3	2	
Biomass 2+ (1 000 t)	101	58	124	62	

It appears that in 1979 the two estimates are in good agreement except for the 2-group (year class 1977). This year class was, however, dominating in the stock of 2-ringers and older fish. One reason for this discrepancy could be that a significant part of this year class spawned in the Baltic Belt Seas area in early 1980 and was subject to fishing in these areas before it returned to Division IIIa on its summer migration. It is noted that the decline in numbers of year class 1977 between the two acoustic surveys corresponds to a $Z = 0.8$ or the same fishing mortality that was used as input for the older age groups in the VPA.

In 1980 there is no apparent agreement between the two estimates. The acoustic survey in September 1980 could be influenced by a breakdown of the transducer (see discussion in para. 3.3). The VPA estimate, on the other hand, is totally dependent upon the fishing mortalities assumed for 1980. The acoustic survey in November 1980 shows a very different picture. It may give a better estimate of the youngest year classes which at this time are moving into deeper water, while the older fish (2-ringers and older) have moved into their over-wintering areas (northern parts of the Sound and the Belt Seas) and so have left the area surveyed.

3.5.2

Catch prognoses for 1981

Using average weights at age data from 1979 gave SOP figures as shown in Table 3.2. The Working Group did not, therefore, calculate new figures.

Two sets of prognoses were made for 1981. One using a stock estimate per 1.1.1981, derived from the array of 1980 F at age and stock per 1.1.1980 from VPA. The other prognosis used the stock estimates obtained by the acoustic surveys in 1980 as a starting point. The estimates for the 0- and 1-groups were taken from the November survey, whereas stock numbers for other age groups were taken from the survey in September.

In order to get an estimate per 1.1.1981, 1/3 of the total mortality in 1980, as given in the VPA, was applied to the September/November stock in 1980.

The resulting catches for different levels of F are given in Tables 3.6 and 3.7 for the two sets. Spawning stock biomasses per 1.1.1982 are presented in Tables 3.8 and 3.9.

Although the two sets of prognoses give different catches for the same level of F, both are heavily influenced by the 2-group. At an F of 0.4 - as an example - the 2-group makes up 35% of the catch in the VPA-based prognosis and 45% in the "acoustic" one. This year class was estimated at average strength in the IYFS in 1980, not covered in the 1979 acoustic survey, and again estimated in November 1980. The last estimation indicates that it would be well above average. Since this year class plays a dominant role in the catches in both 1981 and 1982, and the spawning stock biomass in 1982, the Working Group thought it to be important to have a new estimate of this year class in September 1981 before any recommendation of a TAC for 1982 could be made.

It is therefore recommended that an acoustic survey is made in Division IIIa during September 1981, and the results presented to the ACFM at its November meeting, together with the data on the commercial landings in the first half of 1981.

Concerning the TAC of 53 000 tonnes recommended for Division IIIa in 1981, the Working Group did not find serious grounds for recommending a revision in either direction. As shown by Figure 3.1 and Tables 3.8-3.9 the taking of the recommended TAC, even if it is only concerning fish older than 2-ringers, is unlikely to reduce the spawning stock biomass in 1982 below that calculated for 1981. Even though a pronounced increase is indicated at this level of fishing, the Working Group cannot advocate an increase in the TAC considering the uncertainties about the actual strength of year class 1979 and its origin.

3.6

Recommendation

In view of the importance to the assessment of herring stocks in Division IIIa (and adjacent waters), the Working Group recommends that a workshop on stock components in herring landings from this area be established well in advance of the next meeting of this Working Group and of the Working Group on Division IIIa Stocks. The workshop should attempt a separation of landings into spring and autumn spawned components for as many years back as the available material allows.

The workshop should also consider the exchange of stock elements between Division IIIa and the Baltic-Belt Seas, preferably in cooperation with the members from the Working Group on Assessment of Pelagic Stocks in the Baltic.

4. CELTIC SEA HERRING

4.1 The Fishery

4.1.1 Fishing fleets

The Irish fleet fishing in the Celtic Sea is composed of pelagic pair trawlers and driftnetters. The composition of the trawler fleet since 1977/78 is as follows:

Season	1977/78	1978/79	1979/80	1980/81
Number of boats	22	26	18	35
Average GRT	94	96	99	88
Percentage of Irish catch taken by trawlers	78	58	35	88

It has not been possible to separate the catches into quantities per different class of GRT. This is mainly because the vessels engage in pair trawling and the units of each pair often belong to different GRT classes, and also because in many cases the vessels work together in units of three.

No details are available about the number of vessels engaged in drift-netting nor about the effort of this section of the fleet. The average GRT would, however, be below 50.

Catches by French and Dutch fleets in 1980/81 constituted only a small percentage of the total, and because they are taken as a by-catch no effort figures are available.

4.1.2 Catch data

The prohibition of herring fishing in the Celtic Sea, which was first recommended by ICES in 1976, was introduced in 1977. Since then however, fishing has taken place each year and the catch taken during the 1980/81 season was the highest recorded since 1975/76. As in the last few seasons, the catch came mainly from the Irish pelagic fishery and from by-catch in the Dutch mackerel fishery. Unallocated catches during 1980/81 amounted to 3 800 tonnes. The official catches may in fact be slightly underestimated because of the difficulties in obtaining statistics in a closed fishery.

During 1980/81, the Irish fleet located shoals in a number of areas from which shoals have been absent in recent years, and the total catch could undoubtedly have been increased but for marketing difficulties.

The catch data from the Celtic Sea fishery for the years and seasons since 1971 are shown in Tables 4.1 and 4.2. The 1980 figures are provisional. Some alterations have been made in the 1979 figures, which have slightly raised the total catch in the 1979/80 season.

4.1.3 Catch in number per age

The age composition of the total catch in 1980/81 has been calculated from Dutch and Irish age data, using the same procedure as adopted in previous reports. The 1979/80 figures have been revised because of the changes in the catch data for that season. The age composition of the catches since 1970/71 are given in Table 4.3.

4.2 Spawning Stock

4.2.1 Herring surveys

Young herring surveys have been carried out in 1980 and 1981 in the northwestern Irish Sea (see Section 7 of this report). This area is recognised as being an important nursery area for both autumn and winter/spring spawning herring (C.M.1980/H:4). Although the abundance of 1-ring herring appeared to be considerably higher in 1981 than in 1980, it is not known whether this would indicate an increase in the winter/spring component or whether this component eventually recruits to the Celtic Sea population.

4.2.2 Larval surveys

The larval surveys initiated in the 1978/79 season were continued in 1980/81. Larval abundances are given in Table 4.4 and plotted with data from previous surveys in Figure 4.1. Because only three seasons' data are available, no regression line relating spawning stock biomass to larval abundance can be established. Estimates of relative changes in spawning stock biomass can, however, be made.

The method used to produce the larval abundance indices is described in the report of the Working Group on Herring Larval Surveys (C.M.1981/H:3). Briefly, the areas under the lines joining the <10 mm larval abundance estimates plotted on time were found for each of the periods before and after 1 January. Each larval production index for the later period was multiplied by 1.465 (to adjust for lower fecundities of winter spawners) and added to the corresponding autumn index to produce an index of total spawning stock biomass for each season. These are as follows:

	Autumn index	Winter index x 1.465	Total
1978/79	702	326	1 028
1979/80	733	75	808
1980/81	655	97	752

The results indicate that the spawning stock biomass in 1980/81 was similar to that in 1979/80. However, the high abundances of 10-15 mm larvae in early February and of >15 mm larvae in late February 1981 suggest that a high abundance of <10 mm larvae may have occurred between the surveys with mid-dates on 14 January and 4 February, resulting in an underestimate of the larval index.

4.3 Recruitment

There is no method available to estimate recruitment to the Celtic Sea stock. Although the young herring survey carried out in the northwestern Irish Sea in February 1981 indicated an increased abundance in that area of 1-ring fish, it is not yet possible to decide whether any of these fish recruit to the Celtic Sea stock. The trawl survey carried out during 1979/80 off the southern Irish coast (C.M.1980/H:4) indicated that considerable quantities of 1-ring fish (1977/78 year class) were present in the area. This year class subsequently comprised 54% of the catches in 1980/81.

4.4 Estimates of Fishing Mortality

As in other seasons since the closure in 1977, it has not been possible to calculate F directly from catch per effort data. Trends in total mortality (Z) were, however, studied from an examination of the mean ages in the catches ($Z = 1/(t - t_0)$) and from the construction of catch curves. This was done for three different periods within 1965-80, when effort appeared to be constant. There appeared to be reasonably good agreement between the values of Z calculated from both methods, and it was concluded that Z in the most recent period 1976-80 was at a high level, i.e. 0.80.

As the larval abundance indices from 1977-80 have shown a slight decrease, it was decided to carry out VPA on the 1980/81 catch in number data, assuming a range of input F values (0.4, 0.6, 0.8 and 1.0) to determine which value would give a spawning stock biomass which best reflected the trend in the larval abundance indices. The value of F = 0.80 (Tables 4.5 and 4.6) was considered the most realistic estimate of the fishing mortality in 1980/81. In the VPA, F on 1-ring fish was taken to be 0.1.

The VPA indicates that the 1977/78 year class is the strongest one to have entered the fishery since 1973. This supports the observations on this year class in para. 4.3.

4.5 State of the Stock and Management Advice

The stock size at 1 April 1981 was estimated to be 13 300 tonnes. This was calculated by applying F , adult = 0.8 and F , 1-ring = 0.1 to the 1980/81 catch in numbers per age group. The assumed F of 0.1 corresponds to a continuation of the recent low level of recruitment of 1-ring fish of 30 million. If we assume that the effort in 1981/82 remains at about the same level as in 1980/81, then the catch in 1981/82 will be around 5 500 tonnes and the F generated will be again about 0.80 (Table 4.7). This will result in a stock size at 1 April 1982 of 12 000 tonnes. Alternatively, if no catch is taken in 1981/82 the biomass at 1 April 1982 will be around 17 000 tonnes (Figure 4.2).

The defined management objective for this stock is to rebuild it to a level of 40 000 tonnes, which is considered to be $1/3$ the stock level in a period of light exploitation. At the present level of catches, and assuming a continuation of the recent low level of recruitment, this desired stock level will never be attained. It has, however, been pointed out by the 1980 Working Group that the desired stock level of 40 000 tonnes may not in fact be the most realistic one because of recent changes that have taken place in the stock composition. It has not, however, been possible to redefine the desired stock level because of lack of information.

It is nevertheless apparent that the Celtic Sea stock has, in spite of the recommended closure, for four years remained at a very low level and has shown no sign of a recovery. Apart from some evidence that the 1977/78 year class may be above the average of the most recent years, there is as yet no clear evidence of an improvement in recruitment. There therefore appears to be no adequate scientific evidence available to fulfil the biological criteria for re-opening of herring fisheries and subsequently it is not possible to recommend a re-opening of this fishery in the immediate future.

5. WEST OF SCOTLAND HERRING (Division VIa)

5.1 The Fishery in 1980

5.1.1 Catch data

The total catches reported by each country from Division VIa (excluding the Firth of Clyde) for the period 1971-78, together with the revised catches for 1979 and preliminary estimates of the catch taken in 1980, are given in Table 5.1. As in previous reports the estimated weight of by-catches of herring taken in the sprat fishery in the Moray Firth are also given in this table. The final figure of catch in 1979 is almost identical to the preliminary estimate reported for 1980 (6 660 tonnes).

5.1.2 Catch in numbers by age

Estimates of the numbers of autumn spawning herring per age group caught in Division VIa (including the Moray Firth) in each of the years 1971-80 are given in Table 5.2. The figures for 1979 have been amended, using the revised catch data and a minor revision of the data on age components of these catches.

In contrast to 1979, when 2-ringers comprised about 60% of the catch of adult fish, in 1980 this age group was less well represented in the catches and was, in fact, superseded as the dominant component by 3-ringers. It should be noted, however, that in these two years these catches were almost entirely taken to the northwest of Ireland and may not be representative of the stock composition in the area as a whole. Indeed, the data from the research vessel surveys, discussed

in para. 5.2, would suggest that in 1980 it is not representative of the age composition in the northern part of the area. A further feature of the 1980 catch in number data is the much higher representation of 1-ringers than in 1979, predominantly taken as a by-catch in the Moray Firth sprat fishery. Taken in conjunction with the fact that there was little activity in this fishery, as in 1979, this might point to the 1978 year class being a fairly strong one, when it recruits to Division VIa in 1981.

The catch in number data would also suggest that recruitment to this stock both by the 1976 year class in 1979 and by the 1977 year class in 1980 has been better than in the immediately preceding years.

5.2 Age Composition from Research Vessel Surveys

In the spring of 1980 and of 1981, Scottish research vessels carried out surveys in Division VIa using a GOV trawl. The distribution of trawl hauls and the numbers of herring caught in each trawl are shown in Figures 5.1. and 5.2. As the surveys were carried out at the same time in each year, using the same gear, and as the distribution of sampling was broadly similar in each year and covered the whole area, the results might be considered as providing a rough index of relative population size and their age compositions between the two years.

These data are, however, somewhat marred by the fact that vessels of rather different fishing powers were used in those two years, which might result in some bias in the relative index of abundance, particularly of the older age groups.

Because of minor differences in the distribution of sampling between the two years, the data have been sub-divided into the strata shown on Figures 5.1. and 5.2, mean catches per 1 hour's fishing calculated for each stratum for each age group and, as an overall index for Division VIa, the arithmetic mean of the four strata which were sampled in both years has been used. The results are given in Table 5.3.

These data are reasonably consistent inter se in that both surveys would suggest that the 1976 year class is a fairly strong one and the 1977 year class appreciably stronger. They are inconsistent, however, in that they would suggest that age groups older than 3 rings in 1980 had increased in abundance very appreciably in 1981. The differing fishing power of the ships used in the two years is likely to have had its greatest effect on older fish and may have been the major contributory factor to this inconsistency. These data would also suggest that the 1978 and 1979 year classes, which will recruit to the spawning stock in 1981 and 1982, are appreciably weaker in Division VIa than the two preceding ones. In view of the fact that a major part of the recruitment to the Division VIa population is derived from nursery areas in Sub-area IV, however, this may not be a reliable indicator of the ultimate size of these year classes.

The indications of year class strengths from these data are supported to some extent by other less quantifiable data from research surveys.

In November 1979 and 1980 Scottish vessels carried out fishing and herring sampling in the South Minch for other research purposes. The percentage age compositions from this sampling are given in Table 5.4. These data would also suggest the 1976 and 1977 year classes were very appreciably stronger than the immediately preceding ones, but that the 1978 year class is likely to be weaker.

In Table 5.4 are also given the percentage age compositions derived from sampling of herring catches taken in the course of a number of surveys of pelagic fish stocks in Divisions VIa, carried out by

the Federal Republic of Germany research vessels in 1980. Although based on rather limited sampling, these data would also point to a strong representation of the 1976 and 1977 year classes in the Division VIa herring population in 1980.

5.3 Recruitment

The only relevant data on recruitment to the Division VIa herring population have been discussed in the preceding paragraphs. The catches of both the 1978 and 1979 year classes, as 0-group, were very small in the Scottish sprat fisheries in the Moray Firth and in Division VIa. The 1978 year class, as 1-group, was taken in considerably larger numbers as a by-catch in the Moray Firth sprat fishery in 1980. In view of the current restraints on sprat fishing, however, it is difficult to assess the significance of these by-catches as indicators of year class strength. Perhaps the best indication of recruitment prospects for this stock is provided by the research vessel sampling results given in Tables 5.3 and 5.4. These would suggest that both the 1978 and 1979 year classes are likely to be appreciably weaker than the two preceding ones. This evidence must, however, be interpreted with some caution, because the proportion of the recruitment coming from nursery areas outside Division VIa may vary widely from year to year.

5.4 State of the Stock and Management Advice

5.4.1 Larval surveys and estimates of spawning stock

The herring larval surveys carried out in Division VIa provide the only quantifiable data from which to estimate the size of the spawning stock. In recognition of this, and of the fact that assessment of the current state of the herring stocks in other areas where herring fishing is currently prohibited is highly dependent on similar data, ICES set up a meeting of the Working Group on Herring Larval Surveys South of 62°N in 1981 to re-evaluate the use of such data. This Working Group re-calculated larval abundance indices, on a more consistent basis, for all surveys carried out in Division VIa in the period 1972-80 and the resulting regression equation between spawning stock size and larval abundance. The Herring Assessment Working Group for the Area South of 62°N has based its estimates of the spawning stocks in Division VIa, since the closure of the fishery, on the results given in the report of this meeting of the Herring Larval Surveys Working Group (Doc. C.M.1981/H:3).

The estimates of spawning stock biomass in Division VIa given in this report are:

1978	-	75 000 tonnes
1979	-	201 000 tonnes
1980	-	369 000 tonnes.

It should be noted that: a) the estimate of the spawning stock in 1978 from these data is a minimal value because of some inadequacies in the larval sampling in that year; b) the confidence limits in all of these estimates are rather wide, as is inherent in the use of this technique. Accepting these limitations of the larval estimates, however, they would still point to a very rapid increase in spawning stock size in Division VIa over the period 1978-80 and the question must be faced whether increases of these magnitudes are compatible with data available from other sources. The estimated spawning stock increases from the larval survey estimates were: from 1978-79 2.7; from 1979-80 1.8. Such increases must be principally derived from recruitments to the spawning populations, since increased mean weight at age of a year class will be broadly compensated by mortality.

There are two sets of data from sources other than larval surveys which can be used to see whether increases of these magnitudes appear feasible. The first of these is the catch in number per age group data given in Table 5.2. The age composition of the catches in 1979, if taken as indicative of the age composition of the stock, would suggest that the spawning stock would have doubled between 1978 and 1979, due to the recruitment of the 1976 year class. The 1980 catch composition would suggest a smaller increase of ca. 30% between 1979 and 1980 due to recruitment by the 1977 year class. This latter figure is very appreciably lower than the increase in these years in spawning stock as measured by the larval surveys. It must be borne in mind, however, that the catch in number data is almost entirely generated by the fisheries off the northwest coast of Ireland, and may not, therefore, be indicative of the age composition of the stock as a whole. In the north of Ireland area the increase in larval indices between 1979 and 1980 was very small relative to the increase in the more northern areas.

The other set of data are those derived from the research vessel sampling given in Tables 5.3 and 5.4. Of these, that given in Table 5.3 is probably the better indication of the age composition of the stock in the area as a whole. As discussed in para. 5.2 the data from the 1981 survey are the more reliable as an index of the total age composition of the population in that year. Using these 1981 indices for the fish ≥ 3 rings, and multiplying by the mean weights at age one can convert the indices to a spawning stock in numbers in 1980 by equating the resulting biomass to the measured 1980 biomass from the larval survey of 369 000 tonnes. From these values of spawning stock, in numbers per age group, one can then calculate the spawning stock biomasses in 1978 and 1979 by applying Z s calculated from the appropriate catch in number data given in Table 5.2 and weight at age values. These backward projections give values of 1978 - 81 000 tonnes, 1979 - 161 000 tonnes. These values are not incompatible with those derived from the larval surveys and would suggest that the major increases estimated from the larval surveys in these years find some support in the other data available on stock composition.

From the estimate of the spawning stock biomass in 1980 derived from the larval data, and the age composition of this stock from the 1981 survey data (Table 5.3), one can calculate the stock at 1 Jan. 1980 and F values for 1979 using the catch in number data given in Table 5.2. These can then be used to initiate a VPA which starts from 1979. This has been done as some check on the validity of the assumptions about input F s made by the Working Group when it last did a VPA on this stock starting with the 1978 data and which has some influence on the estimates of spawning stock size used in calculating the spawning stock size - larval index regression. This VPA is not reproduced in this report, as it was run only as a check, and is not a very satisfactory one, since the low F s in 1979 and 1978 resulting from the closure of the fishery will result in only very slow convergence in a VPA to the true F values. It is also a somewhat circular argument since the inputs used to initiate this VPA are themselves largely dependent on the previous one. However, the results, although somewhat different from those of the previous one, are in general conformity with it and support the Working Group's previous estimates that the spawning stock in 1977 and 1978 were at such a low level that closure of the fishery was imperative.

5.4.2 State of stock and management advice

As discussed in the previous paragraph there has been a very major increase in spawning stock biomass in Division VIa between 1978 and 1979 and again from 1979 to 1980. The best estimate of spawning stock

in 1980, of 369 000 tonnes, is very appreciably greater than the target biomass (200 000 tonnes) for a re-opening of the fishery on this stock set by the Working Group in earlier reports. It is of course true that the confidence limits on this estimate are wide, but even the lower confidence limit (284 000 tonnes) of this estimate is considerably greater than the target biomass. This estimate also has some support from the data from research vessel trawl surveys which would suggest that recruitment to this spawning stock in 1979 and 1980 had been high. There would therefore appear to be fairly good evidence to suggest that this fishery could be re-opened in 1981, with a conservative TAC. To calculate such a TAC, the age composition derived from the Scottish survey in 1981 has been used and equated to a spawning stock biomass in 1980 of 369 000 tonnes. This gives the stock size per age group given in Table 5.5. The value of 2-ringers is likely to be an underestimate because of the time at which this survey was done, when recruitment from nursery areas in the North Sea is likely to be far from complete.

The yield per recruit and spawning stock biomass per recruit curves for this stock are shown in Figure 5.3. This gives a value of $F_{0.1}$ of 0.27. This must be a slight overestimate, as it has been assumed that there is no exploitation of fish younger than age 2 rings. This is the only assumption which can be made at this juncture, as there are currently no data which could be used to assess the exploitation pattern on these younger age groups under the present conditions in the sprat fisheries in the Moray Firth and Division VIa in which most of them are caught. An F value of 0.15 would seem a conservative value from which to calculate a TAC for 1981 from these data, and a conservative value should be used in the light of the dubieties which still surround them. This would result in a TAC of 65 000 tonnes in 1981, and a residual spawning stock of not less than 415 000 tonnes in that year. A figure of yield and spawning stock sizes at other F values is given as Figure 5.4.

Estimating a TAC for 1982, at this juncture, has even greater uncertainties attached to it, because of the complete absence of quantifiable information on the strength of the year class which will recruit in that year. In these circumstances, it would seem advisable to use a very conservative value of 240×10^6 for this year class. This is equal to the lowest value ever recorded for this stock. On this basis, and on condition that the TAC given above for 1981 is adhered to, if the same value of $F=0.15$ were retained in 1982 the corresponding TAC would be 60 000 tonnes.

This indicates that even under conservative assumptions on recruitment, the TAC for 1982 could be set at about the same level as in 1981. A similar recruit survey will be carried out in early 1982 as that carried out in 1981, which should enable the Working Group to revise this preliminary TAC at its next meeting.

5.5 Clyde Herring

5.5.1 The fishery in 1980

Landings in the years 1971-80 made entirely by Scottish vessels are given in Table 5.6. The landings in 1980 of 2 081 tonnes were very close to those of 1979 as a result of the TAC regulation in operation in both of those years.

Catches in number (spring and autumn spawners combined) for the period 1967-80 are given in Table 5.7. In 1980, 2-ringers predominated in the landings. In addition, some discarding of small herring may have taken place in an attempt to land only large herring against the TAC and this was probably of 1- and 2-ring fish. Reports from the fishermen indicated that fish were easy to locate and catch in the Firth of Clyde in 1980, which might suggest that the abundance of herring was rather high. 3-ringers (1976 year class) were also well represented in the landings in 1980 in proportion to older fish, and the strong contribution of this year class in the previous two years may indicate that it was a strong one in the Clyde fishery.

5.5.2 Tagging

The number of recaptures by area and month from a tagging experiment carried out in the Clyde in May-June 1980, in which approximately 7 000 externally tagged herring were liberated, are given in Table 5.8.a. In addition, updated recaptures from the 1979 experiment are given in Table 5.8.b.

From the 1980 liberation two tagged herring were recaptured in spawning condition $1\frac{1}{2}$ - $2\frac{1}{2}$ miles off the Mourne coast in the month of October, thus re-inforcing the evidence that Mourne autumn spawners form a component of the Clyde population. Despite returns from the Isle of Man area, there were no returns from the Manx spawning grounds from this experiment, in contrast to the 1979 experiment. Returns, however, were again received from the Donegal area from September onwards, but as there were no maturity or meristic data for these fish, it was not possible to ascribe them to race.

From the 1979 liberation in May, a further 9 tags were returned from the Clyde during the closed period as a result of by-catches in other fisheries. During the Clyde fishery from July-October 1980, a further 63 tags were returned from the Clyde, but none from other areas.

As pointed out in the 1980 report of the Working Group, these tag returns indicate some affinity with adjacent stocks in the Irish Sea and the southern part of Division VIa. In the absence of a directed fishery on herring in other parts of Division VIa, however, the pattern of recaptures may give a biased picture of the proportion of each stock contributing to the Clyde population. The relatively strong contribution of 2- and 3-ringers in the Clyde fishery in 1980 (the 1977 and 1976 year classes respectively) may indicate some influx of fish from Division VIa, because these are also the year classes predominant in landings and research vessel samples taken in that division.

5.5.3 Management advice

The results of the most recent tagging experiments in 1979 and 1980 continue to demonstrate the complex origin of the Clyde herring population. It is, however, impossible to quantify the contribution made by each of the stocks in adjacent areas, and hence to carry out an analytical assessment. For this reason, it is appropriate to continue the approach used in the past three years by treating the Firth of Clyde herring as a separate management unit.

Two factors may improve the basis for an assessment in future years. First, the recommencement of fishing in other parts of Division VIa and associated tag returns should give a better indication of the contribution made by the Division VIa stock. Secondly, it is hoped that a new approach to tagging planned for 1981, using microwire tags, will provide more quantitative information on the contribution of the Irish Sea stocks.

Previous management advice on Clyde herring has taken into account the need for protection of the indigenous Clyde spring spawning stock and of the stocks in adjacent areas. Since there is a continuing need for protection of the Manx herring which contribute to the Clyde population, there is no justification for a large increase in the TAC for the Clyde. The age composition of herring in the Firth of Clyde in 1980, however, indicated the likelihood that there has been some influx of herring from other parts of Division VIa. The stocks in Division VIa and the Mourne, however, have both shown recent increases, and it, therefore, seems likely that a higher proportion of the catches in the Clyde will consist of herring from these stocks. For these reasons, some increase in the TAC for 1982 would appear to be justified and would not be expected to have any significant effect on those stocks in need of more rigid protection.

6. WEST OF IRELAND HERRING

6.1 Herring in Division VIIb,c

6.1.1 The fishery in 1980

The landings by country for 1967-80 are given in Table 6.1. The total landings in 1980 were approximately 24 000 tonnes compared with 14 600 tonnes in 1979 and 7 500 tonnes in 1978. The TAC advised by ACFM in 1980 was 7 000 tonnes, a figure exceeded by a factor of 3.5.

Catches in numbers per age group, based mainly on Irish and Dutch samples, are given in Table 6.2. The predominant age group was the 1976 year class as in the 1979 catches.

6.1.2 Management advice

In previous years the lack of adequate information about the herring population in Division VIIb,c has ruled out the possibility of carrying out an analytical assessment for this area, and precautionary TACs have been recommended both to prevent overexploitation in this area and to prevent a diversion of fishing effort from other areas. The Working Group accepted that the lack of a quantitative assessment for this area is not a situation that can be allowed to continue, and there was a considerable discussion about the basis for an assessment.

The herring fishery in this area takes place across the border between Division VIIb,c and Division VIa. The herring caught in the two areas have no biological characteristics to separate them, their age compositions are very similar, and the spawning area also extends across the border. No information exists, however, from which to calculate what proportion of the population in the combined area spawns in or inhabits each division, or to calculate the degree of mixing between the two areas. Furthermore, it is likely that there was some misallocation of catches between the areas in the earlier years of the fishery. Taking all these facts into consideration, the Working Group accepted that one possible approach would be to carry out a joint assessment of the herring population in Division VIIb,c and that part of Division VIa in which this fishery takes place. Essentially, this means combining all catches in Division VIIb,c, the Irish catches in Division VIa and the Dutch catches in the southern part of Division VIa, which are taken off the northwestern Irish coast.

Using the catches in number for this area given in Table 6.3, VPAs were carried out with a variety of values of input F in 1980.

Summarised results are given in Table 6.4, which tabulates, for the years 1972-80 and for input Fs ranging from 0.2 - 0.8, the weighted mean F on 2-ringers and older, the biomass of 2-ringers and older at 1 January, and the recruitment of 0-ringers. The mean weights at age used to calculate the stock sizes in Table 6.4, based on Irish sampling data (mean weights for the whole year) are given in the text table below:

<u>Age (w.r)</u>	<u>\bar{W} (g)</u>
1	83
2	123
3	168
4	196
5	225
6	223
7	238
8	247
≥ 9	235

The only independent information on which to judge which of the input F values used is the most realistic is that derived from the larval surveys in the southern part of Division VIa (Area D, C.M.1981/H:3). This index is compared with the different VPA estimates of biomass in Figure 6.1.

The larval abundance index indicates a very low level of larval production in 1972 and 1976, high values in 1973 and 1974, and a recent increase to about half the latter level. None of the VPA outputs match this pattern, and it is, therefore, not possible to decide which level of F in 1980 is most nearly correct. It is therefore not possible at present to ascertain the present size of the stock in this area or the current level of fishing mortality rate. Furthermore, even if an assessment of this combined area were possible, this would necessitate a complete re-assessment of the remaining part of Division VIa, including an entirely new analysis of the larval data. The Working Group was not in a position to carry out such a radical re-assessment at the 1981 meeting and therefore took the only other option available, i.e. that a precautionary TAC should once again be advised for Division VIIb,c in 1982.

To make a more realistic assessment in 1982, the Working Group decided that the historic series of catch in number data for Division VIa should be made available, sub-divided into the northern and southern parts of the area (divided at 56°N and west of 7°W). It would then be possible to compare separate assessments of the northern part of Division VIa and the southern part combined with Division VIIb,c, with assessment of the whole of Divisions VIa and VIIb,c combined.

6.2 Herring in Division VIIj (southwest Ireland)

The fishery in Division VIIj is exploited exclusively by Irish boats and the catches from the area in 1980 were about 5 000 tonnes. The TAC for the area in 1980 recommended by ACFM was 6 000 tonnes. This TAC was considered to be a precautionary one because at the moment there is insufficient evidence available to enable the stock size to be estimated. It was considered important to advocate a TAC

to prevent a diversification of effort to the area and to prevent inaccurate reporting of catch statistics - particularly from the adjoining Celtic Sea.

Although the catches in 1980 of about 5 000 tonnes were at about the same level as in 1979, there was a decrease in effort in the area because of lack of markets and because of a change to mackerel fishing. The age distribution of the catches was similar to that in 1980 - the 1974 year class was still well represented and again there appeared to be substantial numbers of the 1976 and 1977 year classes.

It would therefore appear advisable to again recommend that catches from this area should be stabilised at about 6 000 tonnes until the stock size has been estimated.

It is anticipated, however, that sufficient data will be available to enable this stock to be analytically assessed at the 1982 meeting.

7. IRISH SEA HERRING (Division VIIa)

7.1 Introduction

TAC for the North Irish Sea for 1980 was set at 10 000 tonnes, the reported catch from the area was 10 613 tonnes (Table 7.1). Actual catches almost certainly exceeded this because of overweight boxes, unrecorded landings and extensive dumping at sea of smaller herring.

Reported catches were allocated to Manx and Mourne stocks on the basis of vertebral counts, gonad condition and place of capture, as described in Doc. C.M.1979/H:6. The two stocks are considered separately below, and general recommendations given for the North Irish Sea in Section 7.4).

7.2 Manx Stock

7.2.1 Fishing fleets

The composition of the United Kingdom fishing fleet operating on the Manx stock is given in Table 7.2.1. These data were available only for the United Kingdom fleet, which took 91% of the total catch. Over 90% of the United Kingdom catch was taken by vessels under 100 tonnes GRT.

7.2.2 The fishery in 1980

8 660 tonnes of the reported total catch of 10 613 tonnes from the N. Irish Sea were considered to be Manx herring (Table 7.2.2.1). This is the second lowest total in 12 years and reflects not only the relatively low TAC, but also the difficulty experienced in finding the herring. Catch in number by age is given in Table 7.2.3.1.

7.2.3 Estimates of fishing mortality and stock size

In 1980 the Manx fishery did not, as expected, take the whole TAC prior to the closure on 21 September. The remainder of the TAC was taken in the period October to December. There was a general complaint that fish were hard to find despite the large fleet engaged in searching.

These circumstances have not previously arisen since TACs were first set in 1975. It must be concluded that the stock was lower than it has been for several years.

VPAs were carried out with a wide range of input F for 1980. The spawning stock biomass at the beginning of the year was low in 1977. Input F₁₉₈₀ to give a stock biomass in 1980 lower than that in 1977 must be $F = 0.7$ or greater. It is considered that fishing mortality in 1980

was at least as high as in 1977, i.e. $F = 1.0$. VPA with $F_{1980} = 1.0$ is given in Tables 7.2.3.1 - 7.2.3.3. This indicates a spawning stock biomass in 1980 of 5 000 tonnes at spawning time.

7.2.4 Larval survey

Numbers of larvae caught by tow-netting over the spawning area are given in Table 7.2.4. The data are very variable but they indicate that larvae have been few in recent years compared with 1974 and 1975.

7.2.5 State of stock

The stock of potential spawners at 1 January has been declining since 1974, and the actual stock at spawning time has declined since 1970 (see VPA, Table 7.2.3.3). The stock is now very low, and recruitment may be poor because it will be derived from relatively few spawners.

Stock assessments and projections are based on recorded landings; actual landings are almost certainly greater than these, and a cautious approach is recommended. The present low stock size is likely to affect recruitment 3 years hence. It is essential to build up the stock of older fish to reduce the dependence of catches on recruit fish. Fishing mortality should be substantially reduced from the present high level.

Projections were made with input numbers of 1-ring fish in all years at 45×10^6 , which was the value for 1979 derived from VPA. Two projections were made to January 1983, one assuming that the present TAC for 1981 would be taken, generating an F_{1981} on adult Manx fish of $F = 0.5$, and the other assuming that the TAC for 1981 could be reduced.

Stock changes indicated by the projections are as follows, if $F_{1982} = 0.2$:

Spawners (tonnes $\times 10^{-3}$)	$F_{1981} = 0.5$	$F_{1981} = 0.2$ ($F_{0.1}$)
At spawning 1981	6 600	9 100
At spawning 1982	10 600	12 800
At January 1983	17 200	19 400

It should be noted that most of the calculated spawning stock sizes will consist of recruit spawners, and that even the assumed low recruitment may be too high.

Catch and stock weights for a range of F s in 1981 and 1982 are shown in Figure 7.2.5 and yield per recruit in Figure 7.2.6.

7.3 Mourne Stock

7.3.1 The fishery in 1980

The total nominal catch of the Mourne stock in 1980 was 1 953 tonnes which was about 200 tonnes higher than in 1979 (Table 7.2.2.1). The catch was entirely composed of fish for human consumption for the first time since 1969 due to the closure in 1979 of the reduction plant concerned. Although the major part of the catch was taken outside the 12 mile limit along the Irish coast, some catches were in fact taken from the actual spawning grounds which are situated close inshore.

7.3.2 Catch in numbers by age

The total catch in numbers by age was estimated for Mourne herring by the use of age data from catches landed in Northern Ireland, Isle of Man, Ireland and England (Table 7.3.2.1).

Because of the cessation of the industrial fishery in early 1979, there has been a marked change in the overall age composition both in 1979 and 1980. There were no catches of 0-group herring in 1980, and the catches of 1-group herring again decreased.

The cessation of the industrial fishery has meant considerable change in the mean weights at age in the catches, particularly in the younger age groups. For this reason, the mean weights used in the 1981 assessment have been based on data from Northern Ireland and Ireland during the period of the main by-catches of Mourne herring, i.e. August to October. These are given in the text table below.

Mourne stock. Comparison of mean weight (g) at age in catches during August to October 1980.

	N.Ireland data	Irish data	Mean	Date used by 1980 Working Group
1	108 (152) ^x)	101 (62)	106 (214)	60
2	161 (117)	179 (91)	169 (208)	160
3	199 (53)	209 (69)	205 (122)	192
4	218 (51)	229 (51)	224 (104)	221
5	239 (13)	252 (36)	249 (49)	244
6	258 (7)	266 (12)	263 (19)	256
7	280 (3)	266 (3)	273 (6)	261
8	283 (3)	278 (5)	280 (8)	264
>8	325 (1)	298 (1)	312 (2)	266

x) Numbers of fish examined are shown in parantheses.

Apart from the increase in weight at age for the 1-group fish, which was about 77%, there was an average increase of approximately 4% for the 2-8 age group.

7.3.3 Virtual Population Analysis

For Mourne herring, there is no independent information on which to base selection of input fishing mortality in order to carry out a VPA. Therefore, trial VPAs run with a range of input F values of 0.2 to 0.4 were carried out. An input F of 0.3 gave a weighted mean F in 1978 of 0.43 on age groups 2-6. F in 1980 must have been lower than F₁₉₇₈, as there was a directed fishery on the Mourne spawning ground in 1978. A value of F = 0.3 was therefore considered the most likely to reflect the level of fishing intensity during 1980 on age groups 2 and over.

The reduction of F on 1-ringers resulting from the cessation of the industrial fishery required an adjustment of input F on this age group.

About 1/3 of the 1-ring catch over the period 1971-78 can be ascribed to the adult fishery. The mean F on 1-ring fish taken in the adult fishery was estimated at 0.3 during this period, while the mean F on 2-8 age groups for the corresponding period was 0.93. Therefore, it was assumed that the F on 1-ringers in 1980 would have been 1/3 of F = 0.3, that is, F = 0.1. The input value of F for the last age group in 1979 and earlier years was taken from the mean weighted value of F for age groups 2-6 and estimated from the cohort of the previous Working Group. The stock sizes and fishing mortalities derived are given in Tables 7.3.3.1 and 7.3.3.2.

Spawning stock size is based on an estimate that 1/3 of the 1-ringed stock spawn at this age. The spawning stock size at the time of spawning in 1980 was estimated at 6 000 tonnes; at the spawning time in 1979 it was 4 000 tonnes. The results of the VPA support last year's observation that the decline in spawning stock biomass has been arrested.

7.3.4 State of stock

From the VPA regression, a number of 0-group against spawning stock biomass was calculated (Figure 7.1 and Table 7.3.4.1). Using this regression, year class 1979 was estimated at $77 \pm 44 \times 10^6$ 0-group. As the lower limit was somewhat below the lowest 0-group value from the VPA of 46×10^6 , it was decided to use the latter figure in the prognosis. On the evidence of the N.Irish Sea Young Herring Survey (see para. 7.3.6) and the apparent abundance of this year class as 1-ringers, this value was accepted as realistic.

Estimating a TAC for 1982, at this time, has great uncertainties attached to it, as projections are heavily dependent on assumed values of initial strength of year classes 1979 and 1980, and on the catch in 1981. Therefore, in view of these uncertainties it was decided to again use 46×10^6 , the lowest value recorded for this stock as a conservative estimate of year class 1980.

A by-catch estimate of Mourne herring in the Isle of Man fishery for 1981 and 1982 has been partly based on the weight of Mourne stock taken to the west of the Isle of Man in recent years since the closure of the directed fishery (approximately 1/5 of the mixed catch), and partly on the assumption that this proportion will increase substantially as the Mourne stock recovers.

7.3.5 Re-definition of nursery areas

In 1979 the Working Group recommended the closure of the area within 12 miles of the coast of Scotland, England and Wales from 55°N to 53°20'N in order to protect the juvenile component of the Manx stock. Following representations that this measure had excluded fishing from an important adult distribution area off the Mull of Galloway, the Working Group made an appraisal of all available data on juvenile catches in that area. It was concluded that as juveniles appeared to be caught mainly within Logan Bay and because of the paucity of information on the distribution of 0-ring fish from other inshore areas, this important adult fishing area should be re-opened. However, in view of the likelihood of a large section of the coast being a nursery ground, it seems essential that more detailed information on the distribution of juveniles is collected during 1981 and that the situation should again be re-assessed in 1982.

7.3.6 Herring investigations in the North Irish Sea in spring 1981

During the early months of 1980 there were numerous reports from fishermen of substantial shoals of spring spawning herring off the Mourne coast (Doc. C.M.1980/H:4). Following the recommendation of the 1980 Herring Assessment Working Group to obtain information on the distribution and size of the spring spawning component of the Mourne herring, and to obtain information on year class strength, 2 surveys were made by Irish and Northern Irish charter vessels in the months February-March 1981. Preliminary results of these surveys are summarised below.

7.3.6.1 Young herring survey (Republic of Ireland)

A young herring survey was conducted in the North Irish Sea during February 1981. The survey was similar to that conducted in February 1980 (Molloy, 1980), and the same vessel, gear and methods were employed.

An initial analysis of the catches indicates that 1-ringed fish were more abundant in 1981 than in 1980 (average no./haul was 108 in 1980 and 821 in 1981). However, it is difficult to draw any firm conclusions from these data, as comparable surveys have only been done in these two years. The average vertebral counts of the 1-ringed fish during 1980 was 56.83, which was higher than that defined as typical for the Mourne stock (Doc. C.M.1979/H:6). Many of the samples in that year had average vertebral counts higher than 57 and this suggested that some of these young herring had originated from a winter/spring spawning. In samples so far examined the vertebral counts of 1-ringed and 2-ringed fish taken during the 1981 survey were both 56.89. This is a typical value for the Mourne autumn spawners.

7.3.6.2 Northwest Irish Sea herring survey (Northern Ireland)

From the 16-24 February, 14 stations were fished in the Northwest Irish Sea. During the survey, 1- and 2-ringed herring dominated the catch, and no 0-group herring were caught. All samples of 2- and 3-ringed fish showed a maturity distribution which indicated n only a slight influence of spring spawning herring, about 2%. As in the Irish Republic's survey, the mean vertebral count of 1-ringed herring (56.53) was somewhat lower than last year's value (Molloy, 1980), indicating that the herring in the area in 1981 were probably, in the main, members of the Mourne autumn spawning stock. Furthermore, in spite of an intensive echo and sonar search, no herring concentrations were encountered off the Co. Down coast during the period.

Also, in a preliminary examination of plankton samples taken during the egg and larval surveys conducted in March and April 1981, no herring larvae were found.

Thus, any spring spawning component of Mourne herring would appear from these investigations to be extremely small.

7.4 Management advice

7.4.1 TAC

Prior to the spawning season of Manx herring, the fishery in the N.Irish Sea exploits both Manx and Mourne herring in the area west and southwest of the Isle of Man. The Working Group, therefore, recommends that a single TAC be set for herring in the N.Irish Sea rather than separate TACs for Manx and Mourne stocks.

In view of the state of the Manx stock the Working Group considers it imperative that a reduction of TAC in 1981 is implemented in time for the 1981 season. This would have a side-effect of reducing the catch of Mourne herring in the early fishery, which exploits both stocks in the Northwest Irish Sea. The extent of this effect would depend on the TAC set in 1981. The catch corresponding to $F_{0.1} = 0.2$ would be about 2 000 tonnes of Manx fish.

With regard to the Mourne stock two options are presented.

Option 1. Maintaining the ban on directed fishing, the spawning stock biomass should continue to increase. The expected by-catch in 1981 in the Isle of Man fishery should be about 1 400 tonnes on the assumption that the area TAC is retained at 6 000 tonnes, and the spawning stock biomass at spawning time would be some 16 000 tonnes (Figure 7.3).

Option 2. In view of the recovery of the stock, maintain the general ban within the 12 mile zone as advocated previously by the Working Group, but allow a small directed selective gill-net fishery in the Mourne spawning area.

For this stock $F_{0.1}$ is $F = 0.18$ (Figure 7.2); thus, an F value of 0.15 would seem appropriate from which to calculate a TAC for 1981. This would result in a TAC for 1981 of about 1 800 tonnes (Figure 7.3). Taking into account 1 400 tonnes as an unavoidable by-catch in the Isle of Man fishery, this would leave 400 tonnes for the directed selective fishery and would leave a residual spawning stock of approximately 15 000 tonnes in 1981.

The present TAC of 6 000 tonnes recommended by ACFM for 1981 is then likely to be made up of about $4\frac{1}{2}$ thousand tonnes of Manx herring (nominal catch), over 1 thousand tonnes of Mourne herring taken in the mixed fishery, and 400 tonnes selectively fished over the Mourne spawning grounds.

If an $F = 0.2$ for the Manx stock and $F = 0.15$ for the Mourne stock are allowed in 1982, this would, according to the present assessment, result in a total 1982 TAC of about 5 000 tonnes, assuming that the 1981 TAC of 6 000 tonnes is taken. The 5 000 tonnes could probably consist of approximately 2 400 tonnes of Manx herring, about 1 000 tonnes of Mourne herring taken in the Northwest Irish Sea outside the spawning grounds, and about 1 400 tonnes of Mourne herring taken by selective gill-net fishing on the spawning grounds.

It would be wise to reconsider the TAC for 1982 when catches in 1981 are known.

7.4.2

Other conservation measures

Management of the N.Irish Sea fishery in the past has included measures to reduce fishing mortality on the spawning stock by closure of the Manx fishery from the Saturday nearest to 21 September until the Monday nearest to 16 November, prohibition of directed herring fishery in nursery areas, and a minimum size regulation. These measures should be continued.

The Working Group recommends the following alterations to the northern boundary of the nursery areas off the coasts of England and Scotland specified in document C.M.1979/H:6:

This boundary should no longer lie at latitude 55°N but along a line joining the Mull of Galloway (Scotland) to Point of Ayr (Isle of Man). Logan Bay, however, should continue to remain closed to herring fishing. The remaining area within 12 miles of the coast of Scotland,

England and Wales southwards to latitude 53°20'N should remain unchanged.

Directed herring fishing should be prohibited in the whole of the N.Irish Sea for a period from 20 September 1981 to 15 November 1981, except for selective fishing by gill net for a catch not exceeding 400 tonnes of Mourne adult herring. A selective fishery would avoid problems of trawling on the spawning grounds, dumping of juvenile herring, and make possible enforcement of such a small allowance for these grounds.

There was a substantial discarding at sea of small herring, mostly 1-ring fish, 2 years old, in 1980, particularly in June and July. This is likely to become more widespread, if catch quotas are reduced. The possibility of restricting fishing in N.Irish Sea in June and July to selective methods only should be considered.

In 1980 there was no restriction on the number of vessels participating in the Manx fishery, and 155 fishing boats landed herring in the Isle of Man between 2 June and 21 September. Such a large fleet in 1981 and 1982, working to a small TAC, is likely to generate a high fishing mortality by increasing the extent of discarding at sea and of illegal landings. It is recommended that the fishing effort be controlled by relating the fleet size to the TAC and the F appropriate to the TAC.

8. NORTH SEA SPRAT

8.1 The Fishery

8.1.1 Fishing fleets

A major part of the catch is taken by the Danish fleet fishing for industrial purposes and most of the vessels in this fleet take part in the fishery. The smallest vessels are restricted to the fishery in Division IVb east.

The catches landed in England are mainly taken by small inshore vessels and local vessels of about 80 feet. They work both single and pair mid-water trawls. In addition, a variable fleet of visiting Scottish vessels join the fishery when shoals are abundant. The fleet is entirely below 100 GRT. Because of the high availability of the sprat in the winter concentrations, the magnitude of individual vessels' catches are often dictated by market requirements. Effort data of a general nature cannot be used as a means of obtaining valid abundance indices. Nevertheless, in certain circumstances, very detailed catch by haul data may give some index of abundance from year to year.

The Scottish fishery for sprat is carried out largely by small pair trawlers under 100 GRT. The number of vessels fishing for sprat varies from season to season, depending on the abundance and availability of sprat in relation to that of other species.

The Norwegian purse seine fleet fishing for sprat in the North Sea varies considerably during the fishing season pending the opportunities for fishing other pelagic fish such as capelin and mackerel. For this reason, the Norwegian sprat fishery mainly takes place during November and December and in January, before the capelin fishing is started. A large proportion of the purse seine fleet, at least 50-100 vessels, of different size categories, usually takes part in the sprat fishery in the North Sea.

8.1.2 Catch data

Table 8.1 shows the catches by nations and areas in the period 1971-80. The total catch in 1980 of 323 000 tonnes has decreased from the level of 380 000 tonnes in 1979 and 1978. This is mainly due to a decline in Danish catches in Division IVb East and Norwegian catches in Division IVb West. The catches in Division IVc have increased for all the participating countries though they are still at a low level of 27 000 tonnes. In Division IVa East Norwegian catches taken in the fjords are not included in these data. In 1980 they amounted to 2 900 tonnes.

There is a continuation of the decline of Scottish and English catches. This follows the pattern recently developing on the Scottish and English northeast coasts. The customary accumulation of sprat stocks in the winter has not taken place in the 1979/80 winter or in the winter of 1980/81 off the English northeast coast.

In January 1981 a very large concentration of sprat occurred in the inner reaches of the Thames Estuary, in areas which had not seen sprat shoals for some decades. It is interesting to note that the catches in Division IVc were taken by Denmark and Norway in areas not usually fished.

Both Danish and Norwegian vessels found sprat difficult to locate in commercial quantities in the central North Sea towards the end of 1980.

8.1.3 Catch in numbers by age

Denmark, Norway and the United Kingdom supplied catches in numbers by age group and their summed quarterly catches are given in Table 8.2. These catches account for 97% of the total landings. Compared with 1980, the 1-group catches in July-September have decreased while the 2-group catches in January-March have increased.

Table 8.3 shows the catch in numbers accumulated by Sub-divisions in the North Sea. The large reduction in 1-group catches is mainly due to the reduced catches in Division IVb East.

It is believed that these reductions reflect a reduction in abundance of these and the youngeryear class, and is not just an effect of an effort withdrawal.

8.2 Weight at Age

Weight at age data for 1980 were available for the Danish catches. The data are given in Table 8.4, which gives the mean weight by age and month. The annual average is weighted by the catch in numbers.

In view of the fact that over 70% of the catch was taken by Denmark, it was thought that these data should reflect the changes in weight at age data in 1980 better than the combined data of the 1980 report.

8.3 Stock Size Estimates from Acoustic Surveys

The ICES Coordinated Acoustic Survey was completed by English, Scottish and Norwegian vessels in January 1981. The results of the surveys are shown in Figure 8.1, where the calculated biomasses per half statistical rectangle are shown. The integrated signals have been converted to biomasses, using an agreed T/S value of -29dB/kg (Anon., 1981). These results are compared with those for the 1980 survey in the text table below, where these have been referred to -29 dB/kg for comparison.

Biomass of sprat from January surveys 1980 and 1981 ('000 tonnes)

	1980	1981
Norway 1 group	300	19
≥2 group	80	11
Scotland	7	33
England	6	129.7

There is a striking change in the distribution between the two years in addition to the apparent reduction in biomass to about 50%. The English survey extended further into the Southern Bight than in previous years, but ignoring this increase in area it is clear that there has been a large increase in the stock in the southwestern area.

In addition to the ICES Coordinated Acoustic Survey carried out in January 1981, an acoustic and midwater trawling survey was carried out by a Scottish research vessel off the coast of Scotland and northeast England in November 1980. In the area surveyed, the estimated biomass of sprat, assuming a target strength of -29dB/kg, was 87 000 tonnes, most of which was concentrated within about 30 miles of the coast. The comparable estimate for the same area in January 1981 was about 30 000 tonnes. A similar drop in abundance was observed between November 1979 and January 1980 (Johnson, 1980). In the November survey 0-group sprat predominated in almost all the trawl hauls carried out. Comparative trawl hauls at different depths indicated that the smallest 0-group sprat (2.5 cm - 5 cm) inhabited the upper layers, whereas larger sprat were near to the bottom.

In view of the large drop in biomass recorded in the Norwegian survey, the Working Group discussed whether this might be a result of methodological differences. It concluded that there were such levels of uncertainty in certain aspects of the methodology that the absolute tonnages derived must be regarded with caution. It considered that the relative change in biomass between 1980 and 1981 was probably a real reflection of a change in sprat biomass.

These changes in biomass and distribution could explain the characteristics of the 1980 fishery. In January 1981 the Danish fishery was located in association with the patch of high biomasses recorded in the English survey northeast of the Wash. This particular area gave low biomass estimates in the Norwegian survey. There is no ready explanation for this very different estimate, but there was a delay between the two vessels working the area, and the Norwegian survey was conducted under poor weather conditions.

The Working Group wishes to stress the importance of survey vessels making intercalibration runs and that more effort should be made to coordinate the dates of these surveys. In addition, more attention should be paid to changes in weather conditions with resulting changes in background noise levels and perhaps blocking of the transducer. Noise levels should be recorded routinely so that the magnitude of threshold level adjustment will be known.

8.4

Fishing Mortality and Recruitment

The Working Group decided to carry out a VPA although it recognised the fact that it gives very little information for shortlived species. The purpose of the VPA was to estimate recruitment in the past, and to get the levels of fishing mortality, which would give relative stock biomasses in 1980 and 1981 as estimated from the acoustic surveys.

Natural mortality was chosen to $M = 0.8$ for all age groups as in previous assessments.

The input fishing mortalities on the oldest age groups were selected in the same way as in the VPA presented in the 1980 Working Group report. The low catches of the oldest age groups (≥ 4) are due to a low F or a high M on these age groups, and the Working Group adopted the former alternative.

The fishing patterns for the last year were chosen to be $\frac{1}{2} - 1 - 1$ on age groups 1, 2, and 3 respectively. This seems consistent with the fishing patterns in the past years. F_0 in 1980 was chosen to give a recruitment of 140×10^{-9} . F_4 was chosen to be 0.2 in agreement with the above assumptions. The level of fishing mortality on age groups 1-3 was fitted to give a reduction in stock biomass of 50% from 1.1.1980 - 1.1.1981.

The weight at age of the stock used in the stock biomass calculation is presented in the text table below. The weight of the 1-group is chosen to be 1 gram. For age groups 2-5 it is the weight in the catch in January 1980.

Weight at age of the stock

Age	1	2	3	4	5
Weight (g)	1	8.86	13.56	21.60	21.60

Two sets of input F s generating a biomass reduction of the order of magnitude as estimated in the acoustic surveys are shown in Tables 8.5 - 8.6. Table 8.5 shows the VPA with $F = 1.5$ on age groups 2 and 3. The corresponding stock estimates are 345 000 tonnes at 1.1.1980 and 194 000 tonnes at 1.1.1981 which is a reduction of 44%. Table 8.6 shows the VPA with $F = 2.0$. The stock estimates are 296 000 tonnes and 142 000 tonnes, which gives a reduction of 52% from 1.1.1980 to 1.1.1981. This would indicate a fishing mortality at the level of 1.5 - 2.0. It should be stressed that the biomass of the stock is dependent on the recruitment of 0-group in 1980 on which we have no information.

The VPAs which are consistent with the acoustic surveys give an average fishing mortality (age groups 1 to 3, unweighted) of 1.3 - 1.7 in 1980, indicating that the fishing mortality has increased sharply in 1980 compared to 1978 and 1979. No data giving supporting evidence of this increase in fishing mortality were available to the Working Group.

8.5

Management

As in previous years the only independent estimates of stock available are those from acoustic surveys. Again, as in previous years, problems arise in interpreting and quantifying the integrated acoustic signals.

In discussing these estimates at the previous Working Group meeting, note was made that each national participant used a different target strength. The estimated stock estimates were given as 660×10^3 tonnes of 1-group and 350×10^3 tonnes of older fish.

With the agreed revision of the target strength measurements made in 1980, the 1979 estimate was reduced from 1.010×10^3 tonnes to 380×10^3 tonnes. The foregoing uncertainties in target strength illustrates one of the difficulties underlying the use of acoustic surveys in making an estimate of biomass in absolute tonnage.

VPAs were run, fixing the stock size ratios as indicated by the acoustic survey and taking the assumed level of recruitment in the last report. A variety of input F values were tried; the two given in Tables 8.5 and 8.6 gave stock ratios comparable to the acoustic surveys. Both these VPAs indicate a steady decline in sprat biomass over the period and an increase in F. The question was raised as to whether there was any independent evidence for an actual increase in fishing effort of this magnitude. If the fleet had not increased, then concentration by them in sprat areas might also allow an increase in F. There is little evidence to support either explanation.

The Norwegian acoustic survey indicates a major reduction in 1-group abundance in the two years. This feature does not occur in the VPA. If such a feature was to be simulated, great changes in exploitation pattern would be needed.

The Working Group does not consider it possible to provide an assessment of the TAC for 1981 or 1982 with the type of data available and at this time of the year.

The Group points out that the essential requirement for any TAC calculation is a reliable estimate of 1-group. This might be feasible utilising the January to March catch data. The Working Group endorses its comments of the previous year that the time lag between assessment and management arrangements be reduced to 3 months.

9. MEASURES OF FISHING MORTALITY

In the report of the ACFM Study Group on Standard ICES Assessment Computer Programs (C.M.1981/G:4) the advantages and disadvantages of the various single figure measures of fishing mortality are discussed. For the various herring stocks dealt with by the Herring Assessment Working Group usually a weighted average F over a specified range of age groups has been calculated from the VPA for indicating the fishing mortality. If the age groups which are going into these calculations are subject to approximately the same F so that there is not any trend in F with age, this measure of F should not be subject to any bias. The random errors should be smaller than in the case of a simple arithmetic average. Accordingly, the Herring Assessment Working Group saw no reason to change the single measure of fishing mortality used previously, but the range of age groups which the weighted average F was based upon was carefully studied for each stock in order to remove from the calculations age groups which could not be expected to suffer the same fishing mortality as the others.

10. HERRING TAGGING PROGRAMMES

It was reported to the Working Group that the Marine Laboratory, Aberdeen, had purchased an NWI magnetic tag injector and had plans for an experiment in the Clyde in May. A detector system designed for screening herring catches on landing is being developed in cooperation with the designers. These experiments will be extended to the Irish Sea herring fishery.

The Netherlands is continuing its investigation of a screening system for use on freezer trawlers.

An evaluation of the total system as used in the Clyde should be available for discussion by about August. It is then proposed that the Planning Group should meet to prepare its comments for the Statutory Meeting.

The Working Group expressed its interest in the development of this system and in its potential in relation to stock management of the herring stocks.

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Table 2.1.1 HERRING. Catch in tonnes 1971-1980. North Sea (Sub-area IV and Division VIIId) by country.
(Data provided by Working Group members)

Country/Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 [*])
Belgium	681	1 337	2 160	603	2 451	1 430	57	-	-	-
Denmark	185 393	213 738	174 254 ^{a)}	61 728	115 616	34 841	12 769	4 359	10 546	4 458
Faroe Islands	45 524	48 444	54 935 ^{b)}	26 161 ^{b)}	25 854	14 378	8 070	40	10	-
Finland	-	-	-	-	-	1 034	-	-	-	-
France	11 408	12 901	22 235	12 548	20 391	14 468	1 613	2 119	2 560	3 330
German Dem. Rep.	475	127	1 728	3 268	2 689	2 624	2	-	-	-
Germany, Fed. Rep.	3 570	3 065	10 634 ^{c)}	12 470	6 953	1 654	221	24	10	147
Iceland	37 171	31 998	23 742 ^{d)}	29 017	16 286	9 412	-	-	-	-
Netherlands	32 479	24 829	34 070	35 106	38 416	20 146	4 134	18	-	509
Norway	125 842	117 501	99 739	40 975	34 183	27 386	4 065	1 189	3 617	2 110
Poland	2 031	2 235	5 738	9 850	7 069	7 072	2	-	-	-
Sweden	36 880	7 366	4 222 ^{e)}	3 561	6 858	4 777	3 616	-	-	-
UK (England)	4 113	394	2 268	5 699	6 475	9 662	3 224	2 843	2 253	77
UK (Scotland) ^{f)}	25 073	17 227	16 012	15 034	8 904	15 015	8 159	437	162	610
USSR	9 500	16 386	30 735	18 096	20 653	10 935	78	4	-	-
Total North Sea	520 140	497 548	484 012	275 116	312 798	174 834	46 010	11 033	19 158	11 241
Total including unallocated catches									25 148	60 994

a) Total includes 2 107 t for human consumption unspecified to area.

b) Supplied by Fiskirannsóknarstofvan.

c) From Federal Republic of Germany national statistics compiled by Federal Board of Fisheries, Hamburg.

d) Excludes 15 938 t caught on Skagerrak border and allocated to that area on the basis of age analysis.

e) Swedish catches in Danish ports reported by area (North Sea, Skagerrak) used for area allocation of Swedish landings reported as Skagerrak and North Sea in Swedish statistics.

f) Catches from Moray Firth not included.

*) Preliminary.

Table 2.1.2 HERRING. North Sea catches in directed fisheries by area.
(Figures supplied by Working Group members)

Year	IVa W	IVa E	IVb (adult)	IVb (juv.)	IVc + VIId
1972	235 106	22 732	47 787	168 792	23 004
1973	247 697	14 666	57 753	135 626	30 163
1974	84 174	15 377	116 396	51 772	7 383
1975	95 761	9 652	91 110	90 748	25 527
1976	101 552	2 257	41 475	-	17 501
1977	27 923	1 864	4 785	-	1 384
1978	-	1 033	-	-	-
1979	-	1 250 ¹⁾	1 000 ²⁾	-	5 000 ²⁾
1980	1 698	2 449	5 902	-	39 704

1) Including spring spawners: 410 tonnes of autumn spawners assumed for calculating catch in number.

2) Rough estimates

Table 2.1.3 HERRING. By-catch (in weight) by countries in Division IVa west of 2°E

Country	1976	1977	1978	1979	1980
Denmark	4 105	502	-	437	687
Faroe Islands	-	-	25	-	-
France	100	148	486	493	715
German Dem. Rep.	-	-	-	-	-
Germany, Fed. Rep.	-	-	4	10	-
Netherlands	-	-	-	-	-
Norway	-	-	27	-	-
Poland	-	-	-	-	-
Sweden	-	-	-	-	-
U.K. (England)	-	-	-	-	-
U.K. (Scotland)	-	-	-	6	18
USSR	-	-	-	-	-
Total	4 205	650	542	946	1 420

Table 2.1.4 HERRING. By-catch (in weight) by countries in Division IVa east of 2°E

Country	1976	1977	1978	1979	1980
Denmark	-	186	-	2	27
Faroe Islands	-	-	-	-	-
France	11	44	-	68	-
German Dem. Rep.	-	2	-	-	-
Germany, Fed. Rep.	-	-	-	-	-
Netherlands	-	42	-	-	-
Norway	-	-	-	-	21
Poland	-	2	-	-	-
Sweden	-	-	-	-	-
U.K. (England)	-	-	-	-	-
U.K. (Scotland)	-	-	-	-	-
USSR	-	43	4	-	-
Total	11	319	4	70	48

Table 2.1.5 HERRING. By-catch (in weight)
by countries in Division IVb

Country	1976	1977	1978	1979	1980
Denmark	7 682	5 958	4 359	10 107	3 733
Faroe Islands	-	-	15	-	-
France	88	198	302	448	201
German Dem. Rep.	-	-	-	-	-
Germany, Fed. Rep.	-	-	1	-	147
Netherlands	-	-	-	-	35
Norway	-	-	129	2 367	1 607
Poland	-	-	-	-	-
Sweden	-	-	-	-	-
U.K. (England)	165	2 810	2 620	2 252	76
U.K. (Scotland)	-	22	437	156	592
USSR	-	35	-	-	-
Total	7 915	9 023	7 863	15 330	6 391

Table 2.1.6 HERRING. By-catch (in weight)
by countries in Division IVc and VIId

Country	1976	1977	1978	1979	1980
Denmark	-	-	-	-	11
Faroe Islands	-	-	-	-	-
France	25	62	1 331	1 551	2 414
German Dem. Rep.	-	-	-	-	-
Germany, Fed. Rep.	-	-	19	-	-
Netherlands	-	-	18	-	474
Norway	-	-	-	-	482
Poland	-	-	-	-	-
Sweden	-	-	-	-	-
U.K. (England)	-	-	223	1	1
U.K. (Sweden)	-	-	-	-	-
USSR	-	-	-	-	-
Total	25	62	1 591	1 552	3 382

Table 2.1.7 HERRING, North Sea catch in millions of fish by age.

Year	Area	Age in winter rings										Total
		0	1	2	3	4	5	6	7	8	>8	
1972	IVaW of 2 ^o E	-	338.9	830.1	176.8	88.6	19.3	4.1	-	0.5	0.4	1 458.7
	IVaE of 2 ^o E	-	75.1	91.0	17.8	5.8	0.7	0.1	-	-	-	190.5
	IVb	-	25.2	46.4	98.8	20.5	6.7	0.6	0.2	0.6	-	199.0
	IVbYH	750.4	2 896.6	337.9	21.1	6.4	1.2	0.2	-	-	-	4 013.8
	IVc+VIIId,e	-	4.8	135.1	29.3	9.3	5.0	-	-	-	-	183.5
	Total NS	750.4	3 340.6	1 440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6 045.5
1973	IVaW of 2 ^o E	-	52.5	742.1	452.6	58.0	39.5	20.3	2.6	0.5	0.6	1 368.7
	IVaE of 2 ^o E	-	0.3	16.2	23.1	6.3	7.2	1.0	0.3	0.8	-	55.2
	IVb	-	242.5	180.1	39.0	28.3	4.7	7.2	-	-	-	501.8
	IVbYH	289.4	2 070.5	362.5	29.4	2.6	0.5	0.2	0.3	-	-	2 755.4
	IVc+VIIId,e	-	2.2	43.3	115.1	55.0	7.4	1.9	0.5	0.1	0.0	225.5
	Total NS	289.4	2 368.0	1 344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4 906.6
1974	IVaW of 2 ^o E	65.3	162.9	98.5	112.9	97.1	36.0	18.6	4.5	1.5	1.0	598.3
	IVaE of 2 ^o E	5.7	131.8	24.2	10.8	1.0	-	-	-	0.1	-	173.6
	IVb	-	54.0	493.7	212.3	19.5	18.9	3.6	0.3	0.4	0.1	802.8
	IVbYH	925.1	493.5	132.1	5.7	-	-	-	-	-	-	1 556.4
	IVc+VIIId	-	3.9	24.1	20.3	8.4	1.2	0.1	0.2	-	-	58.2
	Total NS	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3 189.3
1975	IVaW of 2 ^o E	-	267.0	120.0	69.0	49.0	40.2	9.8	6.3	2.9	1.1	565.3
	IVaE of 2 ^o E	-	82.5	8.2	7.0	2.4	0.4	0.1	0.1	-	-	100.7
	IVb (adult)	-	268.8	147.1	124.2	81.2	14.8	5.8	2.7	0.5	0.3	645.4
	IVbYH	262.8	1 818.1	139.2	19.8	2.6	-	0.4	-	-	-	2 242.9
	IVc+VIIId	1.0	24.1	127.2	39.6	5.3	1.8	-	-	-	-	199.0
	Total NS	263.8	2 460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3 753.3
1976	IVaW of 2 ^o E	-	19.4	572.9	56.3	17.9	13.2	3.6	2.6	0.5	0.3	686.7
	IVaE of 2 ^o E	-	-	10.6	1.1	0.5	0.5	0.4	-	-	-	13.1
	IVb (adult)	0.9	35.5	205.9	17.6	28.4	20.3	1.8	1.8	0.5	0.1	312.8
	IVbYH	237.3	49.5	17.7	0.5	1.7	-	-	-	-	-	306.7
	IVc+VIIId	-	22.2	94.4	41.8	3.5	0.5	0.3	-	-	-	162.7
	Total NS	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1 482.0
1977	IVaW of 2 ^o E	2.6	2.7	9.3	171.7	8.6	3.8	2.1	0.9	0.2	-	201.9
	IVaE of 2 ^o E	0.4	3.3	+	4.9	1.2	1.1	1.0	0.6	0.5	+	13.0
	IVb (adult)	-	1.1	25.9	6.8	0.3	1.9	1.0	-	+	-	37.0
	IVbYH	253.8	136.3	3.1	-	-	-	-	-	-	-	393.2
	IVc+VIIId	-	0.9	6.4	3.0	0.7	0.2	+	+	-	-	11.2
	Total NS	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7	-	656.3
1978	IVaW of 2 ^o E	-	-	0.1	0.1	1.5	0.2	0.1	+	+	+	2.0
	IVaE of 2 ^o E	-	-	0.2	0.2	1.2	-	+	0.2	+	0.3	2.1
	IVb (adult)	-	0.2	0.6	1.4	1.1	0.1	0.1	+	-	-	3.5
	IVb (indus.)	138.0	168.0	1.4	-	-	-	-	-	-	-	299.4
	IVc + VIIId	-	0.4	2.8	4.0	1.2	+	+	-	-	-	8.4
	Total NS	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	IVaW of 2 ^o E	-	1.9	0.4	0.3	2.2	0.5	+	+	+	-	5.3
	IVaE of 2 ^o E	-	-	2.4	0.3	+	+	+	+	+	-	2.7
	IVb (adult)	-	0.5	2.1	0.4	2.2	0.9	0.1	0.4	0.3	-	6.9
	IVb (indus.)	542.0	156.4	7.6	-	0.1	0.1	+	0.4	0.3	0.1	707.0
	IVc + VIIId	-	0.4	21.6	9.0	5.6	0.6	0.1	-	-	-	37.3
	Total NS	542.0	159.2	34.1	10.0	10.1	2.1	0.2	0.8	0.6	0.1	759.2
1980	IVaW of 2 ^o E	-	+	2.2	6.5	1.2	2.8	0.6	0.8	0.4	0.2	14.7
	IVaE of 2 ^o E	166.8	-	+	0.1	0.1	0.1	+	+	+	-	167.1
	IVb (adult)	-	0.5	0.8	0.4	+	0.2	+	+	+	+	1.9
	IVb (indus.)	624.9	137.3	6.0	1.0	0.6	0.3	+	0.1	+	-	770.2
	IVc + VIIId	+	23.4	99.1	83.8	30.2	18.4	1.7	0.5	+	+	257.1
	Total NS	791.7	161.2	108.1	91.8	32.1	21.8	2.3	1.4	0.4	0.2	1 211.0

Table 2.1.8 Millions of HERRING caught annually per age group (winter rings) in the North Sea over the last 10 years

Year \ Winter rings	0	1	2	3	4	5	6	7	8	>8	Total
1970	898.1	1 196.2	2 002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5 249.3
1971	684.0	4 378.5	1 146.8	662.5	208.3	26.9	30.5	26.8	-	12.4	7 176.7
1972	750.4	3 340.6	1 440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6 045.5
1973	289.4	2 368.0	1 344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4 906.6
1974	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3 189.3
1975	263.8	2 460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3 753.3
1976	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1 482.0
1977	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7	+	656.3
1978	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	542.0	159.2	34.1	10.0	10.1	2.1	0.2	0.8	0.6	0.1	759.2
1980	791.7	161.2	108.1	91.8	32.1	21.8	2.3	1.4	0.4	0.2	1 211.0

Table 2.3.1 0-group estimates for southern North Sea herring

Year class	English surveys, East Anglia coast and Thames estuary in July by mid-water trawl		Dutch sampling in coastal waters by anchored plankton nets in April Numbers per 10 000 m ³
	Number of stations	Mean number per hour fishing	
1967	12	714	11
1968	12	2 060	55
1969	11	1 406	384
1970	12	2 453	131
1971	12	828	75
1972	12	53	155
1973	12	50	230
1974	12	44	194
1975	11	24	11
1976	12	31	22
1977	11	70	57
1978	12	2 153	174
1979	11	159	796
1980			1 100 ^{x)}

x) Preliminary

Table 2.7.1 HERRING. Stock/Area:Divisions IVc and VIId

Age (winter rings)	\bar{w}	Stock 1.1.1980 (No. x 10 ⁻⁶)	Catch 1980	F ₁₉₈₀	Stock 31.12.1980	Stock 1.1.1981
2	.126	505.9	99.1	.23	363.7	550.0
3	.176	427.8	83.8	.23	307.5	363.7
4	.24	154.2	30.2	.23	110.8	307.5
5	.243	93.9	18.4	.23	67.5	110.8
6	.257	8.7	1.7	.23	6.2	67.5
7	.267	2.6	.5	.23	1.8	6.2
8	.271		-	.23		1.8
SSB (1 000 tonnes)					142	

Table 2.7.2 Estimates of 0- and 1-group HERRING in No x 10⁻⁹

Year Class	Total North Sea			Div.IIIa
	0-group Catch	1-group IYFS Estim.	1-group Catch	1-group Catch
1973/4	.996	4.39	2,460	1.471
1974/5	.263	.73	.127	1.474
1975/6	.238	.85	.144	1.437
1976/7	.257	1.57	.169	.876
1977/8	.130	.43	.159	.168
1978/9	.542	1.45	.161	.467
1979/80	.792	1.35		

Table 3.1 HERRING in Division IIIa. Landings in tonnes 1971-80.
(Data mainly provided by Working Group members)

	Country/Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 ^{x)}
SKAGERRAK	Denmark	26 985	34 900	42 098	35 732	29 997	7 326	19 889	6 425	5 153	5 180
	Faroe Islands	5 636	4 115	5 265	7 132	8 053	1 553	10 064	1 041	817	526
	Germany, Fed. Rep.	-	-	-	36	108	6	32	28	181	-
	Iceland	3 066	7 317	15 938	231	1 209	123	-	-	-	-
	Norway (Open Sea)	6 120	1 045	836	698	196	-	-	1 860	2 460	1 350
	Norway (Fjords)	3 166	4 222	1 680	1 720	1 459	2 304	1 837	2 271	2 259	2 795
	Sweden	19 763	19 644	20 429	11 683	12 348	6 505	8 109	11 551	8 104	10 701
	Total	64 736	71 243	86 246	57 232	53 370	17 817	39 931	23 176	18 974	20 552
KATTEGAT	Denmark	50 177	52 755	78 125	54 540	48 974	41 749	38 205	29 241	21 337	25 380
	Sweden	49 760	39 972	40 418	39 779	23 769	30 263	37 160	35 193	25 272	18 260
		Total	99 937	92 727	118 543	94 319	72 743	72 012	75 365	64 434	46 609
	Division IIIa Total	164 673	163 970	204 789	151 551	126 113	89 829	115 296	87 610	65 583	64 192
	Unallocated									8 117	20 053
	GRAND TOTAL									73 700	84 245

x) Preliminary

Table 3.2 HERRING - Division IIIa, 1980.
Landings in numbers at age ($\times 10^{-6}$).

Age	Skagerrak	Kattegat	Division IIIa total	
			Landings	Catch ^{x)}
0	386.23	139.10	525.33	682.09
1	119.92	276.87	396.79	466.72
2	49.68	168.91	218.59	232.47
3	50.26	133.98	184.24	185.29
4	14.65	15.41	30.06	30.09
5	3.05	1.23	4.28	4.28
6	1.16	0.14	1.30	1.30
7	0.08	0.04	0.12	0.12
8+	0.08	-	0.08	0.08
SOP in % of actual	97.8	102.8	101	

x) 7% of total landings (about 6 000 tonnes) added for discards using the age composition of by-catches.

Table 3.3 Virtual Population Analysis 1981. Input data.

CATCH AT AGE							
Age	1974	1975	1976	1977	1978	1979	1980
0	2499	2006	433	934	147	457	682
1	910	1471	1474	1437	876	168	467
2	375	149	325	329	455	583	232
3	135	60	28	61	65	70	185
4	47	57	4	12	10	13	30
5	26	15	3	6	1	4	4
6	9	6	1	4	1	0	1
7	3	1	1	2	0	0	0
8	1	1	1	0	0	0	0

NATURAL MORTALITY AT AGE:									
Age	0	1	2	3	4	5	6	7	8
mort.	0.30	0.25	0.20	0.10	0.10	0.10	0.10	0.10	0.10

Mean fishing mortality calculated for ages 2 to 8 (weighted by stock numbers)

Table 3.4 Virtual Population Analysis 1981.

FISHING MORTALITIES							
Age	1974	1975	1976	1977	1978	1979	1980
0	0.672	0.567	0.141	0.287	0.140	0.152	0.200
1	1.528	1.332	1.308	1.052	0.526	0.257	0.250
2	1.672	1.373	1.488	1.419	1.344	0.856	0.700
3	1.056	1.687	1.059	1.417	1.306	0.724	0.700
4	1.186	2.026	0.397	2.162	0.841	0.907	0.700
5	1.446	1.608	0.490	1.609	1.246	0.875	0.700
6	1.471	1.751	0.352	2.499	1.339	0.323	0.700
7	1.136	0.535	2.080	2.511	0.376	0.376	0.700
8	1.500	1.500	1.500	1.500	1.000	0.700	0.700
Mean ≥ 2	1.46	1.56	1.41	1.46	1.33	0.84	0.700

Table 3.5 Virtual Population Analysis 1981.

STOCK IN NUMBERS							
Age	1974	1975	1976	1977	1978	1979	1980
0	5814	5291	3797	4308	1296	3731	4333
1	1274	2200	2224	2443	2396	834	2374
2	496	215	452	468	665	1103	503
3	216	76	45	84	93	142	384
4	70	68	13	14	18	23	62
5	35	19	8	8	1	7	8
6	12	8	4	4	1	0	3
7	5	3	1	2	0	0	0
8	1	1	1	0	0	0	0
SSB (3-8)	48.5	27.7	10.1	15.1	14.4	21.9	57.7

(10⁻³ tonnes)

Table 3.6 HERRING, Division IIIa. Catch in 1981 for different levels of F.

Stock per 1 January 1981 estimated from acoustic surveys in September and November 1980

Age Winter Rings	F	Catch	F	Catch	F	Catch	F	Catch
0	.2	7.6	.2	7.6	.2	7.6	.2	7.6
1	.2	15.5	.25	18.5	.25	18.5	.25	18.5
2	.2	30.7	.4	56.1	.8	94.1	1.1	108.5
3	.2	7.8	.4	14.1	.8	23.8	1.1	27.3
4	.2	12.3	.4	22.3	.8	37.4	1.1	43.1
5	.2	2.4	.4	4.4	.8	7.4	1.1	8.4
6	.2	0.9	.4	1.6	.8	2.8	1.1	3.1
7	.2	0.1	.4	0.2	.8	0.3	1.1	0.4
Sums								
0+1		23.1		26.1		26.1		26.1
2		30.7		56.1		94.1		108.5
≥3		23.5		42.6		71.7		82.3
0-7		77.9		124.4		191.9		216.9

Table 3.7 HERRING, Division IIIa. Catch in 1981 for different levels of F.

Stock per 1 January 1981 derived from VPA

Catch in tonnes x 10⁻³.

Age Winter Rings	F	Catch	F	Catch	F	Catch	F	Catch	F	Catch
0	.2	7.6	.2	7.6	.2	7.6	.2	7.6	.2	7.6
1	.2	27.5	.25	33.6	.25	33.6	.25	33.6	.25	33.6
2	.2	18.8	.4	34.2	.7	52.5	.9	62.1	1.2	73.5
3	.2	5.0	.4	9.1	.7	13.8	.9	16.3	1.2	19.3
4	.2	5.9	.4	10.7	.7	16.3	.9	19.3	1.2	22.3
5	.2	1.1	.4	1.9	.7	2.9	.9	3.5	1.2	4.1
6	.2	0.14	.4	0.27	.7	0.42	.9	0.5	1.2	0.6
7	.2	0.1	.4	0.15	.7	0.24	.9	0.3	1.2	0.3
Sums										
0+1		35.1		41.2		41.2		41.2		41.2
2		18.8		34.2		52.5		62.1		73.5
≥3		12.1		22.1		33.7		39.9		47.1
0-7		66.0		97.5		127.4		143.2		161.8

Table 3.8. HERRING in Division IIIa. Spawning stock biomass at 1 January 1982 for different levels of F in 1981.

Stock per 1 January 1981 estimated from acoustic surveys in September and November 1980 (tonnes x 10⁻³).

Age Winter Rings	F ₁₉₈₁				Stock 1.1.1981
	0.2	0.4	0.8	1.1	
3	183.4	150.2	111.2	82.4	37.4
4	41.4	34.1	22.9	18.7	63.4
5	54.9	45.1	30.1	24.6	13.1
6	10.6	8.8	5.9	4.8	4.7
7	4.0	3.2	2.2	1.8	0.6
8+	0.5	0.4	0.3	0.2	-
Sum	295.1	241.8	172.6	132.5	119.2

Table 3.9. HERRING in Division IIIa. Spawning stock biomass at 1 January 1982 for different levels of F in 1981.

Stock per 1 January 1981 derived from VPA (tonnes x 10⁻³).

Age Winter Rings	F ₁₉₈₁					Stock 1.1.1981
	0.2	0.4	0.7	0.9	1.2	
3	111.9	91.7	67.9	55.6	41.2	23.8
4	26.6	21.7	16.1	13.2	9.8	30.3
5	26.2	21.5	16.0	13.0	9.6	5.7
6	4.7	3.8	2.9	2.3	1.7	0.8
7	0.7	0.6	0.4	0.3	0.3	0.5
8+	0.4	0.3	0.2	0.2	0.1	-
Sum	170.4	139.6	103.5	84.6	62.7	61.1

Table 4.1 Annual Celtic Sea HERRING catches 1972-1980 (Data provided by Working Group members)

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	UK	USSR	Unallocated	Total
1972	7 327	-	393	20 109	6 758	751	-	618		35 956
1973	5 553	7	294	13 105	5 834	1 125	-	334		26 375 ^{a)}
1974	2 261	-	433	13 991	2 105	954	-	-		19 744
1975	1 924	-	361	8 430	2 825	512	24	1 054		15 130
1976	1 919	147	28	3 705	1 627	324	-	826		8 258
1977	106	-	96	1 394	1 455	-	-	-		3 051
1978	8	-	220	2 725	1 002	-	-	-		3 955
1979	584	-	20	2 123	850	-	-	-	850	4 427
1980*	9	-	2	3 416	392	-	-	-	3 705	7 524

*) Provisional

a) Including 123 tonnes for Bulgaria

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

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	UK	USSR	Unallocated	Total
1971/2	3 383	-	974	13 757	10 600	880	65	-		29 659
1972/3	7 327	-	393	18 846	6 852	751	-	618		34 878
1973/4	4 143	7	294	11 317	5 834	1 139	-	334		23 191 ^{a)}
1974/5	2 150	-	435	11 683	2 462	954	-	-		17 684
1975/6	2 451	-	399	6 524	2 441	579	24	1 054		13 472
1976/7	1 371	147	36	2 970	1 324	257	-	826		7 019
1977/8	95	-	96	1 322	1 378	-	-	-		2 891
1978/9	8	-	220	2 656	1 002	-	-	-		3 886
1979/80	584	-	20	2 920	850	-	-	-	935	5 309
1980/81*	9	-	2	3 582	392	-	-	-	3 803	7 788

*) Provisional

a) Including 123 tonnes for Bulgaria

Table 3.8. HERRING in Division IIIa. Spawning stock biomass at 1 January 1982 for different levels of F in 1981.

Stock per 1 January 1981 estimated from acoustic surveys in September and November 1980 (tonnes x 10⁻³).

Age Winter Rings	F ₁₉₈₁				Stock 1.1.1981
	0.2	0.4	0.8	1.1	
3	183.4	150.2	111.2	82.4	37.4
4	41.4	34.1	22.9	18.7	63.4
5	54.9	45.1	30.1	24.6	13.1
6	10.6	8.8	5.9	4.8	4.7
7	4.0	3.2	2.2	1.8	0.6
8+	0.5	0.4	0.3	0.2	-
Sum	295.1	241.8	172.6	132.5	119.2

Table 3.9. HERRING in Division IIIa. Spawning stock biomass at 1 January 1982 for different levels of F in 1981.

Stock per 1 January 1981 derived from VPA (tonnes x 10⁻³).

Age Winter Rings	F ₁₉₈₁					Stock 1.1.1981
	0.2	0.4	0.7	0.9	1.2	
3	111.9	91.7	67.9	55.6	41.2	23.8
4	26.6	21.7	16.1	13.2	9.8	30.3
5	26.2	21.5	16.0	13.0	9.6	5.7
6	4.7	3.8	2.9	2.3	1.7	0.8
7	0.7	0.6	0.4	0.3	0.3	0.5
8+	0.4	0.3	0.2	0.2	0.1	-
Sum	170.4	139.6	103.5	84.6	62.7	61.1

Table 4.1 Annual Celtic Sea HERRING catches 1972-1980 (Data provided by Working Group members)

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	UK	USSR	Unallocated	Total
1972	7 327	-	393	20 109	6 758	751	-	618		35 956
1973	5 553	7	294	13 105	5 834	1 125	-	334		26 375a)
1974	2 261	-	433	13 991	2 105	954	-	-		19 744
1975	1 924	-	361	8 430	2 825	512	24	1 054		15 130
1976	1 919	147	28	3 705	1 627	324	-	826		8 258
1977	106	-	96	1 394	1 455	-	-	-		3 051
1978	8	-	220	2 725	1 002	-	-	-	850	3 955
1979	584	-	20	2 123	850	-	-	-	3 705	4 427
1980*	9	-	2	3 416	392	-	-	-		7 524

*) Provisional

a) Including 123 tonnes for Bulgaria

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

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	UK	USSR	Unallocated	Total
1971/2	3 383	-	974	13 757	10 600	880	65	-		29 659
1972/3	7 327	-	393	18 846	6 852	751	-	618		34 878
1973/4	4 143	7	294	11 317	5 834	1 139	-	334		23 191a)
1974/5	2 150	-	435	11 683	2 462	954	-	-		17 684
1975/6	2 451	-	399	6 524	2 441	579	24	1 054		13 472
1976/7	1 371	147	36	2 970	1 324	257	-	826		7 019
1977/8	95	-	96	1 322	1 378	-	-	-		2 891
1978/9	8	-	220	2 656	1 002	-	-	-		3 886
1979/80	584	-	20	2 920	850	-	-	-	935	5 309
1980/81*	9	-	2	3 582	392	-	-	-	3 803	7 788

*) Provisional

a) Including 123 tonnes for Bulgaria

Table 4.3 Celtic Sea. Catch in numbers x 10⁻³ (1 April - 31 March).

Season/Age	1	2	3	4	5	6	7	8	>8	Total
1965/6	58	70 937	9 456	15 911	3 433	4 584	12 241	1 391	7 566	125 576
1966/7	6 337	19 146	58 633	9 827	13 193	5 585	3 581	8 742	3 839	128 614
1967/8	6 921	36 168	19 486	47 837	8 954	9 334	3 894	6 462	6 684	145 741
1968/9	11 699	53 028	38 421	11 207	22 286	4 538	3 965	1 251	4 608	151 003
1969/70	7 787	91 994	54 473	32 318	11 881	17 265	4 612	2 130	3 418	225 878
1970/1	640	31 540	48 706	25 937	18 270	7 095	5 751	1 925	3 194	143 058
1971/2	10 262	22 451	34 382	40 536	18 449	9 807	3 779	4 846	2 143	146 655
1972/3	7 279	124 357	16 922	13 817	13 674	4 331	2 654	2 103	749	185 886
1973/4	22 171	34 122	45 162	6 269	8 251	4 655	3 209	1 966	714	126 519
1974/5	4 516	38 285	15 427	19 865	3 782	3 311	2 668	806	742	89 402
1975/6	11 452	13 077	15 709	6 898	6 042	3 252	1 268	964	1 022	59 685
1976/7	<u>7 262</u>	9 090	5 202	5 196	2 092	2 669	1 384	1 005	777	34 701
1977/8	3 859	<u>4 095</u>	3 491	1 534	782	547	289	36	55	14 687
1978/9	1 660	10 373	<u>3 890</u>	1 573	450	471	115	260	130	18 922
1979/80	5 318	8 260	7 946	<u>2 228</u>	1 230	422	305	140	264	26 113
1980/81	2 933	20 520	6 363	4 206	2 147	972	308	151	205	37 805

Table 4.4 Abundances of larvae ($\times 10^{-6}$) in 1980/81* in Celtic Sea

Cruise mid-date	Days from 31/8/80	<10mm	10-15mm	>15mm
8.10.80	38	1 325	234	308
22.10.80	52	9 944	7 388	220
4.11.80	65	15 137	17 683	714
26.11.80	87	4 000	6 582	857
16.12.80	107	7 558	17 539	1 479
14.01.81	136	868	6 330	4 523
4.02.81	157	1 134	35 046	10 094
24.02.81	177	0	1 204	34 816

*Similar data for previous years are given in ICES C.M. 1979/H:48 and C.M. 1980/H:49.

Table 4.5 VPA analysis Celtic Sea HERRING.
Fishing mortalities.

Age w.r.	1965/66	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	1972/73	1973/74
1	0.00	0.03	0.03	0.05	0.06	0.01	0.04	0.10	0.27
2	0.30	0.23	0.24	0.34	0.52	0.35	0.46	0.88	0.76
3	0.21	0.38	0.34	0.39	0.61	0.50	0.68	0.66	0.84
4	0.35	0.31	0.53	0.29	0.58	0.59	0.91	0.57	0.48
5	0.22	0.49	0.45	0.45	0.51	0.67	0.99	0.81	0.71
6	0.21	0.57	0.68	0.38	0.67	0.57	0.82	0.58	0.63
7	0.51	0.23	0.88	0.61	0.74	0.43	0.60	0.48	1.03
8	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
y+	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
F(1-9),W	0.26	0.26	0.28	0.25	0.46	0.42	0.40	0.67	0.61
F(2-9),W	0.31	0.36	0.40	0.38	0.57	0.49	0.73	0.80	0.77

Age w.r.	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
1	0.17	0.43	0.34	0.12	0.07	0.12	0.10
2	0.90	0.85	0.64	0.29	0.45	0.50	0.80
3	0.85	1.07	0.88	0.48	0.43	0.66	0.80
4	1.03	1.08	1.19	0.62	0.37	0.42	0.80
5	0.54	0.92	1.05	0.48	0.33	0.49	0.80
6	0.62	1.11	1.33	0.77	0.53	0.52	0.80
7	0.82	0.45	2.90	0.41	0.32	0.70	0.80
8	0.70	0.70	0.70	0.70	0.70	0.70	0.80
y+	0.70	0.70	0.70	0.70	0.70	0.70	0.80
F(1-9),W	0.75	0.80	0.72	0.26	0.31	0.34	0.73
F(2-9),W	0.87	0.94	0.93	0.41	0.44	0.55	0.80

Table 4.6 VPA analysis Celtic Sea HERRING.
Stock size in numbers (x 10⁻³).

<u>1 April</u>									
Age (w.r.)	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	109825	201997	220471	276424	133274	71338	255286	81383	97860
2	290037	99319	176751	192912	238999	113191	63941	221238	66723
3	52943	195151	71696	125610	124276	129155	72516	36589	82793
4	56034	38929	121004	46397	77241	60917	70743	33108	17104
5	18523	35617	25904	64203	31352	39307	30578	25754	16882
6	25340	13502	19734	14957	36982	17119	18290	10268	10388
7	32241	18578	6932	9031	9232	17137	8775	7287	5192
8	2887	17583	13411	2596	4421	3995	10057	4365	4080
y+	15702	7967	13872	9565	7094	6629	4448	1554	1482
Total	603533	628644	669776	741694	662870	458787	534634	421546	302504
Spawn. Stock	548621	527645	559540	603482	596232	423118	406991	380855	253574
Spawn. Stock Biomass (t)	97 199	95 099	99 149	104 063	106 985	79 308	70 627	65 750	44 752
Age (w.r.)	1974	1975	1976	1977	1978	1979	1980	1981	
1	31109	34138	26550	36959	26030	48 575	32 360	*****	
2	67514	23861	20039	17138	29776	21 975	38901	26 494	
3	28131	24953	9242	9535	11623	17117	12063	15816	
4	32268	10888	7771	3452	5321	6831	7974	4904	
5	9540	10466	3350	2139	1673	3324	4070	3242	
6	7476	5051	3768	1059	1195	1087	1843	1655	
7	4996	3633	1506	899	442	635	584	749	
8	1673	2001	2086	75	540	291	286	237	
y+	1540	2121	1613	114	270	548	389	274	
Total	184247	117111	75926	71370	76869	100382	75747		
Spawn. Stock	168092	100042	62651	52891	63854	76095	70928		
Spawn. Stock Biomass (t)	30 700	18 254	11 048	8 489	10 654	12 489	13 825		

Table 4.7 Prognosis of Celtic Sea HERRING.

Age	Stock 1 Apr. 1980 (No. x 10 ⁶)	Mean weights		Catch 80/81	F 80/81	Stock 1 April 81	F 81/82	Catch 81/82	Stock 1 April 82
		1 April	All Seasons						
1	32.4	118	123	2.9	0.10	30.0	0.10	2.7	30.0
2	38.9	162	194	20.5	0.80	26.5	0.80	14.0	24.6
3	12.1	193	233	6.4	↓	15.8	↓	8.3	10.8
4	8.0	210	249	4.2		4.9		2.6	6.4
5	4.1	220	267	2.1		3.2		1.7	2.0
6	1.8	228	279	1.0		1.6		0.9	1.3
7	0.6	232	281	0.3		0.7		0.4	0.7
8	0.3	235	290	0.2		0.2		0.1	0.3
>8	0.4	238	284	0.2		0.3		0.1	0.2
Biomass (1-9) in tonnes		15 800				13 300			12 000
Spawning Biomass		13 800				11 500			10 200
Catch (1-9) in tonnes				7 788 (SOP = 7 910)				5 500	

Table 5.1 Total catches of Herring (tonnes) in Division VIa, 1971-1980
(Data provided by Working Group members).

Country	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980*
Belgium	-	-	-	-	-	12	7	-	-	-
Denmark	554	150	932	-	374	249	626	128	-	-
Faroe Islands ^{a)}	8 100	8 094	10 003	5 371	3 895	4 017	3 564	-	-	-
France	2 055	680	2 441	547	1 293	1 528	1 548	1 435	3	0.4
German Dem. Rep.	330	935	2 507	2 037	1 994	929	-	-	-	-
Germany Fed.Rep.	7 700	4 108	17 443	14 354	9 099	4 980	221	126	5	256
Iceland	5 416	2 066	2 532	9 566	2 633	3 273	-	-	-	-
Ireland ^{b)}	12 161	17 308	14 668	12 557	10 417	8 558	7 189	12 071	4 569	4 607
Netherlands	9 252	23 370	32 715	19 635	19 360	20 812	8 515	5 929	1 214	640
Norway	76 720	17 400	36 302	26 218	512	5 307	1 098	4 462	-	-
Poland	-	-	5 685	6 368	2 934	3 085	6	-	-	-
Sweden	-	-	-	-	-	2 206	261	-	-	-
U.K. (England)	-	-	-	45	125	20	301	134	54	33
U.K. (N.Ireland)	-	-	-	3	6	1	1	6	2	-
U.K. (Scotland)	99 537	107 638	120 800	107 475	85 395	53 351	25 238 ^{c)}	10 097 ^{c)}	3 ^{c)}	15
USSR	-	?	2 052	5 388	3 232	3 092	-	-	-	-
Unspecified catches	-	-	-	-	-	-	-	-	1 752	1 110
Total	221 825	181 749	248 080	209 564	141 269	111 420	48 568	34 388	7 602	6 661
Scottish juvenile Herring & Sprat fisheries in Moray Firth	5 666	10 242	7 219	13 003	2 454	313	205	1 502	21	273

* Preliminary figures a) Figures supplied by Fiskirannsóknarstovan b) catches prior to 1976 mainly taken in Division VIIb & landed in Division VIa

c) Including by-catch in local sprat fishery (16 tonnes in 1977, 157 tonnes in 1978, 3 tonnes in 1979, 11 tonnes in 1980).

Table 5.2 HERRING autumn spawners. Catch in number x 10⁻³, Division V
Moray north included.

Year/Age (rings)	0	1	2	3	4	5	6	7	8	9	10	> 10
1971	209 598	169 780	286 148	346 206	261 891	94 206	25 876	166 165	16.425	16 286	8 038	5 570
1972	249 941	321 539	753 355	210 243	72 885	83 361	37 428	13 445	94 577	8 154	5 855	5 377
1973	267 872	50 737	273 783	990 183	155 828	66 476	68 522	26 512	8 037	53 767 ¹⁾		
1974	536 119	312 029	153 833	205 806	553 627	90 584	45 144	43 069	18 504	45 393 ¹⁾		
1975	82 698	185 723	257 116	108 284	84 977	228 583	38 929	15 573	20 304	20 689 ¹⁾		
1976	8 446	78 894	386 932	123 947	44 430	36 714	87 477	14 208	5 766	13 078 ¹⁾		
1977	11 871	38 582	60 563	119 880	25 593	12 506	13 046	20 759	2 948	3 262 ¹⁾		
1978	116 976	36 010	69 805	34 763	49 854	13 803	6 595	4 600	8 872	3 581 ¹⁾		
1979	1 614	1 029	22 260	6 677	3 503	1 995	1 732	919	967	982 ¹⁾		
1980*	1 404	13 341	10 767	12 335	4 301	3 750	1 748	1 732	1 281	1 721 ¹⁾		

* Preliminary (Scottish & from by-catch & Irish totals only to date)

1) Age 9 and older

Table 5.3 Mean catches per hours fishing by Scottish Research Vessels in VIa in 1980 and 1981.

1980 Survey March-April

Stratum/ Rings	1	2	3	4	5	6	7	≥8
NW Ireland	12	565	74	10	5	5	1	5
N.Minch	838	13 552	4 226	267	95	38	4	13
S.Minch	2	86	71	7	2	2	0.5	2
Hebrides	1	1	13	10	4	7	2	6
Overall mean	213	3 551	1 096	74	27	13	2	7

1981 Survey February-March

Stratum/ Rings	1	2	3	4	5	6	7	≥8
N.W.Ireland	3	33	170	287	1 442	70	46	26
N. Minch	85	3 301	12 845	4 065	943	517	359	382
S. Minch	0	2	14	9	3	2	1	1
Hebrides	0.2	5	35	55	24	19	16	13
N. Rona	2	56	61	17	3	1	0.3	1
Overall mean *	22	835	3 266	1 104	603	152	105	105

* Excluding N.Rona

Table 5.4. Percentage Age Compositions from other research vessel sampling in VIa

Nationality	Date	Area	1 ring	2 ring	3 ring	4 ring	5 ring	6 ring	7 ring	≥ 8 ring
Scottish	November 1979	S. Minch	46.6	44.8	5.6	1.0	1.4	0.4	0.0	0.2
Scottish	November 1980	S. Minch	6.3	64.6	24.1	1.6	0.5	1.1	0.3	1.6
Germany, Fed. Rep.	March-Nov. 1980	N.W. Ireland	0.5	34.4	32.2	12.9	7.5	4.8	3.2	4.7
"	September 1980	Hebrides	0.0	18.2	47.4	18.2	7.3	4.2	1.6	3.1

Table 5.5. Size Composition of VIa stock in 1981 and 1982

Rings	Numbers x 10 ⁻⁶ 1981		F	Numbers x 10 ⁻⁶ 1982	
	2	409		121	
3	1 600	158	0.15	319	
4	541	175		1 246	
5	295	186		421	
6	74	206		230	
7	51	218		58	
≥ 8	51	224		79	
			TAC 65 000 tonnes	TAC 60 000 tonnes	
			Residual spawning stock 415 000 tonnes	Residual spawning stock 380 000 tonnes	

Table 5.6 Monthly landings (tonnes) of HERRING from the Firth of Clyde (all fishing methods combined).
(Data provided by the Working Group.)

Month	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
January	272	*	*	*	*	*	*	4*	4*	6*
February	491	52*	71*	91*	68*	7*	*	6*	8*	3*
March	495	82*	36*	168*	85	69*	*	7*	13*	8*
April	406	400	316	398	369	521	530	246	12*	4*
May	305	569	385	280	283	436	544	245	4*	2*
June	111	657	468	607	203	281	640	238	356	114
July	260	416	688	690	354	332	494	376	466	656
August	385	700	593	543	240	473	601	587	450	645
September	519	263	668	310	515	541	559	581	374	559
October	461	410	711	451	811	598	556	653	263	79
November	193	463	464	245	571	595	560	647	1*	3*
December	190	166	248	91	120	236	328	272	-*	2*
Not Known		48	67	189	44	50	35			
Total	4 088	4 226	4 715	4 063	3 663	4 139	4 847	3 862	1 951	2 081

* Subject to closure of directed fishery.

Table 5.7 Catch in numbers $\times 10^{-3}$ in the Firth of Clyde, 1967-1980.
(Races combined.)

Year	Age (winter rings)											Total
	0	1	2	3	4	5	6	7	8	9	≥ 10	
1967	-	10 109	24 797	3 950	1 828	8 151	4 775	526	106	63	109	54 414
1968	4	5 354	27 811	11 721	3 145	767	5 218	4 542	412	326	220	59 520
1969	-	3 106	24 336	19 936	6 256	1 282	1 042	1 429	990	89	38	58 504
1970	6	5 008	7 551	10 338	8 745	2 306	741	760	753	227	117	36 552
1971	6	2 207	6 503	1 976	4 355	3 432	1 090	501	352	225	181	20 828
1972	-	1 351	8 983	3 181	1 684	3 007	1 114	656	282	177	132	20 567
1973	-	9 139	5 258	4 548	1 811	918	1 525	659	307	132	114	24 411
1974	86	5 308	8 841	2 817	2 559	1 140	494	700	253	87	59	22 344
1975	-	12 694	1 876	2 483	1 024	1 072	451	175	356	130	67	20 328
1976	-	6 194	10 480	913	1 049	526	638	261	138	178	100	20 477
1977	-	1 041	7 524	6 976	1 062	1 112	574	489	251	146	192	19 367
1978	-	14 123	1 796	2 259	2 724	634	606	330	298	174	236	23 200
1979	-	507	4 859	807	930	888	341	289	156	119	154	9 050
1980	380*	333	5 633	1 592	567	341	204	125	48	56	68	9 347

* Taken as by-catch in the sprat fishery

Table 5.8.a Number of recaptures by month and area of HERRING tagged in the Clyde in May-June 1980.

Area of Recovery	Clyde	Irish Sea	NW Ireland
1980 May - June	30	-	-
July	192	2	-
August	155	1	-
September	152	3	3
October	37	2	1
November	21	-	-
December	1	1	-
1981 January - February	5	1	1
Date unknown	10	-	1
Σ	603	10	6

Table 5.8.b Number of recaptures by month and area of HERRING tagged in the Clyde in May 1979

(3 851 tagged fish released)	Area of recovery			
	Clyde	Irish Sea	Minch	N W Ireland
1979 June	197	6	-	-
July	100	4	-	-
August	88	5	-	-
September	48	7	-	-
October	71	2	-	1
November	-	1	1	2
December	-	-	-	-
1980 Jan.-June	9	-	-	-
July	33	-	-	-
August	12	-	-	-
September	17	-	-	-
October	1	-	-	-
November	1	-	-	-
December	-	-	-	-
1981 Jan.-Feb.	3	-	-	-

Table 6.1. HERRING in Division VIIb,c. Nominal catches (tonnes) 1967-80. (Data for 1967-79 from Bulletin Statistique.)

Year	France	German Dem. Rep.	Germany, Fed. Rep.	Ireland	Netherlands	Poland	U.K.	USSR	Unallocated	Total
1967	-	-	-	108	-	-	-	-	-	108
1968	713	-	-	30	525	-	-	-	-	1 268
1969	-	-	71	145	355	-	-	-	-	571
1970	733	-	180	1 518	179	-	-	2	-	2 612
1971	42	-	52	1 646	61	-	-	-	-	1 801
1972	312	-	23	3 154	71	-	-	347	-	3 907
1973	-	-	5	5 036	200	-	-	-	-	5 241
1974	10	-	-	4 412	51	-	25	1 266	-	5 764
1975	20	-	914	5 576	9 815	-	-	646	-	16 971
1976	-	240	28	5 537	12 306	83	-	118	-	18 312
1977	-	-	-	8 727	4 194	-	-	-	-	12 921
1978	-	-	-	7 057	475	-	-	-	-	7 532
1979	-	-	-	14 341	300	-	-	-	-	14 641
1980*)	-	-	1	14 392	1 265	-	1	-	8 500	24 159

Table 6.2. HERRING catch in number $\times 10^{-3}$ in Division VIIb,c.

Year	Winter rings									
	0	1	2	3	4	5	6	7	8	>8
1970	-	60	456	803	1 237	511	9 015	972	408	393
1971	-	387	124	429	532	602	404	6 077	605	316
1972	-	351	4 671	276	1 054	1 143	1 127	626	11 724	1 278
1973	44	4 972	5 270	3 782	1 932	1 117	870	824	729	14 084
1974	-	320	7 394	8 535	3 557	1 789	1 369	1 706	3 620	7 314
1975	962	10 105	15 279	24 409	16 874	11 194	3 911	5 040	5 058	14 877
1976	62	7 717	14 688	16 823	19 733	15 171	5 136	2 624	2 362	10 050
1977	-	2 220	30 016	7 646	9 835	7 415	6 241	3 893	722	1 957
1978	-	1 965	15 829	14 229	4 068	3 678	2 208	1 782	704	1 267
1979	-	3 839	29 607	13 135	15 560	7 149	6 640	4 123	3 163	2 829
1980*)	-	2 391	29 840	52 611	21 249	19 243	6 274	5 328	3 373	3 979

*) Provisional data.

Table 6.3 HERRING in Fishing Areas VIIb,c and southern part of VIa (W. coast of Ireland, Porcupine Bank).
VPA analysis, catch in numbers.

Unit: thousands

	1967	1968	1969	1970	1971	1972	1973	1974	1975
0	0	0	0	0	0	0	53	0	895
1	549	446	1718	251	1193	1176	7474	3490	16113
2	9242	11810	16294	11672	8385	33514	47268	34694	54884
3	94023	4612	21170	22850	8735	23934	81242	42079	39952
4	12219	111505	4816	16849	14980	7112	22906	39179	40528
5	13500	6031	85569	6360	12024	14417	8769	13563	40101
6	10318	3016	5320	62739	5727	12517	12818	6433	12906
7	5642	1508	3004	5169	53254	4966	9451	9462	8320
8	10301	335	1206	3434	3187	60798	2541	8257	12697
9+	13335	2399	2793	3458	3154	4152	55789	27468	34024
TOTAL	169129	141862	141890	132782	110639	162586	248311	184625	260420
	1976	1977	1978	1979	1980				
0	1067	0	0	0	0				
1	17369	4421	9955	4868	2865				
2	35435	41087	42184	51867	40607				
3	42340	13461	29605	19812	64946				
4	28119	15700	25470	19063	25550				
5	27291	11303	11657	9144	22993				
6	18199	8751	5685	8372	8022				
7	5951	4860	4079	5042	7060				
8	3982	1160	8258	4130	4654				
9+	15673	3419	3250	3811	5700				
TOTAL	195426	104162	140143	126109	182397				

Table 6.4 Summarised results of VPA for Divisions VIIb,c and southern part of VIa.

Year	Input F					
	0.2	0.3	0.4	0.6	0.8	
1972	.21	.21	.21	.21	.21	Weighted mean F (2-ringers and older)
1973	.33	.33	.33	.33	.33	
1974	.28	.28	.28	.29	.29	
1975	.41	.43	.44	.26	.26	
1976	.37	.42	.44	.47	.48	
1977	.18	.22	.24	.27	.29	
1978	.21	.27	.31	.37	.41	
1979	.14	.19	.23	.30	.35	
1980	.20*	.30*	.40*	.60*	.80*	
1972	170	170	170	170	170	
1973	166	166	166	166	166	
1974	146	144	143	143	142	
1975	139	134	132	130	128	
1976	108	100	96	92	90	
1977	107	92	84	76	72	
1978	126	102	89	78	72	
1979	163	122	102	82	72	
1980	185*	130*	102*	74*	61*	
1972	255	236	227	219	214	Recruitment (0-ringers) at 1 January Number x 10 ⁻⁶
1973	277	252	240	228	222	
1974	223	198	185	173	166	
1975	365	299	266	233	217	
1976	309	242	209	177	160	
1977	585	433	357	281	244	
1978	293	206	163	121	100	
1979	35*	35*	35*	35*	35*	
1980	-	-	-	-	-	

* Input values or values generated
by input values

Table 7.1 HERRING. Total catches (tonnes) in North Irish Sea (Division VIIa), 1970-1980 (includes industrial catch).

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980*
France	559	1 815	1 224	254	3 194	813	651	85	174	455 ²⁾	1
Ireland	3 933	3 131	2 529	3 614	5 894	4 790	3 205	3 331	2 371	1 805	1 340
Netherlands	-	-	260	143	1 116	630	989	500	98	-	-
U.K.	17 912	21 861	23 337	18 587	27 489	18 244	16 401	11 498	8 432 ¹⁾	10 078 ³⁾	9 272
USSR	-	-	-	-	945	26	-	-	-	-	-
Total	22 403	26 807	27 350	22 598	38 638	24 503	21 246	15 414	11 075	12 338	10 613

*) Preliminary. 1) Includes 68.5 tonnes of spring-spawned herring.

2) No data basis for allocation to stock.

3) Additional unrecorded catch of 106 tonnes estimated.

Table 7.2.1 Fleet Statistics by Stock.
Manx HERRING landed in Isle of Man by U.K. vessels in 1980.

GRT Class	No. of vessels	Gear	Catch (t)	Effort fishing trips	Tonnes per trip ₁)	Trip per boat
< 100	133	Trawl	5 258	1 460	3.6	11
100-149	8	Trawl	344	72	4.8	9
150-249	3	Trawl	43	10	4.3	3.3
250-499	2	Trawl	101	22	4.6	11
>500	0					

Note: 1) Tonnes catch per fishing trip limited by agreed quotas set weekly by management committee of fishermen and administrators.

Table 7.2.2.1 HERRING. Total catch by stock in North Irish Sea, 1970 - 1979.

Country	1970		1971		1972		1973		1974		1975		1976		1977		1978		1979		1980*	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
France	558	-	1 815	-	1 224	-	254	-	3 194	-	813	-	651	-	85	-	87	87	-	-	1	-
Ireland	-	3 933	-	3 131	-	2 529	-	3 614	1 783	4 111	2 406	2 384	1 816	1 389	2 009	1 322	610	1 761	748	1 054	762	578
Netherlands	-	-	-	-	260	-	-	143	1 116	-	630	-	989	-	500	-	98	-	-	-	-	-
U.K.	15 629	2 283	18 758	3 103	19 308	4 029	13 071	5 516	23 639	3 850	15 408	2 836	12 831	3 570	9 837	1 661	7 663	700	9 382	696	7 897	1 375
Total Manx	16 187		20 573		20 792		13 325		30 677		19 283		16 287		12 431		8 458		10 130		8 660	
Total Mourne	6 216		6 234		6 558		9 273		7 961		5 220		4 959		2 983		2 548		1 753		1 953	

Note: 1 = Manx Stock
 2 = Mourne Stock
 * = Preliminary

Table 7.2.3.1

VPA Analysis MANX HERRING.
Catch in numbers.

UNIT: MILLIONS

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.75	4.98	3.64	1.75	12.95	5.63	9.34	13.98	3.64
2	25.24	54.36	41.76	18.74	95.95	38.94	47.46	33.04	32.41
3	27.89	21.91	26.05	22.74	32.55	36.61	17.38	20.29	11.41
4	13.24	18.68	11.28	10.69	19.41	9.44	13.62	5.85	6.18
5	9.42	9.67	13.15	5.52	9.65	6.17	3.88	3.92	1.44
6	2.88	3.41	6.46	4.07	4.09	4.11	2.41	1.16	1.24
7	2.66	1.74	1.96	2.09	4.55	1.89	2.32	0.81	0.57
8+	0.31	1.16	1.27	1.40	1.03	1.34	1.07	1.02	0.35
TOTAL	82.39	115.91	105.57	67.00	180.18	104.13	97.48	80.07	57.24
	1979	1980							
1	3.66	0.66							
2	35.37	22.82							
3	21.29	17.41							
4	3.55	7.27							
5	1.90	1.54							
6	0.85	0.63							
7	0.50	0.21							
8+	0.19	0.12							
TOTAL	67.11	50.66							

Table 7.2.3.2 VPA Analysis MANX HERRING.
Fishing mortalities.

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0.01	0.04	0.04	0.01	0.16	0.06	0.15	0.17	0.05
2	0.37	0.59	0.51	0.29	0.91	0.83	0.87	0.97	0.62
3	0.42	0.55	0.56	0.51	1.02	0.97	1.02	1.08	0.98
4	0.40	0.49	0.55	0.42	0.99	0.83	1.12	1.06	1.05
5	0.70	0.51	0.67	0.50	0.72	0.90	0.90	1.07	0.73
6	0.51	0.53	0.67	0.40	0.76	0.69	0.99	0.66	1.12
7	0.45	0.58	0.58	0.42	0.93	0.87	0.95	1.00	0.70
8+	0.45	0.58	0.58	0.42	0.93	0.87	0.95	1.00	0.70
F(2-7),W	0.42	0.56	0.56	0.40	0.92	0.88	0.94	1.01	0.74
	1979	1980							
1	0.09	0.20							
2	0.77	1.00							
3	0.98	1.00							
4	0.84	1.00							
5	1.00	1.00							
6	1.20	1.00							
7	0.80	1.00							
8+	0.80	1.00							
F(2-7),W	0.85	1.00							

NATURAL MORTALITY: 0.10000

Table 7.2.3.3 VPA Analysis MANX HERRING.
Stock size in numbers x 10⁻⁶.

1 JANUARY

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	141	126	90	187	93	100	71	95	80
2	86	127	109	78	168	72	85	56	73
3	85	54	64	59	53	61	28	32	19
4	42	51	28	33	32	17	21	9	10
5	19	25	28	15	20	11	7	6	3
6	8	9	14	13	8	9	4	3	2
7	8	4	5	0	8	3	4	1	1
8+	1	3	3	4	2	2	2	2	1
Total	390	399	341	396	384	276	222	204	188
Spawning Stock	249	272	250	209	291	176	151	109	109
Biomass (tonnes x 10 ⁻³) at spawning time	29	28	26	25	20	13	10	7	9
	1979	1980							
1	45	?							
2	69	38							
3	35	29							
4	7	12							
5	3	3							
6	1	1							
7	1	0							
8+	0	0							
Total	161	?							
Spawning Stock	116	82							
Biomass (tonnes x 10 ⁻³) at spawning time	8	5							

Table 7.2.4 MANX HERRING larvae, 1974-1980.

Year	Date	No. of larvae		No. of stations
		≤10 mm	>10 mm	
1974	3-4 Oct.	11 850	250	10
1975	2-6 Oct.	3 618	28	14
1976	4-8 Oct.	434	46	14
1977	3-4 Oct.	1 617	15	14
1978	2-3 Oct.	49	21	14
1979	1-2 Oct.	4	61	14
1980	29-30 Sep.	316	181	13

Table 7.3.2.1 MOURNE HERRING stock. Catch in number x 10⁻⁶.

Year	R i n g s									
	0	1	2	3	4	5	6	7	8	8+
1969	48.1	18.2	7.7	1.0	0.0	0.0	0.0	0.00	0.0	0.0
1970	161.5	23.7	3.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0
1971	100.3	47.4	33.1	12.9	1.1	0.4	0.5	0.2	0.2	0.03
1972	78.4	37.0	14.9	0.9	1.9	0.6	0.3	0.7	0.1	0.3
1973	50.2	40.4	14.0	15.5	0.8	1.4	1.0	0.5	1.0	0.2
1974	57.9	30.3	13.6	7.2	5.1	1.0	0.9	0.6	0.2	0.4
1975	20.3	27.7	9.3	2.8	1.4	1.7	0.1	0.2	0.2	0.1
1976	10.4	25.4	8.7	3.4	1.6	0.7	0.4	0.1	0.1	0.1
1977	26.4	16.3	6.0	2.4	0.9	0.6	0.3	0.1	0.1	0.0
1978	20.8	11.9	4.5	2.0	0.6	0.3	0.1	0.1	0.0	0.0
1979	0.0	8.1	2.9	2.2	0.7	0.3	0.2	0.1	0.1	0.0
1980	0.0	5.18	2.94	2.10	1.25	0.44	0.28	0.15	0.08	0.03

Table 7.3.3.1 VPA Analysis.
MOURNE HERRING.
Fishing mortalities.

	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	0.87	0.76	0.67	0.79	0.40	0.27	0.67	0.65	0.00
1	0.71	0.83	1.03	1.00	1.02	1.10	0.76	0.64	0.50
2	2.22	0.45	0.77	1.10	0.89	0.96	0.75	0.43	0.28
3	1.19	0.29	1.04	1.08	0.62	0.86	0.67	0.53	0.35
4	0.29	0.47	0.39	1.11	0.55	0.77	0.51	0.31	0.32
5	0.26	0.23	0.67	1.09	1.37	0.51	0.65	0.28	0.22
6	0.16	0.28	0.65	1.14	0.25	1.44	0.38	0.19	0.27
7	0.48	0.31	0.93	0.93	0.74	0.37	2.17	0.19	0.26
8	1.65	0.42	0.87	1.12	0.84	0.93	0.68	0.00	0.26
9+	1.65	0.42	0.87	1.12	0.84	0.93	0.68	0.00	0.26
F(2- 6),W	1.64	0.42	0.86	1.10	0.82	0.89	0.68	0.43	0.30

	1980	1971-1978
0	0.00	0.63
1	0.10	0.89
2	0.30	0.95
3	0.30	0.79
4	0.30	0.55
5	0.30	0.63
6	0.30	0.56
7	0.30	0.77
8	0.30	0.81
9+	0.30	0.81

F(2- 6),W 0.30

NATURAL MORTALITY: 0.10000

Table 7.3.3.2 VPA analysis. MOURNE HERRING.
Stock size in numbers x 10⁻⁶.

1 JANUARY

	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	.181	154	108	110	65	46	57	46	63
1	.97	69	66	50	45	40	32	26	22
2	.38	43	27	21	17	15	12	13	12
3	.19	4	25	11	6	6	5	5	8
4	.5	5	3	8	3	3	2	2	3
5	.2	3	3	.2	2	2	1	1	2
6	.4	1	2	1	0	1	1	1	1
7	.1	3	1	1	0	0	0	1	0
8	0	0	2	0	0	0	0	0	0
9+	0	1	0	1	0	0	0	0	0
TOTAL	346	283	236	206	140	113	110	95	111
SPAWN. ST.	101	83	85	62	45	40	33	32	34
Spawn.St. biomass at time of spawning (tonnes)	5 161	8 007	5 689	3 379	3 003	2 482	2 499	3 207	3 989
	1980	1981	1971-1978						
0	0*****		96						
1	57		53						
2	12	47	23						
3	8	8	10						
4	5	6	4						
5	2	3	2						
6	1	1	1						
7	1	1	1						
8	0	0	0						
9+	0	0	0						
TOTAL	87								
SPAWN. ST.	48								
Spawn.St. biomass at time of spawning	5 734								

Table 7.3.4.1 MOURNE HERRING. VPA estimates of 0-group abundance and spawning stock biomass at time of spawning.

Year	Spawning Stock	0-group abundance in year +1
1971	5 161	154
1972	8 007	108
1973	5 689	110
1974	3 379	65
1975	3 003	46
1976	2 482	57
1977	2 499	46
1978	3 207	63
1979	3 989	77)
1980	5 734	112) predicted from regression

Table 8.1. SPRAT catches in the North Sea ('000 tonnes), 1971-80 (data provided by Working Group members).

Country	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 ^{a)}
<u>IVa West</u>										
Denmark	-	-	-	5.3	0.5	0.6	0.1	-	-	-
Faroe Islands	-	-	-	0.2	12.9	2.5	0.4	-	-	-
France	-	-	-	-	-	-	+	-	-	-
German Dem.Rep.	-	-	-	-	-	-	+	-	-	-
Germany, Fed.Rep.	-	-	+	-	-	+	0.6	-	-	0.1
Netherlands	+	+	+	+	+	+	+	-	-	-
Norway	0.9	2.2	-	-	1.5	29.9	16.0	1.3	0	-
Poland	-	+	+	-	0.3	-	-	-	-	-
Sweden	-	-	1.0	2.2	11.0	+	0	-	-	-
U.K. (England)	+	-	0.2	-	-	-	0	-	-	-
U.K. (Scotland)	15.0	29.8	49.4	41.2	9.4	12.7	26.9	16.9	6.8	3.8
USSR	-	-	-	1.0	1.5	1.2	+	-	-	-
Total	15.9	32.0	50.6	49.9	36.9	46.9	44.0	18.2	6.8	3.9
<u>IVa East (North Sea stock)</u>										
Denmark	-	-	-	-	-	0.2	0.1	-	-	-
Norway	-	-	-	-	-	1.9	0.7	0.1	+	0.4
U.K. (Scotland)	-	-	-	-	-	+	0	-	-	-
Total	-	-	-	-	-	2.1	0.8	0.1	...	0.4
<u>IVb West</u>										
Belgium	-	-	-	-	-	+	0	-	-	-
Denmark	9.9	14.4	47.0	55.4	106.6	104.4	57.5	44.1	75.3	76.7
Faroe Islands	-	-	-	4.0	30.0	42.9	1.8	-	2.8 ^{b)}	2.8 ^{b)}
France	-	-	-	-	-	-	+	-	-	-
German Dem.Rep.	-	-	-	1.7	4.5	6.4	0.7	-	-	-
Netherlands	+	+	-	-	-	6.4	0	-	-	-
Norway	-	4.1	3.4	9.5	145.7	73.0	5.5	56.2	47.8	18.3
Poland	-	+	-	-	9.1	10.5	0	-	-	-
Sweden	-	-	-	-	-	7.9	0	-	-	-
U.K. (England)	25.5	21.8	34.6	25.5	32.5	49.7	51.9	53.9	12.9	2.4
U.K. (Scotland)	7.2	3.6	2.9	8.6	4.9	18.1	10.9	14.8	5.0	2.5
USSR	1.2	0.8	17.9	32.9	47.8	50.4	1.6	-	-	-
Total	43.8	44.7	105.8	137.7	381.1	362.3	123.9	169.0	143.8	102.7

a) Preliminary figures as reported.

b) IVb East and West.

+ = less than 0.1.

... = No data available.

- = Magnitude known to be nil.

/Cont'd.

Table 8.1 (Continued)

Country	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 ^{a)}
<u>IVb East</u>										
Denmark	19.9	28.8	93.9	104.0	215.2	201.1	126.8	161.0	191.5	149.0
German Dem.Rep.	-	-	-	-	0.4	-	0.7	-	-	-
Germany, Fed.Rep.	5.1	1.7	11.0	17.5	0.5	1.7	4.3	-	1.8	6.1
Norway	-	-	-	-	-	5.1	0	29.8	27.4	33.7
Sweden	-	-	-	-	-	-	1.5	-	-	0.6
Total	25.0	30.5	104.9	121.5	216.1	207.9	133.3	190.8	222.7	189.4
<u>IVc</u>										
Belgium	0.1	0.1	0.2	+	+	-	0	-	-	-
Denmark	-	-	-	0.9	3.9	0.3	1.4	-	1.5	6.5
France	+	-	+	0.3	0.1	-	+	-	-	-
German Dem.Rep.	-	-	-	-	-	0.1	+	-	-	-
Germany, Fed.Rep.	-	+	-	-	-	-	0.4	-	-	-
Netherlands	1.0	0.4	+	+	0.2	-	0	-	-	-
Norway	-	-	-	-	-	-	-	0.2	3.1	16.2
UK(England)	0.2	+	0.8	3.4	2.9	0.7	0.2	0.0	1.4	4.3
USSR	-	-	-	+	+	0.2	-	-	-	-
Total	1.3	0.5	1.0	4.6	7.1	1.3	2.0	0.2	6.0	27.0
<u>Total North Sea</u>										
Belgium	0.1	0.1	0.2	+	+	+	+	+	+	+
Denmark	29.8	43.2	140.9	165.6	326.2	306.6	179.9	205.1	268.3	232.2
Faroe Islands	-	-	-	4.2	42.9	45.4	2.2	-	2.8	2.8
France	+	-	+	0.3	0.1	-	-	-	-	-
German Dem.Rep.	-	-	-	1.7	4.9	6.5	1.4	-	-	-
Germany, Fed.Rep.	5.1	1.7	11.0	17.5	0.5	1.7	5.3	-	3.8	6.2
Netherlands	1.0	0.4	+	-	0.2	+	+	-	-	-
Norway	0.9	6.3	3.4	9.5	147.2	109.9	22.2	87.6	78.6	68.6
Poland	-	+	+	-	9.4	10.5	+	-	-	-
Sweden	-	-	1.0	2.2	11.0	7.9	1.5	-	-	0.6
UK(England)	25.7	21.8	35.6	28.9	35.4	50.4	52.1	53.9	14.3	6.7
UK(Scotland)	22.2	33.4	52.3	49.8	14.3	30.8	37.8	31.7	11.8	6.3
USSR	1.2	0.8	17.9	33.9	49.1	51.8	1.6	-	-	-
Total	86.0	107.7	262.3	313.6	641.2	621.5	304.0	378.3	379.6	323.4

a) Preliminary figures as reported.

Table 8.2 North Sea SPRAT catch in 1974-80. Numbers caught per age group x 10⁻⁶ in each three-month period.

Year	Months	Age group						
		0	1	2	3	4	5	6
1974	Jan-Mar	-	7 620.0	7 341.8	1 043.2	198.7	40.3	-
	Apr-Jun	-	361.8	2 083.5	148.6	26.1	4.7	-
	Jul-Sep	46.7	4 909.8	1 784.7	36.2	0.9	4.6	-
	Oct-Dec	1 549.3	6 172.9	865.1	74.5	10.6	7.2	-
1975	Jan-Mar	-	4 096.6	14 973.2	3 929.0	233.7	14.1	-
	Apr-Jun	-	446.2	1 163.2	68.9	6.5	-	-
	Jul-Sep	15.0	10 588.1	5 760.0	75.1	3.1	-	-
	Oct-Dec	675.2	6 351.6	6 122.5	660.2	57.3	4.4	-
1976	Jan-Mar	-	9 360.9	9 997.0	6 678.0	373.0	6.2	1.4
	Apr-Jun	-	2 017.2	964.6	740.1	40.9	0.8	-
	Jul-Sep	79.6	16 536.4	599.5	40.1	-	-	-
	Oct-Dec	2 780.4	8 443.7	2 659.4	612.7	37.1	-	-
1977	Jan-Mar	-	4 197.2	11 962.6	962.9	104.7	12.0	-
	Apr-Jun	-	540.3	670.9	52.7	1.5	-	-
	Jul-Sep	57.3	2 803.1	3 248.4	165.9	11.1	-	-
	Oct-Dec	1 060.8	4 705.0	3 049.5	311.2	1.5	-	-
1978	Jan-Mar	-	2 461.9	2 839.3	3 770.1	344.5	-	-
	Apr-Jun	-	1 077.5	123.8	3.2	0	-	-
	Jul-Sep	6.3	17 785.5	216.5	14.7	0.7	-	-
	Oct-Dec	636.8	6 932.7	3 955.8	1 159.0	214.9	-	-
1979	Jan-Mar	-	2 770.0	6 422.2	2 670.6	131.2	0.7	-
	Apr-Jun	-	203.6	452.0	14.0	1.1	-	-
	Jul-Sep	-	25 379.1	388.3	2.1	0	-	-
	Oct-Dec	433.0	8 394.8	1 494.6	122.4	34.9	-	-
1980	Jan-Mar	-	1 448.0	12 764.4	1 323.2	103.7	0.7	-
	Apr-Jun	-	134.0	84.5	2.4	0.3	-	-
	Jul-Sep	15.1	10 143.3	811.6	4.7	-	-	-
	Oct-Dec	515.7	4 518.5	2 767.4	111.8	19.5	-	-

Table 8.3 Total North Sea SPRAT catch 1974-80. Number caught per age group x 10⁻⁶ in each Division.

Area	Year	Age Group						
		0	1	2	3	4	5	6
IVaW	1974	961.6	2 963.1	693.0	112.0	12.2	-	-
	1975	267.2	2 011.1	1 025.4	363.6	11.1	2.2	-
	1976	938.5	2 777.2	715.0	365.3	26.5	0.3	-
	1977	472.5	3 354.4	1 255.8	212.3	5.9	-	-
	1978	199.0	2 312.2	226.9	175.0	15.7	-	-
	1979	254.3	1 049.6	52.6	6.1	0.3	-	-
	1980	-	29.9	485.4	41.9	4.2	-	-
IVaE	1976	6.1	46.1	38.0	24.8	1.3	-	-
	1977	3.1	26.1	15.3	7.8	-	-	-
	1978	-	1.3	4.8	0.7	0.1	-	-
	1979	-	-	-	-	-	-	-
	1980	-	-	-	-	-	-	-
IVbW	1974	609.4	6 848.1	6 033.4	1 095.6	220.8	49.5	20.7
	1975	665.4	5 110.0	17 287.0	4 396.0	282.7	17.0	-
	1976	1 004.2	14 903.6	12 280.6	7 586.0	423.0	6.7	1.4
	1977	480.8	3 878.1	8 538.4	1 144.2	112.1	12.0	-
	1978	444.1	3 839.6	4 917.9	439.0	490.6	2.4	-
	1979	158.2	5 485.3	5 278.6	1 833.9	116.9	0.7	-
	1980	75.8	2 374.0	8 512.8	334.8	41.0	0.7	-
IVbE	1974	3.3	8 486.7	4 727.9	116.5	1.7	3.9	-
	1975	9.8	13 169.0	9 282.0	149.5	6.3	-	-
	1976	911.2	18 631.4	1 193.1	94.9	0.2	-	0.01
	1977	163.5	4 941.4	8 779.7	108.4	-	-	-
	1978	-	23 179.4	1 977.5	370.1	56.1	-	-
	1979	19.8	30 091.8	3 054.2	836.1	40.4	-	-
	1980	384.3	13 463.7	5 580.8	627.8	44.5	-	-
IVc	1974	21.7	766.2	620.8	28.6	1.8	3.3	-
	1975	-	1 182.4	499.1	45.8	1.8	-	-
	1976	-	-	Negligible	-	-	-	-
	1977	-	45.6	342.2	20.0	0.8	-	-
	1978	-	0.2	6.8	10.9	0.2	-	-
	1979	0.7	120.8	371.5	133.0	9.5	-	-
	1980	70.7	376.2	1 848.1	437.7	33.9	-	-
<u>Total</u>								
34 401.8	1974	1 596.0	19 064.1	12 075.1	1 352.7	236.5	56.7	20.7
55 784.4	1975	942.4	21 472.5	28 093.5	4 954.9	301.9	19.2	-
61 975.4	1976	2 860.0	36 358.3	14 226.7	8 071.0	451.0	7.0	1.4
33 918.6	1977	1 118.1	12 245.6	18 931.4	1 492.7	118.0	12.0	-
41 543.2	1978	643.1	28 257.6	7 135.4	4 947.0	560.1	2.4	-
48 914.3	1979	433.0	36 747.5	8 756.9	2 809.1	167.1	0.7	-
34 769.0	1980	530.8	16 243.8	16 427.9	1 442.2	123.6	0.7	-

Table 8.4 North Sea SPRAT 1980 in Danish landings.
Mean weight (g) by month.

Month	1	2	3	4	5	6	7	8	9	10	11	12	·1 - 12
Age group													
0								2.00	2.25	2.15	3.00	4.65	3.16
1	1.96	1.88	1.60			6.47	6.45	7.37	9.10	12.25	9.95	10.31	7.85
2	8.86	6.23	5.80	9.50	14.27	14.27	11.35	13.95	14.32	19.44	19.43	14.34	9.73
3	13.56	16.04	13.33					19.00		21.87	27.88	20.00	15.41
4	21.60	19.27											20.65

Table 8.5 VPA Analysis North Sea SPRAT.

FISHING MORTALITY

	1974	1975	1976	1977	1978	1979	1980
0	0.011	0.004	0.026	0.009	0.004	0.007	0.006
1	0.165	0.375	0.397	0.290	0.703	0.601	0.750
2	0.473	0.827	1.034	0.798	0.559	1.151	1.500
3	0.540	0.780	1.554	0.571	1.184	1.015	1.500
4	0.236	0.443	0.284	0.142	0.987	0.200	0.200
5+	0.236	0.443	0.284	0.142	0.987	0.200	0.200
F(1-3)	0.39	0.66	1.00	0.55	0.82	0.92	1.25

STOCK SIZE IN NUMBERS

1 JANUARY

	1974	1975	1976	1977	1978	1979	1980	1981
0	218840	351278	158668	174619	253873	95472	140541	*****
1	180435	97290	157225	69431	77732	113653	42616	62803
2	45130	68764	30038	47518	23354	17299	27996	9045
3	4547	12635	13508	4800	9611	6002	2458	2807
4	1609	1191	2601	1283	1218	1322	978	246
5+	527	76	48	130	5	6	6	362
TOTAL	451089	531234	362088	297781	365793	233752	214594	
Spawning biomass (1000 tonnes)	668	905	664	586	441	378	345	194

Table 8.6 VPA Analysis North Sea SPRAT.

FISHING MORTALITY

	1974	1975	1976	1977	1978	1979	1980
0	0.011	0.004	0.028	0.010	0.004	0.008	0.006
1	0.169	0.390	0.413	0.308	0.724	0.662	1.000
2	0.473	0.865	1.113	0.858	0.614	1.241	2.000
3	0.436	0.780	1.791	0.673	1.439	1.251	2.000
4	0.103	0.319	0.284	0.197	1.452	0.300	0.300
5+	0.103	0.319	0.284	0.197	1.452	0.300	0.300
F(1- 3)	0.359	0.678	1.106	0.613	0.926	1.051	1.67

STOCK SIZE IN NUMBERS

1 JANUARY

	1974	1975	1976	1977	1978	1979	1980	1981
0	212112	339714	150543	170796	236059	78587	140541	*****
1	175844	94267	152028	65780	76014	105648	35029	62803
2	45130	66705	28692	45207	21723	16551	24488	5790
3	5410	12635	12623	4237	8616	5284	2150	1489
4	3487	1573	2601	946	971	918	679	131
5+	1141	100	48	96	4	4	4	227
TOTAL	443123	514993	346536	287063	343387	206994	202891	
Spawning biomass ('000 tonnes)	749	863	635	546	406	344	296	142

Figure 2.3. Percentage of herring in samples of sprat catches 1979-80.

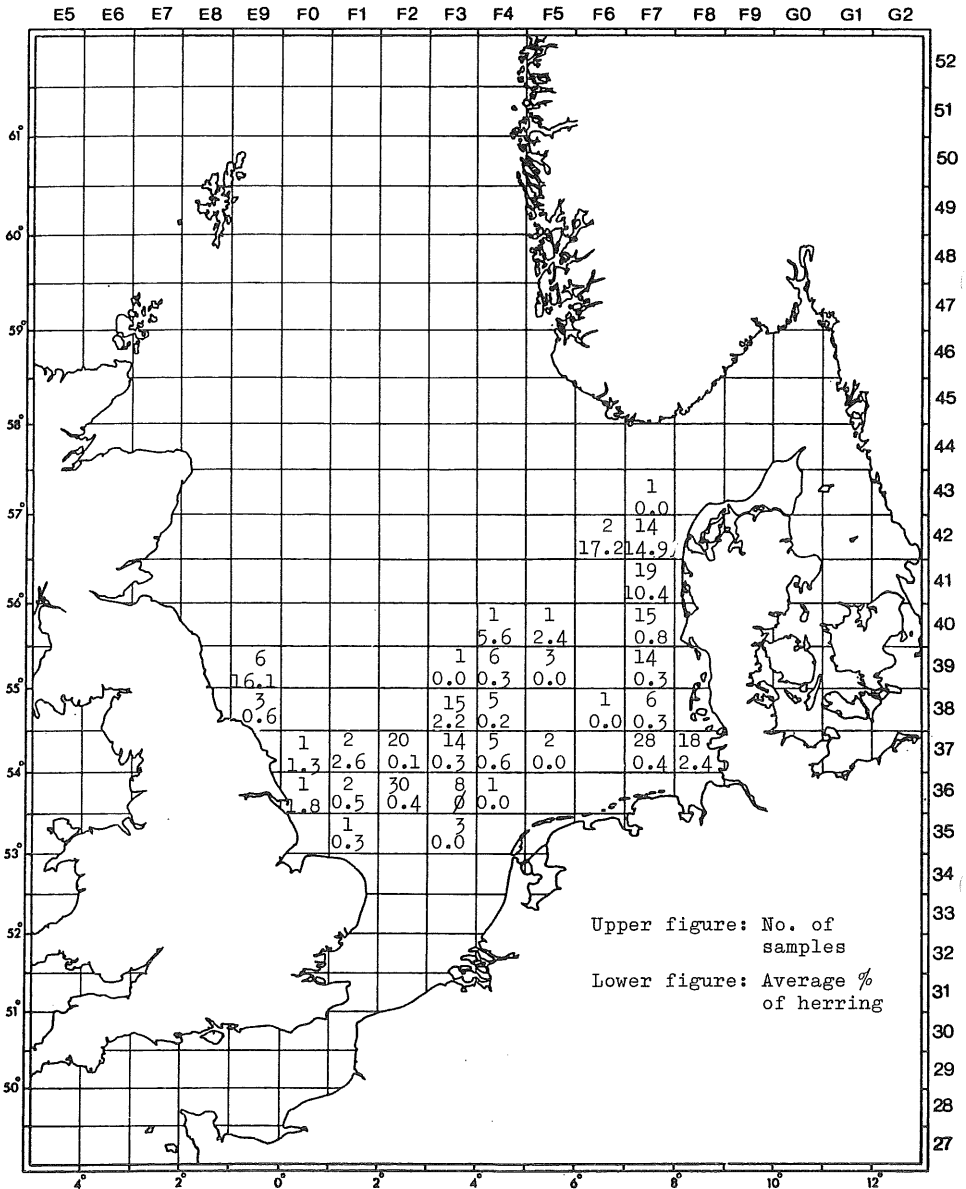


Figure 2.4. Herring, southern North Sea (Divisions IVc + VIIId)
Y/R and spawning stock biomass/R

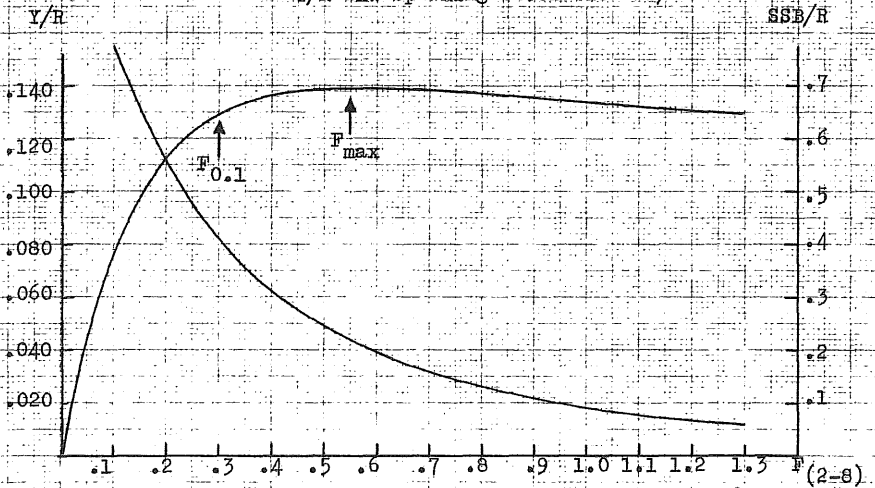
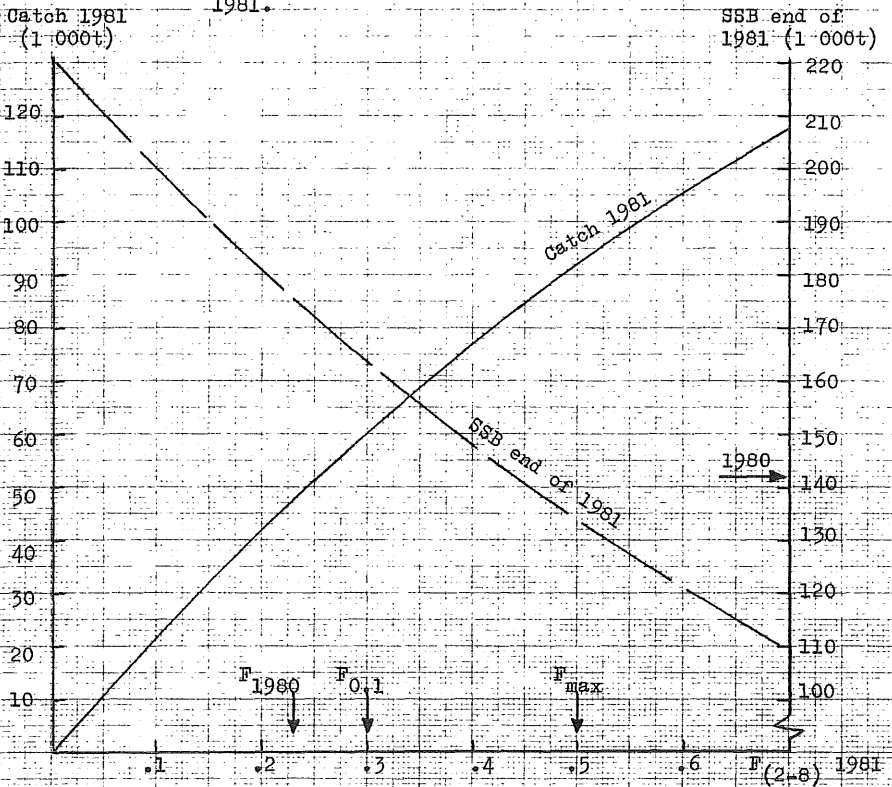


Figure 2.5. Catch in 1981 and spawning stock biomass at the end of 1981 for different levels of F in 1981.



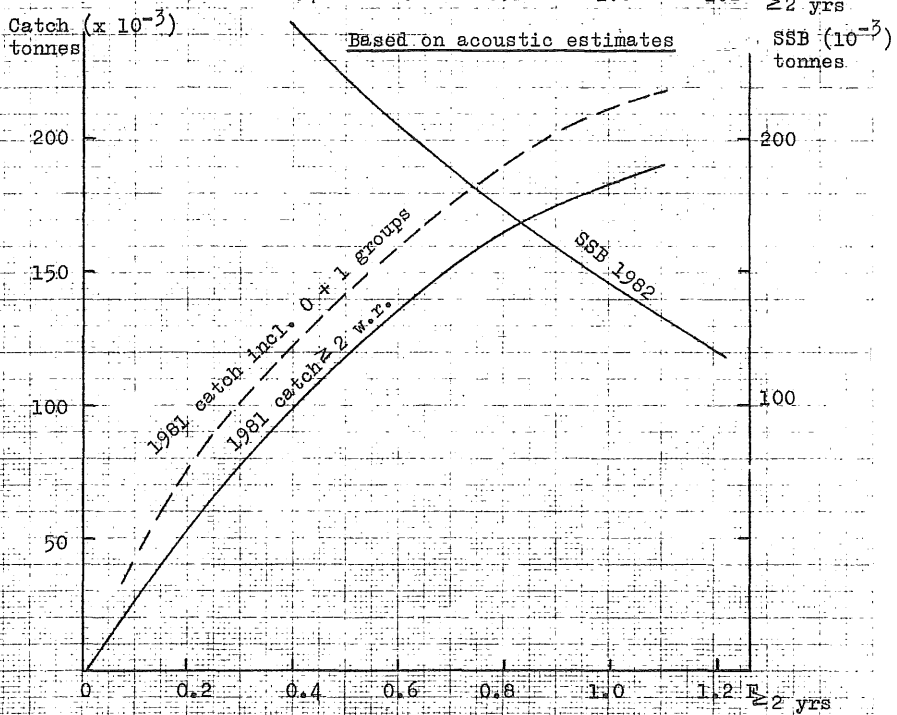
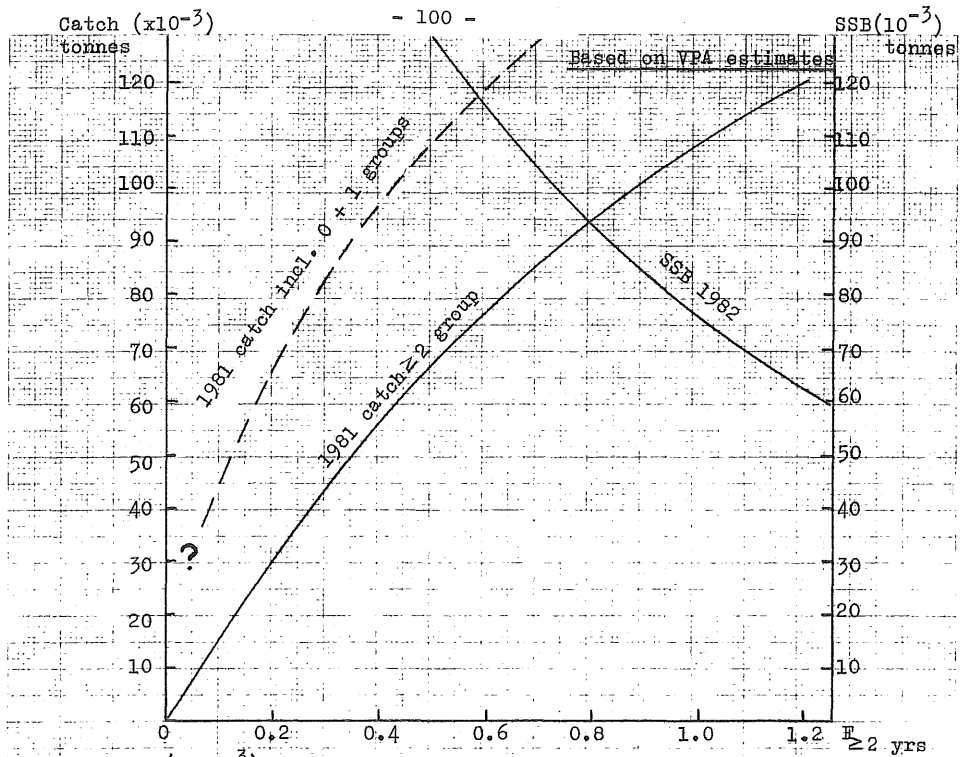
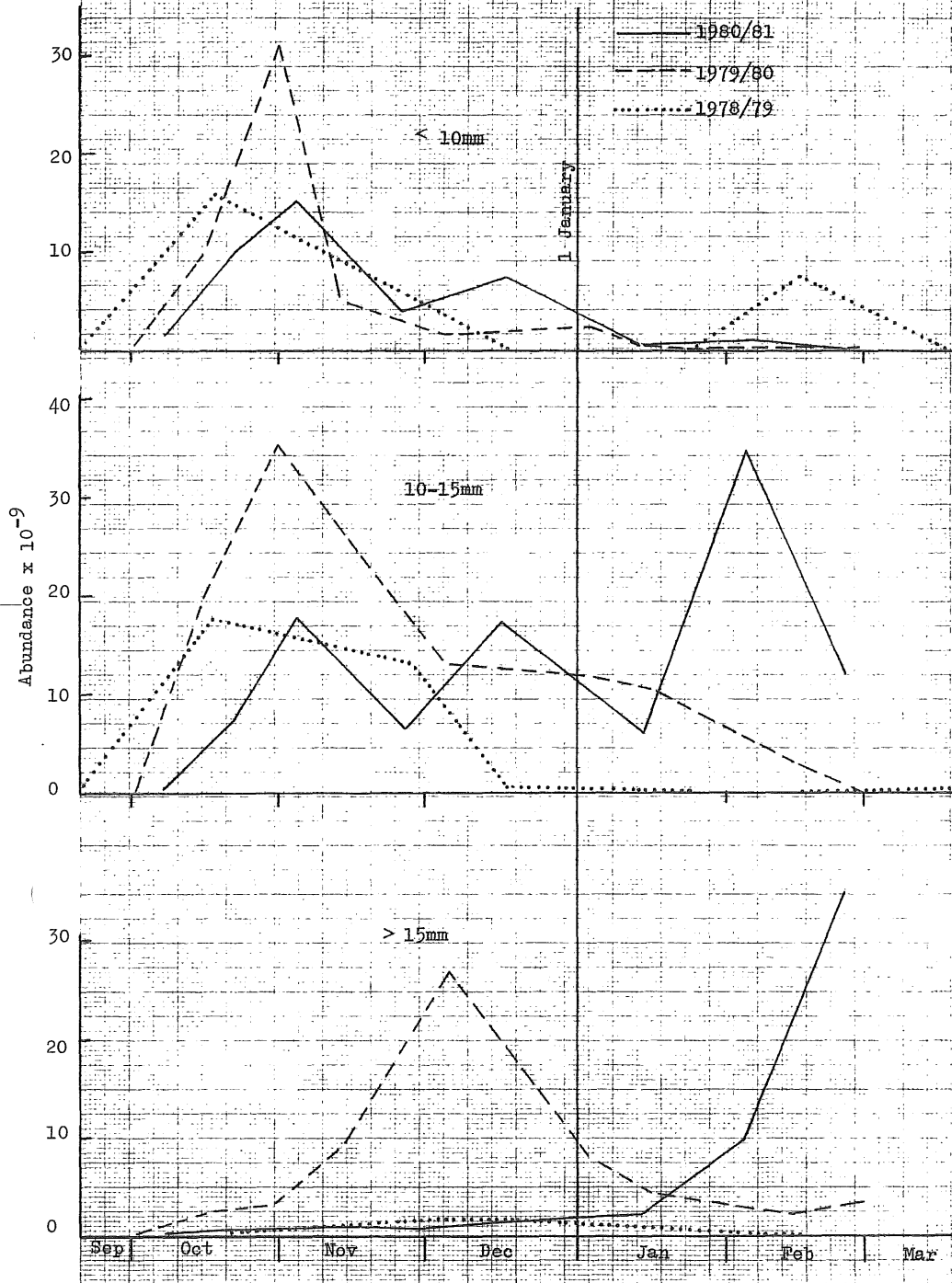


Figure 3.1. Catch in 1981 and spawning stock biomass 1 January 1982 plotted against $F(2+)$ in 1981.

Figure 4.1. Celtic Sea herring. Larval abundance plotted against time (cruise mid-date).



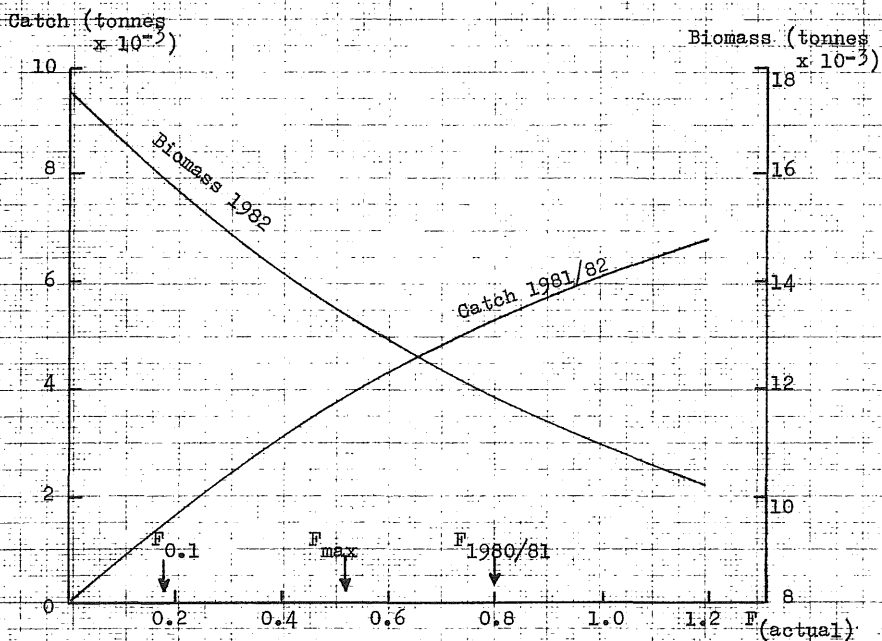


Figure 4.2. Celtic Sea herring catch in 1981/82 and biomass (1.9 ringers) at 1 April 1982 plotted against F in 1981/82.

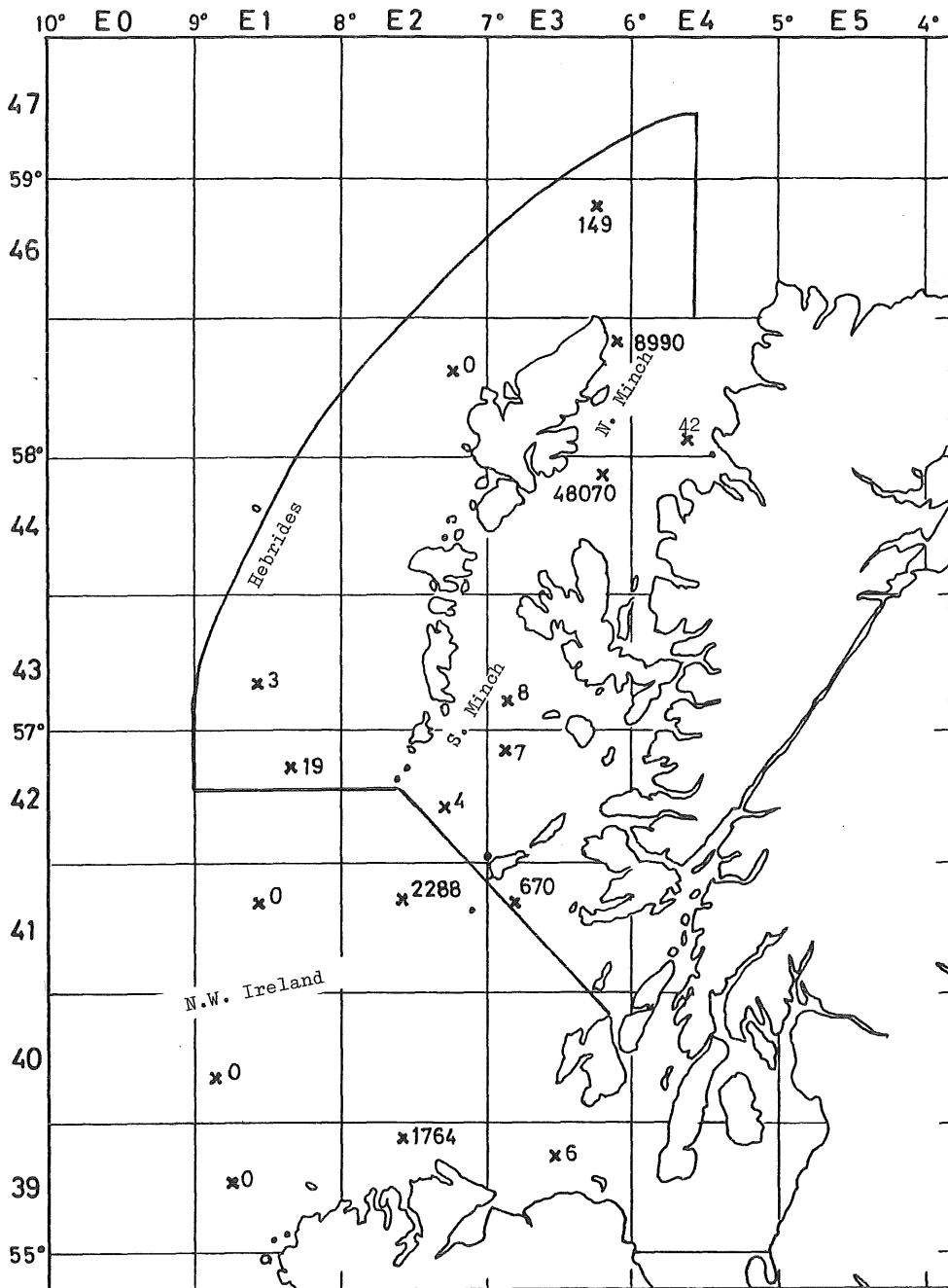


Figure 5.1. Division VIa survey: FRS EXPLORER 14.3.80 - 2.4.80.
n = number of herring caught per hour.

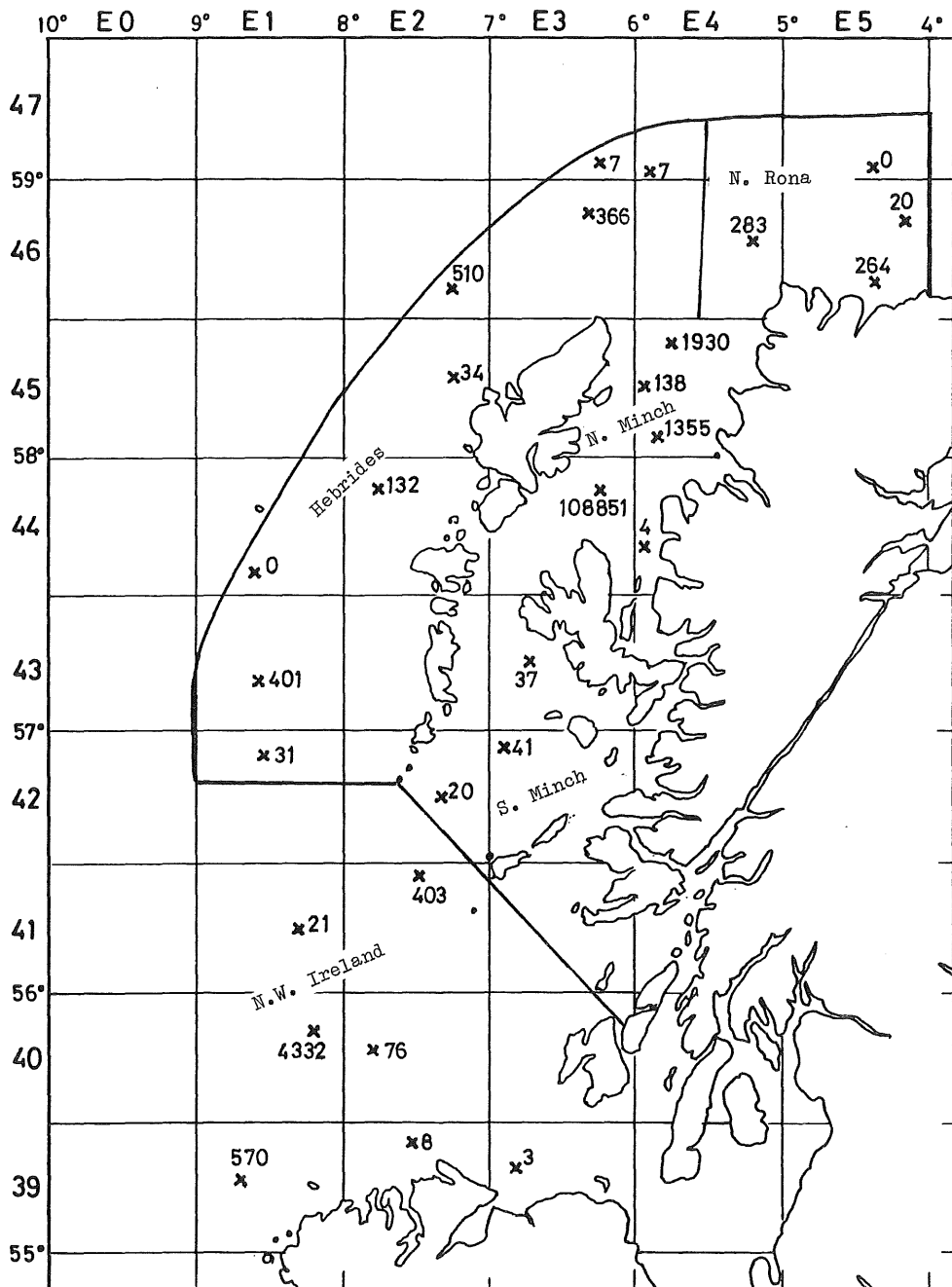


Figure 5.2. Division Via survey: FRS SCOTIA 25.2.81 - 16.3.81.
n = number of herring caught per hour.

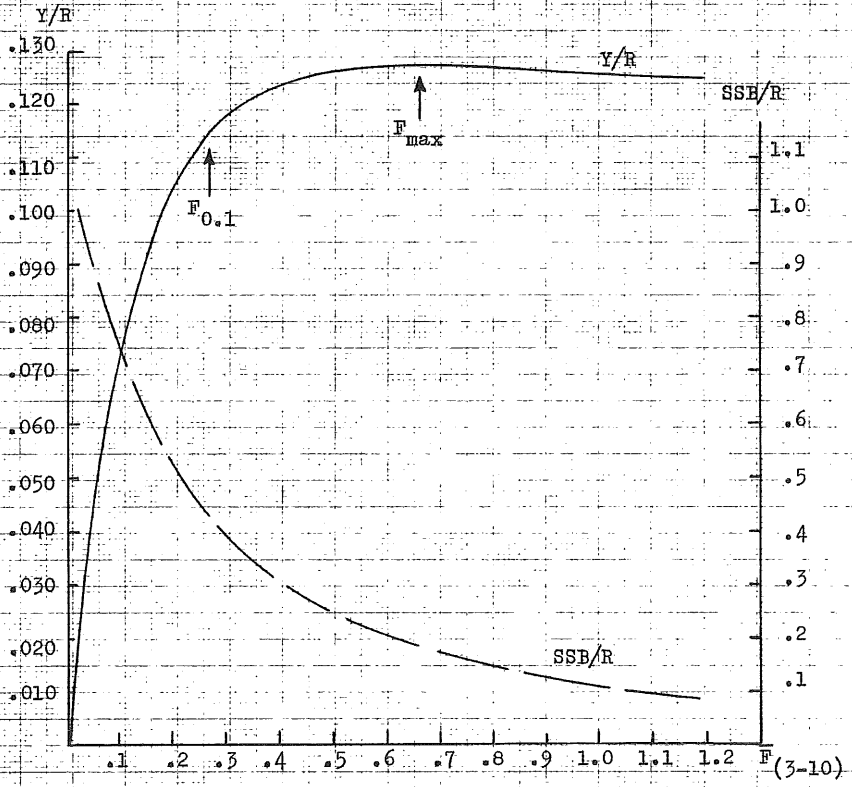
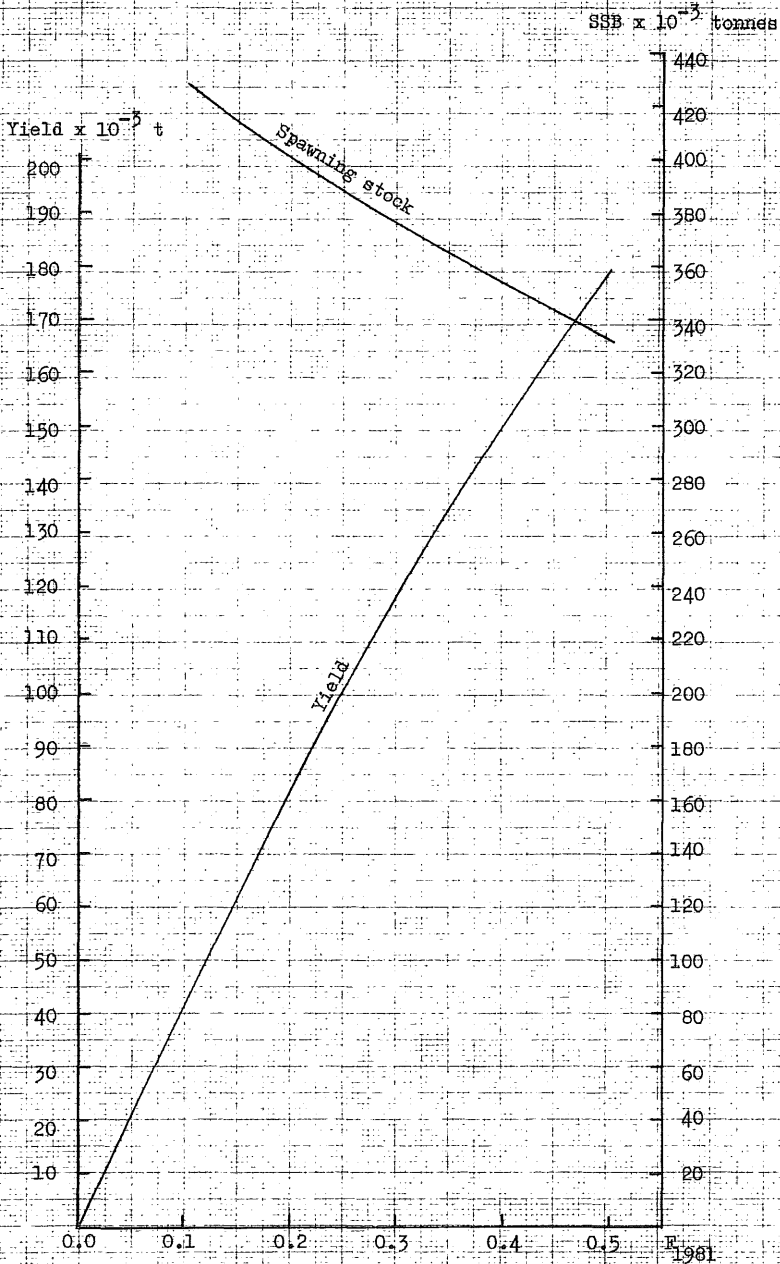


Figure 5.6. Herring in Division VIa. Yield per recruit and spawning stock biomass per recruit.

Figure 5.4. Spawning stock biomass and yield in 1961 for Division
Via stock at different values of F .



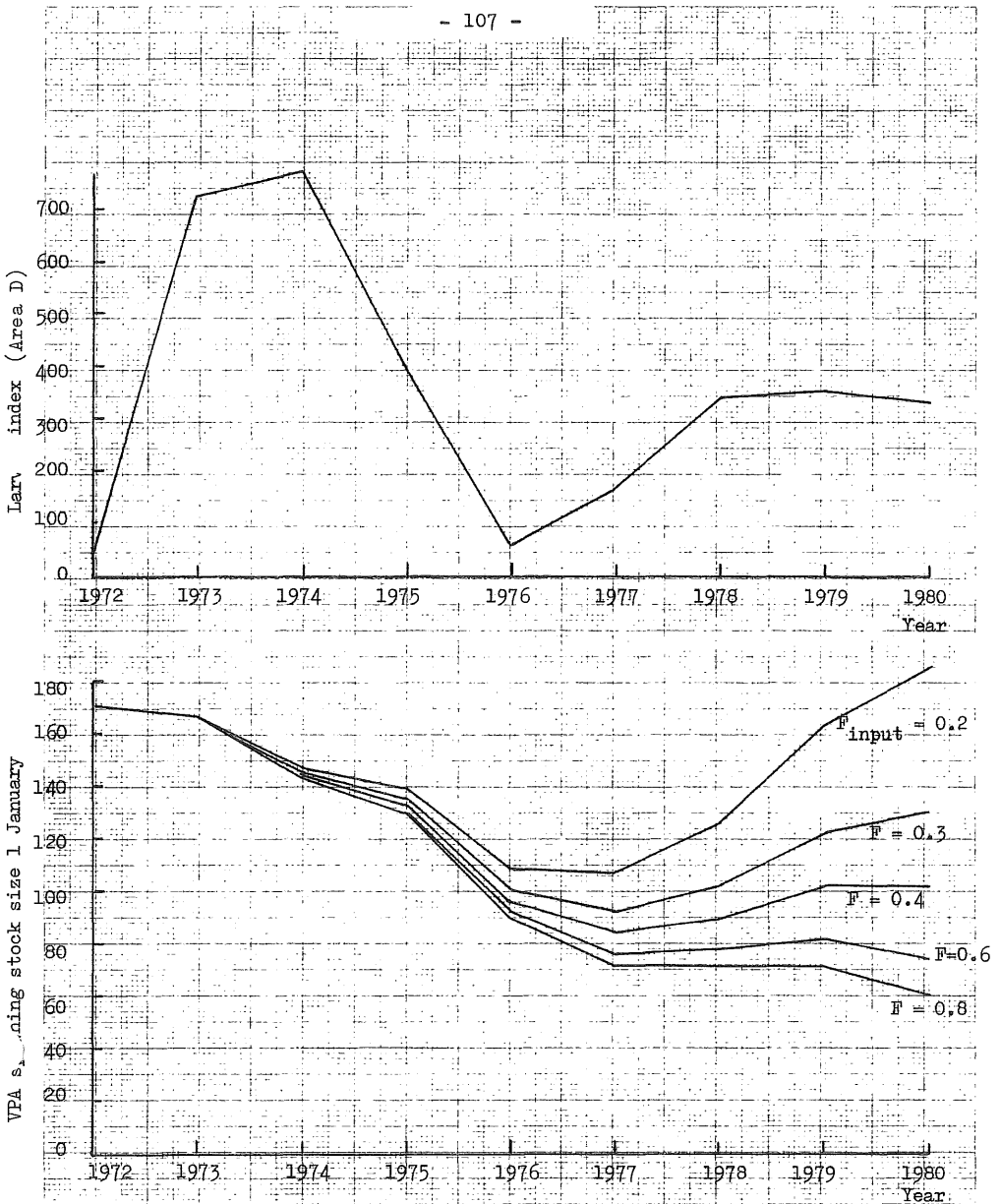


Figure 6.1. Indices of larval production in the area northwest of Ireland and biomasses of 2-fingers and older at 1 January from the VPA of herring in Divisions VIIb,c and the southern part of Division VIa combined, using different values of input F.

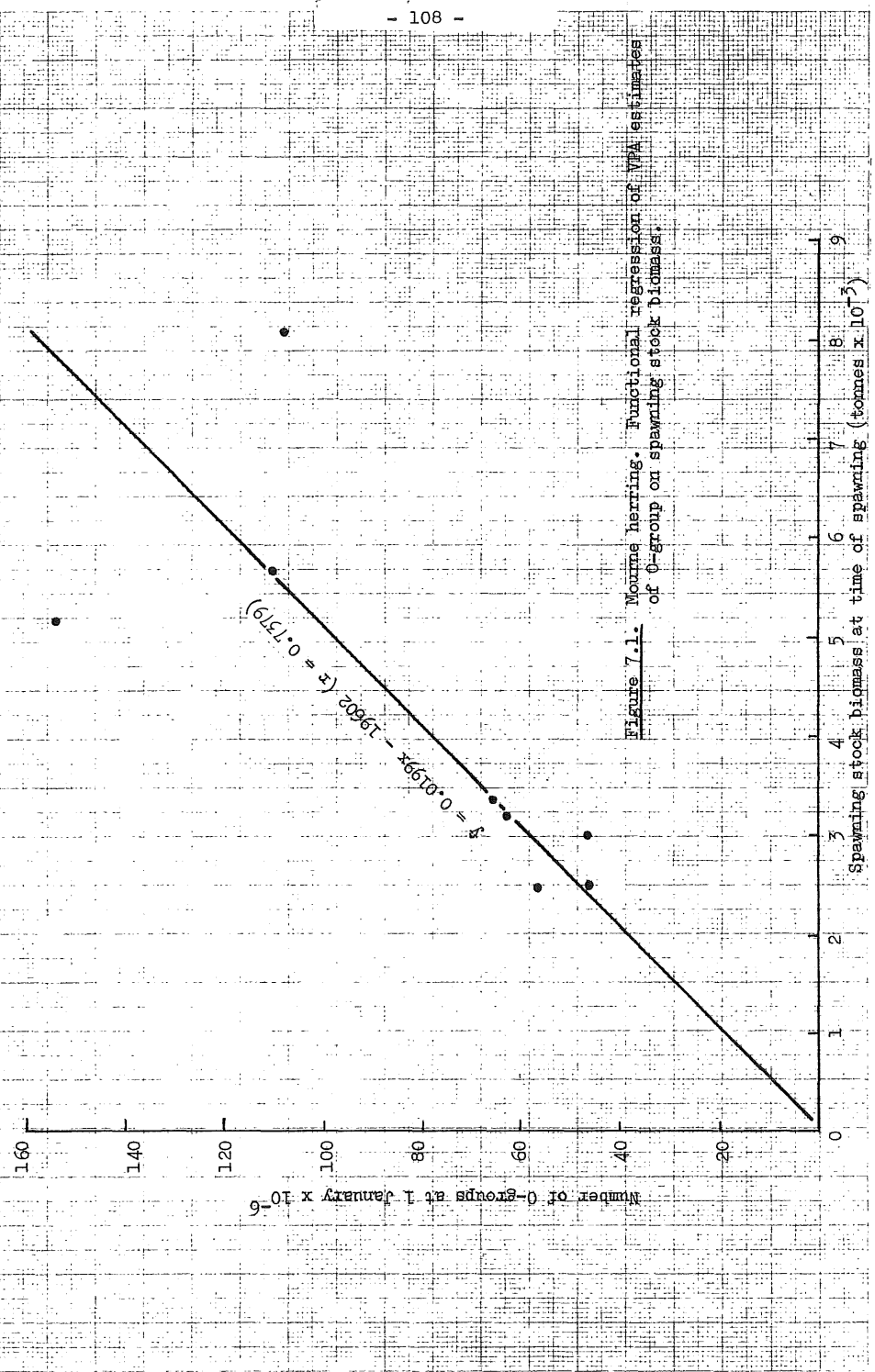


Figure 7.1. Mourne herring. Functional regression of VPA estimates of 0-group on spawning stock biomass.

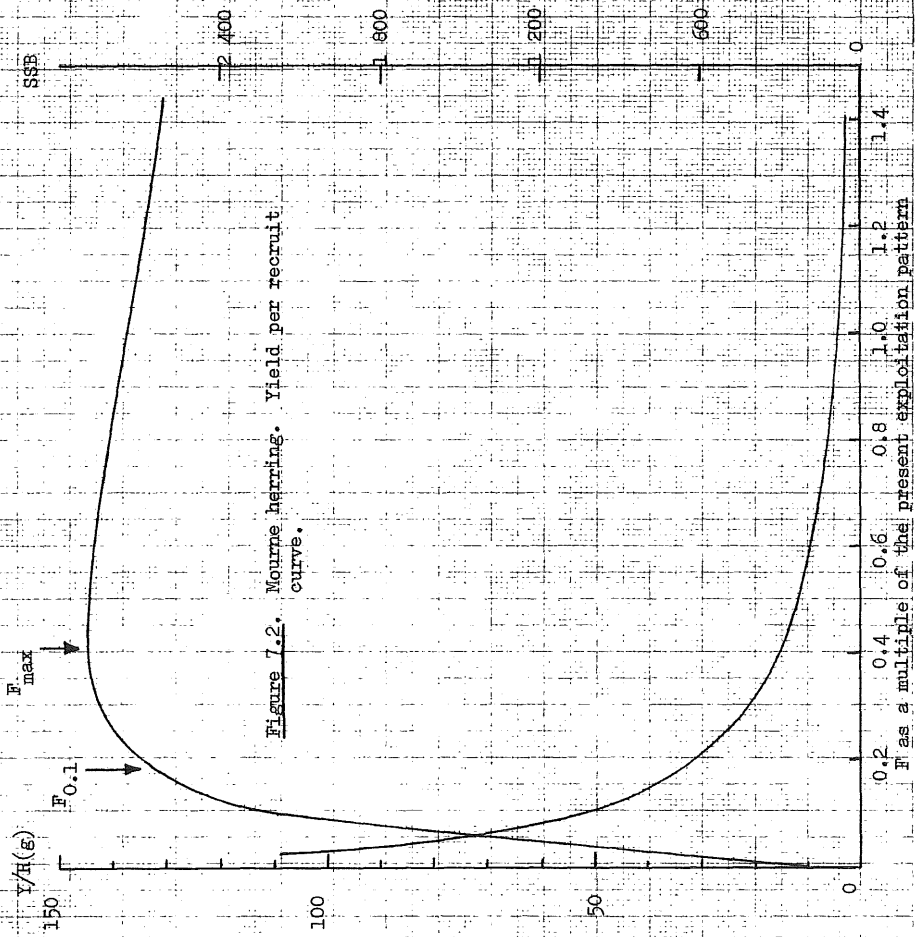


Figure 7.2. Mourne herring. Yield per recruit curve.

F as a multiple of the present exploitation pattern

Figure 7.2.5(a). Manx herring. Catch forecast for 1981 and resulting spawning stock biomass 1981 at spawning time for a range of fishing mortality.

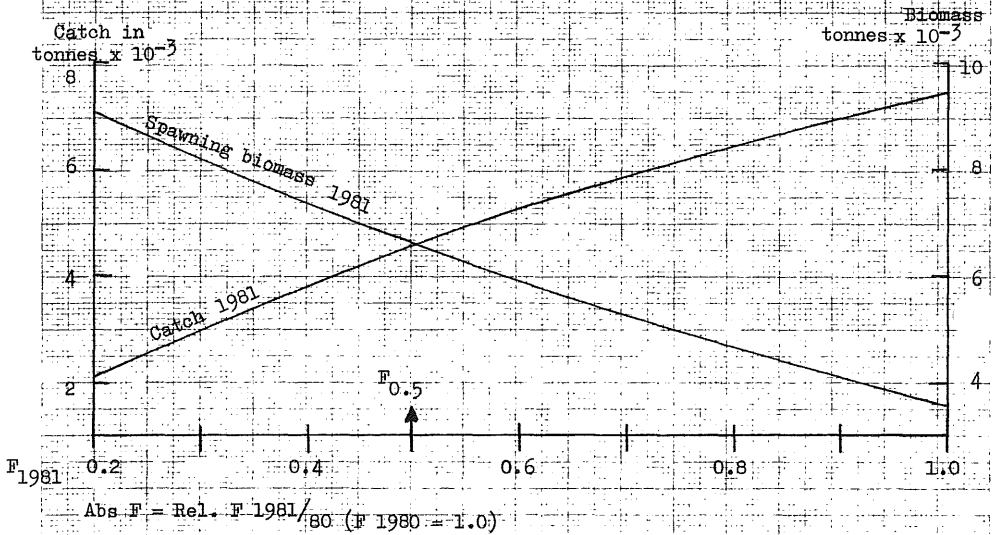


Figure 7.2.5(b). Manx herring. Catch forecast for 1982 and resultant spawning stock 1982 at spawning time assuming $F_{1981} = 0.5$.

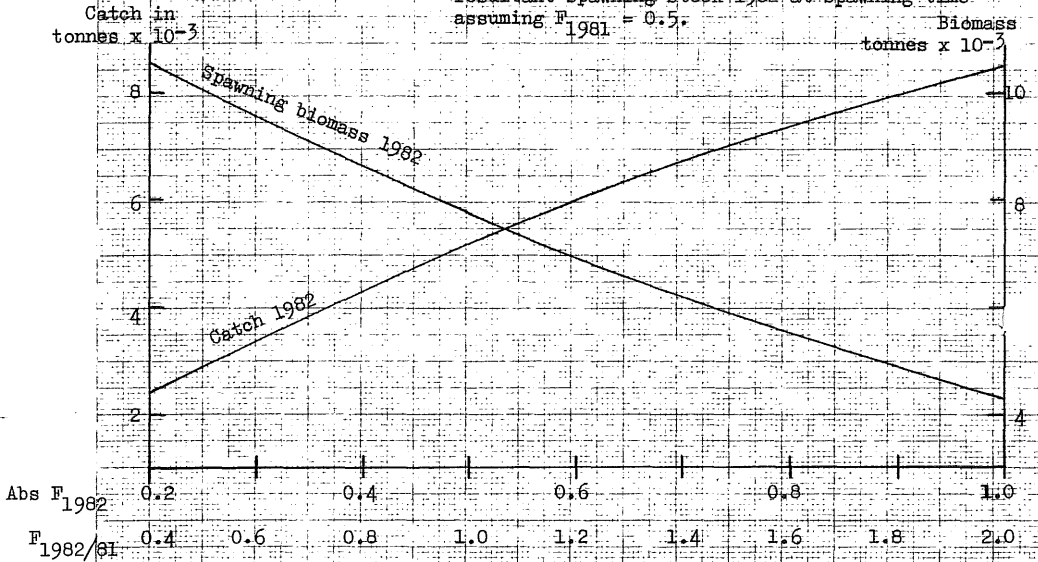


Figure 7.2.5(o). Manx herring. Catch forecast for 1982 and resultant spawning stock 1982 at spawning time assuming $F_{1981} = 0.2$.

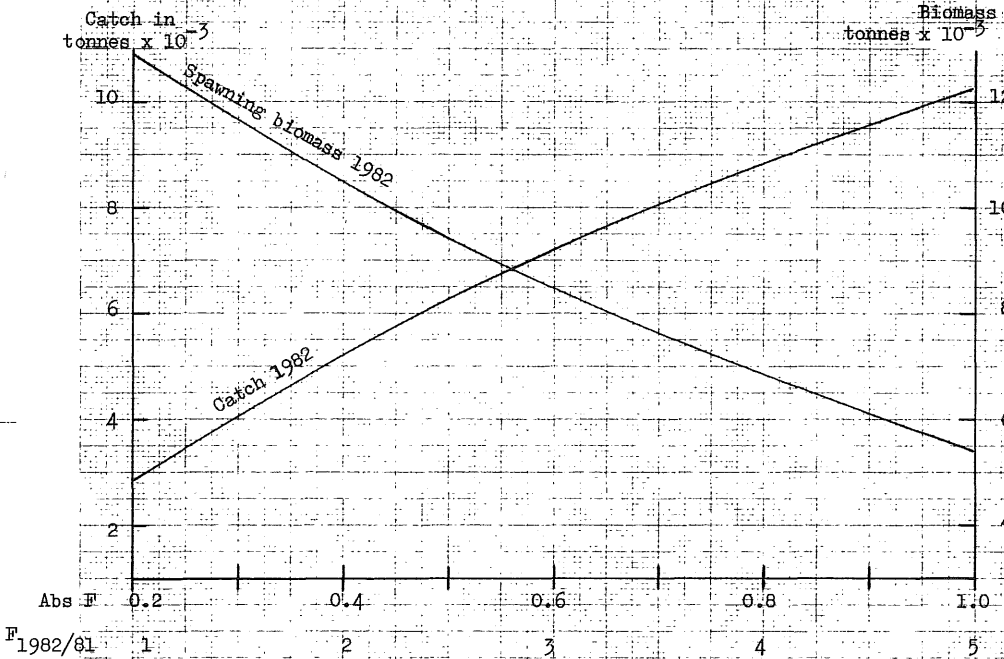


Figure 7.2.6. Manx herring. Yield per recruit and biomass per recruit.

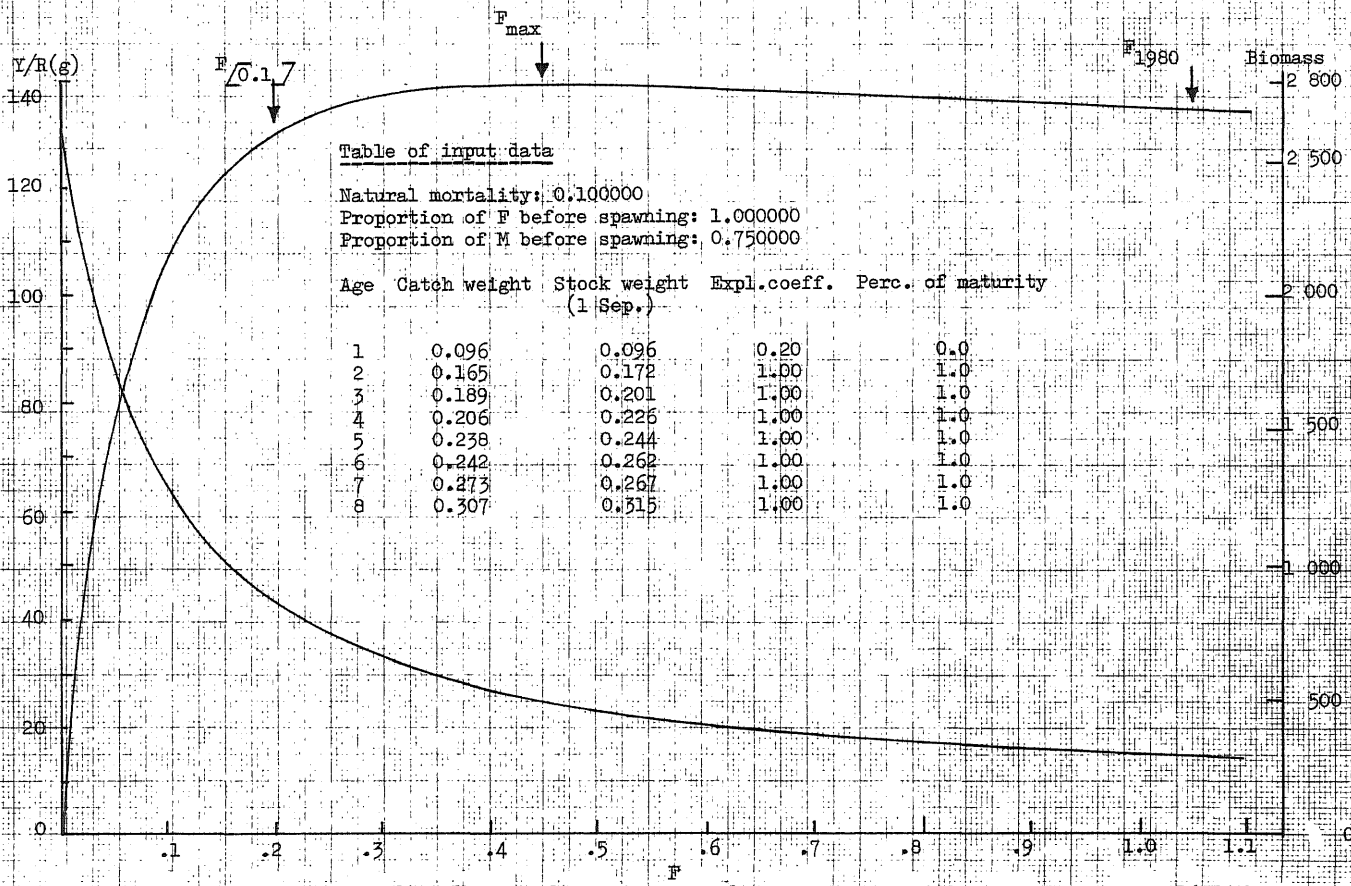


Figure 7.3. Mource herring. Catch Forecasts for 1981 and resultant stock biomass at time of spawning for a range of fishing mortalities in 1981.

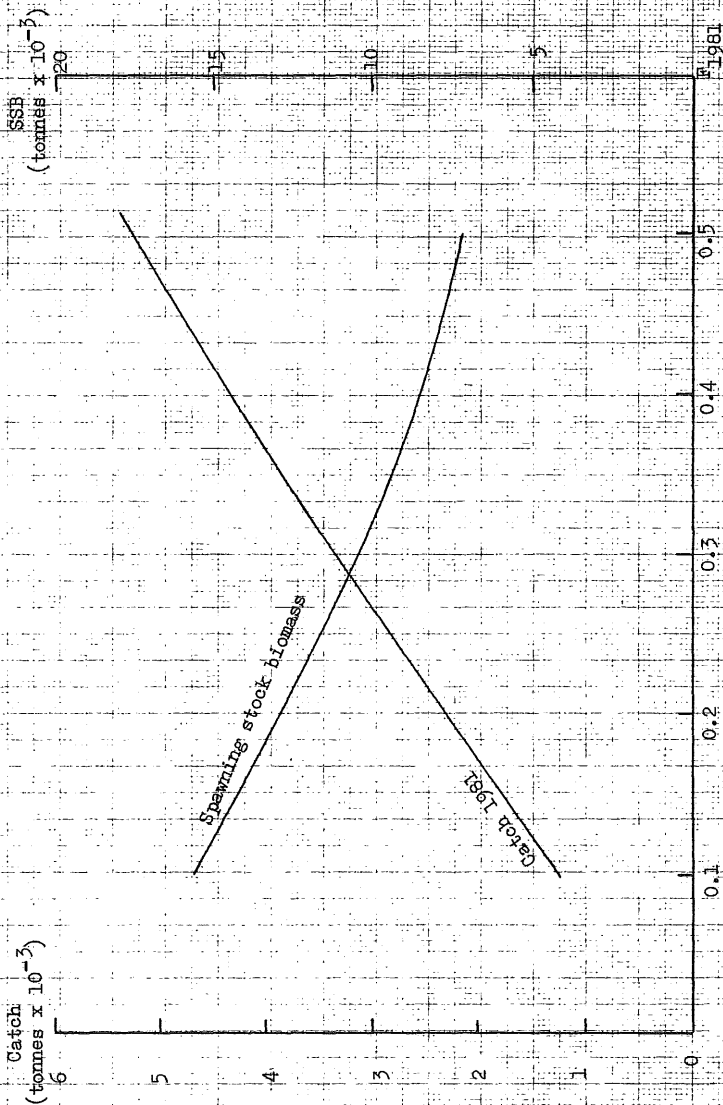


Figure 8.1. Calculated biomasses of sprat ('000 tonnes) per half statistical rectangle in the English and Scottish acoustic surveys (a) and the Norwegian acoustic survey (b) in January 1981.

