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Pelagic Fish Committee

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

Copenhagen, 21 - 26 April 1980

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1. PARTICIPANTS AND TERMS OF REFERENCE

1.1 Participants

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1.2 Terms of Reference

The Herring Assessment Working Group for the Area South of 62°N met at ICES headquarters 21-26 April 1980 in accordance with C.Res.1979/2:28 to:

(1) re-assess the herring stocks in Sub-area IV and VII, Divisions IIIa and VIa and sprat stocks in Sub-area IV,

(2) consider if the present by-catch limitation for herring in the sprat fisheries is the appropriate one and advise accordingly,

(3) review the biological criteria for re-opening the herring fisheries in Sub-area IV and Division VIa,

(4) establish a procedure for making analytical assessments of sprat stocks and advise on the data requirements for such assessments. The logistic requirements for the effective utilisation of such assessments in the management context should also be considered.

2. GENERAL SUBJECTS

2.1 Criteria for Re-opening Fisheries on Herring Stocks which are currently Subject to Bans on Directed Fishing

In the report of the *ad hoc* Meeting on the Provision of Advice on the Biological Basis for Fisheries Management (ICES, 1977), it is stated:

"In the case of depleted stocks, the only hope of recovery would be serious restrictions of fishing until such times as the spawning stock had eventually recovered, so that incoming recruit year classes are generally at the level prior to overexploitation". "Serious restrictions" could mean both a complete fishing ban or very limited fishing, and no guidelines are given in the above cited report for when a fishing can be replaced by small quotas. This question was, however, discussed in the previous report of the Herring Assessment Working Group for the Area South of 62°N, especially for North Sea Herring, and based on that report ACFM stated: "ACFM reiterates its advice, given in previous reports, that the policy should be to rebuild the spawning stock, as quickly as possible, to at least 800 000 tonnes. A limited fishery should not be allowed before there is evidence of a recovery of the spawning stock, and of improved recruitment; and that, therefore, the rebuilding to this goal would take place within a fairly short period with a limited fishery operating".

The Working Group sees no justification for changing the basic criteria for re-opening the fishery as spelled out in the ACFM report. The spawning stock should be rebuilt to the lower level of its optimal range in order to ensure the future of the stock and a viable fishery. Below this level of the spawning stock, failure in recruitment may occur. A very limited fishery could be allowed before this goal actually has been reached, provided that two basic criteria are fulfilled: Firstly, there should be evidence of a recovery of the spawning stock, and of improved recruitment. This means that for example a re-opening of the fishery should not be based only on expected increases in the spawning stock compared to an estimated level in a past year, and/or expected improved recruitment from an increasing spawning stock. Because of a) the errors involved when projecting the stock forwards from a given, but uncertain, starting value, b) the uncertainties about the actual form of the relation between spawning stock and recruitment, and c) the stochastic variability in recruitment around the stock/recruitment curve, it could have disasterous consequences to replace evidence with expectations. Secondly, the observed increases in spawning stock and recruitment should be of an order that ensures that the rebuilding to the defined goal will take place with a limited fishery operating.

Ideally, exploitation should not start before the first strong year class (compared to year class size during the period of depletion) has spawned once and its strength has been confirmed by its contribution to the spawning stock. It is, however, realised that such an approach may be found unacceptable by the fishing communities, arguing that as soon as it is clear that the stock will recover within a short period with a very limited fishery operating, such a fishery should be allowed. Biologically this may be acceptable, if it can be shown that the recovery will take place even under conservative assumptions about strength of recruit year classes and present stock size, taking into account the confidence intervals of the estimates. If it is to some extent uncertain whether a year class will increase the spawning stock to an extent which could allow a limited fishery, its contribution to the spawning stock should be confirmed before exploitation starts.

When considering the effects of a seriously restricted fishery during the period of recovery and building up of the stock, due regard should be given to the practical difficulties of enforcing very low TACs. Assessments should include eventualities of various likely levels of catches exceeding the recommended TAC.

One member of the Working Group, Mr A Corten, did not agree with the biological criteria for re-opening a fishery as outlined above. In his view, biologists can only advise a continued closure of a fishery in situations where even the smallest practicable fishery would pose an immediate threat to the continued existence of the stock. A decision on what the smallest practicable fishery would be should be taken on a management level, and not by biologists. Management objectives such as optimum stock size, and the period in which it should be arrived at, cannot be based on biological criteria alone, but should also take economic and social considerations into account.

2.2 Discards

Management arrangements using TACs combined with minimum landing size for a number of herring stocks have led to an increasing amount of undersized fish being discarded at sea. This is apparent from the fact that several fishing vessels have installed sorting machines on board, and only a small part of the catch is landed unsorted. Although in most countries fishermen are supposed to report all catches discarded, it is evident from the reports that only a very small proportion of the total discard is reported.

The unreported catches of undersized fish, mainly 0-1 group, can seriously bias the stock assessments.

It is recommended, therefore, that immediate action be taken to reduce discards at sea for example by closed seasons and closed areas when the catch of undersized fish is high. Furthermore, reporting systems should be improved in order to get reliable data of discards.

Some members of the Working Group expressed their concern about the use of mechanical sorting machines on board vessels used on directed fisheries for consumption herring. The use of these machines will enable the boats to exploit herring shoals containing a high proportion of undersized fish. It was feared that this practice of using sorting machines, which at present is common in Division IIIa, will spread to the North Sea as soon as limited fishery for consumption herring will be allowed in this area.

3. NORTH SEA HERRING (Sub-area IV and Divisions VIId-e)

3.1 The Fishery in 1979

3.1.1 Catch data

Catch data for the years 1970-78 are given in Table 3.1, with a preliminary estimation for the year 1979.

Previous Working Group reports have advised a ban on directed fishing for herring in the North Sea and a reduction of by-catches in other fisheries. These measures were in principle enforced in 1979 without exception throughout the year, so the main part of the catches reported in the official statistics must be considered as by-catches. Some Working Group members supplied information on catches made of illegal directed fishing on herring. This information is taken into account in the catch tables in weight without national allocation and in the calculation of catches in numbers.

Under these circumstances, the total North Sea catch is estimated at 18 938 tonnes at which about 3 000 tonnes must be added to take into account unreported illegal catches.

Table 3.2 gives the North Sea directed catch by Sub-divisions for the years 1972-79, and the total estimated by-catch is given in Table 3.3 for all fisheries which represent the main part of the overall herring catch in 1979. Of the 22 000 tonnes, about 15 700 tonnes were taken in the sprat fisheries.

In all Divisions, the by-catch figures show some increase, especially in Division IVb, where herring by-catches are essentially generated by the sprat fisheries.

The Group reiterated doubts expressed in last year's report about the reliability of many of the catch figures supplied, and also its great concern regarding the efficiency of the control of landings and the reporting of them.

3.1.2 Catch in numbers by age

Numbers of herring at each age in catches by area are given in Tables 3.4 and 3.5 and summarised in the text table below for the past five years (with the revised figures for 1978).

Millions of herring caught per age group (winter rings)

Year	0	1	2	3	4	5 and older	Total
1975	264	2 461	542	260	141	87	3 755
1976	238	127	901	117	52	46	1 481
1977	257	144	45	186	11	13	656
1978	130	169	5	6	5	1	316
1979	542	159	24	6	8	3	742

The catch of 0-group fish in 1979 was approximately double that in 1975, when a directed herring fishery for industrial purposes was still in operation. It is, however, believed that reporting of by-catches in earlier years was less efficient than at present. This makes a strict comparison difficult. The catch of 0-group herring represents 73% of the total catch in numbers of North Sea herring and the juvenile component (0- and 1-groups) about 95%.

3.2 Age Composition

The International Acoustic Survey carried out on herring in the North Sea (and in Division VIa)gave an opportunity to obtain a considerable number of samples which enables an age composition to be constructed for North Sea herring just prior to the spawning season in Divisions IVa and IVb. These age compositions are given in the text table by month and area (see next page).

In the Orkney-Shetland area, age compositions varied locally but overall the 1974 year class predominated and the 1975 year class was poor.

In the Buchan area, the 1975 year class predominated over the 1976 year class, but the 1974 and 1973 year classes were still of some importance. In the central North Sea the 1974 and 1976 year classes were of considerable importance and the weakness of the 1975 year class, which recruited to the spawning stock in 1978 is confirmed.

An age composition, based on samples of directed illegal catches made in November-December 1979, is also given. It shows the predominance of the 1976 year class and the still good representation of the 1975 year class.

Percentage age composition

Age (w.r.)	Year Class	IVa west Orkney/Shetlands July	IVb Buchan July	IVb N.E. England July	IVb N.E. England August	IVc+VIId Nov.-Dec.
1	1977	27.4	1.5	2.4	21.7	1.16
2	1976	16.6	21.8	15.6	37.8	59.43
3	1975	7.9	35.5	16.5	8.8	24.46
4	1974	28.7	15.4	45.3	18.1	14.43
5	1973	18.6	16.2	8.4	3.8	0.51
6	1972	0.6	3.9	4.7	1.4	
7	1971	0.2	3.1	1.2	5.1	
8	1970	0.01	2.6	6.0	1.7	
9	1969	-	-	-	1.0	
10	1968	-	-	-	0.2	
11	1967	-	-	-	0.4	
Number of fish sampled		4 692	4 652			1 595

3.3 Recruitment

3.3.1 Year class 1977

The final figure for this year class during the 1979 International Young Fish Survey was 139 fish/hour for the herring standard area. At the previous meeting of the Working Group, a preliminary figure of 144 fish/hour was used. At this previous meeting, the Working Group decided that in cases of extremely low year classes, it was not realistic to apply the usual regression formula:

$$Y = 0.0031X - 0.21$$

to estimate the year class strength in absolute numbers from the IYFS abundance index, but that the intercept on the Y-axis should be ignored. The Working Group, therefore, used the formula:

$$Y = 0.0031X$$

in which: Y = year class strength as 1-ringers in nos x 10^9

X = IYFS abundance index.

Substituting the revised IYFS abundance index of 139 in the above formula, the year class strength as 1-ringers is now estimated at 0.43×10^9. Taking into account a catch of 109×10^6 0-ringers in 1978, the strength of the year class as 0-ringers is estimated at 0.62×10^9.

3.3.2 Year class 1978

The IYFS in February 1980 yielded a preliminary abundance index of 585 fish/hour for the herring standard area. This value is considerably above the figure for the preceeding year class, but still 60% below the average of the year classes produced in the period 1968-73, as is shown in the following text table.

Year class	Abundance index IYFS	Year class strength as 1-ringers($\times 10^{-9}$) estimated from VPA	Year class strength as 1-ringers($\times 10^{-9}$) predicted from regression formula
1968	822	3.35	
1969	2 647	7.35	
1970	1 629	5.79	
1971	827	3.82	
1972	1 195	1.75	
1973	1 592	4.39	
1974	452	0.73	
1975	342	-	0.85
1976	575	-	1.57
1977	139	-	0.43x)
1978	(585)	-	(1.60)

x) ignoring constant in regression formula.

The abundance index for year class 1978 is at the same level as the index for the 1976 year class, the highest one obtained after the occurrence of the last good year class (1973) in the North Sea. Applying the usual regression formula

$$Y = 0.0031X - 0.21$$

the strength of the year class in absolute numbers is estimated at 1.60×10^9.

The mean length of year class 1978 was exceptionally low in most parts of the North Sea (Corten, in press). Judging from this low mean length, and also from the high percentage of very small otolith nucleii found in samples of fish from the German Bight, some Working Group members involved in the surveys were of the opinion that this year class contains a high proportion of southern North Sea recruits.

Using the IYFS value as a reference point, the fishing mortality on year class 1978 as 0-ringers is estimated at 0.29, and the stock size as 0-ringers at $2\ 363 \times 10^6$. A comparison with values for previous years is given in the following text table.

Year class	Catch 0-ringers $\times 10^{-6}$	Stock as 1-ringers $\times 10^{-6}$, estimated from IYFS	$F_{0\text{-ringers}}$ (assuming M=0.1)
1975	238	850	0.24
1976	257	1 570	0.14
1977	130	430	0.27
1978	574	1 600	0.29

It should be pointed out, however, that the calculated fishing mortality of 0-ringers is based on the unlikely assumption that the small herring of this age group are subject to the same low natural mortality (M = 0.1) as assumed for adult herring.

Because of the rapid growth of the 0-group in early autumn and segregation of length by water depth, the estimated values of F could be strongly influenced by the time and place in which the main part of the by-catch is taken in a particular year.

3.3.3 Year class 1979

Very high numbers of pre-metamorphosis herring larvae, belonging to year class 1979, were caught by the Isaac Kidd midwater trawl during the IYFS in February 1980. This sampling programme was first started during the IYFS in 1977, and it has now become a routine part of the surveys. The objective of this programme is to investigate whether a relationship exists between the abundance of herring larvae at this age, and the subsequent year class strength. The Working Group has until now not used the results of this programme for the obvious reason that the number of year classes on which data were available was too limited to demonstrate a correlation with year class strength.

However, although such a correlation has not yet been demonstrated, it would be unrealistic to completely ignore the results of the 1980 survey. Both the extent of the distribution area, and the numbers caught per tow were very much higher than in the previous three years (Figures 3.1-3.2). A particularly encouraging sign was the presence of high numbers of larvae in the eastern part of the North Sea which is known as the traditional nursery area for North Sea herring. As a rough abundance index for these larvae, the mean number per haul and per square for the whole North Sea was calculated, and this value is given in the following table for all the years in which larvae have been sampled in February.

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

Although the results from the IKMT sampling in 1980 cannot be taken as a proof of a strong year class 1979, they clearly show that the year class up till the age of ½ year had shown much better survival than any of the preceeding year classes. The chance that this year class will grow up to be a strong one are, therefore, greater than in the past three years.

3.4 The 1979 Acoustic Survey

An acoustic survey employing six ships covered the northwestern and west central North Sea and the northern part of Division VIa between 2 July and 28 August 1979. The results of the survey were described in a preliminary report submitted to the 1979 Statutory Meeting of ICES (Doc. C.M.1979/H:44) and an evaluation of the results is to be submitted as a final report to the 1980 Statutory Meeting.

Identification of echo-traces proved to be very difficult owing to the intermixture of species in some of the areas surveyed. For this reason allocation of "acoustic biomass" to species was based on inadequate evidence and, depending on the precise method used, the herring biomass estimates obtained are very different. For these reasons, and because coverage of the large areas involved was incomplete, the biomass estimates obtained provided little useful evidence of the size of the stocks concerned.

A further acoustic survey is planned for the period June-August 1980 and following a recommendation by the Pelagic Fish Committee, it will be confined to the Orkney/Shetland area of Division IVa. An analysis of the data will be presented to the 1980 Statutory Meeting.

3.5 Estimates of Spawning Stock Biomass from Herring Larval Surveys

3.5.1 Use of larval data for assessment purposes

A basic problem in using larval survey data in order to obtain estimates of spawning stock biomass both in Sub-area IV and Division VIa stems from the fact that reliable indices of larval abundance are available for only a small number of years during which there was a fishery, from which spawning stock biomass can be estimated by VPA, despite the fact that ICES-coordinated surveys of herring larvae commenced in 1967. There are various reasons for this, but the two most important are: 1)inadequate survey coverage of crucial areas in a number of years; 2) an apparent change in the efficiency of sampling <10 mm larvae (the size category normally used), particularly in Division IVa. There is no satisfactory way in which inadequate coverage can be compensated for with any degree of confidence, while the change in efficiency precludes data obtained in the earlier years. The number of reliable individual observations, which can be put into the regressions for estimating stock biomass from larval abundance is, therefore, rather small in all areas.

Other factors which have assumed considerable importance during the past two years and which have not so far been satisfactorily resolved are: 1) the effect which emigration of Division VIa herring, which spent the juvenile phase in the North Sea, might have had on the VPA stock sizes both in Division IVa and in Division VIa, used in the regressions; 2) with the recovery of stocks and increasing larval densities, the problem of how to treat individual station values amounting to many thousands of <10 mm larvae per m^2. This Working Group is still unable to satisfactorily resolve the question of emigration. The ICES Larval Working Group in 1979 strongly recommended that countries participating in larval surveys should work additional stations at short distances around very high density stations. So far this has not been complied with. The Herring Assessment Working Group emphasises the critical importance of obtaining accurate estimates of the surface area likely to be applicable to exceptionally high station densities because of the major effect which such stations have on stock size estimated from larval abundance.

It is also recommended that the ICES Working Group on Herring Larval Surveys should examine the statistical methods used to analyse basic larval data, with a view to providing an agreed reliable index of annual abundance which can be used by the Herring Assessment Working Group.

A small Group of Larval Experts met prior to the 1980 meeting of the Herring Assessment Working Group to discuss related problems and their report is attached as Appendix 1. In this report a different method of obtaining an index of larval abundance is described by Saville for Division IVa, based on the assumption that the mean station density of herring larvae over a sampled area would be representative of the mean density over a larger standard area, if this was not completely covered. Members of the Herring Assessment Working Group were reluctant to accept these indices in the absence of any proof that the assumption was a valid one. They were concerned that variability in the distribution of sampled stations from one survey to another or from year to year within the standard area, could lead to serious bias in the mean index of larval abundance thus obtained.

3.5.2 Estimate of North Sea spawning stock size from larval survey data

The Working Group was unable to accept the regression for Division IVa based on Saville's emigration correction because a) maturity data indicated that only a very small proportion of the autumn spawners caught in the northern North Sea would not spawn at age > 2 rings; b) Division VIa VPA data indicated that, at least in some year classes, emigration from the North Sea was virtually complete at age 2 rings. The Division IVa spawning stock estimate adopted by the Group was, therefore, 185 000 tonnes, derived from the regression equation used by the Working Group in previous years, i.e. $\hat{Y} = 0.0417X + 49.39$, where $\hat{Y}$ is the estimated spawning stock from the regression ($x\ 10^{-3}$ tonnes), and X is the mean survey abundance of herring larvae ($x\ 10^{-9}$).

In Division IVb a spawning stock estimate of 31 000 tonnes based on the new regression given in Appendix 1 ($\hat{Y} = 0.1021X + 7.56$) was accepted. This may be regarded as a minimum estimate in view of the fact that some potential central North Sea spawning herring ≥ 2 rings, taken both in Division IVb juvenile fishery and also possibly in Division IVa, were excluded from the catch in number used to estimate spawning stock size by VPA for the years incorporated in the regression.

The Working Group decided to accept the spawning stock estimate of 39 000 tonnes based on Wood's regression equation ($\hat{Y} = 0.2647X + 6.44$) as being the best available for Divisions IVc and VIId.

This indicates a substantial increase in spawning stock size when compared with previous Working Group estimates for this area in recent years. However, it seems reasonably realistic in view of the estimate of 16 000 tonnes acoustic biomass, of what were considered to be predominantly Downs stock recruit herring, obtained by R/V "Johan Hjort" off the English northeast coast during the ICES survey in July 1979.

The spawning stock sizes estimated from the larval survey data are therefore:

	1979/80	
Division IVa	185 000 tonnes	(1978: 148 000 tonnes)
Division IVb	31 000 tonnes	(1978: 30 000 tonnes)
Divs. IVc+VIId	39 000 tonnes	(1978/79: no valid estimate available due to insufficient survey coverage)
	255 000 tonnes	

3.6 By-Catch Limitations for Herring in the Sprat Fisheries

The only data on by-catch of herring in the sprat fisheries presented to the Working Group were estimated totals for the whole year in each Division in the Danish fishery and percentage values in individual samples in the coastal United Kingdom fisheries. These data were not adequate to make a further evaluation of this problem. They indicate, however, that the amount of immature herring taken was about 15% and 3% of the combined sprat and herring catch in the United Kingdom fishery off the northeast coast of England and east coast of Scotland respectively, and a maximum of 4% in the Danish fishery in Division IVb, assuming no by-catch in industrial fisheries for other species in that area.

These figures, looked at in conjunction with the earlier analysis of this problem in the 1978 report, do not indicate any areas where herring by-catch is consistently high. The data available are totally inadequate to draw any general conclusion and, for this reason, it would be appropriate for members of the Working Group with relevant data to submit them to ACFM separately as an Addendum to this report.

It is likely that the by-catch limit currently in force (10%) had some effect in reducing the by-catch from what it might otherwise have been. Nevertheless, a considerable by-catch of herring was taken in the North Sea in 1979 by the sprat fisheries. It is therefore clear that the by-catch limit alone is not an adequate means of control. Indeed, even a reduction to 5% of the allowable by-catch limit would still potentially have allowed the same absolute by-catch.

Future by-catches are likely to depend to a considerable extent on the respective abundance and distribution of sprat and herring year classes. The following scheme illustrates the likely range of events:-

a) Large sprat year class - small herring year class

By-catch percentage low, so the by-catch rule will have little effect on the sprat fishery. The effect on herring will depend on their relative distribution, but the potential effect, as in 1979, is great, especially if sprat fishing effort is high in the main area of herring distribution.

b) Small sprat year class - large herring year class

By-catch percentage high, so control will divert the sprat fishery to other areas. The effect on herring will therefore be small.

c) Large sprat year class - large herring year class

Intermediate effect, but with adequate by-catch control, the sprat fishery may divert to areas of low herring abundance.

d) Small sprat year class - small herring year class

Intermediate effect, but diversion of sprat fishery to areas of low relative herring abundance may not be possible.

The above arguments suggest that the potential effects of the sprat fishery on herring, even when by-catch control is good, may be greatest when small herring year classes are present. This indicates the need for a reappraisal of the basis for by-catch control in the sprat fisheries, when more data become available.

3.7 State of the Stock and Management Advice

In addition to the estimate of spawning stock biomass from larval surveys, an estimate has been made by projecting stock sizes from the last VPA available (Doc. C.M.1978/H:3).

This was based on the stock size estimated for 1977 starting with an assumed value of fishing mortality in 1976 of 0.2 for 0- and 1-ringers and 0.8 for older fish. Natural mortality of 0.1 was used. Recruitment as 1-ringers was calculated from the standard regression of VPA estimate of 1-group on IYHS catch per effort.

Catch figures in numbers per age group have been used to estimate from the initial stock size fishing mortality for that year and stock size in the following year. These calculations have been continued for the years 1978, 1979 and 1980. For 1980, it was assumed that no catch would be taken. Spawning stock estimate was derived from the stock size at the beginning of the year by applying 2/3 of the total mortality.

The detailed calculations are given in Table 3.6.

It was suggested to the Working Group that a more detailed break-down of catches in numbers per age group by area and season would be more appropriate to estimate the size of the spawning stock. This calculation has been carried through up to 1980 for which the same catch in 1979 was assumed. Comparison of the results shows only small differences (5% in 1978 and 3% in 1979 and 1980).

The results of these estimates and the estimates of spawning stock biomass from larval surveys are summarised in the text table below.

Estimates of spawning stock biomass (1 000 tonnes)

Year	Estimates from projection	Estimates from larval surveys	% difference
1976	155 x)	119	30
1977	180 x)	155	16
1978	271	230	18
1979	442	255	73
1980	508		

x) From previous Working Group reports.

In evaluating the results of the spawning stock biomass estimate by projection, the following points have to be considered:

1) The year class 1977 as estimated by the IYHS as 1-ringed fish is very weak and by far the lowest on record in the history of the survey. One reason could be the unusual temperature regime in the North Sea during the survey period, which resulted in a change in the distribution pattern of 1-ringers towards areas which are not sufficiently covered by the survey and thereby may have introduced a bias to the estimate of recruitment.

The reported catch of 1-ringers in 1979 (1977 year class) is at the same order of magnitude as in the preceeding three years and consequently fishing mortality on this age group in 1979 is higher than estimated for these years. This fact could support the doubts about the size of the 1977 year class as estimated from the survey. On the other hand, it is stated in the report (para. 3.1.1) that in the years prior to 1979 reporting of by-catches has been incomplete which led to the conclusion that fishing mortality on 1-ringers in those years must have been higher than previously estimated and probably would have reached a level close to that estimated for 1979.

In order to evaluate the magnitude of a possible bias, one could assume the 1977 year class to be of the same order as the lowest otherwise on record in the survey which would result in an increase of the 1980 spawning biomass estimate by about 8% over the estimate given in the table above.

If one assumes that fishing mortality on 1-ringers in 1978 would be higher, e.g. about 0.3, which is still below the level of 0.49 estimated for 1979, then the estimated spawning stock biomass would be about 6% lower for 1979 and 1980 compared with the figures given in the table above. Assuming a similar F on 1-ringers for 1977 and 1976 would reduce the estimates of the spawning stock biomass even further. In this context it should be noted that due to the by-catch regulation a considerable amount of adult herring taken as by-catch in the fishery for demersal species has been discarded in 1979, generating additional fishing mortality. The quantities involved are not known, but it would lead to an additional reduction of the spawning biomass estimate.

2) The basic assumption made in the projection is that the recruits as estimated from the IYHS are remaining in the North Sea throughout their lifes. That means that no account has been taken for the Division VIa recruits, which are known to occur in the juvenile fishery and in the survey area, and which are expected to withdraw from the North Sea before they spawn. Thus, the spawning biomass estimate contains a component of herring which does not contribute to the actual spawning in the North Sea, but the quantities cannot be assessed at present, and may vary from year class to year class. It is clear, however, that considering any emigration out of the North Sea in the projection would further reduce the estimated spawning biomass.

In the light of the qualifying explanation given above on the spawning biomass estimate by projection, these estimates are likely to be overestimates of the stock actually spawning in the North Sea. This is apparent when comparing these results with the spawning stock biomass figures derived from larval surveys which are supposed to estimate the true North Sea spawning biomass. It has been suggested in Section 3.5.2 that the larval survey estimates from 1979 may be an underestimate, so the Working Group could only conclude that the true spawning stock biomass in 1979 was probably somewhere between the upper and lower estimates of 255 and 442 thousand tonnes given in the text table above, and the projection would indicate a further growth of about 15% between 1979 and 1980.

The biological criteria for re-opening a herring fishery as outlined in Section 2.1 is that the spawning stock should be rebuilt to the lower level of its optimal range, which has previously been defined to be 800 000 tonnes. The Working Group could find no reason to deviate from

from this management objective. Although continuous rebuilding of the spawning stock has taken place in recent years, the spawning stock biomass in 1980 is still far below the level of 800 000 tonnes, and recent recruitments for which estimates are available are at a low level. The Working Group cannot therefore suggest that ACFM should revise its previous advice on North Sea herring for 1980. Re-opening the fishery in 1980 would reduce the spawning stock and would also reduce the contribution to the spawning stock in 1981 of the 1978 year class. Under these circumstances, the probability that the recovery of the stock will not continue and the stock will remain at dangerously low levels cannot be excluded.

In the present situation, it would be premature to give advice for 1981 since the results of the 1980 larval survey and the 1981 young herring survey are of vital importance for the assessment of spawning stock biomass and recruitment in 1981. It can only be advised that a directed fishery should not be allowed in 1981 before the results of these surveys are evaluated.

Since the stock components of the North Sea herring may be recovering at different rates and since the level of recruitment to these components may differ, re-opening of the total North Sea herring fishery may prevent one stock from recovering while another may remain lightly fished, depending on the distribution of fishing effort. The Working Group therefore recommends that the fishery should not be re-opened until detailed consideration has been given to the way in which the re-opening should be carried out. This should include the assessment of the appropriate duration, location and level of exploitation in the fishery, bearing in mind the need to allow for continued growth of the North Sea stock as a whole, even if there are errors in the assessment.

Three members of the Working Group, Messrs. A Corten, J Massé and A Maucorps, could not agree in the management advice given above, and their views are given in Appendix 2.

4. HERRING IN SKAGERRAK AND KATTEGAT (Division IIIa)[1)]

4.1 Stock Composition

4.1.1 Material

Samples of herring for stock separation are regularly undertaken in Denmark and Sweden. The analysis includes meristic characters (VS, K_2), length measurements, otolith measurements, and electrophoresis on muscle, heart, eye and liver. Some of the material is presented in the report of the Working Group on Division IIIa Stocks (C.M.1980/G:3), but most of it is undergoing a more thorough analysis at the moment. Otolith length measurements seem to be a useful method to separate spring spawners from autumn spawners.

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1) Owing to the fact that these basic data (catch figures and age compositions) from one important fishing country in this area were not made available prior to the meeting to the person responsible for the preparatory work for this section, and since the time schedule was rather tight, it was not possible to have a final draft of the text for this section and the final calculations during the meeting. - It is, however, hoped, that the text to a sufficient extent reflects the discussion in the Working Group.

4.1.2 Herring otolith studies

Following a recommendation by the Division IIIa Working Group last year an Otolith Workshop was held for two days at Lysekil (Sweden) during September 1979. Because of the short time available, attention was exclusively focused on an examination of the size of the first growth zone, both in samples of pure spring and autumn spawning herring from various localities, and in samples of juvenile herring caught within Division IIIa. Each otolith was measured along the axis rostrum-post rostrum, and in all but one case a significant difference was demonstrated between spring spawners and autumn spawners. A component of herring having large first growth zones similar to those in herring spawning in autumn both in the northern and central North Sea was found in a number of samples of 1-ring herring from the Skagerrak. This component was, however, virtually absent from both the 1- and 2-ring herring examined from the Kattegat and in 2-ring herring from the Skagerrak. A summary of the results was presented to the 1979 Statutory Meeting of ICES (Doc. C.M.1979/H:66). An extensive analysis of additional material at the Swedish Research Institute in Lysekil has been conducted since the Otolith Workshop, but unfortunately the results were not available at this meeting of the Working Group.

A brief examination was carried out by the Division IIIa Stocks Working Group into the appearance and size of the otolith nucleus in samples of herring from the North Sea and Division IIIa collected during the 1980 IYHS. Some differences in the proportions of otolith with an opaque type of nucleus were detected between the two areas, and in addition there seemed to be some difference in the hyaline nucleus size. However, due to opaque overgrowth no precise measurement could be made. This could, however, be achieved if the overgrowth was removed by grinding (Postuma, 1974).

The Working Group recommends that the measurement of the first growth zone should be continued and an investigation initiated into the size of the otolith nucleus in herring caught within Division IIIa and in samples of herring in spawning condition both within Division IIIa and adjacent areas. It must also be stressed that meristic characters are essential for all herring included in these investigations.

In view of the interesting results obtained from the examination of the otoliths of 1-ring herring made by the Otolith Workshop it is also recommended that an analysis should be carried out on the length distributions of 0-ring herring in Division IIIa and adjacent areas.

A second Workshop should be arranged in 1981 in order to fully evaluate the results from all these investigations.

At present it appears from meristic characters that adult North Sea herring are virtually absent from Division IIIa, in which the Skagerrak had in certain periods been an important over-wintering area. A limited immigration from the southern Baltic has been shown by tagging experiments (C.M.1980/G:3), but, based on meristic characters, this stock cannot be distinguished from the Kattegat spring spawners. Thus, the spring spawning stocks make up the bulk of the adult herring stock in Division IIIa at present.

4.2 The Fishery in 1979

4.2.1 Catch data

The herring landings during the last decade are shown in Table 4.1 for the Skagerrak and Kattegat, respectively. The preliminary landing figures for 1979, which are unlikely to be subject to any significant future corrections, show a decrease in both areas compared with 1977 and 1978. The decreases are undoubtedly due to the restrictive TACs of 10 500 tonnes for the Skagerrak and 35 000 tonnes for the Kattegat. Even though these resulted in long periods with a ban on directed fishing for herring (Denmark: 154 days, Sweden: 130 days in the Skagerrak, 28 days in the Kattegat), the TACs were exceeded by 59% and 33% in Skagerrak and Kattegat respectively. In 1978 an agreed TAC of 64 500 tonnes was also overfished, but with only short periods of closure.

Because of the quotas and the minimum landing sizes of 20 cm and 18 cm in the Skagerrak and the Kattegat respectively, a certain amount of discarding at sea is bound to have taken place.

The only - and indirect - estimate of the discards that can be made at present is based on landings in a harbour in the southern Kattegat which receives about 50% of the total Danish herring landings from the Kattegat. In this case the catch is landed untreated and sorted into market categories by land-based sorting machines. In 1979 the "discards" from this sorting process amounted to 4.1% of the total landed in that harbour.

This must probably be regarded as an underestimate of the discard rate for the entire Division IIIa. Many of the bigger vessels have sorting machines on board in order to sort the catch into market categories before it is stored in boxes with ice. In order to increase the value of the landed herring under a restrictive quotum,part of the smallest market category may be discarded together with unmarketable fish.

In the case of Swedish trawlers the discards were thought to be about 10% of the catches. In order to make a reasonable correction for discards the recorded landings of herring by-catch from sprat landings and unmarketable fish from directed herring fisheries (total: 7 839 tonnes) were doubled to about 16 000 tonnes. The total catch figure for 1979 would then be about 73 700 tonnes.

4.2.2 Catch in numbers by age

Not all national fisheries in Division IIIa were covered by adequate sampling for age distribution and numbers per unit weight landed. In such cases samples from fisheries in the same area and period, and carried out with the same gear, were applied.

Swedish trawl catches in the Skagerrak were thus apartioned according to Danish trawl samples, Faroese purse seine landings according to Norwegian purse seine samples and Danish consumption landings in the Kattegat according to Swedish trawl samples. The results are shown in Table 4.2 and as input figures in Table 4.3. Compared with earlier years the much lower numbers of 0- and 1-ringers caught are the dominant feature in 1979. This is attributable to the ban on industrial fishery for herring, the minimum landing sizes and partly to the relative weakness of year class 1978 (1-ringers). It is noted that the above-mentioned correction for discards at sea is included as the last column in Table 4.2.

4.3 Biomass Estimates from Acoustic Surveys on Herring Stocks in 1979 and 1980

An acoustic survey was carried out in Division IIIa during September 1979 in accordance with a recommendation by the Working Group (Doc. C.M.1979/H:6, p.11). The preliminary results were presented to ACFM at the 67th Statutory Meeting of ICES.

The results were also discussed at this year's meeting of the Working Group on Division IIIa Stocks. The Group accepted that the survey provided a reasonable estimate of herring stock size within Division IIIa.

The present Working Group discussed the reliability of acoustic estimates in several connections, and some members expressed severe doubts about the factors used to convert integrated echo signals into biomass.

The conversion factor used in the September survey is taken from Hagström et al. (1979).

The results of their estimates of the conversion factor show a range of 15-20 tonnes per square nautical mile and mm using different methods. A value of C = 15 tonnes/Nm^2 and mm was chosen as the best estimate and this was found to be in good agreement with the results obtained in the Baltic corrected for different hydroacoustic conditions in the different areas.

A total herring biomass of 277 x 10^3 tonnes was estimated for the area covered by the survey being 40% of the total area. Fish traces below 100 m and near to the bottom as well as near to the surface were not integrated. During the last part of the survey, weather conditions were furthermore unfavourable for acoustic work, which may have led to underestimates of the biomass covered during this period.

For these reasons the estimate of total herring biomass in September 1979 would have been at least 300 x 10^3 tonnes, if the value of C is approximately correct. This is twice the biomass estimated by a survey of the same area at the same time in 1976.

Many samples were received from trawl hauls carried out both by the Swedish research vessels and by a chartered team of Danish pair trawlers.

The calculated stock composition in numbers x 10^{-6} of the estimated total biomass based on the results of these surveys in September 1979 are given in the text table below.

0	998.8
1	1 010.8
2	1 638.8
3	116.6
4	14.3
5	4.7

More details on the survey are presented in the report of the Working Group on Division IIIa Stocks (Doc. C.M.1980/G:3).

A recent acoustic survey carried out in March 1980 gave a herring biomass estimate of 30 - 40 000 tonnes.

According to length measurements based on 3 pelagic hauls, the 1-group herring dominated and were confined to the Kattegat area. This estimate of 40 000 tonnes was converted to number by applying mean number per kilogramme (29.3) of herring obtained in IYFS surveys carried out one month earlier. This gave a total of 1 172 x 10^6 herring in the area. According to length measurements 80% or 937.6 x 10^6 were 1-group herring.

This estimate is, however, very uncertain. The cruise track consisted only of two lines through the eastern Kattegat and the allocation of the measured biomass on sprat and herring is only based on 6 hauls.

4.4 Recruitment

4.4.1 Estimates from IYFS

Young herring surveys have been carried out since 1972 in the Skagerrak and the Kattegat. The abundance indices of 1-group herring so obtained are shown in the text table below.

Year	Abundance indices 1-group herring
1972	78
1973	181
1974	726
1975	455
1976	1 339
1977	204
1978	575
1979	3
1980	504

The abundance index of 1-group herring in 1980 is very close to the mean of 508 for the years 1972-78, which would indicate that this year class is of average strength. It should be noted that the indices include both spring and autumn spawned progeny as no clear distinction between these has been possible as yet. The heaviest concentrations of 1-ringers in 1980 were, however, encountered in the southern part of the Kattegat, where meristic characters and mean length indicate a predominance of spring spawners amongst the 1-ringers.

4.4.2 Estimates from acoustic surveys

The 1979 year class estimated at average strength in the IYFS in February 1980 was also estimated in the September 1979 survey. The September estimate of 1 000 x 10^6 is certainly an underestimate not only for the reasons set out in Section 4.3 but also because the main part of the O-group in September is still confined to shallower areas than those covered by the survey. The Working Group therefore agreed that the O-group in 1979 was best estimated from the results of the IYFS, i.e. an average year class.

The 1978 year class, which was virtually non-existant according to the results of the IYFS in 1979, proved reasonably abundant in the September survey. Compared with the strength of the same age group in the acoustic survey in 1976 (year class 1975), year class 1978 is 3-4 times less abundant.

4.5 Stock Sizes

4.5.1 Virtual population analysis

As shown in Table 4.3 numbers per age group could be accumulated for the entire Division IIIa only back to 1974, while similar data exist since 1970 in case of the Kattegat.

The age distribution as biomass in numbers obtained by the survey in September 1979 was chosen as a basis for a first estimate of fishing mortalities in that year. The stock at 1 January 1980 was calculated by applying 4/12 of the natural mortality to the survey figures and subtracting the numbers caught at age for the period September-December 1979.

Introducing the stock in numbers so obtained in a cohort analysis gave an F-array for 1979 which was applied as input in a VPA. The calculated numbers of 0-group showed, however, that year class 1977 came out as the strongest on record (6.6×10^9). Considering the reliability of the acoustic survey and taking account of the general uncertainties in the conversion factors used on the survey, the Working Group could not accept a year class strength for year class 1977 so much above the average. The Working Group therefore agreed to set the year class 1977 at the same strength as year class 1974, i.e. 5.8×10^9 0-group herring. The acoustic estimate of the older year classes were adjusted accordingly.

Applying this figure and information on other year classes set out in the previous section gave the array of fishing mortalities shown together with other input data in the text table below:

W.R.	0	1	2	3	4	5	6	7	8
M	0.30	0.25	0.20	0.10	0.10	0.10	0.10	0.10	0.10
F_{79}	0.10	0.20	0.40	0.70	0.70	0.70	0.70	0.70	0.70
$\overline{W}$ catch	12	65	79	140	196	218	241	275	295
$\overline{W}$ stock	-	-	-	116	175	205	225	255	275

The assumed F on 0-ringers of 0.1 in 1979 resulted in a year class strength slightly above the average for 1974-76.

The calculated fishing mortalities are shown in Table 4.4. They are exceedingly high in 1974-77, when the VPA estimates are reasonably stabilised, but characterised by large variations both within age groups and years. The calculated fishing mortalities for 1979 show a decline from those in 1978 of 67% for the weighted means of older fish and of 49% for unweighted means of all age groups.

A decline in F is corroborated by the reduction in effort which must have taken place in 1979 because of the extended periods with a ban on directed fisheries (see Section 4.2.1).

The calculated spawning stock sizes are shown in Table 4.5. They are surprisingly small compared with the nominal landings in the same period.

4.5.2 Prognoses

Based on the corrected catch in numbers in 1979 and the fishing mortalities derived for that year, a number of prognoses were run for 1980 and 1981 under different assumptions of the catch levels in 1980 and assuming that the corresponding F values would be maintained in 1981. The results are shown in the text table on the next page in order to illustrate the theoretical development in catches and spawning stock sizes.

Target catch in 1980 (in tonnes)	Generated F in 1980 3 years and older	F_{80}/F_{79}	Calculated catch in 1981 (in tonnes)	Calculated spawning stock in 1982 (in tonnes)
40 000 (TAC)	0.17	0.243	62 091	442 000
50 000	0.21	0.300	75 555	417 000
60 000	0.26	0.371	88 438	391 000
70 000	0.31	0.443	100 491	367 000
139 000	0.70	1.000	163 913	228 000

Considering the very large reduction in fishing mortality from 1979 to 1980 (about 75%), if only the TAC is taken, the Working Group decided to run two full prognoses: one based on the assumption that only the TAC is taken in 1980 and another where the reduction in F_{80} is only half that amount i.e. $F_{80} = \frac{0.17 + 0.70}{2} = 0.44$ or $F_{80}/F_{79} = 0.629$.

The calculated catch in 1981 and the spawning stock biomass in 1982 for an array of F_{81} values relative to F_{79} is shown in Figure 4.1.

4.6 State of the Stock and Management Advice

4.6.1 State of the stock

The spawning stock sizes calculated from the VPA (Table 4.5) are very low in all the years 1974-79, especially considering the nominal landings in the same period.

It appears, however, that even the lowest stock estimated at about 10 300 tonnes in 1976 was able to produce a year class of reasonable strength and that the stock in 1977 estimated at about 15 600 tonnes produced the relatively strong year class which will enter the spawning stock in 1980 and possibly increase it to about 138 000 tonnes.

This very significant increase is solely due to the high number of 3 years old recruit spawners of year class 1977 which account for about 123 000 tonnes of the calculated spawning stock in 1980. The 1977 year class as 0-group is only estimated as being slightly above average strength. Its high value as recruit spawners must therefore be seen against the background of the regulations introduced in 1978 and 1979. The ban on directed fishing for industrial purposes, minimum landing and mesh sizes, together with by-catch restrictions, have reduced the fishing mortality of the youngest age groups significantly, while an overall reduction in F would accrue from the restrictive TAC in 1979.

It is, of course, an absolutely necessary assumption that the year class 1977 stays in Division IIIa and does not contain significant components which would leave the area and spawn elsewhere. Almost all samples of the year class collected in 1979 show, however, the very low mean K_2 and VS values which characterise the local spring spawning stocks. An emigration from Division IIIa to the western Baltic cannot be excluded but tagging experiments tend to indicate that young Rügen herring stay within the Baltic and only adult fish penetrate the Sound and Belt Seas on a northern feeding migration in summer.

One feature which caused deep concern at last year's meeting both in the Working Group and in ACFM was the alarmingly low abundance index of year class 1978 obtained by the IYFS in 1979 (see text table, Section 4.4.1). The later estimate from September 1979 is more optimistic and indicates the strength to be 25-30% of an average year class. Due to the reduced catch rates of the younger age groups the year class 1978 should, in fact, be above average strength as 2 years old in the stock at the beginning of 1980.

The estimated size of the latter is shown in the text table below.

W.R.	Stock in no. x 10^{-6}	Stock in tonnes
0	(5 000)	-
1	3 718	96 700
2	667	40 000
3	1 063	123 300
4	65	11 400
5	12	2 500
6	4	900
7	+	+
Total	5 530	274 800

There are indications of an increase in stock size in Division IIIa herring:

(i) Despite the prolonged bans on directed fishing the TAC for Kattegat was exceeded by about 33%.

(ii) The Danish Kattegat landings in the 1st quarter of 1980 exceeded those of 1978 with about 20% though the fishery was only open 34 days.

4.6.2 Managament advice

The Working Group, taking everything into consideration, thought that the biomass of Division IIIa herring has increased in 1979 and that the spawning stock is likely to increase considerably in the next two years. On this basis, the TAC of 40 000 tonnes agreed upon for 1980 appears to entail a reduction in F which is so large that a revision of this TAC should be considered.

In case of the TAC for 1981, the Working Group could not agree upon a firm statement but will recommend that a decision is not taken before a further survey in September 1980 has been carried out. The strength of the 1979 year class is of vital importance for projections of catch in 1981 and spawning stock in 1982.

The Working Group also wants to point out that the calculations carried out in the present report strongly underline the importance of keeping the exploitation of the youngest age groups at the lowest level possible. In this connection it would reiterate its recommendation from last year's meeting: that the minimum mesh size in herring fisheries in Division IIIa should be increased from the present 32 mm to 36 mm.

5. CELTIC SEA HERRING

5.1 The Fishery in the 1979/80 Season

5.1.1 Introduction

The prohibition of herring fishing in the Celtic Sea, which was first recommended by the 1976 Working Group was introduced in 1977/78. This prohibition was continued during 1978/79 and 1979/80. In addition to the prohibition on herring fishing ACFM also recommended that the landing of by-catches of herring from this area is also prohibited. ACFM further recommended, in 1979, that the prohibition should remain in operation during the 1980/81 season.

5.1.2 Catch data

In spite of the complete prohibition on fishing, however, considerable catches have been made each season since the initial closure. These catches have mainly come from a directed Irish trawl and drift net fishery and from herring reported as by-catch in the Dutch and French mackerel fisheries. The total catch taken during 1979/80 amounted to about 4 200 tonnes, which was about 10% higher than in the previous season. However, the total figure may, in fact, be underestimated because of inadequate statistics about the Dutch catches taken from around Ireland. The catch data from the Celtic Sea fishery for the years and seasons since 1970/71 are given in Tables 5.1 and 5.2. The 1979/80 figures are provisional, and some very slight alterations have been made in the 1978/79 figures quoted in the previous report.

5.1.3 Catch in numbers by age

The age composition of the total catch in 1979/80 was calculated from Dutch and Irish data, using the same procedure as adopted in previous reports. It was not necessary to make any alteration to the 1978/79 figures. The age composition of the catches since 1970/71 are given in Table 5.3.

5.2 Herring Surveys

During 1979/80 an Irish trawl and echo survey, using two commercial fishing vessels, was carried out during December and January. The purpose of this survey was to provide 1) information on the abundance of shoals on the spawning grounds, 2) information about the duration of the spawning season and 3) samples for biological examination. During the survey shoals of herring were located on a number of occasions and, in general, shoals seemed to be considerably more abundant than those located during a similar survey during 1977/78. While dense concentrations were located in mid-December and at the end of January on the spawning beds along the southeastern Irish coast, shoals were completely absent from those spawning beds situated along the western edge of the Celtic Sea. It must also be remembered that the survey did not take place when the main spawning occurred in October/November (as shown from the larval surveys of 1978/79 and 1979/80). Although it was not possible to quantify the amounts of herring observed during the survey all "traces" of herring recorded have been retained and will serve as a basis for comparison for future surveys. However, the results obtained during 1979/80 would indicate that considerably more herring were present than in recent seasons.

In addition to the above survey, airborne remote sensing trials, using low light level television, were carried out over the spawning areas for one week during December 1979. This survey was conducted in conjunction with the two vessels engaged in the trawl survey which were used to verify fish shoals detected from the air. Although herring shoals were successfully located the incidence of aerial sighting was low because of low phytoplankton biomass levels and unfavourable conditions for imagery observation and interpretation.

The larval survey initiated in the spawning period of 1978/79 following a recommendation from the 1978 Herring Assessment Working Group was repeated in 1979/80. The larval abundances were as follows:

Cruise mid-date	Days from 31/9/79	Abundance of larvae (x 10^{-9})		
		<10 mm	10-15 mm	>15 mm
2/10/79	32	0.27	0	0
16/10	46	9.49	19.71	2.11
31/10	61	31.20	35.43	3.49
31/11	74	5.02	26.71	8.75
5/12	96	1.53	12.97	26.57
3/1/80	125	2.71	11.99	8.05
16/1	138	0.90	10.70	4.63
5/2	158	[0.44]	[2.48]	[0.15] x)
13/2	166	0	3.41	2.51
27/2	180	0.63	0.53	3.24

x) Poor coverage.

Normal distribution curves fitted to the abundances of <10 mm larvae show the autumn larval production in 1979 to have been 11% higher than in the previous year though the 1979 season was shorter (Figure 5.1). However, the decline of the winter spawning component has continued and in 1980 its larval production (which was too small to allow a normal curve to be fitted) was estimated to be only 28% of the previous winter production by integrating the abundances for 15-day periods (Van den Kamp, 1976).

The proportions of the stock biomass attributable to the autumn and winter spawning components in 1978/79 calculated from the areas under the larval production curves and the different fecundities (1979 Working Group report) were 64% autumn spawners and 36% winter spawners.

The plots of the abundances of 10-15 mm and >15 mm larvae (Figures 5.2 and 5.3) show markedly higher abundances in 1979/80.

5.3 Young Herring Surveys

A young herring survey was conducted in the northwestern section of the Irish Sea in July 1979 and again in February 1980. Molloy and Corten (1975) suggested that yearly trawling surveys in this area might provide a reasonably good forecast of recruitment to the Celtic Sea stock. Considerable quantities of both 0 and 1 group herring were located during the July survey, and although direct comparisons with similar cruises conducted in this area in 1972-75 were not possible, it was concluded that young herring were more abundant in this area in in 1979 than in 1972-75. The results of the survey carried out in February 1980 have not yet been examined, but the abundance was considerably lower than in July 1979. The herring examined from the July 1979 survey had very high vertebral counts (56.89 for 0 group and 56.95 for 1 group), which would indicate that they belonged to a winter spawning population. It is not, however possible to say whether they belong to the winter spawning population of the Celtic Sea or to a small stock, which is believed to spawn in January and February in the northwestern Irish Sea.

5.4 Recruitment

Although young herring surveys have been initiated there is still no method available for estimating the recruitment level in the Celtic Sea stock. It does not seem possible to draw any conclusions from the catches in numbers per age group data, about recent trends in recruitment although it could be suggested that there are increased numbers of young fish present (·1-3 groups) during 1979/80. However, this could be due to changes in fishing pattern rather than to increased abundance. It was obvious during the trawling survey in January 1980 that considerable quantities of 1-group herring were present along the southeastern Irish coast. It must also be pointed out that the cessation of the industrial fishery in the Irish Sea in 1979 may also result in an increased survival of young fish and produce an improved recruitment level.

5.5 Estimates of Fishing Mortality

In the years prior to the closure of the fishery in 1977 the only direct mortality estimates for Celtic Sea herring were those derived from Irish catches per unit effort. However, since the closure of the fishery, catch per effort data cannot be used to estimate mortality rates. The 1979 Working Group considered that F in 1978/79 was about 0.80, because it was thought that there had been a considerable rise in effort by the Irish fleet during that season. However it was not then realised that the boats were operating under a severe quota system with the result that effort and consequently F were greatly over-estimated. The effort in 1979/80, when trawling was confined to a short period, would appear to be slightly lower than in 1978/79. In the absence of proper estimates of F, the 1979/80 catch in number data were subjected to a range of F values: 0.2, 0.4, 0.6 and 0.8, in an attempt to calculate stock sizes. An examination of the weighted mean F values obtained indicated that there has been a considerable reduction in F since the closure of the fishery in 1977. Furthermore, the yearly values obtained as a result of F input = 0.4 (Table 5.4) seemed the ones which would most likely reflect the level of effort discussed above. This value of F = 0.4 was therefore considered to be the most accurate one to indicate the level of exploitation since 1977. Calculated stock sizes back to 1973 are given in Table 5.5.

5.6 State of the Stock and Management Advice

If we apply F = 0.40 to the 1979/80 catch in numbers per age group, the calculated stock size at 1 April 1980 is approximately 13 000 tonnes. On the assumption that recruitment during 1980 remains at the very low level used by the 1978 assessment group of 30 million fish and that catches in 1980/81 are again about the level of recent years, then the F generated will be 0.30 and the stock size at 1 April 1981 will be about 14 000 tonnes. If, on the other hand, we assume that recruitment will increase to a level of about 60 million fish, the stock size at 1 April 1981 will be around 18 000 tonnes. (For details of prognosis see Table 5.6.)

The mean weights used in estimating catches in this prognosis have been altered from those in recent assessments, because the fishery is now almost completely carried out in the autumn-winter period. The mean weights used are those derived from Irish data for this period.

The 1979 assessment group concluded that, because there was no direct evidence on the value of fishing mortality in 1977-79 and no information on recruitment levels, it was impossible to make any accurate estimate of stock size for the Celtic Sea. The absence of similar data for 1979/80 further aggravates this situation. The defined management objective for this stock is to rebuild it to a level of 40 000 tonnes, and it has been recommended that the fishery should remain closed until this level has been attained. This desired stock level was defined by the 1976 Working Group as 1/3 of the stock size in a period of light exploitation.

However, the 1977 Working Group (C.M.1977/H:3) stated that if the proportion of the autumn spawning stock increased in the catches it would affect future management policy. The management level of 40 000 tonnes stock had, however, previously been defined by the 1976 Working Group (C.M.1976/H:2) but had been estimated from a period when the fishery was based almost entirely on a winter spawning component. At the moment the autumn spawning component appears to (based on data from the larval surveys) constitute over 64% of the total Celtic Sea stock. Therefore it is possible that the desired stock level of 40 000 tonnes may not be the most realistic level at which to aim. However, at the moment, because of the closure of the fishery and the lack of information about stock sizes and mortality rates, it is not possible to redefine a desired stock level for this stock.

It is apparent that with 1) a constant F = 0.4, 2) catch levels of approximately 3 700 tonnes as in recent years and 3) a recruitment level of 30 million fish the stock will continue to increase although at a very slow rate. However, a failure of recruitment at this low stock level ($\simeq$ 14 000 tonnes) would seriously endanger the eventual recovery of the stock. Section 2.1 of this report, which deals with the biological criteria for re-opening herring fisheries, states that the spawning stock should be rebuilt to the lower level of its optimal range in order to ensure the future of the stock and a viable fishery. It also states that a very limited fishery could be allowed if there is evidence of a recovery of the spawning stock and of improved recruitment to ensure the rebuilding of the stock to the desired level.

The present analysis of the stock indicates that it may have increased from 6 000 tonnes in 1977 to about 14 000 tonnes in 1980. This estimate is, however, completely dependent on the rather uncertain assumption that F = 0.4 in 1979.

There is considerable evidence from the trawling survey that the number of shoals frequenting the spawning grounds in 1978/79 was considerably more than in 1977/78 (Molloy, in press), while evidence from the larval survey suggests increased production by the autumn spawning component of about 11%. Evidence about the possibility of increased recruitment has been commented upon in the relevant section and the indications are that both the 1977 and 1978 year classes may make significant contributions to the adult stocks.

However, because of the lack of firm evidence about increased stock sizes and about improvement in recruitment level, the Working Group cannot estimate to what extent a recovery takes place. In these circumstances it would seem inadvisable to recommend a re-opening of the fishery in 1981. The Working Group would strongly recommend that all possible information should be obtained immediately to enable a better estimate of current stock size and recruitment level. However, one member of the Working Group, Mr Molloy, considered that, at the moment, there was insufficient biological evidence to justify a continued closure of the fishery and consequently recommended that a limited fishery, with catches of about 4 000 tonnes, be allowed in 1980/81.

6. WEST OF SCOTLAND HERRING (Division VIa)

6.1 The Fishery in 1979

6.1.1 Catch data

The total catches reported by each country in Division VIa (excluding the Firth of Clyde) for the period 1970-77, together with the revised catches for 1978 and preliminary estimates of catch taken in 1979, are given in Table 6.1. As in previous reports, estimates also include the weight of herring taken as a by-catch in the fishery for sprat in the Moray Firth. The final figure for catch in 1978 is approximately 2 000 tonnes greater than the preliminary estimate reported in 1979.

The preliminary catch in 1979 (6 028 tonnes) is greatly reduced from the total for the previous year because of the observance by most countries of the ban on herring fishing within Division VIa, excluding the Clyde. The major proportion of the catch that was taken came from the area to the northwest of Ireland, and the bulk of the remainder as by-catch from the mackerel fishery.

6.1.2 Catch in numbers by age

Estimates of the number of autumn spawning herring per age group caught in Division VIa (including the Moray Firth) in each of the years 1970-79 are given in Table 6.2. The figures for 1978 have been amended using revised catches.

In 1979 2-ringed fish (1976 year class) provided the most important component of the catches comprising nearly 50% of the catch in numbers. Fish of 3 rings old and older comprised approximately 40% of the total, and the remainder was almost equally divided between 0-ringed and 1-ringed fish. The exceptionally low proportion of 0- and 1-ringed fish in the catch in 1979 as compared with previous years was as a result of a very poor sprat fishery in the inner Moray Firth, where in recent years most of the catch of herring of these ages has been taken as a by-catch.

6.2 Age Composition

Age compositions of the stock in Division VIa during 1979 were available from samples taken in the fishery in the southern part of the Division and from research vessel sampling during the acoustic survey. Values for the former are given in the catches in number in Table 6.2, and these are expressed as percentages in the text table below. Overall values from the aoustic survey are also given in this text table, which includes data from the Minch, the St. Kilda and North Rona areas. There is good agreement between the two sets of data, and together they indicate a strong predominance of 2-ringers (1976 year class).

Percentage age compositions of herring in Division VIa in 1979

Age(rings)	Year class	Fishery data	Acoustic survey-Jul-Aug
0	1978		-
1	1977	6.2	9.4
2	1976	50.9	54.7
3	1975	15.6	16.8
4	1974	10.6	9.6
5	1973	5.9	8.9
6	1972	4.1	0.3
7	1971	2.3	0.3
8	1970	2.1	-
≥9	1969 + earlier	2.3	+

6.3 Immigration to Division VIa from Sub-area IV

It has for some years been accepted that a proportion of the recruitment to Division VIa originates in nursery areas in the eastern North Sea. At the previous Working Group meeting, a model taking this immigration into account based on parasite tag data was presented, but the Working Group considered the evidence too uncertain to use the assessment based on it. At the present meeting, further documentation of the evidence was provided and the Working Group agreed that it supported the case for believing that some migration takes place at the youngest ages. They continued to feel, however, that the data base was inadequate to quantify the emigration rate at each age over a sufficiently long period. They were therefore unable to use the data in their assessment of the Division VIa stock.

From the results of previous VPAs carried out on Division VIa catches in number given in previous reports, it was clear that the adult value of F was in most years reached on 3-ringers and older. This gave no indication, therefore, of any substantial immigration after this age was reached.

The relative F on 2-ringers varied between years, which indicates that immigration could take place at that age but to a variable extent.

6.4 Recruitment

Owing to the lack of reliable indices of year class strength from young herring surveys in Division VIa, and because the fishery for sprat in the Moray Firth in 1979 (in which juvenile herring attributed to Division VIa are taken) was very erratic in that year and so could not act as indication of year class strength, little information was available about the strength of this year class. However, the strength of the 1977 year class as 0-ringers in the Moray Firth sprat fishery in 1978 was at a very much higher level than in any year since 1974. This year class was also relatively abundant in the northwestern North Sea in 1979, as measured by the International Young Fish Survey. On the basis of this rather inadequate evidence it seems that the 1977 year class is at least unlikely to be a very weak one.

6.5 State of the Stock and Management Advice

6.5.1 Larval surveys and estimates of spawning stock

The herring larval surveys in Division VIa in 1979 provided the only available data from which to estimate the size of the spawning stock (2-ringers and older). Although previous attempts to fit regression lines of spawning stock size on larval abundance indices had suggested a lack of any clear relationship, at least when the immigration from Division IVa was ignored, the Working Group had little alternative but to use this approach if they were to provide any quantitative assessment of this stock.

The larval abundance indices used are based on those published annually and summarised by McKay (C.M.1978/H:50 and C.M.1979/H:37). However, to ensure comparability throughout the series, two adjustments were made to the published series. The value for 1972 was reduced to correct for the high value on the English survey which may have been caused by more efficient sampling of very small larvae mentioned in relation to the North Sea in Appendix 1. Secondly, the values for 1975 and 1976 were adjusted by subtracting the contribution to the index made by stations to the south of the Division VIa boundary.

The larval abundance index for 1978 was published by McKay (C.M.1979/H:37), and it should be re-emphasized here that it is based on a single very incomplete survey in the southern part of Division VIa.

For 1979, the results of Scottish larval surveys were available. One in the southern part of the Division in mid-September was very incomplete and was therefore omitted. On the second survey of this area from 27 September to 6 October, one very high value was recorded off the coast of northwest Ireland. In conformity with the procedure used in a similar situation in the North Sea on the 1978 surveys, this value was reduced by a factor of 10. Stations south of the Division VIa boundary were also excluded from the estimate.

The data base on which the annual indices are based, given in Table 6.3, indicate a large increase in 1979 in larval abundance in the southern area and a more moderate increase in the north.

Spawning stock sizes (2-ringers and older) were obtained from the stock in number at 1 January each year derived by VPA and given in the previous report (C.M.1979/H:6, Table 4.10). To obtain the spawning stock at 1 September, 2/3 of the annual value of M + F were applied to the stock in number and weights at age given in Table 4.11 of that report were used.

A functional regression of spawning stock size on larval abundance index was fitted to the data for the years 1972-77. The regression described by the equation:

$$\text{spawning stock } (t \times 10^{-3}) = 0.21 \text{ larval index} - 78.49$$

is significant at the 5% level (Figure 6.1). Although it shows a large negative intercept on the y axis, this does not rule out its usefulness for predictive purposes, when the value of larval abundance used as a predictor lies well within the range of values on which the regression is based.

Using this regression, spawning stock sizes in 1978 and 1979 (at 1 September) are estimated to be:

1978	69 000 tonnes
1979	290 000 tonnes

This implies a very large increase between the two years. The 1978 value, however, is not only based on incomplete coverage during the larval survey, but also on the high negative intercept on the spawning biomass axis of the regression line. The magnitude of the difference between the two years is therefore subject to considerable doubt.

Using the stock prediction given in the previous report, the size of the stock in 1979 given above implies that the 1976 year class must have been larger than originally thought, constituting some 90% by number of the spawning stock. What data are available indicate that 2-ringers made up about 57% of all 2-ringers and older in 1979 (54% in the Irish Donegal fishery; 60% in the acoustic survey samples from the Minch, St. Kilda and North Rona). The above comparison therefore suggests that the larval data should be treated with some reservation.

6.5.2 Prognoses

Because of the lack of independent evidence to support the results of the 1979 larval survey, the high spawning stock value obtained should be treated with reservation in any management context. Nevertheless,2-ring recruits were clearly predominant in catches and research vessel samples in Division VIa in 1979, making up approximately 60% of the total fish of spawning age. A stock prediction has, therefore, been made from the stock in number at 1 January 1978 given in the 1979 report and the catches in number in 1978 and 1979, correcting the number of recruits of the 1976 year class such that it constitutes 60% of the spawning stock by number in 1979. This stock prediction given in Table 6.4 indicates a spawning stock at 1 September 1979 of 77 000 tonnes compared with an estimated 52 000 tonnes and 45 000 tonnes at 1 September 1977 and 1978 respectively. This is only 27% of the value estimated by the larval survey in 1979.

Using the corrected value of the stock in number at 1 January 1979 given in Table 6.4, a prognosis has been made of the mature stock $\geq$ 2-ringers at 1 January 1980 and 1981 (Table 6.5). For this purpose, the lowest recorded value has been used for recruitment of the 1977 and 1978 year classes. In 1979, values of F have been calculated from the catches in number in Table 6.2, whereas in 1980, F is assumed to be zero on the adult stock and very low (.01) on 1-ringers, in accordance with the current ban on a directed fishery in 1980.

On this basis, the mature stock at 1 January would increase from 85 000 tonnes in 1979, to 114 000 tonnes in 1980 and to 143 000 tonnes by 1981.

The above prediction is based on a lower value of spawning stock in 1979 than that indicated by the larval surveys. Recruitment values are also assumed to be at the lowest recorded level. The estimate for 1981 is therefore likely to be an underestimate.

6.5.3 Management advice

Although there is already some evidence for a recovery of the Division VIa herring stock,a conservative prediction of the spawning stock in 1981 indicates that it will not have reached the level of 200 000 tonnes at which recruitment might be expected to return to the long-term average. Furthermore, there is no firm evidence that recent recruitment is sufficiently high to guarantee that recovery to 200 000 tonnes will take place rapidly. On the basis of the criteria set out in Section 2.1,the Working Group cannot at present advise ACFM to recommend a fishery in Division VIa (excluding the Clyde) in 1981.

Nevertheless, the Working Group was unable to come to any firm conclusions about the present size of the stock on the information available. Since what little evidence there is indicates the possibility that recovery might have proceeded further than that predicted, it urges very strongly that all available effort should be used during 1980 to obtain further evidence on the size of the stock and incoming recruitment.

The following lines of evidence may be of immediate use in this context:

a) full coverage on the 1980 larval survey to confirm the results of the 1979 survey;

b) age compositions of the spawning stock from research vessel samples;

c) acoustic abundance estimates of both the adult and immature components.

6.6 Clyde Herring

6.6.1 The fishery in 1979

Catch data for the years 1969-78 are shown in Table 6.6, with a preliminary estimate for the year 1979. The preliminary catch figure for 1979 of almost 2 000 tonnes was approximately half that of the previous year because of the reduction in the TAC for this area. The directed fishery opened in June and finished in mid-October when the TAC had all but been achieved. During the fishery a quota per man per night was operated and the number of fishing nights regulated on a weekly basis in an attempt to achieve a target catch set by the Producers' Organisation.

Catch in numbers - The total annual catch in numbers at age was available for 1979 and these are given together with those for 1977 and 1978 in Table 6.7. The division into spring and autumn spawned fish based on maturity and VS data given in the previous report was not available for 1979. The figures in Table 6.7 show a marked decrease in the number of 1-ringers caught and an increase in the proportional contribution of 2-ringers (54%).

6.6.2 Tagging

The number of recaptures by area and month from a tagging experiment carried out in the Clyde in May 1979, in which approximately 3 500 externally tagged herring were liberated are shown in Table 6.8.

The recovery of Clyde tagged herring in spawning condition in September from Douglas Bank has provided clear evidence that herring from the Manx autumn spawning stock are to be found in the Clyde during the early summer. In addition, 2 returns of Clyde tagged herring in maturity stage V-VI from a known Mourne spawning ground in Carlingford Lough in September suggest that Mourne autumn spawners too may provide a component of the Clyde population. Unfortunately, maturity data are not available for the returns from the Donegal and Mayo coasts and these returns are therefore rather more ambiguous.

Because in 1979 a directed herring fishery took place in the Clyde, in Divisions VIIa and VIIb,c, but not in Division VIa (except in that area adjacent to Division VIIb,c), the returns from each of these areas may not represent the true pattern of relative movement from the Clyde. For this reason, and because the total level of returns of tags from outwith the Clyde has been at a very much lower level than from within the Clyde, these data must be treated with some caution.

6.6.3 Management advice

In the 1979 report of the Herring Assessment Working Group for the Area South of 62°N it was reiterated that because of lack of firm evidence about the origin of autumn spawning herring in the Clyde, the area should continue to be managed as a separate unit. The recent tagging experiments (the results of which have been described in this document) have not significantly changed this view, as, although some degree of affinity to adjacent autumn spawning stocks has been established, it is still not possible to make realistic quantitative allocations to these component stocks. Accordingly, it is recommended that the original advice given in 1978 to treat the Clyde as a separate unit should be adhered to. It is also still the case that the biological data provide no adequate basis on which to make an assessment of the state of the population in this area.

Accordingly, the Working Group recommends that for 1981 the TAC should be set at the same level as in 1980, i.e. 2 000 tonnes for the Firth of Clyde, which, for this purpose, is defined as that area within a line drawn from Mull of Kintyre to Corsewall Point.

7. WEST OF IRELAND HERRING

7.1 Herring in Division VIIb,c

7.1.1 The fishery in 1979

The total catch taken in 1979 from Division VIIb,c is shown in Table 7.1. The catches in 1979 were approximately 15 000 tonnes compared with 7 500 tonnes in 1978. This size in catch came almost exclusively from Irish boats. Some of these catches may have originated in the lower part of Division VIa.

Catches in numbers per age group, based on Dutch and Irish data, are shown in Table 7.2

7.1.2 Management advice

It has not been possible, because of lack of data, to estimate a stock size for Division VIIb,c. The 1977 assessment group recommended a precautionary TAC of 10 000 tonnes for 1977 for this Division to prevent a diversion of effort to the area. The catch in 1977 was approximately 13 000 tonnes. The 1978 assessment group, having done an assessment for Division VIIb,c and the lower part of Division VIa, recommended a TAC of 7 000 for 1978 and 1979.

The catch in these years was 7 500 tonnes and 15 000 tonnes respectively. ACFM in 1979 recommended a precautionary TAC of 7 000 tonnes for 1979 and 1980, because of the dangers of overexploitation.

Until more information is available about the stock size for this area, the Working Group would therefore again recommend a precautionary TAC of 7 000 tonnes for Division VIIb,c for 1981.

7.2 Herring in Division VIIj (southwest Ireland)

ACFM recommended in 1979 that a precautionary TAC of 6 000 tonnes would be set in 1980 for Division VIIj. This would prevent diversion of effort to the area and the inaccurate reporting of catch statistics. The catch level was based on the average catches taken from the area in recent years. It was pointed out by the 1979 assessment group that it has not been possible to estimate the total stock size from this area because of the absence of reliable catch and effort figures from this fishery. It has thus not been possible to establish mortality rates for this stock.

Revised figures for the area for 1978 and preliminary figures for 1979 indicate that the catch has risen from 3 500 tonnes in 1978 to 5 000 tonnes in 1979. The age distributions indicate that, as in the most recent years, the 1974 year class was dominant, and there also appeared to be significant numbers of the 1976 and 1977 year classes present.

It would appear, therefore, advisable to again recommend that catches from this fishery should be prevented from rising above 6 000 tonnes until such time as more accurate information about the stock size has been obtained.

8. IRISH SEA HERRING (Division VIIa)

8.1 Introduction

Herring fishing in the North Irish Sea is supported almost entirely by two autumn spawning stocks called the Manx stock and the Mourne stock. The location of their spawning grounds, their geographical distribution in relation to the fishery, and their general biology are described in Doc. C.M.1978/H:3, Appendix. The criteria upon which catches are allocated to either stock are given in Doc. C.M.1979/H:6.

To date assessments of both Manx and Mourne herring have been carried out on the assumption that no exploitation of these stocks takes place outside Division VIIa. It should, however, be noted that evidence from the tagging experiments carried out in the Clyde (see Section 6.6) suggest that some additional exploitation of these stocks may well occur in adjacent areas to the north of Division VIIa.

8.2 Manx Stock

8.2.1 The fishery in 1979

Nominal catches are given in Tables 8.1 and 8.2 by country and by stock. The declared catch from the North Irish Sea in 1979 was 12 338 tonnes of which 10 130 tonnes were attributed to the Manx stock and 1 753 to the Mourne stock. 455 tonnes of herring were landed in France from an unknown area of the Irish Sea; however, there were no biological data for these fish so they could not be allocated with confidence to any stock.

The TAC for the North Irish Sea was 11 000 tonnes in 1979, and directed herring fishery was prohibited for 6 weeks from the beginning of October. In fact, fishing by United Kingdom vessels was stopped on 21 September and there was no further fishing on the Manx stock until November. Most of the fishing fleet operated from ports in the Isle of Man; daily catch quotas for these vessels were set by a joint committee of catchers and processors in order to spread the TAC over a reasonable period of time.

Catch in numbers by age - Catch in weight each month was converted to catch in numbers by means of regular counts of herring landed in the Isle of Man in boxes of a declared nominal weight. Age distribution was determined by the application of monthly length/age keys, constructed from otolith readings, to measurements of all the fish in randomly chosen boxes of herring as they were landed. The results are given in Table 8.3. Recruit 2-ring fish (1976 year class) made up half the catch; the proportion of 3-ring fish was higher than in 1978, but older fish were scarce. The mean age of the catch has shown a downward trend since 1973.

8.2.2 Estimates of fishing mortality and stock size

In the past, fishing mortality and stock size have been estimated by means of VPA with an input F derived directly or indirectly from effort data (Doc. C.M.1979/H:6). Administrative control of daily catch per boat in 1979 makes the former method inappropriate. There is now no objective method of choosing an input F_{79} for VPA. Analyses run with inputs ranging from $F_{79} = 0.7$ to $F_{79} = 0.3$ gave a range of 1979 stock size age 2-rings and older from 132×10^6 to 256×10^6 fish with spawning stock biomass 23 500 tonnes to 45 700 tonnes.

The analyses gave relatively stable values for F and stock size for 1976 and earlier years regardless of input F_{79}. Values for 1977 and subsequent years were sensitive to input F. Although one had no method for estimating F_{79}, it was concluded that F = 0.7 was a likely value. The VPA corresponding to this input F is given in Table 8.4.

8.2.3 State of stock and management advice

In 1978 and 1979 local control of United Kingdom effort rendered its use to estimate input F inappropriate and analyses were made with trial values, with no real guide which to choose. The data given in Table 8.5 suggest that input values of F for 1974, 1975 and 1976 were too low. If input F is too low, the population estimate used for the projection becomes too high. Recruitment estimates used in stock prediction have been made by what can be described as a cautious guess based on modal values from earlier years. A TAC based on a two year projection is therefore derived from an input F which usually has been an underestimate, guesses for two years of recruitment which will on average together account for about 70% of the stock by weight in the second year of the projection, and an assumption (rarely justified) that the catch for the first year of the projection willnot exceed the TAC previously recommended. Although TACs calculated two years ahead could be modified after one year in the light of additional data available, the present procedure cannot be regarded as a satisfactory basis for adequate stock management.

VPA runs with a range of input values of F from 0.3 to 0.7 for 1979 all showed that there was a serious decline in biomass of spawning stock from about 56 000 tonnes in 1974 to something between 22 000 and 26 000 tonnes in 1977. VPA indicated that the decline was probably halted in 1978, when the catch of Manx herring was only 8 500 tonnes, and that there may have been some recovery in 1979. Against this, it must be considered that the number of herring larvae found on the 1979 survey was the lowest recorded in the last 6 years, which indicates a low spawning stock biomass, and that the recruits in 1980 will be derived from the 1977 spawning stock. The 1977 stock was the lowest since 1967 and the catch in 1977 was about double that in 1967; there is little or no predictive value in the stock/recruitment relationship, but it would be irresponsible to assume a good recruitment in 1980 from the depleted 1977 stock. The fishery is heavily dependent on recruitment and a 'cushion' of older fish is essential to prevent collapse and closure of the fishery if there were a poor recruitment. It is urged that a cautious rather than an optimistic TAC be applied until such time as there is firm evidence of a recovery of the stock biomass from the recent decline and a reasonable number of fish older than 3 rings is present, and that the supporting measures of closing the fishery for a substantial part of the spawning season, prohibition of directed herring fishery in nursery areas and the minimum size regulation should be continued.

There is no doubt that scientists and administrators have been too optimistic in the past.

The problem remains to find an appropriate level of TAC which could reasonably be expected to produce an acceptable fishing mortality.

ICES has recommended $F_{0.1}$ as a 'target F' which for this stock is F = 0.22; Shepherd in a working document for the Working Group suggested F = 0.3 as a target F for North Sea herring, and Bowers (1980) suggested that F on Manx herring should not exceed F = 0.4.

Two approaches are suggested. The first is to apply the traditional projection from a stock size for 1979 derived from VPA with input F_{79} of 0.7, and assuming a moderate recruitment. The results of this are shown in Table 8.6 with catches resulting from theoretical F_{81}s of F = 0.2, F = 0.3, F = 0.4, and F = 0.5. The catch levels given in Table 8.6 are illustrated in Figure 8.1 as a guide to choice of TAC in 1981.

The second approach utilises directly historical values for the relationship between catch, biomass and fishing mortality. These can be derived by correlating Pope's (1978) index of abundance $\frac{C}{F}$ to biomass estimated by VPA for the years 1967-76. If
C = catch in tonnes of fully recruited herring age 2 rings or more,
F = mean fishing mortality ages 2 to 8+ from VPA and B = biomass in tonnes from VPA, all for the years 1967 to 1976, the correlation coefficient r = 0.909, and a Ricker type regression gives the equation

$$\frac{C}{F} = 0.6924\ B + 1125$$

The relationship is illustrated in Figure 8.2. If one can assume that the stock size has not declined since 1977, then the lower limit of the Manx stock biomass in 1980 is 22 000 tonnes. The upper limit is less certain, but is unlikely to exceed that given by VPA with F_{79} = 0.5, i.e. 25 400 tonnes. The fishing mortality which would be generated by various TACs for these values of stock size is given in the text table below.

TAC (tonnes):	7 000	8 000	9 000	10 000
Stock size 22 000 t	F = 0.43	0.49	0.55	0.61
Stock size 25 400 t	F = 0.37	0.43	0.48	0.54

It is emphasised that these figures are only approximations and may well be biased because there was no winter fishery in the years for which the regression was calculated. If a substantial part of a TAC were taken in winter, a higher F than shown in Figure 8.2 would result, because of lower mean weights.

It should be considered to restrict the fishing season to summer months only.

It is considered preferable to set a rather low but realistic TAC rather than risk closure of the fishery at short notice in 1981, if recruitment in 1980 is very poor. Mean annual catch 1950-59 was 5 580 tonnes; 1960-69, 5 019 tonnes and 1970-79, 16 814 tonnes. The 1970s were characterised by good recruitment; the 1980s could well revert to the earlier lower levels. The stock projection indicates that 5 000 tonnes would generate F = 0.3, 6 000 tonnes, F = 0.4, and 7 000 tonnes an F of nearly 0.5.

If the TAC previously recommended for 1980 cannot be modified at this stage, the TAC for 1981 should not be higher than 5 000 tonnes.

8.3 Mourne Stock

8.3.1 The fishery in 1979

The total nominal catch of herring of the Mourne stock in 1979 was 1 753 tonnes (Table 8.2), made up of 1 708 tonnes consumption and 45 tonnes caught for industrial purposes. The comparable catch data for 1978 were 1 809 tonnes consumption and 739 tonnes for industrial purposes. The consumption fishery was therefore slightly lower than in 1978 while there was a dramatic decrease in the industrial catch due to the closure of the reduction plant concerned in February 1979. The major part of the consumption catch was taken outside the 12 mile limit along the Irish coast as by-catch in the fishery on the Manx stock.

Catch in numbers by age - Total catches by weight of Mourne herring were converted to numbers at each age by the use of data from samples landed in Northern Ireland, Ireland and England. The age composition of the Mourne catch is given in Table 8.7. Because of the cessation of the industrial fishery there was a dramatic change in the overall age composition in 1979 compared with recent years. Because there were no industrial landings after February, 0-ring herring, for the first time for many years, were not present in any of the catches, while the number of 1-ring herring was substantially reduced.
The low catch in the industrial fishery in 1979 resulted in a change in the mean weights at age in the catch of the three youngest age groups. The weights at age in 1979 were not significantly different to those previously given in the 1978 report of the Working Group (C.M.1978/H:3). For this reason, the same weights have been used in the present assessment.

Age(rings)	1	2	3	4	5	6	7	8	9	10
Mean weight(g)	60	160	192	221	244	256	261	264	265	267

8.3.2 The industrial fishery

The Herring Assessment Working Group has advised for several years that the industrial catch would have to be terminated if the Mourne stock was to survive. Early in 1979 the only reduction plant handling the industrial catch closed and the fishery ceased. The only catches of young herring in 1979 were taken during the months of January and February. Estimates of the weight of herring taken in the industrial fishery are shown below for the period 1969-79.

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Tonnes	2 210	3 796	2 715	2 251	1 913	2 190	1 573	779	1 174	739	45

The catch taken in 1979 consisted entirely of 1-ring herring (1977 year class) and were all considered, from sample data, to belong to the Mourne stock. The northwestern part of the Irish Sea, in which the industrial fishery took place, is now recognised as an important nursery area for herring. It is therefore of vital importance that industrial fishing should never again be permitted in the North Irish Sea. Provided that this is ensured there should be a rapid improvement in recruitment to the Mourne spawning stock, and possibly some benefit to other adjacent stocks. The 1979 industrial catch expressed as numbers of herring per age group is included in Table 8.8, which covers the period 1969-79.

8.3.3 Estimates of fishing mortality and stock size

A mean weighted value of fishing mortality in 1979 was recalculated for 2-9 ring fish from the estimated stock in numbers at each age on 1 January 1979, given in last year's report (Doc. C.M.1979/H:6) and the catch in numbers for these age groups taken in 1979. This value of F = 0.26 was used as input F for a new VPA, since the Working Group had no new information, which would lead to a change in the stock size estimate for 1979 obtained last year. The input values of F for the last age group in 1978 and earlier years were taken from the mean weighted value of F for age groups 1.8 years estimated from the cohort of the previous Working Group. The stock sizes and fishing mortalities derived are given in Tables 8.9 and 8.10.

The only available independent estimate of F for the Mourne stock is that derived from Northern Ireland catch per unit effort data in 1975. Examination of the latest VPA run showed that the 1975 mean weighted value F = 0.95 for 1-8 ring fish is still in good agreement with this independent estimate as would be expected. This VPA was therefore accepted as giving the best estimates of stock size and fishing mortality available.

A comparison was made of the values of fishing mortality for 1976 and 1977 which were assumed at the time by previous Working Groups, with the values which are now available from the latest VPA.

Year	Original Working Group estimate of fishing mortality		Latest value of fishing mortality from 1980 VPA	
1976	0-ring 1-3 rings 4-8 rings	F = 0.60 F = 0.95 F = 0.80	0-ring 1-3 rings 4-8 rings	F = 0.25 F = 1.03 F = 0.90
1977	0-ring 1-ring 2-8 rings	F = 0.61 F = 0.59 F = 0.60	0-ring 1-ring 2-8 rings	F = 0.65 F = 0.68 F = 0.69

Clearly, the estimates of fishing mortality for 1976 and 1977 were realistic even though slightly underestimated (except for 0-ring herring in 1976 which was based on an assumed stock number).

In calculating fishing mortality on 1-ring herring in 1979 an initial year class strength of 49 x 10^6 0-ringers was assumed, this being the lowest 0-ring value derived from the latest VPA. This was considered to be an acceptable value in view of the fact that the previous year class, produced by a spawning stock of similar size, was estimated by VPA at 58 x 10^6 0-ring fish. The catch taken in 1979 would then have generated F = 0.42 on the 1-ring herring. As previously mentioned, no 0-ring herring were caught in 1979. There was thus a moderate reduction in fishing mortality on the 1-ring and older herring of the Mourne stock in 1979. The estimated stock in number at 1 January 1980 for ages 1-ring and older has been calculated from the catch in number per age group in 1979 and the above values of fishing mortality. A value of 49×10^6 0-ring herring has also been assumed for 1980.

Millions of fish at 1 January 1980

Age (rings)

0	1	2	3	4	5	6	7	8	9	10	11	Total
49.0	44.4	14.6	9.4	7.0	2.2	1.0	0.6	0.2	0.1	0.1	0.1	128.7

8.3.4 State of the stock and management advice

By applying the mean weights at age tabulated in the 1978 report (C.M.1978/H:3) the spawning stock size at 1 January 1980 was estimated at 7 600 tonnes. At 1 January 1979 it was 6 000 tonnes. Spawning stock size is based on an estimate that 1/3 of the 1-ring stock spawn at that age. It must, however, be noted that the stock in number in both years is heavily dependent on assumed values of initial strength for year classes 1977, 1978 and 1979. It would, therefore, be unrealistic to attempt a stock prognosis beyond 1980. If no further industrial fishing takes place it can be expected that the size of the spawning stock will increase fairly rapidly. This should become apparent during 1980 for which year an increase of 1 600 tonnes in spawning stock biomass has been estimated. Two points must however be borne in mind.

1. A catch of some 2 000 tonnes of Mourne herring will probably be taken as by-catch in the Manx fishery during 1980 prior to the time of spawning. In addition, it is estimated that about 300 tonnes of herring were caught illegally and landed during January-March 1980.
2. The estimates of spawning stock size are based on assumed levels of recruitment for 2 year classes and these may have been overestimated.

It was pointed out in the previous report, that the Working Group was unable to advise an optimal spawning stock size for the Mourne herring due to the fact that this stock has been in a declining state ever since the first assessment was carried out. The Working Group considers that there should be positive evidence of a substantial recovery in the size of the Mourne spawning stock before any directed fishery can again be contemplated.

It is recommended that the present prohibition on fishing for herring within 12 miles of the coast of Ireland between latitudes 53°20'N and 55°00'N should be continued in order to protect the spawning stock.

A possible error in the Mourne assessment - Since 1975 herring have been landed in metric units at ports bordering the Irish Sea (1 unit = 100 kg nominal weight). Extensive sampling at English and IOM ports during the past three years has shown that the weight of a unit is very variable but usually well in excess of 100 kg (C.M.1978/H:3). Similar data are not available for herring landed at Irish ports, but it seems possible that the same situation will be shown when data do become available. On this assumption, the number of Mourne herring by age taken in the consumption fishery over the last 5 years was adjusted using raising factors derived from the IOM and English data, and a new VPA run with the adjusted age distribution.

Although there was some increase in stock biomass, the adjusted catches made very little difference to any of the values of fishing mortality. Moreover, if a new projection is made from the 1977 stock in numbers from this VPA, and the adjusted catches, the same weighted value of fishing mortality 1979 of F = 0.26 is derived for ages 2-8 rings. It would, therefore, appear advisable at the present time to retain the assessment based on the assumption that 1 unit is equivalent to 100 kg in weight and that no adjustment should be made until actual weight data become available for herring landed at ports in Ireland.

8.3.5 Cross border Irish Sea herring study

In 1978 a study on the Mourne herring stock was commissioned by the EEC and the Governments of the Republic of Ireland and of the United Kingdom (Northern Ireland). This study was carried out by Fisheries Development Limited (London) and took place between September 1978 and October 1979. The aim of this study was to provide a basis for formulating management policies for the Mourne herring stock. Investigations were carried out on the abundance and distribution of larval and juvenile herring, the identity of the herring populations in the northwestern Irish Sea, the maturation, spawning and fecundity of the Mourne herring and both the current systems and the effects of winds on surface water movements.

The detailed report of this study was available to the Working Group but lack of time prevented a detailed analysis of the results. In general, the results obtained substantiated the knowledge already available to the Working Group as well as providing additional information particularly about the distribution of the larval herring in relation to the existing currents. However, the tentative estimate of spawning stock size obtained by this study was considerably lower than that obtained by this and previous assessment working groups. This was to be expected because the method employed was based on a direct back calculation of adult stock from an estimate of the total number of larvae produced. This method is likely to lead to an under-estimate of stock size due both to egg mortality (assumed by FDL to be only 8%) and egg predation.

The recommendations formulated in the FDL study report are, however, in broad agreement with current working group thinking. They include:

1. The regular collection of data concerning currents in the northwestern Irish Sea, to which larval drift could be related.
2. Annual larval surveys in the Mourne area to determine changes in the adult stock.
3. Recruit surveys to estimate year class strength.
4. Experimentation on biochemical techniques to improve stock separation.

If put into operation these would provide a valuable basis for the future management of the Mourne herring stock.

8.3.6 Spring spawning herring (Division VIIa)

There were numerous reports from fishermen in February and March 1980 of substantial shoals of spring spawning herring off the Mourne coast. A few biological samples which were obtained from by-catches confirmed that spawning herring were present in the area. A number of age groups were represented in the samples, and it is possible that spring spawners have become more abundant recently as a result of increased recruitment. The previous report of this Group in fact made reference to a catch of 68.5 tonnes of spring spawners landed in 1978.

A young herring survey was conducted in the northwestern section of the Irish Sea in July 1979 and February 1980. This area of the Irish Sea has long been recognised as an important nursery area (Molloy and Corten, 1975). Considerable quantities of both 0- and 1-group herring were located in July 1979 and although direct comparisons were not possible with the results obtained for similar surveys conducted in this area during 1972-75, it was concluded that young herring were more abundant in 1979 than in previous years. Many of the samples examined during July had vertebral counts higher than 57 (Figure 8.3) and were considered to be the result of some spring spawning. On the other hand, samples with autumn spawning counts were conspicuously absent.

The Working Group recommends that investigations should be carried out in February-March 1981 with the objective of obtaining information on a) the size of the spring spawning stock, b) the age composition and biology of the stock.

8.4 Recommendations for North Irish Sea

Management advice for North Irish Sea recommended by the Working Group:

1. If the TACs for the Manx stock in 1980 remains at 10 000 tonnes, the TAC for 1981 should not be more than 5 000 tonnes.
2. If it is considered essential to continue the practice of recommending a TAC two years ahead, provision should be made for a revision of the TAC in the second year.
3. A target biomass for the Manx stock of 40 000 tonnes would be appropriate.
4. Directed herring fishing should be prohibited in nursery areas, as specified in Doc. C.M.1979/H:7. The Working Group discussed the possibility of exempting an area off the Mull o Galloway which was fished in 1978 and 1979. Samples of catch as landed indicated only a small component of immature herring, but there is firm evidence that substantial quantities of juvenile herring were discarded at sea.
5. Directed herring fishing should be prohibited from 22 September 1981 to 16 November 1981 and for a similar period in subsequent years as recommended in Doc. C.M.1979/H:7.
6. Consideration should be given to allowing directed herring fishing only between 26 May 1981 and 22 September 1981 and for a similar period in subsequent years. In this context it should be noted that investigations are planned to determine the possibility of a fishery on a spring spawning component of the Mourne stock.

9. NORTH SEA SPRAT

9.1 The Fishery in 1979

9.1.1 Catch data

Table 9.1 shows the catches by nations and area in the period 1968-79. The total catches in 1978 and 1979 are at the same level of 380 000 tonnes. The main feature in 1979 was an increased fishery in Division IVb east and a corresponding decrease in Division IVb west. This is mainly due to an increased Danish catch in Division IVb east in the 3rd and 4th quarters.

9.1.2 Catch in numbers by age

Denmark, Norway and the United Kingdom supplied catches in numbers by age group and their summed quarterly catches are given in Table 9.2. These catches account for 98% of the total landings.

The age composition in 1979 is dominated by the 1978 year class, basically due to the large catch of one year olds in the 3rd quarter.

Table 9.3 gives the numbers accumulated by Sub-divisions in the North Sea.

9.2 Weight at Age

Weight at age data for 1979 were available from the countries with major sprat fisheries. Because of the somewhat unusual distribution of catches in 1979, the mean weight in each quarter used previously is more appropriate for the calculation of stock biomasses and catch. These values were tabulated in the 1978 report (C.M.1978/H:3) but for easy reference they are given in the text table below.

Mean weights (g) at age in North Sea landings 1976/77

Period	0	1	2	3	4	5
Jan-Mar		2.34	8.54	15.93	20.59	26.22
Apr-Jun		2.32	9.70	15.13	22.75	24.70
Jul-Sep	2.46	7.64	12.48	21.55	22.75	
Oct-Dec	2.60	8.85	17.18	21.57	26.64	

9.3 Estimates of Fishing Mortality and Recruitment

For North Sea sprat there is very little supporting information on which to base the selection of input fishing mortality in order to carry out a VPA. The Working Group recognised that the use of a quarterly VPA in principle yields more accurate results, because the seasonal pattern is more accurately represented (but not because of improved convergence, since this depends on the numbers in the catch dominating those of old fish obtained from the input F). However, in the absence of reliable values for input F, the fundamental problem is to make some rough estimate, rather than to obtain high accuracy. The additional complication of the quarterly VPA makes it more difficult to understand the implications of the VPA, so the Working Group decided to revert in the first instance to an annual VPA, in an attempt to make a rough assessment of the overall state of the stock. A preliminary quarterly VPA prepared for the Working Group (by Burd) also resulted in anomalously high F values for 4-and 5-ring fish, making it very difficult to assess terminal F.

Three annual VPAs with input F on 1- to 3-ring fish of 0.5, 1.0 and 2.0 were, therefore, prepared (Tables 9.4-9.6). Preliminary analyses also led to anomalously high F values on 4- and 5-ring fish. Examination of the catch composition (Table 9.3) showed very few fish of these ages in the catch, clearly indicating either low F or high M on these fish. Since it is known that older fish are not caught in large numbers in the main fishery on 1- and 2-ringers, the Working Group decided to adopt the former alternative, since such fish in any case do not comprise a large part of the catch or the stock. Input F values on 4- and 5-ring fish were therefore selected by trial and error, in such a way as to ensure broad internal consistency within the body of the analysis, judged by similarity of F values on 1-, 2- and 3-ring fish in the same year, over the whole length of the cohorts. The results based on the value of M of 0.8 used previously are obviously somewhat uncertain, but the Working Group felt they were the best it could do with the data available, and that they were adequate for evaluating the consequences of these different assumptions about F in 1979, in the hope that one of these could be selected as most realistic.

The implications of these assumptions are set out in the text table below.

Assumed F (1- to 3-ring) 1979	Spawning biomass (tonnes x 10^{-3})		Recruitment x 10^{-9}	
	(2-5 ring) Jan.1980	Trend	0-ring Average 1974-78	Trend
0.5	731	Stable	269	Stable
1.0	266	Declining	205	Declining
2.0	73	Collapsing	176	Declining sharply

The spawning biomasses have been calculated for 2-ring and older fish using the weights at age for the 3rd quarter given in Section 9.2, and are referred to 1 January. They are therefore not suitable for comparisons with acoustic survey estimates.

The three asumptions lead to quite different conclusions about the state of the stock. If F = 0.5, the situation is stable and the spawning biomass is high. If F = 1, the stock is declining and fishing mortality is increasing sharply in the last three years, as an approximately constant catch is taken from a declining biomass. If F = 2, the stock is on the point of complete collapse. Clearly, if the situation is this serious, it is too late to take any action for 1980 and confirmation will have been obtained by 1981.

All three VPA assessments are internally consistent and no choice can be made between them without using independent information of some sort.

9.4 Stock Size Estimates from Acoustic Surveys

Scottish and English research vessels carried out acoustic surveys in January-February 1978 and 1979. The surveys were limited to the North Sea coastal areas off Scotland and England. The results of the surveys were discussed in the previous report of the Working Group (C.M.1979/H:6). Due to limited coverage, estimates of the total biomass of North Sea sprat could not be made.

During the winter 1979/80 further acoustic surveys have been made:

1979	Nov.	"Johan Hjort"	Skagerrak and central North Sea
	Dec.	"Clione"	English east coast
1980	Jan.	"Corella"	English northeast coastal belt
	Jan.	"Explorer"	Scottish northeast and east coasts
	Jan.	"Johan Hjort"	Central and southern North Sea.

The surveys in January 1980 were the first carried out under ICES coordination, and acoustic intercalibrations were attempted. Very low abundances of sprat were recorded along the United Kingdom coasts. The estimated biomasses in Moray Firth, the Scottish east coast and the Firth of Forth were considerably lower than in previous years. The same was observed off the English coast, resulting in a collapse of the fishery. The survey of the offshore area showed, however, that large concentrations of sprat occurred in the southeastern part of the North Sea in January 1980. The Norwegian observations suggested a marked southeastward shift of distribution compared to November 1979. This shift was also evident in the sprat fishery by Norwegian purse seiners.

The distribution and the abundance of the sprat in the North Sea in January 1980 are shown schematically in Figure 9.1. The results of the three survey vessels are not directly comparable, mainly because the estimates of biomass are based on different values of target strength (TS) of sprat.

For the Norwegian survey, the observed echo intensities assigned to sprat were converted to biomass by applying a length (L) dependent TS determined by experiments accounting for fish tilt angles (Nakken and Olsen, 1977; Foot, 1980, in press). Based on this, Aglen (pers.comm.) found an average TS = 20 log L - 65 dB per individual or in biomass terms TS = - 10 log L - 15 dB per kilogram.

The Scottish biomass estimates assume TS = - 34 dB per kilogram. This value has been used for previous surveys by United Kingdom vessels. For a simple comparison with the Norwegian data, the Scottish figure of biomass should be reduced to 1/8.

TS = - 29 dB per kilogram was used for the English estimate. This should be reduced to ½ for comparison.

The total biomass of the North Sea sprat stock in January 1980 is estimated to be about 660 x 10^3 tonnes of 1-group (1979 year class) and 350 x 10^3 tonnes of older fish, corresponding to 660 x 10^9 1-group and 55 x 10^9 2-group and older, respectively. Since the contributions from the United Kingdom surveys are small, the validity of this estimate is entirely dependent on the result of the Norwegian survey. Due to the differences in the TSs used, and the limited experience with acoustic sprat surveys of wide coverage, the Group found it necessary to utilise the results with caution.

9.5 State of the Stock and Management Advice

The results of the VPA provide no reliable evidence about the present state of the stock. They imply populations of fish aged 2 and older in January 1980 ranging from 49 x 10^9 (F = 0.5) to 5 x 10^9 (F = 2.0).

The results of the acoustic survey imply a population of 55 x 10^9 of these fish, and therefore strongly suggest that F in 1979 was nearer 0.5 than 1.0 or 2.0.

The Working Group therefore decided to accept the analysis based on F in 1979 of 0.5 as being most likely to be correct. It should be clearly recognised, however, that this is based solely on the results of the acoustic survey and the estimate of F in 1979 may easily be in error. Furthermore, the Working Group cannot be sure that the stock is not in a state of decline, although the high abundance of 1-ring fish in 1980 deduced from the acoustic survey data make this rather unlikely, and suggest that in any case a high recruitment may be imminent.

The consequences of the assumed F (1979) for spawning biomass and recruitment are shown in Figure 9.2.

Management advice - The analysis chosen above suggests that the stock is stable and that fishing mortality is not increasing. The stock would be likely to collapse if fishing mortality were as high as 1.0, as may be seen from an examination of yield per recruit and biomass per recruit calculations. Equilibrium spawning biomass per recruit (0-ring group) at F = 1 is only about 1.3 gm/rec. Since over the years, for which data are available, the ratio of recruitment to spawning biomass has been around 0.3 rec./gm, one would expect collapse as the product of these numbers (representing the ability of the stock to reproduce itself) is less than unity.

The Working Group agreed that the stock should therefore be managed to maintain fishing mortality at 0.5, at which value the biomass per recruit is about 3 gm/recruit, so that the stock should be able to replace itself.

At F = 0.5 the yield per recruit is about 1.6 gm/recruit. If recruitment (0-group) continues around its average value (1974 to 1978) of about 280 x 10^9, the long-term average yield obtainable from this stock may be in the region of 400 000 tonnes as previously estimated. However, since the fishery is almost entirely dependent on the catch of 1-ringers, the appropriate TACs would fluctuate considerably around this value, following fluctuations of recruitment.

The TAC for 1980 was set at 400 000 tonnes. If the acoustic survey data for 1-group fish are correct in indicating a high recruitment, this TAC is likely to be taken. Several prognoses have been carried out assuming a catch of 400 000 tonnes in 1980,with various assumptions about recruitment of 1-ringers in 1980. These are:

a) An optimistic prognosis, taking the acoustic survey data at face value, and setting recruitment at 660 x 10^9 1-group;

b) A moderate prognosis, in which the acoustic survey data are used only to indicate that recruitment is high, the actual value being set at 200 x 10^9, typical of the high values for 1974 and 1976 indicated by the VPA for F = 0.5.

c) A cautious prognosis, in which despite the acoustic survey data the recruitment is taken as 140 x 10^9, close to the average of the VPA values for 1974 to 1979.

In each case, the fishing mortality has been adjusted to give a catch of about 400 000 tonnes in 1980 (corresponding to F values of 0.11, 0.3 and 0.4, respectively). The recruitment of 1-ringers in 1981 has in each case been taken as 100 x 10^9, typical of the lower VPA values since it is known that assuming continuing average recruitment can easily generate TACs which lead to stock collapse.

The prognoses have been started from the population estimates from the VPA run with F (1979) = 0.5, raised by 1.13 to give 55 x 10^9 fish of 2-ring and older at 1 January 1980 for consistency with acoustic survey results.

Taking F = 0.5 in 1981 leads to TACs for 1981 as follows (Table 9.7):

Option (a) 1 250 000 tonnes

Option (b) 530 000 tonnes

Option (c) 440 000 tonnes.

Bearing in mind the uncertainties of the acoustic survey data, and the potential for precipitating a stock collapse in this volatile fishery, the Working Group considers it would be most unwise to adopt Option (a). They recommend to ACFM that either Option (b) or (c) would be appropriate. They stress, however, that the increase of TAC under Option (b) would be only temporary and that future TACs would revert to values around the long-term average of 400 000 tonnes.

The Working Group stresses, however, that it is extremely difficult to set an adequate TAC for a full year ahead for this stock, that is a TAC which will both guard against stock collapse and make full use of the stock production.

They therefore strongly suggest that management arrangements should be revised so that the time lag between the assessment and its implementation is reduced to not more than three months. This would enable some account to be taken of recruitment in formulating management advice.

9.6 Procedure and Data Requirements for making Analytical Assessment of Sprat Stocks

Difficulties in estimating present stock size from any data available from the fisheries dictate that independent measures of stock and/or recruitment are required if analytical assessments are to be made correctly. Incoming recruitment on average makes up a high percentage of each year's catch (1-group) and for this reason recruitment estimates are likely to be of the greatest value, so long as they are available in time to manage the exploitation of the 1-group (i.e. around November-January).

Two Norwegian surveys in November 1979 and January 1980 in the offshore waters of the North Sea showed the wide distribution of this age group, and that they were still very small (mean 3-5 cm). That this is not an unusual occurrence is shown by earlier surveys made by the USSR published in "Annales Biologiques". Problems arise, however, because, firstly depth distribution of the small sprat is not adequately described; secondly, there is no adequate measure of target strength for this size group, and, thirdly, the sampling methods used so far may not provide a representative estimate of the true size distribution. Nevertheless, the results of the first two surveys show that an acoustic technique to estimate the absolute size of the incoming year class is worth persevering with.

The alternative would be to use the acoustic technique on a midwater trawling survey to provide an index of abundance. This is unfortunately unlikely to provide an index usable for management for about five years.

Since some experience has been gained in making acoustic estimates of the size of the adult sprat stock in winter (January-February), it is recommended that these surveys should continue. In view of the wide area of distribution, wide coverage is needed and this is most likely to be achieved by international cooperation. The timing of such surveys should cover one month in the period December-February when sprat tend to assemble in overwintering concentrations. Acoustic surveys for sprat in summer carried out by Scottish research vessels are probably not appropriate, because of the dispersed nature of their distribution and the mixing with other pelagic species.

It is clear from Section 9.4 that there is considerable divergence of opinion about the correct target strength of sprat. If the estimates obtained are to be used in an absolute sense, then further direct measurements are urgently required.

Assuming that a reliable recruitment index will not be immediately available, the acoustic surveys for adult sprat each winter should be evaluated as soon as possible after they occur and the results made available to ACFM. It would then be possible for the TAC for the current year to be adjusted, or to set a more realistic TAC for the twelve months beginning 1 July. Shortening the present advisory and administrative procedure is necessary for proper management of this stock.

Other problems in carrying out stock and catch predictions concern the validity of the population parameter, notably natural mortality and the relation between stock and recruitment. The latter requires a considerable number of years' data. It is likely that a series of acoustic surveys combined with catch data will eventually provide a better estimate of M.

REFERENCES

BOWERS, A.B., 1980. The Manx herring stock 1948-1976. Rapp.p.-v.Réun.Cons.int. Explor.Mer, 177, 166-174.

CORTEN, A., 1980. Report on the International Young Fish Survey: Herring data. ICES, C.M.1980 (in prep.).

FOOT, K.G., 1980. Averaging of fish target strength functions. J. Acoust. Soc. Amerc. (in press).

HAGSTROM, O., BILLGREN, O., HÅKANSSON, N. and KOLLBERG, S., 1979. Akustic uppskattning av sill ock skarpsild i östra Skagerrak ock Kattegat 1976-1978. Medd. från havs-fiskelaboratoriet nr.249.

ICES, 1977. Report of the ad hoc Meeting on the Provision of Advice on the Biological Basis for Fisheries Management. ICES, Coop.Res.Rep., No.62.

ICES, 1978. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES, C.M. 1978/H:3 (mimeo).

ICES, 1979. Report of the Working Group on Herring Larval Surveys South of 62°N. ICES, C.M.1979/H:4 (mimeo).

ICES, 1979. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES, C.M.1979/H:6 (mimeo).

ICES, 1979. A Preliminary Report of the ICES-coordinated Acoustic Survey of Herring Stocks in 1979. ICES, C.M.1979/H:44.

ICES, 1979. Report of the Herring Otolith Workshop held at Lysekil 18-19 September 1979. ICES, C.M.1979/H:66.

ICES, 1980. Report of the Working Group on Division IIIa Stocks. ICES, C.M.1980/ G:3.

McKAY, D.W. 1978. The Distribution and Abundance of Herring Larvae to the West of Scotland in 1977. ICES, C.M.1978/H:50 (mimeo).

McKAY, D.W., 1979. The Distribution and Abundance of Herring Larvae to the West of Scotland in 1978. ICES, C.M.1979/H:37 (mimeo).

MOLLOY, J. and CORTEN, A., 1975. Young Herring Surveys in the Irish Sea. ICES, C.M.1975/H:11.

MOLLOY, J., 1980. (in press). Ir.Fish.Leaflet Ser.

NAKKEN, O. and K. OLSEN, 1977. Target Strength Measurements of Fish. Rapp.p.-v. Réun.Cons.int.Explor.Mer, 170: 52-69.

POSTUMA, K.H., 1974. The Nucleus of the Herring Otolith as a Racial Character. J.Cons.int.Explor.Mer, 35(2), 121-129.

VAN DE KAMP, G., 1976. Estimates of Stock Size and Recruitment in Separate Sub-Populations of North Sea Herring by Means of Larval Surveys. ICES, C.M.1976/H:12.

Table 3.1 HERRING. Catch in tonnes 1969-1979. North Sea (Sub-area IV and Divisions VIId and e) by country. Skagerrak (Division IIIa excl. Kattegat) total catch. (Data provided by Working Group members)

Country/Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979*)
Belgium	1 200	681	1 337	2 160	603	2 451	1 430	57	-	-
Denmark	133 331	185 393	213 738	174 254 a)	61 728	115 616	34 841	12 769	4 359	10 546
Faroe Islands	58 365	45 524	48 444	54 935 b)	26 161 b)	25 854	14 378	8 070	40	-
Finland	-	-	-	-	-	-	1 034	-	-	-
France	11 482	11 408	12 901	22 235	12 548	20 391	14 468	1 613	2 119	2 350
German Dem. Rep.	290	475	127	1 728	3 268	2 689	2 624	2	-	-
Germany, Fed.Rep.	7 150	3 570	3 065	10 634 c)	12 470	6 953	1 654	221	24	10
Iceland	22 951	37 171	31 998	23 742 d)	29 017	16 286	9 412	-	-	-
Netherlands	46 218	32 479	24 829	34 070	35 106	38 416	20 146	4 134	18	-
Norway	193 102	125 842	117 501	99 739	40 975	34 183	27 386	4 065	1 189	3 617
Poland	5 057	2 031	2 235	5 738	9 850	7 069	7 072	2	-	-
Sweden	34 670	36 880	7 366	4 222 e)	3 561	6 858	4 777	3 616	-	-
UK (England)	9 702	4 113	394	2 268	5 699	6 475	9 662	3 224	2 843	2 253
UK (Scotland) f)	21 885	25 073	17 227	16 012	15 034	8 904	15 015	8 159	437	-
USSR	18 078	9 500	16 386	30 735	18 096	20 653	10 935	78	4	162
Total North Sea	563 481	520 140	497 548	484 012	275 116	312 798	174 834	46 010	11 033	18 938
Total including unallocated catches										21 938

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

Table 3.2. HERRING, North Sea catches in directed fisheries by area.
(Figures supplied by Working Group members)

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

1) Including spring spawners: 410 t. Autumn spawners assumed for calculating catch in number

2) Rough estimates

Table 3.3 HERRING. By-catch (in weight) by areas and countries.

Country	IVa West				IVa East				IVb				IVc + VIId + VIIe			
	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979	1976	1977	1978	1979
Denmark	4 105	502	-	437	-	186	-	2	7 682	5 958	4 359	10 107	-	-	-	-
Faroe Islands	-	-	25	-	-	-	-	-	-	-	15	-	-	-	-	-
France	100	148	486	385	11	44	-	68	88	198	302	357	25	62	1 331	1 540
German Dem.Rep.	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Germany, Fed.Rep. of	-	-	4	10	-	-	-	-	-	-	1	-	-	-	19	-
Netherlands	-	-	-	-	-	42	-	-	-	-	-	-	-	-	18	-
Norway	-	-	27	-	-	-			-	-	129	2 367	-	-	-	-
Poland	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Sweden	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
UK (England)	-	-	-	-	-	-	-	-	165	2 810	2 620	2 252	-	-	223	1
UK (Scotland)	-	-	-	6	-	-	-	-	-	22	437	156	-	-	-	-
USSR	-	-	-	-	-	43	4	-	-	35	-	-	-	-	-	-
Total	4 205	650	542	838	11	319	4	70	7 915	9 023	7 863	15 239	25	62	1 591	1 541

Table 3.4 HERRING. North Sea catch in millions of fish by age.

Year	Area	Age in winter rings										Total
		0	1	2	3	4	5	6	7	8	>8	
1972	IVaW of 2°E	-	338.9	830.1	176.8	88.6	19.3	4.1	-	0.5	0.4	1 458.7
	IVaE of 2°E	-	75.1	91.0	17.8	5.8	0.7	0.1	-	-	-	190.5
	IVb	-	25.2	46.4	98.8	20.5	6.7	0.6	0.2	0.6	-	199.0
	IVbYH	750.4	2 896.6	337.9	21.1	6.4	1.2	0.2	-	-	-	4 013.8
	IVc+VIId,e	-	4.8	135.1	29.3	9.3	5.0	-	-	-	-	183.5
	Total NS	750.4	3 340.6	1 440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6 045.5
1973	IVaW of 2°E	-	52.5	742.1	452.6	58.0	39.5	20.3	2.6	0.5	0.6	1 368.7
	IVaE of 2°E	-	0.3	16.2	23.1	6.3	7.2	1.0	0.3	0.8	-	55.2
	IVb	-	242.5	180.1	39.0	28.3	4.7	7.2	-	-	-	501.8
	IVbYH	289.4	2 070.5	362.5	29.4	2.6	0.5	0.2	0.3	-	-	2 755.4
	IVc+VIId,e	-	2.2	43.3	115.1	55.0	7.4	1.9	0.5	0.1	0.0	225.5
	Total NS	289.4	2 368.0	1 344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4 906.6
1974	IVaW of 2°E	65.3	162.9	98.5	112.9	97.1	36.0	18.6	4.5	1.5	1.0	598.3
	IVaE of 2°E	5.7	131.8	24.2	10.8	1.0	-	-	-	0.1	-	173.6
	IVb (adult)	-	54.0	493.7	212.3	19.5	18.9	3.6	0.3	0.4	0.1	802.8
	IVbYH	925.1	493.5	132.1	5.7	-	-	-	-	-	-	1 556.4
	IVc+VIId		3.9	24.1	20.3	8.4	1.2	0.1	0.2	-	-	58.2
	Total NS	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3 189.3
1975	IVaW of 2°E	-	267.0	120.0	69.0	49.0	40.2	9.8	6.3	2.9	1.1	565.3
	IVaE of 2°E	-	82.5	8.2	7.0	2.4	0.4	0.1	0.1	-	-	100.7
	IVb (adult)		268.8	147.1	124.2	81.2	14.8	5.8	2.7	0.5	0.3	645.4
	IVbYH	262.8	1 818.1	139.2	19.8	2.6	-	0.4				2 242.9
	IVc+VIId	1.0	24.1	127.2	39.6	5.3	1.8					199.0
	Total NS	263.8	2 460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3 753.3
1976	IVaW of 2°E	-	19.4	572.9	56.3	17.9	13.2	3.6	2.6	0.5	0.3	686.7
	IVaE of 2°E	-	-	10.6	1.1	0.5	0.5	0.4	-	-	-	13.1
	IVb (adult)	0.9	35.5	205.9	17.6	28.4	20.3	1.8	1.8	0.5	0.1	312.8
	IVbYH	237.3	49.5	17.7	0.5	1.7	-	-	-	-	-	306.7
	IVc+VIId	-	22.2	94.4	41.8	3.5	0.5	0.3	-	-	-	162.7
	Total NS	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1 482.0
1977	IVaW of 2°E	2.6	2.7	9.3	171.7	8.6	3.8	2.1	0.9	0.2		201.9
	IVaE of 2°E	0.4	3.3	+	4.9	1.2	1.1	1.0	0.6	0.5	+	13.0
	IVb (adult)	-	1.1	25.9	6.8	0.3	1.9	1.0	-	+	-	37.0
	IVbYH	253.8	136.3	3.1	-	-	-	-	-	-	-	393.2
	IVc+VIId	-	0.9	6.4	3.0	0.7	0.2	+	+	-	-	11.2
	Total NS	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7		656.3
1978	IVaW of 2°E			0.1	0.1	1.5	0.2	0.1	+	+	+	2.0
	IVaE of 2°E				0.2	1.2	-	+	0.2	0.2	0.3	2.1
	IVb (adult)		0.2	0.6	1.4	1.1	0.1	0.1	+			3.5
	IVb (indus.)	138.0	168.0	1.4								299.4
	IVc + VIId		0.4	2.8	4.0	1.2	+	+				8.4
	Total NS	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	IVaW of 2°E		1.7	0.3	0.2	2.0	0.4	+	+	+		4.6
	IVaE of 2°E		+	2.4	0.3	+	+	+				2.7
	IVb (adult)		0.5	1.9	0.4	2.1	0.9	0.1	0.4	0.3		6.6
	IVb (indus.)	542.0	156.4	7.6	-	0.1	0.1	+	0.4	0.3	0.1	707.0
	IVc + VIId		0.2	11.6	5.0	3.7	0.3					20.8
	Total NS	542.0	158.8	23.8	5.9	7.9	1.7	0.1	0.8	0.6	0.1	741.7

Table 3.5. Millions of HERRING caught annually per age group (winter rings) in the North Sea over the last 10 years.

Year \ Winter rings	0	1	2	3	4	5	6	7	8	>8	Total
1970	898.1	1 196.2	2 002.8	883.6	125.2	50.3	61.0	7.9	12.0	12.2	5 249.3
1971	684.0	4 378.5	1 146.8	662.5	208.3	26.9	30.5	26.8	-	12.4	7 176.7
1972	750.4	3 340.6	1 440.5	343.8	130.6	32.9	5.0	0.2	1.1	0.4	6 045.5
1973	289.4	2 368.0	1 344.2	659.2	150.2	59.3	30.6	3.7	1.4	0.6	4 906.6
1974	996.1	846.1	772.6	362.0	126.0	56.1	22.3	5.0	2.0	1.1	3 189.3
1975	263.8	2 460.5	541.7	259.6	140.5	57.2	16.1	9.1	3.4	1.4	3 753.3
1976	238.2	126.6	901.5	117.3	52.0	34.5	6.1	4.4	1.0	0.4	1 482.0
1977	256.8	144.3	44.7	186.4	10.8	7.0	4.1	1.5	0.7	+	656.3
1978	130.0	168.6	4.9	5.7	5.0	0.3	0.2	0.2	0.2	0.3	315.4
1979	542.0	158.8	23.3	5.9	7.3	1.7	0.1	0.8	0.6	0.1	741.7

Table 3.6 Stock Prognosis North Sea HERRING

Ringers	$\bar{w}$	Stock 1-1-78	Catch 1978	F 1978	Spawning stock 1978	Stock 1-1-79	Catch 1979	F 1979	Spawning stock 1979	Stock 1-1-80	F 1980	Spawning stock 1980
0		622	130.0	0.27		2 363	573.5	0.29				
1		$\boxed{1\ 570}$	168.6	0.12		$\boxed{430}$	158.8	0.49		$\boxed{1\ 600}$		
2	126	630	4.9	0.01	582	1 260	23.8	0.02	1 163	238	0	222
3	176	411	5.7	0.01	379	564	5.9	0.01	521	1 118	0	1 042
4	211	525	5.0	0.01	485	368	7.9	0.02	340	505	0	471
5	243	68	0.3	0.01	63	470	1.7	0.01	434	326	0	304
6	251	30	0.2	0.01	28	61	0.1	0.00	56	421	0	393
7	267	20	0.2	0.01	18	27	0.8	0.03	25	55	0	51
8	271	4	0.2	0.05	4	18	0.6	0.04	16	24	0	22
9	271	3	0.3	0.11	3	3 + 2	0.1	0.02	5	16 + 4	0	19
Total Weight (t)					271 000				442 000			508 000
		numbers of 2-ringers from 1978 W.G. report; 1-ringers from 1979 W.G. report	reported to 1980 W.G. meeting.			1-ringers estimated from revised IYFS-index, reported to 1980 W.G. meeting.	reported to 1980 W.G. meeting.			1-ringers estimated from preliminary IYFS-index, reported to 1980 W.G. meeting.		

Table 4.1 HERRING in Division IIIa. Landings in tonnes 1970-79
(Data mainly provided by Working Group members)

	Country / Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979*)
SKAGERRAK	Denmark	30 107	26 985	34 900	42 098	35 732	29 997	7 326	19 889	6 425	5 153
	Faroe Islands	-	5 636	4 115	5 265	7 132	8 053	1 553	10 064	1 041	817
	Germany Fed.Rep.	-	-	-	-	36	108	6	32	28	181
	Iceland	6 453	3 066	7 317	15 938	231	1 209	123	-	-	-
	Norway (Open Sea)	7 581	6 120	1 045	836	698	196	-	-	1 860	2 460
	Norway (Fjords)	1 830	3 166	4 222	1 680	1 720	1 459	2 304	1 837	2 271	2 259
	Sweden	26 930	19 763	19 644	20 429	11 683	12 348	6 505	8 109	11 551	8 104
	Total	72 901	64 736	71 241	66 246	57 214	53 370	17 817	39 424	23 176	18 974
KATTEGAT	Denmark	39 434	50 177	52 755	78 125	54 540	48 974	41 749	38 205	29 241	21 337
	Sweden	40 453	49 760	39 972	40 418	39 779	23 769	30 263	37 160	35 193	25 272
	Total	79 887	99 937	92 727	118 543	94 319	72 743	72 012	75 365	64 434	46 609
Div. IIIa Total		152 788	164 673	163 968	184 789	151 533	126 113	89 829	114 789	87 610	65 583

Table 4.2 HERRING. Division IIIa, 1979
Landings in numbers per age group (x 10^{-6})

Age w.r.	Skagerrak	Kattegat	Div. IIIa Total	
			Landings	Catch*)
0	54.22	170.15	224.37	457.16
1	18.29	100.36	118.65	168.49
2	85.44	454.19	539.63	582.74
3	23.38	44.70	68.08	69.52
4	8.44	4.95	13.39	13.39
5	3.08	0.79	3.87	3.87
6	0.28	0.21	0.49	0.49
7	0.18	0.02	0.20	0.20
8+	-	-	-	-

*) Corrected for assumed discards at sea

Table 4.3. Div. IIIa HERRING
Virtual population analysis 1980. Input Data
Catch at Age

Age	1974	1975	1976	1977	1978	1979
0	2 499	2 006	433	934	147	457
1	910	1 471	1 474	1 437	876	168
2	375	149	325	329	455	583
3	135	60	28	61	65	70
4	47	57	4	12	10	13
5	26	15	3	6	1	4
6	9	6	1	4	1	0
7	3	1	1	2	0	0
8	1	1	1	0	0	0

Natural Mortality at Age:

Age	0	1	2	3	4	5	6	7	8
Mortality	0.30	0.25	0.20	0.10	0.10	0.10	0.10	0.10	0.10

Mean fishery mortality calculated for ages 2 to 8

Table 4.4 Div. IIIa HERRING

Fishing Mortalities						
Age	1974	1975	1976	1977	1978	1979
0	0.672	0.565	0.141	0.207	0.114	0.100
1	1.518	1.329	1.299	1.049	0.333	0.200
2	1.676	1.346	1.476	1.376	1.331	0.400
3	1.059	1.705	1.014	1.389	1.161	0.700
4	1.182	2.048	0.439	1.707	0.770	0.700
5	1.423	1.671	0.403	1.785	0.800	0.700
6	1.787	1.778	0.422	2.450	0.880	0.700
7	1.419	0.799	2.080	1.556	2.789	0.700
8	1.500	1.500	1.500	1.500	1.000	0.700
Mean	1.464	11.560	1.389	1.401	1.295	0.426

Table 4.5 Div. IIIa HERRING

Stock in Numbers						
Age	1974	1975	1976	1977	1978	1979
0	5 817	5 302	3 801	5 761	1 582	5 547
1	1 277	2 202	2 232	2 446	3 471	1 046
2	496	218	454	474	667	1 937
3	216	76	46	85	98	144
4	71	68	12	15	19	28
5	35	20	8	7	3	8
6	11	8	3	5	1	1
7	4	2	1	2	0	0
8	2	1	1	0	0	0
Sp. stock ($\geq$3 w.r.)	48 701	27 401	10 281	15 555	15 533	23 469

Table 5.1 Annual Celtic Sea HERRING catches 1965-78. (Data provided by Working Group members)

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	UK	USSR	Total
1965	1 742	-	353	3 980	7 198	-	1 054	-	14 327
1966	5 506	-	1 143	6 891	16 605	112	197	-	31 454
1967	3 825	-	910	11 133	13 184	300	398	-	29 750
1968	2 637	-	1 662	9 480	15 679	130	598	-	30 186
1969	7 038	-	5 906	18 712	16 256	252	400	-	48 164
1970	3 629	-	1 481	24 702	7 015	1 191	220	-	38 236
1971	3 393	-	974	12 602	9 672	881	65	-	27 587
1972	7 327	-	393	20 109	6 758	751	-	618	35 956
1973	5 553	7	294	13 105	5 834	1 125	-	334	26 375a)
1974	2 261	-	433	13 991	2 105	954	-	-	19 744
1975	1 924	-	361	8 430	2 825	512	24	1 054	15 130
1976	1 919	147	28	3 705	1 627	324	-	826	8 258
1977	106	-	96	1 394	1 455	-	-	-	3 051
1978	8	-	220	2 725	1 002	-	-	-	3 955
1979*)	455		20	2 123	850				3 448

*) Provisional 1) Including 123 tonnes for Bulgaria

Table 5.2 Celtic Sea HERRING catches by season (1 April to 31 March) (Data provided by Working Group members)

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Netherlands	Poland	UK	USSR	Total
1965/6	1 742		353	3 482	13 071	-	1 054		19 702
1966/7	5 506		1 143	8 061	11 459	112	197		26 478
1967/8	3 825		910	10 736	10 204	425	398		26 498
1968/9	2 637		1 662	11 996	12 191	130	598		29 214
1969/70	7 038		5 906	16 712	13 111	261	400		43 428
1970/1	3 627		1 481	19 106	4 667	778	220		29 879
1971/2	3 383		974	13 757	10 600	880	65		29 659
1972/3	7 327		393	18 846	6 852	751	-	618	34 878
1973/4	4 143	7	294	11 317	5 834	1 139	-	334	23 191a)
1974/5	2 150	-	435	11 683	2 462	954	-	-	17 684
1975/6	2 451	-	399	6 524	2 441	579	24	1 054	13 472
1976/7	1 371	147	36	2 970	1 324	257	-	826	7 019
1977/8	95	-	96	1 322	1 378	-	-	-	2 891
1978/9	8	-	220	2 656	1 002	-	-	-	3 886
1979/80*	455	-	20	2 920	850	-	-	-	4 245

*) Provisional a) Including 123 tonnes for Bulgaria

Table 5.3 Celtic Sea. Catch in numbers x 10^{-3} (1 April - 31 March).

Season/Age	1	2	3	4	5	6	7	8	>8	Total
1965/6	58	70 937	9 456	15 911	3 433	4 584	12 241	1 391	7 566	125 576
1966/7	6 337	19 146	58 633	9 827	13 193	5 585	3 581	8 742	3 839	128 614
1967/8	6 921	36 168	19 486	47 837	8 954	9 334	3 894	6 462	6 684	145 741
1968/9	11 699	53 028	38 421	11 207	22 286	4 538	3 965	1 251	4 608	151 003
1969/70	7 787	91 994	54 473	32 318	11 881	17 265	4 612	2 130	3 418	225 878
1970/1	640	31 540	48 706	25 937	18 270	7 095	5 751	1 925	3 194	143 058
1971/2	10 262	22 451	34 382	40 536	18 449	9 807	3 779	4 846	2 143	146 655
1972/3	7 279	124 357	16 922	13 817	13 674	4 331	2 654	2 103	749	185 886
1973/4	22 171	34 122	45 162	6 269	8 251	4 655	3 209	1 966	714	126 519
1974/5	4 516	38 285	15 427	19 865	3 782	3 311	2 668	806	742	89 402
1975/6	11 452	13 077	15 709	6 898	6 042	3 252	1 268	964	1 022	59 685
1976/7	7 262	9 090	5 202	5 196	2 092	2 669	1 384	1 005	777	34 701
1977/8	3 859	4 095	3 491	1 534	782	547	289	36	55	14 687
1978/9	1 660	10 373	3 890	1 573	450	471	115	260	130	18 922
1979/80	4 680	6 638	6 430	1 600	962	261	186	107	163	21 027

Table 5.4 Celtic Sea HERRING. Fishing Mortalities from VPA and weighted Mean Values of F.

Age	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80
1	.27	.17	.44	.38	.10	.07	.10
2	.76	.90	.87	.86	.33	.39	.40
3	.84	.85	1.07	.94	.51	.55	.40
4	.48	1.03	1.07	1.21	.72	.40	.40
5	.81	.52	.93	1.02	.50	.42	.40
6	.63	.80	1.05	1.37	.71	.56	.40
7	.88	.82	.74	2.00	.44	.28	.40
8	1.16	.50	.71	2.77	.21	.79	.40
>8	.70	.70	.70	.70	.70	.70	.70
$\bar{F}$(2-8)	.78	.88	.98	1.07	0.45	0.43	0.4

Table 5.5 Celtic Sea HERRING. Calculated Stock Size in number (10^{-6}) by age and year at 1 April (M = 0.1)

Age	1973	1974	1975	1976	1977	1978	1979
1	97.8	30.7	33.7	24.1	41.0	25.0	51.6
2	66.8	67.4	23.5	19.7	15.0	33.4	21.1
3	82.7	28.2	24.9	8.9	9.2	9.7	20.4
4	17.3	32.2	11.0	7.7	3.1	5.0	5.1
5	15.5	9.7	10.4	3.4	2.1	1.4	3.1
6	10.4	6.3	5.2	3.7	1.1	1.1	0.8
7	5.7	5.0	2.5	1.7	0.9	0.5	0.6
8	3.0	2.1	2.0	1.1	0.2	0.5	0.3
>8	0.8	0.8	1.2	0.9	0.1	0.1	0.2
Biomass of age groups 2-8 (tonnes)	38.5	28.6	15.7	9.0	5.9	9.2	9.5

Table 5.6 Prognosis of Celtic Sea HERRING

Age	Stock 1 April 79	Mean weights 1 April	Mean weights All Seasons	Catch 79/80	F 79/80	Stock 1 April 80	F 80/81	Catch 80/81	Stock 1 April 81
1	51.6	118	123	4.7	0.10	30.0	0.1	2.7 (5.5)	30.0
2	21.1	162	194	6.6	0.40	42.3	0.3	10.4	24.7
3	20.4	193	233	6.4	↓	12.8	↓	3.2	28.3
4	5.1	210	249	1.6		12.4		3.1	8.8
5	3.1	220	267	1.0		3.1		0.8	8.3
6	0.8	228	279	0.3		1.9		0.5	2.1
7	0.6	232	281	0.2		0.5		0.1	1.3
8	0.3	235	290	0.1		0.4		0.1	0.3
>8	0.2	238	284	0.2		0.3		0.07	0.5
Biomass (2-8) in tonnes	9 500					13 300			14 100
Catch (1-8) in tonnes				4 200				4 300	

Table 6.1 Total catches of HERRING (tonnes) in Division VIa, 1970-1979
(Data provided by Working Group members)

Country	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979[*]
Belgium	-	-	-	-	-	-	12	-	-	-
Denmark	-	554	150	932	-	374	249	626	128	-
Faroe Islands[a]	15 100	8 100	8 094	10 003	5 371	3 895	4 017	3 564	-	-
France	1 293	2 055	680	2 441	547	1 293	1 528	1 548	1 435	-
German Dem. Rep.	207	330	935	2 507	2 037	1 994	929	-	-	-
Germany, Fed.Rep. of	16 548	7 700	4 108	17 443	14 354	9 099	4 980	221	126	-
Iceland	5 595	5 416	2 066	2 532	9 566	2 633	3 273	-	-	-
Ireland[b]	11 716	12 161	17 308	14 668	12 557	10 417	8 558	7 189	12 071	4 569
Netherlands	1 102	9 252	23 370	32 715	19 635	19 360	20 812	8 515	5 929	1 214
Norway	20 199	76 720	17 400	36 302	26 218	512	5 307	1 098	4 462	-
Poland	3 709	-	-	5 685	6 368	2 934	3 085	6	-	-
Sweden	-	-	-	-	-	-	2 206	261	-	-
U.K. (England)	1	-	-	-	45	125	20	301	134	54
U.K. (N. Ireland)	1	-	-	-	3	6	1	1	6	2
U.K. (Scotland)	103 530	99 537	107 638	120 800	107 475	85 395	53 351	25 238[c]	10 097[c]	3[c]
USSR	3	-	?	2 052	5 388	3 232	3 092	-	-	-
Unspecified catches	-	-	-	-	-	-	-	-	-	186
Total	179 004	221 825	181 749	248 080	209 564	141 269	111 420	48 568	34 388	6 028
Scottish juvenile herring and sprat fisheries in Moray Firth	1 385	5 666	10 242	7 219	13 003	2 454	313	205	1 502	28

[*] Preliminary figures

[a] Figures supplied by Fiskirannsóknarstovan

[b] Catches prior to 1976 mainly taken in Division VIIb and landed in Division VIa

[c] Including by-catch in local sprat fishery (16 tonnes in 1977; 157 tonnes in 1978; 3 tonnes in 1979).

Table 6.2 HERRING autumn spawners. Catch in number x 10^{-3}, Division VIa Moray Firth included.

Year	Age (Rings)											
	0	1	2	3	4	5	6	7	8	9	10	>10
1970	16 299	238 431	108 872	272 693	124 498	42 623	185 380	24 821	29 920	14 276	5 156	6 903
1971	209 598	169 780	286 148	346 206	261 891	94 206	25 876	166 165	16 425	16 286	8 038	5 578
1972	249 941	321 539	753 355	210 243	72 885	83 361	37 428	13 445	94 577	8 154	5 855	5 377
1973	267 872	50 737	273 783	990 183	155 828	66 476	68 522	26 512	8 037	53 767[1)]	-	-
1974	536 119	312 029	153 833	205 806	553 627	90 584	45 144	43 069	18 504	45 393[1)]	-	-
1975	82 698	185 723	257 116	108 284	84 977	228 583	38 929	15 573	20 304	20 689[1)]	-	-
1976	8 446	78 894	386 932	123 947	44 430	36 714	87 477	14 208	5 766	13 078[1)]	-	-
1977	11 871	38 582	60 563	119 880	25 593	12 506	13 046	20 759	2 948	3 262[1)]	-	-
1978	116 967	36 010	69 805	34 763	49 854	13 803	6 595	4 600	8 872	3 581[1)]	-	-
1979[*)]	2 290	2 467	16 969	5 049	2 974	1 679	1 318	715	716	839[1)]	-	-

*) Preliminary

1) Age 9 and older

Table 6.3 Larval abundance indices in Division VIa on all surveys used in calculating annual index.

Year	Survey period									Larval abundance index
	Northern area					Southern area				
	1-10 Sep	11-25 Sep	26 Sep-10 Oct	10-25 Oct	Mean	11-25 Sep	26 Sep-10 Oct	10-25 Oct	Mean	
1972	2 564*)	1 334	2 388	-	2 095	21	31	-	26	2 121*)
1973	-	2 016	1 665	-	1 840	194	524	-	359	2 199
1974	-	1 051	1 376	788	1 072	-	1 013	727	870	1 942
1975	515	1 132	663	-	770	153	777*)	-	465	1 235*)
1976	-	198	231	145	191	71	-	58*)	64	255*)
1977	404	1 171	-	168	581	17	-	167	92	673
1978	628	-	335	-	482	-	221	-	221	703
1979	1 003	-	354	883	747	-	1 345	666	1 006	1 753

*) Values adjusted by Working Group. Other values for 1972-77 are those used by McKay (1978) to obtain annual indices.

Table 6.4 Recent history of Division VIa herring stock, uncorrected and corrected to obtain 60% of 2-ringers in spawning stock in 1979.

Age (rings)	$\bar{w}$ (g)	UNCORRECTED						CORRECTED		
		$N_n x10^{-6}$ 1 Jan.1978	F 1978	$N_n x10^{-6}$ 1 Jan.1979	$C_n x10^{-6}$ 1979	F 1979	$N_n x10^{-6}$ 1 Sep.1979	$N_n x10^{-6}$ 1 Jan.1978	$N_n x10^{-6}$ 1 Jan.1979	$N_n x10^{-6}$ 1 Sep.1979
1		351	.09					432		
2	121	208	.43	283	17	.06	254	208	357	324
3	158	74	.68	122	5	.04	111	74	122	111
4	175	111	.64	34	3	.10	30	111	34	30
5	186	28	.72	53	2	.03	49	28	53	49
6	206	14	.68	12	1	.12	11	14	12	11
7	218	9	.76	6	+	.12	6	9	6	6
8	224	17	.79	4	+	.22	3	17	4	3
≥9	224	4	.10	7	+	.13	6	4	10	6
Biomass (t x 10^{-3}) (≥ 2-ringers)		71		76			68	71	85	77
2-ringers as % of ≥2 ringers							54%			60%

Table 6.5 Prognosis of Division VIa HERRING

Age (rings)	$\bar{w}$ (g)	Stock in No. x 10^{-6} 1 Jan.1979	F_{1979}	Stock in No. x 10^{-6} 1 Jan.1980	F_{1980}	Stock in No. x 10^{-6} 1 Jan 1981
1		(240)	.01	(240)	.01	(240)
2	121	357	.05	(215)	0	(215)
3	158	122	.04	307	0	(195)
4	175	34	.10	106	0	278
5	186	53	.03	28	0	96
6	206	12	.12	47	0	25
7	218	6	.12	10	0	42
8	224	4	.22	5	0	9
≥9	224	10	.13	12	0	14
Biomass t x 10^{-3} (≥2-ringers)		85		114		143

Table 6.6 Monthly landings (tonnes) of HERRING from the Firth of Clyde (all fishing methods combined). (Data provided by the Working Group).

Month	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
January	446	272	*	*	*	*	*	*	4*	4*
February	1 569	491	52*	71*	91*	68*	7*	*	6*	8*
March	263	495	82*	36*	168*	85	69*	*	7*	13*
April	526	406	400	316	398	369	521	530	246	12*
May	325	305	569	385	280	283	436	544	245	4*
June	793	111	657	468	607	203	281	640	238	356
July	1 249	260	416	688	690	354	332	494	376	466
August	680	385	700	593	543	240	473	601	587	450
September	404	519	263	668	310	515	541	559	581	374
October	824	461	410	711	451	811	598	556	653	263
November	283	193	463	464	245	571	595	560	647	1*
December	342	190	166	248	91	120	236	328	272	- *
NK	59		48	67	189	44	50	35		
Total	7 763	4 088	4 226	4 715	4 063	3 663	4 139	4 847	3 862	1 951

*) Subject to closure of directed fishery.

Table 6.7 Catch in numbers x 10^{-3} in the Firth of Clyde, 1977-1979 (races combined)

Year	Age (Rings)											Total
	0	1	2	3	4	5	6	7	8	9	9+	
1977	-	1 041	7 524	6 976	1 062	1 112	574	489	251	146	192	19 367
1978	-	14 123	1 796	2 259	2 724	634	606	330	298	174	236	23 200
1979	-	507	4 859	807	930	888	341	289	156	119	154	9 050

Table 6.8 Number of recaptures by month and area of HERRING tagged in the Clyde in May 1979

Area of Recovery	Clyde	Irish Sea	N.W. Ireland	Minch
May/June	197	6	-	-
July	98	4	-	-
August	88	5	-	-
September	43	6	-	-
October	67	2	1	-
November	-	1	2	1
$\sum$	493	24	3	1 (521)

Table 7.1 HERRING in Division VIIb, c. Nominal catches (tonnes) 1967-1979. (Data for 1967-1978 from Bulletin Statistique).

Year	France	German Dem.Rep.	Germany Fed.Rep.	Ireland	Nether-lands	Poland	U.K.	USSR	Total
1967				108					108
1968	713			30	525				1 268
1969			71	145	355				571
1970	733		180	1 518	179			2	2 612
1971	42		52	1 646	61				1 801
1972	312		23	3 154	71			347	3 907
1973			5	5 036	200				5 241
1974	10		-	4 412	51		25	1 266	5 764
1975	20		914	5 576	9 815			646	16 971
1976		240	28	5 537	12 306	83		118	18 312
1977				8 727	4 194			-	12 921
1978				7 057	475				7 532
1979 *)	-	-	-	14 341	724	-	-	-	15 065

*) Provisional data.

Table 7.2 Catch in number x 10^{-3}, Division VIIb,c; HERRING

Year	Winter rings									
	0	1	2	3	4	5	6	7	8	> 8
1970	-	60	456	803	1 237	511	9 015	972	408	393
1971	-	387	124	429	532	602	404	6 077	605	316
1972	-	351	4 671	276	1 054	1 143	1 127	626	11 724	1 278
1973	44	4 972	5 270	3 782	1 932	1 117	870	824	729	14 084
1974	-	320	7 394	8 535	3 557	1 789	1 369	1 706	3 620	7 314
1975	962	10 105	15 279	24 409	16 874	11 194	3 911	5 040	5 058	14 877
1976	62	7 717	14 688	16 823	19 733	15 171	5 136	2 624	2 362	10 050
1977	-	2 220	30 016	7 646	9 835	7 415	6 241	3 893	722	1 957
1978	-	1 965	15 829	14 229	4 068	3 678	2 208	1 782	704	1 267
1979	-	3 843	30 383	13 602	16 043	7 319	6 742	4 213	3 273	2 923

Table 8.1 HERRING. Total catches (tonnes) in North Irish Sea (Division VIIa), 1969-1979 (includes industrial catch)

Country	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 x)
France	-	558	1 815	1 224	254	3 194	813	651	85	174	455 2)
Ireland	2 328	3 933	3 131	2 529	3 614	5 894	4 790	3 205	3 331	2 371	1 805
Netherlands	-	-	-	260	143	1 116	630	989	500	98	-
U.K.	9 821	17 912	21 861	23 337	18 587	27 489	18 244	16 401	11 498	8 432 1)	10 078 3)
USSR	-	-	-	-	-	945	26	-	-		
Total	12 149	22 403	26 807	27 350	22 598	38 638	24 503	21 246	15 414	11 075	12 338

x) Preliminary. 1) Includes 68.5 tonnes of spring-spawned herring. 2) No data basis for allocation to stock.

3) Additional unrecorded catch of 106 tonnes estimated.

Table 8.2 HERRING. Total catch by stock in North Irish Sea, 1969 - 1979

Country	1969		1970		1971		1972		1973		1974		1975		1976		1977		1978		1979 x)	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
France	-	-	558	-	1 815	-	1 224	-	254	-	3 194	-	813	-	651	-	85	-	87	87	-	-
Ireland	-	2 328	-	3 933	-	3 131	-	2 529	-	3 614	1 783	4 111	2 406	2 384	1 816	1 389	2 009	1 322	610	1 761	748	1 054
Netherlands	-	-	-	-	-	-	260	-	-	143	1 116	-	630	-	989	-	500	-	98	-	-	-
U.K.	9 139	682	15 629	2 283	18 758	3 103	19 308	4 029	13 071	5 516	23 639	3 850	15 408	2 836	12 831	3 570	9 837	1 661	7 663	700	9 382	696
USSR	-	-	-	-	-	-	-	-	-	-	945	-	26	-	-	-	-	-	-	-	-	-
Total Manx	9 139		16 187		20 573		20 792		13 325		30 677		19 283		16 287		12 431		8 458		10 130	
Total Mourne	3 010		6 216		6 234		6 558		9 273		7 961		5 220		4 959		2 983		2 548		1 753	

Note: 1 = Manx stock, 2 = Mourne Stock x) Preliminary

Table 8.3 Manx stock HERRING. Catch in number x 10^{-6}

Year	Rings								
	1	2	3	4	5	6	7	8 and 8+	Total 2 to 8+	Mean age excl. 1-ring
1965	0.31	20.78	6.78	1.03	0.46	0.63	0.41	0.39	30.48	2.562
1966	0.18	3.89	7.91	1.88	0.33	0.27	0.18	0.07	14.53	3.04
1967	1.02	17.82	4.79	7.61	1.80	0.38	0.20	0.40	33.00	2.92
1968	0.44	24.46	11.29	2.68	4.33	0.70	0.06	0.29	43.81	2.79
1969	0.19	22.84	14.25	6.24	2.47	1.97	0.42	0.02	48.21	2.855
1970	0.75	25.24	27.89	13.24	9.42	2.88	2.66	0.31	81.64	3.339
1971	4.98	54.36	21.91	18.68	9.67	3.41	1.74	1.16	110.93	3.060
1972	3.64	41.76	26.05	11.28	13.15	6.46	1.96	1.27	101.93	2.327
1973	1.75	18.74	22.74	10.69	5.52	4.07	2.09	1.40	65.28	3.468
1974	12.95	95.95	32.55	19.41	9.65	4.09	4.55	1.03	167.23	2.871
1975	5.63	38.94	36.61	9.44	6.17	4.11	1.89	1.34	98.50	3.005
1976	9.34	47.46	17.38	13.62	3.88	2.41	2.32	1.07	88.14	2.952
1977	13.98	33.04	20.29	5.85	3.92	1.16	0.81	1.02	66.09	2 856
1978	3.64	32.41	11.41	6.18	1.44	1.24	0.57	0.35	53.60	2.709
1979	3.66	35.37	21.29	3.55	1.90	0.85	0.30	0.19	67.11	2.632

Table 8.4. VPA analysis MANX STOCK.
Fishing mortalities.

AGE	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	0.01	0.00	0.00	0.01	0.04	0.04	0.01	0.16	0.06	0.15
2	0.34	0.34	0.23	0.37	0.60	0.51	0.29	0.91	0.82	0.86
3	0.28	0.33	0.30	0.43	0.56	0.56	0.51	1.03	0.97	0.98
4	0.47	0.22	0.28	0.46	0.52	0.55	0.42	0.99	0.87	1.11
5	0.70	0.47	0.29	0.75	0.63	0.74	0.51	0.74	0.91	1.00
6	1.57	0.57	0.36	0.58	0.60	1.02	0.47	0.78	0.72	1.01
7	0.41	1.09	0.72	1.05	0.74	0.73	1.00	1.35	0.92	1.07
8	0.37	0.34	0.27	0.45	0.58	0.58	0.42	0.93	0.87	0.91

MEAN F FOR AGES >= 2 AND <= 8 (WEIGHTED BY STOCK IN NUMBERS)

0.37	0.34	0.27	0.45	0.58	0.58	0.42	0.93	0.88	0.93

AGE	1977	1978	1979
1	0.15	0.05	0.10
2	0.94	0.53	0.70
3	1.02	0.90	0.70
4	0.95	0.91	0.70
5	1.05	0.57	0.70
6	0.84	1.06	0.70
7	1.04	1.24	0.70
8	0.90	0.53	0.70

MEAN F FOR AGES >= 2 AND <= 8 (WEIGHTED BY STOCK IN NUMBERS)

0.97	0.64	0.70

AGE-NATURAL MORTALITY

1	2	3	4	5	6	7	8
0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

THE LAST GROUP IS A PLUS GROUP

/Continued ......

Table 8.4. (Continued) Stock size in numbers.

AGE	1967	1968	1969	1970	1971	1972
1	99	128	95	141	126	90
2	65	88	116	86	127	109
3	21	42	57	83	54	63
4	21	14	27	38	49	28
5	4	12	10	19	22	26
6	0	2	7	7	8	11
7	1	0	1	4	3	4
8	1	0	0	0	1	1
TOTAL	211	287	312	377	389	332
SPAWNING STOCK (AGE >= 2)	112	158	217	237	263	243
BIOMASS	19 400	27 900	41 000	48 600	47 700	47 900

AGE	1973	1974	1975	1976	1977	1978
1	188	94	101	72	106	85
2	78	168	73	86	57	83
3	59	53	62	29	33	20
4	33	32	17	21	10	11
5	15	19	11	6	6	3
6	11	8	8	4	2	2
7	3	6	3	4	1	1
8	2	1	1	1	1	0
TOTAL	388	382	276	224	217	205
SPAWNING STOCK (AGE >= 2)	201	288	175	151	110	120
BIOMASS	41 100	55 700	35 100	28 800	22 400	22 500

AGE	1979
1	40
2	73
3	44
4	7
5	4
6	2
7	1
8	0
TOTAL	172
SPAWNING STOCK (AGE >= 2)	132
BIOMASS	23 500

THE LAST GROUP IS A PLUS GROUP

Table 8.5. Division VIIa MANX HERRING stock management and catch, 1967-79.
(Biomass and catch rounded to nearest hundred tonnes.)

Year	Biomass[1]	TAC recommended by Working Group	TAC approved[2]	Catch (nominal)	Mean F 2-8 rings[1]	Input F used by Working Group
1967	19 400	none	none	5 900	0.37	
1968	27 900	"	"	7 600	0.34	
1969	41 000	"	"	9 100	0.27	
1970	48 600	"	"	16 200	0.45	
1971	47 700	"	"	20 600	0.58	
1972	48 000	"	"	20 800	0.58	
1973	41 200	"	"	13 300	0.42	
1974	55 900	"	"	30 700	0.93	0.80
1975	35 500	12 000	18 000	19 300	0.86	0.65
1976	29 700	9 000	12 000	16 300	0.89	0.58
1977	24 200	12 000	13 200[3]	12 400	0.85	0.60
1978	?	9 000	11 000[3]	8 500	?[4]	0.30
1979	?	10 000	11 000[3]	10 100	?	

1) From VPA with catch data to 1979. Input F 0.4, which is an optimistic level.
Small differences in 1976 figures with other input F.
Moderate differences in 1977 figures, increasingly large differences for 1978 and 1979.

2) No TAC applied until 1975. TACs 1975 and 1976 applied to UK vessels only.

3) TAC set for whole of northern Irish Sea. Total catch in northern Irish Sea included some Mourne stock and exceeded TAC (see Table 8.1).

4) Estimates of $\bar{F}_{1978}$ range from 0.38 (with input F_{1979} at 0.30) to 0.64 (with input F_{1979} at 0.7).

Table 8.6. MANX HERRING stock projection.

	N_{1979}	N_{1980}	C_{80}	N_{81}	Catch 1981 at F =				Population 1982; F_{81} =				$\bar{w}$
	F_{79} = 0.7	F_{79} = 0.7	F_{80} = 0.7	F_{80} = 0.7	0.2	0.3	0.4	0.5	0.2	0.3	0.4	0.5	g
2	73	40	19.3	63	10.9	15.6	19.8	23.7	49	49	49	49	163
3	44	32.7	15.8	18.0	3.1	4.4	5.7	6.7	46.7	42.2	38.2	34.6	187
4	7	19.8	9.5	14.7	2.5	3.6	4.6	5.5	13.3	12.1	10.9	9.9	222
5	4	3.1	1.5	8.9	1.5	2.2	2.8	3.3	10.9	9.8	8.9	8.1	234
6	2	1.8	0.9	1.4	0.2	0.3	0.4	0.5	6.6	6.0	5.4	4.9	266
7	1	0.9	0.4	0.8	0.1	0.2	0.3	0.3	1.0	0.9	0.8	0.8	279
8	0	0.4	0.2	0.4	0.1	0.1	0.1	0.2	0.6	0.5	0.5	0.2	304
Total		98.8	47.6	107.1	18.5	26.5	33.8	40.3	128.1	120.5	113.8	107.4	
Tonnes	23 500	18 636	8 968	19 685	3 408	4 865	6 204	7 406	24 450	22 873	21 473	20 117	

Catch 1980 based on TAC 10 000 adjusted for overweight boxes and Mourne stock catch taken in Manx fishery.

Recruitment taken from a spawning stock-recruitment line drawn through the point corresponding to the geometric mean of historical VPA values of spawning stock and recruitment, and origin.

Table 8.7. MOURNE HERRING stock. Catch in number x 10^{-6}.

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

Table 8.8. North Irish Sea. Catch of HERRING in number (10^{-6}) by year and by age in the industrial fishery.

Age (rings) \ Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	48.1	161.5	100.3	78.4	50.2	57.9	20.3	10.4	26.4	20.8	-
1	18.2	23.7	30.3	28.8	29.7	19.0	21.6	11.7	13.3	7.1	1.6
2	7.7	3.6	3.5	1.8	0.6	2.3	1.5	0.1	0.3	0.2	-
3	1.0	1.4	0.4	0.3	0.5	0.8	0.6	-	-	-	-
Total	75.0	190.2	134.5	109.3	81.0	80.0	44.0	22.2	40.0	28.1	1.6
Total in tonnes	2 210	3 796	2 715	2 251	1 913	2 190	1 573	779	1 174	739	45
N/kg	33.9	50.1	49.5	48.6	42.3	36.5	28.0	28.5	34.0	38.0	35.6

Table 8.9. Fishing mortalities by year and age.

Age (rings) \ Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978*)	1979*)	Mean 1971-77
0	0.51	0.94	0.87	0.76	0.67	0.80	0.39	0.25	0.65	0.43		0.63
1	?	0.46	0.71	0.84	1.03	1.00	1.03	1.07	0.68	0.61		0.91
2	?	?	2.25	0.45	0.80	1.10	0.88	0.99	0.70	0.35		1.02
3	?	?	1.18	0.30	1.04	1.18	0.62	0.85	0.72	0.46		0.84
4	?	?	0.30	0.46	0.42	1.11	0.67	0.77	0.50	0.35		0.60
5	?	?	0.20	0.24	0.65	1.28	1.37	0.74	0.66	0.27		0.73
6	?	?	0.20	0.21	0.67	1.06	0.34	1.44	0.74	0.19		0.67
7	?	?	0.34	0.41	0.54	1.00	0.62	0.60	2.17	0.52		0.81
8	?	?	0.33	0.12	0.85	0.99	0.84	1.13	0.84	0.27		0.73
$\overline{F}w$ (0-8 rings)	?	?	0.98	0.71	0.82	0.92	0.68	0.68	0.66	0.46		
$\overline{F}w$ (1-8 rings)	?	?	1.09	0.65	0.95	1.06	0.95	1.01	0.68	0.50		

Table 8.10. MOURNE HERRING stock. Stock size in numbers (x 10^{-6}) from VPA analysis.

Age (rings)	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978*)	1979*)
0	126	278	180	154	108	110	66	49	58	63	?
1	?	68	97	68	66	50	45	40	35	27	37
2	?	?	38	43	27	21	17	14	12	16	13
3	?	?	19	4	25	11	6	6	5	6	10
4	?	?	4	5	2	8	3	3	2	2	3
5	?	?	2	3	3	1	2	1	1	1	1
6	?	?	3	2	2	1	0	1	1	1	1
7	?	?	1	2	1	1	0	0	0	0	0
8	?	?	0	0	1	1	0	0	0	0	0
Total stock in numbers (0-8 rings)	?	?	344	281	235	204	139	114	114	116	?
Total stock in numbers (1-8 rings)	?	?	164	127	127	94	73	65	56	53	65
Total stock biomass (tonnes) (1-8 rings)	?	?	15882	13090	13899	10167	7027	6241	5245	5383	6830

*) Inefficient estimate

Table 9.1. SPRAT catches in the North Sea ('000 tonnes), 1968-1979.
(Data provided by Working Group members.)

Country	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979 a)
						IVa West						
Denmark	-	-	-	-	-	-	5.3	0.5	0.6	0.1	-	-
Faroe Islands	-	-	-	-	-	-	0.2	12.9	2.5	0.4	-	-
France	-	-	-	-	-	-	-	-	-	+	-	-
German Dem.Rep.	-	-	-	-	-	-	-	-	-	+	-	-
Germany, Fed.Rep. of	-	-	-	-	-	+	-	-	+	0.6	-	-
Netherlands	+	+	+	+	+	+	+	+	+	+	-	-
Norway	-	-	-	0.9	2.2	-	-	1.5	29.9	16.0	1.3	0
Poland	-	-	-	-	+	+	-	0.3	-	-	-	-
Sweden	-	-	-	-	-	1.0	2.2	11.0	+	0	-	-
UK (England)	-	-	-	+	-	0.2	-	-	-	0	-	-
UK (Scotland)	13.0	12.4	3.8	15.0	29.8	49.4	41.2	9.4	12.7	26.9	16.9	6.8
USSR	-	-	-	-	-	-	1.0	1.3	1.2	+	-	-
Total	13.0	12.4	3.8	15.9	32.0	50.6	49.9	36.9	46.9	44.0	18.2	6.8
						IVa East (North Sea stock)						
Denmark	-	-	-	-	-	-	-	-	0.2	0.1	-	-
Norway	-	-	-	-	-	-	-	-	1.9	0.7	0.1	+
UK (Scotland)	-	-	-	-	-	-	-	-	+	0	-	-
Total	-	-	-	-	-	-	-	-	2.1	0.8	0.1	...
						IVb West						
Belgium	-	-	-	-	-	-	-	-	+	0	-	-
Denmark	...	...	8.6	9.9	14.4	47.0	55.4	106.6	104.4	57.5	44.1	75.3 b)
Faroe Islands	-	-	-	-	-	-	4.0	30.0	42.9	1.8	-	2.8
France	1.0	-	-	-	-	-	-	-	-	+	-	-
German Dem.Rep.	-	-	-	-	-	-	1.7	4.5	6.4	0.7	-	-
Netherlands	+	2.0	+	+	+	-	-	-	-	0	-	-
Norway	-	-	-	-	4.1	3.4	9.5	145.7	73.0	5.5	56.2	47.8
Poland	+	-	-	-	+	-	-	9.1	10.5	0	-	-
Sweden	-	-	-	-	-	-	-	-	7.9	0	-	-
UK (England)	2.6	3.3	11.2	25.5	21.8	34.6	25.5	32.5	49.7	51.9	53.9	12.9
UK (Scotland)	13.4	22.0	9.5	7.2	3.6	2.9	8.6	4.9	18.1	10.9	14.8	5.0
USSR	-	-	-	1.2	0.8	17.9	32.9	47.8	50.4	1.6	-	-
Total	17.0	27.3	29.3	43.8	44.7	105.8	137.7	381.1	362.3	123.9	169.0	143.8

/Cont'd.

a) Preliminary figures as reported. b) IVb East and West. + = less than 0.1.
... = No data available. – = Magnitude known to be nil.

Table 9.1 (Continued).

Country	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979[a)]
						IVb East						
Denmark	18.1	18.5	16.2	19.9	28.8	93.9	104.0	215.2	201.1	126.8	161.0	191.5
German Dem.Rep.	–	–	–	–	–	–	–	0.4	–	0.7	–	–
Germany, Fed.Rep.of	16.7	6.3	7.6	5.1	1.7	11.0	17.5	0.5	1.7	4.3	–	3.8
Norway	–	–	–	–	–	–	–	–	5.1	0	29.8	27.4
Sweden	–	–	–	–	–	–	–	–	–	1.5	–	–
Total	34.8	24.8	23.8	25.0	30.5	104.9	121.5	216.1	207.9	133.3	190.8	222.7
						IVc						
Belgium	0.4	0.4	0.6	0.1	0.1	0.2	+	+	–	0	–	–
Denmark	–	–	–	–	–	–	0.9	3.9	0.3	1.4	–	1.5
France	+	0.1	+	+	–	+	0.3	0.1	–	+	–	–
German Dem.Rep.	–	–	–	–	–	–	–	–	0.1	+	–	–
Germany, Fed.Rep.of	–	–	+	–	+	–	–	–	–	0.4	–	–
Netherlands	1.0	1.6	1.5	1.0	0.4	+	+	0.2	–	0	–	–
Norway	–	–	–	–	–	–	–	–	–	–	0.2	3.1
UK (England)	6.2	4.2	3.9	0.2	+	0.8	3.4	2.9	0.7	0.2	0.0	1.4
USSR	–	–	–	–	–	–	+	+	0.2	–	–	–
Total	7.6	6.3	6.0	1.3	0.5	1.0	4.6	7.1	1.3	2.0	0.2	6.0
						Total North Sea						
Belgium	0.4	0.4	0.6	0.1	0.1	0.2	+	+	+	+	+	+
Denmark	18.1	18.5	24.8	29.8	43.2	140.9	165.6	326.2	306.6	179.9	205.1	268.3
Faroe Islands	–	–	–	–	–	–	4.2	42.9	45.4	2.2	–	2.8
France	1.0	0.1	+	+	–	+	0.3	0.1	–	+	–	–
German Dem.Rep.	–	–	–	–	–	–	1.7	4.9	6.5	1.4	–	–
Germany, Fed.Rep.of	16.7	6.3	7.6	5.1	1.7	11.0	17.5	0.5	1.7	5.3	–	3.8
Netherlands	1.0	3.6	1.5	1.0	0.4	+	+	0.2	+	+	–	–
Norway	–	–	–	0.9	6.3	3.4	9.5	147.2	109.9	22.2	87.6	78.6
Poland	+	–	–	–	+	+	–	9.4	10.5	+	–	–
Sweden	–	–	–	–	–	1.0	2.2	11.0	7.9	1.5	–	–
UK (England)	8.8	7.5	15.1	25.7	21.8	35.6	28.9	35.4	50.4	52.1	53.9	14.3
UK (Scotland)	26.4	34.4	13.3	22.2	33.4	52.3	49.8	14.3	30.8	37.8	31.7	11.8
USSR	–	–	–	1.2	0.8	17.9	33.9	49.1	51.8	1.6	–	–
Total	72.4	70.8	62.9	86.0	107.7	262.3	313.6	641.2	621.5	304.0	378.3	379.6

a) Preliminary figures as reported. + = less than 0.1. ... = No data available. – = Magnitude known to be nil.

Table 9.2. North Sea SPRAT catch in 1974-1979. Numbers caught per age group x 10^{-6} in each three-month period.

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

Table 9.3. Total North Sea SPRAT catch 1974-79.
Numbers caught per age group x 10^{-6} in each Division.

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

Table 9.4. VPA North Sea SPRAT. M = 0.8. $F_{1-3,1979} = 0.5$.

	Age	1974	1975	1976	1977	1978	1979	1980
Fishing mortality	0	0.010	0.003	0.021	0.007	0.003	0.003	
	1	0.148	0.359	0.317	0.221	0.476	0.5	
	2	0.372	0.705	0.950	0.554	0.381	0.5	
	3	0.278	0.523	1.025	0.480	0.563	0.5	
	4	0.054	0.175	0.154	0.064	0.708	0.07	
	5		0.01	0.01	0.01	0.003	0.003	
	$\bar{F}_{1-3}$	0.199	0.510	0.452	0.362	0.465	0.5	
Stock in number ($N \times 10^{-6}$)	0	227 272	425 411	201 256	235 397	298 062	(228 092)	
	1	199 058	101 071	190 543	88 573	105 052	133 514	(102 181)
	2	55 122	77 114	31 721	62 367	31 918	29 319	36 387
	3	7 954	17 074	17 128	5 513	16 101	9 798	7 990
	4	6 578	2 707	4 546	2 761	1 533	4 122	2 670
	5	8 273	2 801	1 021	1 751	1 164	339	1 727
Biomass (10^3 tonnes)		1 031	1 465	896	1 005	811	680	731

Table 9.5. VPA North Sea SPRAT. M = 0.8. $F_{1-3,1979} = 1$

	Age	1974	1975	1976	1977	1978	1979	1980
Fishing mortality	0	0.011	0.004	0.027	0.009	0.005	0.005	
	1	0.165	0.375	0.389	0.292	0.692	1.0	
	2	0.473	0.827	1.034	0.772	0.565	1.0	
	3	0.540	0.781	1.555	0.572	1.091	1.0	
	4	0.236	0.443	0.284	0.142	0.987	0.2	
	5	0.05	0.05	0.03	0.02	0.007	0.005	
	$\bar{F}_{1-3}$	0.233	0.579	0.561	0.495	0.702	1.0	
Stock in number ($N \times 10^{-6}$)	0	218 884	356 890	157 651	176 617	180 206	(136 974)	
	1	180 421	97 284	159 755	68 970	78 624	80 558	(61 239)
	2	45 123	68 754	30 034	48 642	23 147	17 690	13 316
	3	4 547	12 632	13 505	4 799	10 099	5 911	2 924
	4	1 607	1 190	2 600	1 282	1 218	1 524	977
	5	1 683	570	343	879	500	204	561
Biomass (10^3 tonnes)		741	1 174	735	763	548	389	266

Table 9.6. VPA North Sea SPRAT. M = 0.8. $F_{1-3,1979} = 2.$

	Age	1974	1975	1976	1977	1978	1979	1980
Fishing mortality	0	0.011	0.004	0.031	0.011	0.008	0.008	
	1	0.169	0.390	0.407	0.345	0.886	2.0	
	2	0.473	0.864	1.113	0.836	0.736	2.0	
	3	0.436	0.781	1.789	0.673	1.336	2.0	
	4	0.103	0.319	0.284	0.197	1.452	0.3	
	5	0.02	0.02	0.02	0.02	0.01	0.01	
	$\bar{F}_{1-3}$	0.235	0.602	0.603	0.562	0.899	2.0	
Stock in number ($N \times 10^{-6}$)	0	212 125	343 789	136 876	148 522	124 872	(85 720)	
	1	175 883	94 265	153 868	59 636	66 000	55 686	(38 210)
	2	45 124	66 719	28 690	46 024	18 980	12 228	3 386
	3	5 407	12 632	12 630	4 236	8 968	4 087	744
	4	3 472	1 571	2 600	949	971	1 059	248
	5	4 155	1 407	513	879	350	102	352
Biomass (10^3 tonnes)		864	1 178	704	710	462	268	73

Table 9.7. Stock prognoses for North Sea SPRAT.

Age	Stock size 1.1.80	F 1980	Catch 1980	Stock size 1.1.81	F 1981	Catch 1981	Stock size 1.1.82
Option (a)							
1	(660 000)	0.11	47 700	(100 000)	0.5	28 000	
2	41 032	0.11	2 960	266 000	0.5	74 300	27 300
3	9 010	0.11	651	16 500	0.5	4 620	72 400
4	3 011	0.015	32	3 630	0.07	170	4 500
5	1 947	0.001		2 210	0.003		2 510
Catch			414 000			1 250 000	
Biomass	825 000			3 820 000			2 070 000
Option (b)							
1	(200 000)	0.3	36 400	(100 000)	0.5	2 800	?
2	41 032	0.3	7 470	66 600	0.5	18 600	27 300
3	9 010	0.3	1 640	13 700	0.5	3 820	18 100
4	3 011	0.04	86	3 000	0.07	140	3 720
5	1 947	0.002	-	2 170	0.003	-	2 230
Catch			407 000			531 000	
Biomass	825 000			1 250 000			873 000
Option (c)							
1	(140 000)	0.4	32 600	(100 000)	0.5	28 000	?
2	41 032	0.4	9 560	42 200	0.5	11 800	27 300
3	9 010	0.4	2 100	12 400	0.5	3 460	11 500
4	3 011	0.06	113	2 710	0.07	127	3 370
5	1 947	0.002	-	2 150	0.003	-	2 100
Catch			415 000			438 000	
Biomass	82 500			910 000			718 000

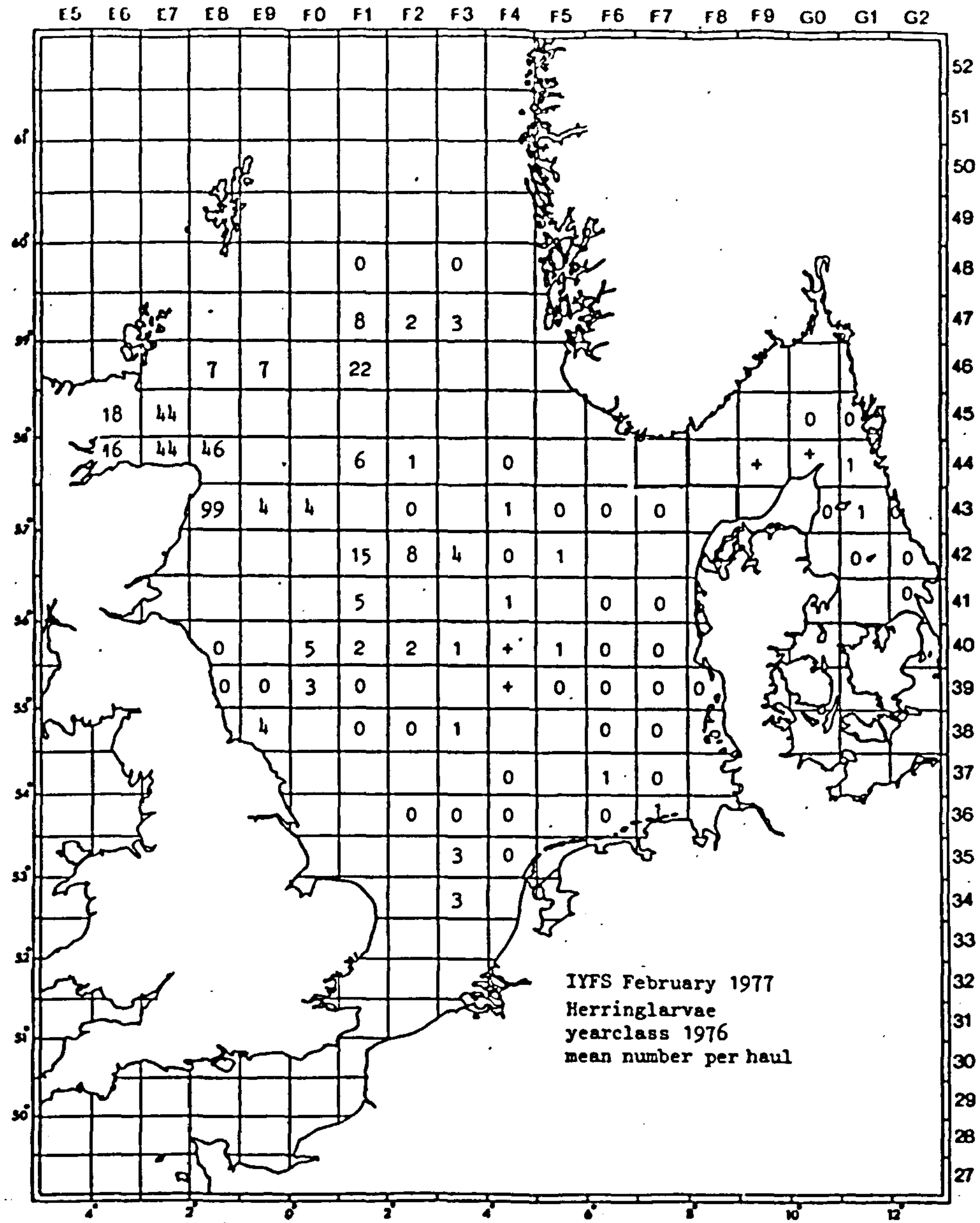


Figure 3.1. Mean number of herring larvae per haul caught by the Isaac-Kidd Midwater Trawl during the IYFS 1977-80.

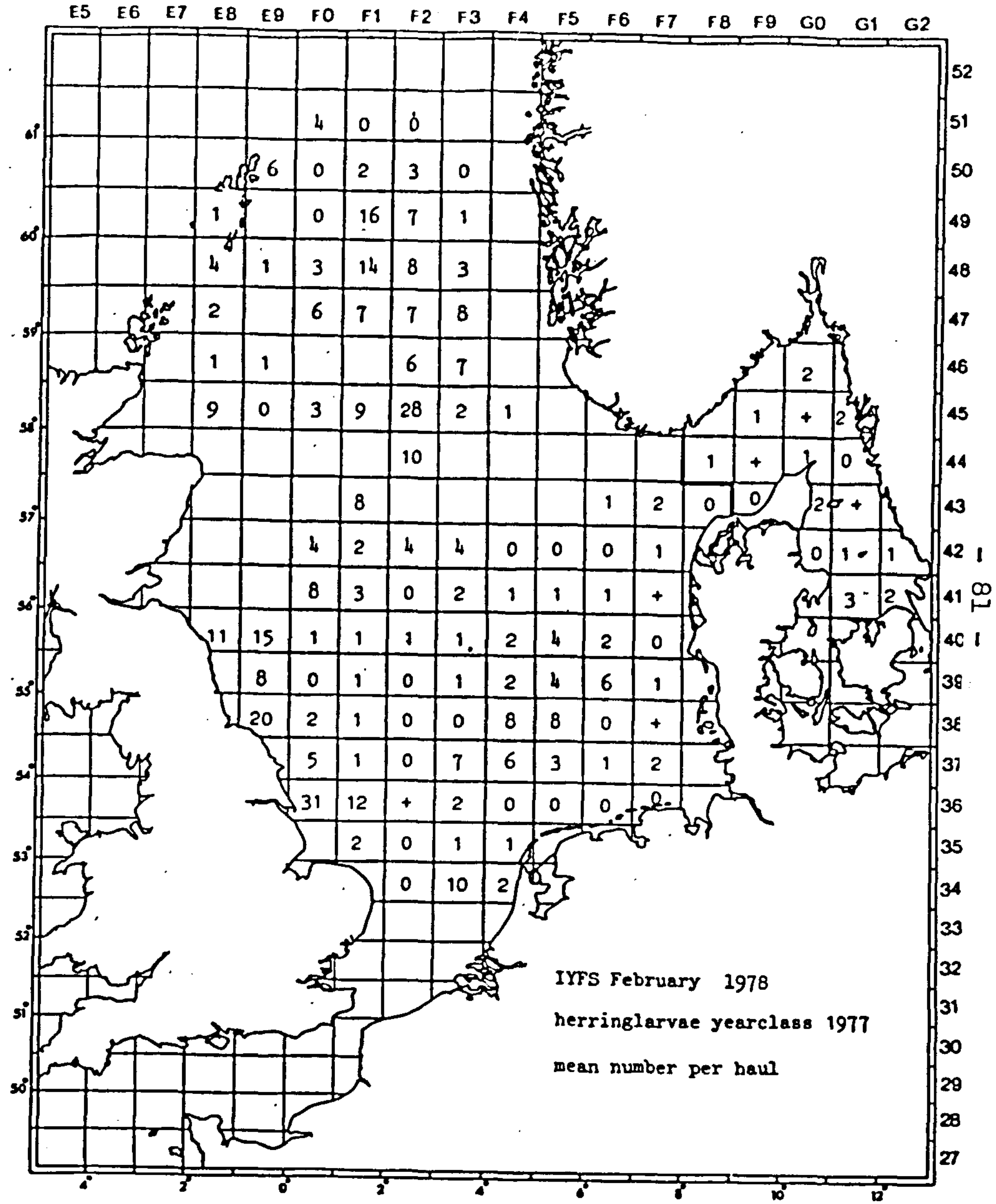


Figure 3.1. (Continued)

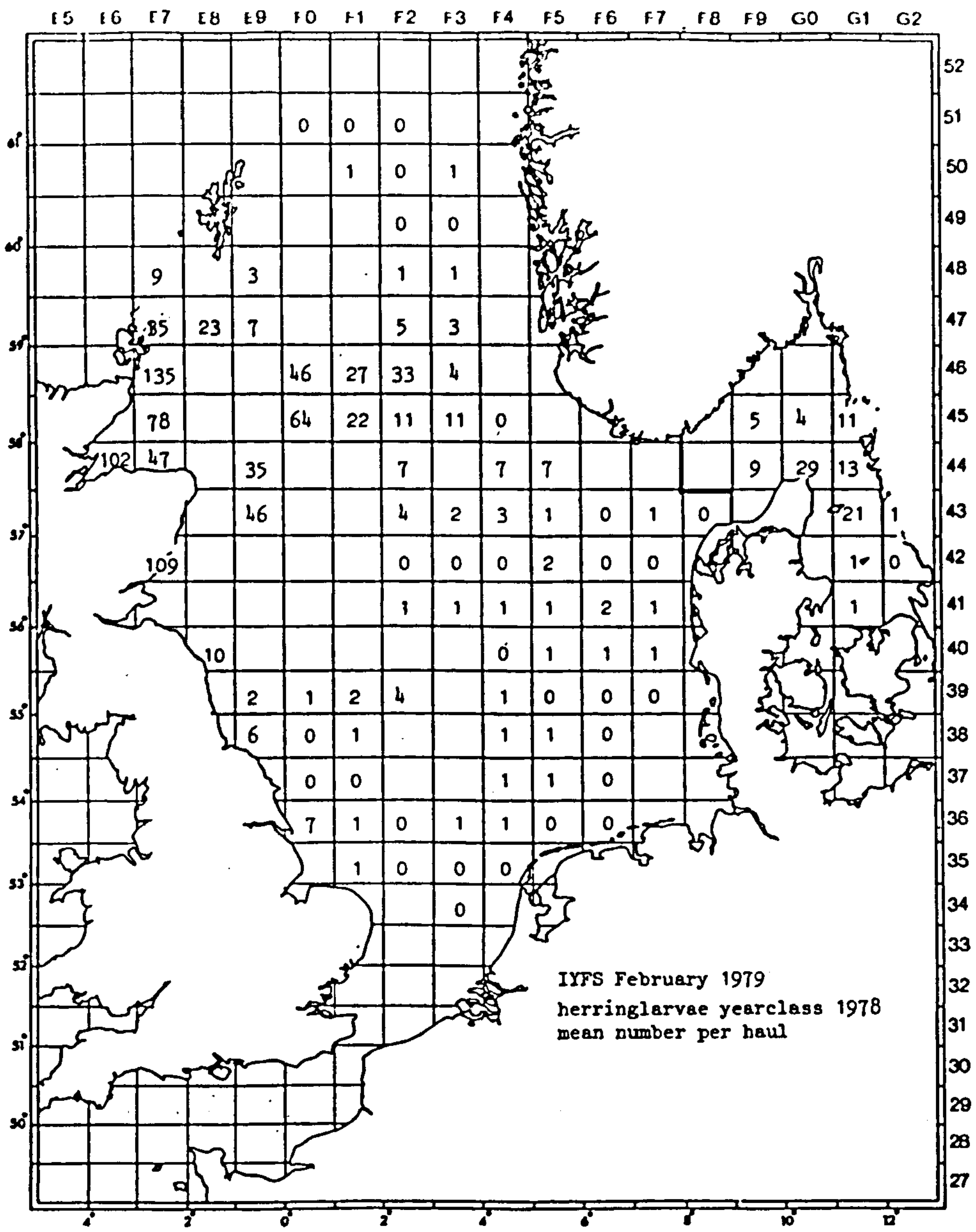


Figure 3.1. (Continued)

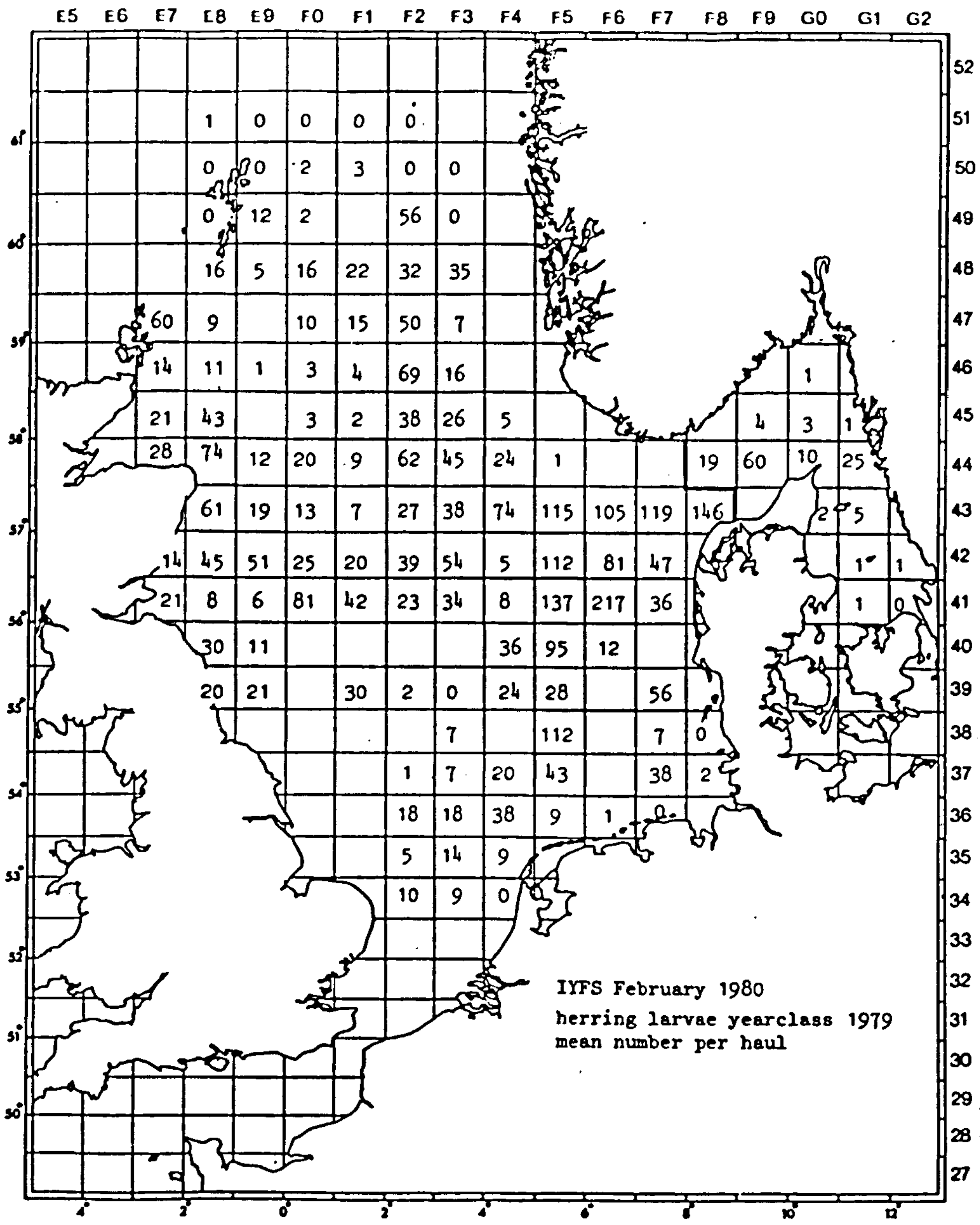


Figure 3.1. (Continued)

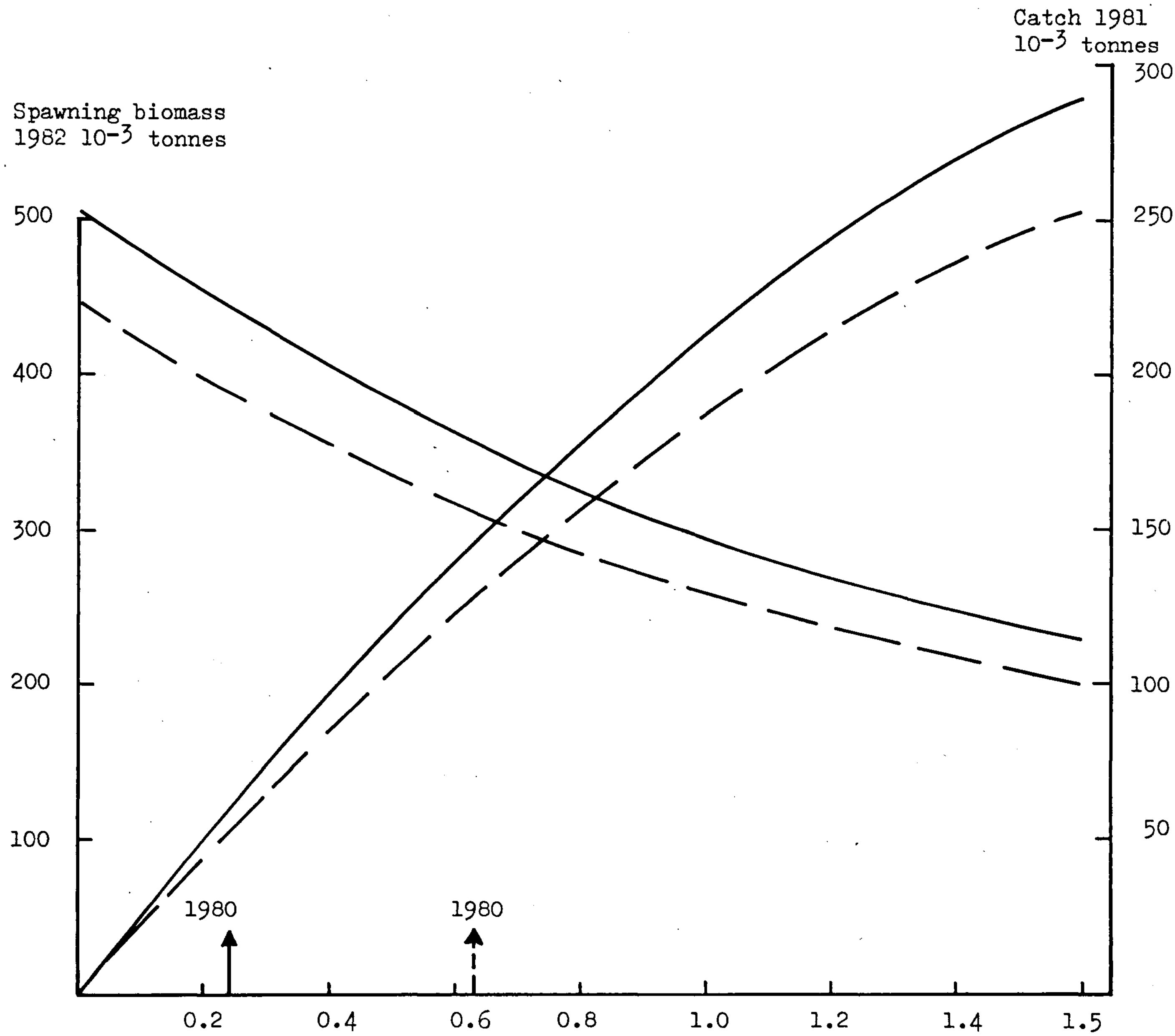


Figure 4.1. Division IIIa herring. Catch in 1981 and spawning biomass in 1982 plotted on different F-values in 1981 relative to F_{1979}. Full-drawn curves based on the assumption that the TAC of 40 000 tonnes is taken in 1980. Hatched curves based on a catch of 95 000 tonnes in 1980.

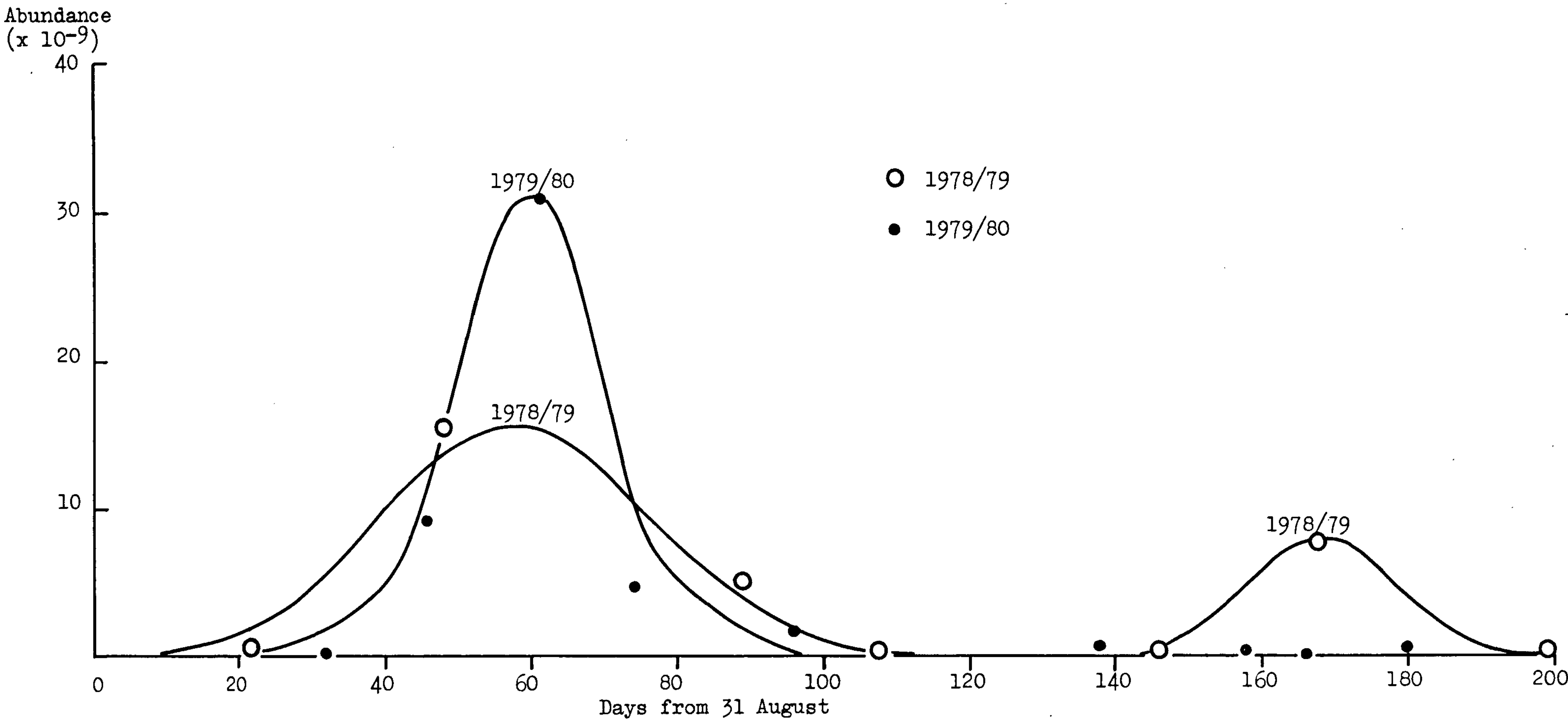


Figure 5.1. Celtic Sea larval survey. Abundance of < 10 mm larvae.

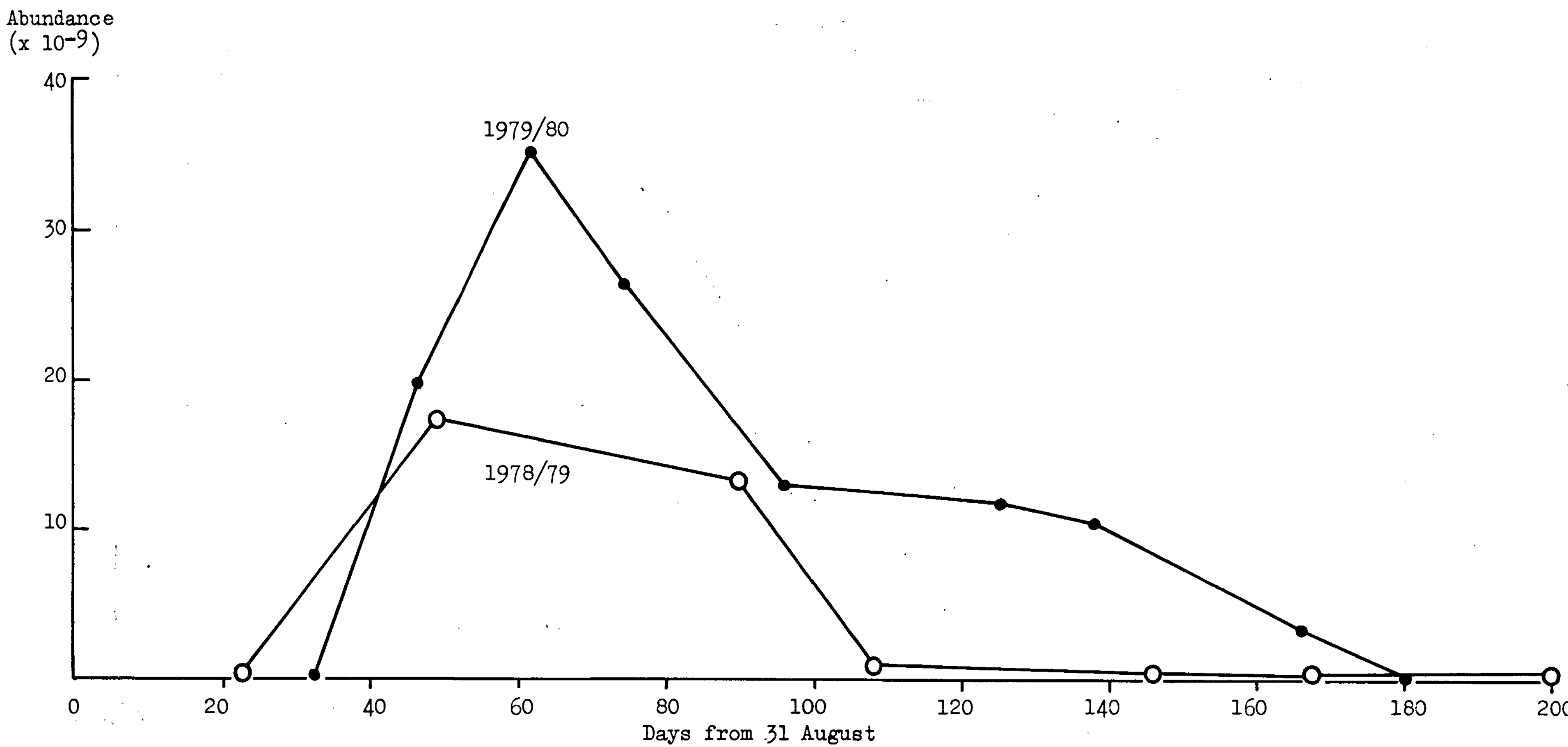


Figure 5.2. Celtic Sea larval survey. Abundance of 10-15 mm larvae.

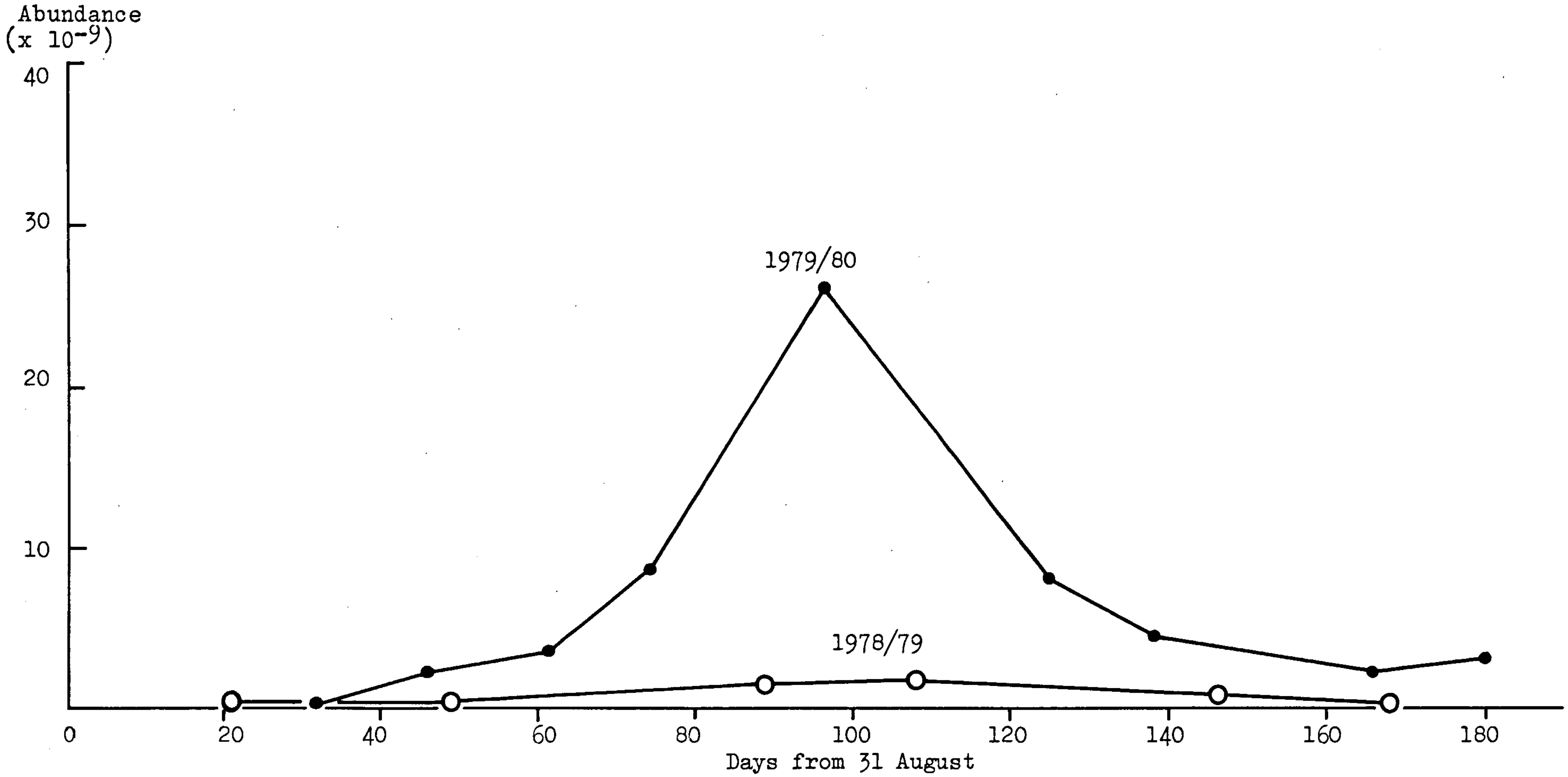


Figure 5.3. Celtic Sea larval survey. Abundance of > 15 mm larvae.

Herring Division VIa.

1) Ordinary regression r = 0.84
LA = 3.95 x SB + 553.9

2) Functional regression
SB = 0.21 x LA - 78.49

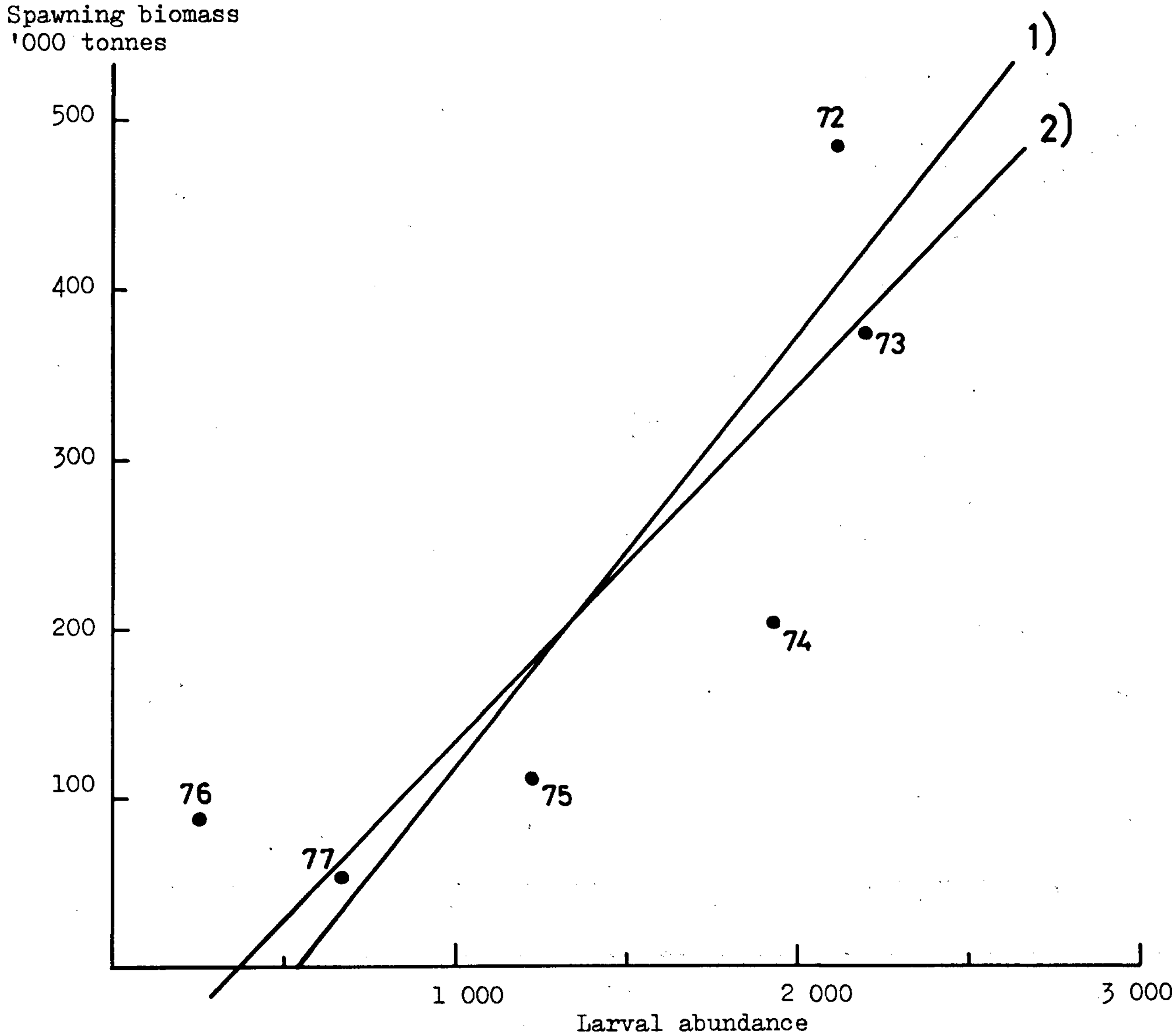


Figure 6.1. Regression of spawning stock biomass as estimated by VPA against larval abundance index.

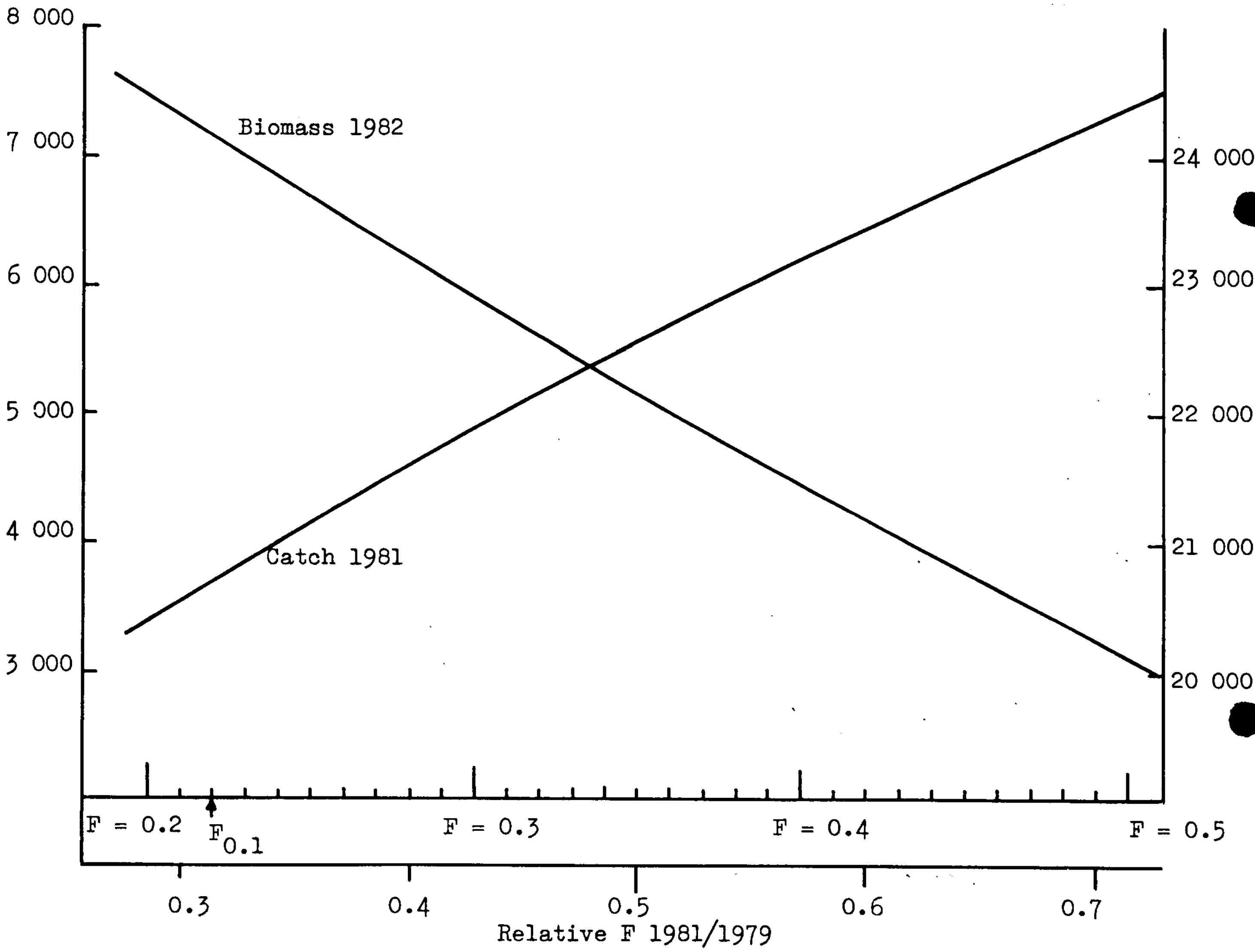


Figure 8.1. Northern Irish Sea. Manx stock projection.

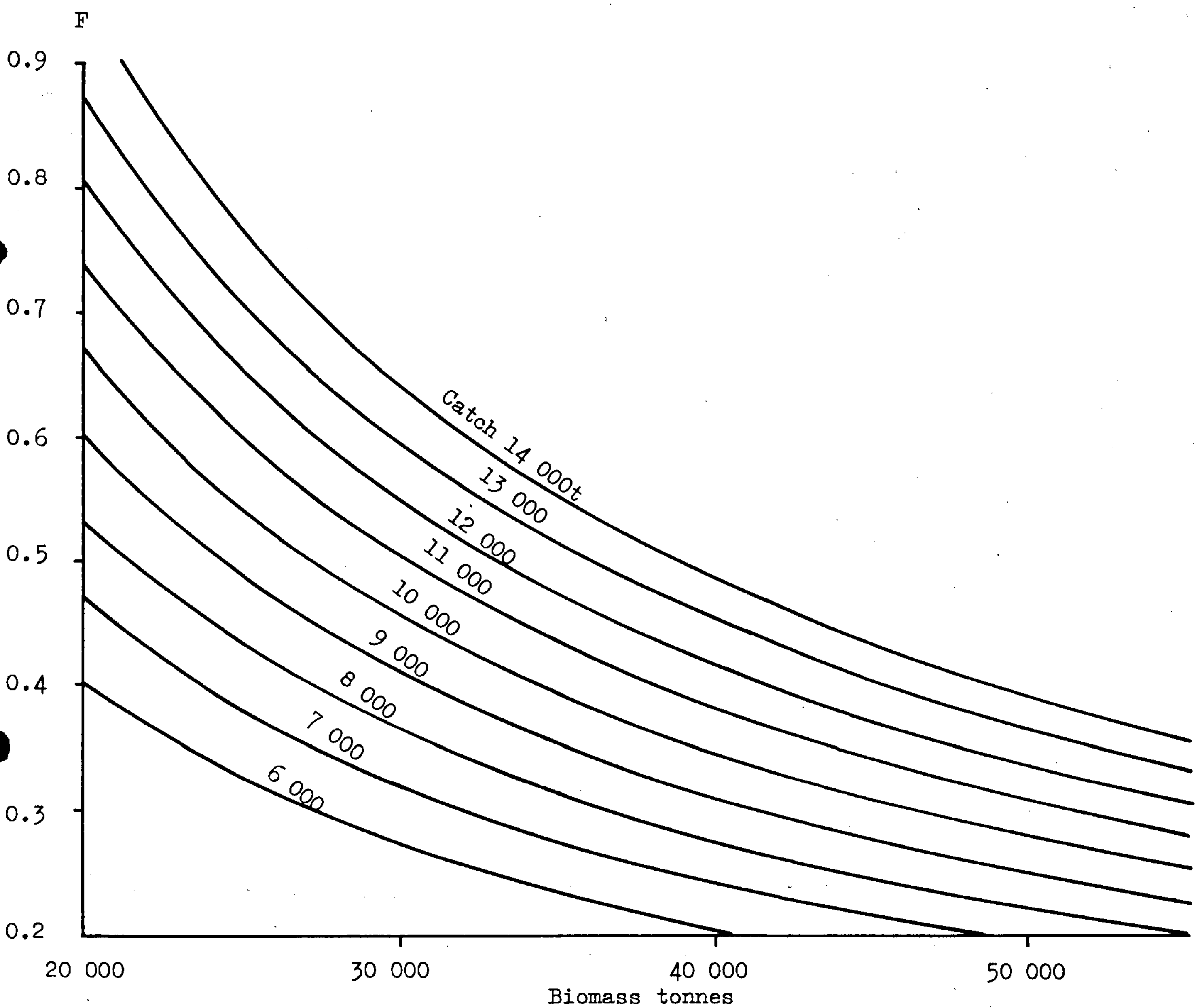
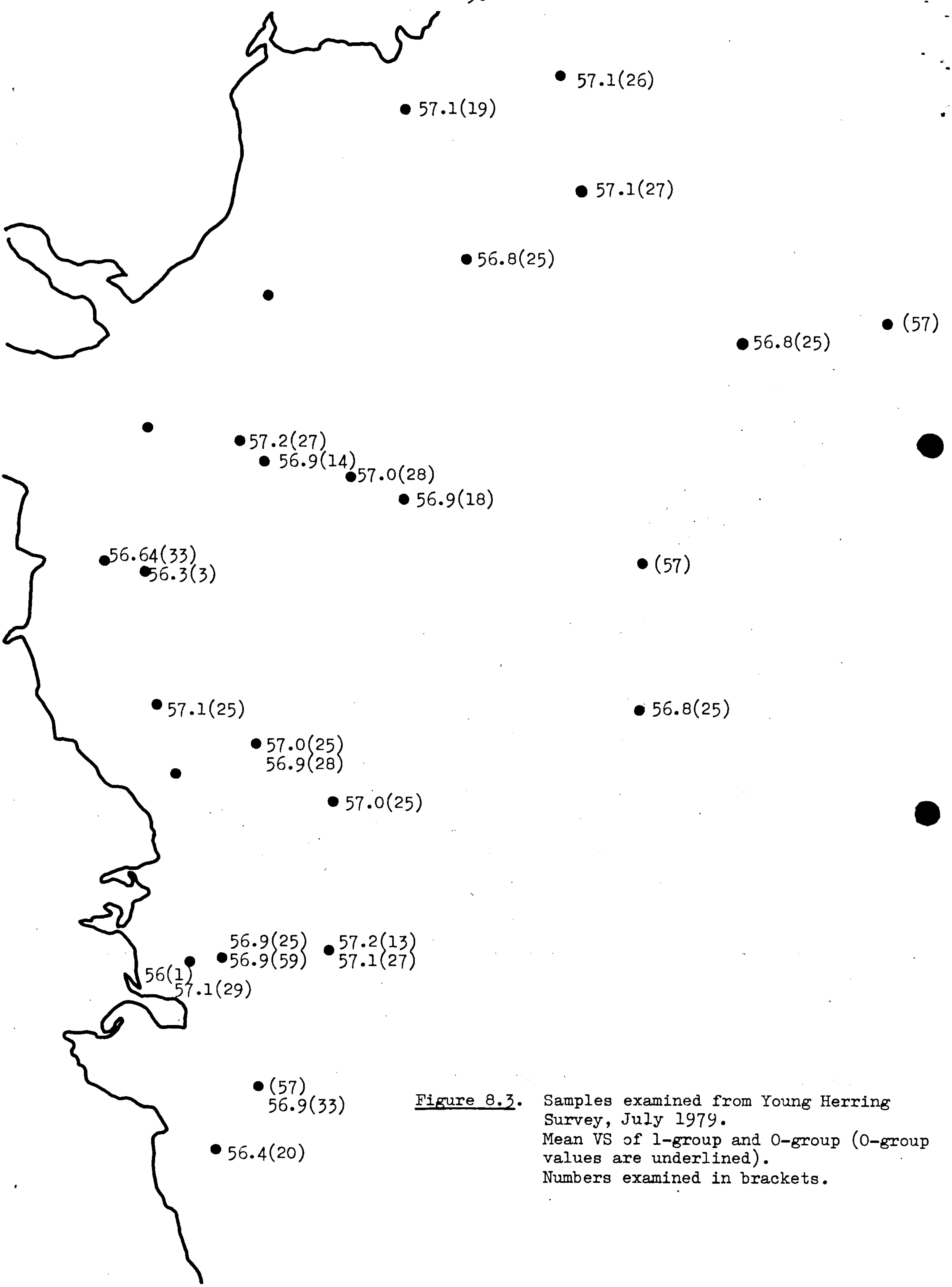


Figure 8.2. Biomass, catch and fishing mortality - MANX HERRING.



<u>Figure 8.3</u>. Samples examined from Young Herring Survey, July 1979. Mean VS of 1-group and 0-group (0-group values are underlined). Numbers examined in brackets.

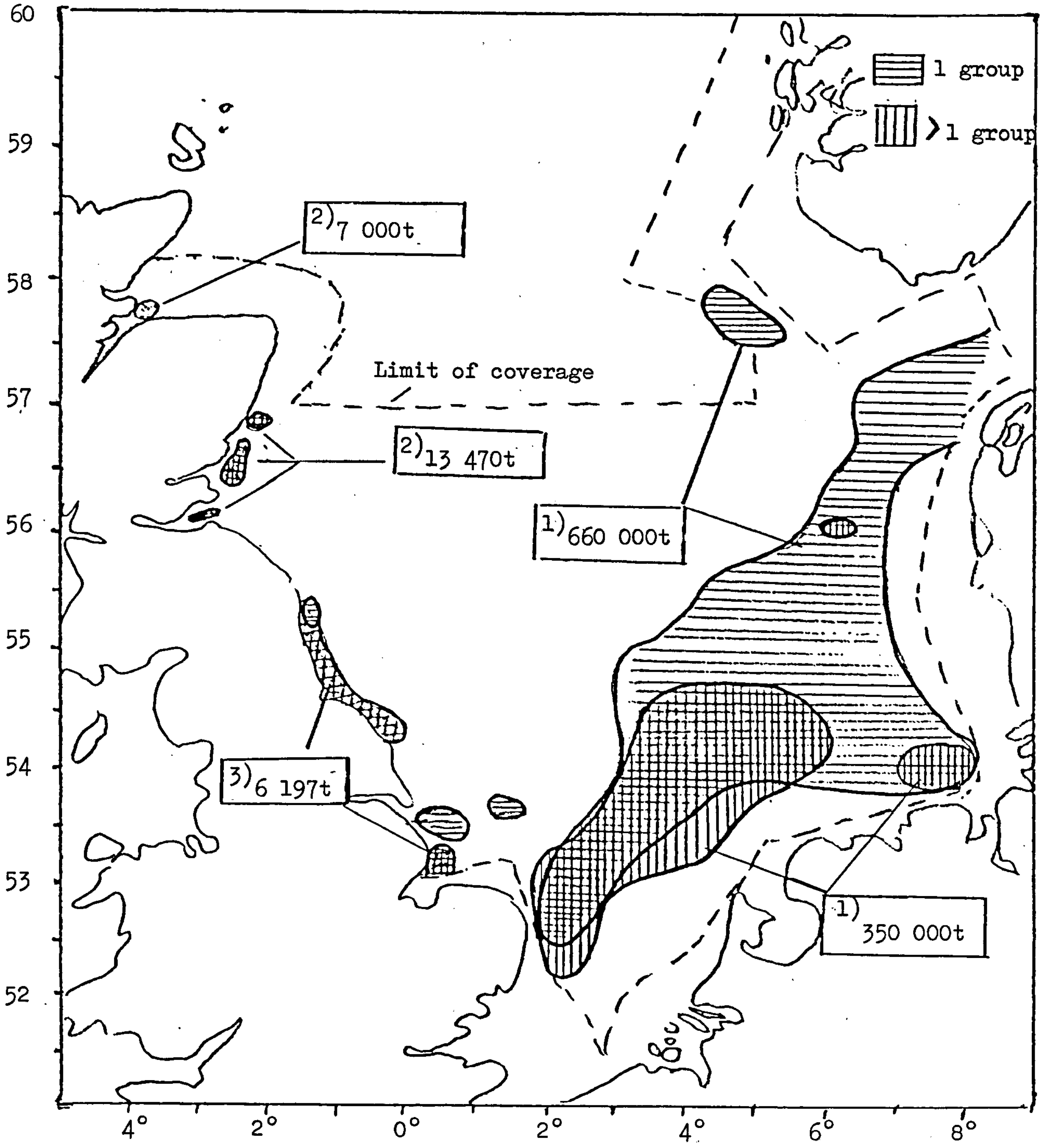


Figure 9.1. SPRAT. Distribution and biomass from acoustic surveys in January 1980.

		Conversion factor:
1) R/V "Johan Hjort"	TS = 10 log L - 15 dB kg^{-1}	1
2) R/V "Explorer"	TS = -34 dB kg^{-1}	x1/8
3) R/V "Corella"	TS = -29 dB kg^{-1}	x½

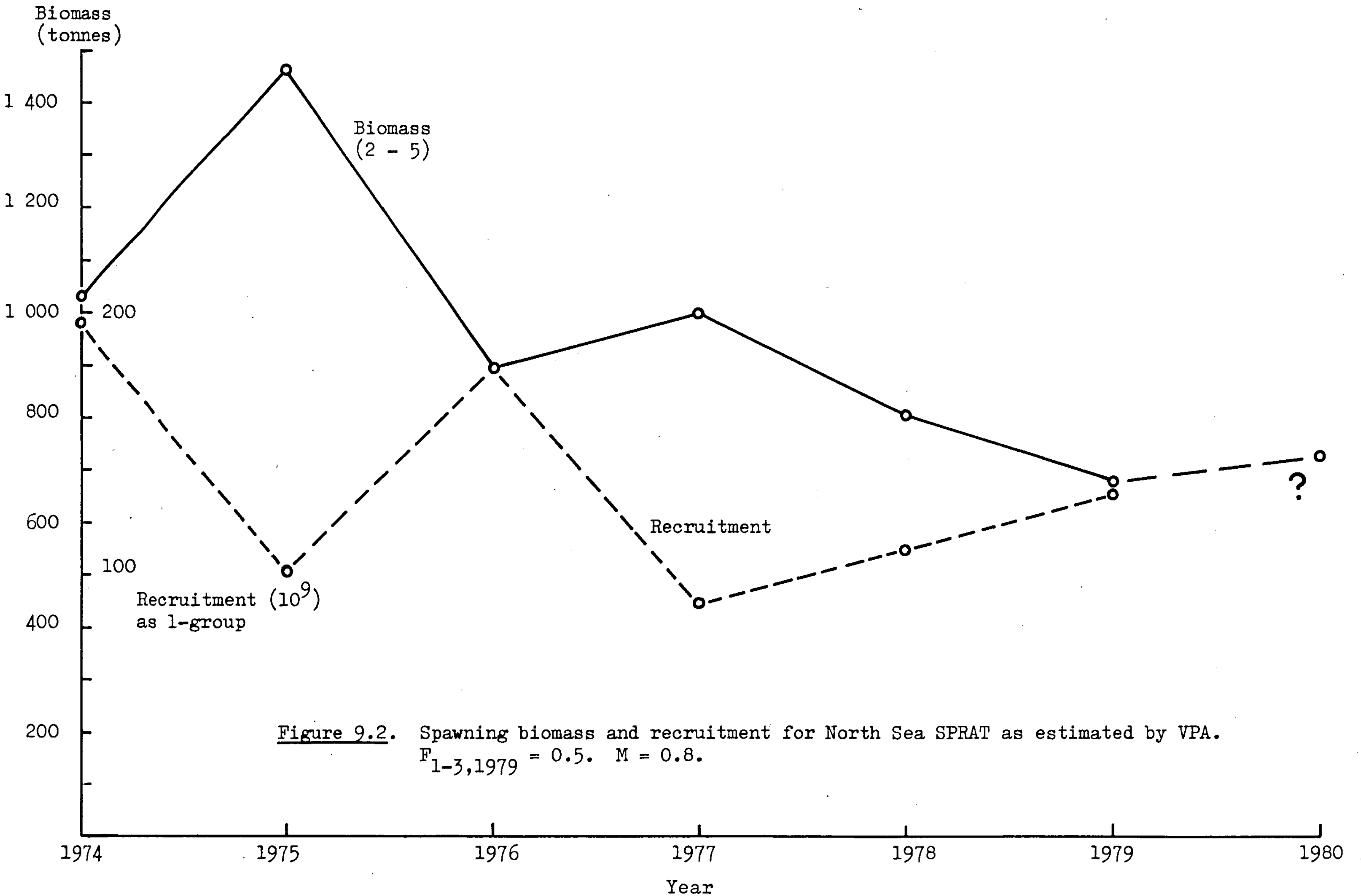


Figure 9.2. Spawning biomass and recruitment for North Sea SPRAT as estimated by VPA. $F_{1-3,1979} = 0.5$. M = 0.8.

APPENDIX 1

REPORT FROM MEETING OF LARVAL EXPERTS

Copenhagen, 20 April 1980

As recommended in C.Res.1979/2:27 Messrs. Corten, Saville, Ulltang and Wood met on 20 April 1980 to evaluate the use of herring larval data for assessment purposes. As the basis for their discussion, they used the document circulated to all members of the Herring Assessment Working Group for the Area South of 62°N by Saville prior to the meeting.

The initial discussion centred on the differences between catches of larvae less than 10 mm long taken by different countries participating in the internatinnal larval surveys when fishing in the same area at approximately the same time. It was recognised that this was a serious problem, which could bias any prediction of spawning stock size, made from regressions of larval indices and spawning stock sizes. This group of experts would strongly recommend that every opportunity should be taken on future surveys to carry out comparative sampling experiments between participating vessels, as far as practicable in areas of high larval abundance.

The Group then went on to consider Saville's treatment of the Division IVb larval indices and spawning stock estimates, which resulted in reducing the high and significant intercept of the regression on the spawning stock axis to a very small insignificant intercept. The first point which was discussed was the discrepancy pointed out by Saville between the sum of products and the reported catch in Division IVb adult fisheries. It was suggested that:

a) in the majority of years this would be accounted for if the total North Sea mean weights at age were not really applicable to the Division IVb catches a high proportion of which is taken in autumn on the spawning grounds.

b) the exception to this is in the year 1970 when the very high sum of products, relative to the reported catch, was in fact due to the human consumption and industrial total catches in Division IVb having been transposed in the relevant tables given in past Working Groups Reports.

Saville said that for the period 1971 onwards, using the Working Group's catch in numbers at age, would not have any appreciable effect on his regression. Not having all the raw data with him to redo the calculations, it was agreed that this would be done as soon as he got back to Aberdeen, and the results would be telexed to the Working Group immediately. (This was done and the revised functional regression equation is that given on the next page.)

The Group then discussed the basis used by Saville for eliminating non-central North Sea spawners from the spawning stock estimates. It was agreed that the catches taken in this area undoubtedly contained a component a Downs fish and that the basis used by Saville in eliminating them was the best available. Mr Wood expressed some disquiet that: a) the component of older fish taken in the industrial catch in Division IVb had been eliminated and that this was liable to mean some underestimate of the spawning stock size. However, it was pointed out that the regressions calculated including and excluding these fish differed only in the intercept being rather smaller in the latter case and that there was no basis for ascribing these fish, predominantly taken early in the year, to any one spawning stock. The Group also expected that there was likely to be some part of the Division IVb spawning population caught in Division IVa, but that there was no way of quantifying this.

The Group then dealt briefly with Saville's addition of the Buchan larval index to the northeast English coast one in getting a total larval index for the whole of Division IVb. The Group accepted that this was a logical procedure as: a) these larvae are produced in an area where part of the total Division IVb catch included in the spawning stock estimate is taken and b) the Buchan larval distribution is quite dinstict spatially from that of the Orkney-Shetland larvae with which they were amalgamated in the previous Working Group regression.

The Group then considered the correction to the larval index for the central North Sea made by Saville, by dividing the indices in surveys carried out by England by 4 to correct for the greater efficiency of England in catching larvae less than 10 mm long. It was agreed that there was rather firm evidence that there was a difference in efficiency between English and vessels of other participating countries but that the quantification of the factor was not very good. The recommendation cited earlier refers to the Group's feeling that a better measure of this factor is required. However, the Group also agreed that on the data currently available the factor of 4 is the best available. Mr Wood made the point that it might have been more appropriate to multiply the catches by other countries by 4 rather than dividing the English ones as this would be likely to give a more reliable index of the true number of larvae present. However, this would not appreciably affect the regression parameters and on the basis of all these considerations the Group accepted Saville's regression ($\hat{Y} = 10.2115X + 7.56$) as being a better representation of the relationship between larval abundance and spawning stock size than that previously used for Division IVb.

The Group then turned to consideration of the relationship between larval abundance and spawning stock size in the Orkney-Shetland area. Three members of the Group accepted Saville's analysis that showed the apparent discrepancy between spawning stock sizes in Divisions IVa and IVb and the larval indices for these two areas could be accounted for by the intercept in the Division IVb regression and the different parts of the hatching curves over which the larval indices were measured in the two areas. Mr Wood still had problems in accepting the very small spawning stock sizes ascribed to Division IVa in Saville's regression and the relation between these and the apparent larval abundances in this area. As Saville's estimates of spawning stock sizes for that area are very dependent on the emigration model, he used, and as the model is outside the competence of the Larval Group, it was decided that it was rather pointless to make any further attempt to reconcile this conflict of views within the Group on this topic.

The Group then discussed a working paper produced by Mr Corten, in which he had further elaborated the analysis of North Sea larval surveys first presented in C.M.1978/H:7. In this method, estimates of total larval production for the whole North Sea are compared with stock estimates from the conventional VPA. This method eliminates the problems discussed earlier in producing spawning stock estimates for the different Divisions within the total North Sea area. In the original paper no significant correlation could be obtained between larval production and VPA stock sizes for the years up to 1976. However, if the series of VPA stock estimates is extended to 1979 by including stock sizes predicted from the International Young Fish Surveys, a significant correlation is obtained both for the larvae less than 10 mm and 10-15 mm. The Group considered this to be an interesting approach, but they realised that the regressions obtained could not be utilised to predict the 1979 spawning stock from the larval production, since the values for this year had been used to calculating the regression. Only for the years after 1979 might the regressions be used in a predictive way.

The Group then estimated spawning stock sizes in 1979 from the results of the larval surveys in that year. The estimates of larval abundance from the surveys in each area and the regression equations used to derive the spawning stock sizes are given below with comments on the adequacy of the survey data in each area.

<u>Estimates of Spawning Stock Biomass for Herring Larval Surveys</u>

The results from all the international surveys of herring larvae which were carried out during 1979/80 in the North Sea and adjacent waters, were available to the Group together with those for Scottish surveys conducted in Division VIa. A comparison was made of the abundance estimates for herring larvae $<$ 10 mm in length, between surveys made in 1978/79 and comparable surveys carried out during 1979/80. The results are given in Table 1.

Northern North Sea

There was a good coverage of the northern North Sea during both the first and second halves of September 1979 by research vessels of the Netherlands, the Federal Republic of Germany and Scotland. There was a substantial increase in overall production of herring larvae in 1979 with very high densities of over 1 000 larvae per square metre at a number of stations. 10-15 mm larvae were exceptionally abundant in 1979, particularly in the southeast of Orkney and it is likely that many of those came from hatchings in this area.

Central North Sea

There was again an excellent coverage of this area in the autumn of 1979 with extensive surveys in five separate periods during September and October. Highest station densities again occurred off the Longstone and the Yorkshire coasts. Overall production in this area was somewhat lower than in 1978. Research vessels of England, Netherlands and Norway participated in these surveys.

Southern North Sea and Eastern Channel

There was a substantially better coverage of this area in the winter of 1979/80 by England, Netherlands and the Federal Republic of Germany. Four individual surveys were carried out, one in December and three in January. Larval abundances during January 1980 were the highest for a number of years and indicated a considerable increase in the size of the Downs stock.

Orkney-Shetland Area (Division IVa)

The estimates of larval abundance for this area measured in the way which has been done in the past are given in Table 2. Using the regression equation used by the Working Group in the past ($\hat{Y} = 4.171X + 49.393$), the larval index of 32.42×10^{11} larvae gives a spawning stock estimate of 185 000 tonnes.

However, Saville pointed out that in some years England had participated in these surveys and Wood (1973) had drawn attention to the fact that England caught larvae less than 10 mm long more efficiently than Scotland by a factor of 3. He had, therefore, reduced English catches by this factor.

In the past estimates of larval survey values for this area have been produced by integrating station values over the area sampled. Inherent in this technique is the assumption that where part of the area had not been sampled, as has happened with considerable frequency, the unsampled area contained no larvae. This appears to be a quite unrealistic assumption. Saville to correct for this took a standard area between 58°N and 60°N, and between 1°W and 4°W, the area which has been fairly consistently sampled in all years under consideration, and calculated the mean catch per square metre per haul for all hauls taken within this area in the first half and the second half of September in each year. These values could then be integrated over the area by multiplying these means by the number of square metres contained within the standard area but as in any case this merely means multiplying each value by a constant it is somewhat irrelevant in the context of a regression parameter so this has not been done. The means of these two annual values was taken as the index of larval abundance for each year. The resulting larval indices are given in Table 2. Those for the period 1972-77 were then used as inputs for a regression calculation against spawning stock estimates for Division IVa, with and without emigration factors, as given in Saville (in press).

In the previous report of the Working Group the problem had been pointed out, in relation to the 1978 larval survey data for this area, which was caused by one exceptionally high station value, when one used the integration over area technique. In calculating the survey indices in this way this problem does not arise to the same extent and Saville gave this station value equal weighting with all others in calculating his mean. In that year the Working Group also had to make an estimate for the second half of September because no full survey had been done at that time which could be utilised by the integration technique. However, in the second half of September 1978 forty stations were sampled and Saville used these to calculate a mean for the second half of September which obviated this problem.

Table 2. Annual indices of larvae less than 10 mm in Orkney Shetland area calculated as mean catch per square metre per haul.

1972	44.97
1973	41.99
1974	11.66
1975	8.03
1976	10.50
1977	21.38
1978	82.43
1979	87.51

This gives a regression equation of $\hat{Y} = 1.34X + 10.38$, where X is the mean catch per square metre per haul calculated as described above, and $\hat{Y}$ is in thousand tonne units and corrected for fish emigration. This regression is significant at the 1% level and the intercept is obviously very small. If one uses stock estimates not corrected for emigration, the relevant regression is $\hat{Y} = 2.63X + 38.72$. This regression is significant at the 2% level, but the intercept is large and significant. The estimates of spawning stock size in 1979 derived from the larval abundance indices calculated in this way for 1978 and 1979 of 82.43 and 87.51 respectively give spawning stock sizes of 121 000 tonnes in 1978 and 127 000 tonnes in 1979 with the emigration correction and of 250 000 tonnes and 262 000 tonnes respectively without an emigration correction. The 1978 values must be treated with caution due to the very poor coverage by the larval survey carried out in the second half of September in that year.

Central North Sea (Division IVb)

As pointed out above, the Group accepted Saville's regression for this area and the corresponding larval indices for 1978 and 1979 were 2.23 and 2.26×10^{11} respectively. Inserting these values in the regression equation given above of $\hat{Y} = 10.2115X + 7.56$, the estimates of spawning stock are 1978: 30 300 tonnes, 1979: 30 600 tonnes.

Southern North Sea (Divisions IVc and VIId)

As pointed out in Saville's document the best relation that he could get between spawning stock size and larval abundance in this area was not quite significant at the 5% level. However, the regression equation is $\hat{Y} = 0.566X + 16.16$, where larval abundance is $\times 10^{-9}$.

Using this equation the indices for this area in 1978/79 and 1979/80 are 10.55 and 80.80 respectively, giving spawning stock estimates of 22 000 tonnes in 1978/79 and 62 000 tonnes in 1979/80.

It was necessary after recalculating spawning stock sizes in Division IVb (based on the Working Group original data, as agreed by the larval experts) for Saville to also recalculate spawning stock sizes in Divisions IVa and VIId. The new predictive regression, $\hat{Y} = 0.35X + 18.34$ was significant at the 5% level and the functional form was $\hat{Y} = 0.7132X + 13.27$ with larval abundances expressed as $\times 10^{-9}$. The spawning stock size estimated from the latter regression is 1978/79: 21 000 tonnes and 1979/80 81 000 tonnes.

Wood (1980) has also calculated a regression equation for the area on a rather different basis. This is $\hat{Y} = 0.2647X + 6.44$. Using the 1979/1980 larval index in this equation gives an estimated spawning stock size for this area of 39 000 tonnes. It should be recognised however that this regression equation is based on the assumption that the Southern Bight and Channel spawning stock is exploited only in Divisions IVc and VIId.

West of Scotland (Division VIa)

The regression for this area given by Saville (in press) was calculated on the assumption that all countries participating in the larval surveys in this area were sampling the <10 mm sizes with equal efficiency. In the light of what is said above in relation to IVa and IVb this now seems highly unlikely and this view is supported by the fact that English surveys in the Cape Wrath area caught considerable numbers of yolk-sac larvae which were of very rare occurrence in Scottish catches.

So Saville has corrected the larval abundance indices for this area for this factor by dividing all English catches of less than 10 mm larvae by 3 - the same factor as used above for the Shetland area. Doing this and calculating the regression between these indices and the same estimates of spawning stock size given in Saville (in press) the predictive regression equation is $\hat{Y} = 6.97X + 4.87$. This is significant at less than the 1% level and the intercept is obviously very small and not significantly different from zero. The corresponding functional regression, which is in the form the Working Groups seems to prefer is $\hat{Y} = 7.43X - 13.67$.

The larval surveys in 1979 covered the area four times, twice in September and twice in October, so the larval index for this year is calculated on a much firmer basis than in 1978. However, for the two years the indices of larval abundance, calculated as described in Saville (in press), are 10.72×10^{11} in 1978 and 31.96 in 1979. Using the functional regression equation given above results in spawning stock estimates of, 1978: 66 000 tonnes, 1979: 224 000 tonnes. Note should be taken of the fact that although larval abundances increased in all parts of Division Va in 1979 the most substantial increase occurred in the area off the Irish coast in the most southerly portion of the Division.

References

Wood (1973) ICES Coop.Res.Rep., No.34.

Wood (1980) ICES Coop.Res.Rep. No.90.

Table 1. Estimates of the abundance of herring larvae in the North Sea and VIa in 1979/80 and comparable estimates for 1978/79

Area	1978/79 ($\times 10^{-9}$)	1979/80 ($\times 10^{-9}$)
Northern N. Sea	5-14 September <10 mm 5 390 •)	29 August - 6 September <10 mm 4 284 5 - 14 September <10 mm 2 864 18 - 27 September <10 mm 2 578
Mean Survey Abundance	3 564[a)] 2 363[b)]	3 242
Central North Sea (Estimates for the Buchan Area given separately)	6 - 13 September <10 mm 1 484 20 - 27 September <10 mm 79 (Buchan 118) 29 Sept.-11 Oct. <10 mm 314 22-29 October <10 mm 2	31 August - 4 September <10 mm 1 217 4 - 12 September <10 mm 135 (Buchan <10mm 150) 18-27 September <10 mm 144 (Buchan <10mm 8) 4-10 October <10 mm 565 13-20 October <10 mm 9
Mean Survey Abundance	588	493
Southern North Sea and Eastern Channel	11-22 December ≤11 mm 17. Total 25 3-10 January <11 mm 4. Total 8	12-20 December <11 mm 2 Total 2 7-10 January <11 mm 216 Total 252 18-21 January <11 mm 25 Total 97
Mean Survey Abundance *	<11 mm 11. Total 16	x) <11 mm 81 Total 124

*) The Survey conducted by the Federal Republic of Germany has not been included as abundance estimates were not available for the three size categories. The total abundance estimate for all sizes of larvae 16-22 January was 136.0×10^9. This value is incorporated however in the mean survey value for total larvae

Area	1978/79 (x 10^{-9})	1979/80 (x 10^{-9})
VIa	1 - 11 September <10 mm 364 23 Sept.-10 Oct. <10 mm 820	30 Aug - 2 Sept 1 002.7 17-23 Sept. 127.0 27 Sept.-6 Oct. 2 997 6 - 16 Oct. 2 636
Mean Survey abundance	592	1 691

*) Estimate giving equal weighting to one quite exceptionally high density station.

a) Larval Working Group estimate for the whole of September based on ratio of abundances first half to second half of September 1974-77 and giving equal weighting to high density station.

b) Larval Working Group estimate for the whole of September but with weighting of high density station reduced to normal value.

APPENDIX 2

MINORITY STATEMENTS ON MANAGEMENT OF NORTH SEA HERRING

Mr. A. Corten did not agree with the advice for the management of North Sea herring and he made the following statement: "The advice to keep the directed herring fishery in the North Sea closed during 1980 is inconsistent with the advice given for other areas with much smaller spawning stocks (Irish Sea, Division IIIa) or no spawning stock at all (Clyde), where small scale fisheries are still allowed to be carried on. The advice is also inconsistent because it advocates a continuation of the ban on directed fisheries, but not a closure of the sprat fishery which according to the latest information is still causing considerable damage to the juvenile herring. From a biological point of view, there is no reason why the sprat fishery should be allowed to continue, while even a limited directed herring fishery could not be tolerated.

According to the stock prognosis given in this report, the increase in spawning stock for the North Sea as a whole during 1980 will be approximately 60 000 tonnes. This must be considered as a minimum estimate, because the expected increase in spawning stock depends largely on an extremely low estimate for year class 1977 from the International Young Fish Surveys. As is shown in other sections of the report, accepting the IYFS-estimate for year class 1977 at its face value means that the fishing mortality on 1-ringers in 1979 has been 0.49. This should be a strong argument for an immediate closure of the sprat fisheries as they appear to have destroyed in 1979 more than 1/3 of the entire year class 1977 which was present at the beginning of that year. The only other alternative is to accept that the IYFS-index for year class 1977 was an underestimate, which will reduce the fishing mortality on 1-ringers in 1979, but at the same time increase the expected growth of spawning stock in 1980. After 1980, the spawning stock is expected to increase more rapidly due to the recruitment of year classes considerably larger than the one that will recruit in 1980. Year class 1978, which will recruit in 1981, will contribute an estimated 140 000 tonnes to the spawning stock (assuming that not more than 15% of this year class will be caught in the sprat fishery in 1980). No firm estimates are available yet for year class 1979 which will recruit in 1982. The Working Group has estimated that the spawning stock in 1979 has been somewhere between 255 000 and 442 000 tonnes. Taking a rather conservative estimate of 300 000 tonnes, the stock/recruitment relationship for North Sea herring (Coop.Res.Rep. 78) predicts an average recruitment of 5×10^9 0-ringers at this level of spawning stock size. Assuming an F of 0.20 on both 0- and 1-ringers, such a year class would contribute more than 300 000 tonnes to the spawning stock as 2-ringers. In this context it should be noted that the first indications for year class 1979, derived from IKMT-sampling, suggest that this year class will be considerably stronger than the preceeding 3 year classes.

Concerning the question of re-opening the fishery in 1980, it must be noted that the spawning stock in that year (3 - 400 000 tonnes) is still considerably below the level of 800 000 tonnes which the Working Group considers necessary for the production of average recruitment. Taking a certain quantity of herring in 1980 will probably prolong the period of below average recruitment, and therefore will reduce the total physical yield that can be taken from the stock over the next decade. The present Working Group, however, is not qualified to judge whether a management policy of taking the maximum physical yield is also the most preferable strategy from an economical and social point of view.

Considering the present estimates for spawning stock size in 1979, and the expected increases during 1980 and subsequent years, it is clear that a TAC of 20 000 tonnes in 1980 (such as proposed by 3 members of the Working Group in the 1979 Working Group report) would not seriously endanger the recovery of the stock. This of course on the condition that management authorities could guarantee a strict enforcement of such a small TAC. If a limited TAC is allowed in 1980 and/or subsequent years, measures should be taken to restrict the fishery to those sub-populations which are showing the fastest recovery at the moment. Measures should also be taken to keep the fishery away from areas with a high abundance of juveniles in order to avoid problems of catching and dumping of juvenile herring".

Disagreement on the advice given by the Working Group for the management of North Sea Herring was also expressed by Messrs. A. Maucorps and J. Massé. They agreed with the general principles regarding biological criteria for reopening a herring fishery in the North Sea (Section 2) although they had some reservations regarding the last paragraph of the relevant section. Their disagreement is based on the interpretatin of the evidences, as considered by the majority of the Working Group, on the improvement of recruitment and on the increase of the biomass both for the Northern North Sea and Southern North Sea - Eastern Channel spawning components of the North Sea herring. In their view the present evidence is sufficient to consider that a very limited fishery would not endanger the continuation of the recovery of these two stocks which both show signs of a significant improvement.

On this basis and their adherence to the results of the analysis made above by A. Corten, they would advise a very limited fishery restricted to the northern North Sea herring stock in August 1980 and to the Southern North Sea - Eastern Channel Stock in December 1980 - January 1981. In such circumstances, of course, the most stringent measures for enforcement and proper control of the catches would have to be guaranteed.

International Council for the
Exploration of the Sea

C.M.1980/H:4

Addendum 1

Revised assessment of Div. IIIa Herring

During the meeting of the Herring Assessment Working Group for the Area South of $62^{o}N$, an acoustic estimate of herring in Div. IIIa in September 1979 was presented. A constant factor C was used to convert integrated echo-signals into biomass, and this factor was based on target strength measurements of herring around 100 g (Hagstrøm et al. 1979). A considerable part of the total biomass registered during the survey was other fish, mostly sprat, and herring smaller than those the target strength measurements were based upon. This could lead to a serious overestimate of both total biomass and herring biomass.

If it is assumed that the reflection coefficients are the same function of length for herring and sprat, $\sigma = k_1 l^2$ (Nakken and Olsen, 1973), and also that the weight of herring and sprat are the same function of length, $w = k_2 l^3$, the C value for herring and sprat would be the same linear function of length, $C(l) = kl$

Based on the measured C-value for herring around 100 g or 25 cm, the function $C(l) = kl$, and the sampling data on length compositions available from the survey, a revised acoustic estimate has been calculated after the Working Group meeting.

The difference between the two estimates is shown below:

	Stock in numbers ($x10^{-6}$)	
Age	Working Group Report	Revised estimate
0	998.8	577.4
1	1010.8	610.7
2	1638.8	1 067.4
3	116.6	92.8
4	14.3	12.7
5	4.7	3.9

The revised estimates are 28 % lower than those given in the Working Group Report. The difference between a VPA and prognosis based on the revised acoustic estimate and those given in the Working Group report will, however, be rather small due to the fact that the Working Group decided to adjust the acoustic estimate downwards to an extent which made the 1977 year class not stronger than the 1974 year class as 0-group. Accepting the revised acoustic estimate as starting point for the VPA, no such adjustment is necessary since in this case the 1977 year class is estimated to be slightly weaker than the 1974 year class.

The revised VPA is given in Table 1-3. Revised stock at 1 January 1980 is given in the text table below:

W.R.	Stock in number $x10^{-6}$	Stock in tonnes
0	(5000)	-
1	3064	79 700
2	518	31 100
3	946	109 700
4	65	11 400
5	12	2 500
6	4	900
7	+	+
Total	4610	235 300

The corresponding spawning stock biomass in 1980 is 125 000 tonnes. The TAC of 40 000 tonnes for 1980 will generate a fishing mortality on 3-ringers and older of 0.18 compared to 0.7 in 1979. $F_{1980} = \frac{0.18 + 0.7}{2} = 0.44$ will generate a catch of about 90 000 tonnes. Calculated catch in 1981 and spawning biomass in 1982 are plotted against F_{81} in Figure 2 for these two catch levels in 1980.

All calculations are based on continuation of the 1979 exploitation pattern. The yield per recruit curve for this pattern is shown in Figure 2. F_{max} is 0.24, and this F would give a catch of 52 000 tonnes in 1980. $F_{0.1}$ is 0.12.

Addendum 1, Table 1. Division IIIa herring.
Input catch data for VPA 1980.

Age	1974	1975	1976	1977	1978	1979
0	2 499	2 006	433	934	147	457
1	910	1 471	1 474	1 437	876	168
2	375	149	325	329	455	583
3	135	60	28	61	65	70
4	47	57	4	12	10	13
5	26	15	3	6	1	4
6	9	6	1	4	1	0
7	3	1	1	2	0	0
8+	1	1	1	0	0	0

Natural mortality at age:

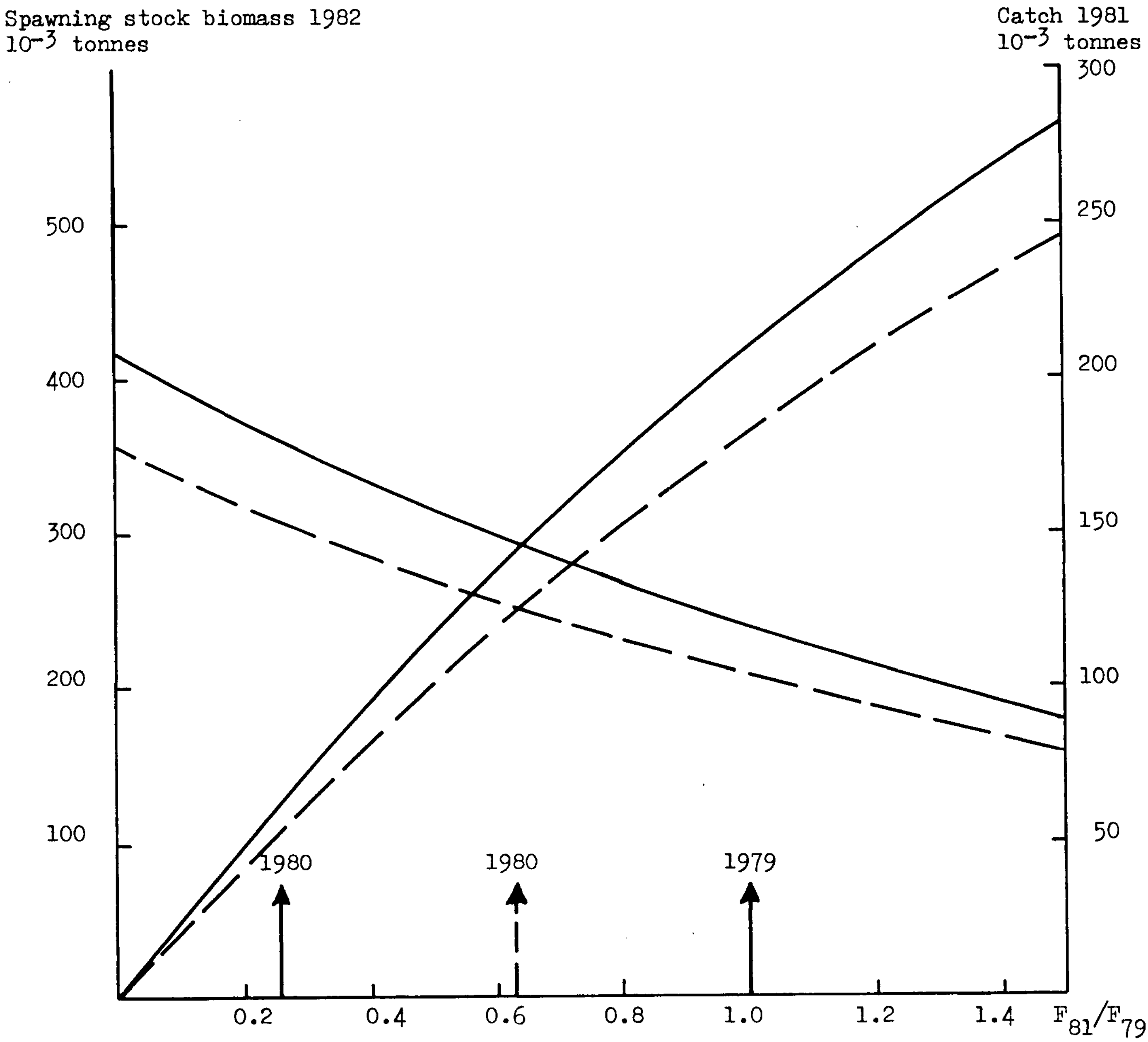
0	1	2	3	4	5	6	7	8
0.30	0.25	0.20	0.10	0.10	0.10	0.10	0.10	0.10

Addendum 1, Table 2. Division IIIa herring.
Fishing mortalities from VPA.

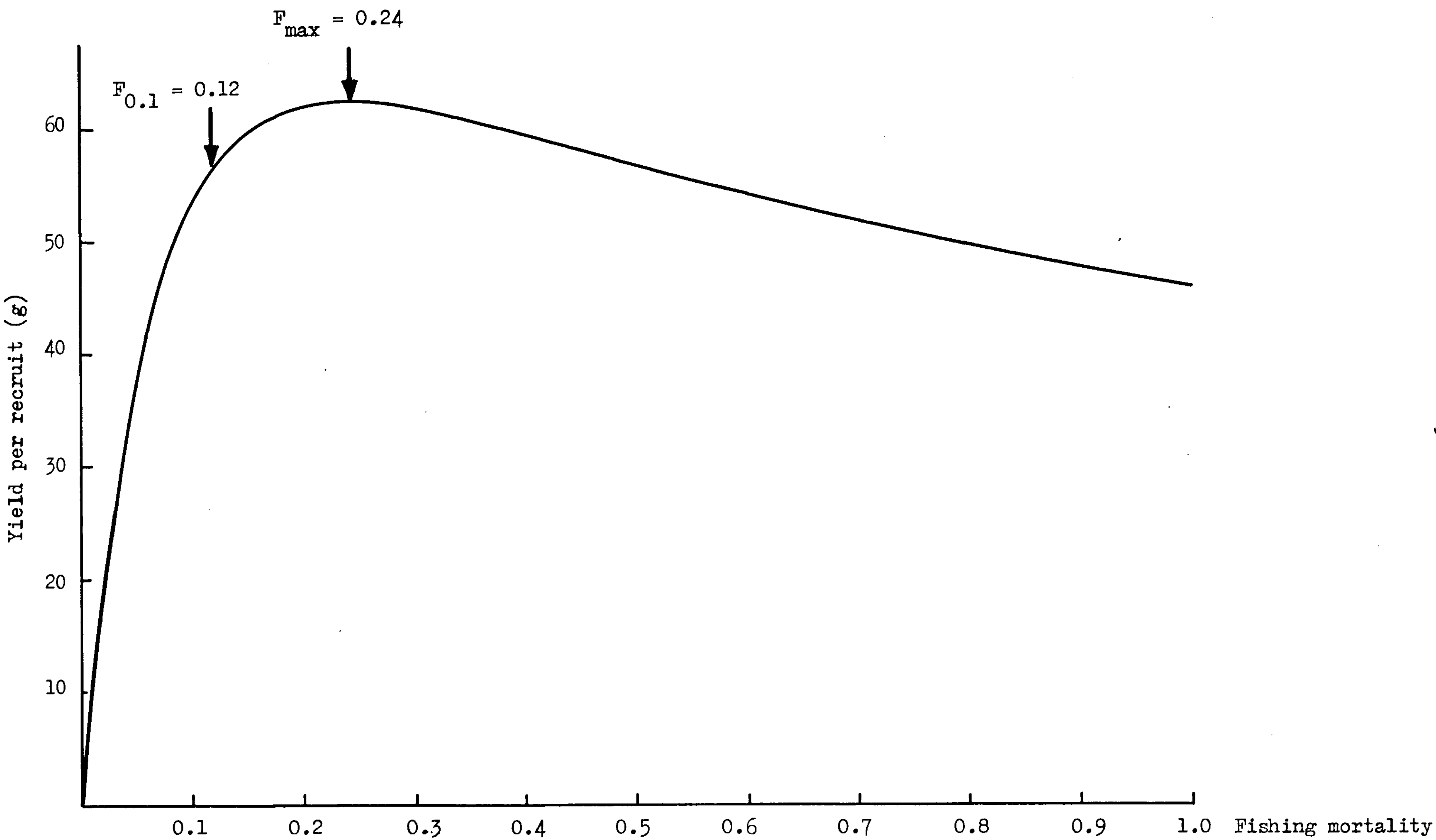
Age	1974	1975	1976	1977	1978	1979
0	0.672	0.565	0.141	0.217	0.137	0.120
1	1.530	1.329	1.299	1.048	0.355	0.250
2	1.677	1.382	1.475	1.382	1.327	0.440
3	1.060	1.716	1.082	1.367	1.184	0.700
4	1.195	2.073	0.415	2.459	0.760	0.700
5	1.464	1.658	0.526	1.852	3.821	0.700
6	1.569	1.863	0.380	5.080	3.821	0.700
7	1.294	0.635	4.473	5.128	0.603	0.700
8	1.500	1.500	1.500	1.500	1.000	0.700
Mean	1.465	1.586	1.402	1.449	1.302	0.464

Addendum 1, Table 3. Division IIIa herring.
Stock size in numbers from VPA.

Age	1974	1975	1976	1977	1978	1979
0	5 817	5 302	3 805	5 511	1 322	4 664
1	1 273	2 202	2 232	2 449	3 286	854
2	496	215	454	474	669	1 794
3	215	76	44	85	97	145
4	70	67	12	14	20	27
5	35	19	8	7	1	8
6	12	7	3	4	1	0
7	4	2	1	2	0	0
8	1	1	1	0	0	0



Addendum 1, Figure 1. Division IIIa herring. Catch in 1981 and spawning biomass in 1982 plotted in different F-values in 1981 relative to F_{1979}. Full-drawn curves based on the assumption that the TAC of 40 000 tonnes is taken in 1980. Hatched curves based on a catch of 90 000 tonnes in 1980.



<u>Addendum 1, Figure 2</u>. Division IIIa herring, yield per recruit. 1979 exploitation pattern.
M = 0.3 on 0-group, 0.25 on 1-group, 0.2 on 2-group and 0.1 on 3-group and older.

Herring by-catch in Sprat Fisheries

1. The by-catch data of 1979

The Chairman of the ICES Herring Assessment Working Group for the Area South of 62°N circulated a request that data should be submitted on herring by-catches in 1978 and 1979. From the data submitted, it has only been possible to produce some estimate of the by-catches by statistical area for 1979 (Figure 1). The international sprat catches for 1979 by ICES rectangles are shown in Figure 2; the totals exceed those given in Table 2 by 3%. The percentage by-catches derived from Figures 1 and 2 are shown in Figure 3. The estimated annual herring by-catch of about 14 000 tonnes has been derived from data referring to the sprat fisheries only, giving an annual herring by-catch percentage of 3.6. The Working Group Report (C.M.1980/H:4) estimated a total herring by-catch of about 18 000 tonnes.

Considerable care must be taken in interpreting the detailed distribution given in Figure 1. Though data of sprat catches were available by rectangle from the United Kingdom and Norway, the Danish data (whose catch accounted for 71% of the 1979 catch) are derived from catches initially reported by much larger areas. These areas are shown in Figure 4, and in addition the Danish estimated annual percentage by-catch by rectangle derived from these data. The data from Figure 4 were used as a basis for the construction of Figure 1.

From individual data for the rectangles adjacent to the English north-east coast, the combined Danish by-catch percentage of 13.35 compares well with the English annual value of 13.40%. Norwegian purse-seiners, only sampled in United Kingdom ports, gave by-catches of the order of 10%, during the short period in which they were fishing.

The use of annual by-catch percentages or indeed annual area distributions of by-catches are misleading as the sprat fishery is markedly seasonal both in timing and area exploited. Table 1 shows the percentage catch taken in recent years, by quarters. An increasing proportion is taken in the third quarter.

For 1979, Table 2 gives the quarterly breakdown by area and country of the sprat catches, the percentage herring by-catch and the number of samples upon which it was based. Despite the repeated requests by ACFM for adequate sampling of herring by-catch, it is seen that the number of samples are low relative to the size of the catches and there is great variability between quarters and within areas.

There must be considerable doubt as to the reliability of these data in assessing the true by-catch rate in the sprat fishery. In the July to September quarter, 43% of the total sprat catch was taken (Table 1). From Table 2, it is seen that this is almost entirely taken by Denmark. From detailed reports on by-catch levels, they are basically related to Danish Areas I and II (Figure 4). The overall by-catch was 4.7% in Division IVb east, but within Area I 20% of the samples had a mean by-catch of 28%. This area is one which formed a major herring nursery area at the time of the 1969/70 Bløden tagging experiment. It was calculated that the industrial fishery in 1970 generated a fishing mortality on the 1968 year class of 0.33 - 0.46 as 1-ringers. At that time, the industrial fishery was exploiting herring. It is of importance to note that now under a total ban on directed fishing for herring, the estimated fishing mortality on 1-ringed fish is 0.49 (C.M.1980/H:4, page 12).

It is clear that the areas identified with high by-catches in the sprat fisheries are the well-known herring nursery areas off the English northeast coast and in the continental coastal areas in the German Bight and off the Danish coasts.

2. The "loss" to the adult stock from the juvenile catches

The juvenile catches reported in Table 3.4 (C.M.1980/H:4) for the year classes 1976, 1977 and 1978 are given below:

Year class	No. x 10^6	
	0-ringers	1-ringers
1976	256.1	168.6
1977	130.0	158.8
1978	592.0	?

Assuming that these fish were not caught but were allowed to enter the spawning stock as 2-ringers, and a natural mortality of 0.1 (which is that used conventionally), then the magnitudes of the increment to the spawning stocks are calculated as follows:

Year class	Increment in biomass as 2-ringers
1976	60 000 tonnes in 1979
1977	40 000 tonnes in 1980
1978	80 000 tonnes in 1981

There are considerable objections to this procedure particularly in relation to the choice of natural mortality applied to the 0-group. It is not unlikely that this loss to the North Sea recruitment is not inconsiderable. The increments in spawning stock biomass estimates derived from larval surveys are given below (C.M.1980/H:4, page 11):

Increment	'000 tonnes
1976-1977	36
1977-1978	45
1978-1979	55

The possible increment of biomass lost from the juvenile catch could be of the same order as the annual increment in biomass achieved under the present management policy.

3. Reducing the juvenile herring loss

3.1. Identification of herring nursery areas

The IYFS data for 1978, 1979 and 1980 have been examined to determine the relative abundances of sprat and herring by statistical rectangles. The results are shown in Figures 5-7. The proportions of herring "by-catch" are very much greater than any reported from the commercial fisheries data for the first quarter of the year. The high by-catches of herring occur in 1978, 1979 and 1980 in the Danish Areas I, II and VIII. In addition, in 1978 and 1979 high catches occurred in Area XII.

By-catch limitation could be achieved by closure in time and space of herring nursery areas if they could be identified with certainty. Variability in relative sprat/herring distributions between years might necessitate such closed areas being large.

The evidence from the IYFS data would identify Danish Areas I, II and XII. Large differences occur in the comparison of the sprat/herring catches in IYFS and in the reported fishery by-catches. For example, in Area VIII the IYFS data give 30.6% herring, while from 13 samples from the fishery the by-catch levels lie between 0-1%. One sample was between 1 and 2%. It has been objected that it is not possible to draw conclusions on the relative abundance of herring and sprat from the IYHS because of the differences in fishing practice from that used in the industrial fishery. However, the industrial fishery also employs high handline bottom trawls as do the research vessels on the IYHS.

3.2. Reduction in by-catch level

If a system of closures were not possible, the loss of potential herring recruitment could be achieved, in the extreme, by closing the sprat fishery or by drastically reducing the sprat TAC.

This would be the only course if sprat could not be caught without also taking herring.

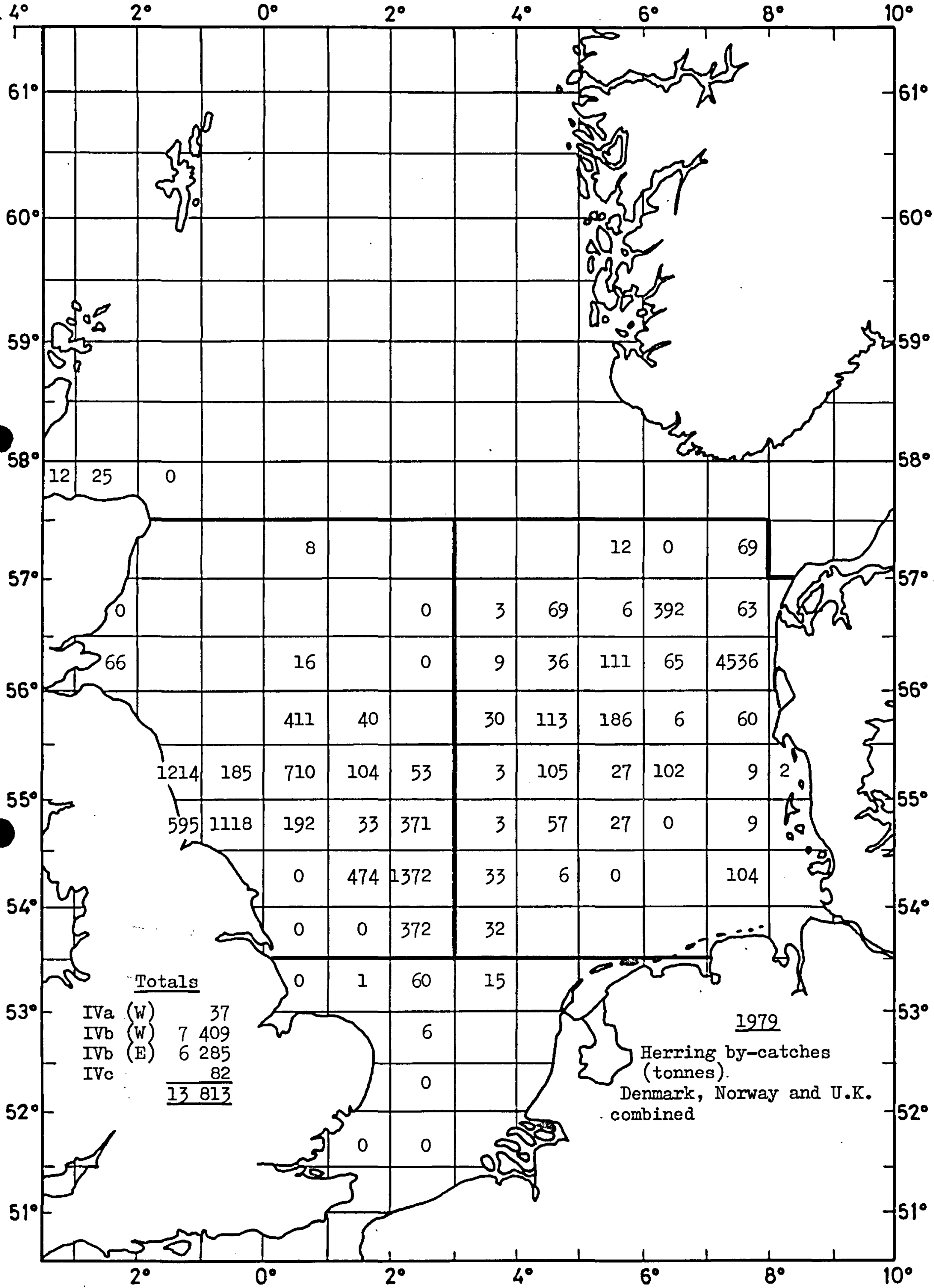
On the other hand, if by a suitable fishing technique a directed sprat fishery could be maintained at certain times or in certain areas, then a change in the allowable by-catch percentage would help to concentrate fishing on sprats. For example, referring to catches onboard ship at any time, a zero or, at the most, 5% herring by-catch might be allowed.

Table 1. Percentage of the North Sea sprat catch taken by quarters.

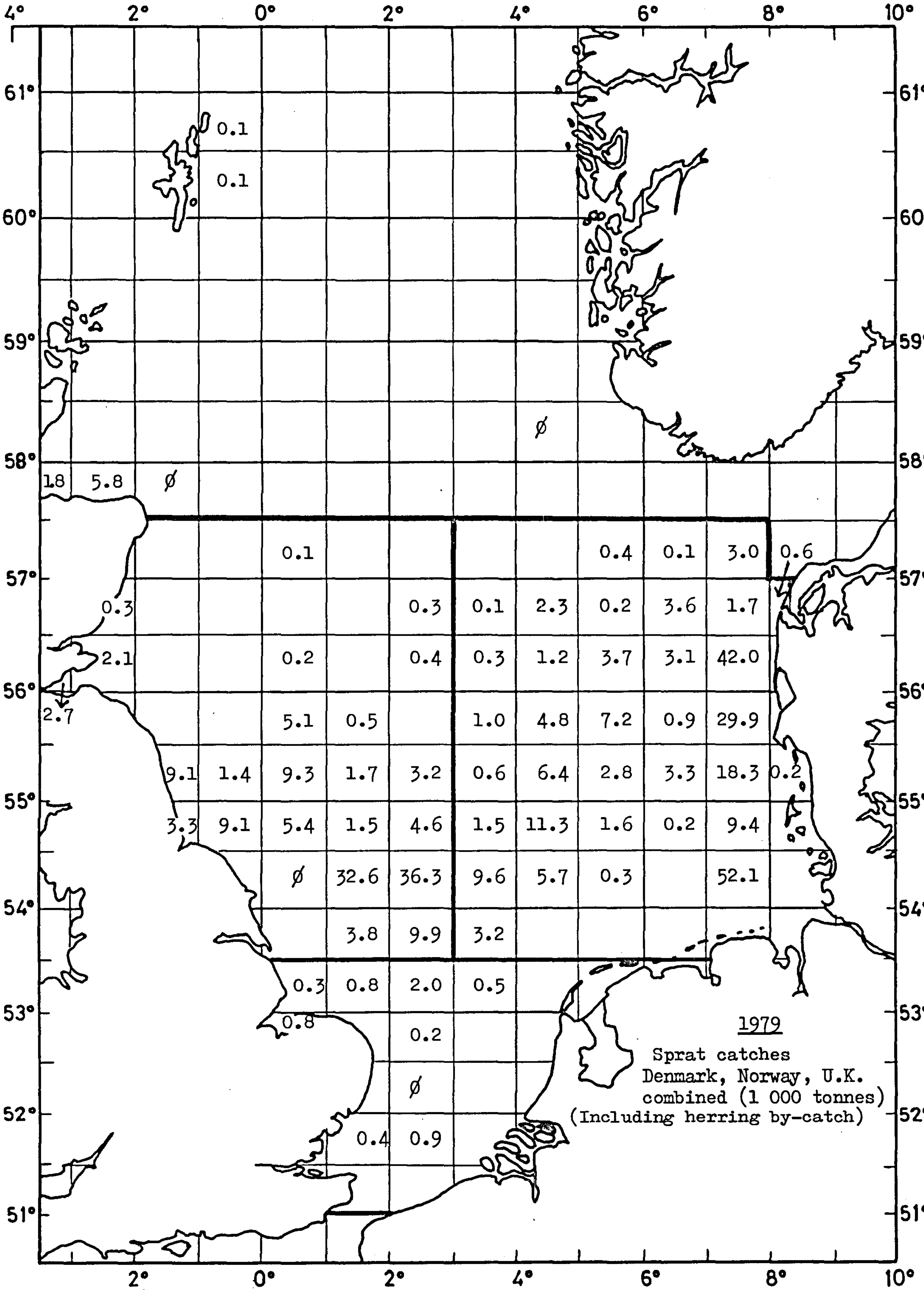
Year	Quarter			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1974	39	9	23	29
1975	37	2	28	33
1976	42	5	26	27
1977	56	4	28	44
1978	24	1	35	40
1979	27	1	43	29

Table 2. 1979 Sprat catch (thousand tonnes) % = % herring, n = no. of samples.

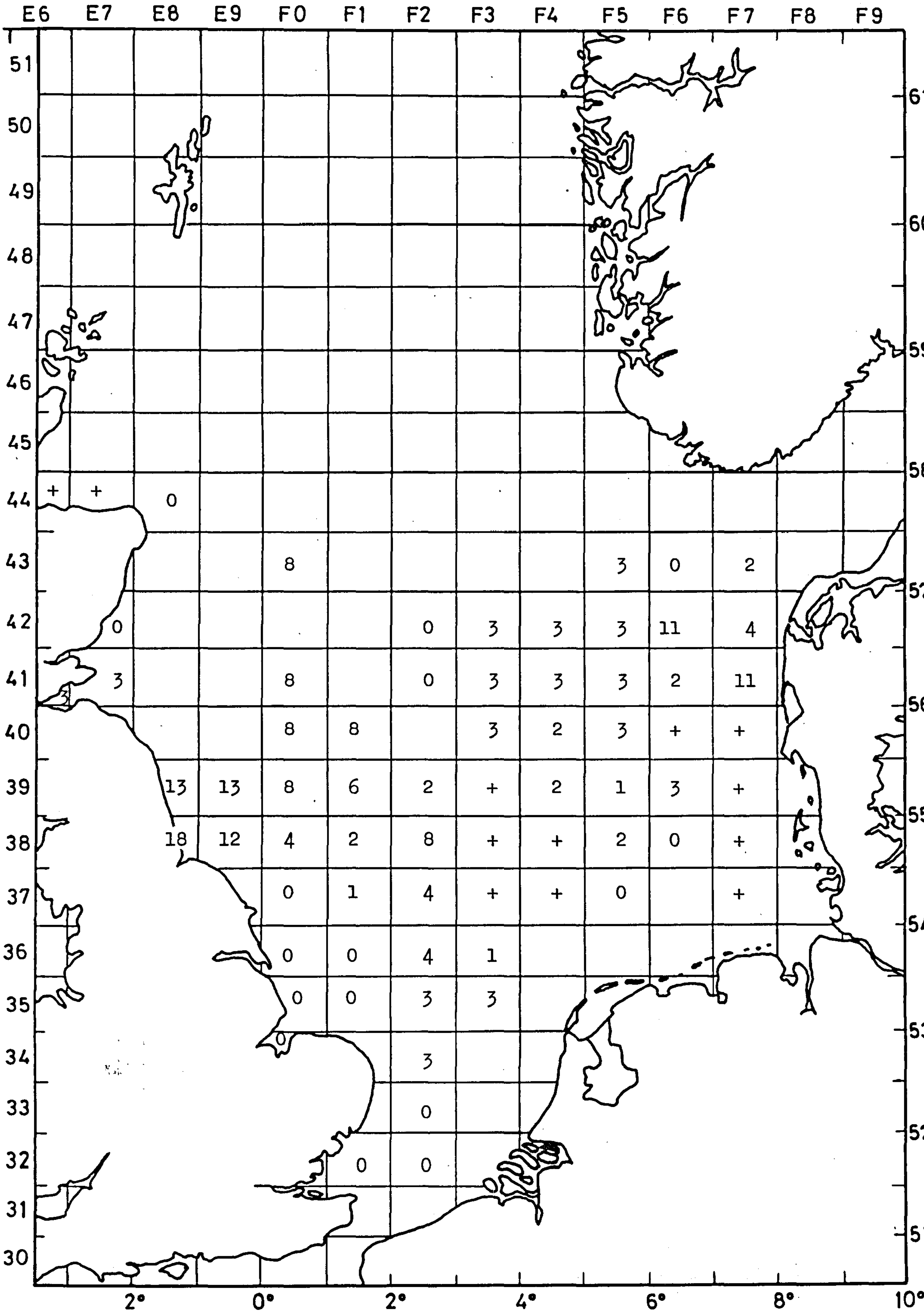
		IVa			IVb						IVc		
	Country	W of 2°E			W of 3°E			E of 3°E					
		C	%	n	C	%	n	C	%	n	C	%	n
Jan.-Mar.	Denmark				27.4	≃1	16	12.5	≃1	11	1.4	<1	4
	England				4.4	5.3	14				-		
	Germany, F.R.				-						-		
	Norway				29.7	5.9	1	18.4	-	-	3.1		
	Scotland	1.7	<1	3	3.9	4.2	10				-		
Apr.-June	Denmark												
	England				1.1			2.8	≃1	2			
	Germany, F.R.							0.8	1.4	1			
	Norway				+			+			+		
	Scotland				0.6								
July-Sept	Denmark							166.5	4.7	84	+		
	England												
	Germany, F.R.							0.9	<1	4			
	Norway												
	Scotland												
Oct-Dec	Denmark				36.4	6.5	18	31.4	≃1	11			
	England				8.5	18.8	21						
	Germany, F.R.												
	Norway				18.2	11.6	3	9.0	-	-			
	Scotland	6.1	<1	15	0.3	2	1						



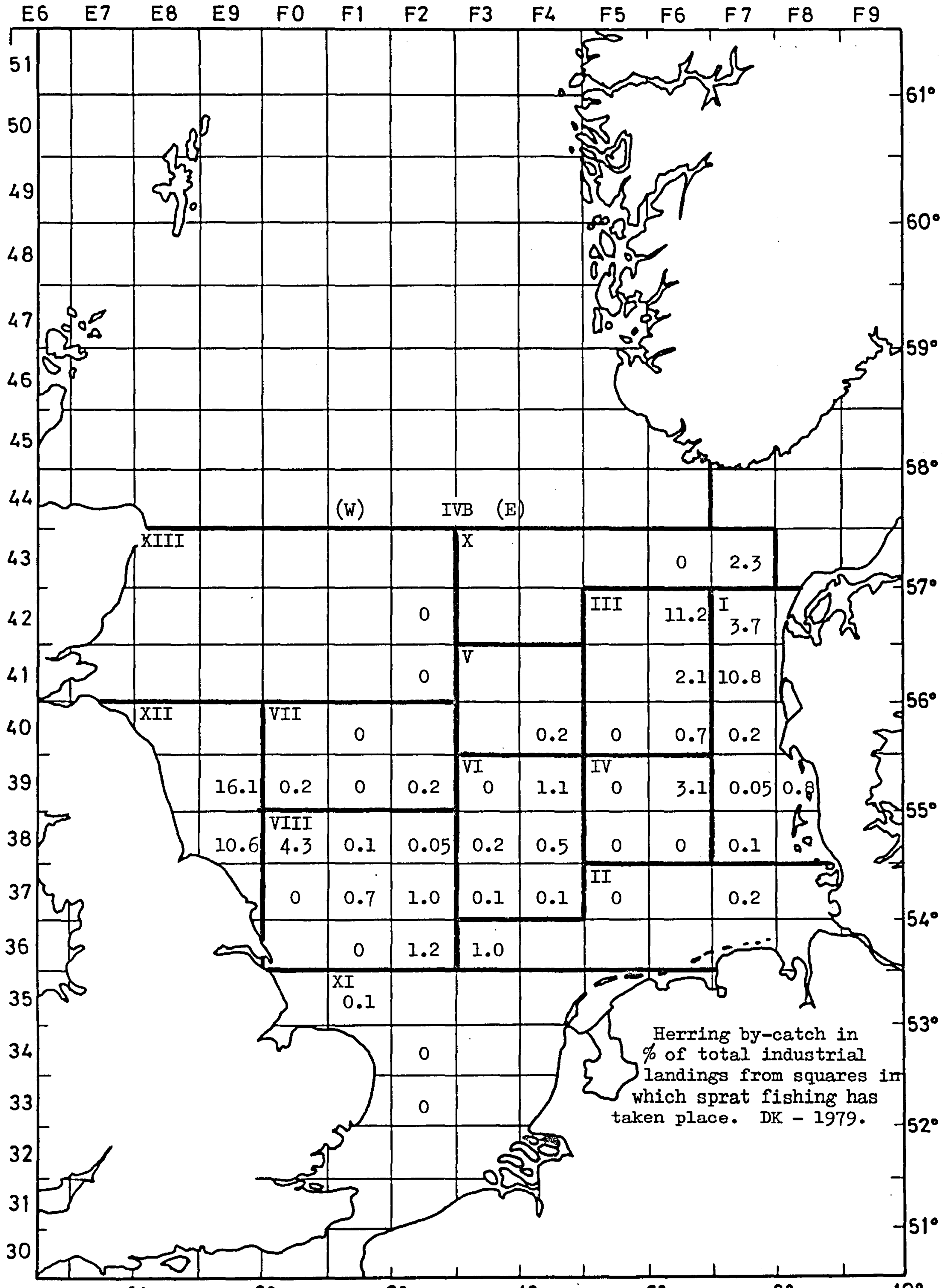
Addendum 2, Figure 1. Estimated herring by-catches in 1979.



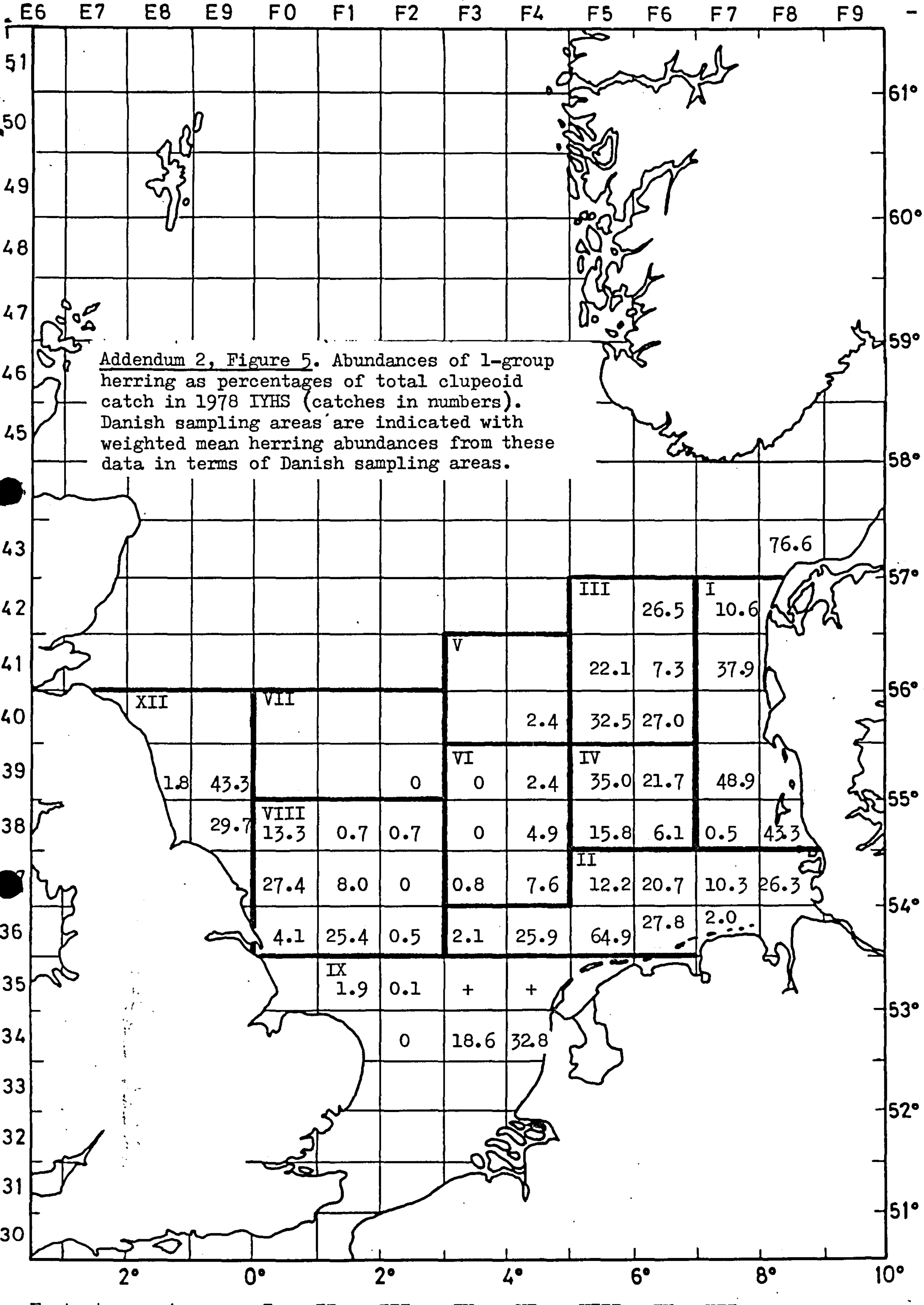
Addendum 2, Figure 2. Estimated sprat catches in 1979.



Addendum 2, Figure 3. Annual % herring by-catches as proportions of the international sprat fisheries.



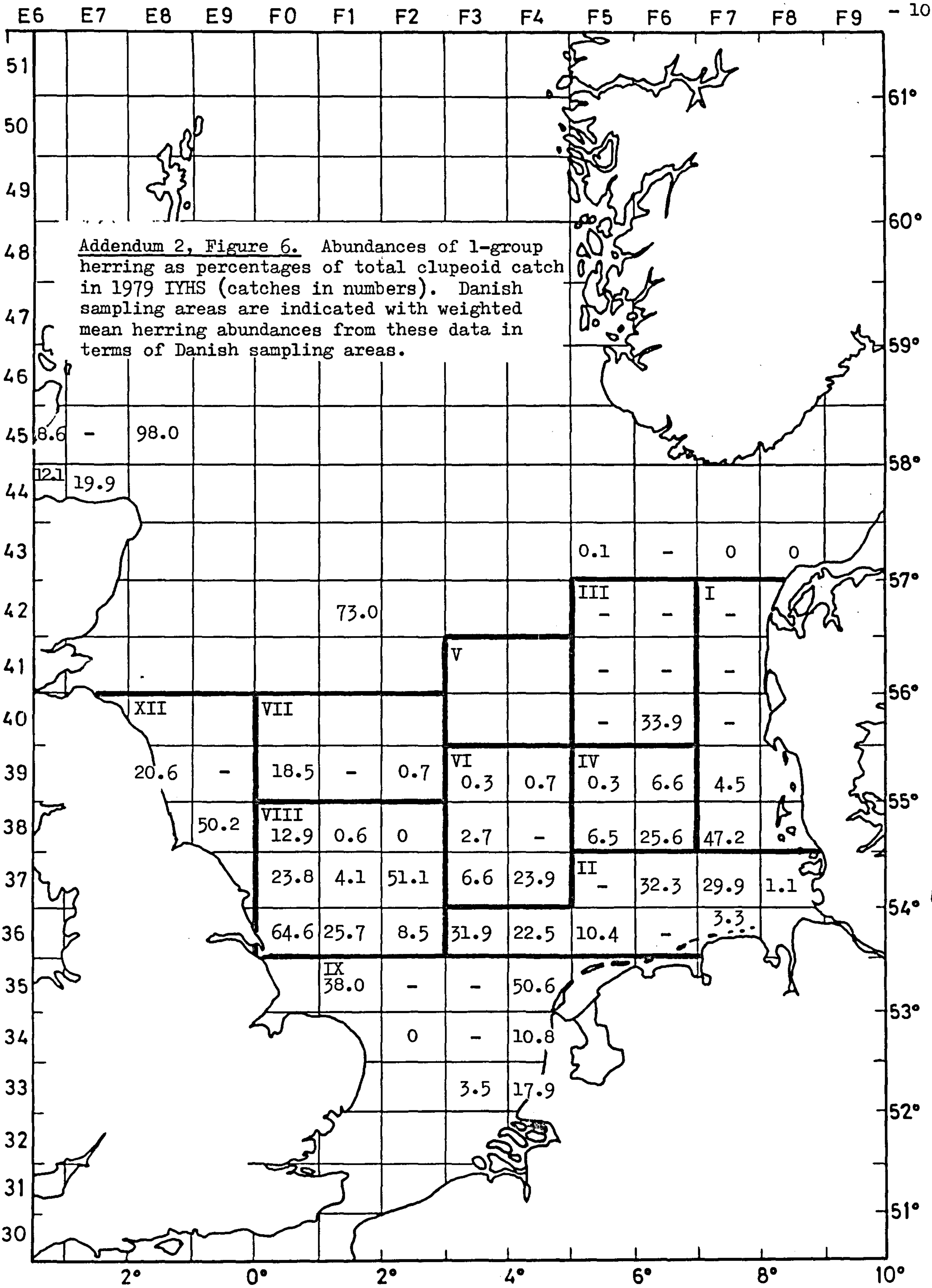
Addendum 2, Figure 4. Danish by-catch percentages and Danish biological sampling areas shown with Roman figures.



Addendum 2, Figure 5. Abundances of 1-group herring as percentages of total clupeoid catch in 1978 IYHS (catches in numbers). Danish sampling areas are indicated with weighted mean herring abundances from these data in terms of Danish sampling areas.

Footnote:

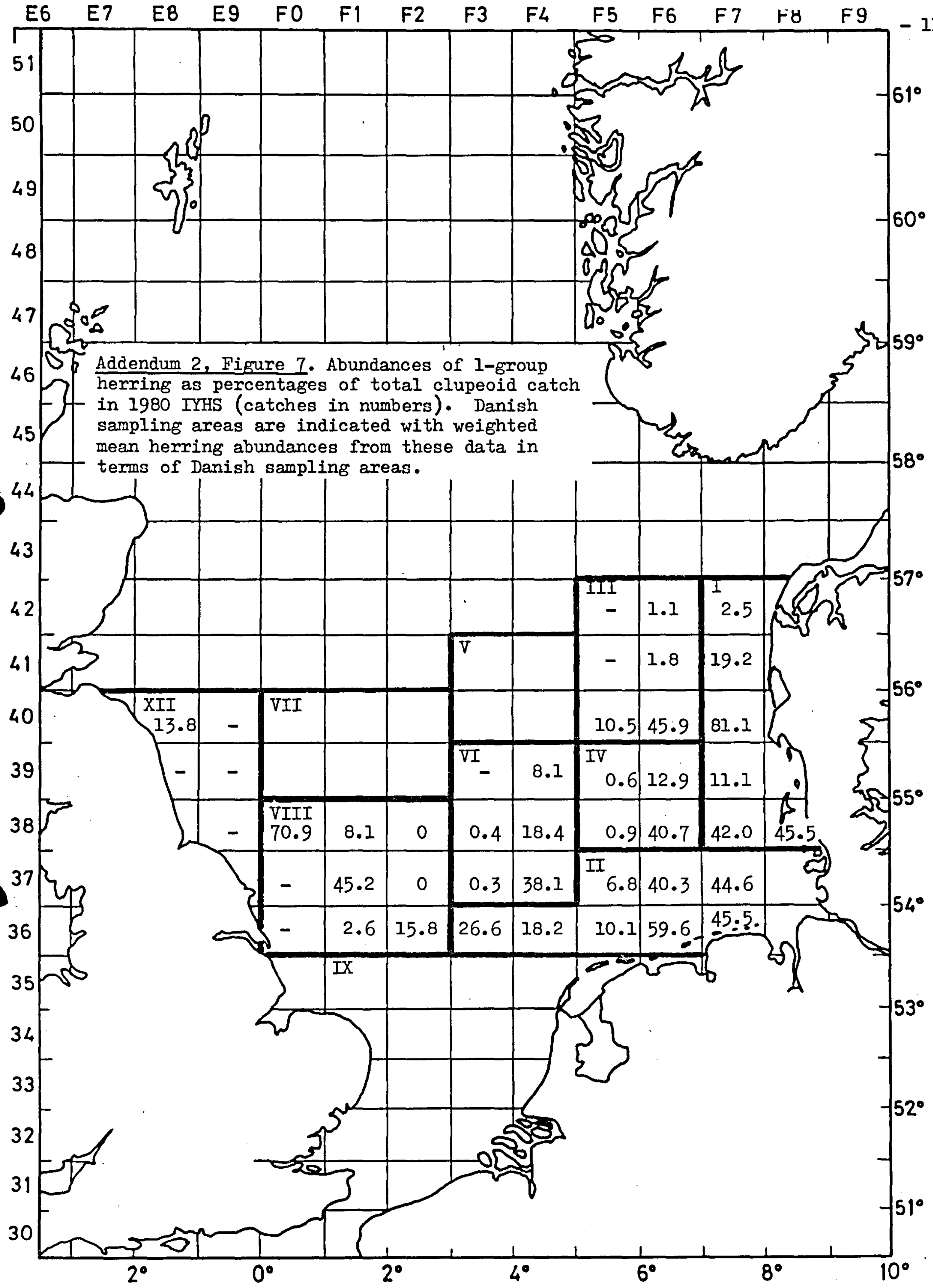
Areas	I	II	III	IV	VI	VIII	IX	XII
%	15.5	14.2	24.1	14.3	5.6	16.4	4.4	16.4



Addendum 2, Figure 6. Abundances of 1-group herring as percentages of total clupeoid catch in 1979 IYHS (catches in numbers). Danish sampling areas are indicated with weighted mean herring abundances from these data in terms of Danish sampling areas.

Footnote:

	Area	I	II	III	IV	VI	VII	VIII	IX	XII
IYFS	%	26.5	16.0	33.9	8.5	3.8	2.2	30.6	11.7	42.5
Danish Catch	no. samples		1			10		13/1		1/1
	%		0-1			0-1		0-1/1-2		0-1/1-2



Addendum 2, Figure 7. Abundances of 1-group herring as percentages of total clupeoid catch in 1980 IYHS (catches in numbers). Danish sampling areas are indicated with weighted mean herring abundances from these data in terms of Danish sampling areas.

Footnote:

Areas	I	II	III	IV	VI	VIII	XII
%	28.9	29.5	9.9	4.0	3.4	15.2	13.8