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REPORT OF THE
HERRING ASSESSMENT WORKING GROUP FOR THE AREA SOUTH OF 62^{0}N

Copenhagen, 24 March - 3 April 1987

*General Secretary
ICES
Palægade 2-4
DK-1261 Copenhagen K
DENMARK

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1 INTRODUCTION

1.1 Participants

A. Aglen	Norway
D.J. Agnew	UK (N. Ireland)
R.S. Bailey (Chairman)	UK (Scotland)
J. Bertrand	France
A.R. Brand	UK (Isle of Man)
V. Christensen	Denmark
A. Corten	Netherlands
O. Hagström	Sweden
O. Halldórsson	Iceland
P. Hopkins	UK (Scotland)
P.O. Johnson	UK (England)
B.W. Jones	UK (England)
E. Kirkegaard	Denmark
K. Popp Madsen (part-time)	Denmark
E. Moksness	Norway
J. Molloy	Ireland
N.A. Nielsen (part-time)	Denmark
A. Schumacher	Federal Republic of Germany
B. Sjöstrand (part-time)	Sweden
H. Sparholt	Denmark

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

1.2 Terms of Reference

In accordance with C.Res.1986/2:5:11, the Herring Assessment Working Group for the Area South of 62^{0}N met at ICES Headquarters from 24 March - 3 April 1987 to:

a) consider the report of the ad hoc Multispecies Assessment Working Group;

b) assess the status of and provide catch options for 1988 within safe biological limits for the herring stocks in Division IIIa, Sub-area IV (and, if possible, separately for Division IVa, Division IVb, and Divisions IVc and VIId), Divisions Va and VIa, and Sub-area VII;

c) provide quarterly catch-at-age and catch and stock mean weight-at-age data and information on the relative distribution at different ages by quarter for North Sea herring for 1986 as input for the Multispecies VPA (to establish an historic data base, appropriate experts should meet on 23 March 1987);

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

e) consider ways to provide catch options for herring in Division IIIa given a combined assessment of herring in Division IIIa and Sub-divisions 22-24 in the Western Baltic;

f) consider safe biological limits and appropriate strategies for the exploitation of each herring stock.

1.3 General Considerations

The area sub-divisions used in the assessment of herring stocks are given in the previous report (Figure 1.3.1 in Anon., 1986a). The only revision to this concerns the Celtic Sea herring assessment (see Section 4.1).

At the request of ACFM, the Working Group adopted new values of natural mortality rate (M) for ages 0 and 1 in the North Sea based on recommendations by the Multispecies Working Group (MSWG) (Anon., 1987a). The MSWG also recommended new values of M for older age groups, and after some smoothing, these were also adopted. Details of these changes are given in Section 2.2. Since it is likely that these new values of M apply more widely than to the North Sea alone, they have also been used in the assessments for other stocks except the Icelandic summer-spawning herring (see Section 8.3). The values used in each stock are listed under the appropriate sections. Changing the values of M used in assessments has repercussions on all aspects of the assessment and predictions. For this reason, the full series of estimates of F and stock size are given in each section, together with new values of biological reference points.

1.4 Safe Biological Limits and Management Strategies for Herring Stocks

At its present meeting, the Working Group had on its terms of reference to "consider safe biological limits and appropriate strategies for the exploitation of each herring stock". This subject was discussed at the 1986 meeting both in relation to herring stocks in general and in relation to a number of individual stocks. The conclusion of that meeting of the Working Group was that a definition of safe biological limits can be obtained more readily from historic time series of stock parameters than from stock-recruitment considerations.

In its evaluation of this approach, ACFM, however, felt that the Working Group should inspect the information provided on stock and recruitment scatter plots (Anon., 1986a) and also indicated that biological reference points based on recruitment considerations might be identified in addition to the conventional ones based on yield-per-recruit calculations.

These questions are considered in more detail in the appropriate sections dealing with each stock.

In considering the subject of herring stock management, the Working Group placed emphasis on the concept of a "buffer stock" which provides a hedge against recruitment fluctuations, thereby reducing the inevitable fluctuations in TAC advice in heavily exploited stocks in which the recruiting year class is a prominent part of the catch. It also reduces the likelihood of a decrease in the stock to levels at which recruitment may be im-

paired as a result of any stock-recruitment relationship.

The idea of a "buffer stock" is not a new concept and an indication of its appropriate magnitude can in principle be estimated from considerations of stock and recruitment. In practice, however, the lack of any identifiable stock-recruitment relationship makes it impossible to define the level of "buffer stock" required to avoid stock-induced recruitment failure. This is essentially why the Working Group at its last meeting preferred to examine the historic record. For several stocks, it is possible to identify periods of relatively stable stock size in which recruitment fluctuated without trend around the long-term average level. The stock size during these periods could then be looked upon as an appropriate size of "buffer stock".

However "buffer stock" is defined or calculated, there is more than one way of managing a fishery to establish and maintain it. The size of the "buffer stock" is, within certain limits, a management choice rather than a purely biological one depending on the risk management is prepared to take. The greater the "buffer stock", the longer the period of weak recruitment that can be bridged.

1) In principle, it could be maintained by "creaming off" the surplus production each year, but this would, of course, give rise to large fluctuations in catch between years.

2) Another alternative is to set a constant TAC at a level that is not expected to allow erosion of the stock below the "buffer" level. This approach has the advantage of providing the fishing industry with foreseeable catch levels for planning its commercial operations and investments.

On the other hand, it would lead to fluctuations in fishing mortality and stock size according to normal recruitment variability. It should be stressed, however, that not only are there annual variations in recruitment, but in most stocks, there have been periods of low recruitment extending over a number of years. Hence, no constant level of TAC can be maintained indefinitely unless it is set at such a low level that it would unnecessarily limit catches during periods of good recruitment.

After a period of weak recruitment when the lower end of the "buffer stock" might be reached, downward adjustment of the stable TAC system is unavoidable. Due to the time-lag between when the seriousness of the situation is recognized and when management is able to react to the new situation, this adjustment might be quite substantial with serious consequences for the fishing industry.

3) A further alternative way of maintaining a "buffer stock" is management at stable levels of fishing mortality. This strategy results in fluctuations in TAC levels as well as in stock biomass. The extent of these fluctuations, however, depends largely on the level of fishing mortality selected as the management target and on the age structure of the stock. If the "buffer stock" is well developed due to low fishing mortality and contains a sufficient number of age groups, then these fluctuations in TAC and biomass will remain within

a tolerable range. With stable fishing mortality, if properly selected, a "buffer stock" above a given level can be maintained.

A gradual downward adjustment in TACs will be the unavoidable consequence during a period with below-average year classes. However, the annual reduction in TAC in such a situation is expected to be less severe compared to a sudden and considerable reduction in TAC that might become necessary under a stable TAC regime.

Under a constant F regime, higher catch levels above the usual range might be possible during a period with above-average year classes. So long as temporary increases in TACs do not lead to the generation of additional catching capacity, this should not present any particular problems.

Fishery management on the basis of fishing mortality does not necessarily mean that F has to be constant. If management wishes to react to fluctuations in recruitment as early as possible, then fishing mortality can be selected at such a level that will be compensated by recruitment. Constancy of TACs cannot be guaranteed by this method, but so long as F is set at the correct level, fluctuations will be buffered by the fact that the recruiting year class will not constitute the major part of each year's TAC. Management bodies would also have the option of smoothing the fluctuations in TAC further, if required.

The appropriate level of F is that which will, on average, be compensated by recruitment. It can be estimated to a first approximation by superimposing lines of constant spawning stock biomass per recruit on the stock-recruitment scatter plot as described by the Methods Working Group (Anon.,1984a). If the aim is to preserve a "buffer stock", then the appropriate level of F is the one corresponding to a line that goes through the median of the stock-recruitment points within the range of "buffer stock" size (Figure 1.4.1).

The Working Group recognized that the management bodies may have particular objectives in managing each herring stock and was, therefore, not in a position to choose between strategies that maximize catch levels in each year or maximize stability.

Regardless of the management strategy selected, it has to be remembered that the word "strategy" implies consistency, which means that once a choice has been made, the approach should be maintained over a long time period, otherwise the management objective will never be reached.

2 NORTH SEA HERRING

2.1 The Fishery

2.1.1 ACFM advice applicable to 1986

At its 1985 meeting, ACFM recommended the following TACs for 1986:

Divisions IVa,b	235,000 t
Divisions IVc, VIId	37,000 - 42,000 t

The TAC for Divisions IVa and IVb was based on a preferred management option of $F_{0.1}$, with fishing mortality on 1-ring herring 29% of the adult F, equivalent to a 1-ring catch of 19,000 t.

The range advised for Divisions IVc and VIId was based on two $F_{0.1}$ options. The lower value assumed the TAC of 90,000 t taken in 1985, and the upper with 50,000 t caught. (A catch of 69,000 t was recorded for 1985.) It was also considered appropriate that up to 20% of the TAC for Divisions IVc and VIId could be transferable to Division IVb to allow for an unknown proportion of this stock likely to be exploited in that division. It was also clearly stated that "since the herring in the management area are not yet firmly re-established, it is reiterated that fishing at $F_{0.1}$ is the level of exploitation on this stock preferred by ACFM".

The TACs adopted by the management bodies were 500,000 t for Divisions IVa,b and 70,000 t for Divisions IVc and VIId.

2.1.2 Catches in 1986

The 1986 landings, including both officially and unofficially reported catches, are shown in Table 2.1.1 for the total North Sea and for each division in Tables 2.1.2-2.1.5. The total provisional catch was 544,801 t compared with 534,173 t in 1985, representing a small increase.

Unallocated catches amounted to 21,094 t (3.9% of the total) compared with 73,641 t in 1985. The Netherlands and unallocated catches included an estimate for discards of 10% of the total.

Adult herring catches

A breakdown of adult herring catches (2-ring and older) by ICES division and quarter is provided in the text table below. The values were derived from the sum of products of estimated numbers and mean weights at age provided by Working Group members.

Division	Quarter (1986) I	II	III	IV	Total
IVa (W of 2^0E)	71.2	35.5	95.3	36.3	238.3
IVa$_2$ (E of 2^0E)[1]	14.0	41.8	6.9	6.9	69.6
IVb[2]	1.4	6.2	25.3	10.0	42.9
IVc + VIId	6.8	0.6	0.5	43.0	50.9
Total	93.4	84.1	128.0	96.2	401.7

[1] Excluding 12.4 transferred to Division IIIa from the second and third quarters.
[2] Excluding 6.7 transferred to Division IIIa from the second and third quarters.
Weights in '000 t.

This table excludes catches of 19,126 t from the second and third quarters transferred to Division IIIa from Divisions IVaE and IVb (see Section 3.1). These were identified as a spring-spawning component discriminated by vertebral number.

Most catches of adult herring were taken in purse seine fisheries and trawl fisheries using a mesh size not less than 32 mm. Considerable catches of 1-ring herring were also taken with these gears in Divisions IVaE and IVb.

The combined catch of 2-ring and older in Divisions IVa and IVb was thus estimated at 350,730 t which compares with the ACFM recommended $F_{0.1}$ TAC of 235,000 t (including 19,000 t of 1-ringers) and an agreed TAC of 500,000 t.

In Divisions IVc and VIId, a catch of 51,000 t was taken compared with the ACFM recommended range of 37,000 - 42,000 t and agreed TAC of 70,000 t.

Juvenile herring catches (0- and 1-ring)

A catch breakdown for juvenile herring is provided in the following text table using data supplied by Working Group members:

Division	Age group	Quarter (1986) I	II	III	IV	Total
IVa (W of 2^0E)	0	-	-	-	-	-
	1	-[1]	1.6	1.4	2.3	5.3
IVa (E of 2^0E)	0	-	-[1]	1.2	0.2	1.4
	1	-[1]	0.4	14.8	16.5	31.7
IVb	0	-	0.3	2.1	-[1]	2.4
	1	3.5	1.7	37.1	38.2	80.5
IVc + VIId	0	-	-[1]	-[1]	-[1]	-[1]
	1	0.1	-[1]	0.2	0.3	0.6
Total	0	-	0.3	3.3	0.2	3.8
	1	3.6	3.7	53.5	57.3	118.1

[1] Less than 50 t.
Weight in '000 t.

The total catch of juvenile herring (122,000 t) shows a considerable increase on that of 1985 (69,250 t) largely due to increased catches of 1-group fish. In 1986, the North Sea catch in weight of 1-ring herring increased by a factor of two from about 58,320 t in 1985 to 118,120 t in 1986 (SOP values). This increase is not reflected in the catch-in-number table (Section 2.1.3) where a relatively small increase is shown (1,620 million in 1985; 1,763 million in 1986). This was primarily due to the fact that a much higher proportion of the 1-ring catch was taken later in the year, shown by the change in mean weight in the catch between 1985 and 1986 from 36 g to 67 g, representing a 46% increase (see Section 2.8).

The 0-group component registered a marked decrease (3,800 t in 1986 compared with about 11,600 t in 1985) mainly due to enforcement of the Danish west coast "sprat box".

Description of fisheries taking 0- and 1-ring fish

Most of the juvenile catch is taken in Division IVaE and the eastern half of Division IVb during the third and fourth quarters of the year. 0- and smaller 1-ring fish are taken in the shallow water coastal fisheries by smaller vessels with 16 mm mesh bottom trawls, and the larger 1-ring fish in deeper water by bigger industrial trawlers using 32 mm and smaller mesh trawls in the eastern half of the central North Sea.

In 1986, there was an increase in the fishery for larger 1-ring herring in both Divisions IVaE and IVb using purse seines, the catches taken mainly for reduction purposes. Relatively small quantities of 1-ring herring were also taken in the primarily adult directed fisheries in Division IVaW and the western half of Division IVb (about 2% of the total in 1986). A more detailed analysis of this is presented in Table 2.7.1.

2.1.3 Catch in number

Age compositions for landings from the North Sea in 1986 were presented by the main countries fishing herring. Data were available for each quarter and for each of Divisions IVa west, IVa east, IVb, and IVc + VIId. For countries which had not reported age compositions, the age compositions of other countries having similar fisheries were used. The data were summed for each area by quarter (Table 2.1.6) and the quarters were summed to give an annual total (Table 2.1.7). Annual data for the areas were then aggregated to give catch age compositions for Divisions IVa and IVb and Sub-area IV as used as input for VPA. (Tables 2.7.11 and 2.7.14).

Some catches of adult fish in Divisions IVa east and IVb taken in an area south and southwest of Norway in the second and third quarters were considered, on the basis of vertebral count data, to be spring spawners. It was considered inappropriate to include these fish in the North Sea assessment, and these catches amounting to 19,126 t were transferred to the Division IIIa assessment (see also Section 3.2.2).

As in previous years, it was not possible to estimate the quantity or number of North Sea fish which were caught in Division IIIa.

Total North Sea age compositions for the period 1970-1986 are summarized for comparison in Table 2.1.8 and these data for the most recent six years are given in the text table below:

Millions of herring caught by age group (winter rings)

Year	0	1	2	3	4	≥5	Total
1981	7,889	447	264	57	40	77	8,773
1982	9,557	840	268	230	34	34	10,963
1983	10,030	1,147	545	216	105	85	12,128
1984	2,189	561	987	417	190	152	4,496
1985	1,293	1,620	1,223	1,188	368	217	5,908
1986	704	1,763	1,155	827	458	237	5,145

The contribution of the 0- and 1-group fish to the catch amounted to 48% in 1986, remaining at the same level as in 1985 (49%) and well below the 92-95% recorded for the years 1981-1983 before the introduction of the "sprat box" off the west coast of Denmark.

The recruiting 1983 year class (2-group) contributed about 43% by number to the adult catch (age groups 2 and older).

Detailed age compositions for 1986 by area and quarter are given in Table 2.1.6, and the percentage contributions of 2- and 3-group and older fish by area and quarter are given in Table 2.1.9.

2.2 Natural Mortality

The results from the ICES Stomach Sampling Project in 1981 and the analyses of these data in the Multispecies Working Group have formed the main elements in the discussion about natural mortality at the two most recent meetings of this Working Group. This year, the report of the ad hoc Multispecies Assessment Working Group (Anon., 1987a) was available to the Working Group.

The text table below summarizes the natural mortalities which have been used by the Herring Assessment Working Group since 1964 and the results of the Multispecies Working Group.

Age	Herring Assessment WG meetings in years				Multispecies WG meetings		
	1964-1970	1970-1983	1984-1986	1987	1984[1]	1985[2]	1986[3]
0	0.20	0.10	1.00	1.00[4]	1.07	0.82	1.067[4]
1	0.20	0.10	0.80	1.00	0.46	0.84	1.023
2	0.20	0.10	0.10	0.30	0.13	0.16	0.253
3	0.20	0.10	0.10	0.20	0.44	0.30	0.274
4	0.20	0.10	0.10	0.10	0.13	0.12	0.131
5	0.20	0.10	0.10	0.10	0.19	0.13	0.131
6	0.20	0.10	0.10	0.10	0.10	0.12	0.117
7	0.20	0.10	0.10	0.10	0.10	0.10	0.100
8+	0.20	0.10	0.10	0.10	0.10	0.10	0.100

[1] Anon. (1984b) key-run, mean 1974-1983.
[2] Anon. (1986b) key-run, mean 1974-1984.
[3] Anon. (1987a) key-run, mean 1978-1982.
[4] Mortality rate per half year.

The Multispecies VPA carried out in 1986 was, according to Anon. (1987a), an improvement on the 1985 MSVPA mainly because:

1) New values were used for M_1, i.e., that fraction of the natural mortality which was caused by factors other than predation by the five MSVPA predators. These new M_1 values were based on new information about predation by sea birds, seals, and other predator fish than the five MSVPA predators.

2) New values were used for mean weight at age in the sea by species. The old figures were typically regarded as being too high, especially for the younger age groups.

3) The consumption rates of the predators used in the MSVPA were related to the weight of the predators, which consequently meant that lower values for weight at age of the predators gave lower consumption rates and thus lower predation mortalities on the prey.

4) O-group fish in the first and second quarters were excluded.

Besides these changes, some of the basic stomach data from the Stomach Sampling Project in 1981 and some of the quarterly catch data and technical details were corrected or improved in the 1986 version of the MSVPA.

As can be seen from the text table above, the Working Group decided to follow the recommendation from the Multispecies Working Group (Anon., 1987a) to use the array of mean natural mortalities for 1978-1982 from the key-run of the MSVPA 1986 version. The figures were, however, to a minor extent smoothed and rounded off.

2.3 Recruitment

2.3.1 IYFS indices

Following a recommendation by the IYFS Working Group, nearly all participants had supplied length distributions and age-length keys by the time of the meeting. The length distributions were processed by the ICES Secretariat, and mean length distributions per rectangle were supplied to the Working Group. These length distributions were split into age groups by hand using age-length keys supplied by six of the participating countries. The provisional survey index calculated in this way is almost certainly within 5% of the final value.

The IYFS Working Group also suggested a method for calculating confidence limits around the predicted value of year-class strength (Anon., 1987b). The IYFS Working Group stressed that extra care should be taken when extrapolating outside the range of existing data pairs, because the predicted value then solely depends on the reliability of the model used. This warning is especially appropriate in the present year when the new IYFS index is more than twice the value of the biggest year class used in calculating the IYFS/VPA regression.

Because of the changes in VPA for the total North Sea (Section 2.8.3), the IYFS/VPA regression had to be recalculated. The data for the 1968-1981 year classes used for the regression are given in Table 2.3.1. The predictive regression of VPA on IYFS (shown in Figure 2.3.1) has an intercept which is not significantly different from zero, and it has, therefore, been forced through the origin. The resulting formula is

$$Y = 0.0062\ X$$

in which Y = VPA estimate of 1-ringers in numbers x 10^9 and X = IYFS abundance of 1-ringers in no/hour for the standard area.

2.3.2 IKMT indices

The validity of the IKMT index as an early indicator of year-class strength is supported by the 1985 year class. The prediction in last year's report, based on IKMT sampling, that the 1985 year class was likely to be a strong one, was confirmed by the IYFS in 1987 (see Section 2.3.5).

The Working Group was rather skeptical, however, about using the existing correlation between IKMT indices and other estimates of

year-class strength for making quantitative predictions. The plots of IYFS indices of 1-ringers and VPA estimates of 0-ringers on IKMT indices show a large scatter of points and there seems to be no justification for calculating a regression between VPA and IKMT for prediction purposes (Figures 2.3.2 and 2.3.3). Moreover, there is still a chance that the high abundance of larvae is merely a reflection of spawning stock biomass, and that the correlation will break down as soon as weak year classes start appearing.

2.3.3 1983 year class

This year class recruited to the adult stock in 1986. It turned out to be a strong one confirming the earlier prediction based on IKMT and IYFS indices. The strength of this year class as 1-ringers is now estimated from VPA at 14.72×10^9, whereas the predicted value from the new VPA/IYFS regression was 20.01×10^9. There is thus a discrepancy between the two estimates.

2.3.4 1984 year class

During last year's meeting, a preliminary IYFS index of 3,613 fish/hour was used. This index was corrected later in the year to 3,473 on the basis of more precise age/length data. Applying the new VPA/IYFS regression presented in Section 2.3.1, the strength of this year class as 1-ringers is now estimated at 21.53×10^9.

The first estimate for the year class from VPA (15.87×10^9) also indicates a discrepancy between the IYFS and VPA estimates. For a possible explanation of this discrepancy, see Section 2.10.5.

2.3.5 1985 year class

Detailed data were available from the 1987 IYFS. The preliminary index for this year class can, therefore, be considered as fairly precise and almost certainly within 5% of the final value.

The preliminary index obtained was 6,096 fish/hour. This is an exceptionally high value, being 76% above last year's strong year class. This increase was noticed in all areas of the North Sea.

When the (rounded) survey index of 6,000 is inserted into the new regression given in Section 2.3.1, a predicted year-class strength of 37.20×10^9 is obtained.

Because of the extreme amount of extrapolation in using the existing regression, it would be unwise to put too much confidence in the exact value for the predicted year-class strength.

2.3.6 1986 year class

Results of the IKMT sampling in February 1987 are presented in Figure 2.3.4 and Table 2.3.2.

The index for the 1986 year class is again very high, indicating the possibility that this may be yet another strong year class.

The distribution charts of IKMT catches show a low abundance of O-group herring in the Skagerrak and Kattegat. However, during a Swedish acoustic survey in December 1986, large numbers of O-group herring were detected in the Skagerrak. The larvae occurred in small shoals that could be seen on the sonar.

2.3.7 Trends in recruitment

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

2.3.8 Recruitment to individual stocks

Estimation of recruits to Divisions IVc and VIId "Downs" stock

In previous years, two main approaches for the prediction of recruitment to the Downs stock have been used. The first has involved attempting probability splits (Cassie method) on length distributions of 1-ring herring taken in the February IYFS in areas of the southern and southeastern North Sea where "Downs" herring are thought to be mainly distributed. The smallest length modes and associated length distributions are thus isolated and proportioned to the total 1-ring abundance indices.

This method has led to problems where modal lengths are not clearly separated and some doubts concerning the accuracy of the procedure have been expressed in past years by Working Group members.

An additional complication has arisen from the general reduction in mean length of 1-ringers over the last two years. Samples taken from Thames power station screens in the winter months have recently shown a component of the smaller 1-ring fish still present close inshore and around the time of the IYFS, and these may not have been adequately sampled by the survey. The 1987 survey length distributions showed only a limited area where the smaller model length components could be reliably split and since these contributed only a very minor part of the total 1-ring stock, it was felt that such an estimate would be of limited value.

An alternative method has used abundance indices derived from O-group herring surveys undertaken along the east coast of England in July each year, where a relationship was established with subsequent 2-ring recruitment to the Downs stock. However, in some years anomalous distributions have arisen which disturb the underlying assumption that the relative proportion of "Downs" O-group herring recruiting to the east coast of England remains relatively constant from year to year.

A comparable time series of potential recruitment is also avail-

able from surveys undertaken in the Dutch Wadden Zee during March-April each year, which assess the relative abundance of late stage herring larvae, most of which are likely to be of "Downs" origin. These have also provided a significant relationship with 2-ring recruitment, but there have been anomalous years when compared with the indices from the English 0-group surveys. A time series of these abundance indices is shown in Table 2.3.3 together with estimates of 2-ring recruitment from a trial VPA run using input Fs determined from the total mortalities between the 1985 and 1986 acoustic surveys (see Section 2.8.2).

Allocation of recruitment to stock management units

As the estimates of recruitment to the total North Sea cannot at present be allocated to individual spawning stocks, a judgment had to be made about the likely percentage of 1-ringers that would recruit to the Division IVa,b stocks. In the absence of evidence to the contrary, it was decided to split it in proportion to the approximate size of the spawning stocks. Accordingly, 90% of the recruitment is assumed to belong to Divisions IVa,b.

From the catch-in-number tables for each division, however, it is clear that almost all the exploitation of 1-ringers of all North Sea stocks combined takes place in Divisions IVa,b. In the predictions, it was, therefore, assumed that the total number of 1-ringers is accessible to exploitation, and the surviving number of 2-ringers is reduced by 10%.

2.4 Acoustic Surveys

2.4.1 Northern North Sea (Division IVa and Buchan Area)

An acoustic survey was carried out in the northern North Sea (57^0-61^0 30'N) in July 1986 by vessels from Norway and the UK. The survey and analysis procedures were as in previous years and the target strength/length relationship used was the one recommended by the Acoustic Survey Planning Group (Anon.,1983):

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

where L is in cm. Estimated numbers at age and the biomass of "spawning" fish (those at maturity stage 3 and over) in each of the areas shown in Figure 2.4.1 are given in Table 2.4.1. As in the previous year's survey, 2-ringer recruits were predominantly found in the areas west of 0^0, and in that area, 20.1% of the 2-ringers and 4.5% of the 3-ringers were not expected to mature in 1986 (i.e., were at maturity stages lower than stage 3). The total spawning biomass in the area surveyed was estimated to be 535,000 t compared with 435,000 t in 1985, an increase of 23%. The comparison with previous years is given below:

Area	Spawning biomass ('000 t)				
	1982	1983	1984	1985	1986
Orkney/Shetland	224	250	320	285	374
Moray Firth/Buchan	?	?	57	13	40
Fladen	?	?	76	73	100
Eastern area	?	?	13	43	10
Egersund Bank area	?	?	?	20	10

The numbers at age in 1984, 1985, and 1986 are given in Table 2.4.2 for areas covered in all three years. Estimates of Z obtained from these values are also given in Table 2.4.2. The weighted mean Z on 2-ringers and older was 0.76 from 1985-1986, compared with 0.83 from 1984-1985. The estimates of Z on 5-ringers and older, however, were considerably higher than in 1984-1985.

2.4.2 Division IVb and Division IVa south of 60°N

The area was covered by two Norwegian research vessels during November and early December. The results were worked out using the same target strength as during the other North Sea surveys. Table 2.4.3 shows the number of fish at age estimated within the sub-areas defined in Figure 2.4.2. The total estimates for the parts of Divisions IVa and IVb covered are:

Year class	Number of fish (millions)	
	IVa	IVb
1983	178	1,039
1982	85	533
1981	107	823
1980	21.0	168.1
1979	8.5	135.1
1978	4.4	21.6
1977	4.3	1.2
<1977	1.2	0.8
Biomass ('000 t) 1983 and older	62	412

The estimate of the 1983 year class and older in Division IVb is considerably higher than the estimate of the Division IVb spawning concentrations during August (Section 2.4.3).

The November estimate for Division IVa is considerably lower than the July Division IVa estimate and lower than the estimate for Division IVa in November 1985. It is important to stress, however, that the coverage of Division IVa in November 1986 was in-

complete and certainly did not cover an area where a fishery was taking place.

The total estimate for Division IVb is dominated by the 1985 and 1984 year classes. A Danish acoustic survey in August 1986 gave much higher estimates of 0-ringers in a rather small area in eastern Division IVb ("Danish coast" in Figure 2.4.1). Similar differences between the August and November surveys were also observed during 1985. However, both surveys indicate a higher abundance of 0-group in 1986 than in 1985, as shown in the text table below:

Survey	Age	Estimated number of fish (millions)	
		1985	1986
Danish coast, August	0-ringers	8,793	15,701
	1-ringers	2,370	2,102
Division IVb total, November	0-ringers	3,723[1]	7,140
	1-ringers	153[1]	8,880

[1] East of 2^0E.

The November survey also briefly covered Division IIIa (Sub-areas K and L). The results from that area are also presented in Table 3.3.2 where they are converted to the target strength given in Section 3.3. It is worth noticing that the 0-group recorded in Division IIIa represents about 45% of the total 0-group estimate for all areas covered when referred to the same target strength and compensated for uncovered areas in the Kattegat.

In most areas, the herring traces were easily separated from other fish recordings, and plankton recordings made problems only along the Scottish coast. In that sense, November seems to be a useful time for working acoustic surveys in the North Sea. The main problem was the weather condition and, in some areas, loss of echo contribution from herring schools staying on the bottom.

2.4.3 Western central North Sea (Division IVb West)

The regular annual survey was undertaken off the northeast coast of England from 20 August to 3 September. The areas intensively covered were a region extending from north of Whitby (54^0 50'N) to south of Flamborough Head (53^0 50'N) up to 20 miles off the coast, and also the Longstone area (55^0 45' - 55^0 28'N). Offshore tracks covered a broader area extending to the western edge of the Dogger Bank (1^0 20'E) (see Figure 2.4.1).

The first stage of the survey concentrated within an area off the Yorkshire coast where Dutch vessels had fished prior to the closure on 14 August, taking a catch of about 6,500 t during the first half of August. Echo-trace signals were generally of a low order, relating to small, thinly scattered shoals. The Longstone

survey was carried out on 22 August, but little was found in this area. The survey subsequently extended offshore and covered the western edge of the Dogger Bank on 23 August. Thinly scattered small shoals were found, these increasing in density towards the south of the grid near Skate Hole.

The first indications of spawning fish were found on 24 August in a patch of larger shoals centered about 9-10 miles east-northeast of Flamborough Head. About 36% of the fish sampled were in maturity stage 6 (ripe spawning) and the remainder mainly stage 5 or 5/6. The maximum biomass estimate for this patch was 16,400 t.

The only major spawning concentration found was surveyed on 31 August - 1 September, this centered about 10 miles off the coast between Whitby and Robin Hood's Bay. The maximum biomass estimate from this patch amounted to 124,000 t, and 95% of the fish sampled were in stage 6 maturity.

The Flamborough area was re-surveyed on 1-2 September, but only scattered low density traces were now in evidence, and little was found in the area southeast of Flamborough Head, where the survey was terminated by bad weather on 3 September.

The length and age distributions of herring taken in the Whitby and Flamborough areas were very similar and consequently combined for target strength estimation (Table 2.4.4). The target strength relationship used was the same as that for the northern North Sea survey (Section 2.4.1). The target strength used for the spawning area fish was - 42.38 dB derived from an overall mean length of 27.6 cm.

It was thus evident that a major spawning developed on 31 August - 1 September, and an examination of results from herring larvae surveys undertaken off the northeast coast during September and October (Section 2.5.5) provided supporting evidence. The near-bottom temperature at the spawning site was 10.8^{0}C which should produce an incubation period of about 11 days. The largest numbers of smaller larvae (<10 mm) were recorded off the Yorkshire coast on two surveys during the latter half of September. Back-tracking this major cohort suggested a growth rate of 0.27 mm per day corresponding to peak hatching around 12-13 September.

The overall distribution and levels of larvae production also indicated major spawnings in the Longstone - offshore NE Bank region, with at least as much production here as off the Yorkshire coast. Spawnings near the western edge of the Dogger and in other areas east of 1^{0}E were relatively minor and later.

It was thus evident that the maximum biomass estimate for the Yorkshire coast spawnings of about 140,000 t could only be a minimal one for the 'Banks' stock. Abundance indices from the larvae surveys were thus used to derive a raising factor accounting for the spawning population not covered by the acoustic survey.

The population of larvae (less than 10 mm) contributed by the Yorkshire coast spawnings south of 54^{0}40'N, averaged over two surveys during the latter half of September, amounted to about

62% of the total larvae production in the latter half of September.

This value was then adjusted to allow for the whole spawning season using the ratio between the larvae abundance index (LAI) for the second half of September and the total LAI for Division IVb.

This provided a seasonal proportion of 47% attributable to the Yorkshire coast spawnings during the acoustic survey period. The acoustic estimate could thus be conservatively raised by a factor of 2, giving 280,000 t for the "Banks" stock.

The maximum biomass estimate for the Yorkshire coast grounds in 1985 was 113,200 t. However, this was considered minimal due to earlier timing of the survey with most of the fish still in stage 5 maturity (noted in 1986 Working Group report). A raising factor of 1.22 was estimated from the 1985 larvae distributions and abundance indices, being lower than in 1986 because a much higher proportion of the total LAI was attributable to the Yorkshire coast grounds. This results in a raised biomass of 138,000 t for 1985 which is likely to be an underestimate.

2.4.4 Southern North Sea and eastern Channel (Divisions IVc and VIId)

In 1986, the only survey undertaken was that with the French research vessel "Cryos" between 13-29 November.

The eastern Channel was covered twice, the first survey from 13-20 November extending to 00^{0} 00'E. At this time, dense pelagic shoal aggregations were found southwest of the Straits of Dover. In this area, there was some mixing of herring and mackerel. The acoustic estimate amounted to 101,000 t of mainly stage 5 maturity herring. The second survey (25-28 November) covered much the same area as the first but only extended to 00^{0} 30'E. The estimated acoustic biomass decreased to 45,000 t during the second survey due to incomplete cover. In the southern North Sea, a very limited area was covered on 29 November, but the biomass estimate was only 800 t.

Estimated numbers at age and mean weights are presented in Tables 2.4.5 and 2.4.6. It is evident that the recruiting 1983 year class was relatively weakly represented (35%), with 3-ringers of the 1982 year class predominant (49-58%).

The age composition of samples taken during the acoustic survey was similar to those from fourth quarter landings (Table 2.4.7). In 1985, November and December were each covered by surveys, and the estimates for each month were considered additive due to the separation in time between surveys (over 3 weeks). The estimate for November 1986 was thus raised by a similar proportional amount (x 1.62) to allow for a component of spawning fish in December not covered by the survey. The spawning biomass at the end of 1986 was estimated at 139,500 t allowing for catches towards the end of the year.

2.5 Herring Larvae Surveys

2.5.1 Herring Larvae Survey Working Group report

The Working Group on Herring Larvae Surveys South of 62^0N (Anon., 1987c) met in February 1987 to further develop the procedure for calculating spawning stock sizes from larvae size distributions, estimates of larval growth and mortality rates, and estimates of fecundity.

The Herring Larvae Working Group decided to make only minor changes in the procedure for estimating larvae production. However, studies presented to the Herring Larvae Working Group showed that drift of larvae from Division VIa(N) into the Orkney/Shetland area poses a problem. Therefore, the Herring Larvae Working Group recommended that the larvae production estimates (LPEs) for the Orkney/Shetland area should be calculated as the difference between the LPEs for the combined Division VIa(N) and Orkney/Shetland area and the LPEs for the Division VIa(N) area.

The LPEs given in the Herring Larvae Working Group report (Anon., 1987c) have been recalculated by the Herring Assessment Working Group, as data for the 1986/1987 surveys were not available to the Herring Larvae Working Group.

The Herring Larvae Working Group discussed the consequences of different sampling strategies which might be adopted as a result of the introduction of the LPE method. The two procedures require different sampling distributions on a temporal scale. The LAI method relies on sampling the very small larvae within approximately the first two weeks of their life. At this time, the larvae have a very patchy distribution, and abundance is difficult to quantify compared to later in the larval stage. The LPE method depends on sampling the larger larvae and it is possible to estimate the production with less sampling effort. However if mortality rates are to be estimated, it is necessary to have a nearly even distribution of samples over time.

2.5.2 Indices based on young larvae (LAI)

Calculations of LAI for all standard areas were made available to the Working Group by the DAFS Marine Laboratory, Aberdeen. The estimates were calculated as described by Saville and Rankine (1985). The LAIs for the time period 1972-1986 are given in Table 2.5.1. It should be noted that the LAI estimate for Orkney-Shetland in 1985 is considered to be a gross overestimate as judged from other available sources. The LAI for Buchan in 1986 is considered an underestimate, as spawning was early in 1986 and large cohorts of larvae were not included in the LAI as they had grown to more than 9 mm before the first sampling took place.

2.5.3 Larvae production estimates (LPE)

Larvae mortality rates (z/k - per mm) for 1986 have been calculated using the method introduced by the Herring Larvae Survey Working Group (Anon., 1986c).

The LPEs have been calculated using the mean mortality rate estimated only for the time period 1980-1986 (Table 2.5.1, bottom line). The few values of z/k that can be estimated for the 1970s are not used, due to insufficient survey coverage and/or low abundances of larvae. From Table 2.5.1, the Working Group concluded that the LPE and LAI estimates in most areas and years are correlated and that the LPE method seems least sensitive to variations in sampling effort, patchy distribution, etc. Fecundity has been calculated as previously. New data from Division IVb, 1982-1985, were available to the Working Group (Table 2.5.2).

The Herring Larvae Working Group recommended that the LPEs for the Orkney-Shetland area should be calculated as the difference between the LPEs for the combined Division VIa(N) and Orkney-Shetland area and the LPEs for the Division VIa(N) area. The present Working Group was unable to use this approach as the LPE for the Division VIa(N) area for 1986 was larger than the estimate for the combined Division VIa(N) and Orkney-Shetland area, possibly as a result of anomalous z/k estimates, thus leaving no production for the Orkney-Shetland area. In consequence, the present Working Group decided to use the LPEs derived separately for the Orkney-Shetland area as the best obtainable larvae production estimates. This may result in misleading results, as in 1977, when considerable drift of larvae from Division VIa(N) into the Orkney-Shetland area is assumed to have taken place. It should be noted that, in recent years, the stock in the Orkney-Shetland area has increased and is now considered approximately twice as big as the Division VIa(N) stock, thus probably reducing the problem compared to earlier years when the relationship was the opposite.

2.5.4 Estimates of SSB

The estimated SSBs from the larvae production estimates are given in Table 2.5.2. It could be expected that the estimates should be underestimates, as no corrections were made for egg mortality. It seems, however, that this is generally not the case. In some years, the SSBs estimated from the LPEs indicate a stock size in excess of that estimated by the VPAs. Unless the VPA estimates for those years were seriously wrong (which is possible), it appears that the SSB estimates based on the LPEs may sometimes overestimate the actual spawning stock sizes. This may be because the mortality of the youngest larvae (with yolk sac) is lower than the mortality of the larvae that are considered when estimating mortality rates [i.e., 8 (10 or 11) -16 mm larvae]. The SSB estimates derived from larvae productions cannot, therefore, be used as absolute measures of stock size.

2.5.5 Herring larvae surveys in 1986-1987

The sampling intensity in all areas in 1986/1987 was at an acceptable level, being broadly comparable to that in the preceding years.

The Orkney-Shetland area was surveyed twice in the first half of September by the Federal Republic of Germany and the Netherlands and once in the second half of September by Scotland. The major concentrations of small larvae were recorded northeast of the Orkneys in the first half of September. Hatching is estimated to have peaked in late August and early September.

The Buchan area was surveyed once in the first half of September by Scotland. In the second half of September, the area was surveyed by Denmark and the central part (covering most of the larvae distribution) was surveyed by Scotland. The major concentrations of larvae were at Aberdeen Bank in the first half of September. The main hatching is estimated to have taken place from mid-August to early September.

The central North Sea was surveyed once completely and once in a half grid in the first half of September by the Netherlands. In the second half of September, the Netherlands made two complete coverages. The sampling in October was less intensive; England made a near-complete survey and a survey omitting the northern and eastern parts in mid-October. The main concentrations of small larvae were recorded at Longstone and the Northeast Bank throughout September and at Whitby in the second half of September. The hatching in the area is estimated to have taken place from late August to early October, with a peak in the second half of September.

The Southern Bight and eastern Channel were surveyed once by the Netherlands in December 1986, once by England in the first half of January 1987, and once by the Federal Republic of Germany in the second half of January.

The main concentrations of small larvae were recorded on the December survey at Sandettie, Ruytingen and off Dieppe. The main hatching is estimated to have taken place in early December and late December-early January.

2.6 Herring Tagging

Herring tagging experiments were carried out in 1986 by Norway and UK (Scotland). The Norwegian experiment using internal tags (9,000 released) was carried out late in the year and few recaptures are yet available. In the Scottish experiment, over 14,000 herring were released with external tags at several localities around the Shetlands in July. To date, 156 recaptures have been reported, mostly in the Orkney-Shetland area. Within this area, however, the returns showed a general southward movement during late July and August, while one tag was recovered in the Clyth Ness spawning fishery (Moray Firth) and five in the spawning fishery on Turbot Bank (in the Buchan area). From this experiment, it is not possible to draw any conclusions about the presence of Bank and Downs herring in the Shetland area in July,

but the results indicate that some Buchan fish were present in the tagging area.

2.7 Mean Weight and Maturity at Age

2.7.1 Mean weight at age in the catch

Mean weights at age in 1986 are presented by divisions and quarters in Table 2.7.1. These values have been weighted by numbers caught.

In the 1986 Working Group report, attention was drawn to evidence for a decline in mean weight at age in the catch when a comparison was made between the 1985 values and those for pre-1985 used in the ICES stock prediction programme (Table 2.16 in Anon., 1985). The 1986 Working Group predictions used the 1985 revised values (Tables 2.9.1 and 2.9.2 in Anon., 1986a).

The 1986 data suggest a continuation of this trend (Table 2.7.2) with the exception of 3-ringers and older in Divisions IVc and VIId and 1-ring fish in most areas where there are indications of increased mean weights.

A comparison between mean weights of 1-ring fish taken as by-catch in directed adult fisheries and those in industrial landings, where the fishery is often directed towards this age group, are presented in Table 2.7.3. These data were supplied by Working Group members and cover a number of different fleets, gears, and mesh sizes divided into ICES divisions and quarters. It is evident that the mean weight of 1-ringers taken in the directed adult fisheries (mainly in Division IVaW of 2^0E) is generally higher, although the difference becomes less later in the year. The catch of 1-ringers in the directed adult fisheries (2,640 t SOP) is also relatively insignificant compared with the catch in the industrial fisheries (111,470 t SOP).

The annual mean weights in the two types of fisheries amounted to 95 g in the directed adult by-catch and 69 g in the industrial fisheries, these values weighted by numbers caught.

2.7.2 Maturity ogive

Information on the maturity ogive in 1986 was obtained from commercial catches and research vessel surveys.

Division IVa

Samples obtained during the acoustic survey of Division IVa in July indicated that 80% of the 2-ringers were at maturity stages 3 and higher, compared with 70% in 1985. Samples from the Scottish commercial fisheries in July indicated a rather lower percentage of immature 2-ringers (5-9% in different areas), but this was probably because the 2-ringers caught in the commercial fishery were on average 1-1.5 cm longer than those sampled on the acoustic survey, indicating that the fleet was selectively fishing in areas in which larger herring were caught. Further evidence of the proportion of 2-ringers that spawned in 1986 was

obtained during the Norwegian acoustic survey in November when 74% of the 2-ringers caught in Division IVa were in stages 7 and 8. In the same month, Scottish commercial samples from the Shetland area indicated 85% of 2-ringers at stage 8.

An estimate of 80% 2-ringers mature in 1986 was adopted.

Division IVb

Samples of 2-ringers taken on the spawning grounds during the spawning season contain 100% mature fish and cannot, therefore, be used to estimate the proportion of 2-ringers that mature in the stock as a whole. No other samples of known Division IVb stock were available from the spawning season, but samples were taken over a large area of Divison IVb on a Norwegian acoustic survey in November. In contrast to Division IVa, only 65% of the 2-ringers caught in Division IVb were in stages 7 and 8, the remainder being in stages 2 and 3. This indicates that a lower proportion of 2-ringers in the Bank stock matured in 1986 than in the Division IVa stock. On the assumption that the fish present in Division IVb in November belonged to the Division IVb spawning stock, an estimate of 65% of 2-ringers mature was adopted.

Divisions IVc and VIId

No information was available since most of the 2-ringed fish caught are taken on or near the spawning grounds and, being mature, cannot be used to estimate a proportion in the total stock.

2.8 State of the Stocks

2.8.1 Divisions IVa and IVb combined

Larvae surveys (Section 2.5) and acoustic surveys (Section 2.4) were conducted in the separate divisions. The indications from those surveys are a 20-30% increase in the Division IVa (including Buchan) spawning stock and a possible decrease in the Division IVb spawning stock. The 1986 catches of the pre-1983 year classes (which should have been in the spawning stocks in 1985) were 9 times larger in Division IVa than in Division IVb. The changes in the separate stocks estimated from the surveys are, therefore, in conflict with the catches. It was considered likely that a considerable, but unknown, part of the Division IVa catches were Division IVb spawners and that some of the Division IVb spawners also might have been recorded in the Division IVa acoustic survey. It was, therefore, decided not to do any separate assessment for each division, but to make a combined assessment.

Combined survey estimates of spawning stock were obtained by adding the larvae production estimates from the larvae surveys for Divisions IVa and IVb and by adding the estimates from the July acoustic surveys in Division IVa to the estimates from the August acoustic surveys in Division IVb. The resulting estimates for the years 1981-1986 are as follows:

Year	Spawning stock biomass ('000 t)	
	Larvae production estimate	Acoustic estimate
1981	221	207
1982	257	256
1983	357	290
1984	687	674
1985	809	573
1986	897	815

The estimates were considered as indices with considerable variance. The method chosen to tune a VPA was to make several VPA runs assuming different values of average F for 3-6 ringers in 1986 and then regress the survey estimates to each of the runs to select the F giving the best fit. The resulting regression parameters are shown below:

$\bar{F}_{(3-6)}$	VPA vs. larvae production estimates 1972-1986			VPA vs. acoustic estimates 1981-1986		
	Slope	Intercept	r	Slope	Intercept	r
0.2	2.02	-77	0.961	2.78	-340	0.951
0.3	1.33	12	0.973	1.74	-107	0.967
0.4	1.03	50	0.970	1.30	-18	0.970
0.5	0.824	76	0.960	1.00	48	0.956
0.6	0.693	92	0.942	0.812	89	0.926
0.7	0.597	105	0.917	0.667	121	0.876

The residuals between values predicted from these regressions and the VPA estimates were added for the latest years. The sum of residuals and the spawning stock sizes plotted against F are shown in Figure 2.8.1. The sum of residuals approaches zero at Fs between 0.45 and 0.60. On this basis, F = 0.5 was considered to give the best fit. This gives about 800,000 t of spawning stock biomass in 1986, which is in the order of magnitude indicated by both the acoustic surveys and larvae production estimates.

Tables 2.8.1-2.8.3 show the input values for the VPA and the resulting stock for the years 1972-1986. The F on 2-ringers was set to 75% of the older age groups which all were given F = 0.5. The resulting age composition in 1986 is quite comparable to those observed in the acoustic surveys (Section 2.4). The proportion of mature 2 ringers was set to 0.75 as a weighted mean of the 80% observed on the acoustic survey in Division IVa during July and the 65% observed on the acoustic survey in Division IVb during November.

Figure 2.8.2 shows the survey estimates and the VPA estimates by year. The ratio between the VPA and the larvae production estimates shifted around 1977.

This VPA differs from the predictions and the combined VPA for Divisions IVa and IVb made in 1986. There is a slight increase in the total biomass for the years up to 1982, which is caused by new values of natural mortality (Section 2.2). For the later years, this VPA gives lower stock sizes. The main reason for this is that the procedure for using the survey estimates to tune the VPA has been changed. Furthermore, the low 1985 acoustic estimate for Division IVb, which last year was omitted, has this year been revised and included in the regression. This revision was based on the method described in Section 2.4.3.

This year, a combined VPA was tuned towards combined survey estimates for Divisions IVa and IVb, while in 1986 separate VPAs were made for the two divisions and the combined was obtained by adding them. This might also be a part of the explanation for the differences between this year's VPA and last year's, bearing in mind that it is likely that Division IVb spawners are exploited in Division IVa and that a part of the Division IVb stock is included in the Division IVa acoustic estimate.

The same mean weights at age in the stock were applied for all years (Table 2.8.3) while the mean weights at age in the catch have decreased during the latest years (Table 2.7.1). As the VPA was tuned with respect to biomass, the number of fish in the stocks was slightly underestimated during the last two years.

2.8.2 Divisions IVc and VIId

In 1986, a French acoustic survey in November (Section 2.4.3) provided a spawning stock estimate of 101,000 t in the eastern Channel. This was probably an underestimate since a large fishery developed in December on the Channel spawning grounds where a catch of 22,750 t was taken (Figure 2.11.2). A raising factor (x 1.62) was thus applied to the November estimate of SSB based on the ratio of SSB estimates made in November-December 1985 when both months were covered by surveys (Anon., 1986a). Allowing for catches in the last quarter, a raised estimate of 127,000 t remained at the end of the year. This was converted to numbers at age and fishing mortalities were determined using the catch in 1986, these used as inputs for a trial VPA run. This assumed all the mortality was generated by the fishing effort in Divisions IVc and VIId. Alternative estimates of F were made using the 1985 and 1986 acoustic estimates of spawning stock as absolute measures of population and this allowed for catches taken elsewhere in 1986.

The average F for ages 2-6 amounted to 0.55 using the first method and 0.61 for the second, which suggested catches were taken outside the area. However, due to the high level of error likely to be associated with the acoustic survey estimates, the trial VPAs and projections made using these data were considered unreliable and not acceptable to the Working Group.

In the 1986 report, abundance indices from French herring trawl CPUE data were provided, but these were not available for 1986 to update the series. It is recommended that analysis of trawl CPUE could provide a useful index for future monitoring, particularly in 1987 when no acoustic surveys are planned.

In previous years' reports (Anon., 1985; 1986a), attention was drawn to continuing discrepancies between VPA results, direct stock estimates, and levels of fishing effort. All the available independent indices of SSB are summarized in Table 2.8.4 for the years 1972-1986. The estimates from larvae and acoustic surveys show no clearly defined trend in stock size since 1981, whereas the spawning stock estimates from VPA have all shown an increasing trend. In the trial runs made this year, the trend was still apparent with input Fs (ages 3-8) less than about 0.6. In view of these problems, it was agreed that an analytical assessment could not be made in 1987.

The explanation offered in the earlier reports, that the stock is also being exploited in other areas of the North Sea, so that VPAs run only on Divisions IVc and VIId catches consistently underestimate fishing mortality over the most recent years, remains a strong possibility. The fishery has been largely dependent on recruitment since its recovery in the early 1980s, but the 1983 year class proved to be a weak one (as predicted from recruitment indices obtained in 1984) and contributed only 31.5% to the catch. The recruitment indices for the 1984 and 1985 year classes suggest that these will be at least average, with the possibility of stronger recruitment from the 1984 year class.

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

A VPA was run for the total North Sea to obtain a time series of year-class strengths for correlation with IYFS indices. The catch numbers used were the sum of Divisions IVa, IVb, IVc, and VIId. The exploitation pattern for 1986 was based on an average for the years 1983 and 1984 (except for 0-group where the high value in 1983 is not typical of more recent values). The average values were smoothed and the exploitation pattern was assumed to be flat on ages 3 and older.

Input values for natural mortality, proportion mature, and input F values for 1986 are given in the table below:

Age group	M	Proportion mature	$F_{(1986)}$
0	1.0	-	0.05
1	1.0	-	0.19
2	0.3	0.75	0.35
3	0.2	1.00	0.47
4	0.1	1.00	0.47
5	0.1	1.00	0.47
6	0.1	1.00	0.47
7	0.1	1.00	0.47
8	0.1	1.00	0.47
9+	0.1	1.00	0.47
			$\bar{F}_{(2-6)} = 0.45$

The VPA was tuned by setting the fishing mortality in 1986 to a level which generated a spawning stock biomass of about 900,000 t

equal to the sum of the estimated biomasses for Divisions IVa, IVb, IVc, and VIId. The resultant VPA analysis is given in Tables 2.8.5-2.8.8 and Figure 2.8.3.

2.9 Projections of Catch and Stock Size

2.9.1 Divisions IVa and IVb combined

Catch predictions for Divisions IVa and IVb combined were made using the input data given in Tables 2.9.1 and 2.9.2. The exploitation pattern, the maturity ogive, and the weights at age in the catch were the same as used in the VPA for 1986. The weights at age in the stock were the same as have been used in the VPA for the whole period 1972-1986. The estimates of numbers of fish in the stock for 1987 for age groups 3 and older were those determined from VPA. The estimate of 1-group fish was based on the IYFS indices (Section 2.3.5). The IYFS estimate of the 1985 year class as an exceptionally strong year class is supported by the results of the acoustic surveys in Division IVb (Section 2.4.2). To account for the uncertainty of the IYFS estimate due to the extreme amount of extrapolation, the Working Group decided to use the value of the lower 95% confidence limit for prediction purposes, which corresponded to 27.85×10^9 fish.

The estimate for the number of 2-group fish was taken from the value determined by the VPA for the total North Sea reduced by 10% to allow for fish of the Downs stock which will move out of the area (see Section 2.3.7).

Using these data, a catch prediction for 1987 was run using a TAC constraint of 560,000 t. To take this catch in 1987 will require $\bar{F}_{(2-6)} = 0.43$ representing a 10% reduction in fishing mortality compared with 1986. For the prediction for 1988-1989, the input data given in Table 2.9.2 were used. The numbers in the stock in 1988 for ages 3-9 are the survivors from the 1987 catch prediction, but for age group 2, the survivors have been reduced by 10% to account for emigration to the southern North Sea. Recruitment of 1-group fish in 1988 and 1989 was taken to be 14×10^9, equal to the long-term arithmetic mean for the total North Sea.

The results of the catch prediction for 1987 and for a range of options for 1988 are given in Table 2.9.3 and Figure 2.9.1. If fishing mortality in 1988 is maintained at the 1987 level, the expected catch is 599,000 t. At $\bar{F}_{(2-6)} = 0.3$, the catch would be 440,000 t and at $F_{0.1} = 0.14$, the catch would be 225,000 t. To take a catch of 500,000 t in 1988 would require fishing mortality to be reduced to $\bar{F}_{(2-6)} = 0.35$. Spawning stock biomass at the time of spawning is expected to increase until 1988. In 1989, the spawning stock biomass is likely to decline only if fishing mortality is increased above the level required to take the 1987 TAC [$\bar{F}_{(2-6)} = 0.43$].

In interpreting the SSB values at spawning time in 1989, it has to be remembered that they also reflect the effect of fishing during two thirds of the year at the same level of F as in the preceding year.

2.10 Management Considerations

2.10.1 Long-term potential yield of the Divisions IVa,b stock

Some idea about the long-term potential yield of this stock can be obtained from a consideration of historic catches in the post-war period. Figure 2.10.1 shows the development of catches in Divisions IVa,b from 1947 to the present. Also shown are the developments in spawning stock and fishing mortality. The two latter parameters refer to the total North Sea stock (no VPA extending back to 1947 is available for Divisions IVa,b). The data on stock size and mortality for the total North Sea will largely reflect the developments in the Divisions IVa,b stock, at least for the period after 1960 when the Divisions IVc and VIId stock became insignificant.

From 1947-1964, the annual catch (including juvenile herring) in Divisions IVa,b varied between 313,000 and 815,000 t. The mean annual catch during this period was 530,000 t, and the mean F for the total North Sea was 0.34. After 1965, fishing mortality increased sharply, which eventually led to a depletion of the stock. Under the exploitation pattern of the pre-1965 years, the average annual potential yield of the stock appears to have been somewhere around 500,000 t.

The potential yield of the Divisions IVa,b stock can also be estimated from a yield-per-recruit calculation. Assuming an average recruitment of 12.6×10^9 (= long-term average for total North Sea minus 10% southern North Sea recruits), the maximum long-term yield for Divisions IVa,b is estimated at approximately 500,000 t at F values equal to about 0.3 and above. F_{max} cannot be defined. Exploitation pattern, mean weights, and natural mortalities were assumed to remain equal to those in 1986.

The mean numbers of recruits used in the yield-per-recruit calculation refers to a period when catches of 0-group herring in Division IIIa were much lower than they are at present. In order to obtain the average Divisions IVa,b catch calculated above, it is probably necessary to reduce catches of 0-group herring in Division IIIa, to make sure that a substantial proportion of the North Sea recruitment is not lost prematurely.

2.10.2 TAC advice for Divisions IVa,b in 1988

The appearance of a strong 1985 year class in the North Sea provides a unique opportunity to create a buffer stock without having to reduce the existing catch level. It should be stressed that such an opportunity seldom arises. Such a buffer stock would enable TACs to remain relatively constant, even if one or two below-average year classes appear. Only in the case of a prolonged period of recruitment failure (which has been witnessed only once in this century) would the TAC eventually have to be reduced below its normal level.

A second advantage of maintaining a buffer stock in the North Sea would be a change in the ratio between adult and juvenile fish. This could lead to less discarding and an improved exploitation pattern.

As pointed out in Section 1.4, the size of the buffer stock is more a management choice than a biological choice. The greater the buffer stock, the longer the period of weak recruitment that can be bridged. If one considers the pattern of recruitment fluctuation in the total North Sea (Figure 2.3.5), it is seen that weak year classes seldom occur in a long succession (the 1970s period must be considered as an anomaly). A spawning stock in the order of 1.5 -2.0 million t would be quite capable of absorbing the normal fluctuations in recruitment.

Considering the advantages of such a buffer stock both in stabilizing the TACs and in reducing the exploitation of younger age groups, it is suggested that a relatively low target F for 1988 be chosen which will result in a considerable increase in spawning stock size. A target F corresponding to a TAC at the expected maximum long-term yield level (500,000 t) would achieve this objective.

2.10.3 Long-term potential yield of the Divisions IVc, VIId stock

Again we can look at the historical development of the catches (Figure 2.10.2). These catches declined very sharply from a level above 200,000 t before 1955 to less than 20,000 t after 1965. The sharp decrease in stock size after 1955 is generally attributed to the concentrated fishing effort on the exposed spawning grounds. Most of the spawning grounds originally used by this stock were abandoned as the stock decreased to less than one tenth of its original magnitude. It is likely that the sharp decrease in spawning stock size has affected the recruitment potential of the stock.

Judging from the catches in this immediate post-war period, it is clear that a catch level of at least 100,000 t would have been sustainable under a regime of reasonably low fishing mortalities. This would correspond to a spawning stock size of at least 300,000-500,000 t. Burd (1978) reported a mean annual catch of 200,000 t for the pre-war period at an F of 0.25. To achieve the full benefit of this stock in the future, it seems imperative, therefore, to build up stock size considerably above its present level.

This potential long-term catch level in Divisions IVc and VIId will depend strongly upon the exploitation rate of herring in Divisions IVa,b. If this exploitation rate is high, a considerable proportion of the potential harvest will be taken during the summer in the northern area, and this will reduce the available TAC for the southern area.

2.10.4 TAC advice for Divisions IVc, VIId in 1988

The TAC advised by ACFM for this area has fluctuated strongly from 62,000 t in 1985 to 22,000 t in 1987. This partly reflects the uncertainty among scientists about the size of this stock, its exploitation in different parts of the North Sea, and the prediction of recruitment.

From the discussions in Section 2.8, it appears that fishing mortality on this stock in recent years has been far above the optimum level. The stock has probably remained at approximately the same level since 1981.

The history of this stock shows that it was considerably larger in the immediate post-war period than at present. If the stock is to be rebuilt to its former level, it is necessary to reduce F considerably below its present level. Such a reduction is desirable in any case, because the stock at this moment is too dependent on recruitment, and a succession of weak year classes would rapidly erode the spawning stock even further.

Fishing mortality sustained by this stock is generated both during the summer in Divisions IVa,b and in the winter in Divisions IVc, VIId. There is not much that can be done about the first component, because management measures taken for Divisions IVa,b are likely to be aimed primarily at the indigenous stocks in this area, and not at what is at present a relatively minor component that occurs mixed with the local stocks. It is only in Divisions IVc and VIId, however, that the southern stock can be given extra protection without affecting other fisheries.

Considering the above mentioned uncertainties about stock size, recruitment, and percentage of the catch taken in various parts of the North Sea, it was not possible to make a precise catch prediction for this stock or area. A less sophisticated, but probably more reliable method is to set a precautionary TAC at a level below the catches taken in the period 1981-1986. Assuming that recruitment in the next few years remains at the recent level, such a reduced TAC should result in a reduction in average F. Because mortality rates on this stock can at present only be estimated as an average over a series of years, the TAC should be kept at a constant low level for a number of years before the effect of such a TAC level on average F can be evaluated.

Catches taken in the period 1981-1986 fluctuated between 40,000 and 70,000 t. A precautionary TAC level, aimed at reducing average F, should be set at a level considerably below the average catch level in the past six years (57,000 t).

2.10.5 Management of juvenile fisheries

According to the information available to the Working Group, the closure of the "sprat boxes" in the North Sea has been reasonably well enforced in the past two years. The reduction in the catch of 0-group herring over this period was a direct result of the increased enforcement of the closures.

Some of the fishermen that used to fish for 0-group herring in the third quarter of the year are now fishing for other species for human consumption. Other fishermen have shifted their operations to Division IIIa where catches of 0-group herring are allowed within the overall TAC for small clupeoids, which was set at 80,000 t for 1986 and 1987.

In the North Sea, the fishery for 0-group herring in the second half of the year has now been replaced by a fishery for 1-ringed

herring, which is conducted further offshore outside the "sprat box". The 1-ringed herring in the second half of the year have mostly reached the minimum landing size, and the exploitation of the age group at this time of the year (according to the latest yield-per-recruit calculations) does not reduce the potential yield from a year class at the level of F suggested for 1988 (0.35). There is, however, some effect on spawning stock biomass per recruit. This is shown in Figure 2.9.1 using mean weights at age in the catch for 1986.

In the beginning of 1987, a directed fishery for small 1-group herring (approximately 13 cm) seemed to have developed in the central North Sea. This fishery was apparently directed at the very large 1985 year class.

Whereas the catches of 0-group herring in the North Sea have now been considerably reduced, they still remain very high in Division IIIa. The 0- (and 1-)group herring caught in this area are also predominantly North Sea recruits, so the continued exploitation of these age groups in Division IIIa will affect yield from the North Sea.

The proposal for a mixed TAC for small clupeoids in Division IIIa was originally intended to gradually reduce the catch of small herring in this area, not to allow the present high level to continue indefinitely.

As explained in Sections 2.3.3 and 2.3.4, there is a discrepancy between the new estimates from VPA for the 1983 and 1984 year classes and the original prediction based on the IYFS. One explanation for this discrepancy could be an underestimate of 1-group catches in the North Sea in 1984 and 1985. Another explanation could be the increased exploitation of 1-group herring in Division IIIa.

The Working Group had no indication of under-reporting of industrial catches from the North Sea for the years up to and including 1986.

Although management of juvenile fisheries has now clearly achieved some results, there is still a need for further reduction of the TAC for small clupeoids in Division IIIa. There is also a need for a continued enforcement of the existing conservation measures in the North Sea, particularly at times when a strong year class is recruiting as 0- or 1-group.

2.10.6 Stock and recruitment

Stock-recruitment scatter plots for Divisions IVa,b combined (2-ringer recruitment) and for the total North Sea (1-ringer recruitment) are given in Figures 2.10.3 and 2.10.4, respectively.

2.11 Requests from Multispecies Working Group

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

The quarterly catch-at-age data base was discussed at the beginning of this Working Group meeting. There were still discrepancies between the catch-at-age tables in reports of the Working Group and the quarterly catch-at-age data reported to the Danish Institute (N.A. Nielsen), and a further check has to be done before the data are submitted to the Multispecies Working Group. The data base will be discussed at the next meeting of this Working Group.

A summary of the 1986 quarterly data is given in Table 2.11.1.

2.11.2 Geographical distribution of the catches in the North Sea in 1986

Data on geographical distribution of the catches in the North Sea in 1986 were available from Denmark, the Federal Republic of Germany, the Netherlands, Norway, UK (England) and UK (Scotland). The data were derived from logbooks or market sampling programmes. For all countries, the geographical data were scaled to the national catches in each month. The available data represent about 94% of the total catch of herring in 1986.

Figures 2.11.1-2.11.12 show the catch of the five countries by ICES rectangles for each month in 1986. In last year's Working Group report, only the geographical distribution of the catches of adult herring was presented. Figures 2.11.1-2.11.12 in this report include both juvenile and adult catches.

3 DIVISION IIIa HERRING

3.1 Stock Composition

The industrial landings of more than 100,000 t in 1986 have not been covered by biological sampling. Age structure as well as stock composition in these landings can only be evaluated indirectly by means of data from consumption landings and research vessel samples. However, available meristic data from these samples do not indicate major changes in the stock composition in 1986 compared to the situation in 1985. The 3-group and older herring caught in Division IIIa were all indigenous spring spawners, whereas 0- and 1-group and 2-group herring in the first half year were a mixture of local spring spawners and North Sea autumn spawners. Examination of length compositions and vertebral counts from the IYFS data and vertebral counts from samples from the acoustic surveys indicate that the 0- and 1-group were predominantly autumn spawners.

In the case of the 2-group herring, 43% of the catches in IYFS in February may be assigned to autumn spawners (Anon., 1986a). Data from consumption catches show that 2-group autumn spawners were still caught in the second quarter but had left Division IIIa in the third quarter.

The fishing pattern in the Skagerrak fishery and difficulties in estimating the adult stock from the acoustic survey in August-September, both of which were discussed in the previous Working Group report, indicate that the adult spring spawners may extend their distribution into the deeper eastern part of Divisions IVa and IVb during the second and third quarters.

Meristic data from the acoustic surveys in August-September and data from the fisheries in May-August in the eastern part of the North Sea show that evidently all 3-group and older herring could be identified as spring spawners of Division IIIa type from the Egersund Bank area to the Skagerrak. Vertebral counts for age groups 1, 2, and 3+ are summarized by rectangle for the period May-August and are shown in Figure 3.1.1. In the case of 1-group herring, they would be assigned to autumn spawners, whereas the vertebral counts of 2-group herring indicate that they could be a mixture of spring and autumn spawners, particularly in the area closest to the Skagerrak. Available data did not allow separation of the 2-group at the meeting.

The Group considered, however, that the 3-group and older herring were Division IIIa herring and decided that catches of these age groups taken in May-August should not be included in the North Sea assessment. The area from which the catches were transferred is indicated in Figure 3.1.1.

It was also noted that the transfer did not isolate a single patch of catches but rather cut through a larger fishing area extending north of Egersund Bank (Figures 2.11.1-2.11.12). For this reason, increased biological sampling is needed in this area in 1987 to gain better information on the distribution of Division IIIa herring within the North Sea.

3.2 The Fishery

3.2.1 Landings

Table 3.2.1 shows the landings by countries and from the Skagerrak and Kattegat, respectively, during 1977-1986. When looking at its content, it should be kept in mind that the Danish data for 1984, the Danish and Swedish data for 1985, and the Swedish data for 1986 were provided by Working Group members and have no official standing.

The total catch in 1986 was 11% lower than in 1985 and 7% lower than in 1984. It was, however, still high compared with the years before 1984. The decrease from 1985 to 1986 was caused by a 30% decrease in the Kattegat, which was almost entirely due to a decrease in the Danish industrial catch in the Kattegat of approximately 25,000 t. This will be discussed further in Section 3.5.2. In the Skagerrak, there was a small increase of 5%.

The distribution of the landings by quarter was 14% in the first quarter, 12% in the second, 43% in the third, and 31% in the fourth.

As in previous years, an important proportion of the landings was taken in the small-mesh trawl fishery, which together with by-catches of small herring in the consumption fishery was used for meal and oil. This amounted to 85,327 t in the Skagerrak and to 44,707 t in the Kattegat. The landings of herring for human consumption were 52,849 t in the Skagerrak and 32,814 t in the Kattegat.

3.2.2 Catch in numbers at age

The species composition in the Danish industrial landings was based on a rather large number of samples collected by the fishery inspectors. The biological data base was, however, far from being satisfactory with respect to the Danish landings of:

1) herring caught in the small-meshed fishery in the Skagerrak and Kattegat, and

2) by-catches of herring in the consumption fishery in the Skagerrak.

The Danish consumption landings both in the Skagerrak and Kattegat were covered by a fair number of samples, as was the by-catch in the consumption herring fishery in the Kattegat.

In the case of the Swedish data, only very few samples were available on species composition and age and length composition for the industrial catch in the Skagerrak. The Swedish industrial landings in the Kattegat were covered by a fair number of samples both with respect to species composition and age-length composition. The Swedish industrial landings in both the Skagerrak and Kattegat were mainly herring taken with 32-mm mesh and rejected for human consumption. The Swedish consumption landings in both the Skagerrak and Kattegat were covered by a fair number of samples.

The Norwegian catches in the Skagerrak were also covered by a fair number of samples.

The catches made by the Faroe Islands and the Federal Republic of Germany were not sampled, and Danish samples from the consumption fishery in the Skagerrak were applied to these catches.

Catch of 2-group and older herring in Division IIIa

As the combined assessment of herring in Division IIIa and Subdivisions 22-24 only concerns 2-group and older herring, the Working Group found it very important at least to try to obtain a catch figure as realistic as possible for 2-group and older herring in Division IIIa, in spite of the bad sampling coverage for a part of the catch. With respect to the catch of 0- and 1-group herring, it was the opinion of the Working Group that reliable figures could not be obtained.

The main part of the catch of 2-group and older herring was covered by a fair number of samples as they were mainly caught in the consumption fishery. However, a significant amount of especially 2-group has, in former years, been caught in the indu-

strial fishery. The following is an attempt to estimate this number in 1986. While the sampling in 1985 was also very sparse, the Danish industrial landings in 1984 in the Skagerrak and Kattegat were covered by a fair number of samples. As the industrial fishery did not seem to have changed to a significant degree since 1984, and since the year-class strengths of 1- and 2-groups in 1984 and 1986 were rather similar according to the IYFS (see Section 3.4), the age distribution and mean weight at age from the Danish industrial landings in 1984 in the Skagerrak and Kattegat separately and by quarters were used for the unsampled Danish industrial catches in 1986.

The estimated catch number obtained in this way is shown in Table 3.2.2. The age distribution from 1984 was given as the number of 0-groups, 1-groups, 2-groups, and >3-groups. It was, therefore, not possible to separate the "3-groups and older" into separate age groups and, because the industrial catches usually contain very few old herring and because the number of "3-groups and older" was rather small, it was assumed that all the herring in this category were 3-ringers.

The possibility of using biological data from the acoustic surveys in August-September was rejected because it was impossible to define the distribution of the industrial catch by area.

As mentioned above, a proportion of the catch of 3-ring and older herring caught in Divisions IVa,b was transferred to the Division IIIa-Sub-division 22-24 herring stock based on racial characteristics. The amount in number and their mean weight at age are shown in Table 3.2.3.

The total catch and mean weight by age of herring in a proportion of Divisions IVa,b and Division IIIa, obtained as mentioned above, is shown in Table 3.2.4.

3.2.3 Advice and management applicable to 1986

As in 1985, there was a TAC in 1986 for the mixed sprat/juvenile herring fishery with small-meshed gears for industrial purposes in Division IIIa. The TAC for this fishery was increased from 58,000 t in 1985 to 80,000 t in 1986. Before 1985, it was prohibited to catch herring with small-meshed gear. Nevertheless, large amounts of herring caught as by-catch in the sprat fishery were landed in the first half of the 1980s, when the dominance of sprat was replaced by a dominance of herring.

The total catch of 0- and 1-group herring in Division IIIa in 1986 was probably the major part of the total industrial catch of herring (120,000 t). The actual amount is unknown because of the lack of samples from the major part of the industrial landings of herring in 1986. However, a certain but unfortunately unknown fraction was by-catch in the human consumption fishery which usually consists of older herring. Compared to the amount of 0- and 1-groups in 1985 which amounted to more than 100,000 t (see Anon., 1986a), no major change seems to have occurred in the total catch. However, the catches of herring in the small-meshed fishery in the Kattegat have been reduced. As mentioned in Section 3.2, the industrial catch of herring decreased by about

25,000 t. This was due to the strong enforcement of the quota system in that part of Division IIIa. The non-existent or only very small increase in the catches of 0- and 1-group herring in Division IIIa should be seen against the background of the probably very large amount of juvenile herring in Division IIIa in 1986, as indicated by both the acoustic estimates and the IYFS indices in February 1986 and 1987.

The TAC for 1987 for the mixed sprat/juvenile herring fishery was set at 80,000 t.

There was no agreed TAC for the catch of herring for human consumption in Division IIIa in 1986. For 1987, an agreement was reached between management parties in this area to set a TAC at 138,000 t.

3.3 Biomass Estimates from Acoustic Surveys

Three acoustic surveys of herring abundance were carried out in 1986. In August, the Skagerrak and Kattegat were surveyed by R/V "Dana". In September, the same area was covered by R/V "Argos". A third survey by R/V "G.O. Sars", covering Division IIIa and the North Sea, was made in November.

The integration was carried out using 38 khz echosounders and a Simrad QD integrator ("Dana") and a NORD-10 computer system ("Argos" and "G.O. Sars"), respectively. All systems were calibrated on standard copper spheres. An intercalibration of the system on board R/V "Argos" and R/V "Dana", carried out in 1984, resulted in good agreement with insignificant differences. In the 1985 surveys, the integrator output was pooled. In 1986, the results from "Dana" and "Argos" were worked up separately in order to compare the two survey estimates. The idea was that the timing of the survey could be critical to the estimates and that September was the best period for doing the survey, because the big herring particularly would then have moved entirely into the survey area and would be more vulnerable both to acoustic integration and pelagic trawling. The estimates of older herring (≥3-groups) in former surveys have been found to be underestimates of the adult stock as the actual catch of adult herring has exceeded the acoustic stock estimate (Anon., 1986a). However, bad weather in September resulted in an underestimate of the herring abundance in the "Argos" survey. Therefore, the estimates from "Dana" in August were found more reliable. As "Dana" did not cover some of the shallow water areas, estimates from the "Argos" survey were used for these areas. In spite of the bad weather in September, it could, however, be concluded that the timing of the survey was not the cause of the underestimation of the older herring. "Argos" in September did not come up with a higher proportion of older herring relative to younger herring than "Dana" in August.

In the first two surveys, a depth stratification was used, whereas in the November survey, statistical rectangles were used as strata.

The results of the August-September survey are based on 1,532 nautical miles of integrations and the species composition in 68

pelagic trawl hauls. In the November survey, integration was carried out over 710 nautical miles, and a total of 10 pelagic trawl hauls were made.

Recorded echo levels were split on species according to the composition in the catches. The following length-dependent TS regressions were used:

Herring and sprat:

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

(Halldórsson and Reynisson, 1983)

Gadoids:

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

(Anon., 1984c)

For mackerel, spurdogs, and other species without a swimbladder, a TS 6 dB below that of herring was used. The TS regressions applied are consistent with those used in previous years. The number of herring was allocated to age according to the age composition in the trawl samples.

The estimates for the herring stocks in Division IIIa in August-September for the period 1979-1986 are given in Table 3.3.1. It should be noted that the estimates from 1979-1983 are not raised to the area used in 1984-1986. The November estimates in 1982-1986 are given in Table 3.3.2.

A striking feature in the 1986 stock estimates is the very high number of 0-ringers both in August-September and in November. Usually, the 0-group is distributed in shallow waters and consequently not adequately covered by the August-September survey. This year, as in 1985, the 0-group was distributed over the whole area, including the deeper parts, and not concentrated in the Kattegat and the shallow waters of the Skagerrak, as was seen in earlier years. The high estimate of the 0-group was to some degree confirmed by the IYFS 1-group index for Division IIIa in February 1987 (see Section 3.4), although not to the same extreme level.

The estimate of the number of 1-groups was very high in the August-September survey but a little less than in former years in the November survey. The high estimate in August-September was supported by a very high IYFS 2-group index in February 1987 (see Section 3.4).

The estimate in August-September of older herring (> 3-group) was in line with estimates from previous years which have been found to be underestimates of the adult stock, as indicated above (Anon., 1986a).

The November survey estimated the abundance of adult herring to be zero as in the previous two years (Anon., 1986a). This is suspected to be caused by inefficient trawling during this survey.

3.4 Recruitment

3.4.1 General remarks on the 1987 survey

The 1987 IYFS survey was carried out in February during a period of extensive ice cover in the Kattegat and the eastern part of the Skagerrak. The ice situation was more severe than in the preceding two years and some shallow standard stations in the part of the Kattegat where high abundance of herring normally occurs were not worked. In spite of the ice situation, a total of 42 herring hauls were completed. The corrections for missing standard stations have not been applied to the indices and they could, therefore, be slightly underestimated.

3.4.2 Abundance of 1-group herring

The highest catches of 1-group herring were obtained in the Kattegat and in the eastern part of the Skagerrak, whereas lower catches were made in the western part close to the North Sea. The total index in 1987 was 11,733, which is still very high compared to the long-term mean, but only 50% of the 1986 index.

An attempt to split the 1-group herring into spring- and autumn-spawned components was carried out using the same method used in previous years (Anon., 1984d). The indices for the period 1980-1987 are shown in the text table below.

Year	Index		
	Total	Spring spawners	Autumn spawners
1980	2,311	1,607	704
1981	3,246	966	2,250
1982	2,560	1,408	1,152
1983	5,419	1,522	3,897
1984	6,035	2,793[1]	3,242[1]
1985	7,994	-[1]	-[1]
1986	21,489	-[1]	-[1]
1987	11,733	-[1]	-[1]

[1] Separation not valid.

A modal length analysis based on different depth strata gave components with mean lengths between 13.4 and 16.3 cm and mean vertebral counts of 56.24 - 56.51. Data on each component are shown in the text table below.

Mean length (cm)	Mean VS
13.4	56.25
13.6	56.21
14.3	56.43
14.7	56.49
15.3	56.51
16.3	56.40

It is clear from the mean vertebral count that it has not been possible to separate the spring- and autumn-spawned components, and the results could not be accepted. The vertebral count shows that the autumn spawners dominated the 1-group herring in 1987 and indicate a weak year class of local spring spawners.

3.4.3 Abundance of 2-group herring

The 2-group herring index in 1987 was 3,871, which is an increase of about 50% compared to the 1986 index and the highest on record. The total index is a mixture of spring- and autumn-spawned herring, and these components were separated by the same method attempted in the analysis of 1-group herring. The indices are shown in the text table below.

Year	Index		
	Total	Spring spawners	Autumn spawners
1980	387	307	80
1981	1,393	1,318	75
1982	549	445	104
1983	1,063	946	117
1984	1,947	1,419	528
1985	2,473	1,867	606
1986	2,738	1,562	1,176
1987	3,671	2,921	949

The split gave components with mean length in the range of 15.1 - 23.0 cm and mean VS of 56.00 - 56.38. Vertebral counts of each component found in the four strata are shown in the text table below.

Mean length (cm)	Mean VS
15.1	56.00
16.1	56.18
18.9	56.05
20.0	56.13
20.3	56.24
21.5	56.18
22.5	56.37
23.0	56.38

The tendency observed in previous years of decreasing mean length of the 1-group autumn-spawned herring is now also observed in the 2-group component of the same herring stock. The reduced growth of the North Sea herring has influenced the separation of the 2-group herring,. The VS values of the separated component indicate that the separation of the 1987 data is not as complete as in previous years.

The indices of spring and autumn spawners will, to some extent, be influenced by the uncertainty of the origin of components with intermediate VS values. The spring-spawner components with VS counts of about 56.00 were found to be distributed mainly in the most shallow strata which have the highest weighting factor, and these components account for about 75% of the total index. In the case of autumn spawners, about 15% of the total index could be assigned as pure autumn spawners with VS of 56.30 or more. The remaining 10%, which is still a mixture, could only result in minor changes in the indices. The proportion of the spring-spawner index in 1987 is 0.74, which is very close to the mean value of 0.73 in 1981-1986.

3.5 State of the Stock and Management Considerations

3.5.1 General remarks

In the 1986 round of the assessment working group meetings dealing with the herring stocks in Division IIIa and in the western Baltic-Belt Sea, a new assessment strategy was applied.

On the basis of racial composition and tagging experiments, which have been discussed in previous reports, the spring-spawning herring in these areas have been treated as a single stock, and a joint assessment was carried out by the Working Group on Assessment of Pelagic Stocks in the Baltic (Anon., 1986d). Due to insufficient data on number at age and racial composition of the catches of 0- and 1-group, the combined assessment was based on catches of 2-group and older.

To account for a marked difference in seasonality of the fisheries with a dominance of catches in Division IIIa in the second half of the year and a dominance in the western Baltic in the first half, the assessments were carried out on a half-year basis.

The assessment was tuned to a series of combined 2-group IYFS indices covering Division IIIa in February and GDR 1-group indices in Sub-division 24 in November of the year preceding the IYFS survey.

At the meeting of this Group, strong evidence was presented, based on meristic data, that a proportion of the Division IIIa-western Baltic spring-spawning stock was distributed and caught in the eastern North Sea in the second and third quarters in 1986. A transfer of about 20,000 t of 3-group and older herring was, therefore, recommended by this Group to be included in the joint assessment.

As both working groups involved in the joint assessment of this stock held meetings overlapping in time, a sub-group was arranged which agreed on how the 1987 assessment should be carried out.

The results of the 1987 assessment, management considerations, and state of the stock (with a stock summary) will be given by the Working Group on Assessment of Pelagic Stocks in the Baltic.

3.5.2 Allocation of predicted catch of herring in the combined assessment in Division IIIa and Sub-divisions 22-24

In the prediction for the time period 1986-1987, ACFM decided to use the proportion of the catches taken in the two management areas and assumed that the relative levels of fishing mortality in these areas would remain the same as in recent years.

It was noted that although the catches by number of 2-group and older herring are comparable in Division IIIa and Sub-divisions 22-24, the catches are generating higher unweighted F values in the Baltic part of the assessment area, the reason being that the fisheries in the southwestern Baltic, which are carried out mainly within or close to the spawning season, are more concentrated on the oldest age groups in the adult stock. As the present assessment and prediction only includes the 2-group and older, it is expected that a change in exploitation strategy aiming at another distribution of F on the adult stock between the areas would give only a marginal increase in yield of this stock. Consequently it was not possible to recommend a change in the distribution of F from a biological point of view, and a proportional reduction in F would be preferable if a reduction in F of the adult stock was the target.

However, one way of improving the yield of the stock would be a further reduction in the catches of juvenile herring mainly exploited in Division IIIa. A reduction in 0-group catches would benefit mostly the North Sea stock with the present stock composition, whereas a reduction in the 1-group catches would increase the yield in both stocks of 2-group and older.

4 CELTIC SEA AND DIVISION VIIj HERRING

4.1 Introduction

The herring fisheries to the south of Ireland in the Celtic Sea and in Division VIIj are considered to exploit the same stock. The assessment of the stock and the management of the fisheries has been combined since 1982. The area for which this assessment is made together with the area for which the TAC is set by the EC is shown in Figure 4.1.1.

4.2 The Fishery in 1986-1987

4.2.1 Catch data

The total catches from the combined areas both by year and by season (1 April - 31 March) are given in Tables 4.2.1 and 4.2.2. The total catch of 14,700 t taken during 1986-1987 decreased by about 14% on the figure for 1985-1986 and continued the declining trend evident since 1983. Almost all of the catch was taken by the Irish fleet during the period October-March by boats fishing the spawning concentrations. As has been the pattern for a number of years, the total catch was restricted by a lack of markets, and the Irish fleet fished throughout the season on small nightly quotas.

Some slight changes have been made to the 1985-1986 catches because of revisions to the Irish catch.

4.2.2 Catches in numbers at age

The total seasonal catches in numbers at age are shown in Table 4.2.3. These are based mainly on Irish sampling data and good coverage of the spawning fishery was obtained. The 1985-1986 catch-in-number data were altered slightly because of the change made in the Irish catch. The age composition was dominated by the strong 1981, 1982, and 1983 year classes which together constituted over 90% of the total catch. The 1983 year class (2-w.ring) constituted 39% of the total. The recruitment of three strong year classes to the fishery in recent years followed a period of poor recruitment and heavy exploitation. There are, therefore, relatively few old fish present in the catches.

4.2.3 Advice and management applicable to 1986

The TAC recommended by ACFM for this fishery for 1986-1987 was 17,000 t. The TAC adopted by the management body for the calendar year 1986 was 17,200 t. The catch in the 1986-1987 season was thus about 14% below the recommended level. In recent years, the fishery has been more effectively controlled than previously. In 1986, the fishery was not opened until 1 October and was closed again in mid-December. It was subsequently re-opened from 1 January to mid-February. In addition, all boats participating had to be licensed and fished under quota systems imposed by a local management committee. These measures caused a substantial reduction in the amount of herring landed for "withdrawal" purposes

and also discouraged an increase in the number of vessels which otherwise would have participated in the fishery.

4.3 Larvae Surveys

The larvae surveys which were initiated in this area in 1978 were discontinued in 1985. It does not appear likely that they will be resumed in the near future.

4.4 Mean Weights at Age

As the entire fishery takes place during the spawning season, the mean weights at age in the catch are taken to be the same as the mean weights at age at spawning time. The mean weights at age in 1986-1987 were slightly higher than in the previous year and these were used for that season in the VPA (Table 4.2.5).

4.5 Stock Assessment

Because of the absence of larvae surveys and any other fishery-independent methods of stock assessment and because of the absence of any measures of effort, it is difficult to detect recent trends in stock development. Following the last larvae surveys carried out in 1984-1985, ACFM calculated that the overall spawning stock size was over 110,000 t, which was about the highest level recorded over the time series since 1958. The 1986 Working Group carried out a VPA using an input F which would re-create a stock of about 100,000 t. However, ACFM considered that the data available for this stock were not adequate to carry out an analytical assessment. In an effort to obtain additional values of Z, it was decided at the present meeting to examine the catch-in-numbers-at-age data for different time periods since 1958. These periods were selected to coincide with different levels of exploitation. Catch curves were constructed for each period and values of Z calculated. However, in the most recent period selected, i.e., 1982-1986, the catches were dominated by three exceptionally strong year classes with very few old fish present. It was, therefore, not possible to obtain a realistic estimate of Z for the most recent period.

The fishery both in 1985-1986 and in 1986-1987 has been rather stable. The catch in both seasons has been about or below the level recommended by ACFM. At the same time, nearly all the catch has been taken by Irish boats and the maximum number of boats involved has been constant for the last three seasons (around 52). The 1983 year class was well represented in the catches in 1986-1987 and as there has been no obvious change in the exploitation pattern, this would indicate that this year class is at least average. Fishermen have also reported very strong concentrations of fish on the spawning grounds, with spawning during 1967-1987 starting in October and continuing until March. There are, therefore, no reasons to suspect that the stock has declined since 1985. On this basis, the Working Group carried out a VPA using an input F in 1986 which would re-create a spawning stock biomass in 1985 of about 100,000-110,000 t. The appropriate value was $\bar{F}_{2-7} = 0.15$ (F on 1-w.ring = 15% of F on adult)(Table 4.2.4).

In this VPA, the values of M adopted were the same as those used in other stocks (1.0 on 1-w.ring, 0.3 on 2-w.ring, 0.2 on 3-w. ring, and 0.1 on older fish).

The stock sizes calculated from the VPA were very similar to those calculated by the 1986 Working Group. The spawning stock in 1986 was estimated to be about 107,000 t and has increased each year since 1980 when it was only 27,600 t (Table 4.2.5, Figure 4.5.1). The recovery of the spawning stock really commenced in 1983 with the recruitment of the 1980 and 1981 year classes to the spawning stock. Weighted values of F have decreased each year since the high value of 0.88 recorded in 1981 when the stock was at a low level. As a result of the new values of M used in the VPA, the numbers of recruiting 1-w.ring fish are not comparable with those calculated by previous working groups. In general, however, recruitment of 1-ringers was at a low level during the period 1974-1980 when it averaged about 170 million fish (geometric mean). Recruitment improved, however, in 1981 with the influx of the 1979 year class and from 1981 to 1985, averaged 706 million fish (geometric mean).

4.6 Recruitment

Young herring surveys have been carried out in the northwestern Irish Sea since 1981. Although this area is a recognized nursery area for young herring, it has not been possible to relate the abundance indices obtained to either the Celtic Sea stock or the Manx/Mourne stock. Therefore, the only information about recruitment must come from an examination of the number of 1-w.ring fish in the catches. The indications are that the 1984 year class constituted only about 3% of the catches, which is the lowest for a considerable number of years. This may indicate that it is a poor year class and this should be taken into consideration if any predictions are made for this stock. Previous working groups have used the geometric mean of the numbers of 1-w.ring fish as a basis for calculating a recruitment index for stock prediction. The geometric mean over the period 1975-1985, which included a period when recruitment was very poor as well as the more recent period of high recruitment, was calculated as 330 million fish. It should be stressed, however, that this figure is not comparable with that used by previous groups because of the new values of M adopted for this analysis.

4.7 Stock Projections

Due to a lack of data, the VPAs carried out for this stock in 1986 and 1987 cannot be considered as the basis for an analytical assessment.

4.8 Management Considerations

4.8.1 Safe biological limits and biological reference points

The 1986 Working Group carried out a fairly comprehensive examination of possible long-term yields for this fishery. This examination covered yield-biomass ratios, maximum sustainable yields, and catches at $F_{0.1}$ level. It was generally concluded that if the stock is at a high level, then catches should not exceed 20% of the spawning stock. Under conditions of average recruitment, catches of between 15,000-20,000 t could probably be maintained. A precautionary TAC of 18,000 t was recommended by ACFM for the 1987-1988 season. There is some evidence that the 1984 year class may be a weak one, and it must again be pointed out that this stock has been shown in the past to react very quickly to increases in effort and decreases in recruitment. Therefore, every effort should be made to detect changes in these two parameters.

As requested by ACFM, a scatter plot of stock and recruitment has been constructed and is shown in Figure 4.8.1. There is no clear relationship evident from this plot, but it does suggest that low stock sizes have tended to produce low levels of recruitment. The lines corresponding to $F_{(high)}$, $F_{(med)}$, and $F_{(low)}$ have been drawn and the appropriate values of F taken from the yield-per-recruit curves are $F_{(low)} = 0.07$, $F_{(med)} = 0.33$, and $F_{(high)}$ was not calculated.

4.8.2 Protection of spawning shoals

In recent years, the greatest proportion of the catch from this fishery has been used to service the Japanese roe market. It appears that this trend will continue and the market will probably expand further. This means that the major effort of the fishery will be directed at shoals just prior to or while they are actually spawning. The amount of damage that continuous trawling may do to the shoals or to the spawning grounds during the spawning season is debatable. It has been shown, however, that in this particular fishery, very high levels of F have been generated by uncontrolled fishing on the spawning grounds. This has been caused by the inability of boats to adhere to their small nightly quotas because of the densely packed nature of the shoals, and this in turn has led to considerable discarding. In addition, the overall TAC for the area has been consistently exceeded except in recent years. The spawning stock has just recovered after a long period of overexploitation and the population is still mainly composed of young fish. Therefore, because of the nature of the fishery, this young stock is particularly vulnerable to any rapid increase in effort which may arise because of an increased demand for spawning fish. The spawning grounds for this stock are well known and are all located in shallow water along the Irish coast. There is, therefore, a unique opportunity of ensuring that a proportion of the total stock will be able to spawn each year without being exploited by selectively prohibiting fishing on one of the main spawning grounds each season.

5 WEST OF SCOTLAND HERRING

5.1 Division VIa (North)

5.1.1 The fishery

The catches reported by each country for this area are given in Table 5.1.1. There have been some small changes to the preliminary total catch for 1985 given in last year's report. The preliminary total catch reported for 1986 is 82,280 t. This is about 86% above the 1985 level of 43,814 t and substantially higher than the agreed TAC of 51,850 t. This is almost entirely due to extremely high unallocated catches representing 46% of the total.

5.1.2 Catch in numbers at age

The estimated numbers at age caught in Division VIa (North) in each of the years 1970-1986 are given in Table 5.1.2. For 1986, age composition data were available from the Federal Republic of Germany, the Netherlands, Norway, and Scotland. The Faroese catches were converted to numbers at age using data from the Norwegian fishery which operated in a similar manner to the Faroese.

In previous years, catches of 1-ringed herring in the Moray Firth have been included in the catch-in-numbers data in Division VIa (North) on the basis that these fish recruit primarily to the west coast stock. In 1985 and 1986, only negligible catches of Moray Firth juveniles were recorded.

The 1983 year class (2-ringers) made up 35% of the total catch in numbers and, as in 1984 and 1985, the 1981 year class again represented a high proportion of the catch (26% by numbers in 1986). This indicates that both of these year classes are very abundant.

5.1.3 Larvae surveys

The survey coverage in time and space was excellent in 1986 and better than in the preceding years. The area was surveyed once in the first half of September by Scotland and once in the second half by the Federal Republic of Germany. In October, Scotland made two complete surveys, one in each of the two half-month periods. The main concentrations were recorded west of Uist and off the north coast of Scotland in September and near St. Kilda in October. Hatching is estimated to have taken place from mid-August to early October, with a peak around 1 September.

As last year, two outputs from the surveys were available to the Working Group (Table 5.1.3). First, the abundance index (LAI) giving an index of the abundance of small larvae (<10 mm); secondly, the larvae production estimate (LPE) calculated in the way described by the Herring Larvae Survey Working Group (Anon., 1987c). The LPE was converted into estimates of spawning stock biomass using the mean fecundity/kg values as done by the Herring Larvae Survey Working Group. No attempt has been made to

account for egg mortality.

The estimated mortality rates (z/k) used to convert length distributions into production of 6-mm larvae over time are given in Table 5.1.3. The mortality rate of 0.24 for 1986 is the lowest that has been estimated for Division VIa (North). For the estimation of larvae production, the average of the mortality rates over the years 1980-1986 was used (z/k = 0.37). The estimates from the 1970s are not included due to insufficient area coverage.

The LPE for 1986 is approximately twice the estimate for 1985. The same marked increase was not observed in the LAI.

5.1.4 Acoustic survey

An acoustic survey of Division VIa (North) was carried out by RV "Scotia" during November 1986. The survey was a repeat of one carried out in 1983 and another one in 1985.

Fish echo-traces were sampled using a midwater trawl, and on the basis of the length distributions of herring catches, three sub-areas were defined for the purposes of analyzing the data. Target strengths for herring were estimated for sub-areas of the survey. Mean target strength per fish was calculated using the relationship:

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

where L = length in cm. Mean weight per fish was calculated from a weight/length relationship ($W = 6.119 \times 10^{-6} L^{3.046}$; L in mm, W in grammes).

The results indicated a total population during the survey of 285,900 t, with 273,400 t being mature fish. Adding on the commercial catch of 2-ringers and older from September, October, and half of November (23,500 t), gives an estimated spawning stock at 1 September of 297,000 t. However, this estimate is considered an underestimate on the grounds that the area coverage was incomplete due to bad weather conditions and that the 1983 year class was not fully represented in the survey.

The number of 1-ringed fish (taken as a minimum estimate of recruitment in the previous assessment) was 85.6 million, which indicates the 1984 year class to be a poor one. These results do not conflict with the results of the Scottish demersal trawl surveys carried out in the first quarter of 1987 (see Section 5.1.5).

5.1.5 Recruitment

At previous Working Groups, catch rates of 2-ringers from Scottish bottom trawl surveys carried out during the first quarter of each year were used to estimate the number of recruits by regression against VPA results. The survey results were taken as indications rather than as precise estimates, since a convincing relationship with VPA results could not be established.

These surveys have covered the whole of Division VIa (North), but only data from hauls off the north coast of Scotland and in the North Minch were used for this analysis, since 2-ringed herring have been almost entirely restricted to catches in the two areas.

Abundance indices of 2-ringers were calculated for the years 1981-1986 according to the following procedure:

i) Catch rates of 2-ringers were normalized to a tow duration of 1 hour. (All tows were normally of 1-hour duration.)

ii) Mean catch per tow was calculated as the arithmetic mean of catch rates for all valid hauls in each of the sub-areas.

iii) Mean catch rates for the sub-areas were combined as an unweighted mean to give the recruitment index.

The results, along with the number of hauls used to estimate the index in each year, are shown in Table 5.1.4.

The index for the 1981 year class stands out as being an order of magnitude higher than any other in the series. Whilst it is clear from the catch-in-number data, as well as from the results of the VPA, that the 1981 year class is very large, one should be cautious about using the trawl survey index as a quantitative measure, since it is clearly influenced by the timing of the arrival of recruits from the North Sea and hence on the occurrence of 2-ringers off the north coast of Scotland. Furthermore, the results are based on only a small number of hauls in each year.

The acoustic survey in November can only provide a minimum estimate of the abundance of the recruiting year class. However, the 1983 survey was clearly a gross underestimate of the 1981 year class which arrived in large numbers from the North Sea later than usual during the trawling survey, causing this to be biassed upwards relative to other years.

The estimated numbers for the 1984 year class in both the trawling and acoustic surveys in 1987 and 1986, respectively, are very small and less than half the smallest VPA estimate in the whole time series. Although the results cannot be used as a quantitative estimate, they are taken as an indication that the 1984 year class is not very abundant.

Therefore, for the purpose of projecting catches and stock sizes in 1988 and 1989, respectively, the likely recruitment of 2-ringers in 1987 was assumed to be of the same order as the smallest on record since 1970, i.e., 220 million.

For the prediction years 1988 and 1989, the 1973-1982 geometric mean of the number of 2-ringers from the VPA (430 million) was used. The selected time period contains no outstanding year

classes and is considered conservative.

5.1.6 Mean weight at age

The mean weights at age in the catch and in the stock for this population were revised at the 1985 Working Group meeting in order to adjust the data to the changed fishing pattern after the reopening of the fishery in this area.

Mean weights at age from the 1985 fishery are substantially lower than the revised data from previous assessments as a result of the change in the geographical distribution of the fishery in 1985.

Weight-at-age data from the 1986 fishery were available from Scotland, the Federal Republic of Germany, the Netherlands, and Norway. These data were smoothed by fitting a von Bertalanffy curve and are given in Table 5.1.5. The SOP for 1986 is 9.6% higher than the reported catch.

Mean weights in the stock are as used in last year's assessment.

5.1.7 Spawning stock biomass and fishing mortality in 1986

Last year's assessment was based on SSB estimates derived from larvae production estimates (LPE), in view of the superior theoretical basis of the LPE. However, since the 1986 estimate was very high compared to the LAI, possibly due to the very low z/k for 1986 (see Section 5.1.3), it was only considered as an indication of a further increase in SSB during 1986, mainly as a result of the strong 1983 year class entering the spawning stock.

Therefore, the larvae abundance indices (LAI) were used to tune the VPA. As in last year's assessment, a series of VPAs using the revised natural mortality values (see Table 5.1.8 and Section 2.2) were run for the years 1973-1986 with F values for 1986 ranging from 0.2-0.5. The SSB estimates obtained from the different runs were then regressed against the LAIs. All of these regressions are significant (Figure 5.1.1). The results are summarized in Figure 5.1.2 and are as follows:

i) The sums of the residuals for the last 3 and 5 years approach zero at a fishing mortality of 0.26.

ii) SSB from the regression is 366,000 t and the estimate from VPA is 351,000 t.

Since the SSB estimate from the acoustic survey of 297,000 t was considered an underestimate, the higher SSB estimate from the VPA may correct for this, and on these grounds, a fishing mortality of 0.26 was accepted as the best estimate for 1986.

5.1.8 Results of the assessment

As a consequence of the high year-to-year variability in the catch of 1-ringers, which does not necessarily reflect year-class

strength, converged VPA estimates of this age group cannot be used to predict recruitment in catch projections. Calculations of 1-ringer population size are, therefore, of little significance in the VPA of this stock and are consequently not included in the analysis.

The results of the assessment are given in Tables 5.1.6 and 5.1.7 and are shown in Figure 5.1.3. Despite small differences which result from the revised natural mortalities, they are in good agreement with those obtained at the previous Working Group meeting, both in terms of SSB and fishing mortality. Also, the trend in the development of the SSB from larvae production estimates is reasonably well reflected.

The spawning stock biomasses in the VPA (Table 5.1.7) show that there was a rapid recovery of the stock once the fishery was closed in mid-1978. This recovery was, however, halted with the reopening of the fishery in 1981.

The increase in the spawning stock biomass in the 1984-1986 period was due to the recruitment to the spawning stock of the good 1981 and 1983 year classes. The intervening 1982 year class was also above average size.

Only two years after the reopening of the fishery, fishing mortality increased to the level of 0.4, followed by a continous decrease to 0.2 in 1985, which is the lowest in this series.

The reduction in F from 1983 to 1985 is consistent with the reduction in effort since 1984 due to diversion of fishing activity of Scottish vessels to the Shetland area, resulting in a lower catch in Division VIa (North). However, the high catches taken in 1986 are reflected in a recent increase in fishing mortality despite the increased stock biomass.

5.1.9 Projection

Due to the revision of the M-at-age values (see Section 2.2), revised yield-per-recruit and spawning-stock-biomass-per-recruit curves had to be calculated (Figure 5.1.3). $F_{0.1}$ is now estimated as 0.166 compared to 0.141 in the previous assessments based on M = 0.1 for all age groups.

The results of the assessment were used to project yields in 1988 and stock biomasses for adult (2+) herring at the beginning of the year as well as at spawning time (spawning stock biomass) for different levels of fishing mortality in 1988. Estimates of spawning stock biomass in 1989 have been made by applying 2/3 of both the natural and fishing mortality of the previous year in 1989.

The 1-ringers contribute to the total catch in a range from 0.4% to 14.6%, with an average of 7.0% in the 1981-1986 period. Due to this high variability, and since recruitment estimates as 1-ringers are not available (see Section 5.1.8), it was not possible to estimate likely catches from this age group . On these grounds, this age group has not been included in the projection.

The projections were made assuming a catch of 50,000 t in 1986. The parameters used are given in Table 5.1.8 and the results are shown in Figure 5.1.3. Selected management options are given in the text table below.

1987				1988					1989	
Stock biom. (2+)	SSB	$\bar{F}_{2-7}$	Catch (2+)	Mgmt. option	Stock biom. (2+)	SSB	$\bar{F}_{2-7}$	Catch	Stock biom. (2+)	SSB (2+)
378	304	0.18	50	$F_{0.1}$	365	296	0.166	46	360	291
				$F_{88} = F_{86}$		278	0.260	69	334	253

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

In interpreting the SSB values at spawning time, it has to be remembered that they also reflect the effect of fishing during 2/3 of the year at the same level of F as in the preceding year.

It is clear from the projections that, if the main aim is to at least maintain the spawning stock biomass at the present level to reduce the risk of recruitment failure, the exploitation rate will have to be reduced to at least the $F_{0.1}$ level and maintained there. This management option is associated with a catch of 46,000 t in 1988.

Continued fishing at the present (1986) level of exploitation would reduce the size of the spawning stock by more than 10% at the 1989 spawning season compared to the two preceding years.

5.1.10 Long-term potential yield

Total annual catches from the west of Scotland herring stock are documented from 1930 onwards. The data were presented by Saville and Bailey (1980), and these authors performed a VPA back to 1957 to examine the changes in fishing mortalities and stock sizes over this period.

From 1930-1965, catches were stable with a mean value of approximately 52,000 t with a standard deviation of 14,000 t. From 1968-1971, catches increased by a factor of more than 2 reaching a peak of over 200,000 t in 1973. However, during the same period, mean F on ages 2-7 increased from the stable level between 0.20 and 0.35 for the period 1957-1970 to over 0.8 in 1974. The estimated spawning stock size over the same period rose from the stable pre-1965 level of approximately 200,000 t to about 600,000 t in 1972.

Following the peak catches and fishing mortalities in the early 1970s, which corresponded with the introduction of purse seine fishing in the area, catches declined very rapidly to only 22,000 t in the first half of 1978, coincident with an all-time minimum spawning stock size of 70,000 t. At this point, the fishery was closed.

Stock size recovered rapidly during the closure and fishing commenced again in 1981. Catches since 1981 have been relatively stable, although fishing mortality was relatively high (0.46) in the period immediately following reopening.

The establishment of a summer fishery in the Shetland area following the recovery of the North Sea herring stocks has reduced fishing pressure on the west of Scotland stock, and catches and fishing mortality rates are now similar to those observed in the stable period up to 1965.

Examination of the catch- and stock-in-number data shows that the massive increase in catches in the early 1970s was sustained almost entirely by a single exceptional year class (1969) which was the biggest on record. The estimated numbers of this year class joining the stock as 2-ringers in 1972 was 3,000 million. Recruitment of this age group in the stable period prior to 1965 was generally in the range of 300-600 million. On this basis, and considering the yield-per-recruit value at the $F_{0.1}$ level, the long-term yield from the west of Scotland herring is within the range of 45,000-60,000 t, which corresponds to the average catch in the stable period.

5.1.11 Safe biological limits

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

Inspection of the historic fishing mortality data of the stable period prior to 1965 indicates that an F not exceeding 0.35 did not drive the stock to collapse. Therefore, that level might indicate the upper value which should not be exceeded in the management of the stock. This does not mean that this level should constantly be used as a target. A fishing mortality in the order of $F_{0.1}$ is preferable and would reduce the risk of approaching or even exceeding the safe biological limit.

However, management of the stock on the basis of a mortality rate criterion contains an element of risk after a period of above-average recruitment, due to inertia in the ability of fleets to adapt to lower catch levels when, as most inevitably happens, recruitment returns to levels more typical for the stock. This typical level may be regarded as a primary biological characteristic of the environment occupied by the stock. In view of this, a safe exploitation limit might be regarded as the annual catch which the stock is able to sustain during periods of typical recruitment (see Section 5.1.10). Authorization of catches in excess of this during periods of recruitment consistently above average must contain a high risk factor even though they may be safe in the immediate term with respect to fishing mortality.

At the request of ACFM, the reference values of $F_{(low)}$, $F_{(med)}$, and $F_{(high)}$ have been calculated (Figure 5.1.4). The results are as follows:

$$F_{(low)} = 0.07; \; F_{(med)} = 0.28; \; F_{(high)} = 0.80.$$

5.1.12 Research and data requirements

Catch and biological data for this stock are generally of a high quality and are well documented. This is a situation which must be maintained.

With regard to the fishery-independent estimates of spawning stock size, the larvae surveys appear to be providing a good record of trends in stock size and should be continued. In this context, it is most important that new fecundity data be collected from this stock, as the existing data are almost 15 years old.

The acoustic surveys covering the whole of Division VIa (North) for the first time in 1985 have been used by this Working Group to provide an estimate of stock size and recruitment. For these reasons, this survey should be continued.

5.2 Clyde Herring

5.2.1 The fishery

The reported landings from the Firth of Clyde in 1986 were 3,395 t (Table 5.2.1) against a TAC preferred by ACFM of 3,070 t and an agreed TAC of 3,400 t.

In addition, an estimated 8 t was caught as by-catch in the sprat fishery.

Sampling for discarding was carried out on a number of vessels in each month of the fishery from May to September inclusive. Verbal accounts indicated that it was at a very low level in October and November. Over the season as a whole, an estimated 14.6% of the catch by weight was discarded, which is half the proportion in 1985. Making a further allowance for overweight boxes, the estimated total catch from the Clyde in 1986 is estimated to be 4,650 t.

Monthly catches in numbers at age in 1986 estimated from samples of landings and discards are given in Table 5.2.2. The age composition of the catch in 1986 was similar to that in 1985, except that 2-ringers were better and 1-ringers less represented.

Effort data (numbers of days absent from port by all vessels taking part in the fishery) were available for the period 1974-1986. Revised data for all years up to 1985 and new data for 1986 are given in Table 5.2.3. This indicated a low level of effort in 1986.

5.2.2 Weight at age

Monthly weights at age in 1986 are given separately for landings and discards in Table 5.2.4.

5.2.3 Stock assessment

Because of uncertainties in the catches of 1-ringers prior to 1984, a VPA was carried out on 2-ringers and older using the new values of M (0.3 on 2-ringers, 0.2 on 3-ringers, and 0.1 on 4-ringers and older).

To examine the exploitation pattern, a separable VPA was carried out. This indicated rather constant selection on all age groups in the VPA. Fishing mortality in the current year was then predicted by regressing converged values of mean fishing mortalities against effort data. This was used to initiate a new VPA, and the regression of converged values against effort was recalculated. This was repeated until there was no change in the predicted fishing mortality. The resulting regression is shown in Figure 5.2.1 and gave a predicted F in 1986 of 0.24. The VPA results based on an input F of 0.24 are shown in Tables 5.2.5 - 5.2.7 and Figure 5.2.2. The matrix of log catch ratio residuals from the separable VPA is shown in Table 5.2.8.

5.2.4 Stock and catch projections

The estimated stock in numbers at age at 1 January 1987 is given in Table 5.2.7. Recruitment of 2-ringers in 1987 and 1988 was assumed to be the geometric mean over the years 1970-1986 (24.7 million). In 1987, the agreed TAC is 3,500 t, excluding discards.

The likely level of discarding in 1987 can be obtained from an examination of the proportions of F at age attributable to discarding in 1984-1986 (Table 5.2.9). The proportions in 1986 were rather different from those in 1984 and 1985, and two alternative projections were made based on the mean proportions and the 1986 proportions, respectively. Mean weights at age in discards and landings used in the projections were estimated as the mean of those for 1985 and 1986.

Using these input values, values of F in 1987 were calculated that would produce landings at the level of 3,500 t. These are given in Tables 5.2.10 and 5.2.11 for the two alternative predictions. They indicate values of F of 0.26 and 0.25 for the two alternatives. Predicted stock in numbers at 1 January 1988 is also given in Tables 5.2.10 and 5.2.11.

Catch and stock projections were made using a range of values of F and are given in the text tables below for the two alternative predictions:

Assuming proportions of F attributable to discards are the average over 1984-1986

1986		1987			1988				
Spawn. stock biom.	F	Land- ings	Dis- cards	Spawn. stock biom.	Management option	F	Land- ings	Dis- cards	Spawn. stock biom.
17,704	0.26	3,534	701	14,756	$F_{0.1}$	0.16	2,117	426	14,465
					$F_{88} = F_{87}$	0.26	3,279	664	13,220
					$F_{88} = F_{86}$	0.24	3,056	618	13,460

Weights in t.

Assuming proportion of F attributable to discards at 1986 level

1986		1987			1988				
Spawn. stock biom.	F	Land- ings	Dis- cards	Spawn. stock biom.	Management option	F	Land- ings	Dis- cards	Spawn. stock biom.
17,704	0.25	3,517	573	14,339	$F_{0.1}$	0.16	2,107	357	14,584
					$F_{88} = F_{87}$	0.25	3,309	531	13,449
					$F_{88} = F_{86}$	0.24	3,192	512	13,517

Weights in t.

5.2.5 Management considerations

As described in Section 5.2.1, the proportion of the catch in weight discarded in 1986 was considerably less than in 1984 and 1985. This was partly due to poor recruitment of the age groups subject to the heaviest discarding, but there was also a decrease in the proportion of the 2- and 3-ringers discarded. Because the TAC depends to some extent on the discarding level, there is every indication that the 1986 practice will be continued and that discarding will remain at the lower level.

Recruitment of 2-ringers in 1986 was relatively poor, and this, combined with an assumed recruitment in 1987 and 1988 at the geometric mean level, implies a decrease in the adult stock biomass over the next two years. While this trend is the result of the assumptions made in the projection, it is clear that F in this population is at about its optimum level.

As in 1986, there is no evidence of any recovery in the local spring-spawning stock that spawns in the Firth of Clyde. It is, therefore, appropriate to maintain the closure of herring fishing in the area during the period January-March.

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

6.1 The Fishery

6.1.1 Catch data

The catches by each country fishing in this area from 1977-1985 and the preliminary catches for 1986 are shown in Table 6.1.1. The preliminary catch for 1986 increased to 28,800 t, which was 5,400 t or over 23% higher than in 1985. The 1985 catches have been altered slightly, but the total remains the same. The main catches from the area are those taken by the Irish fleet, while over 40% of the total catch in 1986 must be placed in the "un-allocated" category.

The main catches by the Irish fleet were made in the second and third quarters during the closed season of the mackerel fishery, while the Dutch fleet took most of its catches during the third quarter. As has been the pattern in recent years, most of the fishing took place along the Irish coastline. The total quantity of herring landed was restricted because of marketing difficulties throughout the year.

6.1.2 Catches in numbers at age

The catches in numbers at age for this fishery are shown in Table 6.1.2. No changes have been made in the 1985 data. The 1986 figures are based on Irish and Dutch sampling data and, in general, good coverage of the fishery was obtained. The age distribution is still dominated by the strong 1981 year class which constitutes over 40% of the catches. This year class appears to be evenly distributed throughout all catches. The 1983 year class, which appears to be a strong one in the adjoining Division VIa N, constituted less than 18% of the catches in the first and second quarters, but appeared to be more abundant in the catches taken during the third and fourth quarters, particularly those taken in the northern part of the area. The 1984 year class constituted less than 1% of the catch, but 1-winter-ring fish, in general, contribute a negligible amount to the catches.

6.1.3 Advice and management applicable to 1986

ACFM recommended a TAC for this area for 1986 of 15,000-17,000 t. The TAC subsequently adopted by the management body was 17,000 t, while the actual catch exceeded the TAC by over 60%. Since 1983, the total catch for this area has been on average more than twice the level recommended by ACFM.

6.2 Larvae Surveys

Larvae surveys have been carried out in this area for a number of years by Scotland and Ireland. The Scottish surveys, which have been carried out since 1972, have not always covered the southern part of Division VIa S and, in some years, have not extended over the entire spawning season. The Scottish surveys of this area were discontinued in 1986 and are not likely to be resumed in the

near future. The Irish surveys, which cover the main spawning areas in both Divisions VIa S and VIIb,c, have been carried out each year since 1981.

In 1986, the area was surveyed by Ireland twice in October and once in November. There were no surveys in September. Hatching is estimated to have taken place from mid-September to late October with a peak in mid-October. The main concentrations of larvae were recorded in inshore waters north of Donegal and off the Mayo coast.

The larvae abundance indices (LAI) and larvae production estimates (LPE) are given in Table 6.2.1 together with estimates of fecundity and SSB from the LPE. The LPEs have been calculated using the mean mortality rate of 0.54 per mm for all years.

As in previous years, all regressions to predict spawning stock biomass from larvae results have a very high intercept and have not, therefore, been used to estimate spawning stock biomass.

6.3 Weight at Age

The mean weights at age were calculated from Irish and Dutch data. The mean weights at age in the catch were approximately 10% higher than those of the previous year, reflecting the increased catches taken in the third quarter. The mean weights at age in the stock at spawning time (September and October mean weights) also showed a slight increase (8%). The updated figures were used in the VPA, while the weights at age used in the stock prediction were based on the average of the last four years. The 1986 values compared with the mean values used in the predictions by the previous Working Group are shown below:

Category	1	2	3	4	5	6	7	8
Catch 1986 obs.values	95	138	164	194	212	225	239	208
1986 WG values	108	130	166	193	210	222	232	238
Stock 1986 obs.values	98	169	209	238	256	276	280	287
1986 WG values	120	169	210	236	260	275	283	290

Weights in g.

As there are very few differences between the two sets of data, the mean values used in the previous predictions were not altered.

6.4 Stock Assessment

The only fishery-independent method available to detect changes in stock abundance in this area is the larvae surveys (Section 6.2).These have been carried out since 1981. The larvae abundance indices (LAI) and the larvae production estimates (LPE) show a steep decline in stock abundance from 1982 to 1985 and an increase in 1986. The 1985 values obtained from the larvae surveys may, however, be underestimated because, as pointed out by the

1986 Working Group, the timing of the surveys in that year may have meant that the early spawning was not covered. The larvae surveys also do not reflect the increase in stock size which came about as a result of the recruitment of the strong 1981 year class in 1984. If the larvae surveys are in fact an indication of the spawning stock biomass and the high value of LAI in 1986 is ignored, then it is possible that the stock in 1984-1985 was only about half of what it was during the 1981-1983 period. A series of VPAs were, therefore, run with different values of F in 1986 in an attempt to identify which value of F might have caused a halving of the stock in 1984-1985. The trends in estimated spawning stock, together with larvae indices, are shown in Figure 6.4.1. As can be seen, it is extremely difficult to select an appropriate value of input F. Values below 0.5 do not indicate any substantial decrease in spawning stock, while values above 0.6 produce stock sizes below 50,000 t, which appear unrealistically low and far below anything observed over the time series of the VPA extending back to 1970. During the period 1976-1983, the spawning stock has fluctuated between about 75,000 and 108,000 t, the catch has been between 19,000 and 33,000 t, and the F has varied between 0.24 and 0.51.

The increased catches in 1986 were probably due to an increase in effort by both the Irish and Dutch fleets. The Irish fleet has increased in recent years by the addition of extremely efficient pelagic boats which, in 1986, fished for herring during the mackerel closed season. In addition, the 1986 Working Group commented that herring stocks in the area appeared difficult to locate. It was, therefore, decided that a high input F value in 1986 of about 0.6 might be the most appropriate one to use.

A VPA was, therefore, carried out using F = 0.6 on adults in 1986 and F = 0.06 on 1-w.ringers. (In this analysis, values of M were the same as those suggested as a result of discussion of the Multispecies Working Group report.) The results (Tables 6.4.1 and 6.4.2 and Figure 6.4.2) show that the spawning stock declined from over 100,000 t in 1984 to approximately 51,000 t in 1986. Values of F remained very constant up to 1985 and, in general, remained below 0.4, with the exception of 1983 when high catches (over 33,000 t) increased the value to 0.51. However, the increased effort in 1986 appeared to have produced an increase in F from 0.37 in 1985 to 0.60. The 1981 year class which entered the fishery appears to have been the strongest since 1970, while the two subsequent year classes, i.e., those of 1982 and 1983, appear to have been very weak.

6.5 Recruitment

There are no fishery-independent estimates of recruitment to this stock. Although young fish surveys have been carried out by Ireland in this area, it has not been possible to use the results for predictive purposes. The numbers of 1-winter-ring fish present in the catches cannot be used to give any idea of future recruitment because the amounts taken depend on the location of the fishery. Previous Working Groups have, therefore, used the geometric mean of the number of 1-winter-ring fish present in the stock over a number of years as an estimate of recruitment for predictive purposes. Since the catch-in-numbers-at-age data in

1986 indicate an unrealistically low level of recruitment, it was decided to use a geometric mean of 2-w.ring fish to give a better recruitment index. This was, therefore, calculated for the period 1980-1985, but excluding the very strong 1981 year class. The calculated value was 171 million 2-winter-ring fish and this was used in the stock predictions.

6.6 Stock and Catch Projections

Stock and catch projections were made using the stock at 1 January 1987 calculated from VPA. The level of recruitment for 1987-1989 was assumed to be 171 million 2-winter-ring fish. The predictions were carried out using two levels of catch in 1987: a) the TAC of 17,000 t and b) a catch at about the same level as in 1986, i.e., about 29,000 t. The input parameters and the results of these predictions are shown in Tables 6.6.1 and 6.6.2. Catches of 17,000 t in 1987 will produce an F = 0.37 and a spawning stock in that year of 50,000 t. Fishing in 1988 at $F_{0.1}$ = 0.15 will generate catches of 8,000 t and an increase in spawning stock to 60,000 t. A continuation of fishing at the 1986 level in 1987, i.e., catches of around 29,000 t, will generate an F = 0.75 and a spawning stock of only 39,000 t. Fishing in 1988 at $F_{0.1}$ = 0.15 will generate catches of 6,000 t and an increase in spawning stock to 48,000 t.

6.7 Management Considerations

As has been indicated in Section 6.4, the stock sizes estimated by this assessment are far below any that have previously been recorded. The main factors that generate this conclusion are the low indices by the larvae surveys in 1984 and 1985 and the poor recruitment of the 1982 and 1983 year classes. Even if the 1987 TAC of 17,000 t is adhered to, the catches in 1988 will have to be reduced considerably if fishing at a level of $F_{0.1}$ is to be achieved. The highest catch that could be permitted in 1988 and still allow some increase in spawning stock would be about 17,000 t. The apparent increase in mortality that has taken place has been due to an increase in effort by Irish and Dutch boats which, because of restrictions in the mackerel fishery, have concentrated on herring fishing for a large part of the year. It is important that every possible attempt be made to reduce the effort on the herring stocks in this area, otherwise the stock may fall to such a low level that it may take a considerable time to recover.

The plot of spawning stock biomass and the number of recruits (2-winter-ring fish) is shown in Figure 6.7.1. The lines corresponding to $F_{(low)}$, $F_{(med)}$, and $F_{(high)}$ have also been drawn and the F values corresponding to each have been calculated as $F_{(low)}$ = 0.05, $F_{(med)}$ = 0.18, and $F_{(high)}$ = 0.45. It can be noted that the present value of F is considerably above $F_{(high)}$.

6.8 Deficiencies in Data

The apparent decline in stock size in this area is a cause of much concern. Apart from the obvious enforcement of any recom-

mended management measures, it is extremely important to obtain further information about recruitment in the area. This may be possible by a critical examination of the young fish surveys already carried out and their continuation in a standard form. Further examination of the larvae surveys, particularly the 1984 survey, may be worthwhile and may indicate why the 1984 survey failed to indicate the strong influx of the 1981 year class. New data are also required to update the maturity ogive which, at the moment, is considered as knife-edged.

7 IRISH SEA HERRING (DIVISION VIIa)

7.1 The Fishery

7.1.1 Total catch

The catches by each country fishing in Division VIIa from 1976-1986 are given in Table 7.1.1. For 1986, the total catch reported was 7,440 t, of which 1,424 t (19%) were unallocated to country. This may be compared with the TAC of 6,300 t recommended by ACFM and subsequently adopted by the EC. The reported landings are probably near the actual catches this year, since the discarding of young fish, which has often been at a high level in the early months of this fishery in recent years, fell to a very low level in 1986. A Northern Ireland survey programme to determine the rate of discarding was stopped after a few weeks, when discarding was found to be minimal. This change in discarding practice probably resulted from several changes in the management of the fishery, including the availability of different fishing areas (see below) and the change to fortnightly catch quotas per boat.

The UK fishery opened on 2 June and closed on 4 September, with fortnightly quotas per boat in operation throughout the season. At the start of the season, there was very little market demand, effort was low, and landings were infrequent. The catches were, therefore, low in June, increased through July, and were highest in August. In the early season, the boats fished grounds to the south of the Mull of Galloway and in the mid-channel area between the Isle of Man and Northern Ireland. In July and August, some fishing was centred on the Rigg ground near the coast of Northern Ireland (which was opened again for fishing this season after a period of closure), but most was around the south of the Isle of Man. For the first time in several years, a number of landings were also made from the Manx spawning grounds to the east of the Isle of Man in August and early September. All the landings made by boats from the Republic of Ireland were from the mid-channel area to the southwest of the Chickens Rock in August. The selective (gillnet) fishery on the Mourne spawning grounds in September and October reported a catch of 563 t caught between 9 September and 17 October; the fishery, therefore, failed to catch the 600 t allocated to it, despite a high effort.

Adequate data are not available to split the catch into the Manx and Mourne stock components. However, estimates of stock composition made from the location of catches suggest that those in June and July were predominantly of Mourne origin, whilst the large catches in August were composed of a mixture of the stocks, and small quantities were taken from the Manx spawning grounds.

There is, therefore, no evidence to suggest that the fishery in 1986 made a disproportionate impact on either stock.

7.1.2 Catch in numbers at age

The catch in numbers at each age group for the years 1972-1985 is given in Table 7.1.2. This has been estimated from data derived from samples of catches landed in the Republic of Ireland, Northern Ireland, and the Isle of Man, combined with the quantities of herring landed.

Two-ring fish were the dominant age group in the catch, but with significant quantities of 1-ring fish also landed, some 48% of the catch was made up of the recruiting year classes.

7.1.3 Advice and management applicable to 1986

The TAC of 6,300 t for 1986 recommended by ACFM was adopted by the EC. The UK set aside a quota of 600 t for the Mourne gillnet fishery and introduced a detailed management programme to control the uptake of the remainder of the allocation. This included the licensing of all vessels, controlling the dates of opening and closing the fishery, fortnightly catch quotas per boat, and the reporting and monitoring of all catches through a control vessel. The usual closed season on the spawning grounds from 21 September - 16 November was also in operation, though the UK fishery actually closed on 4 September when the TAC had been taken.

The Republic of Ireland also introduced measures to control the fishery, including licensing vessels and restricting herring fishing to the month of August.

These various control measures produced better management of the fishery than in 1985, though the total catch was still some 18% greater than the TAC.

7.2 Mean Weight and Maturity at Age

Mean weights at age in the catch are given in the text table below. Apart from 1-ring fish, weights at age appeared to be greater in 1986 than in 1985, although not as high as in 1976-1983. The weights at age in the text table below were used in the VPA to calculate biomass in the appropriate years.

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

Weights in kg.

The proportions of fish in each age group likely to reach maturity were similar to those found in previous years. The propor-

tions used in estimates of the spawning stock size were the same as those used by the Working Group in 1986 (see Table 7.5.1).

7.3 Stock Assessment

7.3.1 Estimation of fishing mortality rate

In the absence of data independent of the fishery, the selection of an input F value to start the VPA was problematical. Several different methods have been used for this stock in previous years, two of which are attempted here.

a) Estimate by projection

Projections made from the VPA produced by the 1986 Working Group on the 1985 data suggest that the catch in 1986 would have generated an F of about 0.27 on ages 2-7. This was based on the exploitation pattern used by the Working Group in 1985, with full exploitation of herring 2-rings and older and exploitation of 1-ring fish 15% of that for fully-recruited age groups.

b) Estimate by fishing effort

The effort data available are the numbers of landings by trawlers in Northern Ireland and the Isle of Man (UK landings). Trial VPAs were run with a range of input F of 0.20 - 0.35. Unweighted mean $\bar{F}_{2-7}$ was extracted from these VPAs and converted to the proportion of the total mortality generated by the UK by comparison of UK catch and total catch. This proportional $\bar{F}_{(2-7\ UK)}$ was compared with UK effort for the years 1980-1985 inclusive (Figure 7.3.1, Table 7.3.1). The fishing mortality and effort values throughout this period are obviously closely correlated and regression analysis of these relationships is given in Table 7.3.2. As explained in the 1984 Working Group report (Anon., 1984d), there was a major change in the fishery in 1981 with catch, effort, and fishing mortality all showing a marked fall as a result of the management measures that were introduced. Consequently, the data for the 1980 season may not be strictly comparable, so the regression relationships have also been calculated for the period 1981-1985 inclusive and these are also given in Table 7.3.2.

All the regressions show good correlations between fishing mortality and effort. However, analysis of the goodness of fit of the various regressions does not help select an input F value since the regressions are very similar for a range of input F values. In addition, the correlation coefficients show no signs of progression towards a maximum within the range of input F values, studied. Neither did the calculation of residuals between the predicted and calculated F values produce an optimum value for input F. The values of F_{86} predicted by the effort regressions increased slightly with increasing input F, but fell between 0.2 and 0.3 for a wide range of input F values (Figure 7.3.2) for both sets of data. Under these circumstances, it may be most appropriate to select the input F_{86} value which corresponds most closely to the predicted F_{86} value. For the two sets of regres-

sions, including and excluding the 1980 season, this gives input F values of approximately 0.26 and 0.21, respectively. A value of 0.25 was chosen as the input F in 1986 in a VPA.

7.3.2 Results of VPA

A VPA was performed on the catch data for the years 1972-1986 with the input parameters as follows:

Input F at age for 1986 was 0.25, an intermediate value indicated by the analyses in Section 7.3.1. In addition, the proportional F on 1-ring fish was adjusted to 0.08 of the F on ages 2-7. This reflected the changes in exploitation pattern in the last few years.

The terminal F on the oldest age group in all years was obtained from the unweighted mean $\bar{F}_{2-7}$ by iteration. Natural mortality was changed to that proposed in Section 2.2 as a result of the Multispecies Working Group recommendations, 1.0 on 1-ring fish, 0.3 on 2-ring, 0.2 on 3-ring, and 0.1 on all older fish. The results of this VPA are shown in Tables 7.3.3 (fishing mortality) and 7.3.4 (stock size) and in Figure 7.3.3.

The stock appears to have recovered from the large catch in 1985 and is continuing to increase from the low level in 1980. The Working Group in 1986 expressed concern about the level of recruitment in 1985 and the fact that SSB had declined in 1985 in contrast to the previous four years when it had increased. This year's VPA, in addition to utilizing an extra year's catch data, has been adjusted to the new natural mortality figures. Whilst the new M values have not changed the general trends through the 1970s, the absolute values of recruitment have necessarily changed and are not directly comparable with the results of the 1986 Working Group. It seems that the 1982 and 1983 year classes were poor in comparison to the 1980 and 1981 year classes and that the subsequent low recruitment in 1984 and 1985, combined with the high catch (which exceeded the TAC by 84%), served to depress SSB in 1985. Assuming that the exploitation pattern did not change in 1986, the SSB appears to have increased as a result of good recruitment.

7.4 Recruitment

7.4.1 Estimates

A stock-recruitment relationship was plotted using SSB at spawning time and recruits at 1 January from a VPA run with F_{86} = 0.25. There appears to be a reasonable relationship between R_{86} and SSB and a Shepherd curve (Shepherd, 1982) was fitted to the data with parameters a = 35.25, b = 0.9, and k = 12.93 (Figure 7.4.1). Using this relationship and the SSB figures estimated by the VPA, the numbers of 1-ring recruits in 1987 and 1988 would be 296 and 313 million, respectively, but these estimates are highly dependent on the input F in 1986 for the estimates of spawning stock biomass in the parent years. However, this corresponds closely to the geometric mean recruitment over the years 1972-1982 (1970-

1980 year classes), which produces a slightly lower average recruitment of 283 million 1-ring fish.

7.4.2 Irish young fish survey

Young herring surveys have been carried out during the spring in the NW Irish Sea since 1980. The area concerned is the east coast of Ireland from Belfast to Dublin and is thought to contain young fish recruiting to both the Mourne and Celtic Sea stocks. It is unlikely that many of these young fish recruit to the Manx stock; nevertheless, the index produced from these surveys may be some indication of at least part of the north Irish Sea herring recruitment.

The index for the period 1980-1987 is given in the text table below (number of 1-ring fish caught per hour), together with corresponding Irish Sea recruits estimated from the VPA.

Year of survey	1980	1981	1982	1983	1984	1985	1986	1987
Year class	1978	1979	1980	1981	1982	1983	1984	1985
Index (fish/h)	121	725	1,078	474	409	723	951	1,021
VPA 1-ring (millions)	163	219	244	280	169	220	358	-

The 1981 year class was good for both the Irish Sea and the Celtic Sea stocks, but this is not reflected by the index. The young fish index may, therefore, be unreliable for the 1981 year class. If this year is eliminated from the index series, there appears to be a relationship between the index and the VPA estimate of recruitment described by the equation:

$$I = 3.73R - 185.5$$

where I is the index and R is the number of recruits in millions estimated from the VPA (correlation coefficient = 0.75). This predicts the number of 1987 1-ring recruits as 324 million.

However, since this index does not reflect the Manx component of the stock, it is probably better to use the more cautious estimate of recruitment of 283 million based on the geometric mean for the period 1973-1982, for the predictions of future catch.

7.5 Stock and Catch Projections

The results of yield-per-recruit and spawning-stock-biomass-per-recruit analyses are shown in Figure 7.3.3. There is no F_{max}, and $F_{0.1}$ = 0.164. F_{high}, F_{med}, and F_{low} were calculated by first obtaining the gradients of lines drawn on the stock-recruitment curve (Figure 7.4.1) which were higher than 90, 50, and 10% of the points, respectively. The reciprocals of these gradients were then taken as values of SSB/R. These were compared with the SSB/R curves on Figure 7.3.3 and the F values corresponding to F_{high}, F_{med}, and F_{low} were plotted at 0.875, 0.45, and 0.35, respec-

tively. This method is described in Anon. (1984a).

Predictions of stock size and catch in the years 1987-1989 were performed with the input variables given in Table 7.5.1. Recruitment input for these projections was that calculated as the geometric mean of the years 1972-1982 (Section 7.4).

Two situations were considered for 1987. The first was that the catch in 1987 would equal the TAC; this has been set at 4,500 t by the EC, although the ACFM recommended 4,300 t. The second is that it would exceed the TAC by 20% (5,400 t), a figure that reflects recent overshoots of the TAC for the north Irish Sea but is considerably less than the catch in the last two years.

Three projections were performed in each case for levels of fishing mortality in 1988 corresponding to $F_{0.1}$ (0.164), F_{86} (0.25), and F_{low} (0.35). The management options associated with these projections are summarized in the text table below.

1987				1988				1988	
Stock biom.	SSB	$\bar{F}_{2-7}$	Catch	Management option	Stock biom.	SSB	$\bar{F}_{2-7}$	Catch	Stock biom.	SSB
Catch = TAC										
64	33	0.114	4.5	$F_{0.1}$	71	38	0.164	7.3	74	41
				$F_{88} = F_{86}$	71	35	0.250	10.7	71	35
				F_{low}	71	32	0.350	14.3	67	30
Catch = TAC + 20%										
64	33	0.139	5.4	$F_{0.1}$	70	37	0.164	7.2	73	40
				$F_{88} = F_{86}$	70	34	0.250	10.5	70	35
				F_{low}	70	31	0.350	14.0	67	30

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

Catches both equalling the TAC and exceeding the TAC by 20% in 1987 would result in the F_{87} being lower than $F_{0.1}$ (0.114 and 0.139, respectively). In both projections, this would result in an increase in SSB at spawning time from 25,000 t in 1986 to about 33,000 t in 1987, with further increases in 1988 and 1989, even if F in 1988 and 1989 increased to 0.25.

Experience with this fishery suggests it is realistic to expect some overshoot of the TAC in 1987, especially since this TAC is significantly lower than in the past two years. At $F_{0.1}$, the catch in 1988 would be 7,200 t and, if recruitment occurs at the geometric mean level, this would allow SSB to increase to the levels existing before the stock collapsed in the 1970s.

If more stability in catches between years was required, a possible increase in TAC in 1987 could be considered, but it should be borne in mind that the predicted catch in 1987 depends on the reliability of the estimate of 2-ringers in 1987, which is very

dependent on assumptions about the fishing mortality rate on 1-ringers in 1986.

7.6 Management Considerations

7.6.1 Safe biological limits and biological reference points

Y/R and SSB/R relationships are shown in Figure 7.3.3 and the biological reference points $F_{0.1}$, F_{low}, F_{med}, and F_{high} are indicated. It is clear that $F_{0.1}$ is lower than F_{low}.

F_{low} and F_{med} may have some relevance as biological reference points, since throughout the period of stock decline (1972-1980), $\bar{F}_{2-7}$ was greater than F_{med}. This does not imply that the stock will always decline when $F > F_{med}$, but that F_{med} may be a dangerously high, unsustainable level of F.

7.6.2 Spawning and nursery area closures

Since the collapse of the north Irish Sea herring stocks in 1980, management of the fishery in this area has included closures to fishing of spawning and nursery areas. These were reviewed by the 1985 Working Group and some modifications recommended. The Working Group considers that the spawning area and nursery area closures applied by the EC to the 1986 fishery should continue.

8 ICELANDIC SPRING- AND SUMMER-SPAWNING HERRING

8.1 The Fishery

8.1.1 The fishery in 1986

No signs of recovery of the Icelandic spring-spawning herring were observed, and the fishery in 1986 was entirely (99.4%) based on Icelandic summer-spawning herring.

The landings of summer-spawning herring from 1969-1986 are given in Table 8.1.1. The 1986 landings amounted to about 65,500 t. In the last few years, the drift and set net fishery has gradually decreased and in 1986, practically all herring were caught in the purse seine fishery. Only 56 t were taken in set nets and no herring were caught in drift nets in 1986. The main fishery started on 5 October and finished by 15 December. Of a total catch of about 65,500 t, about 12,000 t went for reduction. In 1986,the fishery was almost entirely limited to the fjords at east Iceland, and about 55% of the total catch was taken in one fjord. The text table below gives the landings and the TACs recommended during the last few years for this fishery:

Year	Landings	TACs	Recommended TACs
1983	58.7	52.5	50.0
1984	50.3	50.0	50.0
1985	49.1	50.0	50.0
1986	65.5	65.0	65.0

Weights in '000 t.

8.1.2 Catch in number and weight at age

The catches in numbers at age for the Icelandic summer spawners for the period 1969-1986 are given in Table 8.1.1. In the first years after the fishery was opened in 1975, the 1971 year class was most abundant. During the period 1979-1982, the 1974 and 1975 year classes predominated in the catches. Since 1983, the fishery has been dominated by the very strong 1979 year class. In 1986, it still made up about 35% of the total catch by number. The weights at age for each year are given in Table 8.1.2. In 1986, the mean weight at age was close to the average weight for the period 1982-1984, but was about 6% lower than the average weight at age in 1985. The maturity at age is given in Table 8.1.3.

8.2 Acoustic Surveys

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

In November and December 1986 and in January 1987, two surveys were carried out for this purpose. The survey in November and December was aimed at the 0- and 1-ringed herring in fjords and shallow waters off west and north Iceland. Based on target-strength values used previously for this herring (Halldórsson and Reynisson, 1983), the 0- and 1-ringers (1985 and 1984 year classes) were estimated to count 72.4 and 113.0 million individuals, respectively. These estimates of juvenile herring are much lower than those of the corresponding age groups obtained the previous year. Compared to an average year class of about 400 million individuals, an estimate of 72 million is very low and it is believed that the whole distribution area was not surveyed. Compared to the previous year's estimate of the 1984 year class, the present estimate is also low.

The survey in January 1987 was aimed at the adult component of the stock. During this survey, the adult herring were distributed in all the east Iceland fjords. The combined results of the two acoustic surveys can be seen in Table 8.2.1. Compared to projected numbers at age from last year's assessment, which was tuned on the whole series of acoustic estimates (Halldórsson et al., 1986), the estimated numbers at age are considerable underestimates. This is especially the case for the 1979-1982 year classes, where the difference is 36% compared to the projected number from last year's assessment. The difference in the estimate for the 1979 year class alone is about 46%. These year

classes account for almost 90% of the total stock in number of 3-ringed herring and older. These discrepancies between this year's acoustic estimate and the projections from the previous ones can be explained by an unusual distribution pattern of the younger component of the adult stock and by the behaviour pattern in the fjords during the present acoustic abundance survey. In some of the east Iceland fjords, the herring were very close to the shore, and as the densest concentrations were located there, an underestimate is likely to result. In addition, the Marine Research Institute received information from one of the branch laboratories just after the survey that there were considerable concentrations of young age groups of herring in the open sea off the south and the southwest coast, outside the area surveyed in either of the surveys.

8.3 Stock Assessment

Because of the obvious discrepancies between the most recent acoustic estimate and projections from the previous ones, the most recent survey estimates have not been included in this year's assessment of the stock. Last year's assessment was based on ten surveys carried out in the period 1973-1985 (Halldorsson et al., 1986). Instead, the fishing mortality rate in 1986 was found by applying the catch in number in 1986 to the stock in number at 1 January 1986 (Anon.,1986a). Table 8.3.1 shows the stock and catch in number for 1986 and the corresponding fishing mortality rates. The rather high fishing mortality rates for the older age groups can be explained by the distribution of the stocks. As mentioned earlier, the older herring were located in the fjords at east Iceland during the fishing season, but the younger herring were distributed in the open sea off the south and the southwest coast where no fishing took place. This led to higher catches of the older herring than expected and also to higher fishing mortalities. The weighted mean values of F are 0.39 for 7- to 14-ringed herring and 0.20 for 4- to 6-ringed herring. For this stock, it has been usual to use weighted mean Fs to tune a VPA to reduce unexpected fluctuations in fishing mortality in individual year classes. These fluctuations may occur as a result of imprecision in sampling small year classes. In 1986, this procedure only changed the F values for the 9- and 14-ringed herring to any extent, which are two of the smallest age groups in the stock at present. The Fs for 4- to 6-ringed herring are slightly lower than the target exploitation rate ($F_{0.1}$ = 0.22) or 0.20. Despite these high fishing mortalities for the older herring, the weighted average fishing mortality is only slightly higher than the target level for 4-ringed and older herring in 1986 (F_{4+} = 0.24). The F for the 1-ringers in 1986 was chosen to give an average year class of approximately 400 million individuals at 1 January 1986.

Although analysis carried out by the Multispecies Working Group (Anon., 1987a) indicates that the annual natural mortality for the North Sea herring is higher than 0.1 for the younger age groups (0-3 ringers), it is believed that M for the Icelandic herring is lower than in the North Sea. Analysis of feeding habits of demersal fish species in Icelandic waters (Palsson, 1983) shows that herring is not an important food for cod or other demersal species in the area. These results are in accor-

dance with the distribution pattern of the herring, which has a limited oceanic distribution compared to capelin, which is the most important food for cod in the area (Palsson, 1983). Furthermore, the whiting, which is the main predator on herring in the North Sea, is found in much smaller numbers in Icelandic waters than in the North Sea. Since there is no basis for a change in values of M on Icelandic herring, it was decided to retain the value of 0.1 on all age groups which has been used previously in the VPA for the Icelandic herring. While the values of M on 0-and 1-group may be higher than 0.1, the catches of these age groups are very small and the use of different M values on those age groups will have no effect on the assessment.

Using the catch-at-age data given in Table 8.1.1 and the 1986 F values given in Table 8.3.1, a VPA was run. Fishing mortality at age, stock in numbers at age, and spawning stock biomass on 1 July are given in Tables 8.3.2 and 8.3.3, respectively.

The results of the assessment indicate that the spawning stock biomass increased from about 11,000 t in 1972 to about 200,000 t in 1980. Some decline occurred in 1981 but due to the strong 1979 year class the spawning stock increased again in 1983, and it is estimated that it was about 318,000 t in 1986.

8.4 Catch and Stock Projections

Catches were calculated over a range of Fs for 1987 using the parameters given in Table 8.4.1. The stock-in-numbers data were derived from Table 8.3.3, apart from the 1-ringers which were assumed to be 400 million. This age group is practically absent from the catch and has no effect on the results of the predictions. Last year, a new method was used to estimate weight at age in the catch from this stock. In this projection, the same method was used which is expressed in the following equation:

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

where W_i and W_{i+1} are the mean weights of the same year class in year i and i+1, respectively, for the period 1976-1985. This relation was used to calculate the weight at age in the catch in 1987 for 1- to 8-ringed herring. For the older herring, the mean weight at age from 1984-1986 was used. It was assumed that the exploitation pattern will be similar to what was observed in the last few years.

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

1986		1987			1988
Catch	F_{4+}	SSB at 1 July	F_{4+}	Catch	SSB at 1 July
65.5	0.24	385	0.15	45	420
			0.22	70	400
			0.30	90	375

Weights in '000 t.

During the period 1980-1983, the fishing mortality rate in the adult component was about 0.3. This is in excess of the $F_{0.1}$ level, which has been advised by ACFM, and corresponds to $F = 0.22$ (Figure 8.4.1). In 1984 and 1985, F was below this level. In 1986, the fishing mortality rate was slightly higher than this target level. Exploiting this stock at the $F_{0.1}$ level in 1987 would result in a catch of 70,000 t.

8.5 Management Considerations

In the Northeast Atlantic, the Icelandic herring can be considered to live at the outer limits of the herring distribution area (Jakobsson, 1980). The environment around Iceland is very variable and large differences in the environment may occur between successive years. These large fluctuations in the environment are reflected in both the primary and the secondary production in the area (Thordadottir, 1977; Jakobsson, 1978; Astthorsson et al., 1983). In 1965, large changes occurred in Icelandic waters where the production in general decreased. In the following years, the exploitation of the Icelandic summer-spawning herring increased and at the same time, the recruitment to the stock decreased compared to years with more favourable conditions in the sea (Figure 8.4.2). The result of this increase in exploitation was that the stock collapsed almost completely in the early 1970s. The collapse of both the Icelandic summer- and spring-spawning herring stocks are examples of the danger of high exploitation rates during periods of changing environmental conditions (Jakobsson, 1980).

During the period of decline of the Icelandic summer spawners, the fishing mortality rates increased rapidly and reached 1.5 in 1971. By 1972, the spawning stock had been reduced from a level of more than 300,000 t in 1961 to a level of 11,000 t. Because of this rapid decline in the stock, a fishing ban was introduced in 1972.

When the herring fishery started again in 1975, the exploitation strategy was to keep the fishing mortality at the $F_{0.1}$ level, which is 0.22 for this stock. This has, in general, been observed for the period 1975-1986. Using this level of exploitation, the spawning stock biomass had, by 1986, increased to the same level as before the decline of the stock, or about 320,000 t. During the recovery of the stock, the catch also increased and was 65,000 t in 1986. The recent history of the stock indicates that one of the main advantages obtained by exploiting stocks such as the Icelandic herring with low fishing mortality rates is that annual fluctuations in the fishery caused by variable recruitment

will be reduced.

In recent years, the recruitment has been variable, with large year classes in 1979 and in 1983, but small year classes in 1976, 1977, and 1978. The differences in year-class strength in the last years may reflect changes in the environment. For the Icelandic summer spawners, there is no obvious stock-recruitment relationship (Figure 8.4.3), and there is thus no evidence to suggest a decrease in recruitment at the present high stock sizes. For this stock, it is, however, observed that the recruitment has been higher in periods with high stock levels than in periods with lower stock levels. On these grounds, it is strongly recommended that exploitation should be kept at low levels for the next years. Experience shows that $F_{0.1}$ is an appropriate target level for the exploitation of the Icelandic summer spawners.

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10 WORKING PAPERS

The following working papers were presented.

1. A. Aglen. Results from a herring acoustic survey in the North Sea and Skagerrak/Kattegat, November 1986.

2. A. Aglen. Norwegian tagging experiments, November 1986 and March 1987.

3. J. Bertrand. French acoustic survey in 1986.

4. V. Christensen. Larvae production estimates, larvae abundance indices for 1982-1986, and a summary of the Report of the Working Group on Herring Larvae Surveys South of 62°N (10-12 February 1987).

5. A. Corten. Long-term potential yield of the IVa, b stock.

6. O. Hagström. Preliminary report on the Swedish acoustic survey in ICES Division IIIa in September 1986.

7. M. Heath. An acoustic survey in Division VIa (N) during November 1986.

8. P.J. Hopkins. Biological reference points.

9. P.O. Johnson. Results of an English acoustic survey in the west central North Sea (Division IVb).

10. P.O. Johnson. Prediction of recruitment to Downs stock.

11. P.O. Johnson. Recent fecundity observations on Banks herring.

12. E. Kirkegaard, P. Lewy and K.-J. Stæhr. The Danish acoustical survey in Division IIIa and eastern North Sea August 1986.

13. J. Morrison. Scottish herring tagging experiments 1986.

14. E.J. Simmonds. Accuracy of mortality estimates (from acoustic surveys).

Table 2.1.1 HERRING. Catch in tonnes 1977-1986 North Sea, Sub-area IV, and Division VIId by country. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1977	1978	1979	1980	1981
Belgium	57	-	-	-	-
Denmark	12,769	4,359	10,546	4,431	21,146
Faroe Islands	8,078	40	10	-	-
France	1,613	2,119	2,560	5,527	15,099
German Dem.Rep.	2	-	-	-	-
Germany,Fed.Rep.	221	24	10	147	2,300
Netherlands	4,134	18	-	509	7,700
Norway	4,065	1,189	3,617	2,165	70
Poland	2	-	-	-	-
Sweden	3,616	-	-	-	-
UK (England)[2]	3,224	2,843	2,253	77	303
UK(Scotland)[2]	8,159	437	-	610	45
USSR	78	4	162	-	-
Total North Sea	46,010	11,033	19,158	13,466	46,663
Total including unallocated catches	-	-	-	60,994	140,972

Country	1982	1983	1984	1985	1986[1]
Belgium	9,700	5,969	5,080	3,482	414
Denmark	67,851	10,467	38,777	129,305[1]	121,631
Faroe Islands	-	-	-	-	1,580
France	15,310	16,353	20,320	14,400	9,730
German Dem.Rep.	-	-	-	-	-
Germany, Fed.Rep.	349	1,837	11,609	8,930	4,026
Netherlands	22,300	40,045	44,308	79,335[1]	85,998
Norway	680	32,512	98,714	161,279[1]	219,598
Poland	-	-	-	-	-
Sweden	-	284	886	2,442	1,872
UK (England)	3,703	111	1,689	5,564	1,404
UK (Scotland)[2]	1,780	17,260	31,393	55,795	77,459
USSR	-	-	-	-	-
Total North Sea	122,056	124,838	252,776	460,532	523,710
Total including unallocated catches	235,925	305,954	317,263	534,173	544,801

[1] Preliminary.

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

Table 2.1.2 HERRING, catch in tonnes in Division IVa West. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1980	1981	1982	1983	1984	1985	1986
Denmark	687	11,357	3,155	4,282	26,786	77,788	48,590
Faroe Islands	-	-	-	-	-	-	1,580
France	651	1,851	1,970	680	1,408	2,075	462
Germany, Fed.Rep	-	-	-	1,542	12,092	4,790	2,602
Netherlands	-	-	-	15,745	19,143	49,965	42,900
Norway	-	-	-	16,971	21,305	10,507	63,848
UK (Scotland)	18	2	1,706	16,136	24,634[1]	52,100[1]	71,285[1]
Sweden	-	-	-	213	-[1]	-[1]	-[1]
Unallocated	1,762	6,492	300	3,955	24,030	4,249	-
Total	3,118	19,702	7,179	61,738	129,398	201,474	231,267

[1] Included in Division IVb.
[2] Transferred from Division IVb.

Table 2.1.3 HERRING, catch in tonnes in Division IVa East. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1980	1981	1982	1983	1984	1985	1986
Denmark	-	-	491	-	126	-	4,540
Norway	21	70	680	-	49,125	111,307	115,068
UK (Scotland)	-	-	-	257	74	-	-
Unallocated	2,476	937	-	431	-	-	-
Total	2,497	1,007	1,171	688	49,325	111,307	119,608

Table 2.1.4 HERRING, catch in tonnes in Division IVb. These figures do not in all cases correspond to the official statistics and cannot be used for management purposes.

Country	1980	1981	1982	1983	1984	1985	1986
Denmark	3,733	9,689	64,205	6,050	13,808	51,517	67,966
France	176	524	561	705	2,299	1,037	605
Germany, Fed.Rep	147	2,300	118	-	2	4,139	1,424
Netherlands	35	-	219	300	4,600	-[3]	21,101
Norway	1,607	-	-	14,156	25,820	39,465	40,682
UK (England)	76	13	3,128	40	1,956[1]	5,214	1,101[1]
UK (Scotland)	592	43	74	867	2,477	2,894	6,057
Sweden	-	-	-	71	884[2]	2,442[2]	1,872[2]
Unallocated	9,258	65,811	90,262	159,124	41,294	47,799	1,594
Total	15,624	78,380	158,567	181,313	93,140	154,507	142,402

[1] Includes catches misreported from Division IVc.
[2] Includes Division IVa catches.
[3] Included in Division IVa.

Table 2.1.5 HERRING, catch in tonnes in Divisions IVc and VIId.

Country	1980	1981	1982	1983	1984	1985	1986
Belgium	-	-	9,700	5,969	5,080	3,482	414
Denmark	11	100	-	135	53	-	535
France	4,700	12,724	12,799	14,968	16,613	11,288	8,662
Germany, Fed.Rep	-	-	183	295	-	-	-
Netherlands	474	7,700	22,081	24,000	21,922	32,370	21,997[4]
Norway	482	-	-	1,385	-	-	-
UK (England)	1	290	602	71	571[1]	350[2]	303[5]
UK (Scotland)	-	-	-	-	-	799	117
Unallocated	37,418	21,069	23,307	17,606	1,788	21,595	19,495
Total	43,086	41,883	68,652	64,430	46,027	69,884[3]	51,523

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

Table 2.1.6 NORTH SEA HERRING, 1986, millions caught by year class, age group (winter rings), division and quarter.

Division	Quarter	1985 0	1984 1	1983 2	1982 3	1981 4	1980 5	1979 6	1978 7	1977 8	1976 9+	Total	011 rings
IVa	I	-	0.5	216.8	186.9	123.6	33.6	18.9	5.3	5.5	7.2	598.2	0.5
(W of	II	-	27.1	127.9	57.0	29.2	9.6	2.4	2.5	0.2	0.4	256.4	27.1
2°E)	III	-	16.0	205.7	167.8	79.9	25.1	11.5	2.7	1.6	1.0	511.2	16.0
	IV	-	25.1	88.0	64.9	50.2	10.0	2.7	2.6	2.8	1.4	247.7	25.1
	Total	-	68.7	638.4	476.7	283.0	78.3	35.5	13.0	10.0	10.0	1,613.6	68.7
IVa	I	-	0.7	12.2	32.3	29.8	8.9	6.5	1.8	2.3	3.0	97.6	0.7
(E of	II	0.3	5.0	165.4	36.5	44.8	15.0	3.6	1.9	0.3	1.1	273.7	5.3
2°E)	III	108.3	159.8	25.5	12.2	5.6	1.6	1.2	0.2	0.1	-	314.3	268.1
	IV	11.8	186.0	31.7	7.3	6.9	1.6	1.0	0.7	0.5	0.1	247.4	197.8
	Total	120.4	351.4	234.7	88.2	87.0	27.1	12.2	4.6	3.2	4.2	933.0	471.8
IVb	I	-	247.1	15.8	6.3	1.0	0.1	0.1	-	-	-	270.4	247.1
	II	159.7	65.3	42.8	3.6	1.9	0.6	0.2	+	-	-	274.0	224.9
	III	413.2	511.3	75.2	48.9	26.4	5.6	2.9	0.2	+	-	1,083.8	924.5
	IV	2.1	508.5	40.6	9.7	13.4	2.5	0.9	0.4	0.1	-	578.2	510.6
	Total	575.0	1,332.2	174.3	68.5	42.7	8.8	4.1	0.7	0.1	-	2,206.5	1,907.2
IVc+VIId	I	-	3.6	12.5	43.1	7.7	4.3	1.3	0.2	+	-	72.8	3.6
	II	0.5	0.2	0.1	0.9	1.0	1.5	0.6	0.1	-	-	4.8	0.7
	III	8.2	3.7	1.1	2.1	0.3	0.1	-	-	-	-	15.5	11.9
	IV	-	3.4	94.0	147.6	36.6	7.6	7.2	1.7	+	0.4	298.6	3.4
	Total	8.7	10.9	107.6	193.7	45.7	13.5	9.2	1.9	0.1	0.4	391.6	19.6

Table 2.1.7 HERRING North Sea catch in millions of fish by age and year class, 1986.

Division	1985 0	1984 1	1983 2	1982 3	1981 4	1980 5	1979 6	1978 7	1977 8	1976 9+	Total
IVa (W of 2^0E)	-	68.7	638.4	476.7	283.0	78.3	35.5	13.0	10.0	10.0	1,613.6
IVa (E of 2^0E)	120.4	351.4	234.7	88.2	87.0	27.1	12.2	4.6	3.2	4.2	933.0
IVb	575.0	1,332.2	174.3	68.5	42.7	8.8	4.1	0.7	0.1	-	2,206.5
IVc+VIId	8.7	10.9	107.6	193.7	45.7	13.5	9.2	1.9	0.1	0.4	391.6
Total	704.0	1,763.2	1,155.1	827.1	458.3	127.7	61.1	20.2	13.4	14.6	5,144.6

Catches made in the South Buchan area of Division IVb included in Division IVa (W of 2^0E) in 1984-1986.

Table 2.1.8 Millions of HERRING caught annually per age group (winter rings) in the North Sea, 1970-1986.

Year	Winter ring										Total
	0	1	2	3	4	5	6	7	8	>8	
1970	898.1	1,196.2	2,002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5,294.3
1971	684.0	4,378.5	1,146.8	662.5	208.3	26.9	30.5	26.8	-	12.4	7,176.7
1972	750.4	3,340.6	1,440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6,045.5
1973	289.4	2,368.0	1,344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4,906.6
1974	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3,189.3
1975	263.8	2,460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3,753.3
1976	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1,482.0
1977	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7	+	656.3
1978	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	542.0	159.2	34.1	10.0	10.1	2.1	0.2	0.8	0.6	0.1	759.2
1980	791.7	161.2	108.1	91.8	32.1	21.8	2.3	1.4	0.4	0.2	1,211.0
1981	7,888.7	447.0	264.3	56.9	39.5	28.5	22.7	18.7	5.5	1.1	8,772.9
1982	9,556.7	840.4	268.4	230.1	33.7	14.4	6.8	7.8	3.6	1.1	10,963.0
1983	10,029.9	1,146.6	544.8	216.4	105.1	26.2	22.8	12.8	11.4	12.2	12,128.2
1984	2,189.4	561.1	986.5	417.1	189.9	77.8	21.7	24.2	10.6	17.8	4,496.1
1985	1,292.9	1,620.2	1,223.2	1,187.6	367.6	124.1	43.5	20.0	13.2	15.9	5,908.3
1986	704.0	1,763.2	1,155.1	827.1	458.3	127.7	61.1	20.2	13.4	14.6	5,144.7

Table 2.1.9 Percentage age composition of North Sea HERRING (2-ring and older), 1986.

Division	Quarter	2 (1983)	3 (1982)	Older	Total no.caught (millions)
IVa (W of 2^0E)	I	36.3	31.3	32.5	597.7
	II	55.8	24.9	19.4	229.3
	III	41.5	33.9	24.6	495.3
	IV	39.5	29.2	31.3	222.6
	Total	41.3	30.9	27.8	1,544.9
IVa (E of 2^0E)	I	12.6	33.3	54.1	96.9
	II	61.6	13.6	24.8	268.4
	III	55.1	26.3	18.6	46.2
	IV	63.7	14.7	21.6	49.7
	Total	50.9	19.1	30.0	461.2
IVb	I	67.7	27.0	5.2	23.3
	II	87.1	7.3	5.5	49.1
	III	47.2	30.7	22.1	159.3
	IV	60.0	14.4	25.7	67.6
	Total	58.2	22.9	18.9	299.3
IVc + VIId	I	18.1	62.2	19.7	69.2
	II	2.0	21.5	76.5	4.1
	III	29.1	57.5	13.4	3.6
	IV	31.8	50.0	18.1	295.1
	Total	28.9	52.1	19.0	372.0
IVa + IVb	I	34.1	31.4	34.5	717.8
	II	61.5	17.8	20.8	546.8
	III	43.7	32.7	23.6	700.8
	IV	47.1	24.1	28.8	339.9
	Total	45.4	27.5	27.1	2,305.4
Total North Sea	I	32.7	34.1	33.2	787.0
	II	61.0	17.8	21.2	550.9
	III	43.6	32.8	23.6	704.4
	IV	40.0	36.1	23.8	635.1
	Total	43.1	30.9	26.0	2,677.4

Table 2.3.1 1-group HERRING abundance in International Young Fish Survey.

Survey Year	Year class	Abundance 1-group in no./hour/ rectangle in standard area	VPA estimate 1-group x 10^9
1970	1968	822	7.88
1971	1969	2,647	14.60
1972	1970	1,629	11.52
1973	1971	827	7.24
1974	1972	1,195	3.62
1975	1973	1,592	7.44
1976	1974	452	1.00
1977	1975	342	0.93
1978	1976	575	1.50
1979	1977	139	1.61
1980	1978	535	3.49
1981	1979	551	4.89
1982	1980	1,293	8.19
1983	1981	1,797	15.28
1984	1982	2,714	13.56
1985	1983	3,227	(14.72)[2]
1986	1984	3,473	(15.87)[2]
1987	1985	6,096[1]	-

[1] Preliminary.
[2] Estimates strongly dependent on input figures.

Table 2.3.2 Results of IKMT sampling compared with VPA estimates of 0-group stock size.

	Mean number of larvae per rectangle						
Year class	North Sea NW	North Sea NE	North Sea SE	North Sea SW	Skagerrak/ Kattegat	IKMT index weighted by area[1]	VPA estimates of 0-group stock size x 10^9
1976	19.82	1.50	1.14	11.00	0.17	7.32	4.48
1977	4.19	6.07	1.82	6.75	0.94	3.74	4.58
1978	42.67	5.35	0.81	15.60	8.64	14.56	10.33
1979	12.03	25.89	38.08	34.52	18.47	28.21	14.53
1980	12.43	0.33	28.69	17.78	33.67	20.25	34.31
1981	23.25	7.27	49.62	26.67	12.83	30.73	56.30
1982	2.63	9.79	37.96	14.23	47.92	23.10	52.27
1983	3.27	12.17	51.60	23.23	33.86	28.88	43.47
1984	19.18	5.83	52.24	40.85	22.31	34.49	45.18
1985	24.88	17.89	54.45	49.12	6.69	38.12	(22.74)[2]
1986	50.88	17.78	77.69	80.33	6.87	58.70	-

[1] Number of rectangles per area in NW North Sea 38, NE North Sea 18, SE North Sea 61, SW North Sea 35, Skagerrak/Kattegat 17. The areas are those given in Figure 2.2 of the 1985 Report (Anon., 1985.)
[2] Strongly dependent on input values.

Table 2.3.3 Abundance indices of Downs recruits derived from English O-group and Dutch larvae surveys.

Year class	VIc/VIId[1] VPA 2-ring (millions)	English O-group (no./hr)	Dutch larvae $no./m^3$ $(x10^{-4})$
1975	87	26	10.7
1976	201	36	21.5
1977	247	65	57.1
1978	762	1,650	174.0
1979	511	157	795.5
1980	597	521	930.6
1981	559	1,596	608.9
1982	(1,055)	863	933.2
1983	(477)	33	1,696.6
1984	-	10,527	1,646.2
1985	-	3,580	2,435.2
1986	-	-	-

[1] Trial VPA run with input Fs derived from "Z" between 1985 and 1986 acoustic surveys.

Table 2.4.1 Numbers of herring at age (million) and spawning biomass ('000 t) on acoustic surveys in July 1986, by areas given in Figure 2.4.1.

Age (rings)	Orkney-Shetland Moray Firth Buchan (0° west of) (Scottish survey)	Fladen area (Norwegian survey)	Eastern area (Norwegian survey)	Egernsund Bank area (Norwegian survey)
0	-	-	-	-
1	496.1	6.1	0.2	54.2
2	1,933.9	204.8	17.2	19.0
3	729.0	246.6	23.0	24.8
4	190.4	108.0	12.6	12.0
5	45.3	32.9	3.7	3.3
6	10.9	7.4	0.8	1.1
7	4.6	2.7	0.2	0.2
8	-	1.1	0.1	0.1
>9	2.7	-	0.1	0.2
Total	3,413.3	609.4	58.0	114.8
Spawning biomass[1]	414.0	100.3	10.0	10.3

[1] Fish at stage 3 and over.

Table 2.4.2 Numbers of herring at age estimated by acoustic survey of Division IVa in 1984, 1985, and 1986 and estimates of Z.

Year class	July 1984	July 1985	July 1986	Z_{84-85}	Z_{85-86}
1984	-	-	1,638.6	-	-
1983	-	726.3	2,155.9	-	-
1982	550.7	1,818.9	998.6	-	0.60
1981	1,717.6	835.6	310.0	0.72	0.99
1980	609.6	227.6	81.9	0.98	1.02
1979	264.1	81.0	19.1	1.18	1.44
1978	81.5	28.5	7.5	1.05	1.34
1977	36.0	13.3	1.2	1.00	2.40
1976	45.9	23.3	pre-1977 2.8	0.68	2.72
1975	38.1	pre-1976 19.4	-	1.35	-
pre-1975	36.9	-	-	-	-
				Z (>2 - >3)	
>2-ringers	2,829.7	3,047.6	3,577.0		
>3-ringers	1,112.1	1,228.7	1,421.1	0.83	0.76

Covers Orkney-Shetland, Moray Firth, Buchan, Fladen, and eastern area, in Figure 2.4.1.

July 1984 estimates taken from Table 2.10 in Anon.(1985).

Table 2.4.3 Acoustic estimate of number (millions) of HERRING per age group within sub-areas, November 1986.

Age (no.of winter rings)	Sub-area												Total
	A	B	C	D	E	F	G	H	I	J	K	L[1]	
0	-	4.7	164.8	52.8	519.0	3,545.3	509.0	77.9	434.7	2,030.1	1,754.6	4,305.3	13,398.2
1	1.2	113.1	3.5	28.5	-	3,685.7	4,536.0	447.4	112.6	85.0	432.2	35.1	9,480.4
2	32.3	78.4	1.1	125.9	-	605.3	358.9	13.8	0.2	1.0	-	-	1,217.0
3	14.5	5.6	0.8	121.4	-	389.0	83.3	3.1	-	-	-	-	617.7
4	10.6	1.2	0.7	180.1	-	688.0	46.4	2.7	-	-	-	-	929.8
5	2.4	-	0.1	35.2	-	137.6	13.4	0.6	-	-	-	-	189.1
6	1.6	-	-	13.1	-	128.8	-	-	-	-	-	-	143.6
7	0.9	-	-	6.7	-	18.4	-	-	-	-	-	-	26.0
8	2.9	-	-	2.6	-	-	-	-	-	-	-	-	5.5
9+	0.3	-	-	1.7	-	-	-	-	-	-	-	-	2.0
Total	66.8	203.0	171.0	568.0	519.0	9,198.0	5,547.0	545.5	547.5	2,116.1	2,186.8	4,340.4	26,009.3
2+	65.6	85.2	2.7	486.7	-	1,967.0	502.0	20.2	0.2	1.0	-	-	3,130.7
Biomass	10.3	21.4	3.9	85.2	7.7	675.0	416.1	34.6	16.1	34.3	62.3	65.2	1,432.2
2+	10.2	9.8	0.4	80.9	-	308.5	61.7	2.4	-	0.1	-	-	474.2

[1] Compensated for uncovered areas.

Table 2.4.4 Division IVb. Combined age composition of herring samples taken during the northeast coast acoustic survey, 24 August-1 September 1986 ("Clione" cruise 10/1986).

Item	2 (1983)	3 (1982)	4 (1981)	5 (1980)	6 (1979)	7 (1978)	8≥ (≤1977)	Total
				Whitby-Flamborough				
% number	51.3	15.6	28.0	2.8	0.7	0.9	0.7	100.0
% weight	42.4	16.5	33.7	4.0	1.1	1.5	1.0	100.0
Mean length (cm)	26.19	28.20	29.29	30.95	31.25	31.95	32.58	27.62
(SD)	(0.86)	(0.77)	(0.80)	(0.25)	(0.91)	(1.04)	(1.51)	(1.79)
Mean weight (g) (stage 5 maturity)	155.6	199.7	227.4	274.0	284.0	306.4	328.7	189.0
				Sample from Netherlands Freezer-Trawler 12 August 1986 (Whitby)				
% number	46.5	30.0	22.1	1.4	-	-	-	100.0
% weight	39.8	32.4	26.0	1.8	-	-	-	100.0
Mean length (cm)	26.13	28.01	29.02	29.75	-	-	-	27.39
(SD)	(0.86)	(0.77)	(0.86)	(-)	-	-	-	(1.49)
Mean weight (g) (maturities mainly 5-6)	145.9	184.0	200.3	209.0	-	-	-	170.3

Table 2.4.5 Estimated numbers at age and mean weight in the eastern Channel.

Age (wr)	13-20 November 1986		25-28 November 1986	
	N (million)	w (gr)	N (million)	w (gr)
2	231.7	122	110.3	117
3	325.2	162	181.5	155
4	86.3	190	14.0	193
5	10.6	202	5.9	193
6	5.2	240	0.8	243
7	2.6	262	0.5	233
Total	661.6	-	313.1	-

Table 2.4.6 Estimated numbers at age and mean weight in the southern North Sea (29 November 1986).

Age (wr)	N (millions)	w (gr)
2	1.4	114
3	2.0	147
4	1.0	189
5	0.8	193
6	0.1	266
Total	5.2	-

Table 2.4.7 Percentage age compositions from acoustic survey samples compared with commercial catch age compositions, Southern Bight and eastern Channel.

Category	2	3	4	5	6	7≥
	(1983)	(1982)	(1981)	(1980)	(1979)	(1978)
French surveys (Division VIId)						
13 - 20 Nov	35.0	49.2	13.0	1.6	0.8	0.4
25 - 28 Nov	35.2	58.0	4.5	1.9	0.3	0.2
Fourth Quarter (commercial catches)	31.5	49.4	12.3	2.6	2.4	0.6

Table 2.5.1 Larvae production estimates (LPE x 10^{11} larvae) calculated using area-specific natural mortality rates (z/k) compared to larvae abundance indices (LAI) from Saville and Rankine (1985).

Year	Orkney-Shetland		Buchan		IVa (incl.Buchan)		Central N.Sea		IVc + VIId	
	LPE	LAI	LPE	LAI	LPE	LAI	LPE	LAI	LPE	LAI
1972	142	578	-	1	142	579	25	11	16	2
1973	73	239	-	1	73	240	85	73	8	1
1974	54	128	-	38	54	166	48	(63)	1	-
1975	39	44	-	44	39	88	49	6	1	-
1976	15	66	-	-	15	66	11	8	1	-
1977	(<130)	132	-	23	-	155	72	17	2	-
1978	85	371	-	36	85	407	78	46	3	1
1979	233	565	-	20	223	585	60	19	10	4
1980	240	398	-	2	240	400	111	21	102	12
1981	165	394	-	2	165	396	201	36	353	49
1982	248	380	92	100	340	480	80	34	164	37
1983	202	335	277	448	449	783	80	66	216	24
1984	156	354	433	430	589	783	560	105	146	23
1985	248	1,049	477	435	725	1,484	669	380	171	41
1986	163	550	831	378	994	928	485	203	288	48
z/k	0.26	-	0.37	-	-	-	0.36	-	0.54	-

Table 2.5.2 SSB_1 ('000 tonnes) estimated from larvae production estimates (LPE x 10^{11} larvae), and number of eggs (x 10^5) per kg SSB compared to SSB from VPA.

Year	IVa (incl.Buchan)			IVb			IVa + IVb		IVc + VIId			North Sea	
	LPE	Eggs/ kg	LPE SSB	LPE	Eggs/ kg	LPE SSB	LPE SSB	VPA SSB	LPE	Eggs/ kg	LPE SSB	LPE SSB	VPA SSB
1972	142	(1.56)	91	25	(1.79)	14	105	273	16	0.94	17	122	291
1973	73	(1.56)	47	85	(1.79)	47	94	253	8	0.93	9	103	237
1974	54	(1.56)	35	48	(1.79)	27	62	185	1	0.87	1	63	165
1975	39	1.59	25	49	(1.79)	27	52	105	1	1.01	1	53	88
1976	15	1.52	10	11	(1.79)	6	16	125	1	0.74	1	17	85
1977	-	1.57	-	72	(1.79)	40	-	99	2	1.02	2	-	58
1978	85	1.57	54	78	(1.79)	44	98	118	3	1.18	3	101	79
1979	223	1.64	136	60	(1.79)	34	170	131	10	1.07	9	179	123
1980	240	1.69	142	111	(1.79)	62	204	149	102	1.14	89	293	148
1981	165	1.51	109	201	(1.79)	112	221	172	353	1.06	333	554	218
1982	340	1.60	213	80	(1.83)	44	257	263	164	1.11	148	405	306
1983	449	1.53	313	80	(1.82)	44	357	417	216	1.10	196	553	471
1984	589	1.67	352	560	1.67	335	687	713	146	1.04	140	827	782
1985	725	(1.60)	453	669	1.88	356	809	722	171	(1.08)	158	967	839
1986	994	(1.60)	621	485	(1.76)	276	897	796	288	(1.08)	267	1,164	941

Table 2.7.1 North Sea HERRING 1986.
Mean weight (g) at age (year class) weighted by numbers caught.

Division	Quarter	1985 0	1984 1	1983 2	1982 3	1981 4	1980 5	1979 6	1978 7	1977 8	1976 9+
IVa	I	-	27	79	118	150	177	188	226	226	248
(W of	II	-	60	129	166	203	226	236	251	269	285
2°E)	III	-	88	154	199	235	254	293	296	331	364
	IV	-	93	135	169	183	198	217	229	281	266
	Total	-	78	121	159	185	210	227	246	258	263
IVa	I	-	38	86	123	149	177	186	227	235	256
(E of	II	9	71	133	169	191	224	219	269	252	284
2°E)	III	11	93	123	157	199	222	278	243	264	-
	IV	20	89	117	154	180	193	210	227	230	208
	Total	12	90	128	149	176	206	206	245	236	261
IVb	I	-	14	46	76	135	177	183	199	205	224
	II	2	26	118	159	189	211	215	269	-	279
	III	5	73	133	166	195	230	238	222	264	-
	IV	20	75	126	165	186	200	221	216	205	208
	Total	4	60	120	157	191	219	232	220	207	237
IVc+VIId	I	12	18	70	95	118	145	167	200	202	-
	II	2	25	83	104	129	153	163	198	202	-
	III	5	59	120	156	179	199	201	238	-	-
	IV	20	80	113	152	174	214	220	170	-	232
	Total	5	51	108	139	164	185	208	174	202	232
IVa	Total	12	88	123	158	183	209	222	246	253	263
IVa+IVb	Total	6	67	122	158	184	210	223	245	253	263
North Sea	Total	6	67	121	153	182	207	221	238	252	263

Table 2.7.2 Comparison between mean weights at age in catch of North Sea HERRING (adult) from earlier years and 1985/1986.

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

Table 2.7.3 A comparison between the mean weights of 1-ring fish taken as a by-catch in directed adult HERRING fisheries and those from industrial landings.

Fishery	Division	Quarters (1986) I $\bar{w}$	I No. ('000)	II $\bar{w}$	II No. ('000)	III $\bar{w}$	III No. ('000)	IV $\bar{w}$	IV No. ('000)	Year $\bar{w}$	Year No. ('000)
Norwegian purse seine	IVa W[1]	76	(0.1)	84	(0.5)	102	(8.9)	95	(12.2)	98	(21.7)
	IVa E	40	(0.6)	71	(5.0)	93	(159.8)	89	(186.0)	90	(351.4)
	IVb	-	-	62	(1.9)	81	(313.8)	94	(3.7)	81	(319.4)
Danish purse seine and trawl	IVa W[1]	-	-	-	-	-	-	-	-	-	-
	IVb	-	-	-	-	83	(0.1)	93	(1.0)	93	(1.0)
								90	(1.2)	89	(1.3)
Scottish purse seine and trawl	IVa W[1]	-	-	-	-	103	(0.2)	84	(1.6)	86	(1.8)
Netherlands trawl	IVa W[1]	-	-	-	-	76	(2.0)	-	-	76	(2.0)
	IVb	-	-	67	(0.1)	55	(3.6)	-	-	55	(3.7)
Danish industrial trawl (small mesh)	IVa W	14	(0.4)	-	-	-	-	-	-	14	(0.4)
	IVa E	14	(0.1)	25	(0)	-	-	-	-	-	-
	IVb	14	(250.1)	25	(63.2)	58	(187.0)	75	(225.6)	45	(725.9)
Danish industrial trawl (32 mm mesh)	IVb	-	-	-	-	-	-	98	(214.7)	98	(214.7)
Overall values (weighted by number caught)											
Directed adult		76	(0.1)	84	(0.5)	97	(11.2)	93	(16.0)	95	(27.8)
Industrial		14	(251.2)	29	(70.2)	77	(664.2)	87	(630.0)	69	(1,615.5)

[1] By-catch in directed adult fisheries.

Table 2.8.1 VIRTUAL POPULATION ANALYSIS

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

CATCH IN NUMBERS UNIT: millions

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	740	289	996	263	238	257	130	542	792	7889	9553	10029
1	3336	2366	842	2436	104	143	168	159	138	440	820	1122
2	1305	1301	749	415	807	38	2	13	9	42	67	293
3	315	544	342	220	76	183	2	1	8	16	9	111
4	121	95	118	135	49	10	4	5	2	20	7	41
5	28	52	55	55	34	7	0	2	3	22	8	15
6	5	29	22	16	6	4	0	0	1	19	5	20
7	0	3	5	9	4	2	0	1	1	18	6	12
8	1	1	2	3	1	1	0	1	0	5	3	11
9+	0	1	1	1	0	0	0	0	0	1	1	12
TOTAL	5852	4681	3131	3554	1319	645	307	722	954	8472	10478	11666

	1984	1985	1986
0	2187	1293	695
1	496	1607	1752
2	776	909	1047
3	291	1004	633
4	152	322	413
5	54	111	114
6	19	35	52
7	23	19	18
8	10	13	13
9+	17	16	14
TOTAL	4025	5329	4753

Table 2.8.2 VIRTUAL POPULATION ANALYSIS

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

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

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	.82	.98	1.05	1.18	1.05	.18	.01	.05	.04	.12	.08	.20
3	.89	1.14	.84	1.23	.76	.81	.01	.01	.05	.11	.04	.20
4	.80	.72	.77	.93	.98	.20	.03	.04	.02	.15	.06	.22
5	.49	.86	1.11	.94	.55	.30	.01	.01	.03	.26	.07	.16
6	.52	1.23	1.04	1.09	.20	.10	.01	.00	.01	.22	.07	.24
7	.08	.65	.59	1.71	.90	.07	.01	.05	.03	.23	.09	.25
8	.80	1.00	1.00	1.00	.80	.30	.01	.02	.03	.20	.05	.20
9+	.80	1.00	1.00	1.00	.80	.30	.01	.02	.03	.20	.05	.20
(2- 6)U	.70	.98	.96	1.07	.71	.32	.01	.02	.03	.17	.06	.20

	1984	1985	1986
2	.24	.36	.38
3	.33	.60	.50
4	.43	.69	.50
5	.45	.57	.50
6	.27	.52	.50
7	.43	.40	.50
8	.30	.40	.50
9+	.30	.40	.50
(2- 6)U	.34	.55	.48

Table 2.8.3 VIRTUAL POPULATION ANALYSIS

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

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

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

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
2	2652	2357	1299	675	1397	272	188	272	246	416	996	1877
3	578	867	657	337	154	361	169	138	191	175	273	680
4	250	194	223	233	81	59	132	136	112	149	128	215
5	76	94	85	95	84	28	44	116	119	99	116	109
6	13	42	36	25	34	43	19	39	103	105	69	98
7	3	7	11	12	8	25	35	17	35	93	76	58
8	2	2	3	6	2	3	21	32	14	31	67	63
9+	1	1	2	2	1	0	32	5	4	6	22	70
TOTAL NO	3555	3564	2321	1585	1760	790	639	755	825	1074	1746	3170
SPS NO	1496	1359	950	519	669	477	532	613	680	793	1292	2121
TOT.BIOM	635038	649863	457849	271620	315903	159090	139525	161864	181248	233690	349606	613131
SPS BIOM	272753	252811	184510	105205	125407	98575	118947	135261	153274	176512	267523	421538

	1984	1985	1986	1987
2	4183	3421	3799	0
3	1140	2438	1761	1925
4	457	672	1097	875
5	156	269	304	602
6	85	90	138	167
7	69	59	49	76
8	41	41	35	27
9+	69	50	38	40
TOTAL NO	6200	7039	7221	
SPS NO	3816	3696	4020	
TOT.BIOM	1149442	1355258	1395496	
SPS BIOM	719510	727928	796231	

Mean weight at age in stock 1970-1986

155
187
223
239
276
299
306
312

Table 2.8.4 HERRING in Divisions IVc + VIId. SSB indices.

Year	LAI (10^9)	LPE ('000 t)	Acoustic surveys ('000 t) Div.VIId Nov	Div.VIId Dec	Div.IVc Nov	Div.IVc Dec	Div.IVc Feb	Acoustic end of year	Divisions IVc + VIId catch ('000 t)
1972	171	17	-	-	-	-	-	-	23.0
1973	133	9	-	-	-	-	-	-	30.2
1974	25	1	-	-	-	-	-	-	7.4
1975	25	1	-	-	-	-	-	-	25.5
1976	18	1	-	-	-	-	-	-	17.5
1977	23	2	-	-	-	-	-	-	1.4
1978	111	3	-	-	-	-	-	-	-
1979	403	9	-	-	-	-	-	-	(5.0)
1980	1,193	89	-	-	-	-	-	-	43.1
1981	4,855	333	-	23	-	73	-	96	41.9
1982	3,709	148	-	-	-	-	143	146	68.7
1983	2,354	196	104	-	70	-	-	150	64.4
1984	2,267	140	111	-	36	-	-	133	46.0
1985	4,065	158	85	53	-	69	-	124	69.9
1986	4,780	267	101	-	-	-	-	127	51.5

Table2.8.5 VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

CATCH IN NUMBERS UNIT: millions

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
0	0	0	0	0	0	0	150	219	164	96	279	97
1	0	3	0	0	462	722	1023	1451	2072	1697	1483	4279
2	494	247	478	535	660	1346	1322	1493	1931	1860	1644	1029
3	416	672	644	1039	959	576	1003	1111	1032	1221	736	999
4	638	328	396	617	1255	610	474	591	479	516	644	322
5	526	601	287	290	650	652	386	361	337	249	344	461
6	756	487	652	254	262	464	473	330	232	194	207	147
7	431	400	462	331	142	236	278	379	120	104	147	73
8	627	252	414	195	206	166	118	194	109	104	100	46
9+	634	665	623	402	239	388	275	317	106	188	153	72
TOTAL	4571	3655	3956	3661	4815	5160	5502	6445	6581	6228	5737	7526

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0	0	195	1269	142	443	497	157	375	645	859	112	898
1	1609	2393	336	2147	1262	2972	3209	1383	1674	2425	2503	1196
2	4934	1142	1889	270	2961	1548	2218	2570	1172	1795	1883	2003
3	489	1967	480	797	177	2243	1325	741	1365	1494	296	884
4	497	166	1456	335	158	148	2039	450	372	621	133	125
5	233	168	124	1082	81	149	145	890	298	157	191	50
6	249	113	158	127	250	95	152	45	595	145	50	61
7	120	126	61	145	22	256	118	65	68	163	43	8
8	82	129	56	86	42	26	413	96	82	14	27	12
9+	219	142	88	87	51	58	78	236	173	92	25	12
TOTAL	3431	6539	5917	5218	5427	7992	9854	6850	6241	7746	5264	5249

cont'd.

Table 2.8.5 cont. VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

CATCH IN NUMBERS UNIT: millions

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	684	750	289	996	264	238	257	130	542	792	7889	9557
1	4379	3341	2368	846	2461	127	144	169	159	161	447	840
2	1147	1441	1344	773	542	902	45	5	54	108	264	268
3	663	344	659	362	200	117	186	6	10	92	57	230
4	209	131	150	126	141	52	11	5	10	32	40	34
5	27	33	59	56	57	35	7	0	2	22	29	14
6	31	5	31	22	16	6	4	0	0	2	23	7
7	27	0	4	5	9	4	2	0	1	1	19	8
8	0	1	1	2	3	1	1	0	1	0	6	4
9+	12	0	1	1	1	0	0	0	0	0	1	1
TOTAL	7177	6046	4907	3189	3753	1482	656	315	759	1211	8773	10963

	1983	1984	1985	1986
0	10030	2190	1293	704
1	1147	560	1620	1763
2	545	976	1223	1155
3	216	422	1173	827
4	105	193	366	458
5	26	78	124	128
6	23	22	43	61
7	13	24	20	20
8	11	11	13	13
9+	12	18	16	15
TOTAL	12128	4492	5891	5145

Table 2.8.6 HERRING in the total North Sea (Sub-Area IV).

Age	Weight at age in the stock 1947-1986	Proportions of maturity				
		1947-1955	1956-1971	1972-1984	1985	1986
0	15	-	-	-	-	-
1	50	-	-	-	-	-
2	155	0.70	1.00	0.82	0.70	0.75
3	187	1.00	1.00	1.00	1.00	1.00
4	223	1.00	1.00	1.00	1.00	1.00
5	239	1.00	1.00	1.00	1.00	1.00
6	276	1.00	1.00	1.00	1.00	1.00
7	299	1.00	1.00	1.00	1.00	1.00
8	306	1.00	1.00	1.00	1.00	1.00
9+	312	1.00	1.00	1.00	1.00	1.00

Table 2.8.7 VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

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

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
0	.00	.00	.00	.00	.00	.00	.00	.01	.01	.01	.00	.00
1	.00	.00	.00	.00	.05	.07	.09	.11	.20	.16	.25	.14
2	.12	.04	.07	.11	.17	.31	.30	.30	.36	.52	.41	.51
3	.16	.25	.15	.22	.32	.23	.43	.47	.37	.43	.42	.50
4	.19	.17	.22	.20	.42	.32	.29	.46	.36	.30	.40	.32
5	.22	.24	.20	.22	.29	.35	.31	.34	.46	.29	.30	.49
6	.27	.29	.40	.24	.28	.32	.41	.42	.33	.46	.37	.18
7	.34	.20	.44	.32	.19	.39	.29	.59	.24	.22	.67	.19
8	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.40
9+	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.30	.40
(2- 6)U	.19	.20	.21	.20	.29	.31	.35	.40	.38	.40	.38	.40

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0	.00	.03	.02	.00	.01	.01	.01	.02	.03	.03	.01	.04
1	.22	.25	.13	.09	.12	.31	.25	.19	.30	.30	.33	.27
2	.42	.43	.61	.25	.30	.39	.77	.59	.42	1.33	.78	.97
3	.52	.32	.35	.62	.27	.41	.74	.70	.80	1.87	.91	1.26
4	.48	.32	.39	.42	.22	.36	.77	.57	.91	1.07	.87	1.32
5	.55	.26	.37	.49	.15	.30	.63	.82	.81	1.17	1.05	.87
6	.48	.26	.37	.71	.16	.23	.49	.37	.98	1.12	1.53	1.08
7	.20	.42	.19	.59	.23	.24	.44	.36	1.30	1.43	1.11	1.00
8	.30	.30	.30	.40	.30	.40	.67	.69	.90	.90	.90	1.00
9+	.30	.30	.30	.40	.30	.40	.67	.69	.90	.90	.90	1.00
(2- 6)U	.45	.32	.42	.50	.22	.34	.68	.61	.79	1.31	1.03	1.10

cont'd.

Table2.8.7 cont. VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

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

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	.03	.06	.05	.07	.14	.14	.09	.05	.09	.09	.43	.30
1	.60	.58	.67	.44	.68	.22	.27	.19	.17	.08	.15	.17
2	.88	.81	1.02	1.03	1.24	1.52	.19	.02	.09	.28	.29	.22
3	1.21	.80	1.33	.96	1.50	1.17	1.34	.04	.06	.40	.25	.48
4	1.21	.80	.99	.98	1.30	1.71	.27	.09	.08	.26	.28	.22
5	1.06	.53	.94	1.18	1.79	1.27	1.14	.01	.05	.21	.35	.14
6	2.43	.49	1.26	1.05	1.26	.89	.42	.07	.01	.06	.32	.12
7	2.69	.08	.72	.61	1.82	1.42	.50	.03	.38	.06	.79	.15
8	.00	1.00	1.00	1.00	1.00	1.00	.80	.10	.10	.30	.30	.30
9+	.00	1.00	1.00	1.00	1.00	1.00	.80	.10	.10	.30	.30	.30
(2- 6)U	1.36	.69	1.11	1.04	1.41	1.27	.67	.05	.06	.24	.30	.24

	1983	1984	1985	1986
0	.35	.08	.05	.05
1	.12	.07	.19	.19
2	.28	.26	.36	.35
3	.30	.40	.60	.47
4	.40	.45	.68	.47
5	.24	.52	.52	.47
6	.30	.28	.55	.47
7	.30	.53	.41	.47
8	.30	.38	.54	.47
9+	.30	.38	.54	.47
(2- 6)U	.31	.38	.54	.45

Table 2.8.8 VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .667
PROPORTION OF ANNUAL M BEFORE SPAWNING: .667

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
0	62581	43142	35805	44837	40613	53578	61009	48067	49059	28154	139813	34427
1	19227	23022	15871	13172	16495	17148	19710	22357	17556	17945	10302	51272
2	5082	7075	8467	5839	4846	5800	5891	6660	7388	5272	5627	2944
3	3146	3342	5029	5863	3868	3026	3152	3238	3663	3832	2331	2773
4	3908	2201	2132	3537	3866	2305	1959	1681	1655	2072	2042	1248
5	2771	2930	1680	1553	2615	2309	1508	1323	961	1044	1386	1237
6	3502	2008	2081	1248	1130	1769	1471	998	855	551	709	928
7	1576	2270	1355	1265	889	774	1160	885	591	554	514	445
8	2534	1018	1674	789	832	669	476	736	441	421	402	145
9+	2767	2689	2521	1625	968	1570	1111	1282	427	758	620	230
TOTAL NO	106892	89696	76616	79728	82121	88949	97447	87275	82574	60603	165546	95649
SPS NO	18441	16829	17373	15496	12967	12026	10651	10190	9500	9699	9061	6636
SPS BIOM	4451364	3903609	3866736	3391044	2877954	2706641	2360140	2217677	1938778	2009690	1853268	1405934

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
0	44897	12211	109038	46366	47743	62787	54905	27868	40287	38706	21586	41074
1	12608	16517	4379	39575	16974	17306	22809	12750	10035	14446	13752	7876
2	16400	3718	4712	1418	13245	5517	4680	6560	3897	2740	3937	3641
3	1310	7963	1786	1895	820	7292	2773	1601	2689	1893	539	1353
4	1375	536	4752	1031	838	512	5957	1088	649	935	239	178
5	824	773	418	2920	615	608	325	1654	559	237	305	91
6	683	524	541	261	1618	480	409	155	656	224	66	96
7	700	382	367	339	116	1246	344	226	97	223	66	13
8	353	520	226	274	170	84	884	200	143	24	48	20
9+	834	574	354	276	206	183	168	495	304	161	44	20
TOTAL NO	80014	43819	126573	94154	82346	96016	71253	52599	59316	59640	40583	54341
SPS NO	14457	10536	8689	5545	12436	10750	7351	6779	5008	2231	2536	2248
SPS BIOM	2665308	2115686	1805799	1219749	2258351	2105324	1514542	1302866	948087	438681	435935	382383

cont'd.

Table 2.8.8 cont. VIRTUAL POPULATION ANALYSIS

NORTH SEA HERRING (FISHING AREA IV)

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY: THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .667
PROPORTION OF ANNUAL M BEFORE SPAWNING: .667

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	32382	20364	10304	21775	3123	2910	4482	4583	10330	14528	34305	56296
1	14597	11516	7241	3623	7435	997	955	1501	1610	3487	4887	8187
2	2216	2942	2380	1358	858	1379	294	261	455	501	1190	1541
3	1020	679	968	639	360	185	273	180	189	308	279	656
4	309	248	250	210	201	66	47	59	142	146	170	177
5	43	84	101	84	71	50	11	32	48	119	102	116
6	35	14	44	30	23	11	13	5	29	42	87	65
7	30	5	8	11	11	6	4	8	3	26	36	57
8	0	2	2	3	6	2	1	2	7	2	22	15
9+	0	1	1	2	2	1	0	3	1	0	4	4
TOTAL NO	50631	36352	21300	27742	12090	5606	6059	6632	12815	19159	41082	67115
SPS NO	1565	1703	1357	919	484	507	326	423	653	759	1176	1669
SPS BIOM	267251	290654	237088	165323	88074	85115	58086	78538	123154	148423	218088	305999

	1983	1984	1985	1986	1987
0	52272	43466	45181	22742	0
1	15284	13556	14724	15872	7958
2	2550	4962	4663	4488	4829
3	913	1410	2844	2415	2343
4	351	553	776	1279	1236
5	129	200	313	356	723
6	92	91	108	171	202
7	52	61	62	56	96
8	44	35	33	37	32
9+	49	59	40	41	44
TOTAL NO	71696	64394	68750	47458	
SPS NO	2579	4449	4608	5055	
SPS BIOM	479657	781915	858946	940790	

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

HERRING IN DIVISIONS IVA + IVB
The reference F is the mean F for the age group range from 2 to 6

The number of recruits per year is as follows:

Year	Recruitment
1987	27850.0

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

Data are printed in the following units:

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

age	1987 stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
1	27850.0	.20	1.00	.00	67.000	90.000
2	4343.0	.38	.30	.75	122.000	166.000
3	1925.0	.50	.20	1.00	158.000	201.000
4	875.0	.50	.10	1.00	184.000	234.000
5	602.0	.50	.10	1.00	210.000	255.000
6	167.0	.50	.10	1.00	223.000	283.000
7	76.0	.50	.10	1.00	245.000	302.000
8	27.0	.50	.10	1.00	253.000	309.000
9+	40.0	.50	.10	1.00	263.000	315.000

Table 2.9.2
List of input variables for the ICES prediction program.

HERRING IN DIVISIONS IVA + IVB
The reference F is the mean F for the age group range from 2 to 6

The number of recruits per year is as follows:

Year	Recruitment
1988	14000.0
1989	14000.0

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

Data are printed in the following units:

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

age	1988 stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
1	14000.0	.20	1.00	.00	67.000	90.000
2	7702.0	.38	.30	.75	122.000	166.000
3	2286.0	.50	.20	1.00	158.000	201.000
4	1005.0	.50	.10	1.00	184.000	234.000
5	505.0	.50	.10	1.00	210.000	255.000
6	347.0	.50	.10	1.00	223.000	283.000
7	96.0	.50	.10	1.00	245.000	302.000
8	44.0	.50	.10	1.00	253.000	309.000
9+	39.0	.50	.10	1.00	263.000	315.000

Table 2.9.3 HERRING in Divisions IVa and IVb. Results of catch predictions.

1987			1988					1989
SSB	$\bar{F}_{(2-6)}$	Catch	Management option	$\bar{F}_{(2-6)}$	SSB	Catch (ages 1-9)	Catch (age 1)	SSB
913	0.43	560	$F_{0.1}$	0.144	1,526	225	35	1,950
				0.30	1,385	440	71	1,555
				0.35	1,345	500	81	1,481
			0.8 F_{86}	0.38	1,317	542	89	1,383
			F_{87}	0.43	1,279	599	99	1,292
			F_{86}	0.48	1,241	654	109	1,207

Weight in '000 t.
SSB is given at spawning time.

Table 2.11.1 HERRING Total North Sea 1986.
Numbers at age ('000) and weight at age caught in each quarter year.

Quarter		1985 0	1984 1	1983 2	1982 3	1981 4	1980 5	1979 6	1978 7	1977 8	1976 9+	Total	Tonnes
1	Number	-	251,803	257,221	268,553	162,049	46,934	26,835	7,316	7,860	10,259	1,038,830	96,123
	Ave.wt.	-	14.1	76.4	113.8	148.0	174.2	186.4	225.8	228.3	250.1		
2	Number	160,415	97,603	336,196	97,955	76,874	26,675	6,704	4,490	566	1,442	808,920	92,436
	Ave.wt.	2.0	37.8	129.8	166.5	194.7	220.3	220.1	257.7	257.7	284.2		
3	Number	529,678	690,755	307,459	230,970	112,239	32,372	15,671	3,064	1,626	1,015	1,924,849	181,313
	Ave.wt.	6.2	77.5	145.9	189.6	223.9	247.9	281.2	287.4	328.4	364.2		
4	Number	13,914	723,024	254,205	229,574	107,155	21,759	11,842	5,296	3,318	1,917	1,372,004	153,882
	Ave.wt.	20.0	79.4	123.3	157.3	180.2	203.4	218.2	209.4	271.6	254.7		
Total	Number	704,007	1,763,185	1,155,081	827,052	458,317	127,740	61,052	20,166	13,370	14,633	5,144,603	523,694
	Ave.wt.	5.5	67.0	120.8	153.3	181.9	207.5	220.6	238.0	252.4	262.0		

Table 3.2.1 HERRING in Division IIIa. Landings in tonnes 1977-1986. (Data mainly provided by Working Group Members.)

Country	1977	1978	1979	1980	1981
Skagerrak					
Denmark	14,152	7,753	8,729	22,811	45,525
Faroe Islands	10,064	1,041	817	526	900
Germany, Fed.Rep.	32	28	181	-	199
Norway (Open sea)	-	1,860	2,460	1,350	6,330
Norway (Fjords)	1,837	2,271	2,259	2,795	900
Sweden	8,109	11,551	8,140	10,701	30,274
Total	34,194	24,504	22,586	38,183	83,768
Kattegat					
Denmark	38,205	29,241	21,337	25,380	48,922
Sweden	37,160	35,193	25,272	18,260	38,871
Total	75,365	64,434	46,609	43,640	87,833
Division IIIa total	109,559	88,938	69,195	81,823	171,601

Country	1982	1983	1984	1985	1986[1]
Skagerrak					
Denmark	43,328	54,102	64,621	88,192	94,022
Faroe Islands	715	1,980	891	455	520
Germany, Fed.Rep.	43	40	-	-	11
Norway (Open sea)	10,140	500	-	2,752	677
Norway (Fjords)	1,560	2,834	1,494	1,673	860
Sweden	24,859	35,176	59,195	40,349	42,996
Total	80,645	94,632	126,201	133,421	139,086
Kattegat					
Denmark	38,609	62,901	71,359	69,235	41,669
Sweden	38,892	40,463	35,027	39,829	35,852
Total	77,501	103,364	106,386	109,064	77,521
Division IIIa total	158,146	197,996	232,587	242,485	216,607

[1] Preliminary.

Table 3.2.2 Catch in numbers ('000) and mean weight (g) at age in 1986 for the Danish industrial fishery (and by-catch in the consumption fishery in Skagerrak) in Division IIIa.

Age	Quarter 1		2		3		4	
	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$
Skagerrak								
2	3,752	73.3	6,084	119.0	103,129	114.4	4,017	92.6
⩾3	713	97.7	1,295	93.5	5,624	132.3	-	125.6
Tonnes (SOP)⩾2	341	-	869	-	12,542	-	372	-
Total all ages	2,889	-	2,795	-	49,572	-	20,665	-
Kattegat								
2	23,180	58.8	4,497	58.7	1,103	65.3	7,704	75.8
⩾3	2,481	92.7	771	77.8	-	80.6	-	109.5
Tonnes (SOP)⩾2	1,593	-	324	-	72	-	584	-
Total all ages	9,210	-	664	-	10,288	-	6,151	-

Table 3.2.3 Catch in number ('000) and mean weight (g) at age of herring in Divisions IVa,b in 1986 which were transferred to the Division IIIa/Sub-divisions 22-24 herring stock.

Age	Quarter			
	2		3	
	N	$\bar{w}$	N	$\bar{w}$
3	49,014	156.56	3,768	159.41
4	38,889	171.62	3,124	177.10
5	13,819	193.57	798	210.45
6	2,515	209.79	236	213.85
7	1,853	214.49	85	263.71
8	584	209.33	18	252.00
9	610	283.10	41	282.90
Tonnes (SOP)	18,243	-	1,411	-

Table 3.2.4 Catch in number ('000) and mean weight (g) at age of 2-group and older HERRING in part of Divisions IVa,b and in Division IIIa in 1986.

Age	Quarter							
	1		2		3		4	
	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$	N	$\bar{w}$
2	122,224	63.77	102,309	63.82	158,899	104.74	32,025	74.64
3	65,820	67.91	116,402	108.71	63,883	117.37	27,938	93.47
4	18,488	86.27	60,034	151.60	31,723	147.56	7,020	144.80
5	1,337	140.46	20,789	175.20	6,918	162.74	2,845	164.30
6	120	192.69	3,525	196.53	1,846	195.33	524	232.11
7	30	176.90	2,593	195.34	825	192.70	-	-
8	-	-	834	194.41	148	186.15	60	203.20
9	-	-	610	283.10	41	282.90	-	-
Tonnes (SOP)	14,075	-	33,460	-	30,506	-	6,620	-

Table 3.3.1 Estimated abundance of herring in Division IIIa from acoustic surveys during August/September 1979-1986.

Winter rings	Numbers at age (millions)							
	1979	1980	1981	1982	1983	1984	1985	1986
0	577	482	1,840	6,171	1,424	1,004	6,515	14,885
1	611	477	698	2,349	3,526	1,992	1,111	5,277
2	1,067	434	1,260	989	1,160	2,069	1,132	1,473
3	93	473	44	221	413	756	73	317
4	13	84	22	31	122	126	11	77
5	4	28	2	8	13	34	1	8
6	-	3	1	1	-	2	-	2
Total	2,365	1,981	3,867	9,770	6,658	5,983	8,843	22,047
Biomass ('000 t)	-	-	-	340	325	551	222	622
Biomass adult	-	-	-	123	185	403	9	61

Table 3.3.2 Estimated abundance of herring in Division IIIa from acoustic surveys during November/December 1982, 1983, 1985, and 1986. No survey was carried out in 1984.

Winter rings	Numbers at age (millions)			
	November 1982	December 1983	November 1985	November 1986[1]
0	2,530	5,089	9,303	10,421
1	1,060	1,393	918	783
2	380	22	12	-
3	40	-	-	-
4	5	-	-	-
Total	4,015	6,504	10,233	11,204
Biomass ('000 tonnes)	168	153	215	217

[1] The estimates for Kattegat extrapolated for unsampled areas.

Table 4.2.1 Celtic Sea and Division VIIj HERRING landings (t), 1977-1986. (Data provided by Working Group members.)

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

[1] Provisional.

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

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

[1] Provisional.

Table 4.2.3 VIRTUAL POPULATION ANALYSIS

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

CATCH IN NUMBERS UNIT: thousands

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1519	12658	8422	23547	5507	12768	15517	8159	2800	11335	7162	39361
2	37260	25315	157690	58135	42808	15429	11115	12516	13385	13913	30093	21285
3	50087	37563	17855	55805	17184	17783	7286	8610	11948	12599	11726	21861
4	26481	41904	15842	7012	22530	7353	7011	5280	5583	8636	6585	5505
5	18763	18759	14531	9651	4225	9006	2872	1585	1580	2889	2812	4438
6	7853	10443	4645	5325	3737	3520	4785	1898	1476	1316	2204	3436
7	6351	4276	3012	3552	2978	1644	1980	1043	540	1283	1184	795
8	2175	4942	2574	2332	903	1136	1243	583	858	551	1262	513
9+	5367	2239	1020	1209	827	1194	1769	470	482	635	565	866
TOTAL	155656	156097	205591	146364	100699	69813	51576	39944	38652	52957	63593	97860

	1982	1983	1984	1985	1986
1	15339	11484	16456	15018	2451
2	42725	87253	73324	47824	33441
3	8728	22895	54672	50392	25270
4	4817	2735	13527	15438	19406
5	1497	1579	2066	1933	5180
6	1891	277	915	191	664
7	1670	315	517	71	58
8	355	790	195	145	17
9+	596	261	152	111	7
TOTAL	77598	127589	146624	109123	86494

Table 4.2.4 VIRTUAL POPULATION ANALYSIS

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

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

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.01	.02	.05	.12	.07	.14	.10	.08	.03	.08	.08	.17
2	.30	.36	.69	.60	.64	.47	.30	.25	.30	.39	.56	.72
3	.46	.60	.56	.74	.66	.65	.45	.42	.39	.53	.73	1.20
4	.38	.85	.52	.42	.72	.63	.55	.65	.51	.51	.56	.89
5	.61	.94	.73	.61	.43	.63	.48	.21	.56	.47	.27	.82
6	.53	.73	.56	.57	.44	.67	.73	.59	.27	.51	.71	.54
7	.42	.55	.42	.92	.64	.32	.91	.30	.30	.35	1.10	.53
8	.60	.60	.60	.60	.60	.48	.57	.38	.38	.49	.60	.88
9+	.60	.60	.60	.60	.60	.48	.57	.38	.38	.49	.60	.88
(1- 7)W	.29	.19	.45	.37	.42	.54	.22	.18	.19	.21	.35	.33
(2- 7)W	.43	.64	.65	.65	.64	.57	.44	.32	.35	.46	.58	.88

	1982	1983	1984	1985	1986
1	.04	.02	.05	.03	.02
2	.52	.52	.27	.19	.15
3	.83	.65	.43	.17	.15
4	.93	.64	.99	.28	.15
5	.57	.81	1.35	.31	.15
6	.91	.17	1.61	.35	.15
7	.49	.32	.27	.42	.15
8	.40	.40	.30	.17	.15
9+	.40	.40	.30	.17	.15
(1- 7)W	.14	.14	.14	.10	.12
(2- 7)W	.59	.55	.55	.19	.15

Table 4.2.5 VIRTUAL POPULATION ANALYSIS

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

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY: THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .200
PROPORTION OF ANNUAL M BEFORE SPAWNING: .500

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	242340	874196	273770	517947	137592	155206	210257	176274	138274	235168	139091	386408
2	165993	88385	314246	95835	103400	47429	49750	69658	60129	49243	79959	47029
3	147857	91256	45665	116723	38781	40466	22058	27596	40953	33151	24665	33787
4	65087	76156	41115	21406	45761	16397	17239	11527	14707	22789	16038	9729
5	42820	32025	29543	22275	12725	29111	7900	8963	5436	8021	12443	8280
6	19879	20994	11278	12817	10950	7511	9679	4429	6606	3421	4522	8591
7	19308	10553	9127	5809	6560	6376	5468	4235	2211	4577	1850	2008
8	5041	11453	5502	5404	2093	3119	4211	1269	2843	1489	2925	558
9+	7805	5139	2564	2802	1917	3278	5992	1557	1597	1716	1509	1544
TOTAL NO	714127	1210207	752409	600944	359788	299895	330554	305308	272736	359574	282802	497933
SPS NO	464110	534520	458353	318145	217469	163194	162270	160514	154040	172693	155837	197408
TOT.BIOM	126575	172952	119720	95158	61164	48582	49454	45987	43140	52700	44582	67285
SPS BIOM	90247	88740	78498	57440	40967	30328	28227	27631	27663	29512	27669	30362

	1982	1983	1984	1985	1986	1987	Mean weights (g) 1983-1985	1985	1986
1	691020	1040900	908377	770257	195496	0	104	104	112
2	119565	245311	376252	324619	276851	70495	152	140	155
3	16910	52413	107872	212028	199665	176528	189	170	172
4	8296	6067	22450	57222	146218	140701	201	201	187
5	3607	2061	2905	7555	39050	113875	230	134	215
6	3300	1847	1188	685	5003	30396	250	248	248
7	4521	1202	1408	216	457	3896	254	256	236
8	1054	2510	789	973	122	340	262	260	284
9+	1893	829	615	745	53	141	264	263	332
TOTAL NO	850178	1354039	1421855	1380299	862880				
SPS NO	332433	559623	692957	749100	641814				
TOT.BIOM	109427	177226	164269	176165	136299				
SPS BIOM	47410	81500	91589	106064	106906				

Table 5.1.1 Catch in weight, Division VIa (North) HERRING 1977-1986.

Country	1977	1978	1979	1980	1981
Denmark	626	128	-	-	1,580
Faroes	3,564	-	-	-	-
France	1,548	1,435	3	-	1,243
German Dem. Rep.	-	-	-	2	-
Germany, Fed. Rep.	-	26	-	-	3,029
Iceland	-	-	-	256	-
Ireland	-	-	-	-	-
Netherlands	8,705	5,874	-	-	5,602
Norway	1,098	4,462	-	-	3,850
Sweden	261	-	-	-	-
UK (England)	301	134	54	-	1,094
UK (Scotland)	25,238	10,097	3	33	30,389
USSR	-	-	-	15	-
Unallocated	-	-	-	-	4,633
Total	41,341	22,176	60	306	51,420

Country	1982	1983	1984	1985	1986[1]
Denmark	-	-	96	-	-
Faroes	74	834	954	104	400
France	2,069	1,313	-	20	18
German Dem. Rep.	-	-	-	-	-
Germany, Fed. Rep.	8,453	6,283	5,564	5,937	2,769
Iceland	-	-	-	-	-
Ireland	-	-	-	-	6,000[2]
Netherlands	11,317	20,200	7,729	5,500	5,160[2]
Norway	13,018	7,336	6,669	4,690	4,799
Sweden	-	-	-	-	-
UK (England)	90	-	-	-	-
UK (Scotland)	38,381	31,616	37,554	28,065	25,294
USSR	-	-	-	-	-
Unallocated	18,958	-4,059	16,588	502	37,840[2]
Total	92,360	63,523	75,154	43,814	82,280

[1] Preliminary.
[2] Including discards.

Table 5.1.2

HERRING IN THE NORTHERN PART OF VIA
CATEGORY: TOTAL

CATCH IN NUMBERS UNIT: thousands

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	16299	209598	24941	267872	556119	82676	8225	11508	108199	1614	0	3003
1	238738	169947	801663	51170	309016	172879	69055	34836	22525	392	12867	36740
2	205454	372615	804097	235627	124944	202087	319604	47739	46284	225	1335	77961
3	359711	560348	219502	608267	151025	89066	101548	95834	20587	122	452	105600
4	139718	357745	63069	131484	519178	63701	55502	22117	40692	31	246	61341
5	53320	113391	35920	65071	82486	188202	25195	10083	6879	21	62	21473
6	20462	54571	37341	54642	49683	30601	76289	12211	3833	12	43	12623
7	29141	131592	13377	18242	54629	12297	10918	20992	2100	7	40	11583
8	32860	18042	100938	6506	22470	13121	3914	2758	6278	2	5	1309
9+	30651	36395	20465	32223	21042	13698	12014	1486	1544	0	1	1526
TOTAL	1309354	2074244	2171513	1669104	1850572	868328	662262	259564	258921	2426	15049	332959

	1982	1983	1984	1985	1986
0	219	144	0	372	1985
1	15304	81923	2961	45663	59336
2	250010	77810	253291	77063	180519
3	72179	92743	66857	166112	100267
4	93544	29262	46963	19269	138462
5	58452	42535	20057	17027	21942
6	25530	27318	15259	7422	20969
7	11516	14709	12478	7731	3003
8	13814	8437	5940	3720	16540
9+	4027	8484	2629	2450	2296
TOTAL	540645	383365	426426	346829	525119

Table 5.1.3 HERRING in Division VIa (North). Larvae abundance indices (numbers x 10^9), larvae mortality rates (Z/K), fecundity estimates (10^5 eggs/kg) and spawning stock biomass ('000 t, age 2+ at spawning time).

Year	LAI	Z/K	LPE	Fecundity	Spawning stock biomass from		
					LPE	LAI[1]	VPA
1973	2,442	0.74	318	(1.39)	229	305	426
1974	1,186	0.42	238	(1.39)	171	174	225
1975	878	0.46	157	1.46	108	142	129
1976	189	-	60	1.23	49	71	108
1977	787	-	223	1.49	150	133	77
1978	332	-	132	1.37	109	86	78
1979	1,071	-	118	1.49	79	162	112
1980	1,436	0.39	287	2.04	141	200	195
1981	2,154	0.34	448	2.12	211	275	194
1982	1,890	0.39	267	1.95	137	247	196
1983	668	-	112	1.88	60	121	172
1984	2,133	0.57	253	1.75	145	273	298
1985	2,710	0.37	418	(1.86)	225	332	327
1986	3,037	0.24	907	(1.86)	488	366	351

[1] Predicted from (1973-1986) regression.
$Y = 51.527 + 0.1036x$ ($r = 0.87$).

Table 5.1.4 HERRING in Division VIa (North). Scottish bottom trawl survey indices of 2-ringed herring catch rates in January-March and acoustic survey indices of the same year class in the preceding November.

Trawl survey year	Year class	Number of GOV hauls	2-ringer index (millions)	Acoustic estimate no. of 1-ringers (millions)
1981	1978	9	1,237	-
1982	1979	10	2,361	-
1983	1980	12	11	-
1984	1981	12	12,456	28.1
1985	1982	17	98	-
1986	1983	12	359	1,039.0
1987	1984	15	40	85.6

Table 5.1.5 HERRING in Division VIa (North). Mean weights at age (kg).

Age (rings)	Weight in the stock	Weight in the catch		1986	
		1982-1984	1985	Observed	Fitted
1	0.090	0.090	0.069	0.109	0.113
2	0.164	0.140	0.103	0.136	0.145
3	0.208	0.175	0.134	0.173	0.173
4	0.233	0.205	0.161	0.193	0.196
5	0.246	0.231	0.182	0.219	0.215
6	0.252	0.253	0.199	0.228	0.230
7	0.258	0.270	0.213	0.247	0.242
8	0.269	0.284	0.223	0.242	0.251
9	0.292	0.295	0.231	0.257	0.258

Table 5.1.6 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN PART OF VIA

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

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	.180	.422	.294	.500	.489	.724	.708	.282	.249	.001	.002	.315
3	.415	1.155	.509	.581	.765	.860	1.159	.512	.201	.011	.002	.284
4	.441	.905	.340	.624	.892	.858	1.009	.823	.403	.000	.002	.355
5	.442	.684	.498	.592	.915	.861	.852	.795	.580	.000	.001	.247
6	.328	.984	.443	.603	1.205	.950	.944	1.265	.717	.002	.001	.216
7	.625	.483	.608	.559	.864	1.025	.980	.652	.665	.002	.006	.212
8	.408	.899	.480	.597	.879	.955	.985	.628	.363	.001	.001	.228
9+	.408	.899	.480	.597	.879	.855	.985	.628	.363	.001	.001	.228
(2- 7)U	.405	.772	.449	.543	.855	.876	.942	.721	.468	.001	.002	.271
(2- 7)W	.321	.728	.338	.565	.805	.812	.825	.490	.296	.001	.002	.294

	1982	1983	1984	1985	1986
2	.497	.250	.204	.128	.260
3	.582	.369	.376	.212	.260
4	.413	.469	.307	.167	.260
5	.594	.298	.602	.156	.260
6	.414	.543	.148	.413	.260
7	.278	.436	.453	.094	.260
8	.373	.300	.280	.210	.260
9+	.373	.300	.280	.210	.260
(2- 7)U	.463	.394	.348	.195	.260
(2- 7)W	.488	.335	.240	.173	.260

Table 5.1.7 VIRTUAL POPULATION ANALYSIS

HERRING IN THE NORTHERN PART OF VIA

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

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

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	1435605	1239098	3629184	684630	309694	446058	716836	223061	241602	355561	635199	330983
3	1159511	886659	601767	2004077	307628	168028	160221	261723	124599	139540	263213	469422
4	410581	626619	229134	296068	917651	117146	58240	41154	128441	83478	114136	215092
5	156204	239145	229548	147531	143519	340255	45846	19218	16550	77656	75505	103040
6	761763	90827	109179	126164	73815	52037	130188	17695	7865	8284	70246	68260
7	65538	496340	30711	63414	62461	20011	18214	45819	4519	3493	7484	63520
8	102721	31735	277135	15135	40086	23823	6512	6185	21606	2103	3154	6734
9+	95815	64018	56188	74955	37559	24871	19988	3531	5514	0	1051	6822
TOTAL NO	4185759	3674442	5162644	3411969	1952372	1192229	1156045	618185	550294	670115	1169988	1263874
SPS NO	2954476	2011675	3457314	2044936	1027663	609347	567652	386803	391590	576261	1002318	916544
TOT.BIOM	874864	770643	956554	708515	430191	251048	220850	124253	109999	129445	224877	264779
SPS BIOM	617444	420659	640915	426127	224625	128688	107917	76866	78408	112406	194506	195864

	1982	1983	1984	1985	1986	1987
2	730255	404906	1583755	738354	906759	0
3	178869	329213	253654	957177	481116	517949
4	289387	81866	186272	131232	654144	303721
5	136470	173208	46360	124006	100492	442427
6	72860	68178	116581	22975	96036	70111
7	49784	43582	35831	90824	13753	67002
8	46482	34122	25500	20602	14836	9595
9+	13550	34312	11286	13568	10515	59548
TOTAL NO	1517656	1169388	2259038	2098785	2517652	
SPS NO	959076	820636	1611611	1618660	1707101	
TOT.BIOM	305627	244188	411869	420002	472208	
SPS BIOM	196133	172075	297646	325665	351259	

Table 5.1.8
List of input variables for the ICES prediction program.

HERRING VIA NORTH
The reference F is the mean F for the age group range from 2 to 7.

The number of recruits per year is as follows:

Year	Recruitment
1987	220000.0
1988	430000.0
1989	430000.0

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

Data are printed in the following units:

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

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
2	220000.0	1.00	.50	1.00	.145	.164
3	517949.0	1.00	.20	1.00	.173	.208
4	303721.0	1.00	.10	1.00	.196	.233
5	442427.0	1.00	.10	1.00	.215	.246
6	70111.0	1.00	.10	1.00	.230	.252
7	67002.0	1.00	.10	1.00	.242	.258
8	9595.0	1.00	.10	1.00	.251	.269
9+	59548.0	1.00	.10	1.00	.258	.292

Table 5.2.1 Monthly landings (tonnes) of HERRING from the Firth of Clyde (all fishing methods combined). (Data provided by Working Group).

Month	1975	1976	1977	1978	1979	1980
January	-[1]	-[1]	-[1]	4[1]	4[1]	6[1]
February	68[1]	7[1]	-[1]	6[1]	8[1]	3[1]
March	85	69[1]	-[1]	7[1]	13[1]	8[1]
April	369	521	530	246	12[1]	4[1]
May	283	436	44	245	4[1]	2[1]
June	203	281	640	238	336	114
July	354	332	494	376	466	656
August	240	473	601	587	450	645
September	515	541	559	581	374	559
October	811	598	556	653	263[1]	79[1]
November	571	595	560	647	1[1]	3[1]
December	120	236	328	272	-[1]	2[1]
Not known	44	50	35	-	-	-
Total	3,663	4,139	4,847	3,862	1,951	2,081

Month	1981	1982	1983	1984	1985	1986
January	15[1]	2[1]	+[1]	-[1]	-[1]	-[1]
February	15[1]	16[1]	1[1]	-[1]	-[1]	-[1]
March	14[1]	1[1]	1[1]	-[1]	-[1]	-[1]
April	32[1]	2[1]	-[1]	-[1]	-[1]	-[1]
May	25[1]	615	1[1]	554	527	272[1]
June	429	850	265	847	831	724
July	982	757	519	944	815	763
August	511	262[1]	681	276	661	786
September	106[1]	-[1]	604	246	187[1]	555[1]
October	-[1]	-[1]	457[1]	124[1]	1[1]	218[1]
November	2[1]	-[1]	1[1]	-[1]	-[1]	77[1]
December	4[1]	1[1]	-[1]	-[1]	-[1]	-[1]
Not known	-	-	273[2]	247[2]	-	-
Total	2,135	2,506	2,803	3,238	3,022	3,395

[1] Subject to closure of directed fishery for whole or part of the month.

[2] Landed in Northern Ireland and Isle of Man.

Table 5.2.2 Monthly catches of Clyde herring in number at age (thousands) in landings and discards, 1986.

Age (rings)	May		June		July		August		September	
	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards
0	-	-	-	-	-	-	-	1	40	-
1	1	34	-	312	5	-	36	21	54	7
2	232	523	363	781	520	682	447	7	526	79
3	461	143	640	363	469	247	1,046	-	516	75
4	419	19	925	236	931	391	951	-	461	58
5	196	7	706	52	737	63	367	-	358	33
6	142	1	561	17	564	41	270	-	190	21
7	54	-	124	1	104	3	195	-	120	9
8	75	-	50	-	94	2	14	-	43	3
9	31	-	78	-	64	1	44	-	31	2
>10	6	-	12	-	18	-	34	-	8	1

Age (rings)	October		November		By-catch in sprat fishery	Total		
	Landings	Discards	Landings	Discards		Landings	Discards	Combined (incl. by-catch)
0	33	-	6	-	668	79	1	748
1	77	-	2	-	129	175	374	678
2	315	-	99	-	-	2,502	2,072	4,574
3	346	-	125	-	-	3,603	828	4,431
4	182	-	49	-	-	3,918	704	4,622
5	121	-	39	-	-	2,524	155	2,679
6	22	-	18	-	-	1,767	80	1,847
7	26	-	8	-	-	631	13	644
8	3	-	3	-	-	282	5	287
9	-	-	-	-	-	248	3	251
>10	-	-	-	-	-	78	1	79

Table 5.2.3 Number of days absent from port by pair trawlers in the Firth of Clyde, 1974-1986.

Year	Days absent
1974	3,376
1975	3,209
1976	3,016
1977	4,186
1978	4,379
1979	2,933
1980	1,982
1981	1,529
1982	1,755
1983	1,644
1984	1,401
1985	1,688
1986	1,375

Table 5.2.4 Weights at age (g) of Clyde herring by month in landings and discards 1986.

Age	May		June		July		August	
(rings)	Landings	Discards	Landings	Discards	Landings	Discards	Landings	Discards
1	76	72	-	53	101	-	119	106
2	132	113	170	139	191	173	199	134
3	163	135	196	168	216	191	215	-
4	196	160	218	183	229	196	247	-
5	205	162	243	204	265	220	268	-
6	219	172	253	225	271	228	295	-
7	245	-	292	229	296	272	308	-
8	246	-	316	-	297	276	362	-
9	261	-	277	-	308	312	321	-
>10	287	-	322	-	322	-	322	-

Age	September		October		Whole year (weighted means)			By-catch
(rings)	Landings	Discards	Landings	Discards	Landings	Discards	Catch	in sprat fishery
1	120	128	103	119	111	59	76	30
2	202	203	175	179	183	146	166	-
3	229	224	192	195	204	174	199	-
4	256	248	217	207	229	195	224	-
5	280	271	234	226	254	223	253	-
6	284	271	270	255	266	238	265	-
7	326	319	220	285	297	301	297	-
8	347	331	304	291	298	309	298	-
9	335	325	-	-	298	321	298	-
>10	342	330	-	-	321	330	321	-

Table 5.2.5 SUM OF PRODUCTS CHECK

CLYDE HERRING
CATEGORY: TOTAL

CATCH IN NUMBERS UNIT: thousands

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	7551	6503	8985	5258	8641	1876	10480	7524	1796	4859	5633	2372
3	10358	1976	5181	4548	2817	2483	913	6976	2259	807	1592	2785
4	8745	4355	1684	1811	2559	1024	1049	1062	2724	930	567	1622
5	2306	3432	3007	918	1140	1072	526	1112	654	888	341	1158
6	741	1090	1114	1525	494	451	658	574	606	341	204	433
7	760	501	656	659	700	175	261	489	550	289	125	486
8	753	352	282	307	253	356	138	251	298	156	48	407
9	227	225	177	132	87	130	178	146	174	119	56	74
10+	117	181	132	114	59	67	100	192	236	154	68	18
TOTAL	31558	18615	19216	15272	16950	7654	14283	18326	9057	8543	8634	9355

	1982	1983	1984	1985	1986
2	11511	10109	11829	2951	4574
3	4079	5232	5774	4420	4451
4	2440	1747	3406	4592	4622
5	1028	965	1509	2806	2679
6	663	555	587	2654	1847
7	145	415	489	917	644
8	222	189	375	681	287
9	63	85	74	457	251
10+	53	38	80	240	79
TOTAL	20004	19333	24122	19718	19414

Table 5.2.6 VIRTUAL POPULATION ANALYSIS

CLYDE HERRING

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

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	.599	.437	.459	.455	.677	.262	.468	.695	.151	.325	.322	.106
3	.546	.327	.426	.479	.507	.436	.209	.715	.496	.099	.177	.278
4	.798	.443	.484	.435	.516	.330	.314	.377	.650	.370	.089	.261
5	.609	.754	.553	.471	.476	.376	.251	.565	.359	.401	.201	.236
6	.443	.576	.519	.534	.443	.311	.357	.421	.611	.297	.134	.373
7	.604	.539	.729	.588	.444	.246	.265	.451	.405	.588	.151	.473
8	.788	.553	.587	.808	.415	.377	.279	.390	.484	.302	.159	.879
9	.603	.505	.529	.534	.495	.346	.292	.471	.454	.322	.151	.348
10+	.603	.505	.529	.534	.495	.346	.292	.471	.454	.322	.151	.348
(2- 9)U	.624	.517	.536	.538	.497	.335	.304	.511	.451	.338	.173	.369
(2- 9)W	.624	.474	.479	.477	.581	.341	.401	.640	.361	.282	.236	.204

	1982	1983	1984	1985	1986
2	.299	.252	.269	.105	.240
3	.282	.233	.238	.162	.240
4	.395	.178	.222	.286	.240
5	.235	.238	.206	.257	.240
6	.185	.172	.200	.584	.240
7	.184	.151	.202	.480	.240
8	.364	.342	.178	.421	.240
9	.277	.206	.195	.304	.240
10+	.277	.206	.195	.304	.240
(2- 9)U	.278	.222	.214	.325	.240
(2- 9)W	.294	.233	.245	.215	.240

Table 5.2.7 VIRTUAL POPULATION ANALYSIS

CLYDE HERRING

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .900
PROPORTION OF ANNUAL M BEFORE SPAWNING: .670

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2	19107	21015	27945	16474	20457	9355	32085	17088	14771	20133	23497	27325
3	26871	7775	10052	13086	7746	7699	5332	14886	6517	9409	10782	12615
4	16607	12745	4591	5377	6638	3819	4077	3544	5960	3148	6975	7393
5	5288	6766	7406	2559	3149	3584	2484	2694	2200	2817	1967	5773
6	2166	2603	2879	3856	1446	1770	2227	1749	1385	1390	1707	1456
7	1752	1258	1324	1551	2045	840	1174	1410	1039	680	934	1351
8	1442	866	664	578	730	1187	594	815	813	627	342	726
9	524	594	451	334	233	466	737	407	499	453	419	264
10+	270	478	336	288	158	240	414	535	677	586	509	64
TOTAL NO	74029	54101	55649	44105	42653	28960	49124	43127	33661	39242	47132	56967
SPS NO	37333	31175	31261	25061	22154	18791	29449	21302	21319	26311	35190	41077
TOT.BIOM	20092	14577	14528	11802	11171	7925	12348	11391	8939	10123	12151	14790
SPS BIOM	10165	8406	8191	6732	5929	5165	7555	5736	5589	6842	8713	10615

	1982	1983	1984	1985	1986	1987
2	50290	52122	57620	34212	24665	0
3	18214	27629	29999	32611	22821	14373
4	7824	11245	17913	19366	22717	14698
5	5151	4767	8516	12975	13167	16170
6	4124	3685	3400	6274	9078	9372
7	907	3103	2808	2519	3165	6462
8	762	683	2413	2077	1411	2253
9	273	479	439	1827	1234	1004
10+	230	214	473	960	588	1154
TOTAL NO	87776	103927	123580	112820	98647	
SPS NO	57676	72605	85986	82065	70887	
TOT.BIOM	17873	21493	26033	25209	22914	
SPS BIOM	11893	15237	18590	18164	16625	

Table 5.2.8

Title : CLYDE HERRING
At 17.17.41 30 MARCH 1987
from 70 to 86 on ages 2 to 9
with Terminal F of .240 on age 4 and Terminal S of 1.000

Initial sum of squared residuals was 35.228 and
final sum of squared residuals is 15.064 after 56 iterations

Matrix of Residuals

Years	70/71	71/72	72/73	73/74	74/75	75/76						
Ages												
2/ 3	.354	-.004	-.091	-.219	.226	-.033						
3/ 4	.083	-.357	-.006	-.064	.178	.317						
4/ 5	.118	-.178	.004	-.209	.006	.099						
5/ 6	-.101	.545	.045	-.084	.032	-.077						
6/ 7	-.438	-.052	-.089	.096	.166	-.025						
7/ 8	-.020	.055	.185	.316	-.146	-.280						
8/ 9	.143	-.098	-.083	.349	-.436	-.097						
	.000	.000	.000	.000	.000	.000						
WTS	1.000	1.000	1.000	1.000	1.000	1.000						
Years	76/77	77/78	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86		WTS
Ages												
2/ 3	.253	.449	-.199	-.150	1.031	-1.349	-.059	.039	.914	-1.182	.000	.296
3/ 4	-.105	.391	.098	-.698	.510	-.465	.248	.118	.363	-.610	.000	.500
4/ 5	-.036	-.064	.504	-.069	-.202	-.164	.310	-.182	.310	-.047	.000	1.000
5/ 6	-.093	-.003	-.227	.371	.247	-.092	-.031	.140	-.475	-.196	.000	.754
6/ 7	.282	-.055	-.085	-.071	-.359	.469	-.153	-.202	-.332	.827	.000	.568
7/ 8	.102	-.049	-.023	.784	-.616	.214	-.826	-.166	-.161	.631	.000	.453
8/ 9	-.249	-.448	-.155	-.270	-.124	1.022	.124	.398	-.289	.195	.000	.491
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	
WTS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		

....ctd

Table 5.2.8(ctd)

Fishing Mortalities (F)

	70	71	72	73	74	75	76			
F-values	.6028	.5046	.5290	.5359	.4953	.3461	.2924			
	77	78	79	80	81	82	83	84	85	86
F-values	.4711	.4542	.3216	.1512	.3482	.2773	.2056	.1955	.3036	.2400

Selection-at-age (S)

	2	3	4	5	6	7	8	9
S-values	.9461	.9192	1.0000	1.0260	1.0281	1.0603	1.1816	1.0000

Table 5.2.9 Estimates of proportions of F attributable to discarding in CLYDE HERRING, 1984-1986.

Age (rings)	1984	1985	1986	Mean
2	0.61	0.72	0.45	0.593
3	0.20	0.43	0.19	0.273
4	0.07	0.12	0.15	0.113
5	0.03	0.06	0.06	0.050
6	0.04	0.02	0.04	0.033
7	-	0.01	0.02	0.010
8	0.01	0.01	0.02	0.013
9	-	-	0.01	0.003
10	-	-	0.01	0.003

Table 5.2.10 Input parameters for Clyde HERRING projections, using average proportions (1984-1986) of F attributable to discards.

Age	Stock in no. ('000) at 1 Jan 1987	F in 1987	Catch in no. ('000) in 1987			Weight at age (g)			Stock in no. ('000) at 1 Jan 1988
			Total	Landings	Discards	Landings	Discards	Spawn.stock at 1 Sep	
2	24,700	0.26	4,917	2,001	2,916	168	147	157	24,700
3	14,373	0.26	2,995	2,177	818	201	174	193	14,109
4	14,698	0.26	3,209	2,846	363	232	194	226	9,074
5	16,170	0.26	3,530	3,354	177	256	214	253	10,255
6	9,372	0.26	2,046	1,978	68	270	236	268	11,282
7	6,462	0.26	1,411	1,397	14	302	304	302	6,539
8	2,253	0.26	492	486	6	295	296	294	4,509
9	1,004	0.26	219	218	1	299	316	299	1,572
⩾10	1,154	0.26	252	251	1	310	305	311	1,506
Tonnes	-	-	-	3,534	701	-	-	-	-

Table 5.2.11 Input parameters for Clyde HERRING projections, using 1986 proportions of F attributable to discards.

Age	Stock in no. ('000) at 1 Jan 1987	F in 1987	Catch in no. ('000) in 1987			Weight at age (g)			Stock in no. ('000) at 1 Jan 1988
			Total	Landings	Discards	Landings	Discards	Spawn.stock at 1 Sep	
2	24,700	0.25	4,748	2,611	2,137	168	147	157	24,700
3	14,373	0.25	2,893	2,343	549	201	174	193	14,252
4	14,698	0.25	3,099	2,634	465	232	194	226	9,166
5	16,170	0.25	3,410	3,205	205	256	214	253	10,359
6	9,372	0.25	1,976	1,897	79	270	236	268	11,396
7	6,462	0.25	1,363	1,335	27	302	304	302	6,605
8	2,253	0.25	475	466	9	295	296	294	4,554
9	1,004	0.25	212	210	2	299	316	299	1,588
≥10	1,154	0.25	243	241	2	310	305	311	1,521
Tonnes	-	-	-	3,517	573	-	-	-	-

Table 6.1.1 Estimated HERRING catches in tonnes in Divisions VIa (south) and VIIb,c, 1977-1986.

Country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986[1]
France	-	-	-	-	-	353	19	-	-	-
Germany Fed.Rep.	221	100	5	-	2,687	265	-	-	-	-
Ireland	15,916	19,128	18,910	27,499	19,443	16,856	15,000	10,000	13,900	15,450
Netherlands	4,423	481	1,939	1,514	2,790	1,735	5,000	6,400	1,270	1,550
Poland	6	-	-	-	-	-	-	-	-	-
UK (N.Ireland)	1	6	2	1	2	-	-	-	-	-
USSR	1	-	-	-	-	-	-	-	-	-
Unallocated	-	-	1,752	1,110	-	-	13,000	11,000	8,204	11,785
Total	20,567	19,715	22,608	30,124	24,922	19,209	33,019	27,400	23,374	28,785

[1] Provisional.

Table 6.1.2 SUM OF PRODUCTS CHECK

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

CATCH IN NUMBERS UNIT: thousands

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	155	885	1001	6425	3574	7360	10615	4435	10170	5919	2856	1620
2	35114	6177	28780	40390	29406	41308	29011	44512	40320	50071	40058	22265
3	26007	7038	20554	47589	41116	25117	37512	13596	27079	19161	64946	41794
4	13243	10856	6191	16863	44579	29192	26544	17176	13308	19969	25140	31460
5	5395	8826	11145	7452	17657	23718	25517	12209	10685	9549	22126	12812
6	40181	5956	10057	12583	8882	10703	15000	9924	5556	8422	7748	12746
7	2932	40553	4245	9191	10901	5909	5208	5534	4270	5443	6946	5461
8	1667	2286	47182	1969	10272	9378	5596	1360	3658	4423	4544	2735
9+	1911	2160	4505	30980	30549	32029	15705	4150	5524	4090	5334	5220
TOTAL	125155	82717	133444	195020	196956	184714	174504	112746	118150	126847	179498	134113

	1982	1983	1984	1985	1986
1	748	1517	2794	9606	918
2	18155	45688	81481	15145	27110
3	17004	49534	23660	67355	24818
4	26220	25316	17654	12756	09563
5	13280	31782	7190	11241	14644
6	3121	18520	12856	7658	7988
7	4089	6695	5974	9185	5096
8	5249	5329	2008	7587	5422
9+	2875	4251	4026	2168	2127
TOTAL	100722	184432	162817	142679	155106

Table 6.2.1 Larvae production estimates (LPE) and larvae abundance indices (LAI) for Divisions VIa (South) and VIIb,c.

Year	LAI(10^{11})	LPE(10^{11})	Fecundity (eggs/kg)	SSB ('000 tonnes)
1981	58	254	1.42	179
1982	76	198	1.44	138
1983	68	192	1.41	136
1984	36	81	(1.43)	57
1985	26	84	(1.43)	59
1986	62	124	(1.43)	87

Table 6.4.1 VIRTUAL POPULATION ANALYSIS

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

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

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.00	.00	.00	.02	.01	.03	.04	.01	.02	.01	.01	.01
2	.35	.05	.11	.17	.18	.25	.24	.25	.27	.18	.17	.18
3	.19	.11	.24	.29	.29	.25	.40	.17	.25	.21	.40	.28
4	.14	.11	.15	.30	.47	.32	.42	.31	.24	.29	.44	.33
5	.18	.11	.14	.21	.52	.43	.45	.31	.29	.24	.52	.37
6	.15	.26	.17	.21	.36	.61	.47	.29	.20	.34	.29	.56
7	.28	.19	.45	.20	.25	.39	.60	.28	.17	.28	.47	.18
8	.32	.32	.32	.32	.32	.32	.38	.27	.27	.24	.33	.30
9+	.32	.32	.32	.32	.32	.32	.38	.27	.27	.24	.33	.30
(1- 7)U	.18	.12	.17	.20	.30	.32	.37	.23	.21	.22	.33	.27
(2- 7)U	.21	.14	.20	.23	.35	.37	.43	.27	.24	.26	.38	.32

	1982	1983	1984	1985	1986
1	.00	.00	.02	.08	.06
2	.12	.33	.24	.19	.60
3	.22	.60	.41	.33	.60
4	.30	.55	.42	.30	.60
5	.23	.57	.26	.45	.60
6	.38	.45	.42	.44	.60
7	.31	.55	.23	.53	.60
8	.23	.40	.28	.45	.60
9+	.23	.40	.28	.45	.60
(1- 7)U	.23	.44	.28	.33	.52
(2- 7)U	.27	.51	.33	.37	.60

Table 6.4.2 VIRTUAL POPULATION ANALYSIS

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

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

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

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	408685	843607	791566	565036	587759	444870	652643	541414	966224	816213	422497	501438
2	137499	150268	309852	290618	204153	214262	159384	230458	196568	349543	290827	153767
3	161954	72010	106031	204915	180812	126124	123528	93343	132797	111278	216205	185690
4	108692	109163	52611	68335	125169	111072	80665	67477	64557	84366	75858	118733
5	24249	85771	88462	41724	45858	71034	72820	47839	44766	45604	57396	43013
6	309759	18243	69225	69460	30699	24570	41802	41908	31708	30371	32393	30985
7	12795	242104	12771	53088	51096	19358	12106	23617	28506	25606	19495	21961
8	6380	8749	180568	7555	39311	35890	11915	6026	16120	21739	16196	11061
9+	7313	8266	16475	195103	116913	122577	52052	18589	14729	20103	19887	21111
TOTAL NO	1177234	1538183	1627542	1495815	1381730	1169756	1206896	1070471	1495774	1502823	1154753	1087760
SPS NO	609124	572555	649766	697899	574886	524009	383540	389536	391734	513566	516220	428846
TOT.BIOM	230436	268293	284786	280849	253305	219639	202859	177197	229640	239381	203564	188489
SPS BIOM	145803	138030	148031	160797	132726	120741	86213	85363	85184	106491	107554	94028

	1982	1983	1984	1985	1986	1987
1	480765	1217935	272323	201371	24815	0
2	133526	176428	447170	98558	68525	8597
3	94908	120455	93549	261811	60092	27860
4	114453	62400	54315	50877	153843	27001
5	77602	76796	32500	32227	33958	76396
6	20775	52876	39410	22586	18512	16853
7	15974	16550	30490	23497	13201	9193
8	16585	10576	8620	21919	12566	6555
9+	14676	13505	17257	6264	4929	8688
TOTAL NO	1025264	1747501	995654	719111	390420	
SPS NO	414249	539876	510726	365821	220920	
TOT.BIOM	176810	262135	176160	124720	65824	
SPS BIOM	90777	74669	101938	73805	50755	

Table 6.6.1

List of input variables for the ICES prediction program.

Herring in Divisions VIa (South) and VIIb,c. The reference F is the mean F for the age group range from 2 to 7.

The number of recruits per year is as follows:

Year	Recruitment
1987	171000.0
1988	171000.0
1989	171000.0

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

Data are printed in the following units:

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

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
2	171000.0	.60	.30	1.00	.138	.169
3	27860.0	.60	.20	1.00	.164	.209
4	27001.0	.60	.10	1.00	.194	.238
5	76396.0	.60	.10	1.00	.212	.256
6	16853.0	.60	.10	1.00	.225	.276
7	9193.0	.60	.10	1.00	.239	.280
8	6555.0	.60	.10	1.00	.208	.287
9+	8688.0	.60	.10	1.00	.288	.312

Table 6.6.2 HERRING in Division VIa (South) and VIIb,c. Management options table.

1987				1988					1989	
Stock biom. (2+)	SSB	$\bar{F}_{2-7}$	Catch (2+)	Management option	Stock biom. (2+)	SSB	$\bar{F}_{2-7}$	Catch (2+)	Stock biom. (2+)	SSB
73	50	0.37	17	$F_{0.1}$	76	60	0.15	8	89	71
				$F_{88} = F_{86}$		44	0.60	25	68	39
	39	0.75	29	$F_{0.1}$	61	48	0.15	6	78	61
				$F_{88} = F_{86}$		35	0.60	20	60	35

Weights in '000 t.

Stock biomass calculated at 1 January = SSB at 1 January.

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

Table 7.1.1 HERRING. Total catches (t) in North Irish Sea (Division VIIa), 1977-1986.

Country	1977	1978	1979	1980	1981
France	85	174	455[2]	1	-
Ireland	3,331	2,371	1,805	1,340	283
Netherlands	500	98	-	-	-
UK	11,498	8,432[1]	10,078[3]	9,272	4,094
Others	-	-	-	-	-
Total	15,414	11,075	12,338	10,613	4,377

Country	1982	1983	1984	1985	1986[5]
France	-	48[2]	-	-	-
Ireland	300	860	1,084	1,000	1,640
Netherlands	-	-	-	-	-
UK	3,375	3,025	2,982	4,077	4,376
Others	1,180[4]	-	-	4,110[4]	1,424[4]
Total	4,855	3,933	4,066	9,187	7,440

[1] Includes 68.5 t of spring-spawned herring.

[2] No data basis for allocation to stock.

[3] Additional unrecorded catch of 106 t estimated.

[4] Unallocated.

[5] Preliminary.

Table 7.1.2 VIRTUAL POPULATION ANALYSIS

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

CATCH IN NUMBERS UNIT: thousands

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	40640	42150	43250	55530	54740	30280	15540	11770	5840	5050	5100	1305
2	46660	32740	109550	48240	56160	39040	36950	38270	25760	15790	16030	12162
3	26950	38240	39750	39410	20780	22690	13410	23490	19510	5200	5670	5598
4	15180	11490	24510	10840	15220	6750	6780	4250	8520	2790	2150	2820
5	13750	6920	10650	7670	4580	4520	1740	2200	1980	2300	330	445
6	6760	5070	4990	4210	2810	1460	1340	1050	910	330	1110	484
7	2660	2590	5150	2090	2420	910	670	400	360	290	140	255
8+	1670	2600	1630	1640	1270	1120	350	290	230	240	380	59
TOTAL	152270	141800	239480	147630	137930	106770	76780	81720	63110	29990	30910	23128

	1984	1985	1986
1	1168	2429	4491
2	8424	10050	15266
3	7237	17336	7462
4	5841	13287	8550
5	2221	7206	4528
6	580	2651	3198
7	229	667	1464
8+	479	724	877
TOTAL	25979	54350	45836

Table 7.3.1 North Irish Sea herring: Effort and fishing mortality.

Year	UK effort[1] (landings)	UK catch (t)	UK proportion of total catch	UK proportion of F Input F_{86} for VPA			
				0.20	0.25	0.30	0.35
1980	2,165	7,249	0.68	0.668	0.688	0.703	0.706
1981	956	2,962	0.68	0.301	0.321	0.336	0.341
1982	629	2,760	0.57	0.161	0.175	0.187	0.194
1983	536	2,350	0.59	0.091	0.101	0.110	0.116
1984	677	2,477	0.61	0.077	0.088	0.097	0.104
1985	714	2,820	0.31	0.088	0.104	0.119	0.131
1986	607	3,475	0.47	0.094	0.117	0.141	0.164

[1] Isle of Man and Northern Ireland.

Table 7.3.2 Regressions of fishing mortality generated by the UK catch and fishing effort.

Input F (unweighted)	r	Intercept on F axis	Predicted $F_{86(total)}$
	1980 - 1985 inclusive		
0.20	0.975	-0.12	0.228
0.25	0.974	-0.10	0.256
0.30	0.974	-0.09	0.281
0.35	0.975	-0.08	0.297
	1981 - 1985 inclusive		
0.20	0.822	-0.20	0.205
0.25	0.831	-0.21	0.231
0.30	0.838	-0.20	0.254
0.35	0.844	-0.19	0.270

Table 7.3.3 VIRTUAL POPULATION ANALYSIS

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

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

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	.166	.104	.214	.152	.230	.158	.105	.141	.058	.037	.034	.007
2	.362	.344	.825	.752	.792	.856	.535	.751	1.053	.385	.271	.176
3	.522	.614	1.012	.907	.976	.994	.922	.864	1.316	.363	.246	.151
4	.533	.418	1.005	.824	1.101	.993	.908	.828	.875	.619	.420	.176
5	.611	.524	.755	.955	.909	1.075	.664	.757	1.084	.542	.119	.127
6	.630	.421	.795	.679	.992	.739	1.001	.988	.728	.450	.485	.229
7	.534	.466	.880	.825	.956	.934	.809	.841	1.017	.475	.310	.173
8+	.534	.466	.880	.825	.956	.934	.809	.841	1.017	.475	.310	.173
(2- 7)U	.532	.465	.879	.823	.954	.932	.807	.838	1.012	.472	.308	.172
(2- 7)W	.452	.454	.875	.819	.877	.916	.645	.794	1.099	.412	.275	.169

	1984	1985	1986
1	.011	.018	.020
2	.100	.208	.250
3	.160	.325	.250
4	.140	.461	.250
5	.184	.372	.250
6	.137	.309	.250
7	.145	.335	.250
8+	.145	.335	.250
(2- 7)U	.144	.335	.250
(2- 7)W	.128	.320	.250

Table 7.3.4 VIRTUAL POPULATION ANALYSIS

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

STOCK SIZE IN NUMBERS UNIT: thousands

BIOMASS TOTALS UNIT: tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .900
PROPORTION OF ANNUAL M BEFORE SPAWNING: .750

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	414199	667530	349121	368885	263019	324085	248255	139725	163266	219117	244024	279967
2	176352	129043	221249	103699	116548	76916	101828	82360	44651	56680	77679	86811
3	72510	90992	67762	71850	56215	39112	24199	44168	28798	11533	28578	43892
4	35395	35230	40302	20158	23750	11176	11855	7880	15241	6523	6569	18297
5	31457	17740	20990	13352	8002	7148	3746	4328	3117	5747	3082	3907
6	15111	15456	9501	8929	4657	2918	2208	1744	1838	954	3023	2476
7	6726	7278	9181	3883	4099	1563	1261	734	588	803	551	1684
8+	4223	7307	2906	3047	2151	1924	659	532	376	664	1494	390
TOTAL NO	753973	970576	721012	593804	458441	464843	394010	281471	257853	301321	365000	437424
SPS NO	189195	183696	140220	96985	75506	58096	68787	57280	33944	50493	79974	114997
TOT.BIOM	95438	105762	92599	68984	54472	49308	43401	35223	29393	30598	39141	48810
SPS BIOM	35778	32589	24481	16890	12782	9453	10965	9704	5710	8087	13268	19823

	1984	1985	1986	1987
1	169309	219637	358210	0
2	102235	61606	79388	129169
3	55928	68532	37066	45805
4	30892	37633	40533	23634
5	13878	24304	21466	28565
6	5112	10449	15161	15127
7	1781	2455	6940	10684
8+	5725	2665	4158	7821
TOTAL NO	378861	427282	562922	
SPS NO	153173	136899	147181	
TOT.BIOM	49317	52894	60323	
SPS BIOM	26595	21882	24959	

Table 7.5.1
List of input variables for the ICES prediction program.

HERRING IN THE NORTHERN IRISH SEA
The reference F is the mean F for the age group range from 2 to 7.

The number of recruits per year is as follows:

Year	Recruitment
1987	283000.0
1988	283000.0
1989	283000.0

Proportion of F (fishing mortality) effective before spawning: .9000
Proportion of M (natural mortality) effective before spawning: .7500

Data are printed in the following units:

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

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
1	283000.0	.02	1.00	.08	68.000	68.000
2	129169.0	.25	.30	.85	143.000	143.000
3	45805.0	.25	.20	1.00	167.000	167.000
4	23634.0	.25	.10	1.00	188.000	188.000
5	28563.0	.25	.10	1.00	215.000	215.000
6	15127.0	.25	.10	1.00	228.000	228.000
7	10584.0	.25	.10	1.00	239.000	239.000
8+	7821.0	.25	.10	1.00	254.000	254.000

Table 8.1.1 Catch in numbers, millions and catch in weights, tonnes. Icelandic summer-spawning herring.

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

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

AGE	1983	1984	1985	1986
1	1.470	0.421	0.111	0.100
2	22.422	18.011	12.800	8.161
3	151.198	32.237	24.521	33.893
4	30.181	141.324	21.535	23.421
5	21.525	17.039	84.733	20.654
6	8.637	7.111	11.836	77.526
7	14.017	3.915	5.708	18.228
8	13.666	4.112	2.323	10.971
9	3.715	4.516	4.339	8.583
10	2.373	1.828	4.030	9.662
11	3.424	0.202	2.758	7.174
12	0.552	0.255	0.970	3.677
13	0.100	0.260	0.477	2.914
14	0.003	0.003	0.578	1.786
JUVENILE	78.323	24.055	15.363	11.744
ADULT	194.960	207.179	161.356	215.006
TOTAL CATCH	58.665	50.293	49.092	65.413

Table 8.1.2 Weight at age, in grammes, Icelandic summer-spawners.

AGE	1969	1970	1971	1972	1973	1974	1975
1	82.0	85.0	88.0	96.0	90.0	80.0	110.0
2	157.0	169.0	165.0	177.0	199.0	189.0	179.0
3	195.0	216.0	237.0	278.0	257.0	262.0	241.0
4	264.0	263.0	273.0	332.0	278.0	297.0	291.0
5	284.0	312.0	301.0	358.0	337.0	340.0	319.0
6	304.0	329.0	324.0	379.0	381.0	332.0	339.0
7	339.0	338.0	346.0	410.0	380.0	379.0	365.0
8	372.0	357.0	368.0	419.0	397.0	356.0	364.0
9	379.0	378.0	390.0	470.0	385.0	407.0	407.0
10	390.0	396.0	409.0	500.0	450.0	410.0	389.0
11	376.0	408.0	412.0	500.0	450.0	410.0	430.0
12	401.0	425.0	420.0	500.0	450.0	423.0	416.0
13	409.0	430.0	442.0	500.0	450.0	423.0	416.0
14	414.0	450.0	450.0	500.0	450.0	423.0	416.0

AGE	1976	1977	1978	1979	1980	1981	1982
1	103.0	84.0	73.0	75.3	68.9	60.8	65.0
2	189.0	157.0	128.0	145.3	115.3	140.9	141.0
3	243.0	217.0	196.0	182.4	202.0	190.5	186.1
4	281.0	261.0	247.0	230.9	232.5	245.5	217.3
5	305.0	285.0	295.0	284.7	268.9	268.6	273.7
6	335.0	313.0	314.0	315.7	316.7	297.6	293.3
7	351.0	326.0	339.0	333.7	351.6	329.8	323.0
8	355.0	347.0	359.0	350.4	360.4	355.7	353.8
9	395.0	364.0	360.0	366.7	379.9	368.3	384.6
10	363.0	362.0	376.0	368.3	382.9	405.4	388.7
11	396.0	358.0	380.0	370.6	392.7	381.5	400.4
12	396.0	355.0	425.0	350.0	390.0	400.0	393.5
13	396.0	400.0	425.0	350.0	390.0	400.0	390.3
14	396.0	420.0	425.0	450.0	390.0	400.0	419.5

AGE	1983	1984	1985	1986
1	59.3	49.3	53.2	60.0
2	131.7	131.4	146.0	139.7
3	179.7	188.6	219.0	200.4
4	218.1	216.8	265.8	251.6
5	259.9	244.9	285.3	282.2
6	308.6	276.9	314.6	297.9
7	328.7	314.6	334.6	320.1
8	356.5	321.7	365.0	334.4
9	370.2	350.7	388.2	372.7
10	406.9	333.8	400.5	379.6
11	436.6	361.9	453.0	393.9
12	458.6	446.3	468.9	407.8
13	429.9	417.4	432.8	404.8
14	471.5	392.3	446.7	438.9

Table 8.1.3 Proportion of mature herring in each group. Based on samples taken in Sept-Dec by purse seine.

AGE	1969	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2	0.08	0.22	0.38	0.29	0.64	0.14	0.27
3	0.73	0.89	0.98	1.00	0.99	0.94	0.97
4	0.99	1.00	1.00	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00

AGE	1976	1977	1978	1979	1980	1981	1982
1	0.00	0.00	0.00	0.00	0.00	0.00	0.02
2	0.13	0.02	0.04	0.07	0.05	0.03	0.05
3	0.90	0.87	0.78	0.65	0.92	0.65	0.85
4	1.00	1.00	1.00	0.98	1.00	0.99	1.00
5	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00

AGE	1983	1984	1985	1986
1	0.00	0.00	0.00	0.00
2	0.00	0.01	0.00	0.03
3	0.64	0.82	0.90	0.89
4	1.00	1.00	1.00	1.00
5	1.00	1.00	1.00	1.00
6	1.00	1.00	1.00	1.00
7	1.00	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00

Table 8.2.1 Comparison of the results obtained in the acoustic surveys in December 1986 and January 1987 and stock in numbers on 1 January 1987 derived from last year's assessment. Numbers in millions.

Ring	Acoustic survey estimate January 1987	Stock in number 1 January 1987
1	74.9	400.0
2	114.5	361.9
3	216.2	787.9
4	201.7	252.1
5	71.3	99.4
6	47.3	87.3
7	181.7	347.0
8	41.5	41.3
9	24.4	15.4
10	20.0	9.5
11	21.8	19.5
12	16.7	19.8
13	7.9	9.3
14	6.6	2.6

Table 8.3.1 Stock in number at 1 January 1986, catch in number in 1986, and corresponding fishing mortality rate. Numbers in thousands.

Ring	Stock at 1 January 1986	Catch 1986	Estimated F in 1986	Smoothed F used in VPA
1	400,000	100	0.00	0.00
2	879,467	8,161	0.01	0.01
3	314,135	33,893	0.12	0.12
4	134,195	23,421	0.20	0.20
5	117,854	20,654	0.20	0.20
6	463,715	77,526	0.19	0.20
7	64,774	18,228	0.35	0.39
8	39,052	10,971	0.35	0.39
9	15,893	8,583	0.83	0.39
10	29,686	9,662	0.41	0.39
11	27,572	7,174	0.32	0.39
12	18,869	3,677	0.23	0.39
13	6,636	2,917	0.61	0.39
14	3,263	1,786	0.85	0.39

Table 8.3.2 Icelandic summer-spawners. Fishing mortalities.

AGE	1969	1970	1971	1972	1973	1974	1975
1	0.107	0.064	0.140	0.002	0.000	0.000	0.008
2	0.849	0.947	0.647	0.006	0.002	0.011	0.018
3	0.591	1.020	0.554	0.010	0.014	0.013	0.105
4	0.657	0.661	1.542	0.025	0.009	0.024	0.117
5	0.722	0.779	1.193	0.083	0.003	0.009	0.238
6	0.829	0.726	1.354	0.040	0.005	0.009	0.097
7	0.920	0.855	2.009	0.059	0.006	0.001	0.098
8	0.899	1.014	3.213	0.055	0.015	0.001	0.165
9	0.857	1.717	2.353	0.628	0.008	0.003	0.146
10	0.943	0.655	1.963	0.485	0.253	0.003	0.012
11	1.219	0.548	0.989	0.223	0.080	0.112	0.003
12	1.110	1.204	0.008	0.016	0.097	0.097	0.141
13	0.799	3.564	0.035	0.027	0.018	0.119	0.119
14	0.700	1.000	1.000	0.040	0.010	0.020	0.150
AVERAGE WEIGHTED BY STOCK IN NUMBERS							
AVE 4-14	0.751	0.765	1.578	0.047	0.007	0.019	0.155

AGE	1976	1977	1978	1979	1980	1981	1982
1	0.001	0.002	0.016	0.004	0.014	0.002	0.002
2	0.061	0.040	0.064	0.104	0.078	0.023	0.017
3	0.039	0.187	0.130	0.168	0.183	0.111	0.167
4	0.140	0.123	0.139	0.236	0.299	0.139	0.352
5	0.160	0.254	0.130	0.219	0.322	0.267	0.256
6	0.230	0.204	0.318	0.152	0.210	0.314	0.431
7	0.147	0.332	0.313	0.318	0.235	0.178	0.553
8	0.120	0.266	0.710	0.187	0.370	0.167	0.225
9	0.187	0.184	0.492	0.411	0.144	0.417	0.319
10	0.228	0.325	0.501	0.242	0.579	0.104	0.590
11	0.367	0.059	0.632	0.417	0.557	0.740	0.321
12	0.004	1.130	0.043	0.081	0.001	2.175	1.651
13	0.183	0.004	0.605	0.168	0.388	0.158	1.915
14	0.150	0.250	0.250	0.250	0.350	0.350	0.500
AVERAGE WEIGHTED BY STOCK IN NUMBERS							
AVE 4-14	0.150	0.221	0.247	0.239	0.300	0.257	0.398

AGE	1983	1984	1985	1986
1	0.007	0.001	0.000	0.000
2	0.099	0.093	0.038	0.010
3	0.166	0.181	0.159	0.120
4	0.244	0.207	0.158	0.200
5	0.304	0.189	0.165	0.200
6	0.183	0.139	0.174	0.200
7	0.246	0.106	0.142	0.390
8	0.295	0.095	0.076	0.390
9	0.165	0.134	0.124	0.390
10	0.161	0.103	0.152	0.390
11	0.344	0.017	0.198	0.390
12	0.104	0.035	0.093	0.390
13	1.534	0.058	0.075	0.390
14	0.300	0.130	0.160	0.390
AVERAGE WEIGHTED BY STOCK IN NUMBERS				
AVE 4-14	0.248	0.185	0.158	0.243

Table 8.3.3 Icelandic summer-spawners. VPA stock size in number (millions) and spawning stock biomass at 1 July.

AGE	1969	1970	1971	1972	1973	1974	1975
1	46.823	33.785	70.348	84.793	416.049	134.325	194.733
2	143.018	38.074	28.666	55.320	76.584	377.216	121.520
3	19.396	55.372	13.369	13.576	49.750	69.145	337.744
4	11.242	9.721	18.075	6.949	12.160	44.371	61.774
5	20.344	5.275	4.541	3.499	6.133	10.904	39.204
6	5.263	8.942	2.190	1.246	2.916	5.533	9.779
7	2.409	2.079	3.914	0.512	1.083	2.626	4.963
8	2.073	0.869	0.800	0.475	0.436	0.974	2.374
9	1.104	0.763	0.285	0.029	0.407	0.389	0.880
10	0.724	0.424	0.124	0.025	0.014	0.366	0.351
11	0.422	0.255	0.199	0.016	0.014	0.010	0.330
12	0.216	0.113	0.134	0.067	0.011	0.011	0.008
13	0.207	0.064	0.031	0.120	0.060	0.009	0.009
14	0.154	0.084	0.002	0.027	0.106	0.053	0.008
JUVENILE	183.749	69.573	87.685	124.071	444.117	462.879	293.575
SP.STOCK BIOMASS	16.699	19.873	13.259	10.650	28.349	45.105	116.001

AGE	1976	1977	1978	1979	1980	1981	1982
1	557.685	420.303	179.375	221.811	242.304	1290.982	276.639
2	174.758	504.032	379.635	159.801	199.819	216.254	1165.961
3	108.008	148.768	438.147	322.078	130.251	167.172	191.274
4	275.227	94.015	111.682	348.016	246.268	98.146	135.331
5	49.728	216.608	75.186	87.904	248.722	165.234	77.289
6	27.972	38.340	152.011	59.731	63.925	163.102	114.529
7	8.028	20.109	28.298	100.094	46.447	46.888	107.828
8	4.070	6.272	13.055	18.727	65.874	33.216	35.496
9	1.820	3.267	4.351	5.806	14.049	41.176	25.438
10	0.688	1.366	2.459	2.407	3.483	11.007	24.545
11	0.314	0.496	0.893	1.348	1.709	1.766	8.979
12	0.298	0.197	0.423	0.430	0.804	0.886	0.762
13	0.006	0.268	0.058	0.366	0.358	0.726	0.091
14	0.008	0.005	0.242	0.028	0.280	0.220	0.561
JUVENILE	720.526	933.594	640.217	490.113	442.553	1560.240	1407.461
SP.STOCK BIOMASS	128.674	131.947	174.875	196.157	207.100	177.595	184.412

AGE	1983	1984	1985	1986
1	236.847	399.618	952.569	350.330
2	249.882	212.910	361.187	861.808
3	1036.766	204.801	175.537	314.648
4	146.382	794.539	154.705	135.548
5	86.161	103.813	584.783	119.534
6	54.162	57.547	77.758	448.677
7	67.336	40.808	45.317	59.121
8	56.139	47.628	33.205	35.583
9	25.652	37.834	39.188	27.838
10	16.727	19.683	29.945	31.338
11	12.315	12.882	16.074	23.268
12	5.892	7.897	11.464	11.926
13	0.132	4.807	6.903	9.451
14	0.012	0.026	4.102	5.793
JUVENILE	859.965	647.264	1331.310	1220.895
SP.STOCK BIOMASS	244.334	288.954	322.453	318.396

Table 8.4.1 Input parameters used in catch prediction for the Icelandic summer-spawning (Division Va) HERRING.

Ring	Stock in number ('000) at 1 January 1986	Proportional F	Mean weight in catch and spawning stock (g)
1	400,000	0.005	60.0
2	316,896	0.15	129.3
3	772,037	0.50	194.1
4	252,511	1.00	243.5
5	100,416	1.00	285.2
6	88,553	1.00	310.1
7	332,388	1.00	322.9
8	36,219	1.00	352.6
9	21,799	1.00	370.5
10	17,054	1.00	371.3
11	19,198	1.00	402.9
12	14,255	1.00	441.0
13	7,306	1.00	418.3
14	5,790	1.00	426.0

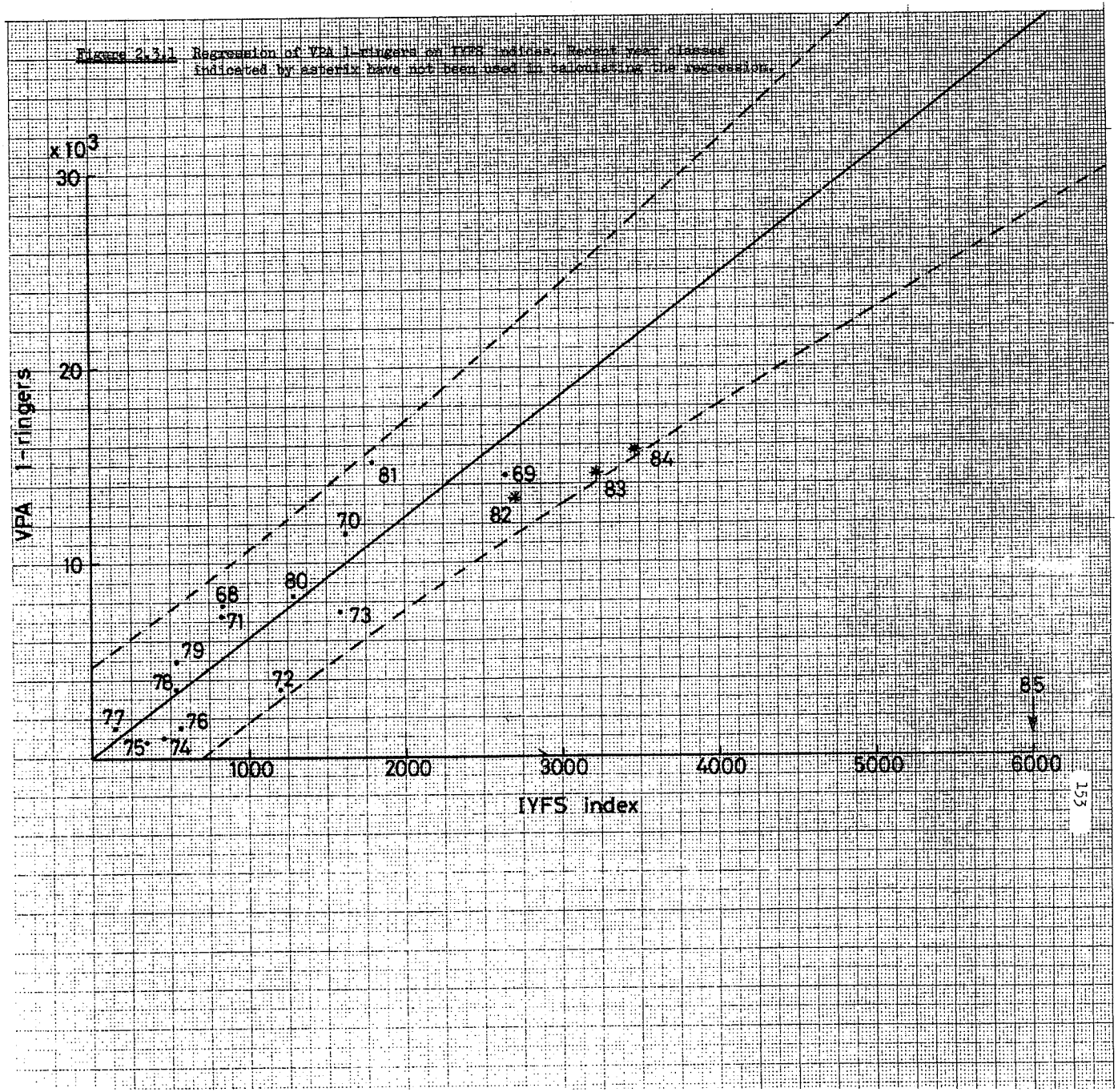


Figure 2.3.1 Regression of VPA 1-ringers on IYFS indices. Recent year classes indicated by asterix have not been used in calculating the regression.

Figure 2.3.2 Plot of IYFS index as 1-group on IKMT indices as 0-group for total North Sea and Division IIIa.

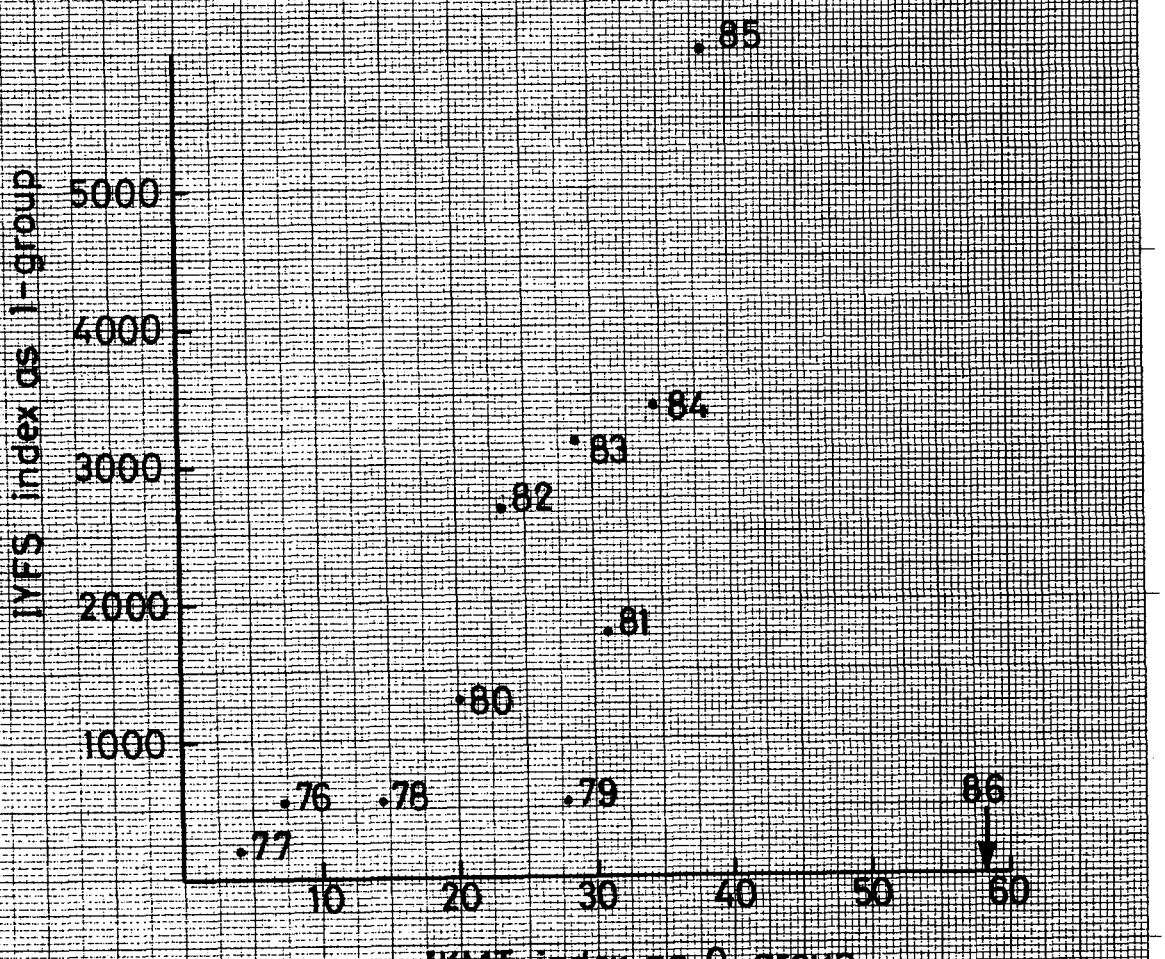
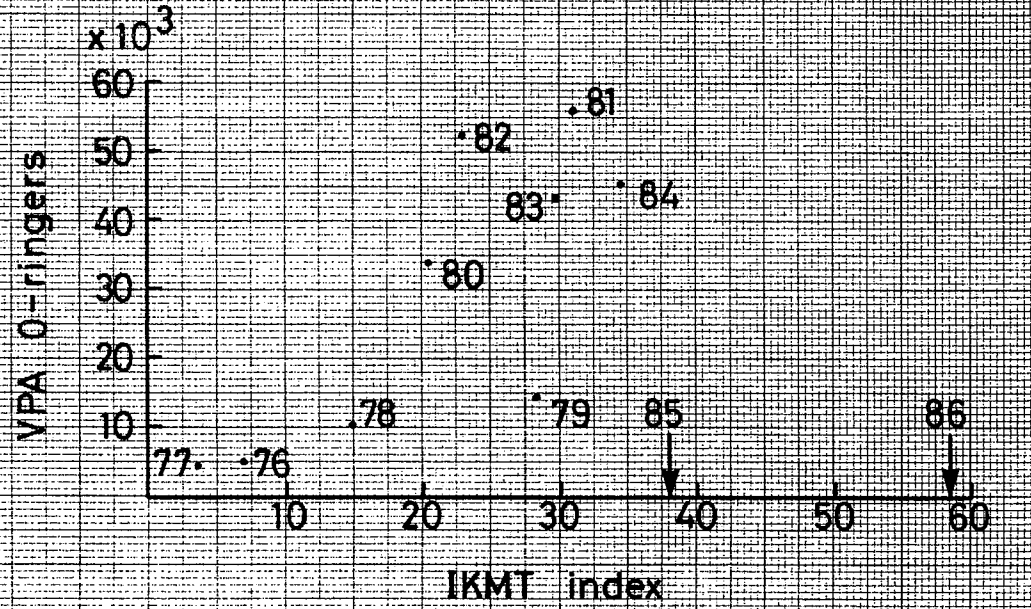


Figure 2.3.3 Plot of VPA 0-ringers on IKMT indices for total North Sea and Division IIIa.



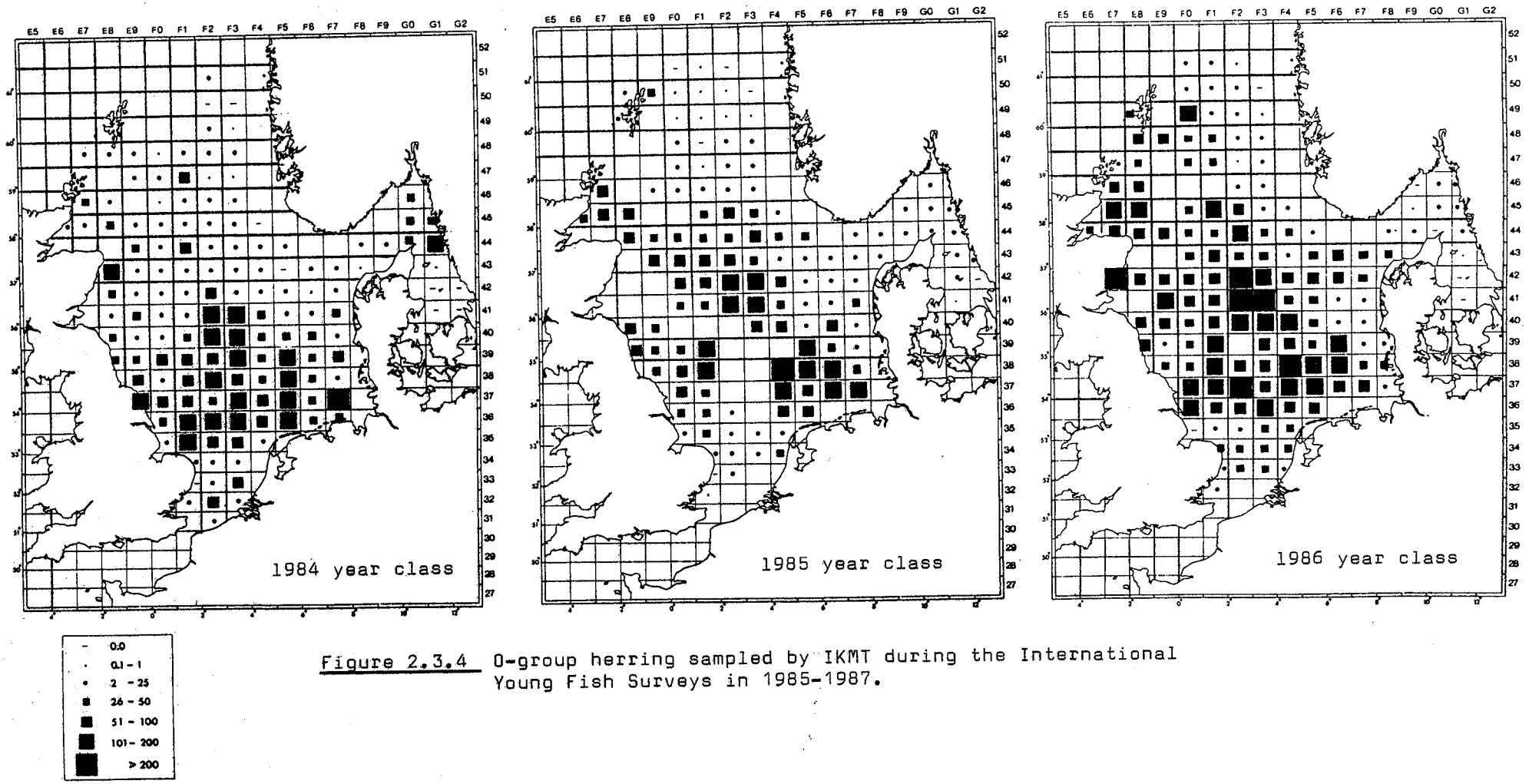


Figure 2.3.4 0-group herring sampled by IKMT during the International Young Fish Surveys in 1985-1987.

Figure 2.3.5

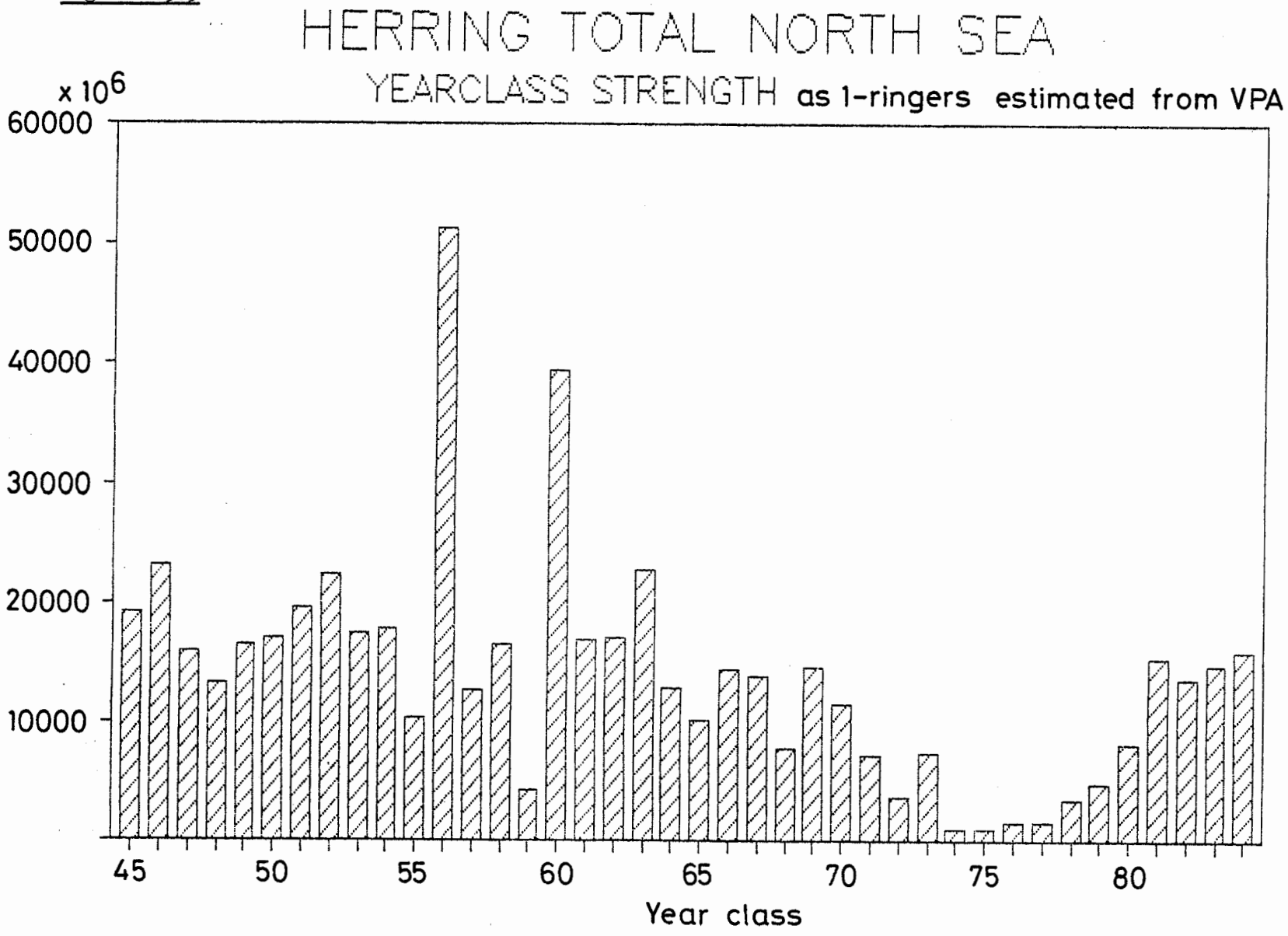
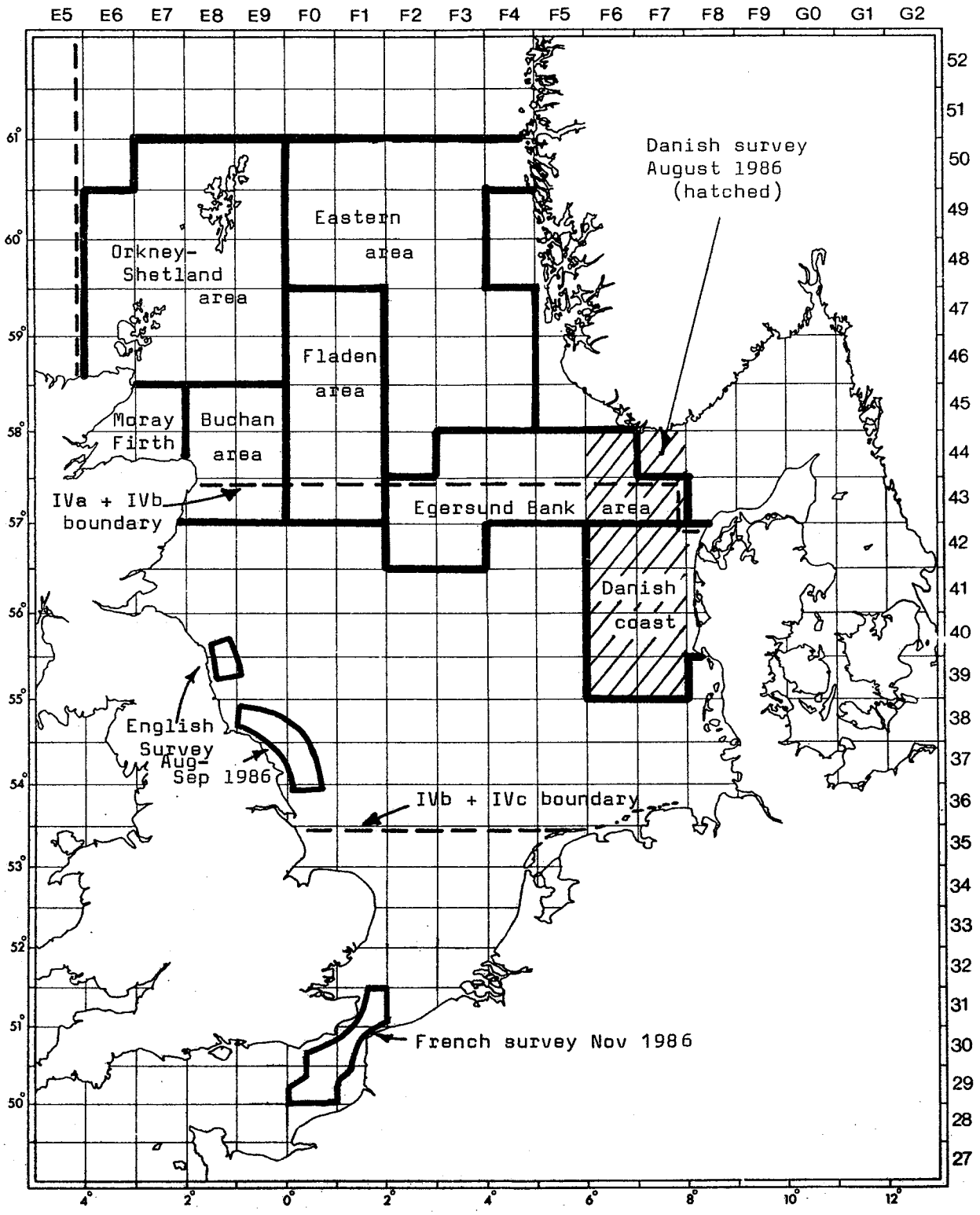

HERRING TOTAL NORTH SEA
YEARCLASS STRENGTH as 1-ringers estimated from VPA
x 10^6
60000
50000
40000
30000
20000
10000
45
50
55
60
65
70
75
80
Year class

Figure 2.4.1 Area Sub-divisions used for presenting results of acoustic surveys (see Tables 2.4.1-2.4.7).



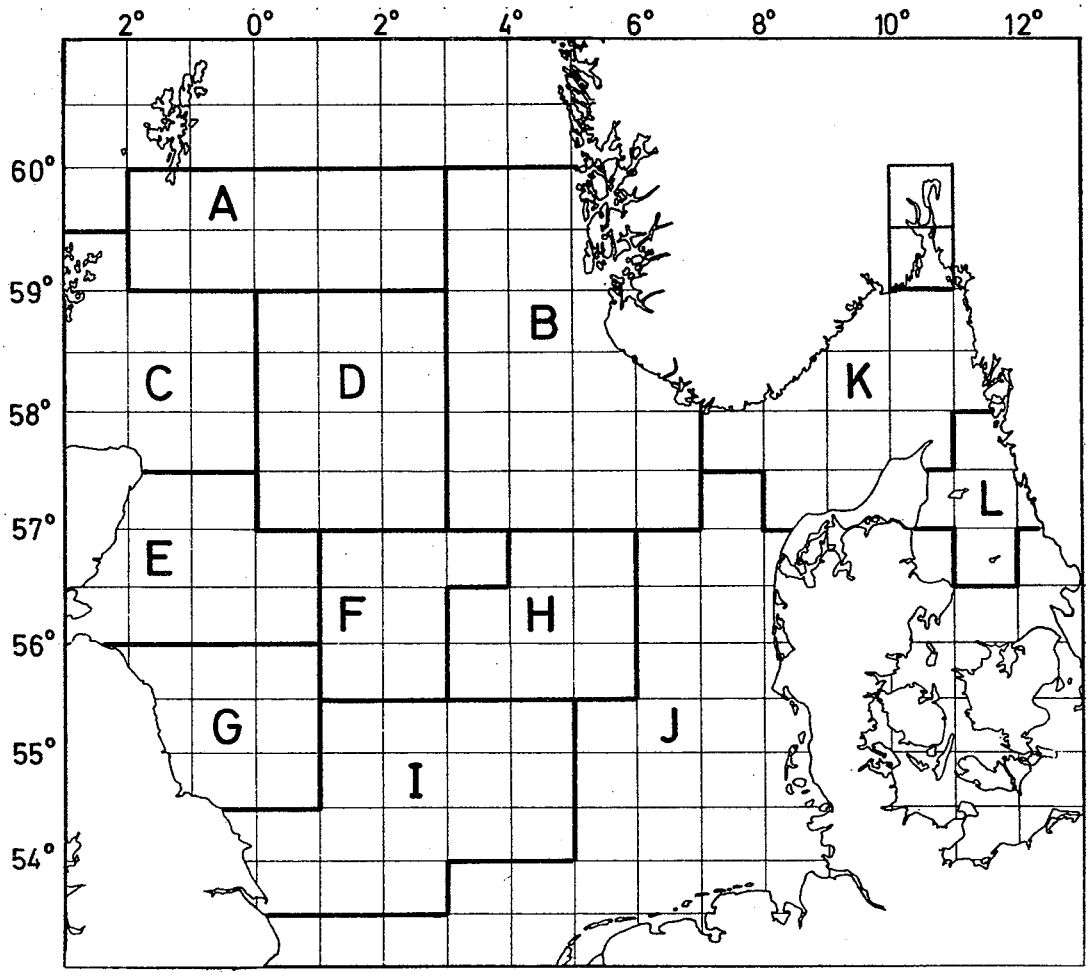


Figure 2.4.2 Definition of sub-areas, November-December, acoustic survey.

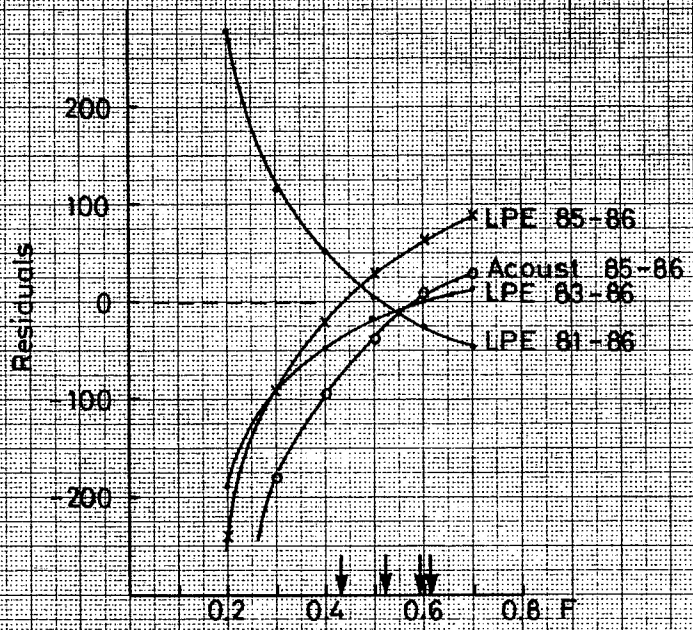


Figure 2.8.1.a Sum of residuals between SSB predicted from regressions of survey indices and SSB from the VPA plotted against F.

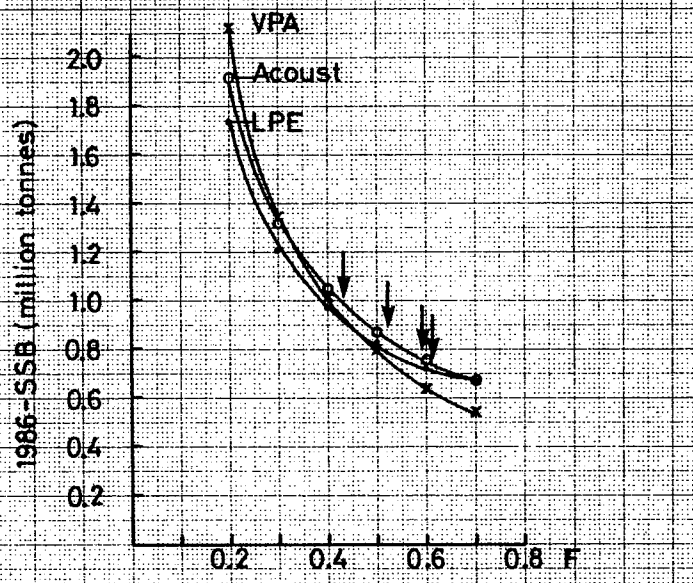


Figure 2.8.1.b Estimates of SSB ('000 t) for 1986 predicted from regressions of survey indices and SSB from the VPA plotted against F.

Figure 2.8.2 Estimates of spawning stock from VPA (SSB), larval surveys (LPE) and acoustic surveys (ACOUSTIC), VPA based on F_{2-6} = 0.48.

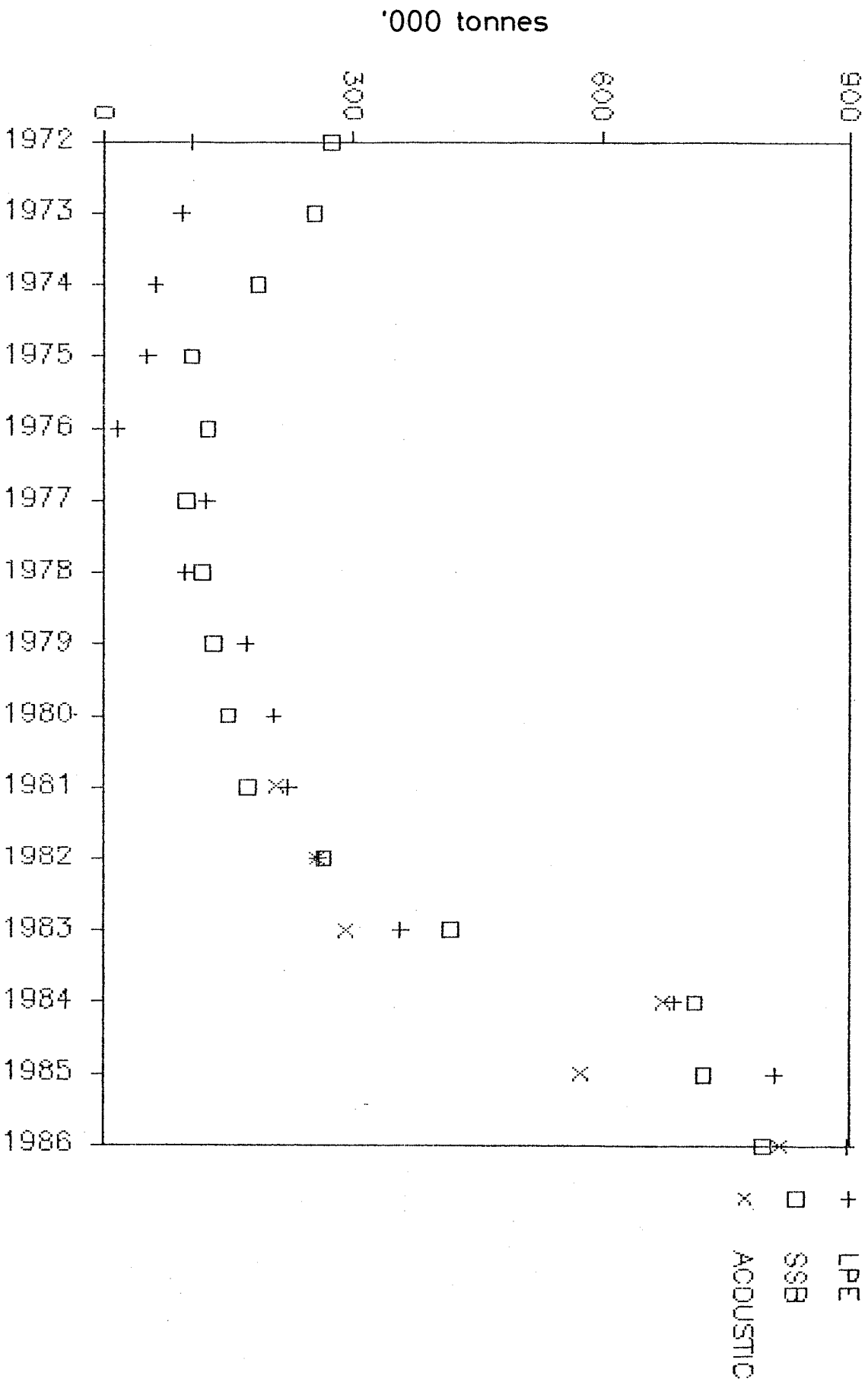
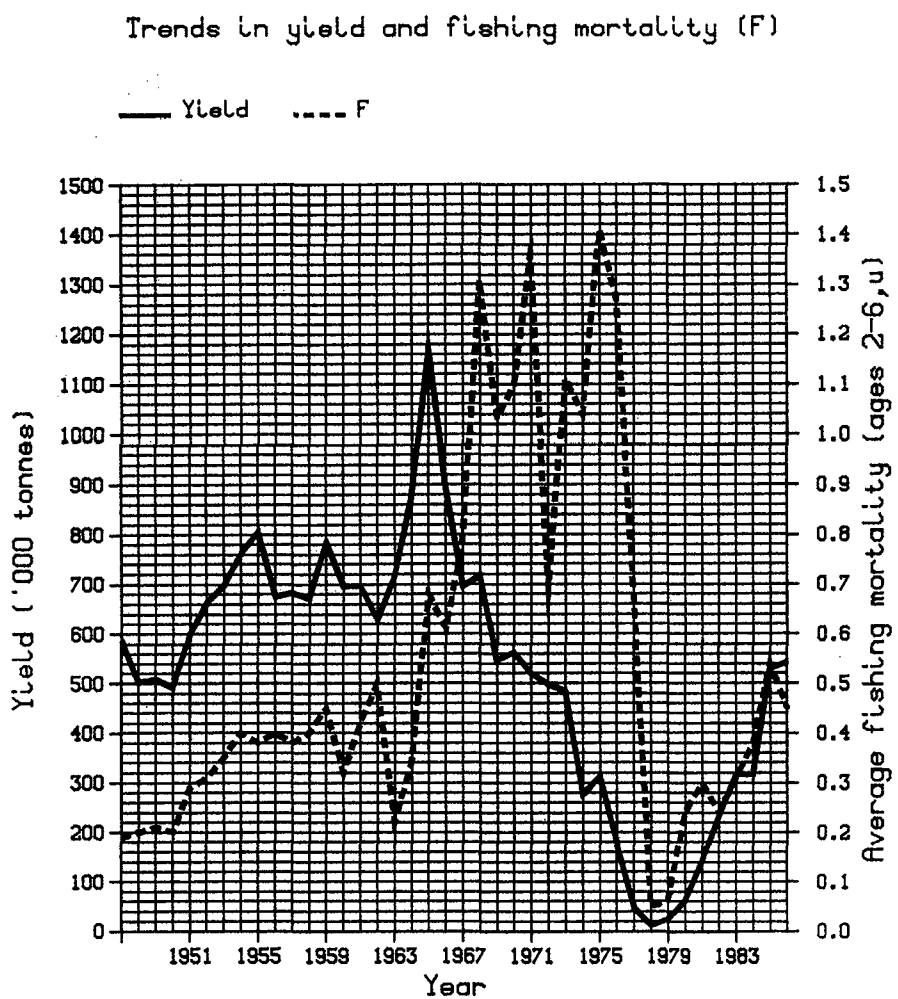


Figure 2.8.3

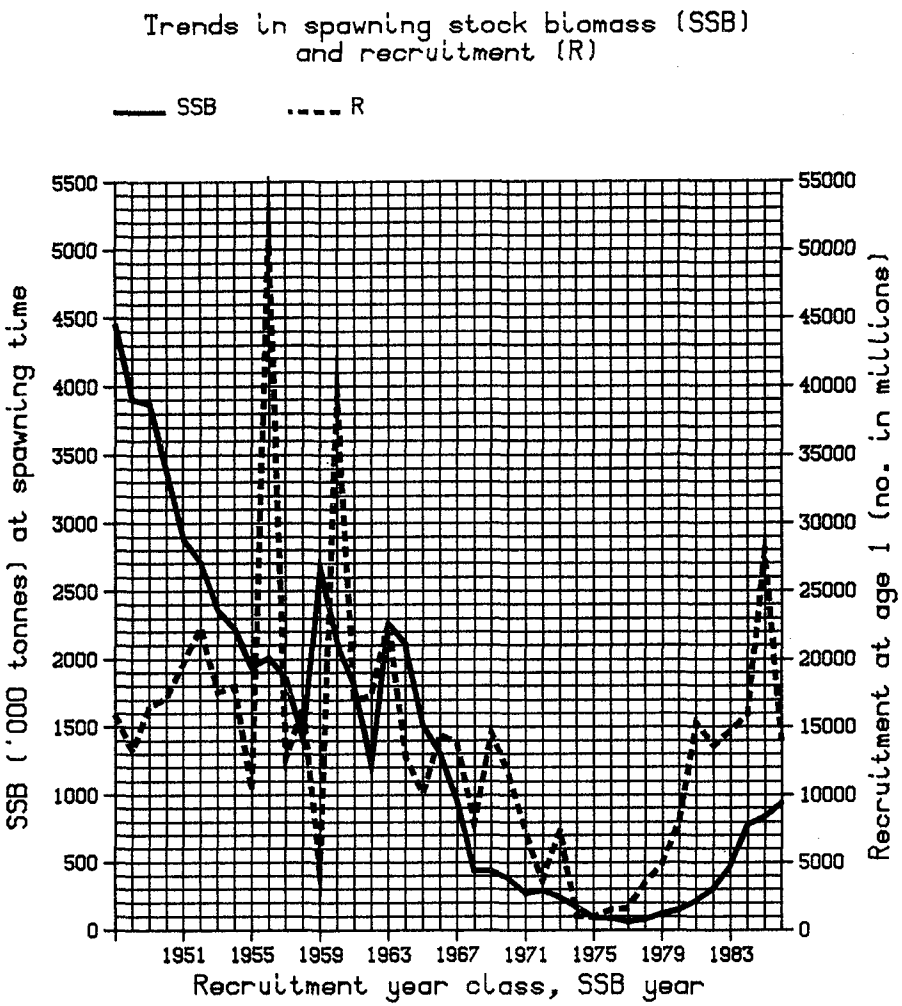
FISH STOCK SUMMARY

STOCK: Herring – North Sea (Sub–area IV)

13–04–1987



A

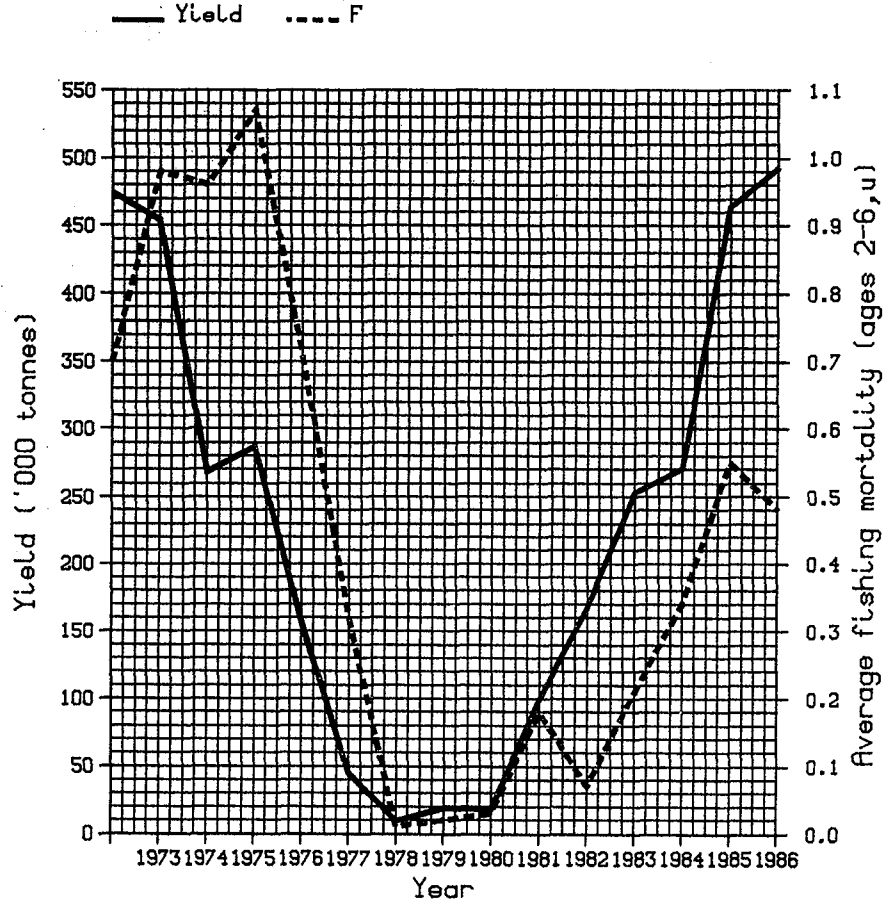


B

Figure 2.9.1

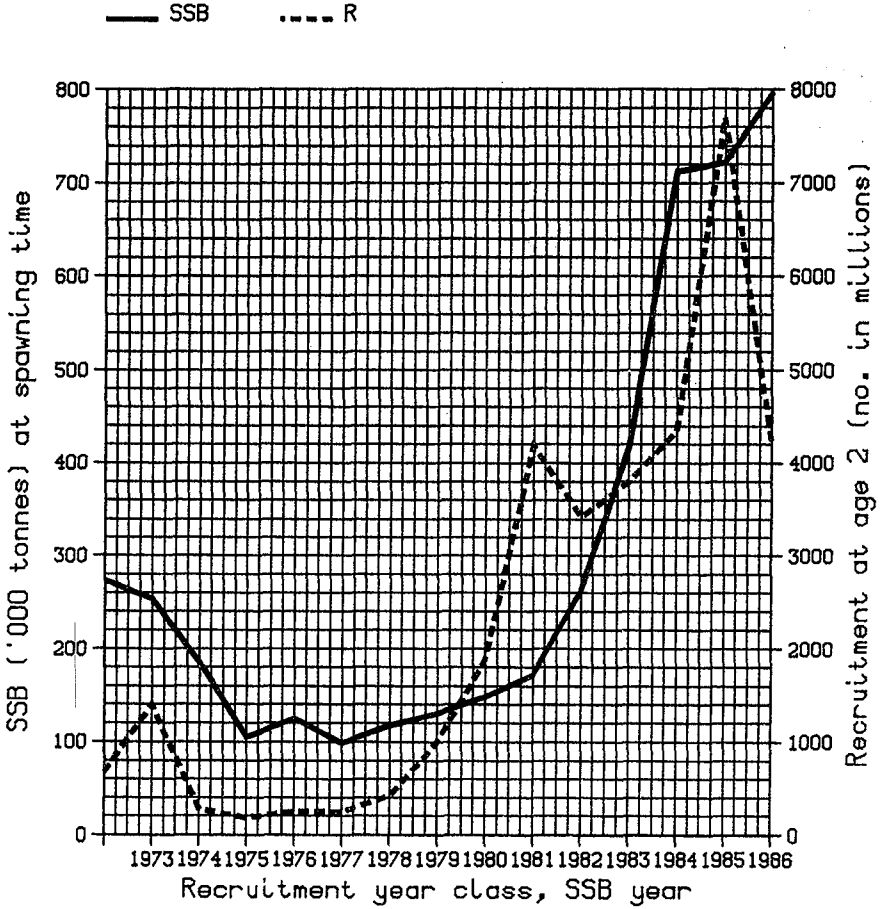
FISH STOCK SUMMARY
STOCK: Herring – IVA and IVB
13–04–1987

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)

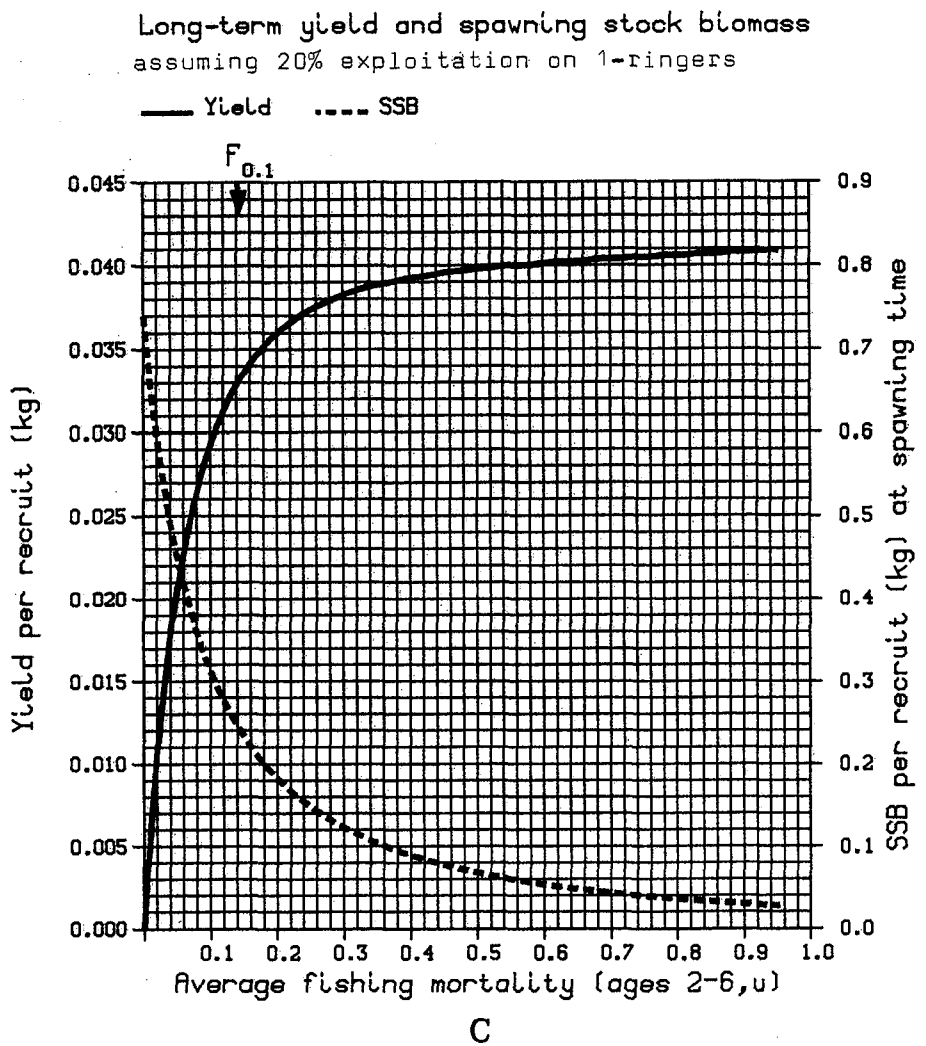


B

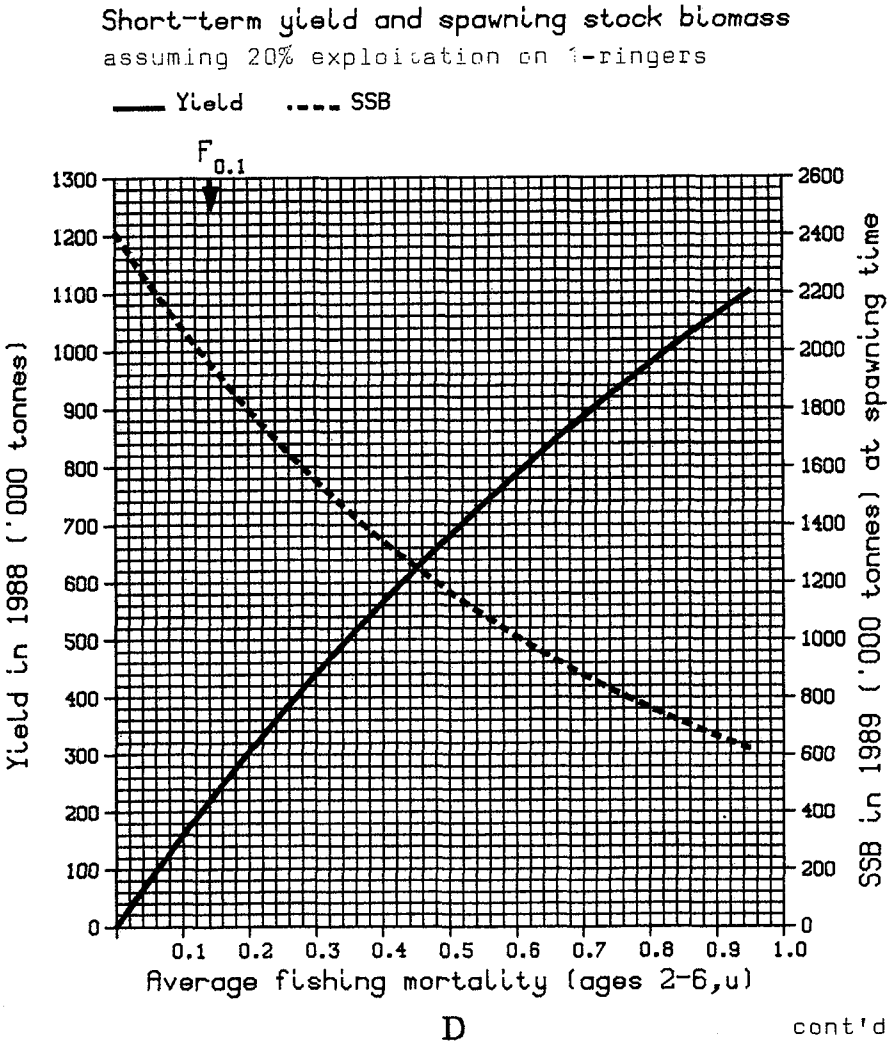
cont'd.

Figure 2.9.1 cont'd.

FISH STOCK SUMMARY
STOCK: Herring – IVA and IVB
13–04–1987



C

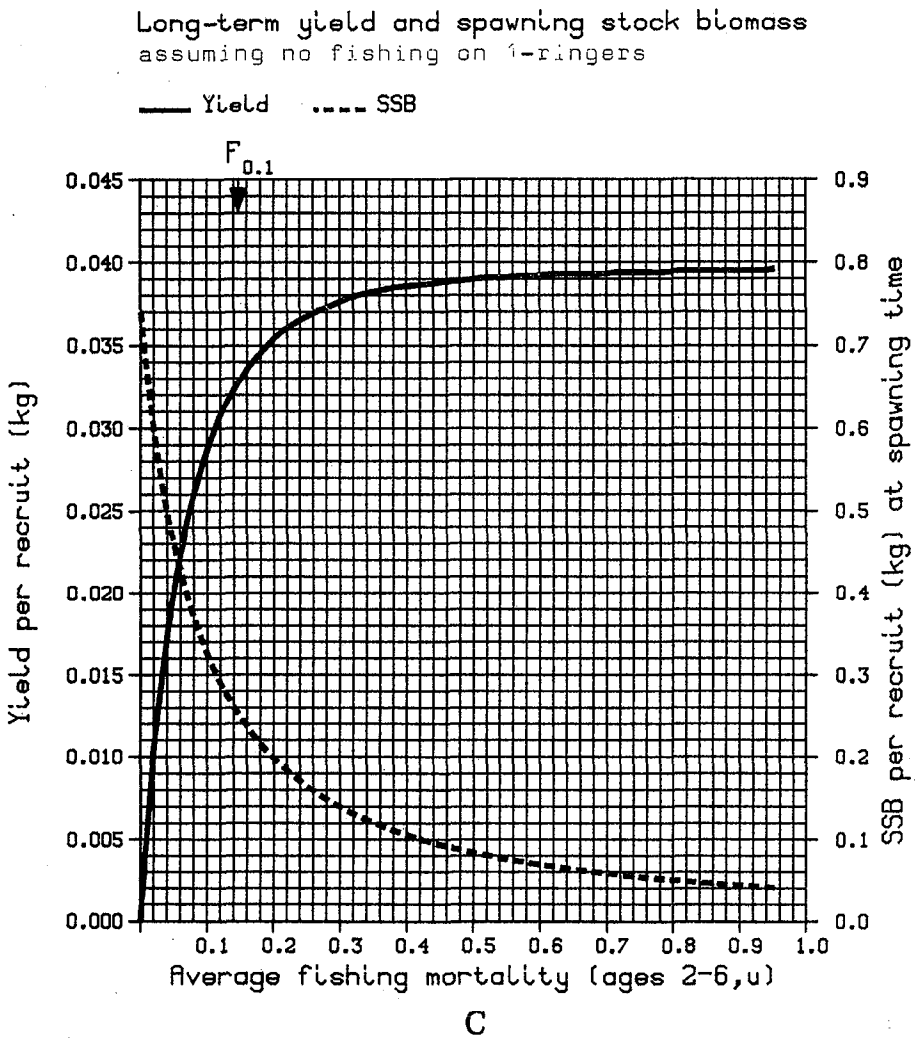


D

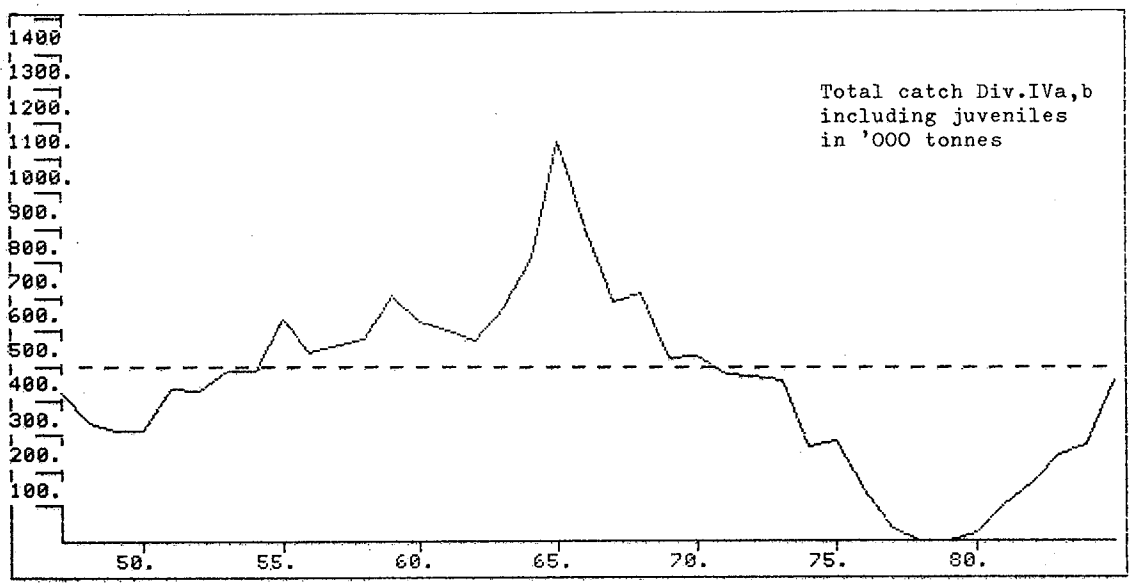
cont'd

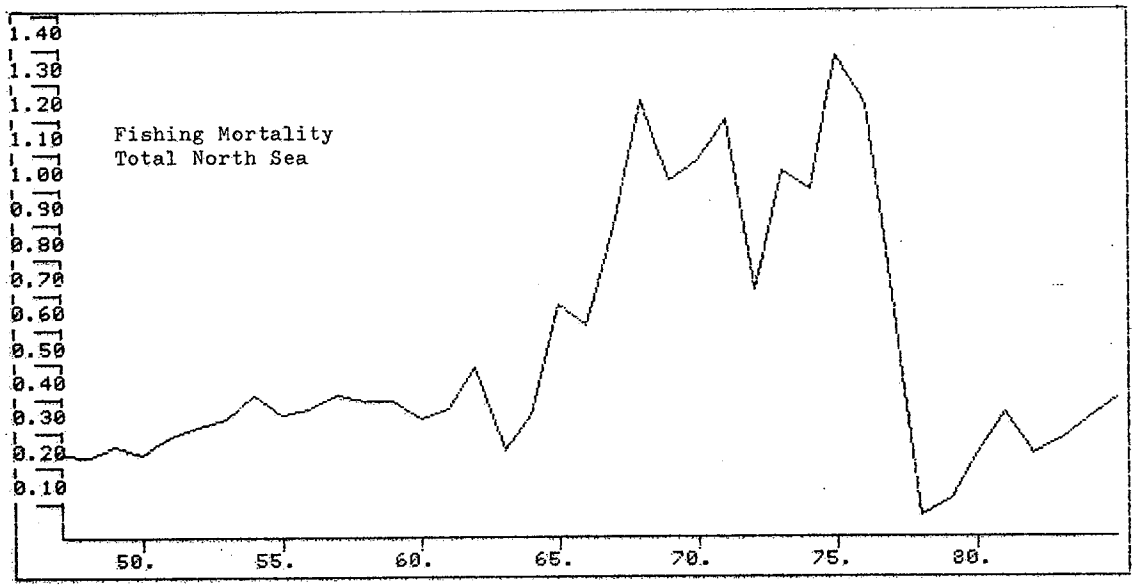
Figure 2.9.1 cont'd.

FISH STOCK SUMMARY
STOCK: Herring – IVA and IVB
13–04–1987



C





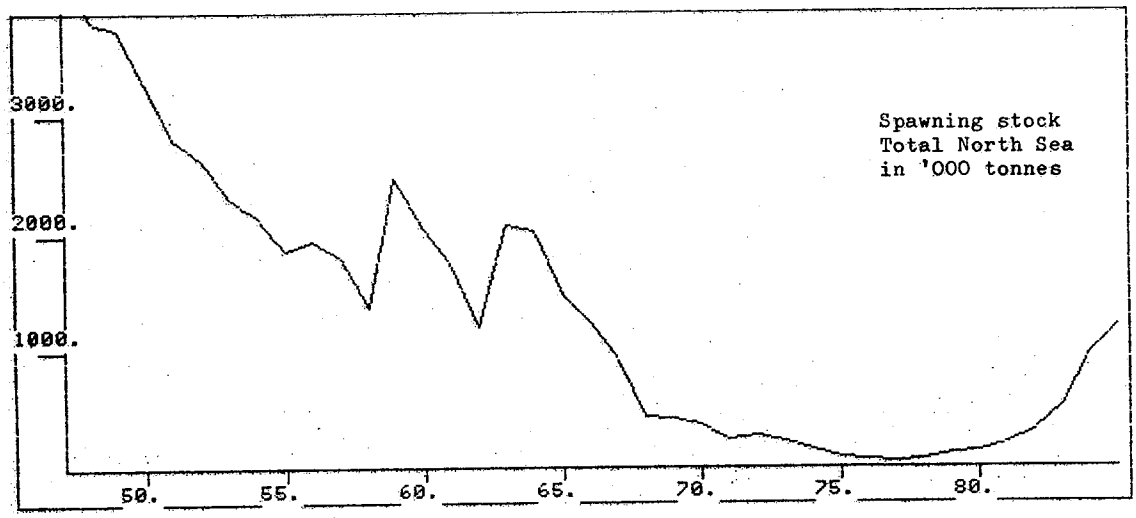


Figure 2.10.1 Catches in Divisions IVa,b, compared with spawning stock and F in total North Sea.

Figure 2.10.2

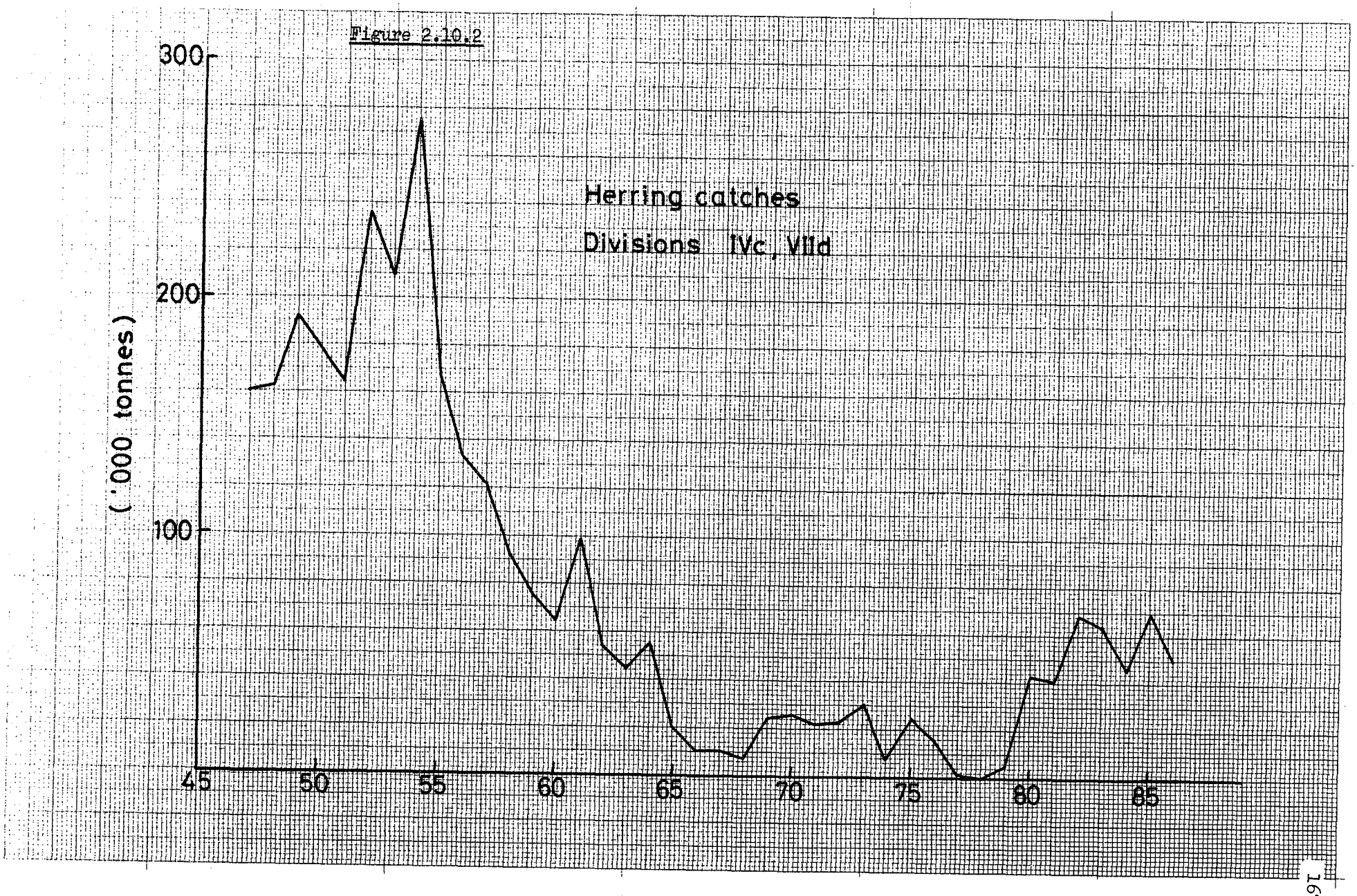
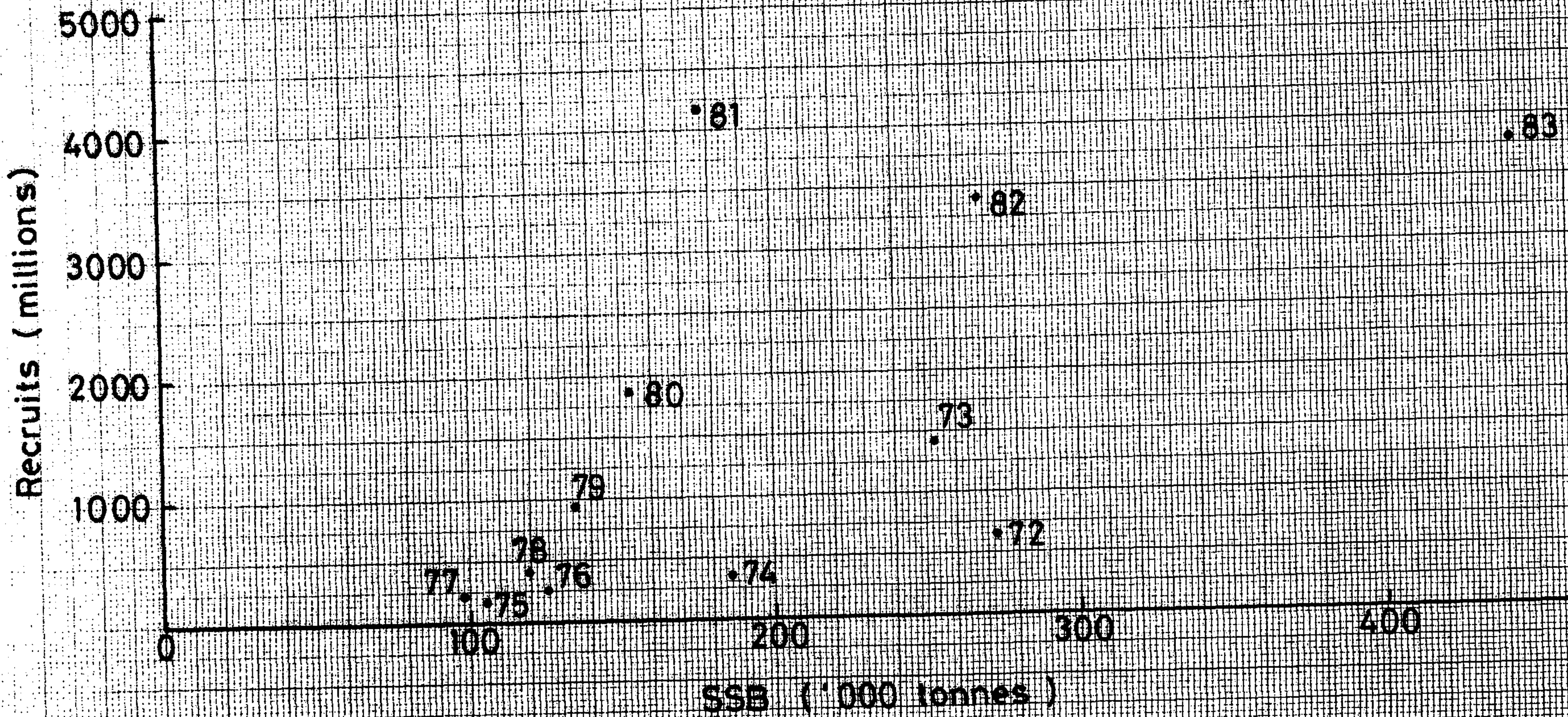

Herring catches
Divisions IVc, VIId
('000 tonnes)
300
200
100
45
50
55
60
65
70
75
80
85

Figure 2.10.3 Herring in Divisions IVa and IVb. Relationship between spawning stock biomass and recruitment (2-ring). Figures indicate years.



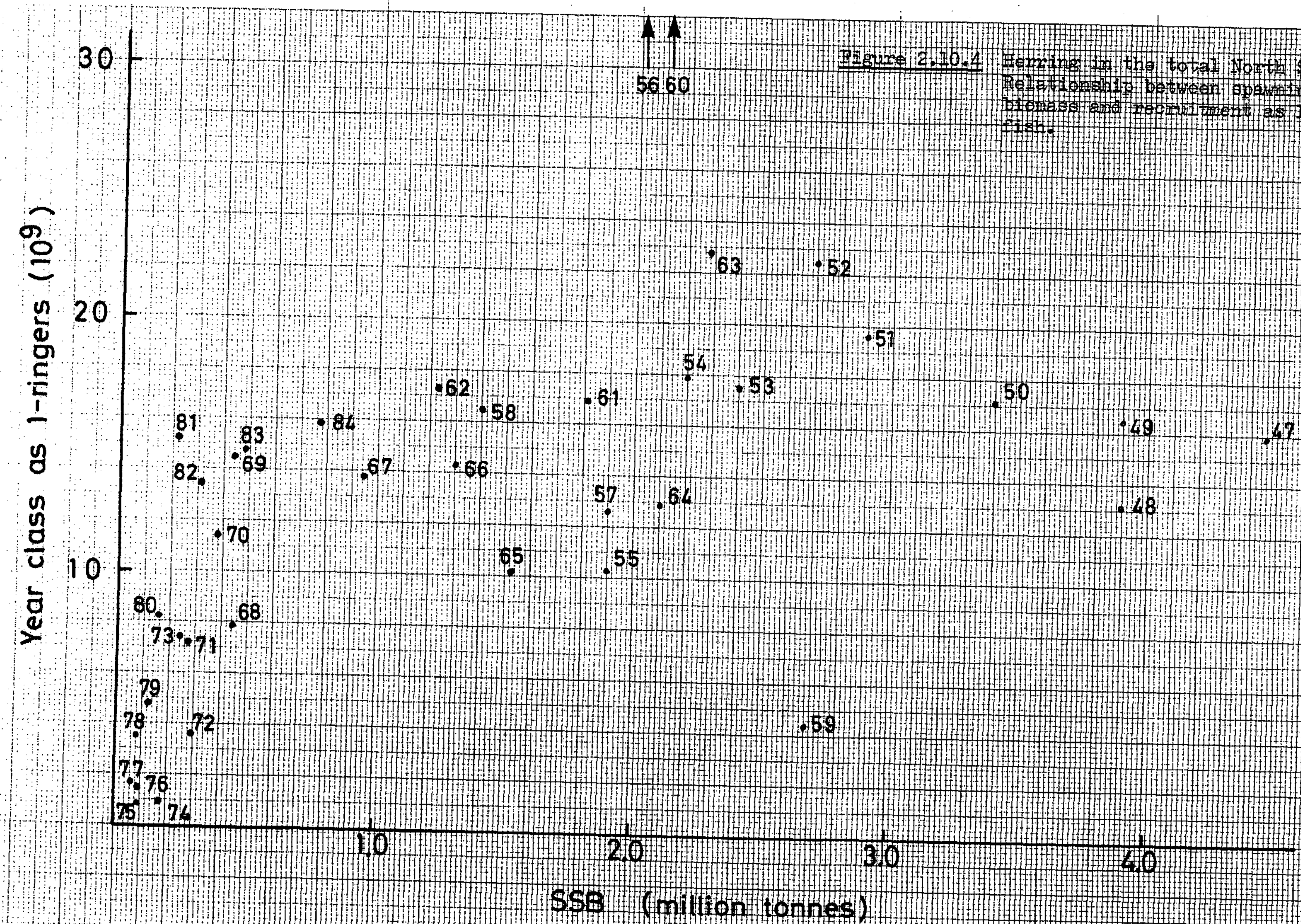
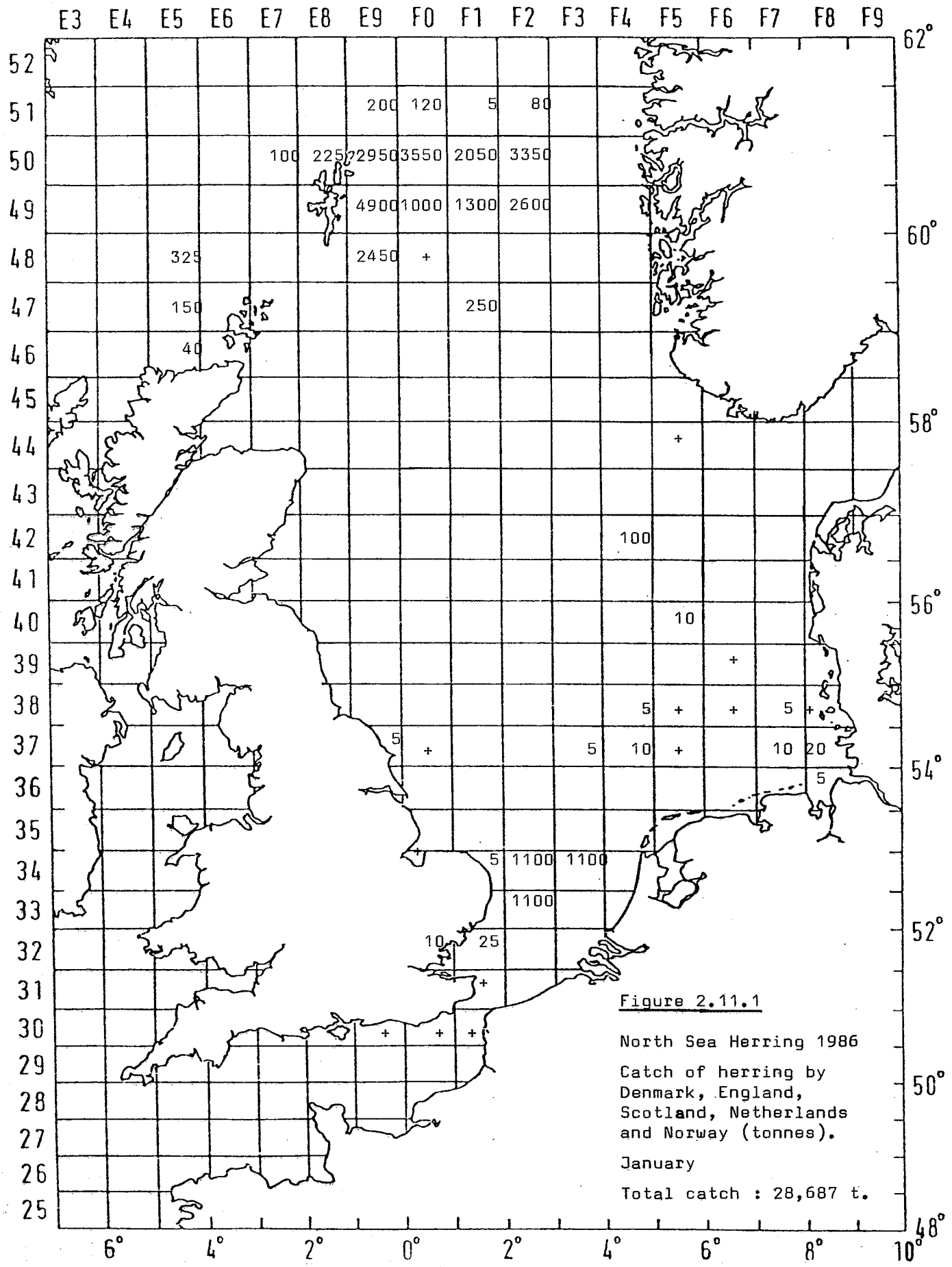


Figure 2.10.4 Herring in the total North Sea. Relationship between spawning stock biomass and recruitment as 1-ring fish.


E3 E4 E5 E6 E7 E8 E9 F0 F1 F2 F3 F4 F5 F6 F7 F8 F9
52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25
62° 60° 58° 56° 54° 52° 50° 48°
6° 4° 2° 0° 2° 4° 6° 8° 10°
200 120 5 80
100 225 2950 3550 2050 3350
4900 1000 1300 2600
325 2450 +
150 250
40
+
100
10
+
5 + + 5 +
5 + 5 10 + 10 20
5
5 1100 1100
1100
10 25
+
+ + +
Figure 2.11.1
North Sea Herring 1986
Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).
January
Total catch : 28,687 t.

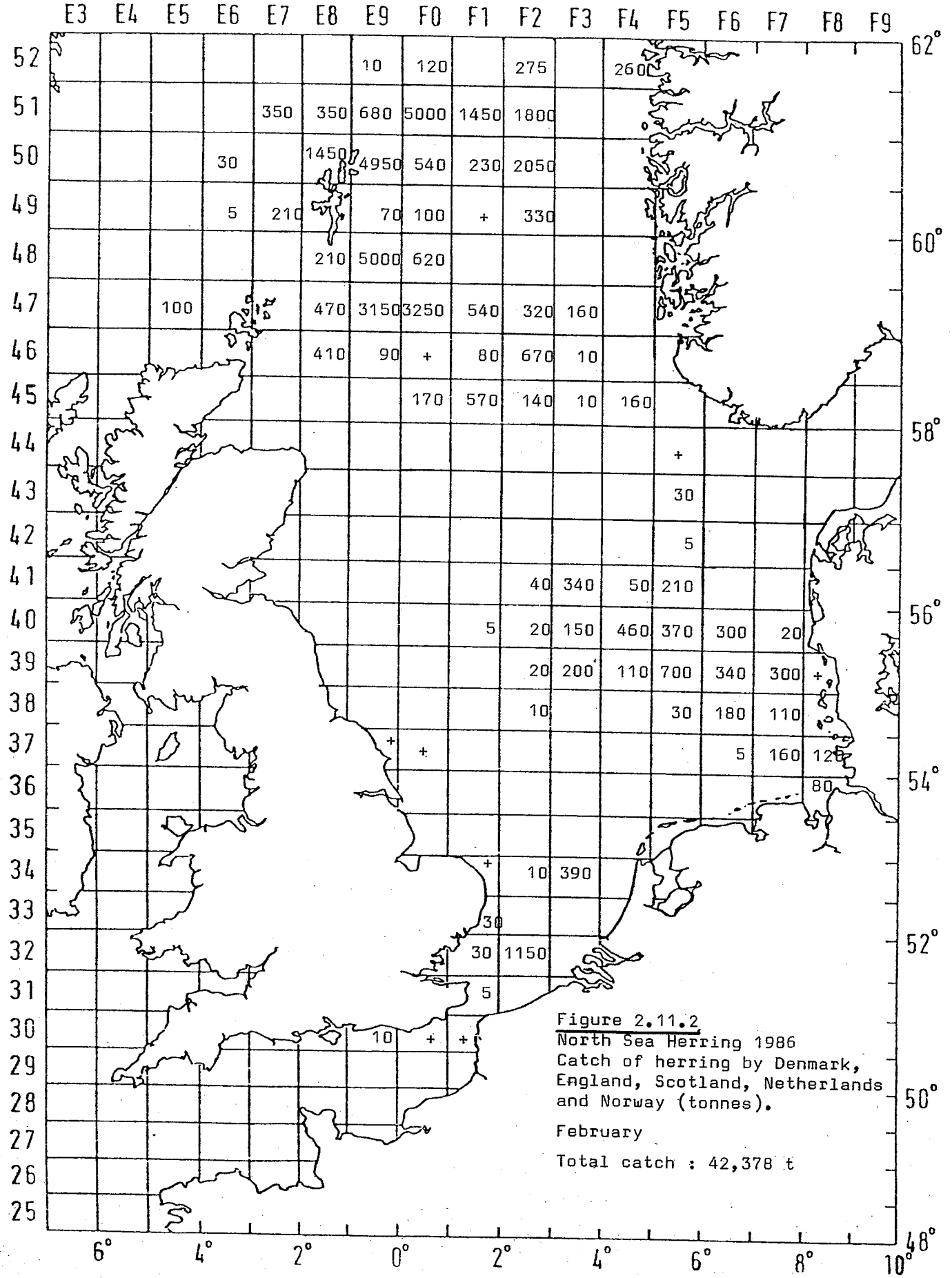


Figure 2.11.2
North Sea Herring 1986
Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

February

Total catch : 42,378 t

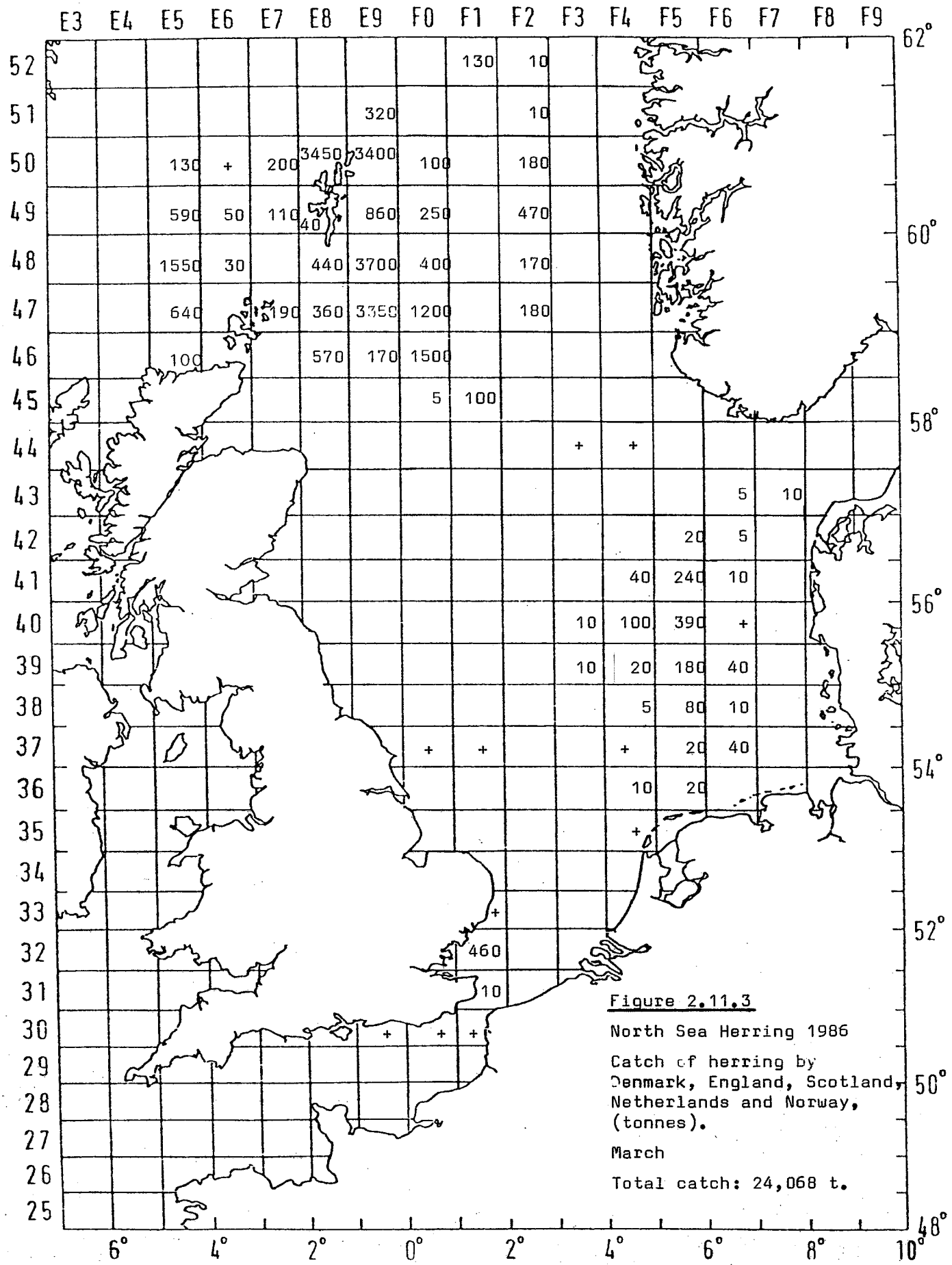


Figure 2.11.3

North Sea Herring 1986

Catch of herring by Denmark, England, Scotland, Netherlands and Norway, (tonnes).

March

Total catch: 24,068 t.

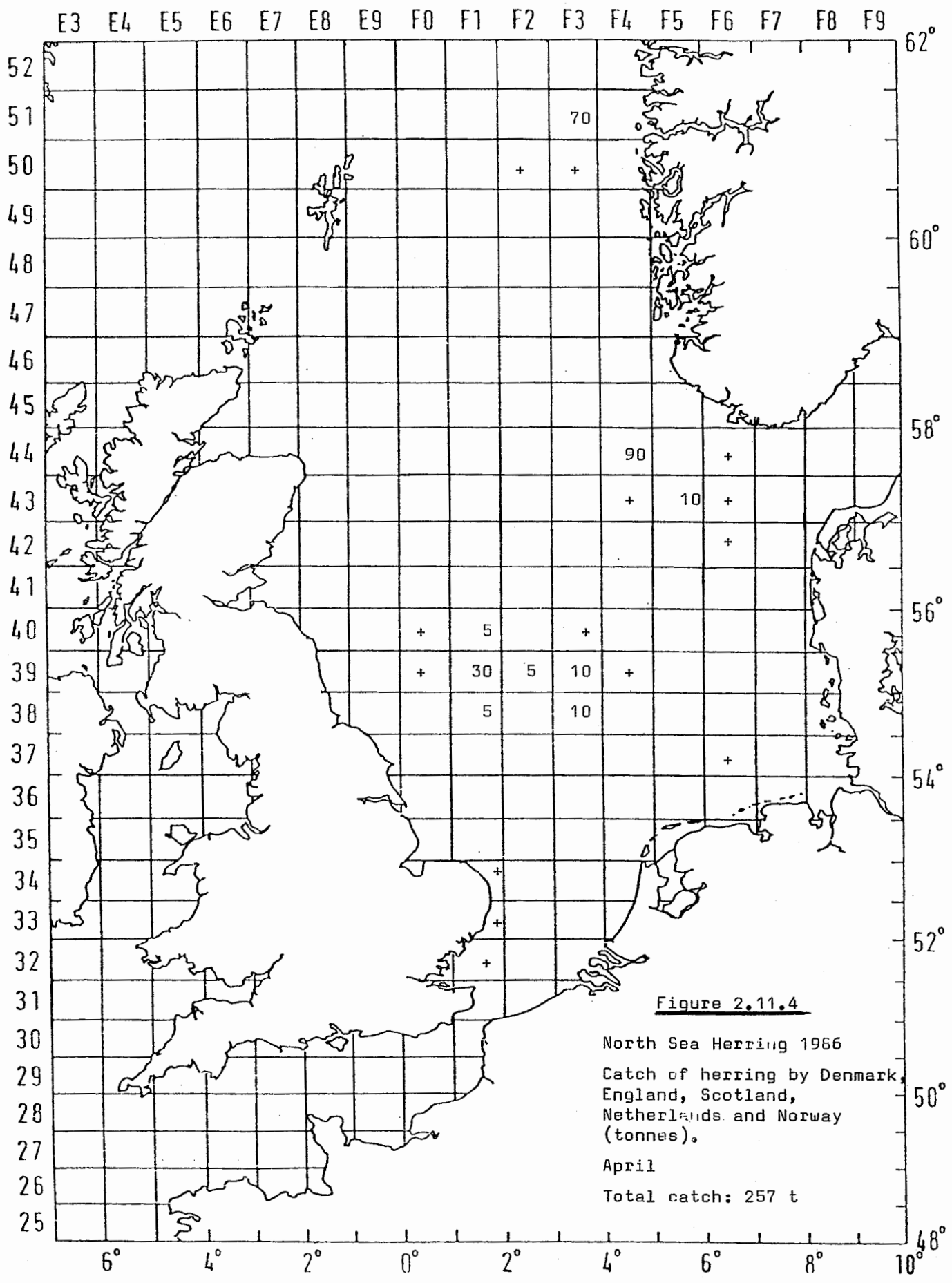


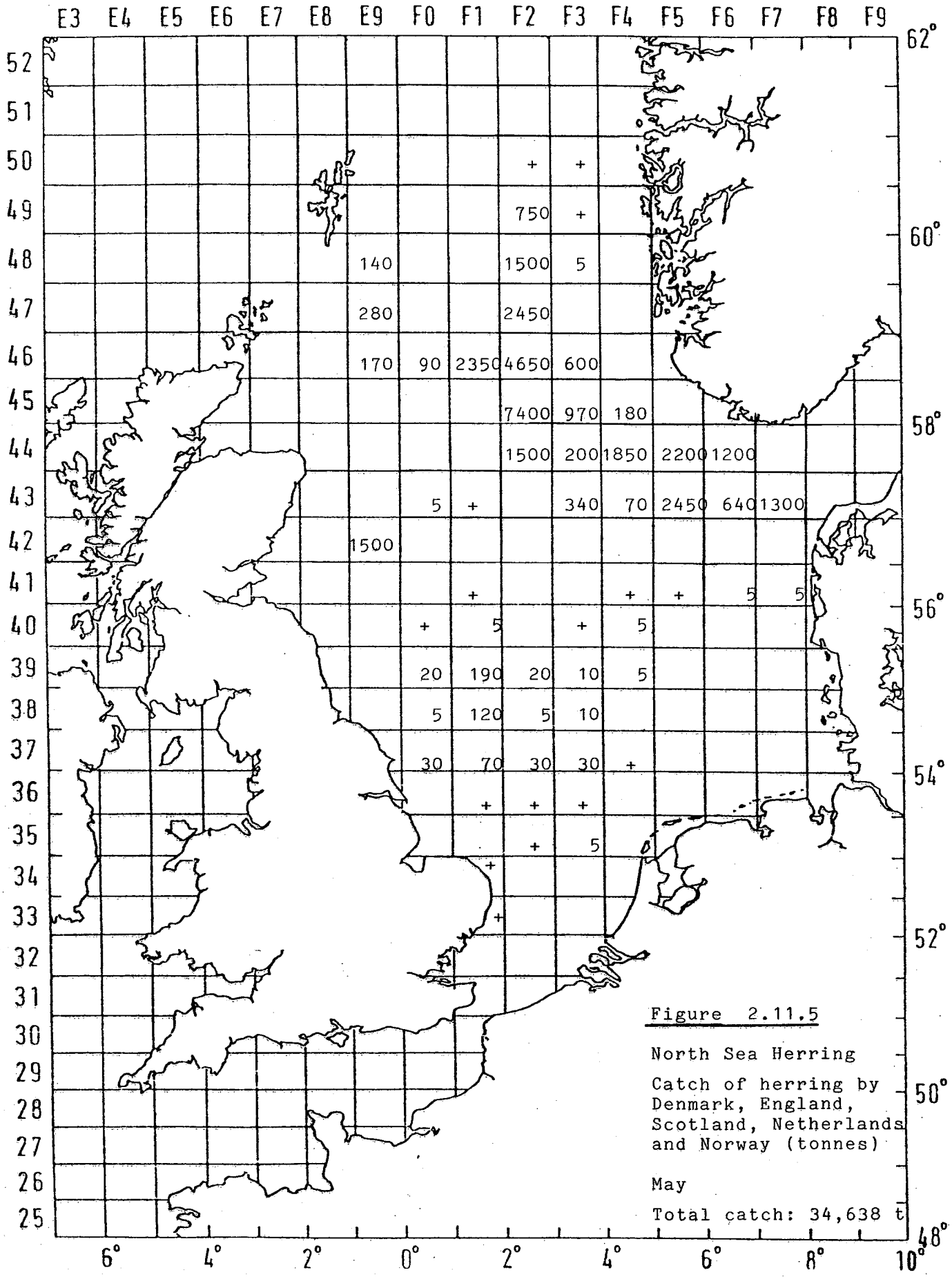
Figure 2.11.4

North Sea Herring 1966

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

April

Total catch: 257 t


E3 E4 E5 E6 E7 E8 E9 F0 F1 F2 F3 F4 F5 F6 F7 F8 F9
52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25
62° 60° 58° 56° 54° 52° 50° 48°
6° 4° 2° 0° 2° 4° 6° 8° 10°
140
280
170 90 235 4650 600
750
1500 5
2450
7400 970 180
1500 200 1850 2200 1200
5 340 70 2450 640 1300
1500
5 5
5 5
20 190 20 10 5
5 120 5 10
30 70 30 30
Figure 2.11.5
North Sea Herring
Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes)
May
Total catch: 34,638 t

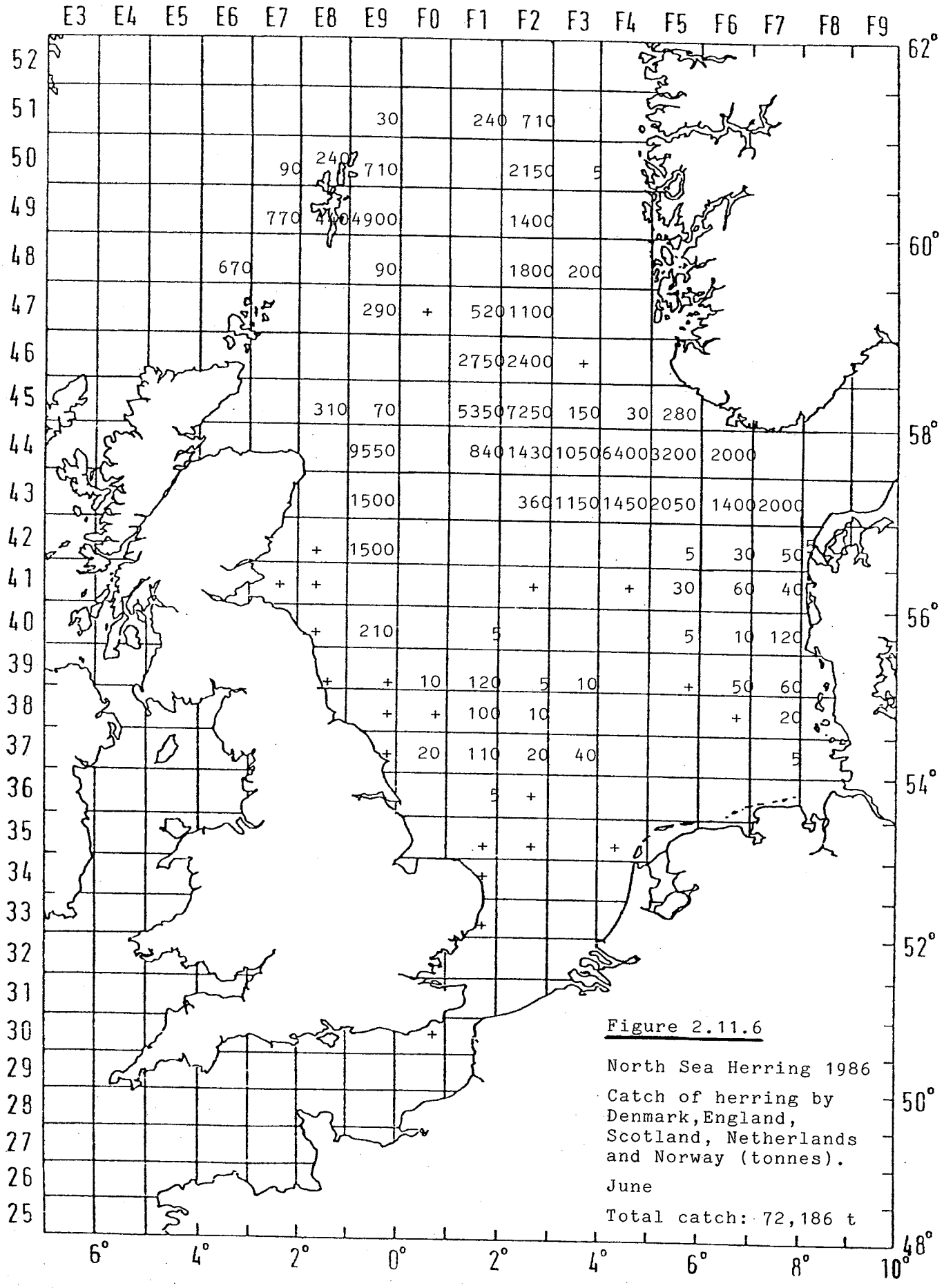


Figure 2.11.6

North Sea Herring 1986

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

June

Total catch: 72,186 t

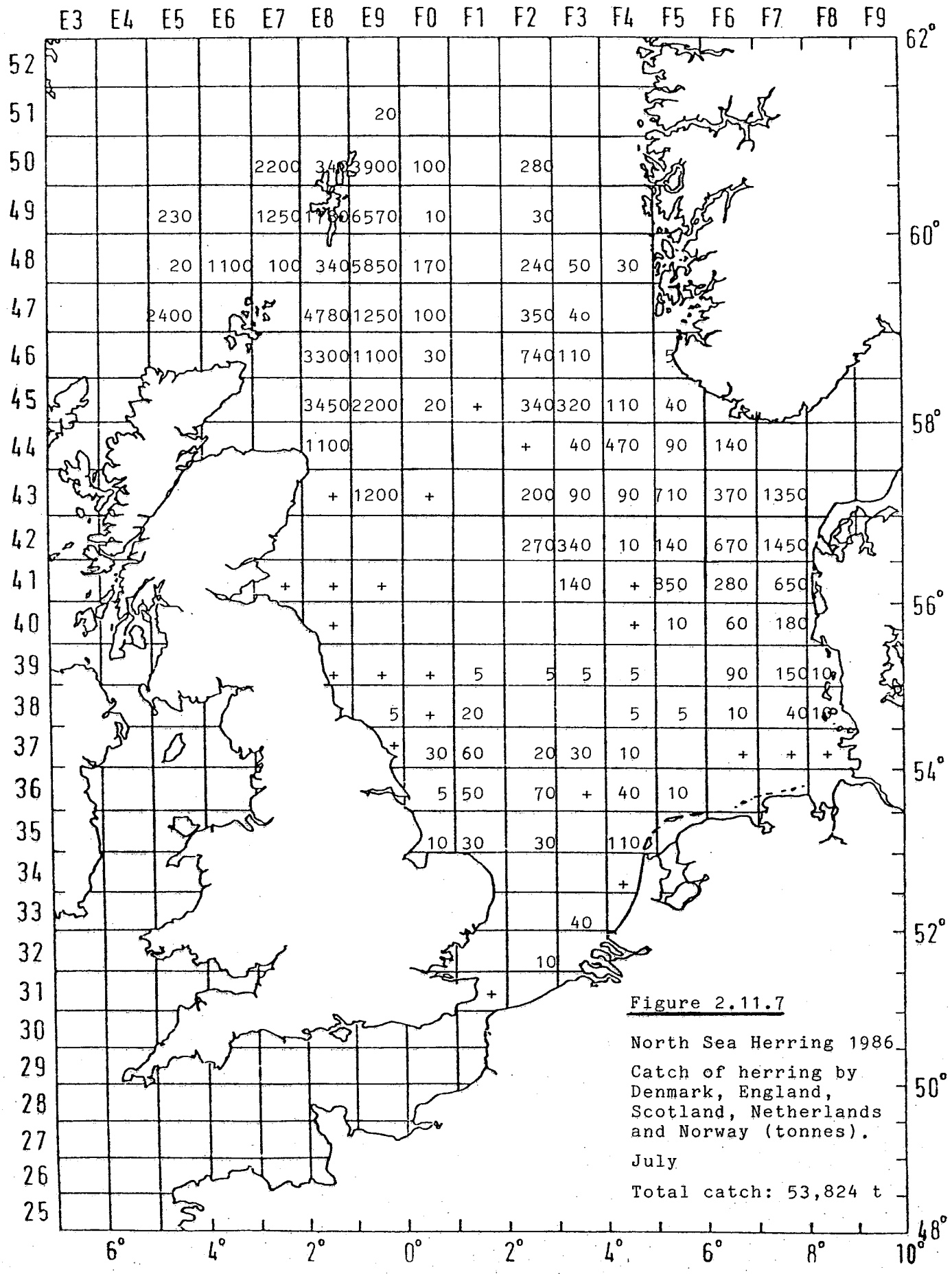


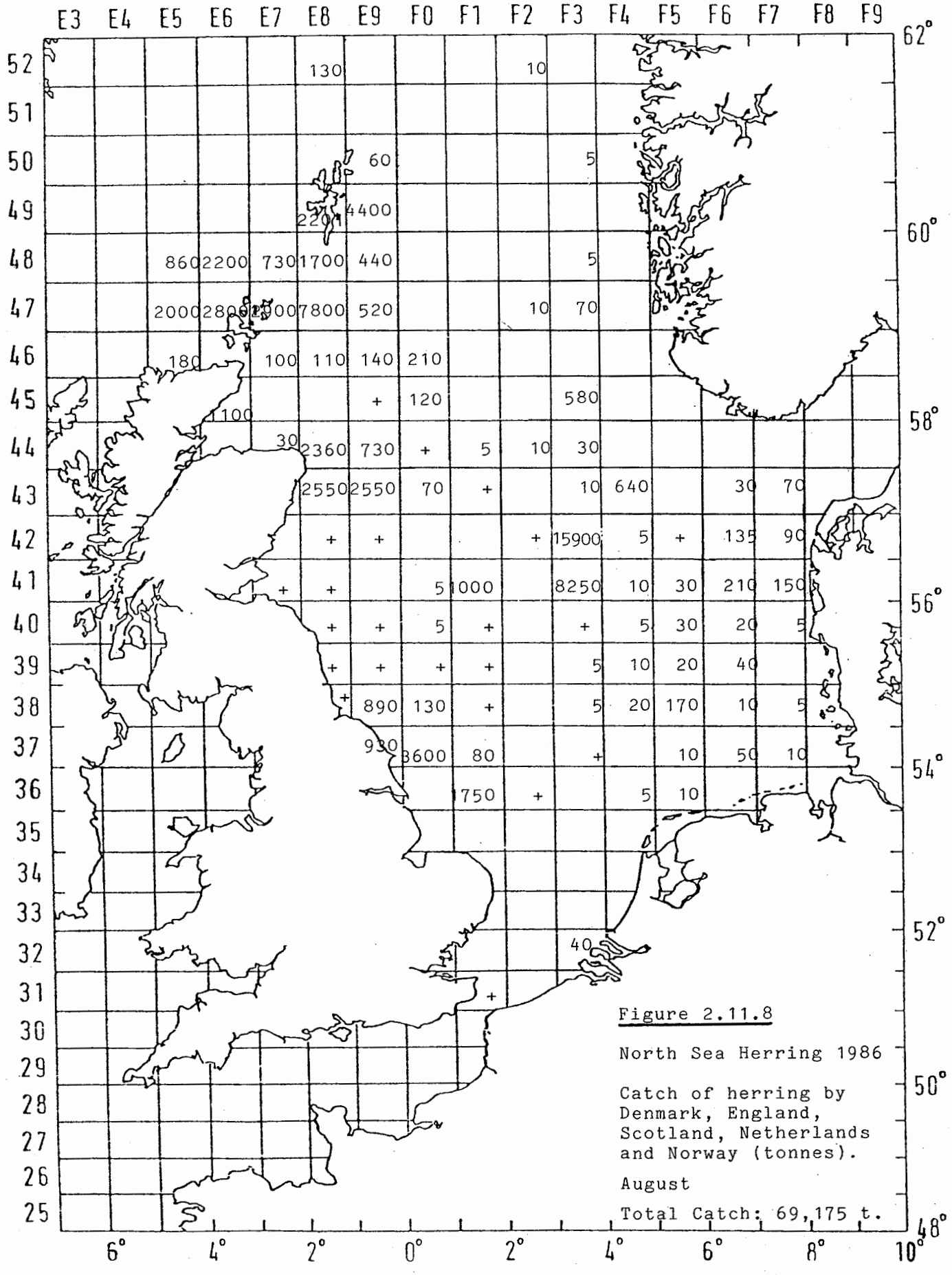
Figure 2.11.7

North Sea Herring 1986

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

July

Total catch: 53,824 t


E3 E4 E5 E6 E7 E8 E9 F0 F1 F2 F3 F4 F5 F6 F7 F8 F9
52 51 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35 34 33 32 31 30 29 28 27 26 25
62° 60° 58° 56° 54° 52° 50° 48°
6° 4° 2° 0° 2° 4° 6° 8° 10°
130 10
60 5
2201 4400
860 2200 730 1700 440 5
2000 2800 1900 7800 520 10 70
180 100 110 140 210
100 + 120 580
30 2360 730 + 5 10 30
2550 2550 70 + 10 640 30 70
+ + + 15900 5 + 135 90
+ + 5 1000 8250 10 30 210 150
+ + 5 + + 5 30 20 5
+ + + + 5 10 20 40
+ 890 130 + 5 20 170 10 5
930 3600 80 + 10 50 10
1750 + 5 10
40
+
Figure 2.11.8
North Sea Herring 1986
Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).
August
Total Catch: 69,175 t.

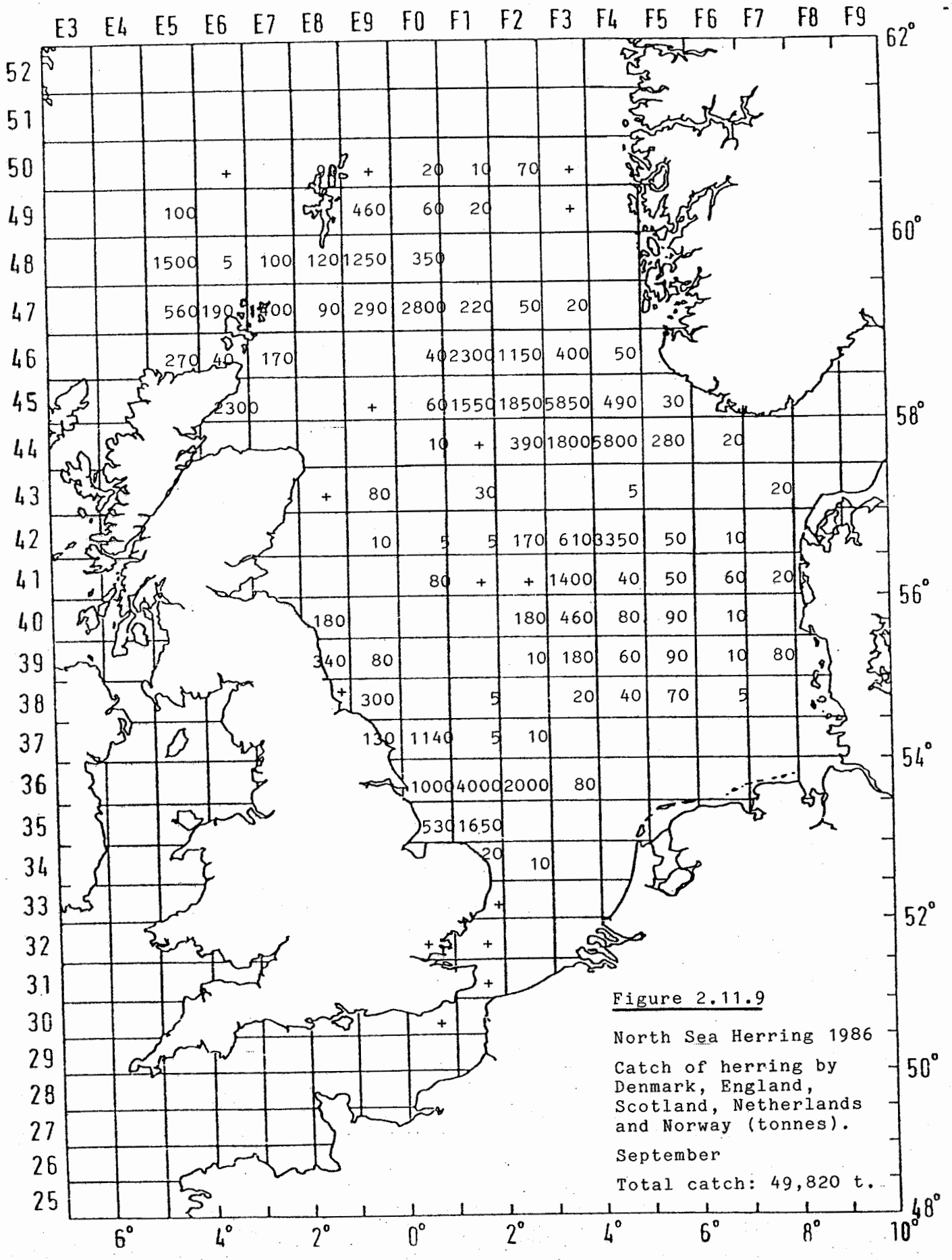


Figure 2.11.9

North Sea Herring 1986

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

September

Total catch: 49,820 t.

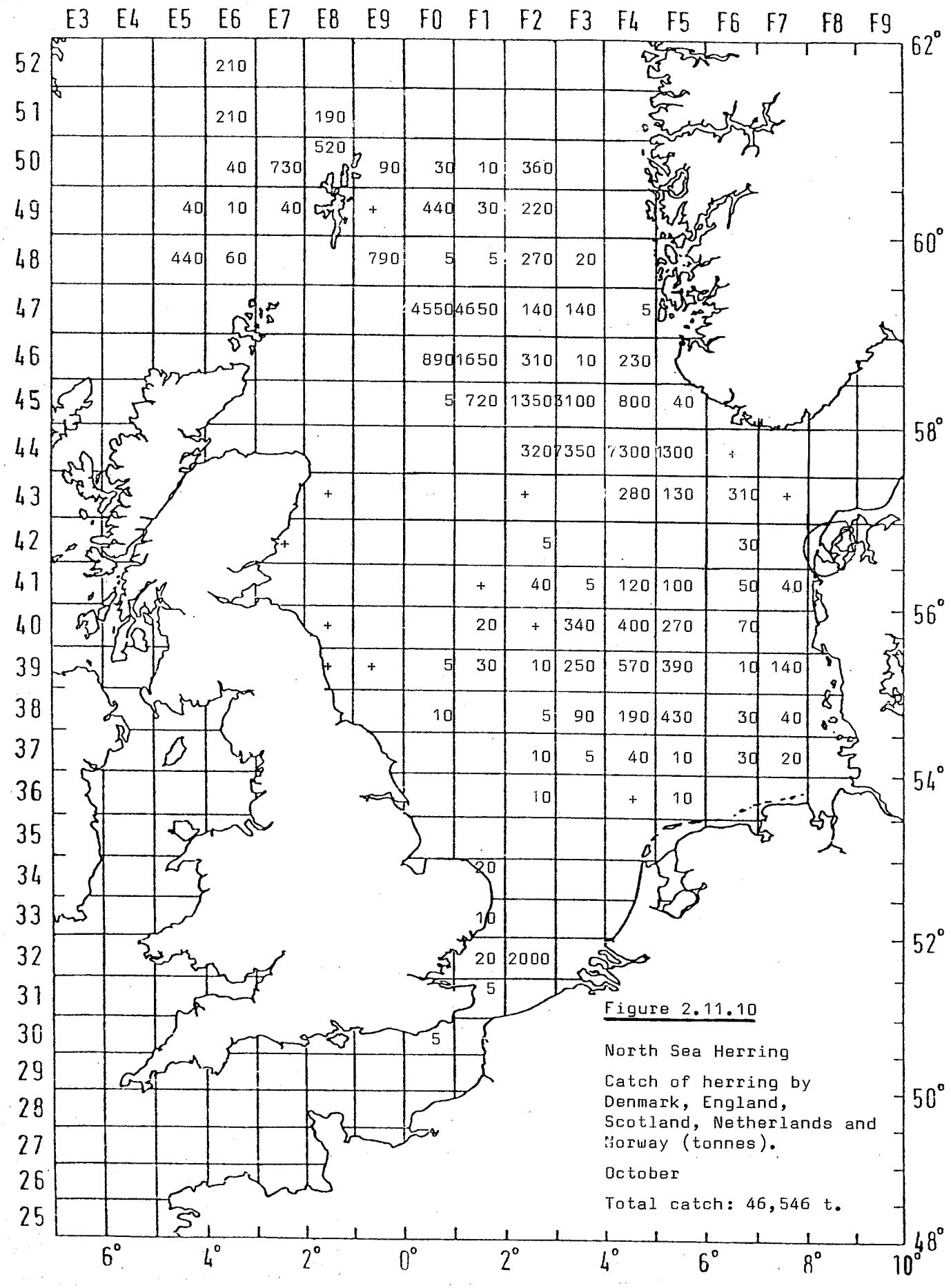


Figure 2.11.10

North Sea Herring

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

October

Total catch: 46,546 t.

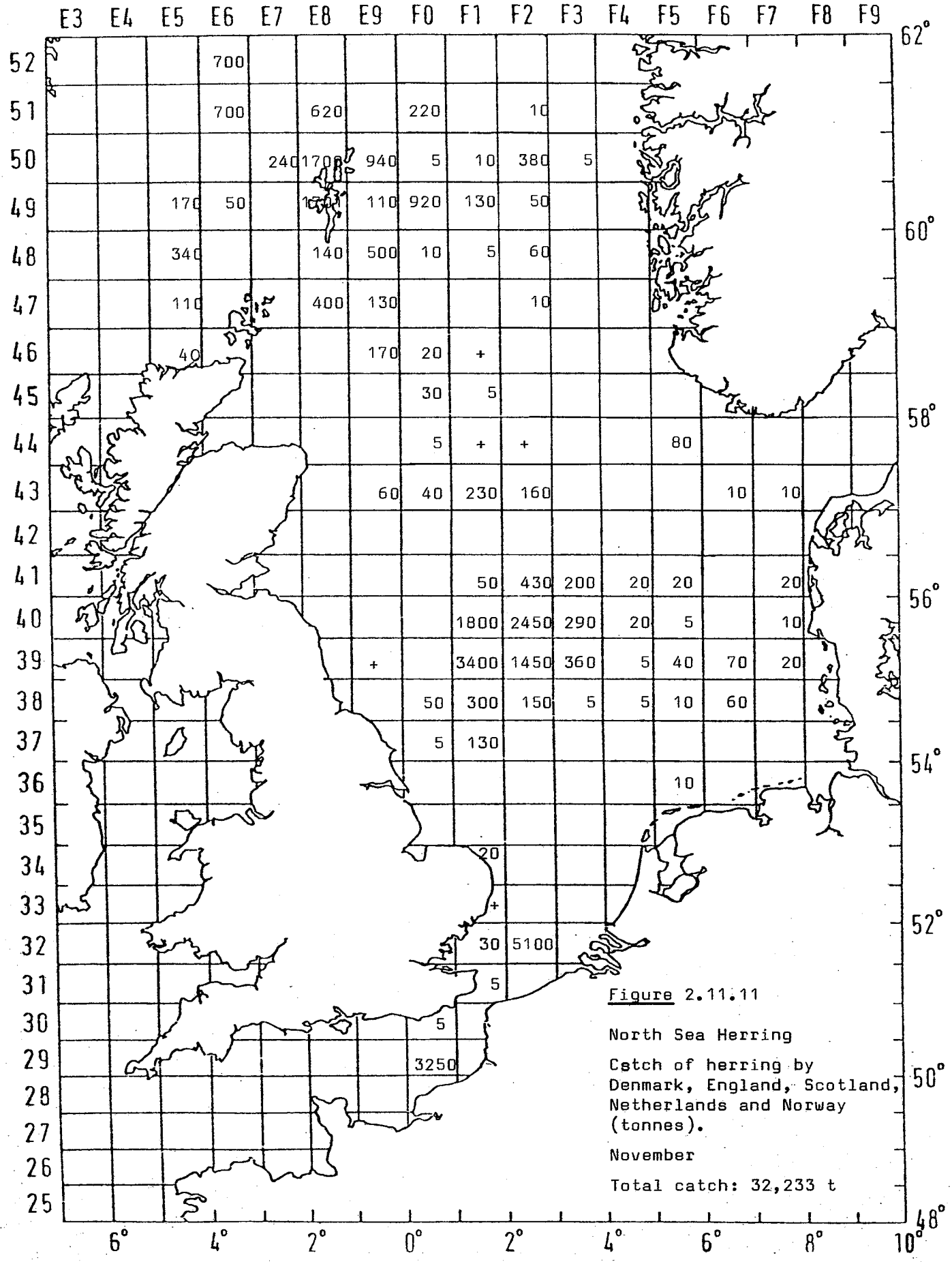


Figure 2.11.11

North Sea Herring

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

November

Total catch: 32,233 t

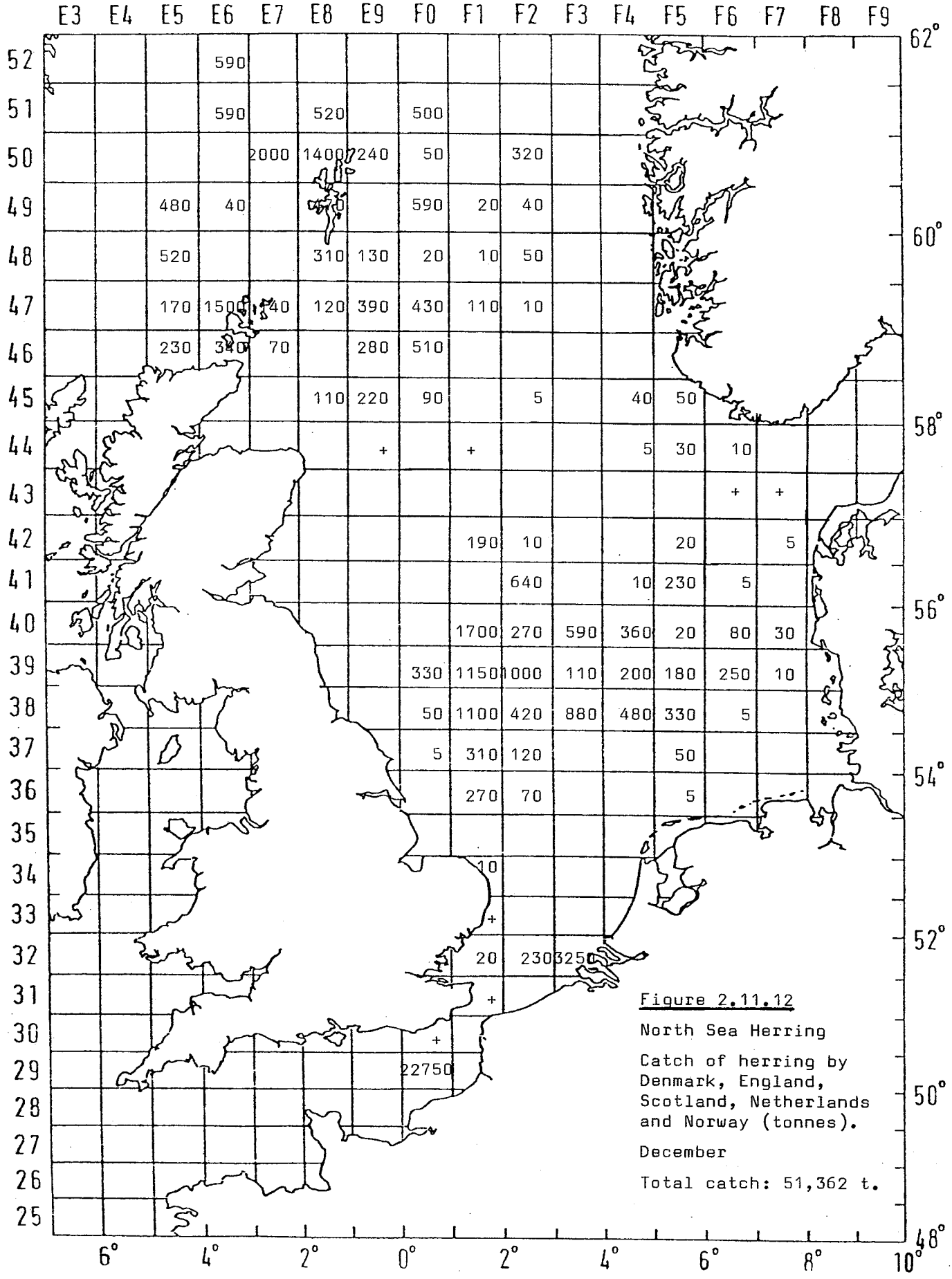


Figure 2.11.12

North Sea Herring

Catch of herring by Denmark, England, Scotland, Netherlands and Norway (tonnes).

December

Total catch: 51,362 t.

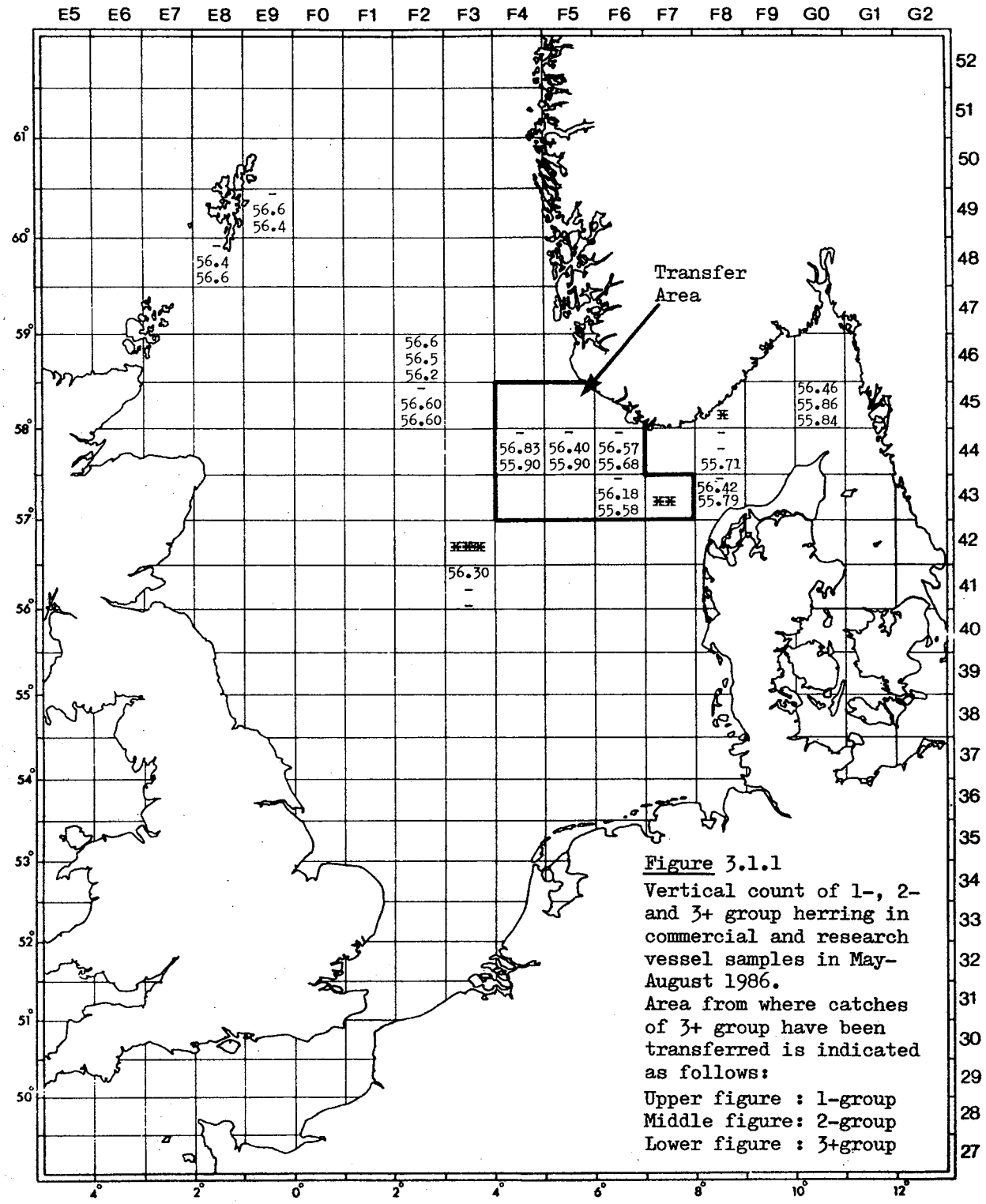


Figure 3.1.1
Vertical count of 1-, 2- and 3+ group herring in commercial and research vessel samples in May-August 1986.
Area from where catches of 3+ group have been transferred is indicated as follows:
Upper figure : 1-group
Middle figure: 2-group
Lower figure : 3+group

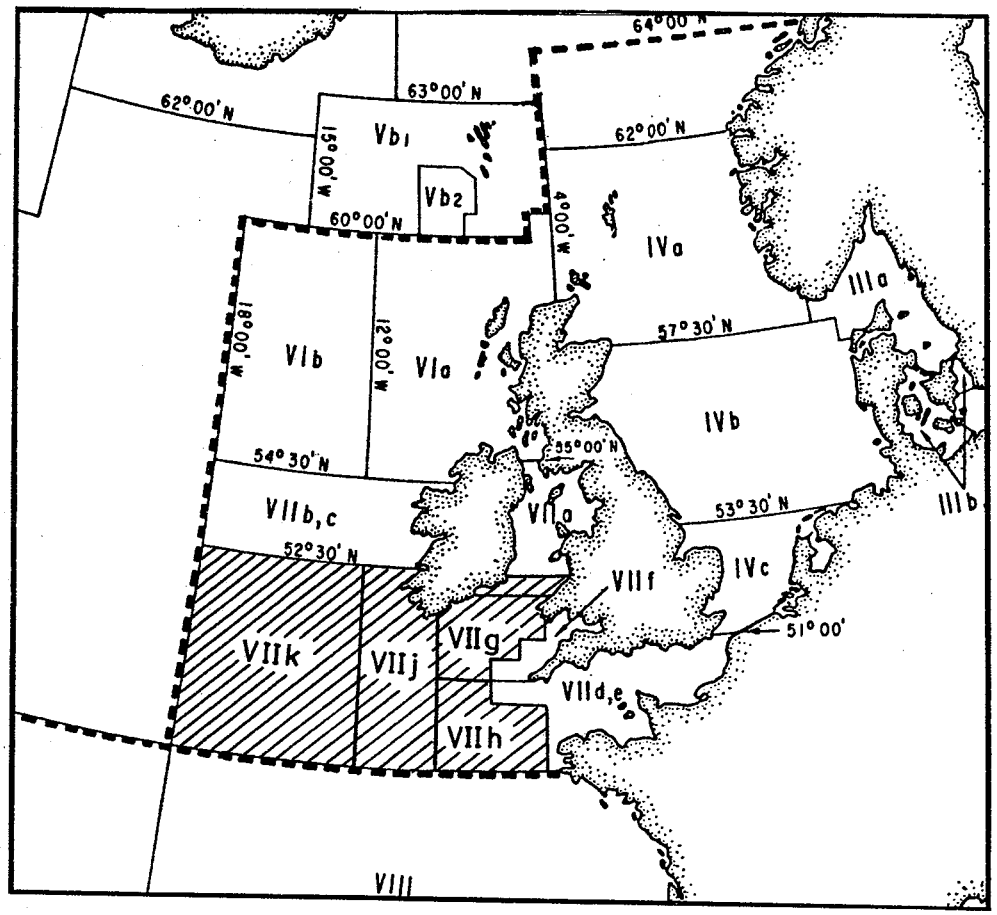


Figure 4.1.1 The assessment covers the area Divisions VIIj and VIIg and that part of Division VIIa below 52°30. TAC is set by EC for Divisions VIIg-k and that section of Division VIIa below 52°30.

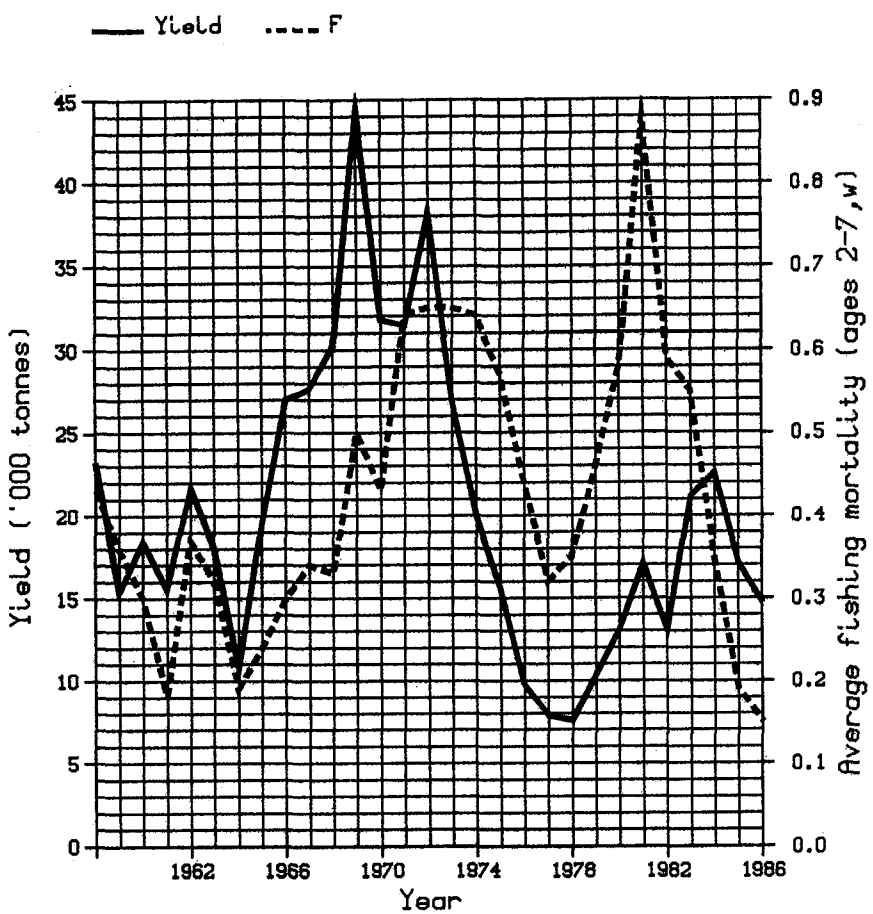
Figure 4.5.1

FISH STOCK SUMMARY

STOCK: Herring – Celtic Sea and VIIj

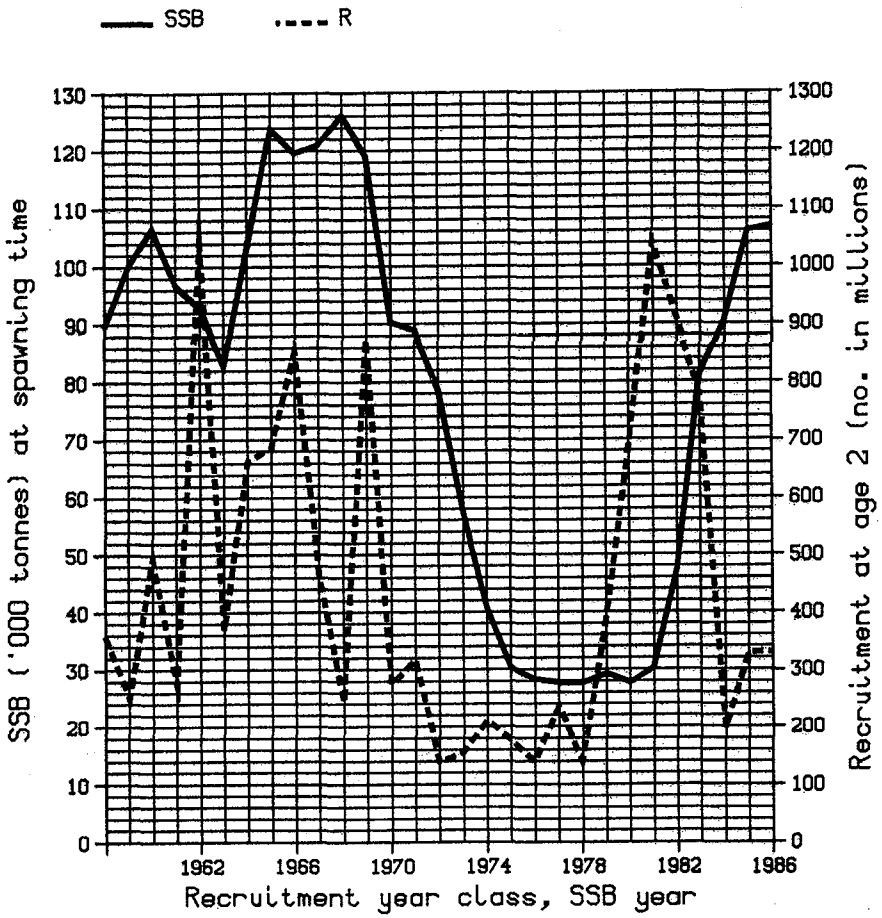
14–04–1987

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

Figure 4.8.1 Celtic Sea Division VIIj- Stock and recruitment plot.

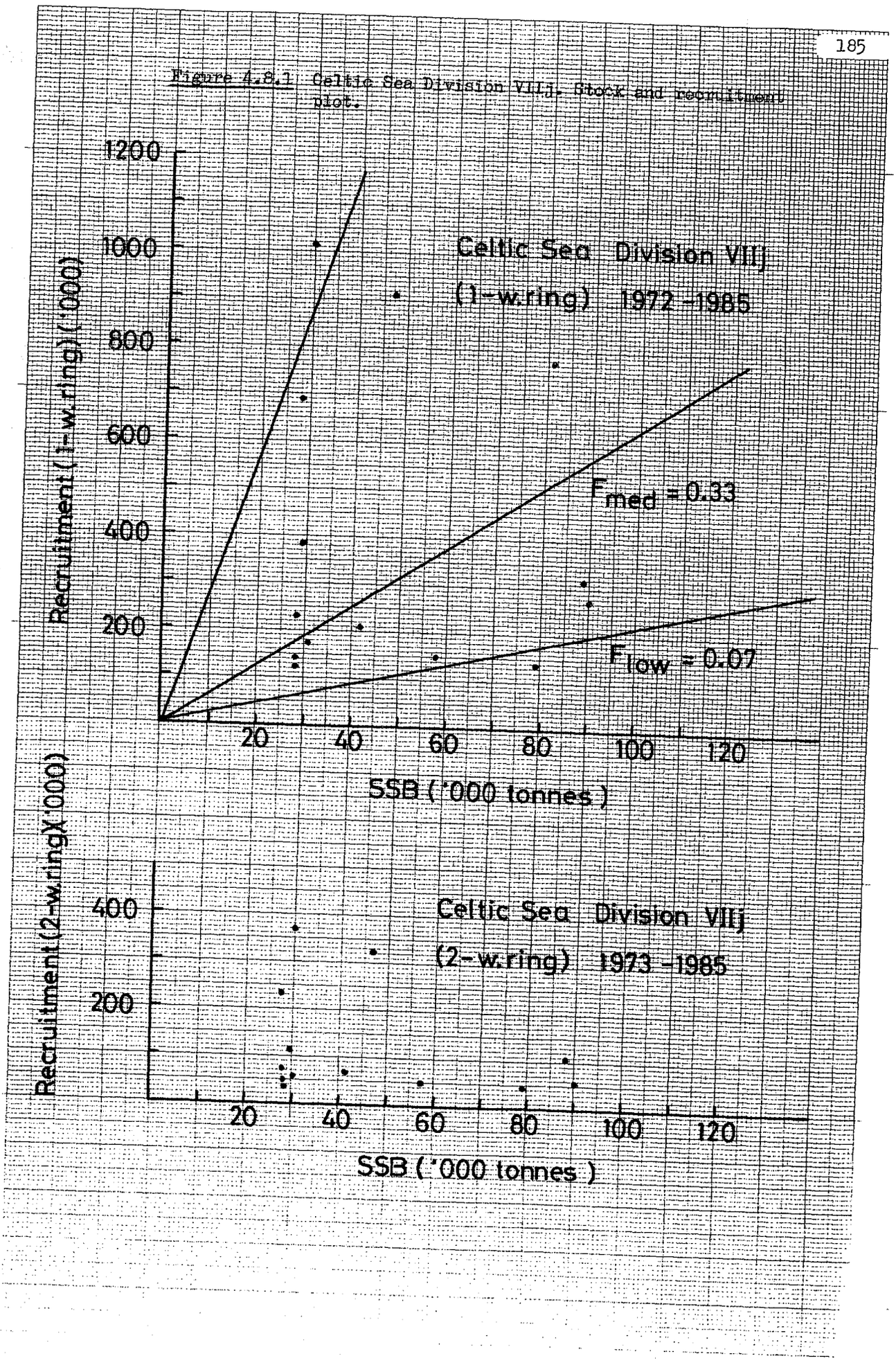


Figure 5.1.1 Herring in Division VIa North.

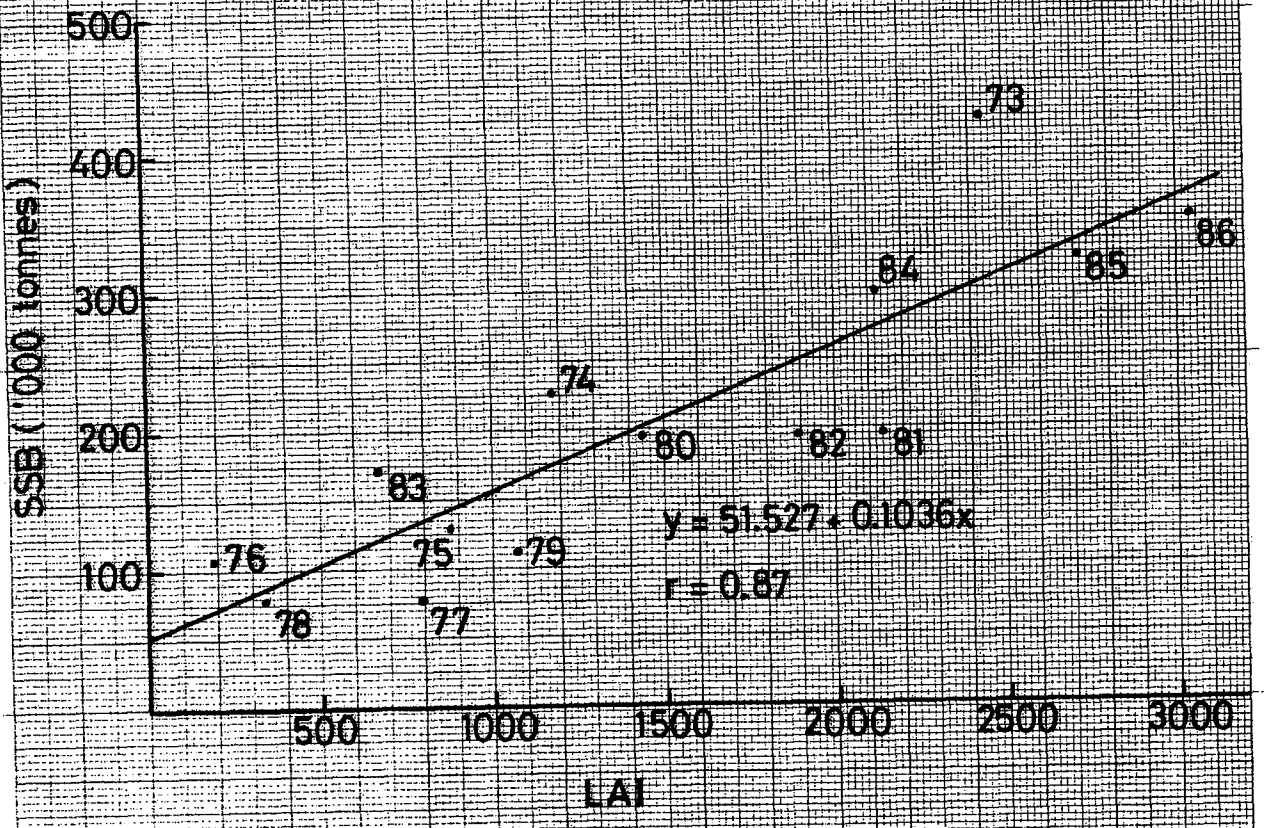


Figure 5.1.2 Herring in Division VIa North.

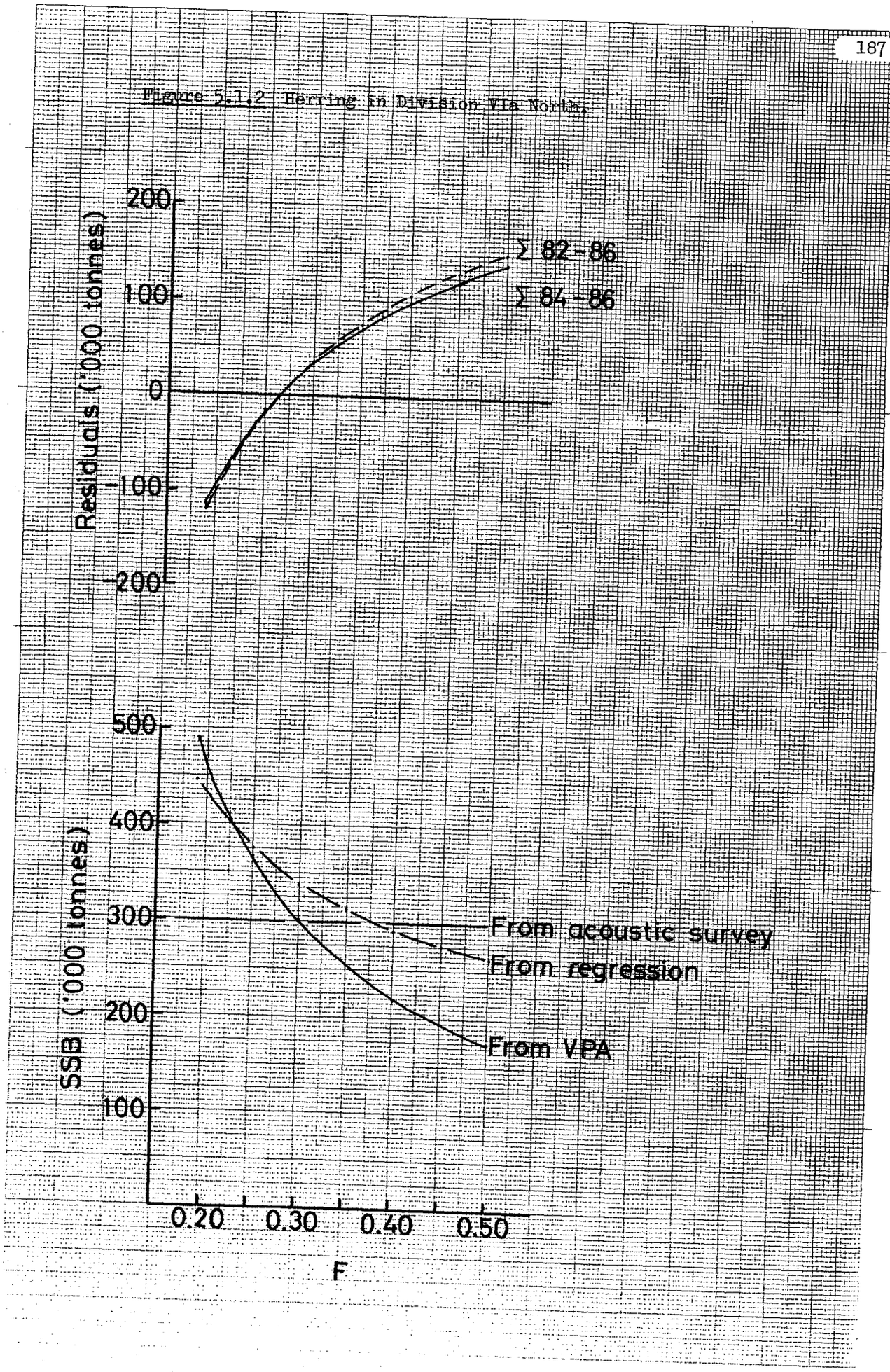
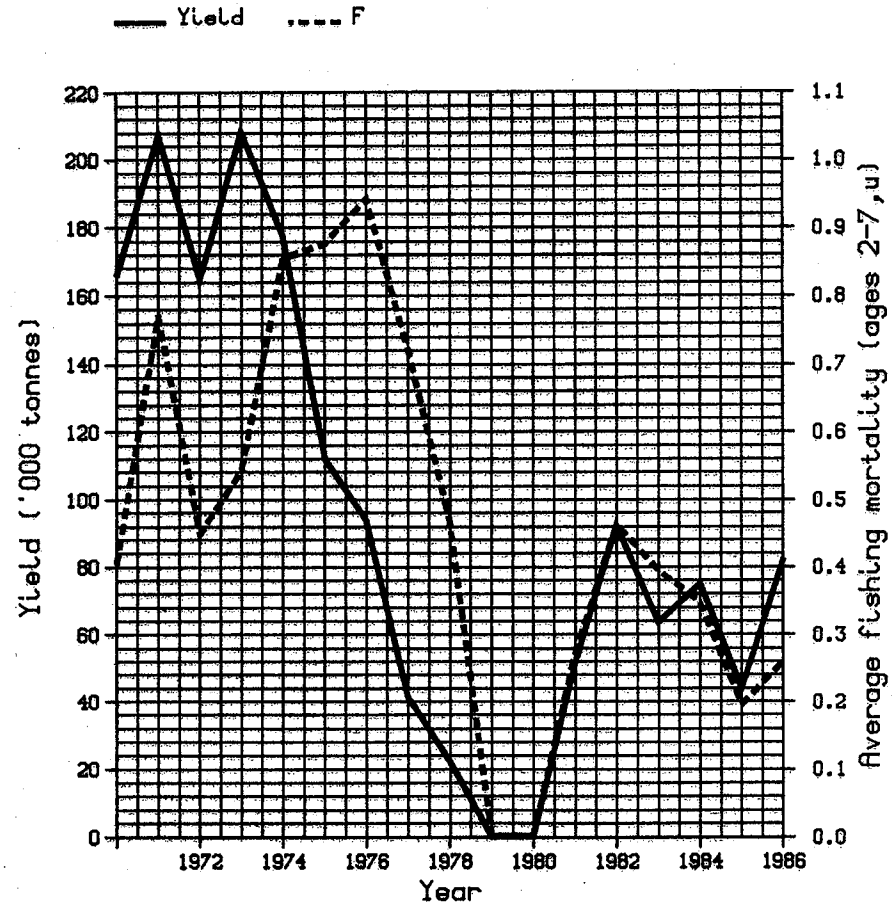


Figure 5.1.3

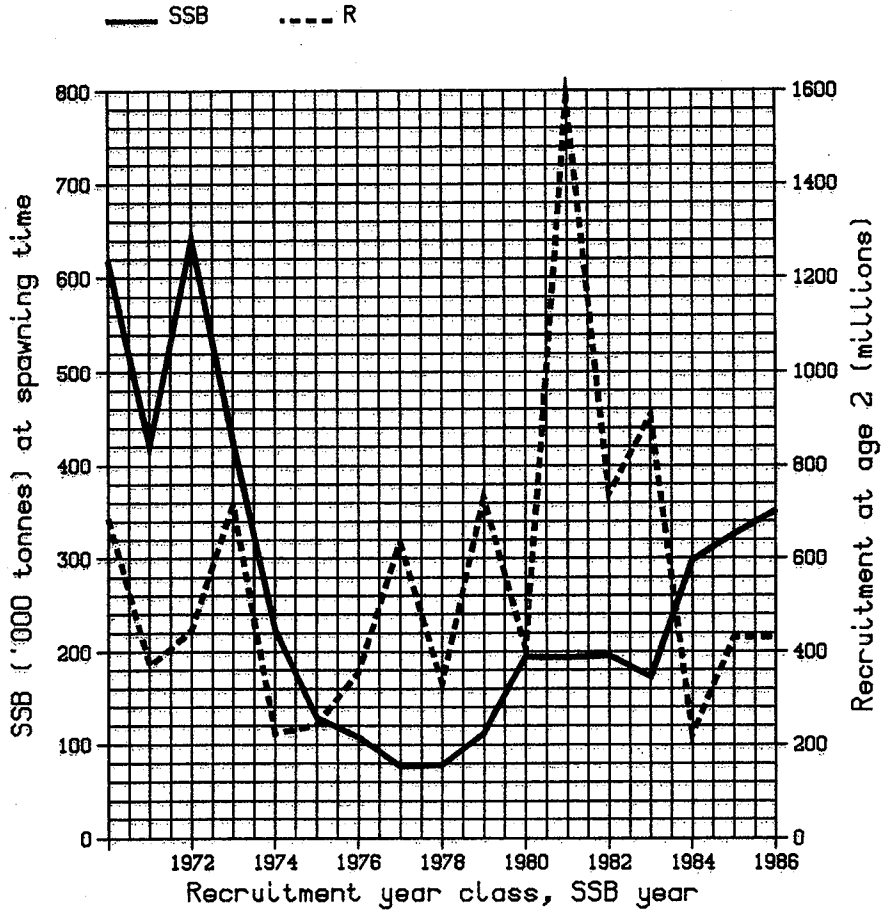
FISH STOCK SUMMARY
STOCK: Herring – VIa North
14–04–1987

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



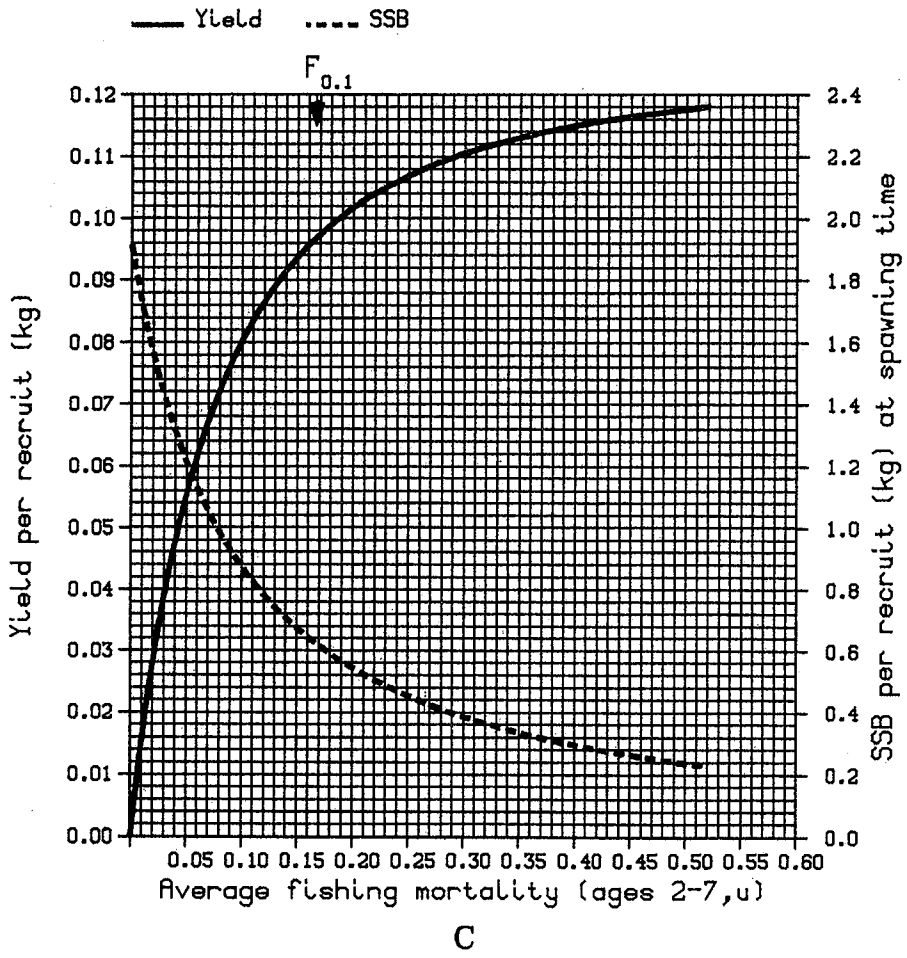
B

cont'd.

Figure 5.1.3 cont'd.

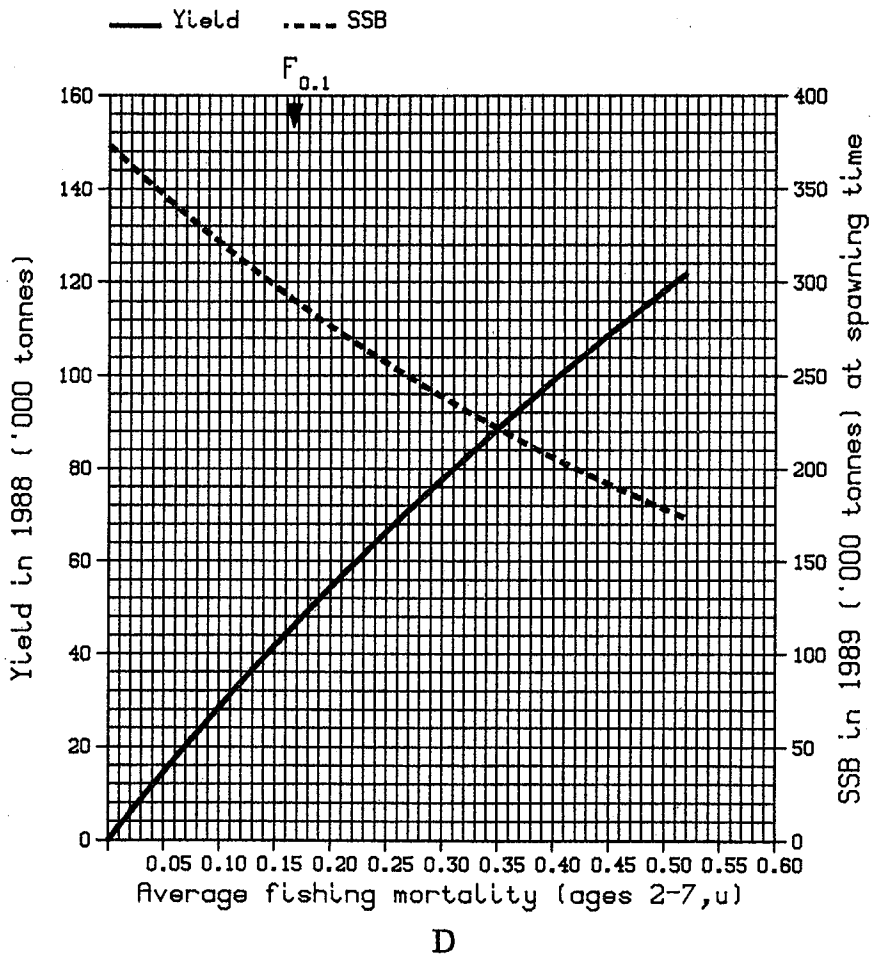
FISH STOCK SUMMARY
STOCK: Herring – VIa North
14–04–1987

Long-term yield and spawning stock biomass



C

Short-term yield and spawning stock biomass



D

Figure 3.1.4 Herring in Division VIa North. Stock-recruitment plot with biological reference lines.

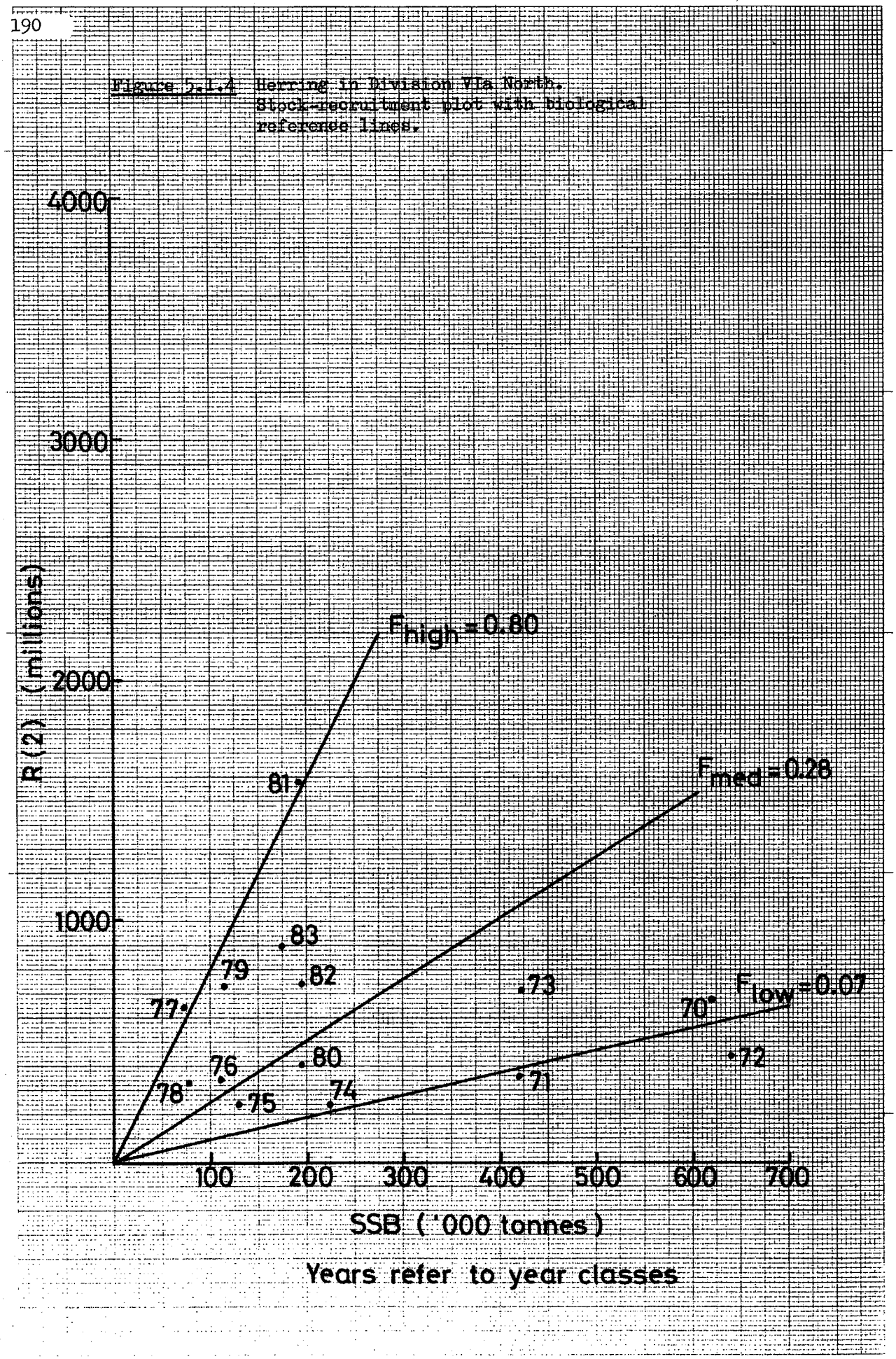
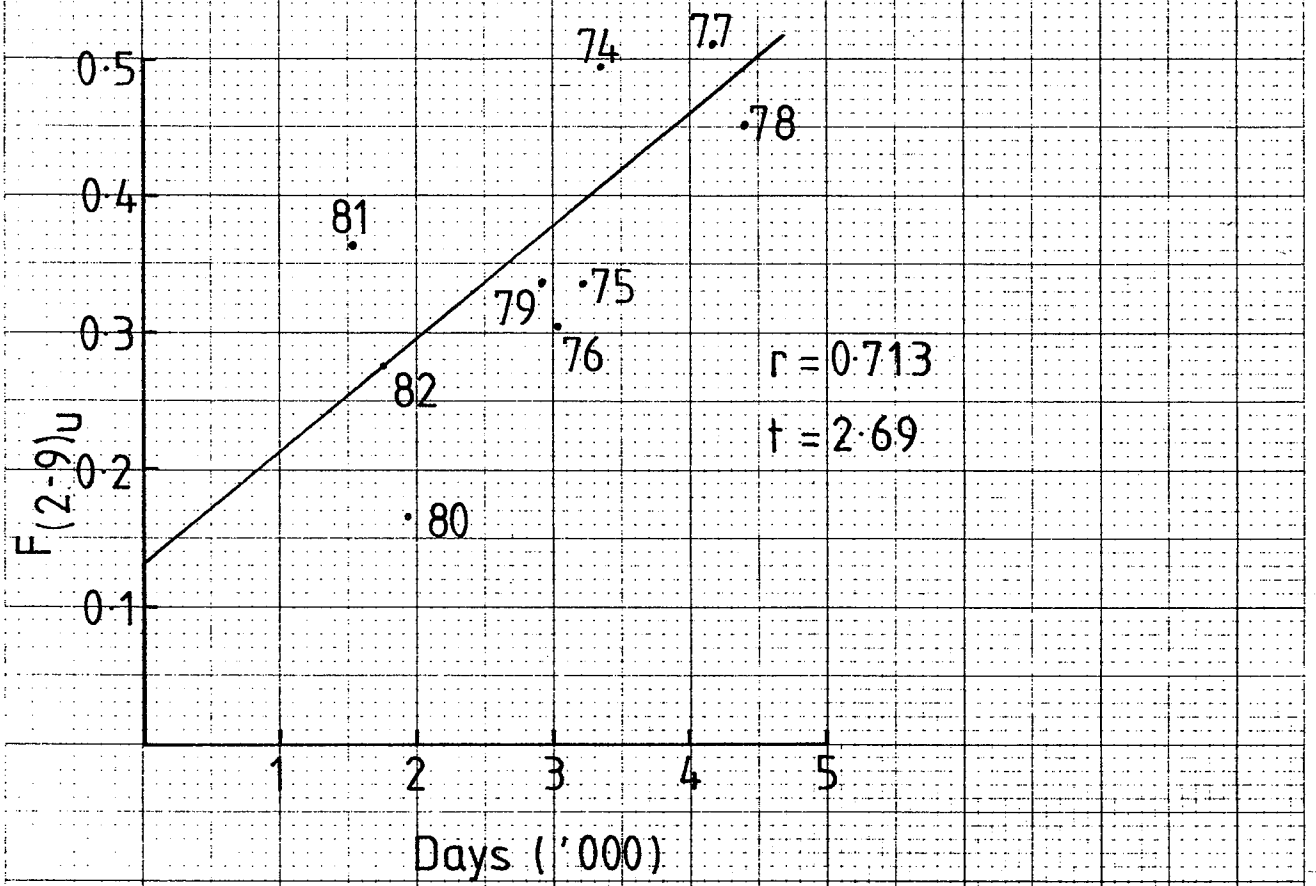


Figure 5.2.1 Clyde herring. Scatter plot of estimated fishing mortality rates from VPA against number of days absent from port, 1974-1982.



$F_{(2-9)} = 0{\cdot}136 + 0{\cdot}077\,(\text{Effort})$

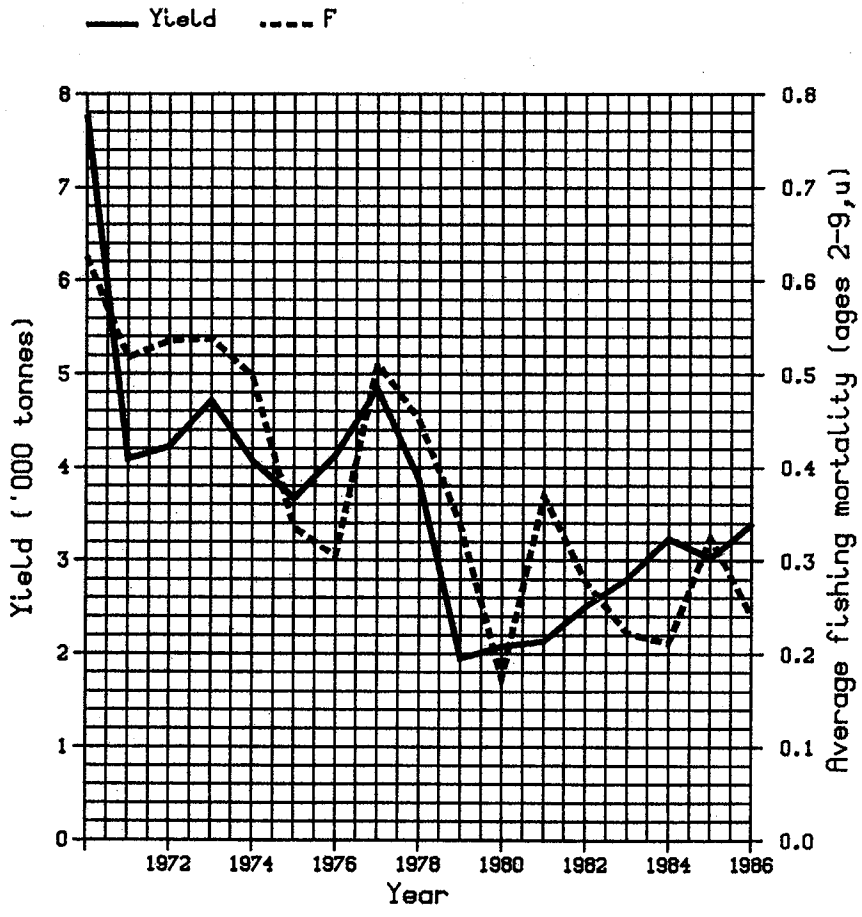
1986 Effort $= 1{\cdot}375 \times 10^{3}$ days

$F = 0{\cdot}24$

Figure 5.2.2

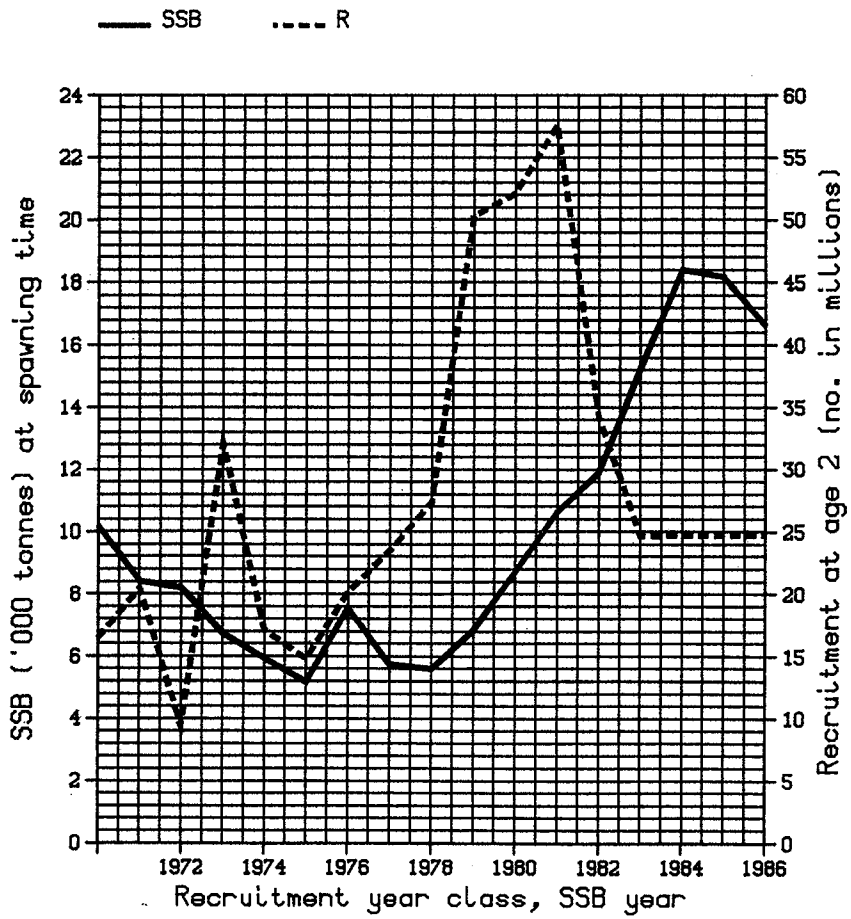
FISH STOCK SUMMARY
STOCK: Clyde Herring
14–04–1987

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

Figure 6.4.1 Comparison between trends of larval indices and SSB with different F values in 1986.

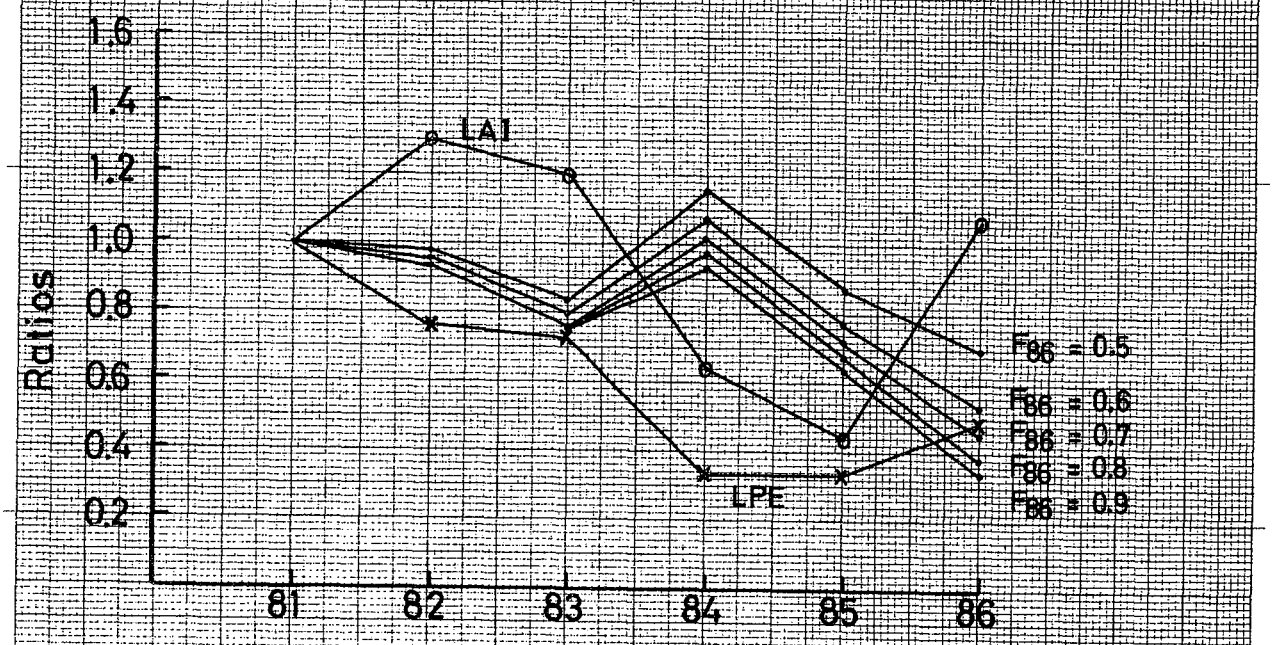


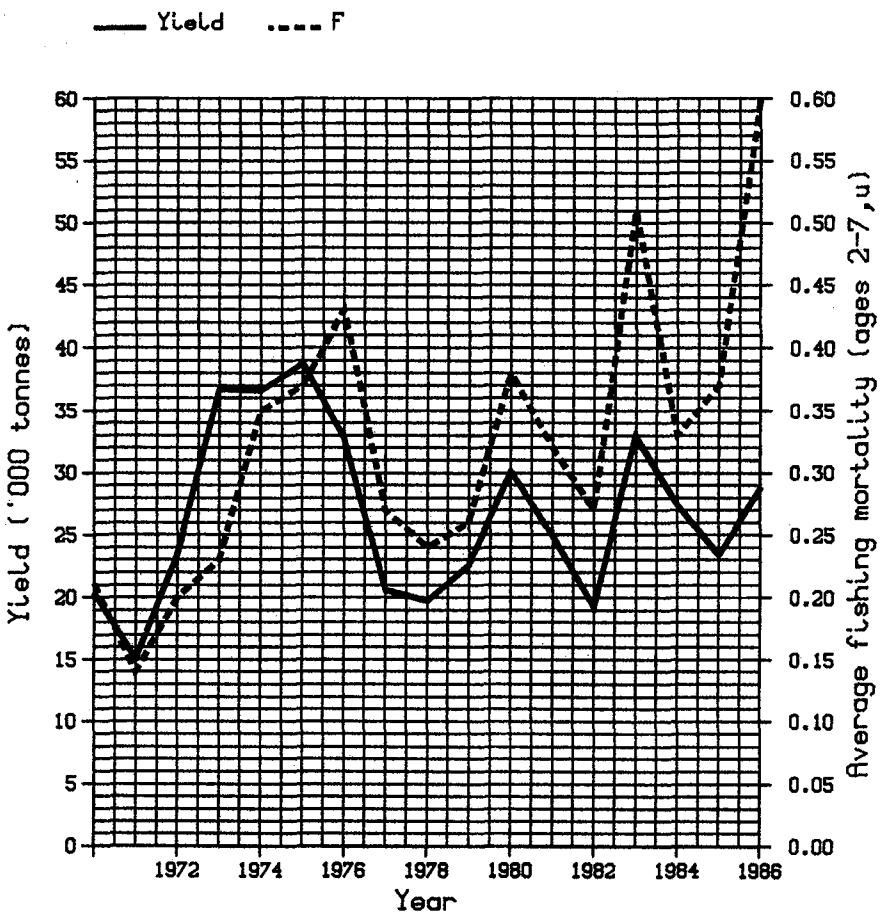
Figure 6.4.2

FISH STOCK SUMMARY

STOCK: Herring – VIaS and VIIb,c

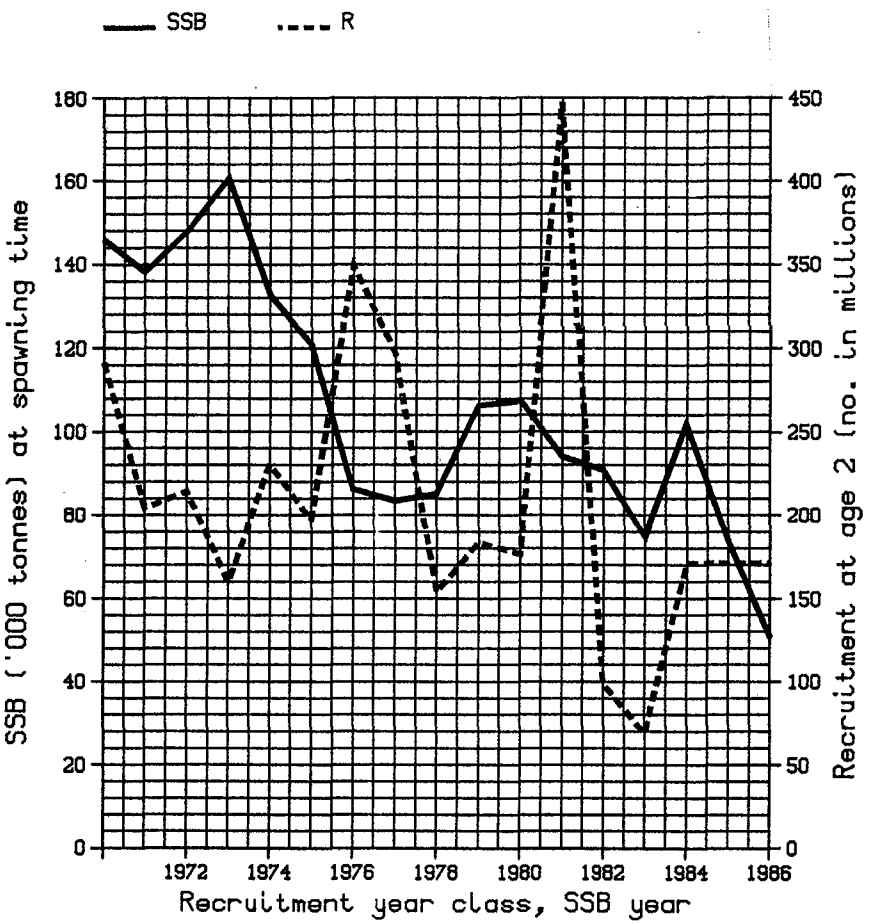
14–04–1987

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

cont'd.

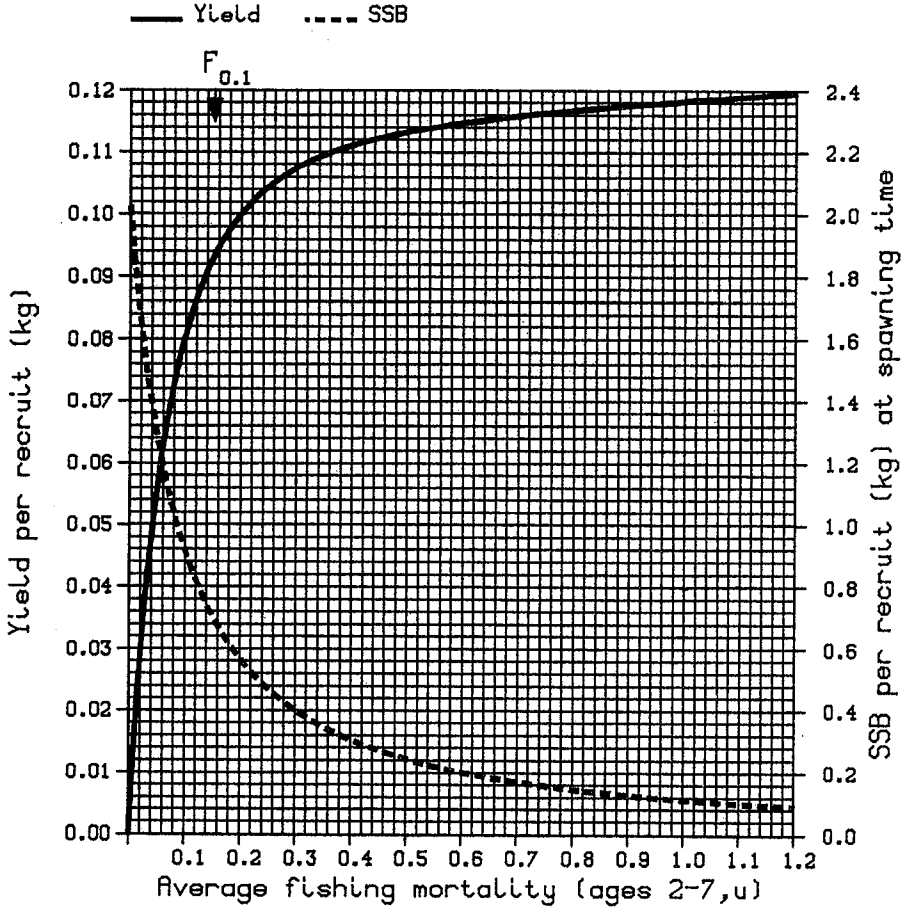
Figure 6.4.2 cont'd.

FISH STOCK SUMMARY

STOCK: Herring – VIaS and VIIb,c

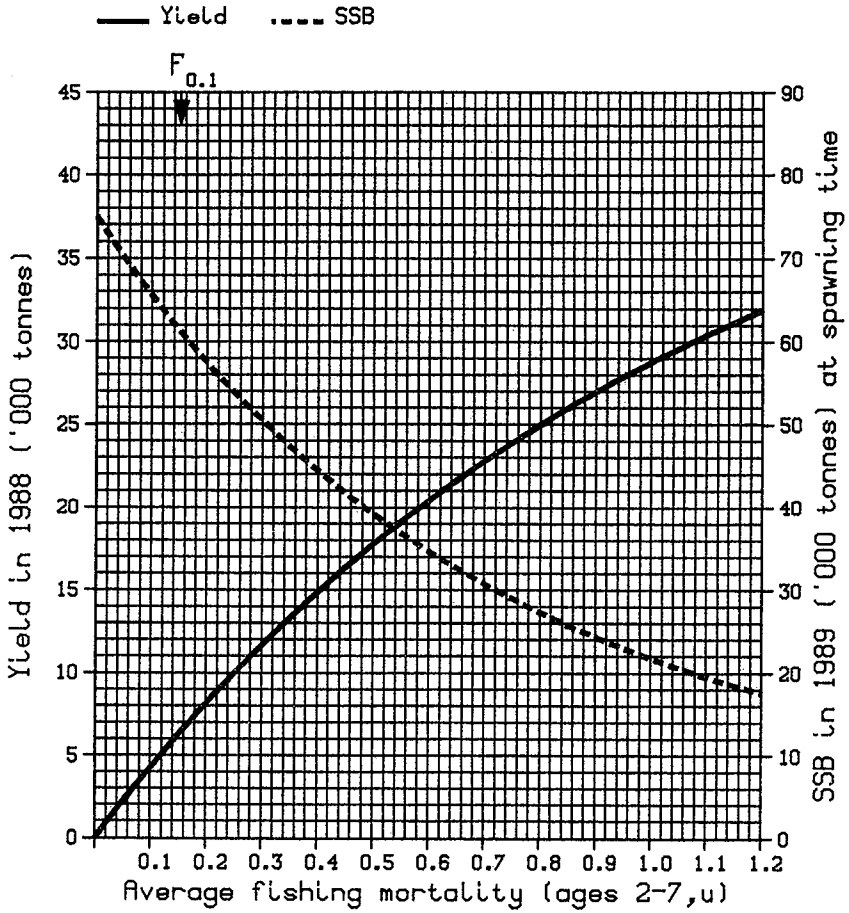
14–04–1987

Long-term yield and spawning stock biomass



C

Short-term yield and spawning stock biomass
assuming catch of 29,000 t in 1987



D

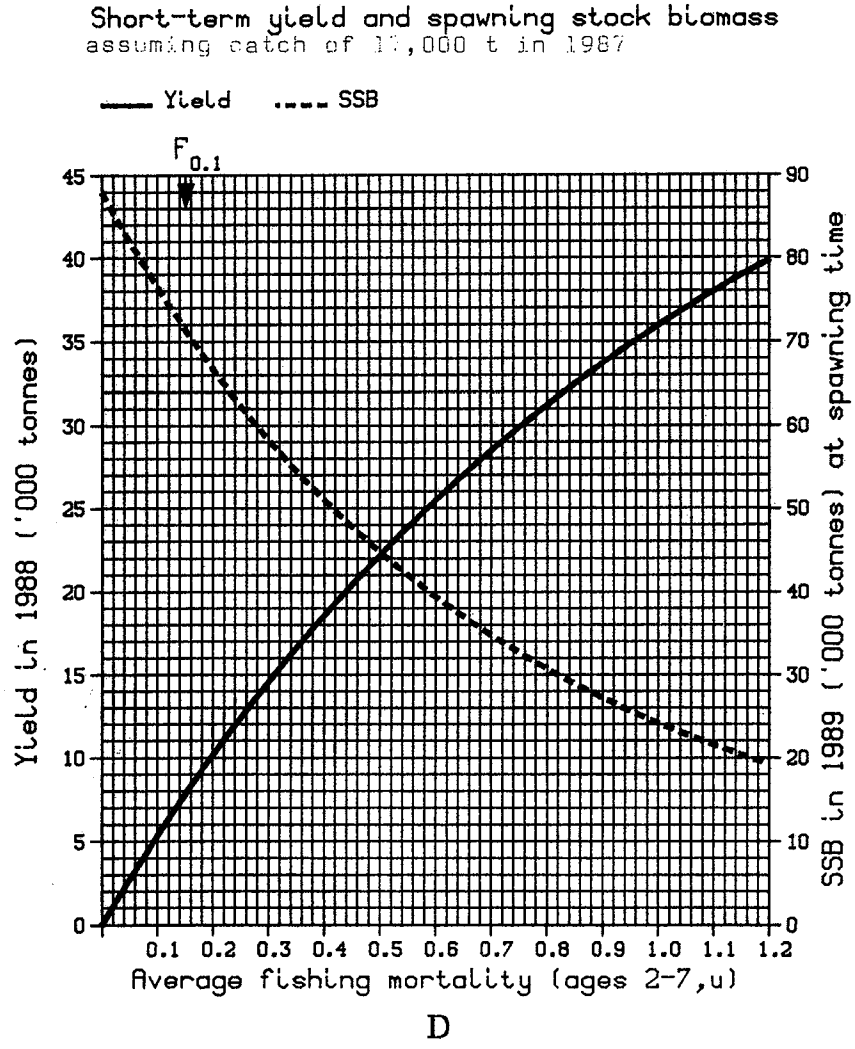
cont'd.

Figure 6.4.2 cont'd.

FISH STOCK SUMMARY

STOCK: Herring – VIaS and VIIb,c

14–04–1987



D

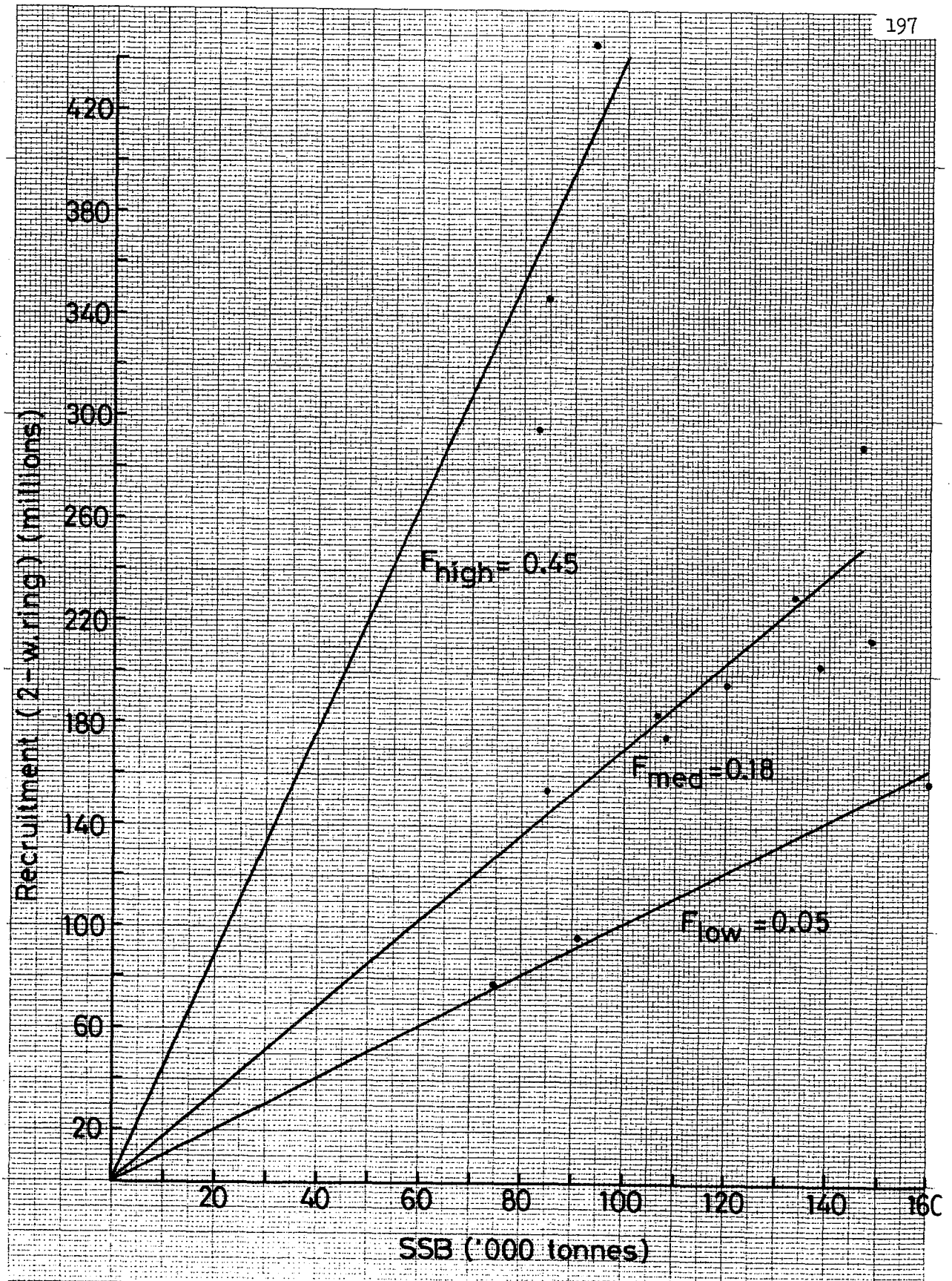


Figure 6.7.1 Divisions VIa S and VIIb. Stock-recruitment scatter plot.

Figure 7.3.1 Irish Sea herring in Division VIIa. Trends in UK proportion of fishing mortality $F_{(2-7,UK)}$ and UK landings.

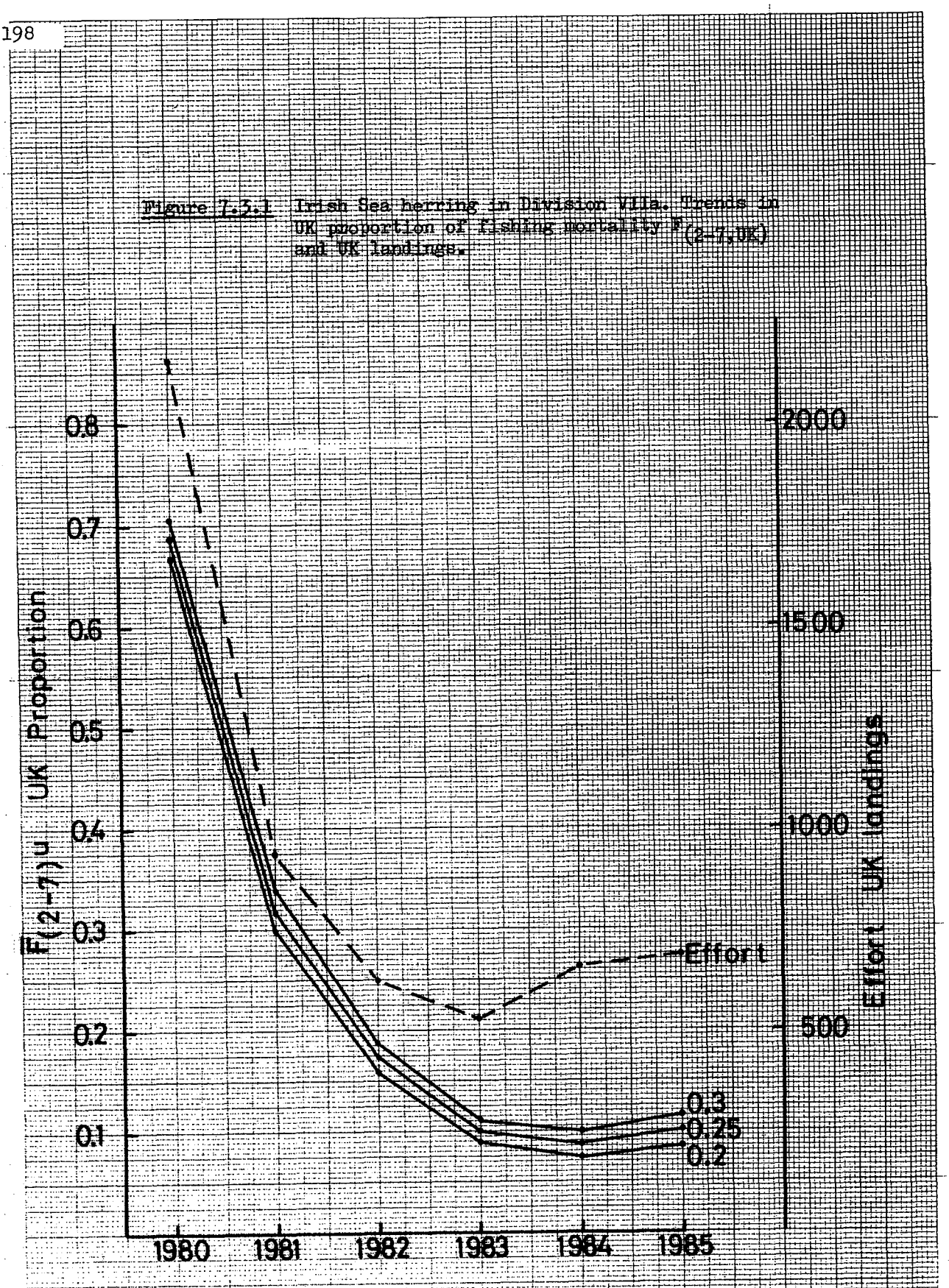


Figure 7.2.2 Trend of F_{86} predicted from effort regressions against F_{86} used to generate VPA.

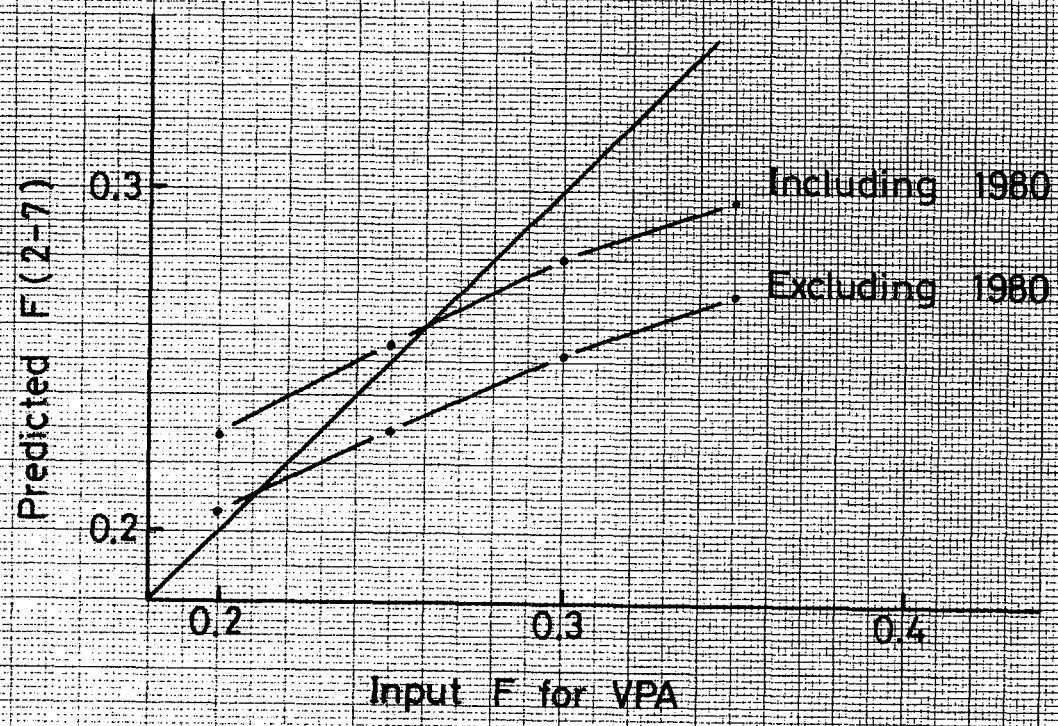


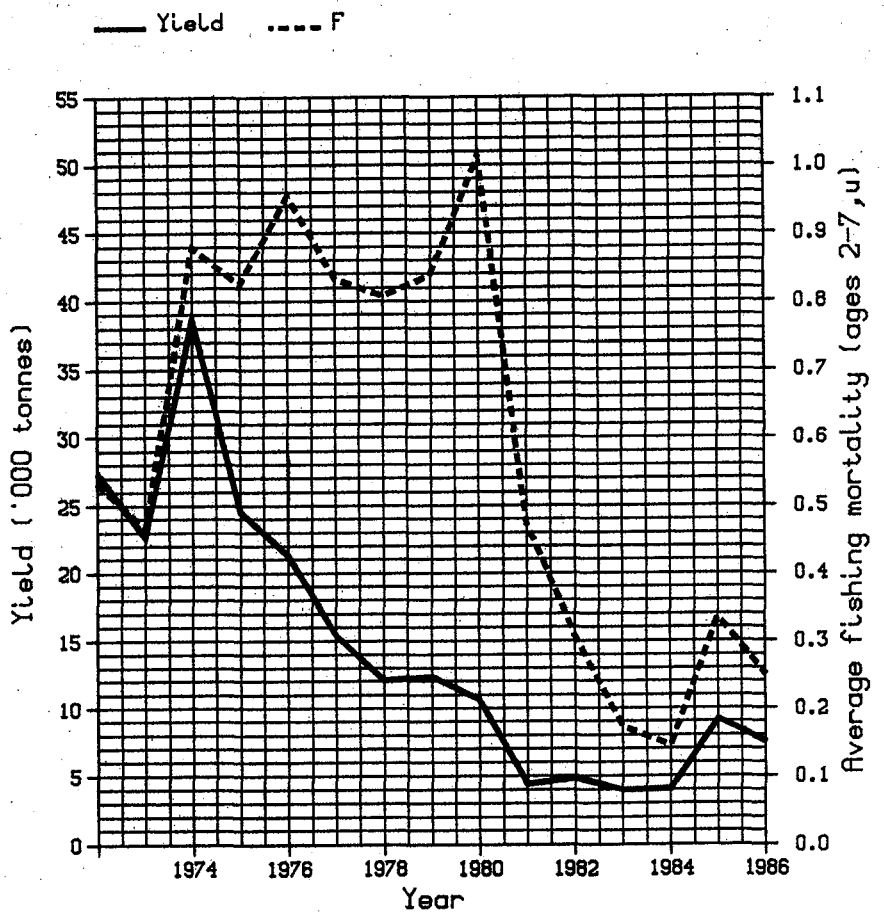
Figure 7.3.3

FISH STOCK SUMMARY

STOCK: Herring – Northern Irish Sea

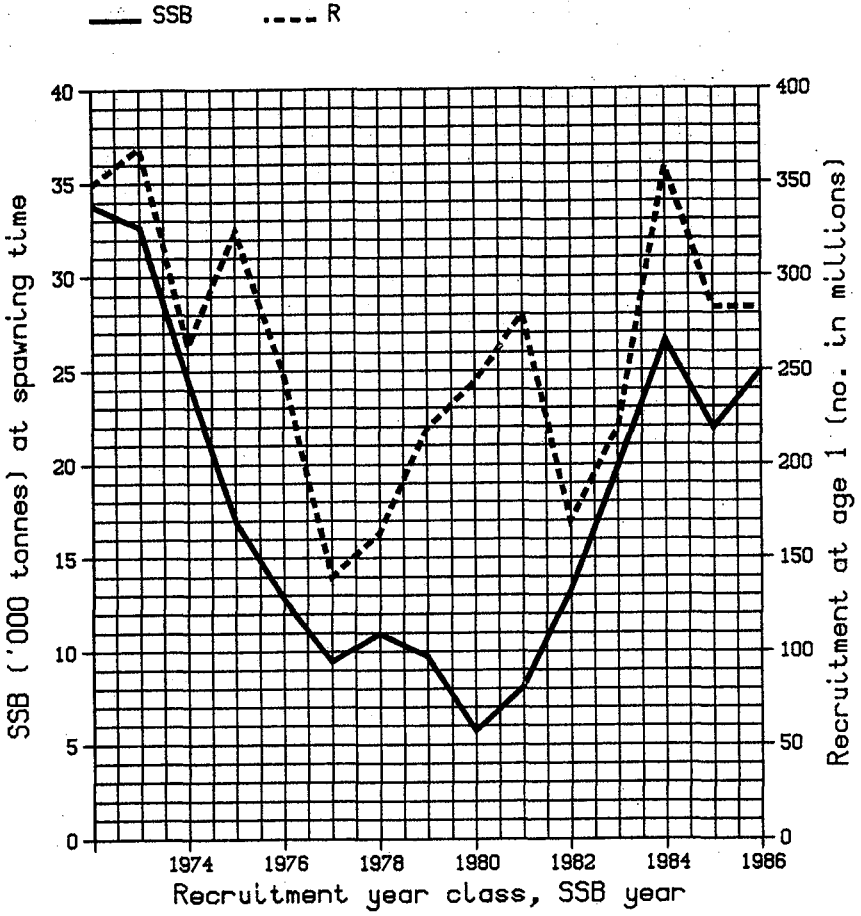
14–04–1987

Trends in yield and fishing mortality (F)



A

Trends in spawning stock biomass (SSB) and recruitment (R)



B

cont'd.

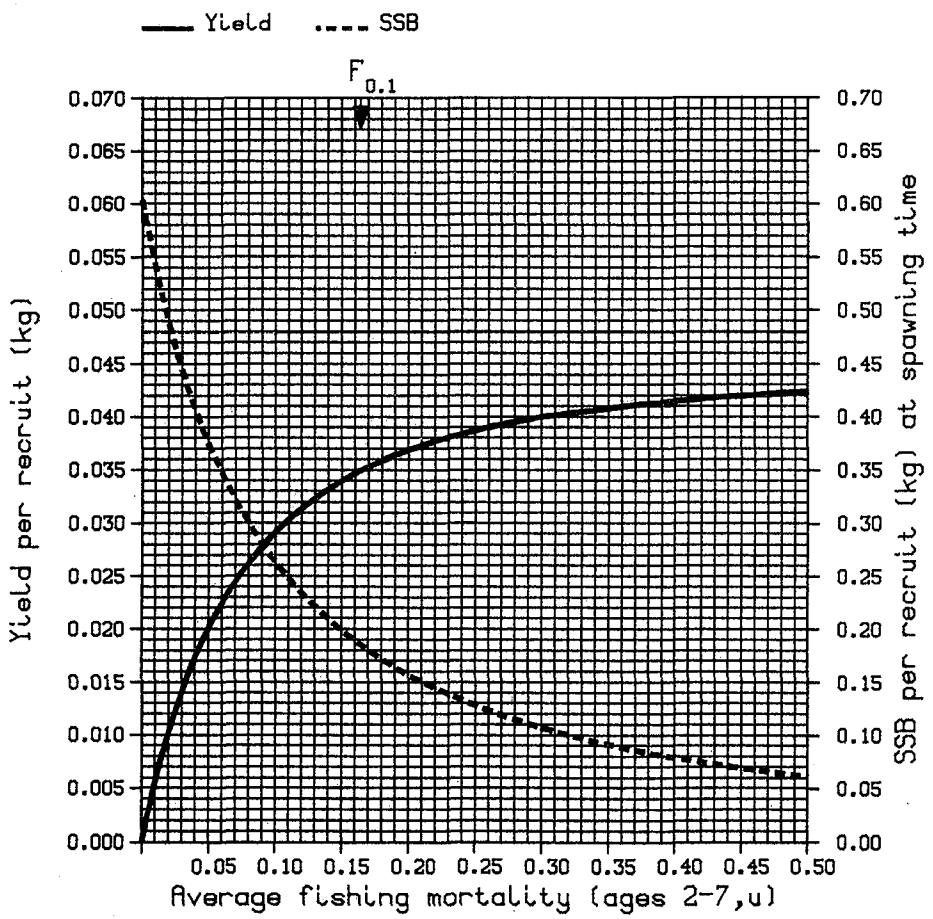
Figure 7.3.3 cont'd.

FISH STOCK SUMMARY

STOCK: Herring – Northern Irish Sea

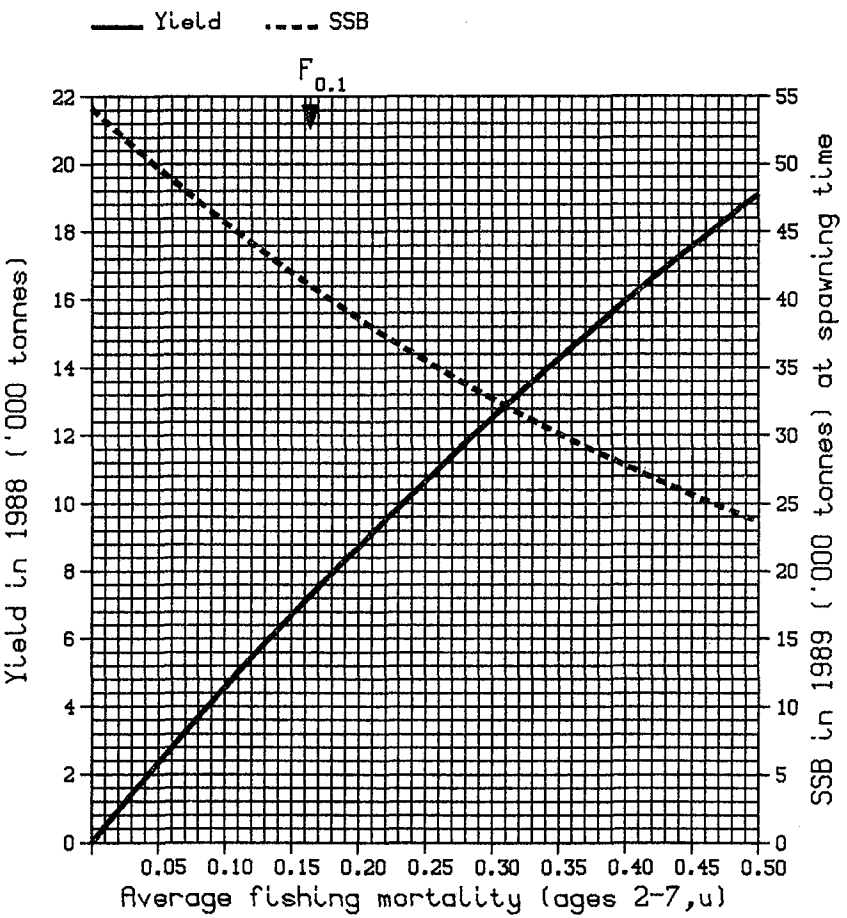
14–04–1987

Long-term yield and spawning stock biomass



C

Short-term yield and spawning stock biomass
assuming catch at 4,500 t in 1987



D

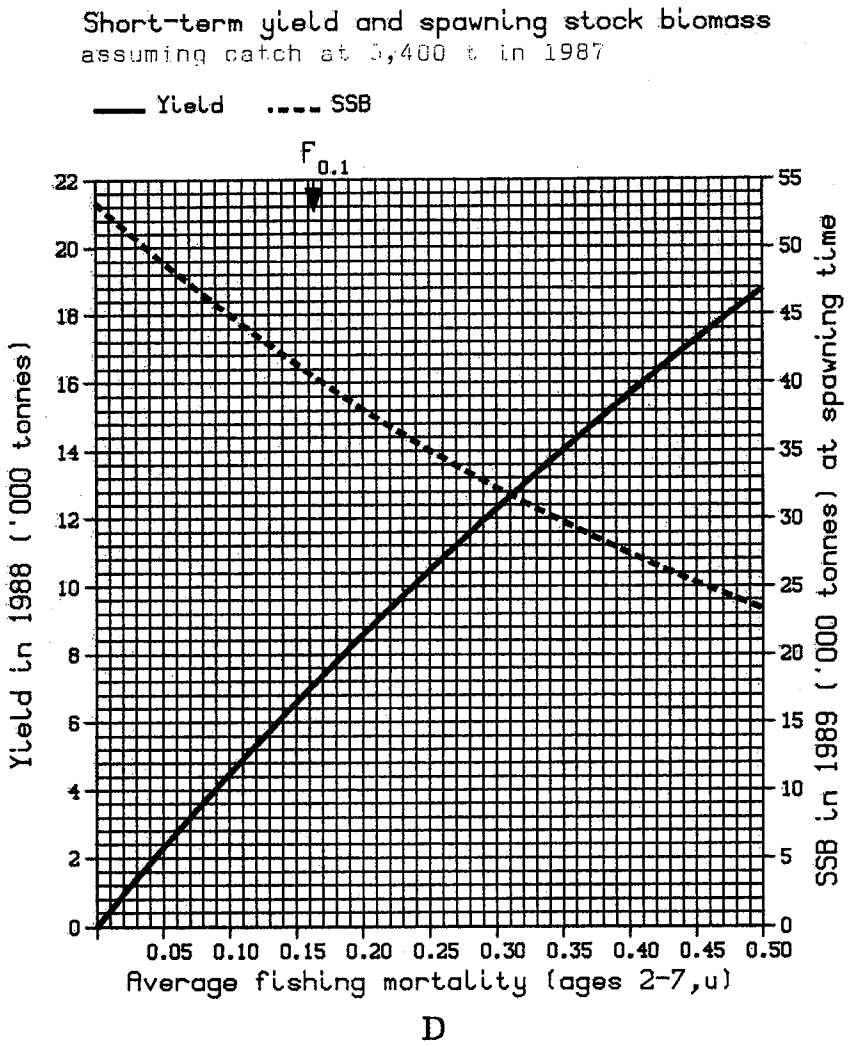
cont'd.

Figure 7.3.3 cont'd.

FISH STOCK SUMMARY

STOCK: Herring – Northern Irish Sea

14–04–1987



D

Figure 7.4.1 SSB:R curve for Irish Sea herring (Division VIIa) with biological reference lines. Derived from VPA with $F_{86} = 0.25$.

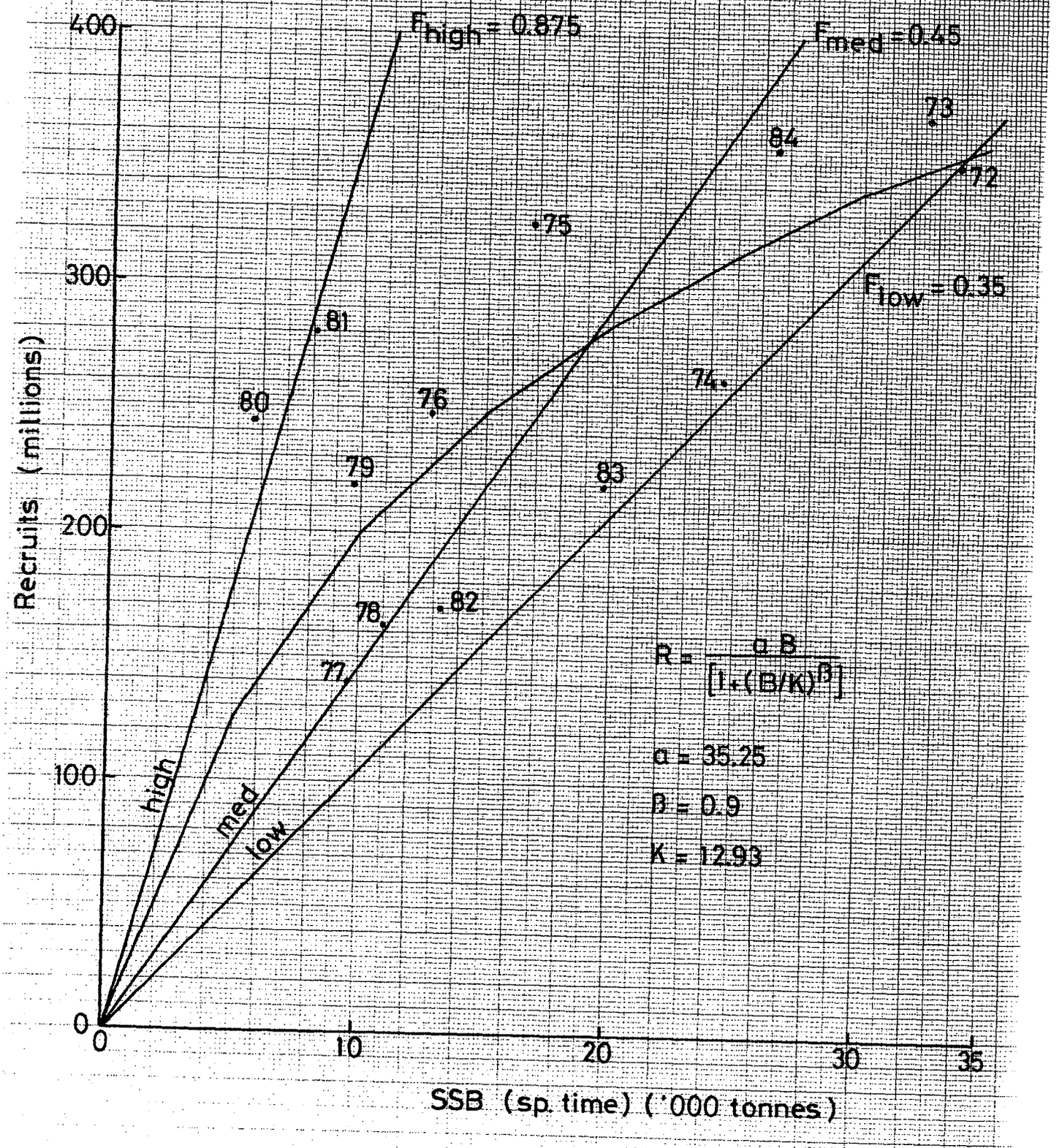


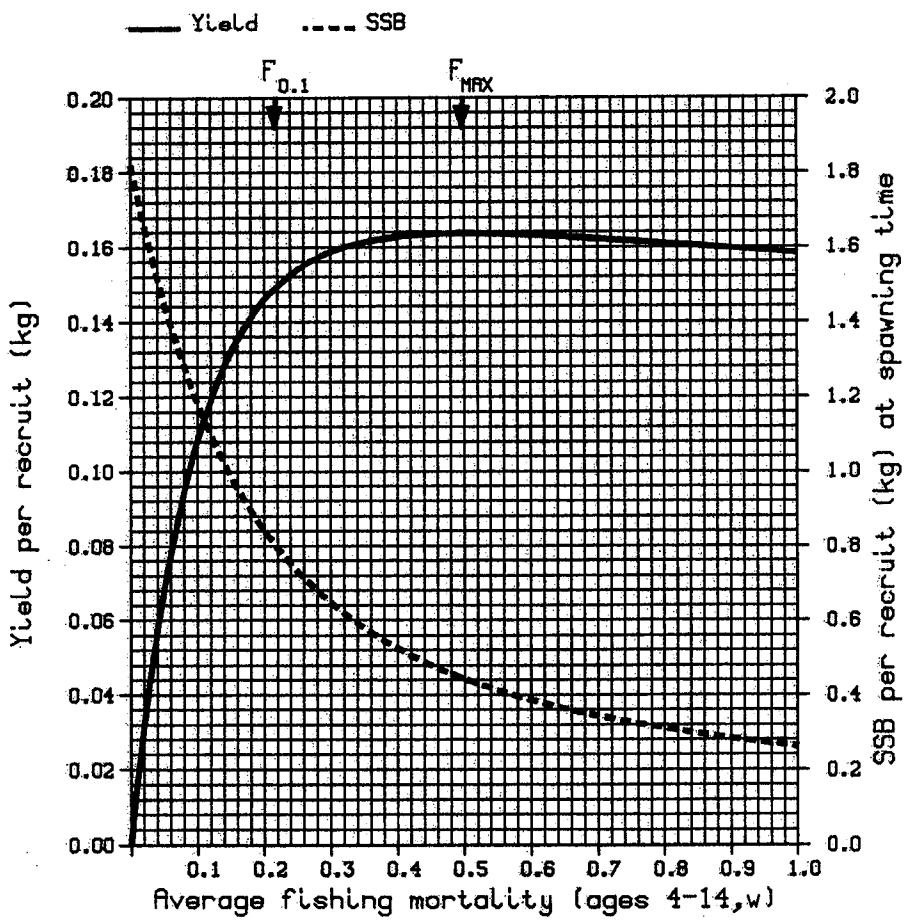
Figure 8.4.1

FISH STOCK SUMMARY

STOCK: Herring – Va (Summer)

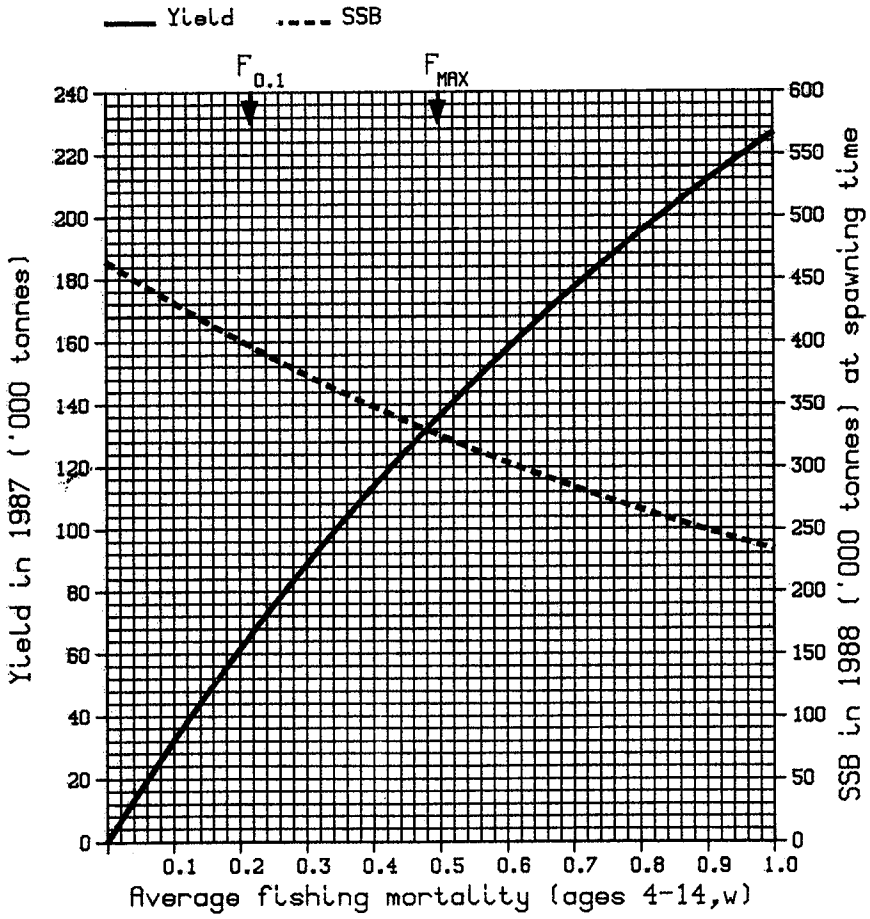
13–04–1987

Long-term yield and spawning stock biomass

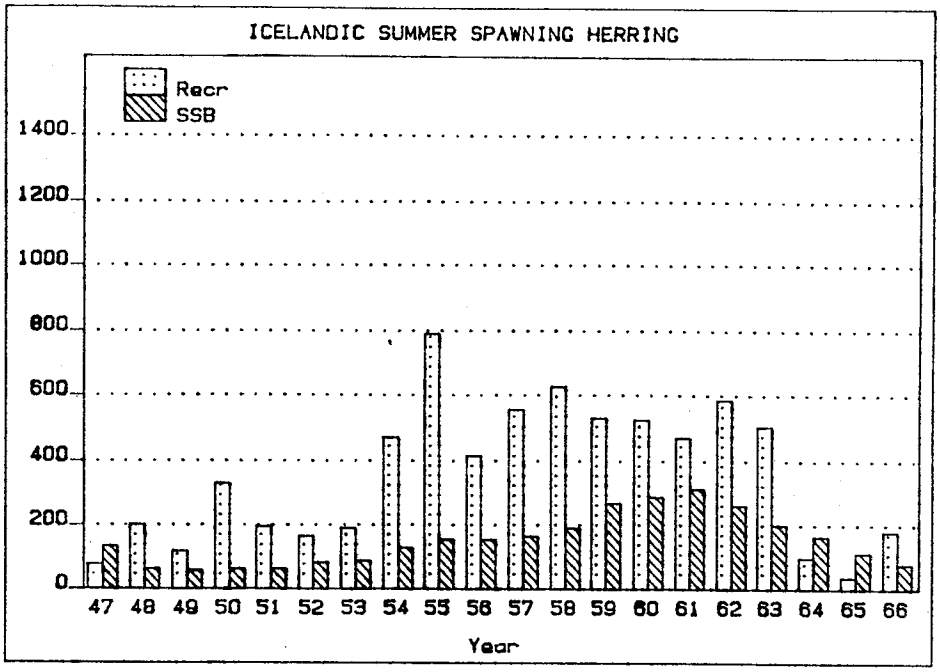


C

Short-term yield and spawning stock biomass



D



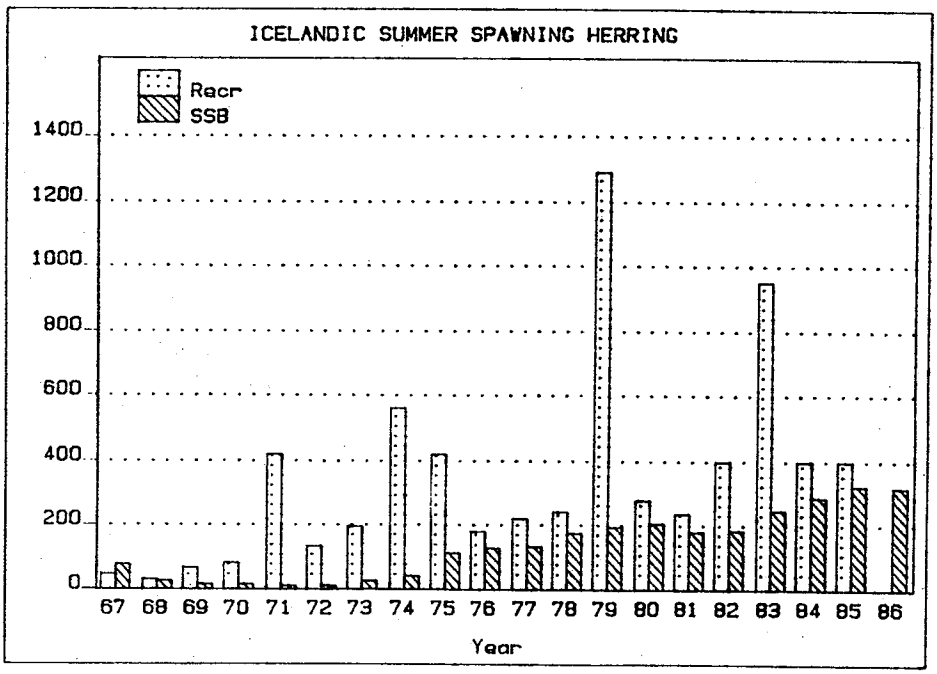


Figure 8.4.2. Trends in spawning stock biomass (SSB) and recruitment (Recr) for the Icelandic summer-spawning herring. Recruitment, year class as number 1-ringers $x10^{-6}$. SSB, year in '000 tonnes.

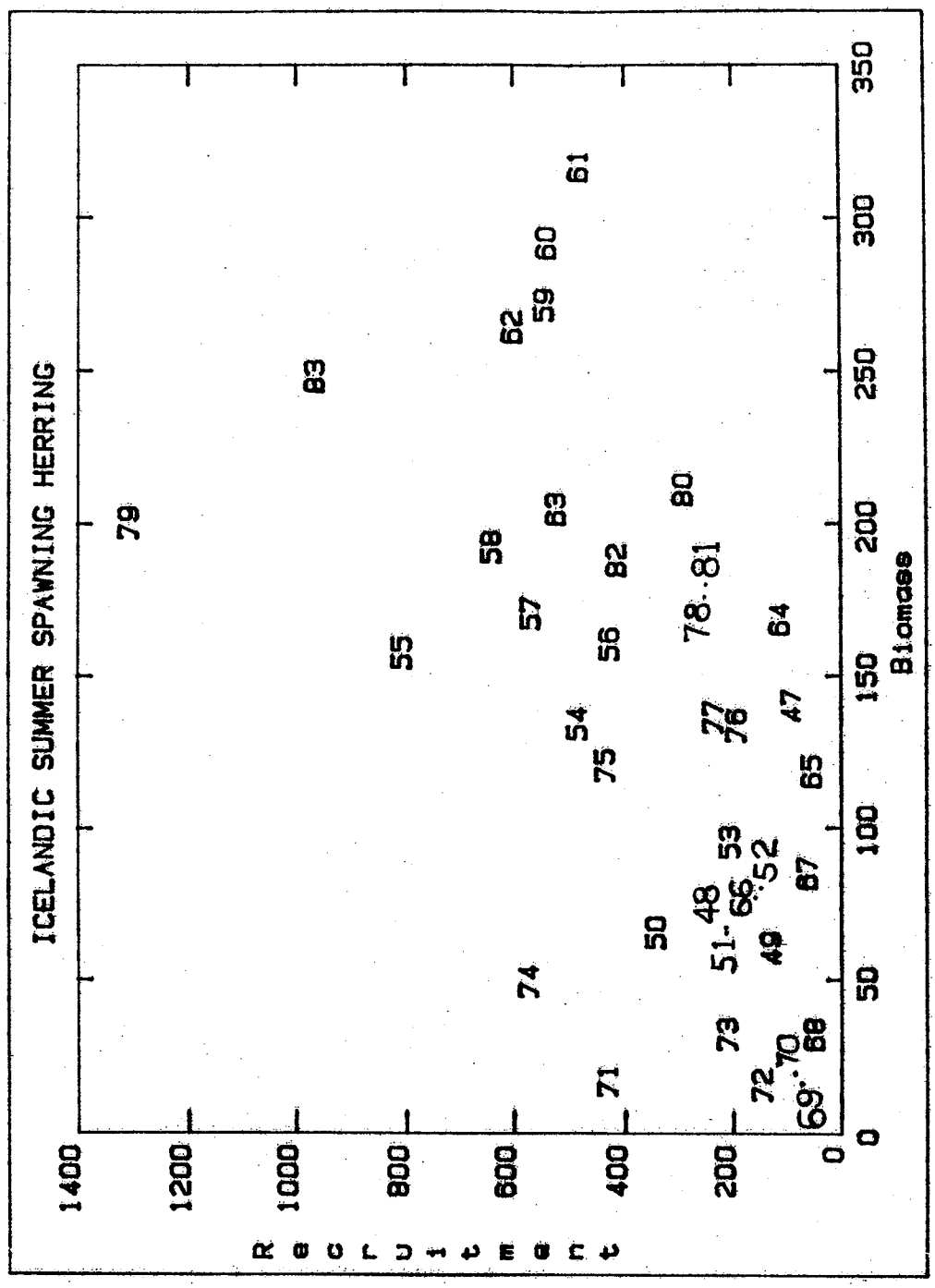


Figure 8.4.3. Stock-Recruitment plot for the Icelandic summer-spawning herring.