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REPORT OF THE MACKEREL WORKING GROUP

Charlottenlund, 20-24 February 1978

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1. INTRODUCTION

At the 65th Statutory Meeting of ICES it was decided (C.Res.1977/2:29) that the Mackerel Working Group should meet to "..... re-assess the mackerel stocks in Sub-areas III, IV, VI, VII and VIII".

Further, the ICES Advisory Committee on Fishery Management (ACFM) has requested a review of biology, distribution, state of exploitation, and distribution of fisheries on shared stocks, or revisions of draft reviews made previously. For the Mackerel Working Group this relates to the species: mackerel, horse mackerel and pilchard.

The Working Group met at Charlottenlund 20-24 February 1978 with the following participating members:

E D Andersen	USA
R S Bailey	UK (Scotland)
E Bakken (Chairman)	Norway
H B Becker	Netherlands
J C Guéguen	France
S J Lockwood	UK (England)
J P Molloy	Ireland
E Nielsen	Denmark
J Shepherd	UK (England)
Ø Ulltang	Norway

V Nikolaev attended the meeting as ICES Statistician.

To assess the state of the two mackerel stocks in the Northeast Atlantic the Working Group made extensive use of catch and biological data. In addition, two other major sources of information were obtained.

Tagging returns from Norwegian tagging experiments in the North Sea were used not only to split the North Sea catch into its component stocks, but also to provide estimates of natural mortality and of recent fishing mortality. These analyses are described in Section 3.

At an ad hoc meeting of the Mackerel Working Group 28 November - 1 December 1977, a new estimate of the size of the Western spawning stock based on English and French egg surveys was presented. Since considerable changes require to be made to the report from that meeting, the Working Group decided that it should be considered as a working document. Consequently, a brief summary of the methodology and results of the egg surveys and subsequent treatment of the data is presented in Section 4 of this report. A fuller account will be presented to the 66th Statutory Meeting of ICES by Lockwood et al.

The results of these analyses are used in Section 5 to make further assessments of the state of the stocks, and in Section 6 Total Allowable Catches (TACs) are presented for 1978 and 1979.

In response to the Council's and ACFM's requests, two Annexes are appended to the report. The first lists shortcomings in the data required to carry out reliable assessments. The second presents a little additional information on shared stocks.

2. THE MACKEREL FISHERIES

2.1 The North Sea

Landings by each country for the period 1967-77 are given in Table 2.1. The figures for 1967 to 1976 published in the previous report have been checked and updated. The main change is in the 1976 landings, the total in that year being 314 000 tons instead of 297 200 tons reported in the previous Working Group report (Anon. 1977). This change is mainly due to the Danish catch, which was about 20 000 tons greater than reported, whereas the Faroese total assumed to be from Division IVa was about 4 000 tons lower than previously estimated.

Although provisional, the 1977 landings were 45 000 tons lower than those of 1976 and were approximately the same as in 1971. The reduction is attributed mainly to the Faroese and Norwegian landings which decreased by 35.2 and 12.3% respectively. Nevertheless, the Total Allowable Catch (TAC) recommended by the Working Group for 1977 was exceeded by 21%.

In Table 2.2 a breakdown of the 1977 catch is given by area. It shows that, as in previous years, the bulk of the catch comes from Division IVa (about 85%).

The quarterly catch in the North Sea, Skagerrak and Kattegat is given in Table 2.3. As in previous years, most of the catch (87%) was taken in the third quarter of the year (July - September).

2.2 The Western area

Landings by each country for the period 1967-77 are presented in Table 2.4, updated where necessary. The 1976 total for ICES member countries was 465 800 tons to which 41 300 tons caught by Bulgaria and Romania must be added. In the previous year's report, landings by USSR, Faroe, France and England and Wales had been underestimated while those for Ireland and Spain were overestimated.

In 1977 total landings amounted to 315 000 tons which represent a dramatic drop of 38% from those of 1976. This can be attributed mainly to the cut in the eastern European countries' fishing activity in this area; their share represented only 10% of the level of the previous year. By contrast, the U.K. landings more than doubled and represent more than 50% of the international total. An increase of about the same proportion also occurred in the Dutch landings.

Table 2.5 shows that the part of the landings originating from Sub-areas VII and VIII represents 76% of the total from the Western area.

In Sub-area VII, the main fishing period was again the autumn and winter, first and last quarters, while in Division VIa the peak of the fishery was in summer and autumn (Table 2.3).

3. TAGGING RESULTS

Extensive use was made of results from the Norwegian tagging experiments. Taggings have been carried out in the North Sea every year since 1969 and now provide a series of return data over the most recent eight years. The taggings in the Celtic Sea give data of limited use because tag returns with corresponding data on the likely proportion of tags returned are only obtained from the northern North Sea. Furthermore it is not known if the tagged mackerel are representative of the Western stock as a whole. For details of the tagging technique reference is given to papers by Hamre (1970, 1975 and 1977 in prep.) and to previous Working Group reports.

3.1 Tag returns

The numbers of tags returned by year class from the Norwegian industrial fishery in the North Sea are given in Table 3.1 together with corresponding catches in number calculated by applying corrections for magnet efficiencies. For the years 1970 to 1975, the returns can be related to either the area north and east of Shetland (Sh) or to the eastern part of Sub-Area IVa (NS). For the two recent years such a division cannot be made because the Norwegian fishery in 1976 did not take place in the two areas at separate time periods, but shifted during the season gradually from west to east. In 1977 the change of fishing pattern mainly resulted from altered national fishing regulations. The division made for 1976 in the last report (Anon. 1977) is now considered to be unreliable and should be disregarded. Recapture data for 1976 and 1975 given in Table 3.1.1 of that report have been revised, and for the post 1969 year classes data are now given for each year class (Table 3.1).

3.2 The Western stock catch at Shetland

In previous reports, the catch of mackerel from the Western stock in the Shetland area has been estimated from the equation given by Hamre (1975):

$$p_j = \frac{P_{Nj}}{P_{Sj}} \cdot \frac{\sum r_{ijS}}{\sum r_{ijN}}$$

where:

- p_j is the proportion of North Sea stock in the Shetland catches of the year class under consideration in year j ;
- P_{Nj} is the catch of that year class taken in the North Sea area in year j which was effectively screened for tag recoveries;
- P_{Sj} is the catch of that year class taken in the Shetland area in year j which was effectively screened for tag recoveries;

$\sum r_{ij}$ are recoveries of fish of that year class in the year in question summed over all releases; with the subscripts S and N denoting recoveries from the Shetland and north-eastern North Sea areas respectively.

For 1976 and 1977 it has not been possible to split the tag recoveries into the Shetland area (Sh) and the northeastern North Sea (NS) (Table 3.1). The Working Group therefore had to estimate the Western stock component of the catch in Division IVa by a different method. For this purpose it was assumed that all 3 year old mackerel caught in Division IVa were from the North Sea stock.

The proportion of the North Sea stock in the IVa catches of the older age groups was estimated by

$$p_{j+1} = p_j \cdot \frac{\sum r_{ij+1}}{P_{j+1}} / \frac{\sum r_{ij}}{P_j}$$

where P_j is the catch of the year class in year j effectively screened for tags, $\sum r_{ij}$ the recoveries of fish of that year class in year j summed over all releases prior to year j, and p_j the proportion of the IVa catches belonging to the North Sea stock in year j. The estimated proportions are given in Table 3.2 for the years 1971-77.

The new estimates of proportions were, however, only applied to the 1976 and 1977 catches keeping the catch in number by age group and stock given in the previous report (Anon. 1977) for the years prior to 1976 unchanged. The estimated catch of Western stock mackerel in Division IVa for 1976 (Table 5.2) differs from that given in the previous report (Anon. 1977 Table 2.2.3) probably because the split of the recoveries between the Shetland area and the northeastern North Sea used in the previous report is not valid. The difference is particularly great for the 1969 year class.

3.3 Estimation of mortality

Hamre (1975) pointed out that tag returns (Table 3.1) raised to the total international catch (Table 3.3) can be used in a cohort analysis using assumed values for natural mortality and survival from one or more tagging releases. Hamre and Shepherd have shown in working papers presented to the Working Group at the 1978 meeting that, by minimising variability in tagging survival, this method may be used to estimate natural mortality and variation in tagging survival from year to year. Since, in addition, no individual tagging survival can exceed 100%, the overall level of tagging survival can also be estimated. Tagging survival varies appreciably from year to year (Table 3.4), with a mean value nearer to 0.7 than to the 0.85 previously assumed, and both authors conclude that M probably lies between 0.10 and 0.15. As these estimates of M differ significantly from the value of 0.2 used in previous assessments, the upper value of 0.15 in this range has been used in this year's assessment.

Use of these parameters leads to estimates of fishing mortality for the North Sea which are very consistent with those obtained from a conventional analysis of tag returns using the same values of M and tagging survival. The estimates of fishing mortality obtained are:

Year class	1971	1972	1973	1974	1975	1976
Pre-1969	0.16	0.12	0.18	0.20	0.20	0.19
1969	0.09	0.09	0.18	0.20	0.23	0.20

See also Table 3.4.

Thus, the terminal F in the North Sea stock cohort analysis used in the previous report by the Working Group (Anon. 1977) seems to be reasonable. At the present meeting, the Working Group also used the estimates of tagged fish remaining at the beginning of 1977 and the raised returns in 1977 for the pre-1969 and 1969 year classes to estimate F in 1977. The results are 0.30 for the 1969 year class and 0.32 for the pre-1969 year classes. The increase in F in 1977 compared to 1976 is consistent with (a) the fact that North Sea catches in 1977 were substantially, 21%, in excess of the TAC based on an F of 0.2, and (b) the revision of the proportions of catches from each of the two stocks at Shetland in 1976 of the 1969 year class (see Section 3.2) which implies that the size of this year class, and hence the stock, was overestimated in the previous Working Group report.

The Working Group also considered obtaining an estimate of F in 1977 by analysing the 1976 release and 1977 recaptures using a method outlined by Shepherd in his working paper to the meeting. Relatively few fish were, however, tagged in 1976, and the recapture data show internal inconsistencies. Further, the analysis suggests that tagging survival was low, around 0.6, and the estimates of F in 1977, between 0.20 and 0.25, appear to be much less reliable than those given above.

4. EGG SURVEY RESULTS

Lockwood *et al* (1977a) described a series of six plankton surveys carried out in the Bay of Biscay, Celtic Sea and West of Ireland during the period March to July 1977. These surveys aimed to collect mackerel eggs from the major part of the Western mackerel stock spawning grounds with a view to making a stock assessment. The results were presented to the Working Group and an estimate of the spawning stock size was made from them.

4.1 Egg production estimate

Mackerel eggs were removed from the plankton samples, ascribed to one of six development stages (Lockwood et al, 1977b) and counted. The numbers at each stage in the sample were raised first to an estimate of the number of eggs per m² and then corrected to numbers per m² per day using observed sea temperature data and a stage duration correction factor (Lockwood et al, 1977b). For the purpose of making a stock size estimate, only stage 1 eggs were used.

The distributions of stage 1 eggs over the survey area during the six surveys are shown in Figure 4.1.

A variety of methods were tried for estimating the total egg production. The method adopted was a logarithmic transformation for estimating a mean daily egg production for the entire spawning ground on each survey. The observed daily production estimates per station were transformed to:

$$x = \ln (m + 1)$$

where m is the number of eggs/m²/day. The mean of the transformed data was calculated and retransformed to the arithmetic mean using the equation given by Jones (1956):

$$\bar{m} + 1 = \exp \left\{ \bar{x} + \frac{S^2}{2} \left(\frac{n - 1}{n} \right) \right\}$$

where \bar{m} = arithmetic mean
 \bar{x} = mean of logarithmically transformed data
 S^2 = variance of logarithmically transformed data
 n = the number of samples in the survey

The lower 95% confidence limit to these estimates was calculated from

$$\bar{m}_e - 2s.e.$$

where $s.e.$ = standard error of \bar{x} .

The mean daily egg production for each cruise, the daily egg production for the survey area for each cruise, and the estimated total spawning production for 1977 are given in Table 4.2 with their confidence limits. The results of cruise "La Pelagia Olmag 77" are given separately and combined with "Cirolana 4/77" as shown in Figure 4.1 b. The combined estimate is used for the total production estimate as in this way they give complete cover of the spawning ground.

The estimates of total daily egg production were plotted against time and the total spawning season estimated by measuring the area beneath the observations linked by straight lines (Figure 4.3).

The total spawning production was estimated as: 1.61×10^{15} eggs.

The confidence limits on this estimate were obtained as follows.

Confidence limits for the production estimates for each cruise are given in Table 4.2. These have been estimated from the variance of the $\ln(m + 1)$ transformed data. However, Ulltang has shown in a working paper presented to the Working Group that, even after this transformation, the frequency distributions of the data are not normal. Consequently, the retransformed mean is often still an underestimate of the arithmetic mean, and variance is underestimated. However, for the two most important cruises (Cirolana 5/77 and Cirolana 6/77) the bias of the mean is small, and it is considered that a total production estimate using this method is not significantly in error. The estimates of variance obtained by Ulltang using a simple $\ln(m)$ transformation on non-zero data only are, however, considered to be more appropriate. These indicate logarithmic standard errors of about 0.22 for the most important cruises, and similar values for the others. These are small enough that they may be converted to arithmetic variances and summed to give an estimate of the variance of the total production estimate. This gives an overall standard error corresponding to an upper confidence limit of +31% and a lower confidence limit of -24% on the production estimate.

4.2. Estimation of fecundity

Macer (1976) estimated the fecundity at length for Western stock mackerel 28-35 cm in length. During the plankton surveys, further samples were collected and the range of data extended to cover the range 28-45 cm. From the combined data (Figure 4.4) a fecundity-length relationship was calculated where:

$$\text{fecundity} = 0.04 l^{4.48}$$

where l is the total length in centimetres (Lockwood and Macer in prep.).

In an effort to establish the youngest age group making a significant contribution to the spawning stock the results from 5 years biological samples (English) taken from January to June were examined. It was assumed that all fish at maturity stages IV, V or VI would contribute to the spawning. All samples where maturity identification was not possible were disregarded, as were fish not given a definite age. The number of spawning fish were then expressed as a percentage of the total examined per age group. The results are given below:

	Age								
	0	1	2	3	4	5	6	7	> 7
% mature	0	0	12	64	100	100	100	100	100

Without data to support an alternative hypothesis, it was assumed as an approximation that all fish 3 years old and older spawned, and that all fish less than 3 years old were immature.

A weighted mean fecundity for Western stock mackerel was calculated from the length frequency data of the fish older than 2 years in the combined Dutch, English and French catches from Sub-area VII, January - June 1977, and the fecundity length relationship given above. The weighted mean fecundity was $282\,530 \pm 16\,000$.

When analysing the maturity data described above, it was found that the sex ratio of mature fish in the English fishery was 1.57 females : 1 male. Thus, the female spawning stock estimates should be raised by

$$\frac{1.57 + 1}{1.57} = 1.64$$

to give a total spawning stock estimate.

4.3 Stock size estimate

With 1.61×10^{15} eggs produced during the 1977 spawning season, and a mean fecundity of 282 530 per female, the spawning stock is estimated to be:

$$\frac{1.61 \times 10^{15}}{282\,530} \times 1.64 = 9\,346 \times 10^6 \text{ fish.}$$

These fish were distributed across the 1975 to 1969 and older year classes according to the percentage at each age in the 1977 Western stock catch. The numbers at age were raised to weight using the mean weights at age for the first quarter of the year given in Table 5.3. The estimated spawning stock biomass is 2.72×10^6 tons as shown below:

Year class	Catch in number	% of catch in spawning stock	Spawning stock estimate	Mean weight, g	Biomass, tons
Pre 1969	139.7	17.6	1645.0	378	1 056 343
1969	97.7	12.3	1149.6		
1970	77.4	9.8	915.9	356	326 063
1971	123.9	15.6	1458.0	309	450 514
1972	46.7	5.9	551.4	246	135 648
1973	160.2	20.2	1887.9	233	439 879
1974	148.4	18.7	1747.7	177	309 343
1975	276.1				
1976	135.8				
1977	2.0				
Spawning stock biomass, tons $\times 10^6$					2.72

5. CATCH IN NUMBERS, MORTALITIES AND STOCK SIZE

5.1 Catch in numbers at age

The North Sea stock

Catches in weight were converted to catch in numbers at age for the North Sea catches using Norwegian data from the purse seine fishery in the northern North Sea, the gill-net fishery off the west coast of Norway and the trolling fishery of the Norwegian coast. The Norwegian data were also used to raise the Swedish, Faroese and Scottish purse seine landings. The Dutch, Danish and USSR landings were raised using Dutch sampling data. Scottish trawl and French landings were raised using Scottish trawl sampling data. The catches in number of fish caught in the North Sea were allocated to the North Sea and Western stocks using the proportions given in Table 3.2.

The changes in reported catches for 1976 also necessitated a revision of the 1976 estimates of catch in number at age. The Faroese catches in number were reduced according to the age distribution for areas IVa and Shetland given in the previous Working Group report. The updated catches from areas other than IVa were raised using the age distributions for Divisions IVb and c given in the previous report.

Catches in numbers at age from the North Sea stock for 1975-77 are given in Table 5.1. This shows the continuing high dependence of the North Sea fishery on the 1969 year class which in 1977 made up 30% of the total catch in number.

The Western stock

Estimates of catch in numbers of the Western stock in 1977 were made in a similar way to previous years. Catch at age data for Division VIa were available from Ireland, Netherlands and Scotland. These data were used to raise the catches of other nations fishing in the division. For Divisions VIIId-k and Sub-area VIII the combined catch at age data from England, France and Netherlands were applied to the annual total catch of the Federal Republic of Germany, Ireland, Poland and Spain. The catches of the German Democratic Republic and USSR were raised by catch at age data for the first quarter only as this was when they took the bulk of their catch. Thus, 25% of the catch in numbers data were raised by the sample data from the remaining 75% of the catch. This represents a great improvement on previous years when less than 50% of the catch was adequately sampled.

The catches in numbers at each age from the Western area in 1976 given in the previous report were also revised in proportion to the decrease in reported total catch in weight. To these were added the revised catch in number from the Shetland area. The catch in numbers at age from the Western stock for 1975-77 are given in Table 5.2.

In Table 5.2, 1977 catch at age data for Divisions VIIa, b and c are given separately from those in the rest of Sub-area VII as these fish may more appropriately be grouped with those caught in Sub-area VI. They are kept separate in the table to enable the catches in Division VIa to be compared with those in previous years. These data were provided by France and Ireland.

In Sub-area VI there is very little difference between 1976 and 1977 in the catch in numbers of fish of the 1972 class and older, but there was a notable increase in the total number of fish younger than the 1972 year class. Among these younger fish the 1973 year class, 4-year-olds, were most important, and 1974 year class equalled the 1971 year class in the 1977 catch.

In common with the catches from Sub-area VI the most abundant year class in Divisions VIIa, b and c was that of 1973, and 1971 was the second most numerous year class.

In Divisions VIIId-k and Sub-area VIII the most abundant year classes were younger fish. The two-year-olds, the 1975 year class, were most abundant, but the 1973 year class was also quite strong compared with the younger 1974 year class. As in all Western areas the 1971 year class was the most numerous among the older fish.

5.2 Mean weight at age

The North Sea

In previous reports of the Working Group, the North Sea stock biomass was calculated from the estimated numbers of fish in each year class and the mean weight at age data published by Castello and Hamre (1969). These weight data were used as they were thought to be the most reliable data available (Anon. 1976). At this meeting, weight at age data by quarters for several years were available from the Netherlands, Norway and Scotland. From these combined data, new mean weights at age by quarters were calculated for Division IVa where most of the North Sea stock is taken. It was clear that there were considerable differences from the earlier values used. Since the new data were taken from more representative sampling, it was decided that they should be used for calculating stock biomass and TAC's. The data on 1 year-olds were most abundant in the fourth quarter, and until more data are available for the other quarters, this value is used in preference to the weighted annual mean.

The annual mean weight at age was obtained by weighting each quarter's observations according to that proportion of the North Sea catch known to have come from the quarter of the year (Table 2.3), and weighting each age according to its frequency in the 1977 catch. The weights at age are given in Table 5.3.

The main difference between these new values and those previously used for weight at age are in the younger age groups. The new weight are higher.

The Western area

No new weight at age data were considered. Stock biomass was calculated using the weights presented in the previous report of the Working Group (Anon. 1977) and given in Table 5.3.

5.3. Assessment of the North Sea stock

Catch in numbers at age for 1977, and revised figures for 1976, are given in Table 5.4.

The Working Group used a natural mortality of 0.15 and a terminal F of 0.30 in 1977 (See Section 3.3) to carry out a cohort analysis. Partial recruitment as shown by the previous pattern of fishing mortality, was assumed to be 66% on 2-year-olds and 10% on 1-year-olds. The results are displayed in Table 5.4.

The estimated F on fully recruited age groups in 1974, 1975 and 1976 are around 0.2, in agreement with the tagging data and the assumptions made in 1977 by the Working Group (Anon. 1977). The correction of the catches of the 1969 year class has, however, improved the internal consistency of the data, as the values of F in earlier years were anomalously low for this year class in the 1977 analysis.

The data indicate a continuing decline in population size and spawning stock biomass (See Figure 6.1). The 1975 recruitment appears to be as low as any recorded at about 160 million fish, and first indications are that the 1976 year class is also small. With continuing poor recruitment and a spawning stock depleted from 1 500 000 tons in 1972 to 400 000 tons 1978, the stock is suffering from recruitment failure.

5.4 Assessment of the Western stock

Catch in numbers at age for 1977, and revised figures for 1976 are given in Table 5.5.

The Working Group adopted a natural mortality of 0.15 as derived for the North Sea stock from tagging data. The value of terminal F was chosen so that the size of the population of age 3 or more in 1977 is about 10 000 million, in agreement with the estimate obtained from the egg survey.

The current estimate of F in 1977 is 0.1 for fully recruited ages. This implies that F in 1976 was about 0.2, rather than 0.4 as assumed in 1977 by the Working Group. The present estimate, matched to the egg survey results, also agrees with estimates of the population size of all year classes aged 4 or more arriving at Shetland from the Western stock in 1973, 1974 and 1975, as derived from the North Sea tagging data (Table 3.3).

The revised allocation of the catch of the 1969 year class to the Western stock in 1976 has removed the anomalously high fishing mortalities on this year class evident in the cohort analysis reported previously (Anon. 1977).

The downward revision of the estimate of terminal F implies that stock size had previously been substantially underestimated. This is evident in the population sizes and spawning stock biomasses given in Table 5.5 (See also Figure 6.2). The spawning stock biomass has remained stable between 3 and 4 million tons since 1972 as the effects of fishing have been balanced by a sequence of good year classes.

Recruitment has remained high, the lowest value being about 1 500 million (as 1-year-olds) in 1972. The 1975 year class seems to be very large (about 7 000 million), nearly double the size of the good 1971 year class. First indications suggest that the 1976 year class is also good.

6. TOTAL ALLOWABLE CATCHES (TAC's)

6.1 The North Sea stock TACs

The basic input data for any calculation of TAC for the North Sea stock are the estimates of stock in number per age at 1 January 1977 and the estimated F's on each age group in 1977, given in Table 5.4. From these, the stock surviving at 1 January 1978 was calculated. The 1976 and later year classes have in all calculations been assumed to be of the same strength as the 1972 year class as 1 year olds, 160×10^6 fish. This is the weakest year class of those for which one has reliable estimates. It is now clear that the 1975 year class is very weak and indications from the catches of 1-year-old mackerel in 1977 are that the 1976 year class is also very weak.

The spawning stock in the North Sea has continuously declined since 1972 when the 1969 year class recruited to the adult stock (Fig. 6.1). The adult stock biomass (3 years and older) at 1 January 1978 has been calculated at 473 000 tons.

The decline in the spawning stock size is a result of recruitment failure. Figure 6.1 indicates that one is now in a situation where the spawning stock may be below the level required to produce a year class of reasonable strength. The last year class of any strength is the 1974 year class. In 1974, the spawning stock was about 1 100 000 tons, i.e. more than twice the present level. The only way of improving the chance of recovery of the North Sea stock is to minimize the fishing on the stock as soon as possible. This is intended to prevent a further decline in the spawning stock.

In the previous report of the Working Group (Anon. 1977), a TAC of 190 000 tons was recommended for the North Sea area in 1978. It is now estimated that about 50 000 tons of this, if caught, will be taken from the Western stock in Division IVa in the Shetland area during the summer.

A prognosis has been run on two alternatives:

- a) that the catch of the North Sea stock in 1978 is minimized by decreasing the TAC and taking all of it in the Shetland area in order to fish mackerel mostly from the Western stock. Under this alternative, the catches from the North Sea stock in 1978 have been assumed to be zero in the calculations;

- b) that the area TAC in 1978 is not changed and that 140 000 tons of the North Sea stock will be caught.

Alternative (b) would imply a fishing mortality in 1978 of 0.29 on the fully recruited age groups, against 0.20 advocated by the Working Group in 1977 when calculating the TAC for 1978. The reason for this increase in F is partly that the 1977 catches were 21% higher than the recommended TAC for 1977, and partly that the stock size in 1977 is now believed to have been less than previously estimated. The result of the calculations are given in the text table below. For both alternatives (a) and (b) zero catch of the North Sea stock in 1979 has been assumed.

	Age							
	1	2	3	4	5	6	7	> 7
Mean weight (g) in catch	245	329	363	392	438	455	520	580
Mean weight (g) in stock 1 Jan 1978		234	325	338	350	346	468	472
Stock in number (10 ⁶) 1 Jan 1978	160.0	136.5	99.4	167.3	156.8	30.4	111.9	556.7
Fishing mortality (a) in 1978	0	0	0	0	0	0	0	0
(b)	0.03	0.19	0.29	0.29	0.29	0.29	0.29	0.29
Stock in number (a) (10 ⁶) 1 Jan 1979	160	137.7	117.5	85.6	144.0	135.0	26.2	575.5
(b)	160	135.8	97.2	64.0	107.7	101.0	19.6	436.6
Stock in number (a) (10 ⁶) 1 Jan 1980	160	137.7	118.5	101.1	73.7	123.9	116.2	517.6
(b)	160	137.7	115.2	83.7	55.1	92.7	86.9	387.5

Spawning stock biomass (in thousands of tons):

	Alternative	
	(a)	(b)
1 Jan 1978	469	
1 Jan 1979	448	338
1 Jan 1980	440	341

Under alternative (a), the spawning stock in 1979 and 1980 decreases slightly below the 1978 level (Figure 6.1). Under alternative (b), the spawning stock is reduced to about 340 000 tons in 1979 and 1980. The assumed recruitment and the growth seems to balance the natural mortality so that zero catch in 1979 will stabilize the spawning stock, but the level at which it is stabilized will be approximately 100 000 tons, i.e. 23%, lower for alternative (b) than for alternative (a).

The calculations are, of course, very dependent on the assumed recruitment. As discussed above, there are indications that the

1976 year class is very weak. Nothing is known about the 1977 year class.

The Working Group recommends that the catches of the North Sea stock should be kept at a minimum level until improved recruitment rebuilds the spawning stock to a level of about 1 000 000 tons, i.e. that level which produced the 1969 year class and the 1974 year class, which is the last of reasonable size. It is not possible to estimate when this may occur.

It is further recommended that one should reduce catches to a minimum in 1978, as this would improve the chances of rebuilding the stock. To achieve this, catches of the North Sea stock in both 1978 and 1979 should be minimized by allowing mackerel fishing only in Sub-area IV north of 60°N and west of 2°E. Catches in this area are likely to be predominantly from the Western stock. If the two stocks are mixed proportionally to their stock size, the estimated 1978 stock sizes would imply that only about 14% of the catches in this area would be mackerel of the North Sea stock (See Section 6.3).

6.2 The Western stock TAC

Although we have greater confidence in the estimates of current fishing mortality and stock size obtained for the Western stock at this meeting compared to last year, they constitute marked changes from our previous estimates. We cannot yet be certain that these new estimates are correct, and we therefore advocate that exploitation should be increased cautiously. We have therefore adopted a value for F of 0.15 on the fully recruited year classes in calculating TAC's. This corresponds to a TAC in 1978 of 535 000 tons. Since the English winter fishery in 1977-1978 is now finished, it is thought unlikely that all of this will be taken. We have therefore assumed that the 1978 catch from the Western stock will be about 485 000 tons. This level of catch would correspond to a fishing mortality rate on fully recruited age groups of 0.135 in 1978.

The basic input data used in calculating the 1979 TAC for the Western stock are given in the text table below:

	Age							
	1	2	3	4	5	6	7	≥ 8
Mean weight (g) in catch	112	169	207	269	318	362	398	505
Stock in number (10 ⁶) 1 Jan 1978	1500	3318	4988	1306	1410	411	1091	2771
Fishing mortality in 1978	.027	.068	.135	.135	.135	.135	.135	.135
Stock in number (10 ⁶) 1 Jan 1979	1500	1257	2668	3751	982	1060	309	2904
Fishing mortality in 1979	.030	.075	.150	.150	.150	.150	.150	.150

Even though preliminary data suggest that the 1976 year class may possibly be of a comparable size to the strong 1975 year class, it was conservatively assumed to be only at the level of the mean recruitment observed in 1972-76, which was about 4 000 million fish at age 1. In the absence of any information about the size of the 1977 and 1978 year classes, the Working Group assumed these to be equal in size to the poorest year class observed previously (1972) which was about 1 500 million fish at age 1.

The 1979 TAC for the Western stock corresponding to an F of 0.15 is then estimated at 520 000 tons.

6.3 Area TAC's for 1978 and 1979

On the basis of the assessments outlined above, the Working Group recommends that catches from the North Sea mackerel stock should be as low as possible.

As described previously, however, Western stock mackerel form a large proportion of mackerel found at Shetland in the summer. On the assumption that the two stocks are mixed in proportion to their stock size, catches from the Shetland area would, at present stock levels, be expected to contain about 85% of Western stock mackerel. The mixing ratios are, however, very variable and the contribution from the North Sea stock might possibly be higher than the estimated 15%.

Since the Western stock can sustain rather large catches and mackerel of this stock predominate in the Shetland area i.e. north of 60°N and west of 2°E, it seems unnecessary at present to stop fishing in the North Sea altogether. The Working Group, therefore, calculated the TAC for the North Sea area with the prime objective of reducing the catch of mackerel from the North Sea stock to an acceptable level which was set to around 15 000 tons. In relation to the spawning stock size higher catches would be highly undesirable. Consequently, the Working Group recommend that the TAC's for the North Sea and Western areas in 1978 and 1979 should be:

	Western area (Sub-areas VI, VII, VIII)	North Sea area (Sub-area IV and Division IIIa)
1978	450 000 tons	100 000 ^x) tons
1979	435 000 tons	100 000 ^x) tons

^x) To be taken north of 60°N and west of 2°E only.

In these TAC's for the North Sea it is assumed that 85 000 tons will be taken from the Western mackerel stock in both years.

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8. SUMMARY

In the North Sea area (Sub-area IV, Divisions IIa and IIIa) the total landings in 1977 were 45 000 tons lower than in 1976, mainly because of restrictions in the Faroese and Norwegian fishery. The recommended TAC was exceeded by 21%.

In the Western area (Sub-area VI, VII and VIII), the landings were about 315 000 tons, a decrease of 190 000 tons, 38%, compared to 1976. This was mainly caused by the reduced fishing possibilities of USSR and other east European countries in the area. The UK landings more than doubled and now represent 60% of the international total.

The Working Group made extensive use of catch and biological data to assess the two mackerel stocks. In addition, two other major sources of information were used.

Tagging returns from Norwegian experiments were used to split the North Sea catch into its component stocks, to provide estimates of natural mortality and to estimate fishing mortality in the North Sea stock in recent years.

A new estimate of the size of the Western spawning stock in 1977 based on English and French egg surveys was presented.

It seems evident from the tagging data that the overall natural mortality of the North Sea stock is 0.10 - 0.15, rather than 0.20 previously assumed, and a value of 0.15 has been adopted for both mackerel stocks.

The data now available, including revisions of 1976 catch figures, indicate that for the North Sea stock the fishing mortality increased to 0.3 in 1977. The 1969 year class made up 30% of the total catch in number. As pointed out in previous reports, there has been a continuous decline in stock biomass, mainly caused by the lack of recruitment. By contrast, the fishing mortality of the Western stock decreases to about 0.1 in 1977 and the stock biomass remained stable as the effect of fishing was balanced by a sequence of good year classes.

When calculating a prognosis for the North Sea stock the recruiting year classes have been assumed to remain weak. With the decline in the stock size resulting from previous recruitment failure, the spawning stock may be below the level required to produce a year class of reasonable strength. To prevent a further decline of the spawning stock and to improve the chance of recovery of the North Sea stock, it is necessary to minimise the fishing on this stock as soon as possible.

The prognosis has been calculated on two alternatives: (a) the catch of the North Sea stock in 1978 is minimized by decreasing the TAC previously recommended, and by restricting catches to the Shetland area in order to fish mackerel mostly from the Western stock, (b) the TAC for the North Sea area remains 190 000 tons. For both alternatives zero catches of the North Sea stock in 1979 has

been assumed.

Under alternative (a), the spawning stock in 1979 and 1980 decreases slightly below the 1978 level. Under alternative (b), the spawning stock is reduced to about 340 000 tons in 1979 and 1980. The assumed recruitment and growth seems to balance the natural mortality so that zero catch in 1979 will stabilize the spawning stock, but the level at which it is stabilized will be approximately 100 000 tons, or 23%, lower for alternative (b) than for (a).

For the Western stock, the latest estimates of stock parameters constitute marked changes from previous estimates by the Working Group and owing to some uncertainty it is advocated that exploitation should be increased cautiously. When calculating the prognosis, a fishing mortality of 0.15 on the fully recruited year classes has been adopted. It is assumed that recruitment from the 1976 year class will be at the level of the mean for previous year classes while the 1977 and 1978 year classes are assumed to be equal to the poorest year class previously observed. The 1978 catch in the Western area may possibly be somewhat less than the TAC now recommended, and the 1979 TAC has been calculated assuming a catch of 400 000 tons in the Western area in 1978. It is further assumed that a catch of 85 000 tons from the Western stock will be taken in the Shetland area in both 1978 and 1979.

On the basis of the assessments outlined above, the recommended TAC's for each of the two areas are:

North Sea (IV, IIIa)	1978	100 000 tons ^{x)}
	1979	100 000 " ^{x)}
Western area(VI, VII, VIII)	1978	450 000
	1979	435 000

^{x)} To be taken north of 60°N and west of 2°E only.

Table 2.1 Nominal catch (tons) of mackerel in the North Sea, Skagerrak and Kattegat (IV and IIIa) 1967-1977.

(Data for 1967-1976 as officially reported to ICES).

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977 ¹⁾
Belgium	201	77	139	19	85	129	78	145	134	292	47
Denmark	20 282	9 887	10 851	26 753	17 590	2 023	7 459	3 890	9 836	27 988	21 823
Faroe Islands	-	-	3 080	2 134	3 603	7 551	11 202	18 625	23 424	63 476	41 123 ²⁾
France	7 486	4 684	11 353	4 677	9 061	6 882	636	2 254	2 749	2 607	2 669
German Dem.Rep.	915	349	399	51	166	346	214	234	141	259	41
Germany Fed.Rep.	2 132	1 353	1 161	225	407	374	563	270	276	284	3 867
Iceland	105	352	612	1 492	649	687	3 079	4 689	198	302	
Netherlands	11 964	5 986	4 928	2 956	4 945	4 436	2 339	3 259	2 390	2 163	9 362
Norway ³⁾	866 548	779 084	683 045	278 631	200 635	160 141	298 877	255 132	241 533	207 867	182 200
Poland	2 261	1 629	12	205	130	244	561	4 520	2 313	2 020	298
Sweden	15 246	11 783	10 820	4 407	3 163	4 748	2 960	3 579	4 789	4 581 ¹⁾	3 522 ⁴⁾
U.K. (England&Wales)	46	55	35	35	23	32	31	61	33	89	10
U.K. (Scotland)	742	583	231	148	616	395	2 943	390	578	1 199	1 590
U.S.S.R.	4 098	6 094	12 516	718	2 600	611	17 150	8 161	9 330	1 231	2 784
Total	932 026	821 916	739 182	322 451	243 673	188 599	348 092	305 209	297 724	314 358	269 336

¹⁾ Preliminary

²⁾ Includes VI

³⁾ Includes catches from Div. IIa (1973 - 21 573 tons, 1974 - 6 818 tons, 1975 - 34 662 tons, 1976 - 10 516 tons, 1977 - 1 400 tons)

⁴⁾ From ICES Data Form 5 (Jan-Dec)

Table 2.2 Landings (tons) of mackerel by Division in the Norwegian Sea, Skagerrak and Kattegat, and the North Sea.

Year	Division				
	IIa	IIIa	IVa	IVb	IVc
1966	950	24 594	496 873	8 014	247
1967	897	20 069	895 163	14 973	906
1968	42	12 867	796 538	10 605	1 557
1969	7	24 917	700 816	11 529	1 521
1970	200	32 410	257 328	26 674	5 988
1971	358	15 462	199 280	17 217	11 548
1972	88	5 961	174 387	5 596	2 309
1973	21 573	8 220	297 459	19 433	1 407
1974	6 829	6 218	275 499	12 163	4 511
1975	35 272	10 994	231 536	16 691	3 841
1976	10 526	7 013	271 833	21 641	3 355
1977 ¹⁾	1 400	3 100	229 100	27 100	5 300

¹⁾ Preliminary

Note:

Denmark	IVb includes IVa		1966 to 1973
France	IVa	" IVb,c	1966
German.Dem.Rep.	IVb	" IIIa	1966-1972
Norway	IVa	" IVb	1966 to 1972
Sweden	IVa	" IVb and IIIa	1966 to 1974
Sweden	IVb	" IVa,c	1975
"	IVa	" IVb	1976
U.S.S.R.	IVa	" IVb,c	1966 to 1973

Netherlands catches not allocated by area. Mainly IVb, rest IVc 1967-

Table 2.3 Landings of mackerel (tons) by quarters, 1977.

Fishing Area	Quarters					TOTAL
	I	II	III	IV	Not known	
IV and IIIa	713	7 540	194 215	20 131	45 428	268 027
VI	663	2 129	47 299	22 101	2 097	74 289
VII	84 179	16 098	10 456	84 267	21 205	216 205
VIII	329	754	420	183	22 975	24 661

Table 2.4 Nominal catch (tons) of mackerel in the Western area (VI, VII and VIII).
(Data for 1967-76 as officially reported to ICES).

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977 ¹⁾
Belgium	7	2	11	8	2	1	3	7	17	10	-
Denmark	-	-	-	-	-	-	-	-	-	3	-
Faroe Islands	-	-	-	-	-	-	635	8 659	1 760	5 539	2)
France	34 494	34 896	31 356	42 899	33 141	35 354	41 664	37 824	25 818	33 556	34 387
German Dem.Rep.	949	95	9	130	93	214	1 733	2 885	9 693	4 509	431
Germany, Fed.Rep.	333	613	428	783	258	98	559	993	1 941	391	4 249
Iceland	-	-	-	90	86	74	52	-	21	10	-
Ireland	2 245	2 164	1 615	1 055	3 107	4 592	8 314	8 526	11 567	14 395	18 585
Netherlands	3 859	2 597	4 441	3 828	3 837	6 166	7 785	7 315	13 263	15 007	27 723
Norway	-	-	-	-	1 611	-	34 600	32 597	1 907	4 252	200
Poland	520	1 518	2 149	6 054	10 832	13 219	10 536	22 405	21 573	21 375	2 240 ³⁾
Spain	27 863	20 753	21 571	31 368	37 506	31 416	25 677	30 177	23 408	18 480	18 000 ⁴⁾
Sweden	-	-	-	-	-	-	-	-	-	38	2)
UK (England&Wales)	2 634	2 585	2 692	3 374	4 791	6 923	13 081	21 132	31 546	57 311	134 597
UK (N.Ireland)	158	151	279	243	315	57	93	75	30	95	3
UK (Scotland)	490	537	402	807	805	1 412	5 170	8 466	16 174	28 399	52 490
U.S.S.R.	-	-	6 147	13 555	36 390	71 249	65 202	103 435	309 666	262 384	22 248
Total, ICES memb.	73 552	65 911	71 100	104 194	132 774	170 775	215 104	284 496	468 384	465 754	315 155
Bulgaria	-	-	-	-	-	-	4 341	13 558	20 830	28 195	-
Rumania	-	-	-	-	-	-	-	-	2 166	13 222	-
Total	73 552	65 911	71 100	104 194	132 774	170 775	219 445	298 054	491 380	507 178	315 155

1) Preliminary

2) See Table 2.1

3) Working Group estimate

4) From ICES Data Form 5 (Jan-Dec)

Table 2.5 Landings of mackerel (tons) by Sub-areas in the Western area.

Year	Sub-area	
	VI	VII+VIII
1966	4 403	67 086
1967	5 413	68 138
1968	5 064	60 847
1969	4 760	66 340
1970	3 854	100 340
1971	10 213	122 561
1972	13 013	157 762
1973	52 166	167 279
1974	64 136	234 081
1975	64 849	416 538
1976	67 765	439 413
1977 ¹⁾	74 829	240 866

¹⁾ Preliminary

Table 3.2 Proportion of Catch in Division IVa attributable to the North Sea Mackerel Stock.

Year Class	Year						
	1971	1972	1973	1974	1975	1976	1977
Pre 1969	0.60	0.74	0.41	0.58	0.45	0.56	0.75
1969		1.00	0.93	0.71	0.80	0.47	0.71
1970			1.00	0.58	0.50	0.65	0.32
1971				1.00	0.92	0.29	0.51
1972					1.00	0.27	0.55
1973						1.00	0.94
1974							1.00

Table 3.1 Tag recoveries from the Shetland area (Sh) and the northeastern North Sea(NS) in Norwegian catches as a number $\times 10^{-6}$ effectively screened for tags (P_j). Tagged in the North Sea.

Year class	Release		Recapture													
	Year	No	1970		1971		1972		1973		1974		1975		1976	1977
			Sh	NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS		
Pro 1969	1969	4187	15	195	47	6	4	5	22	2	8	9	2	5	6	3
	1970	2420			30	10	6	19	23	26	13	15	2	14	12	7
	1971	2450					21	36	35	52	23	48	6	36	24	20
	1972	2126							32	80	21	68	5	44	33	33
	1973	1518									17	79	8	62	37	30
	1974	1344											4	47	23	33
	1975	1048													20	39
	1976	304														13
	P_j		41.5	212.7	170.5	8.6	60.2	32.3	204.6	62.9	114.7	30.7	80.5	36.0	53.8	33.5
1969	1970	1085			4	9	3	11	9	21	4	22	2	17	7	12
	1971	6900					36	113	109	232	64	170	16	137	85	72
	1972	9447							108	401	92	382	29	284	163	160
	1973	4642									33	270	22	216	92	96
	1974	2740											7	132	58	77
	1975	4716													123	152
	1976	996														36
	P_j				7.5	24.3	17.8	52.3	51.9	120.3	75.2	112.3	18.2	97.7	93.2	65.6
1970	1971	0														
	1972	245							2	8	1	8	1	6	2	3
	1973	702									6	24	3	31	14	12
	1974	185											0	9	6	4
	1975	423													11	13
	1976	70														2
	P_j						0.4	0.5	6.1	6.4	16.7	20.3	13.6	11.8	9.2	19.1
1971	1972	0														
	1973	415									3	10	2	14	5	7
	1974	104											1	2	1	2
	1975	725													16	21
	1976	88														2
	P_j										9.2	12.0	12.4	17.2	39.4	27.8
1972	1973	0														
	1974	82											1	3	1	1
	1975	625													14	16
	1976	105														4
	P_j										0.8	9.5	1.3	6.7	7.5	4.1
1973	1974	37											0	0	0	0
	1975	846													17	21
	1976	53														1
	P_j														13.9	18.3
1974	1975	1612													28	35
	1976	146														3
	P_j														24.4	18.4

Table 3.3 Tag recoveries from the Shetland area (Sh) and the northeastern North Sea (NS) raised to total catch as number $\times 10^{-6}$ (C_T). Tagged in the North Sea.

Year class	Release		Within season	Recapture											
	Year	No		1971		1972		1973		1974		1975		1976	
				Sh	NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS
Pre-1969	1970	2420	872	65	50	17	43	37	47	25	27	7	29	6	39
	1971	2450	147			60	82	56	93	45	85	14	69	32	26
	1972	2126	83					52	143	41	121	12	85	30	65
	1973	1518	182							33	141	19	120	37	39
	1974	1344	284									9	91	24	26
	1975	1048	184											19	52
	C_T			369.9	43.2	173.3	73.5	330.1	112.7	222.5	53.9	174.0	71.0	67.2	45.9
1969	1970	1085	84	9	34	8	26	15	38	8	37	5	29	11	9
	1971	6900	411			100	271	176	422	124	284	37	264	127	101
	1972	9447	311					174	729	179	637	67	544	193	242
	1973	4642	532							64	450	51	413	123	119
	1974	2740	430									16	253	95	53
	1975	4710	835											136	198
	C_T			16.3	91.6	49.2	125.5	83.8	218.7	146.0	186.0	39.2	192.9	123.8	116.1
All	1970	3505	936	74	84	25	69	52	85	33	64	12	58	17	48
	1971	9350	558			160	353	232	515	169	369	51	333	160	127
	1972	11818	419					232	892	222	793	80	644	226	315
	1973	7277	814							116	731	75	645	193	182
	1974	4493	664									27	380	138	95
	1975	8383	1419											218	456
	C_T			386.2	134.8	224.3	235.5	428.8	370.7	422.8	312.0	255.4	364.1	335.7	315.6

Table 3.4 Results of analysis of North Sea tagging data by cohort method.

All yearclasses, North Sea stock. Natural mortality = 0.122

Tagging survival

	Year of release					
	1970	1971	1972	1973	1974	1975
	0.66	0.68	0.71	0.82	0.63	0.69

Numbers of tags present
in population at 1 January

Year of release	Year of recapture						
	1971	1972	1973	1974	1975	1976	1977
1970	1304	1006	802	581	423	309	212
1971		5441	4334	3134	2268	1646	1187
1972			7525	5604	4006	2865	2027
1973				4879	3522	2440	1807
1974					2044	1426	1043
1975						4125	3018

Mortality during years

Mortality		Year of recapture					
		1971	1972	1973	1974	1975	1976
Total	(Z)	0.26	0.23	0.31	0.33	0.34	0.32
Fishing	(F)	0.14	0.11	0.18	0.21	0.22	0.20

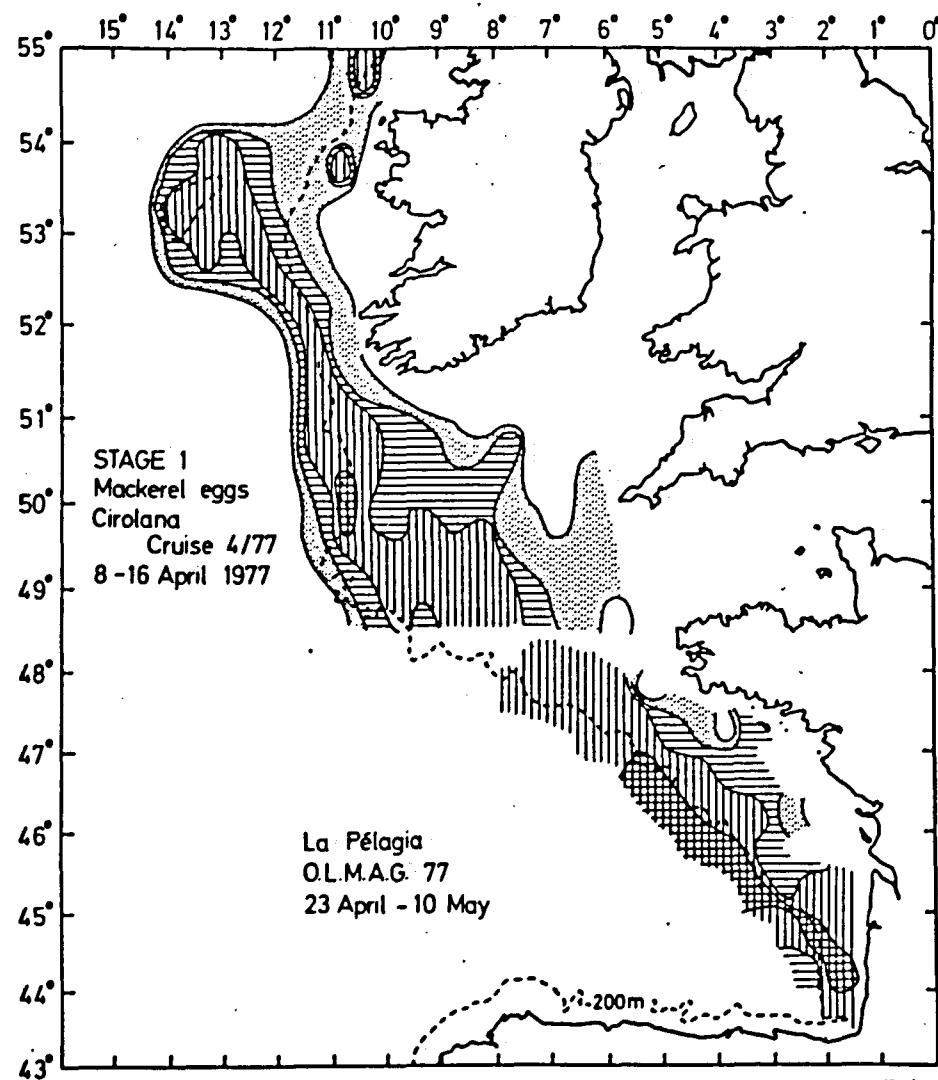
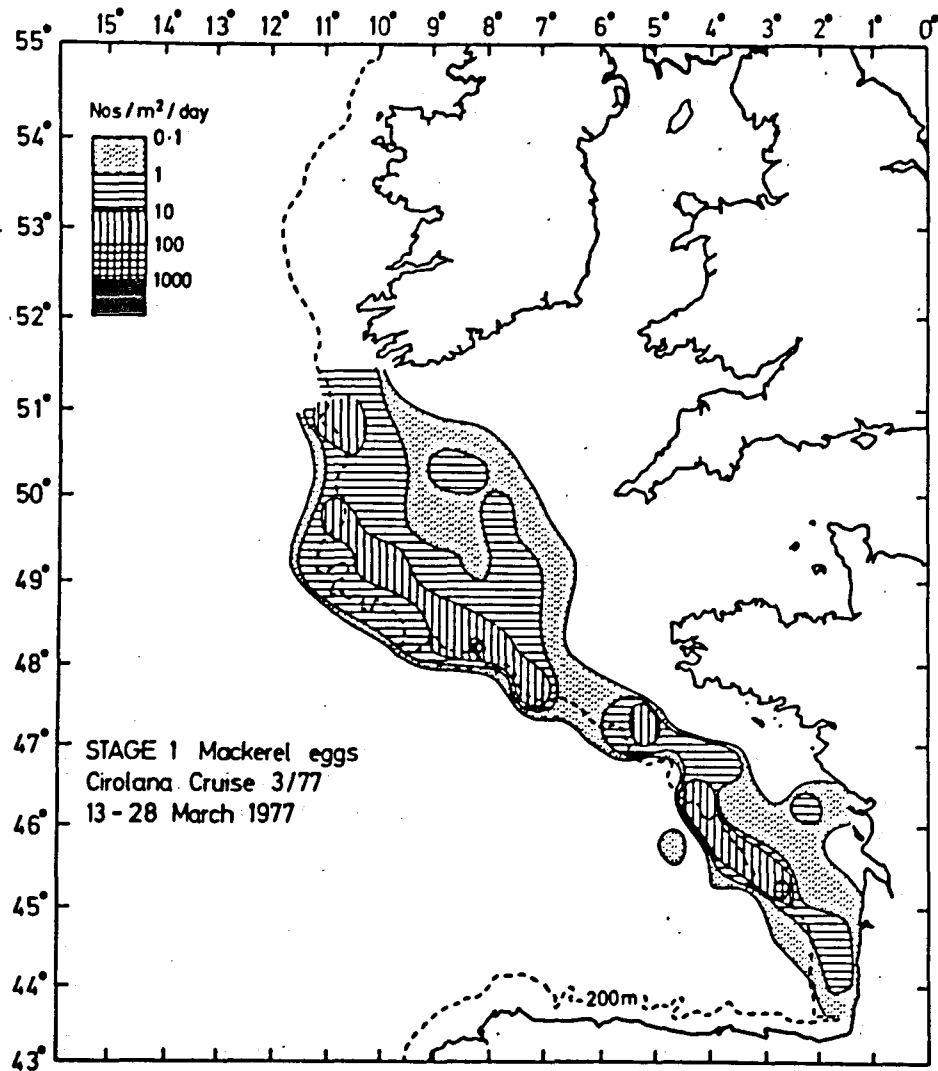


Fig. 4. 1 Distribution of daily mackerel egg production.

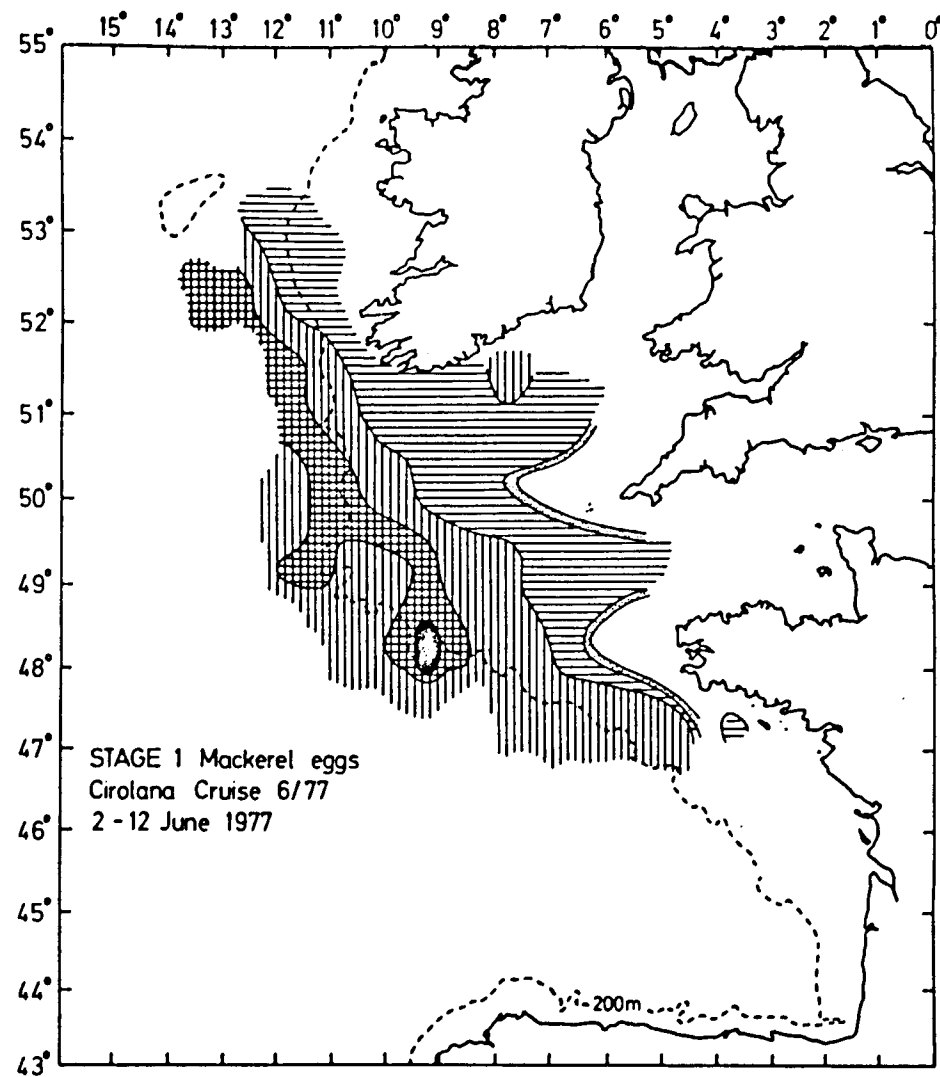
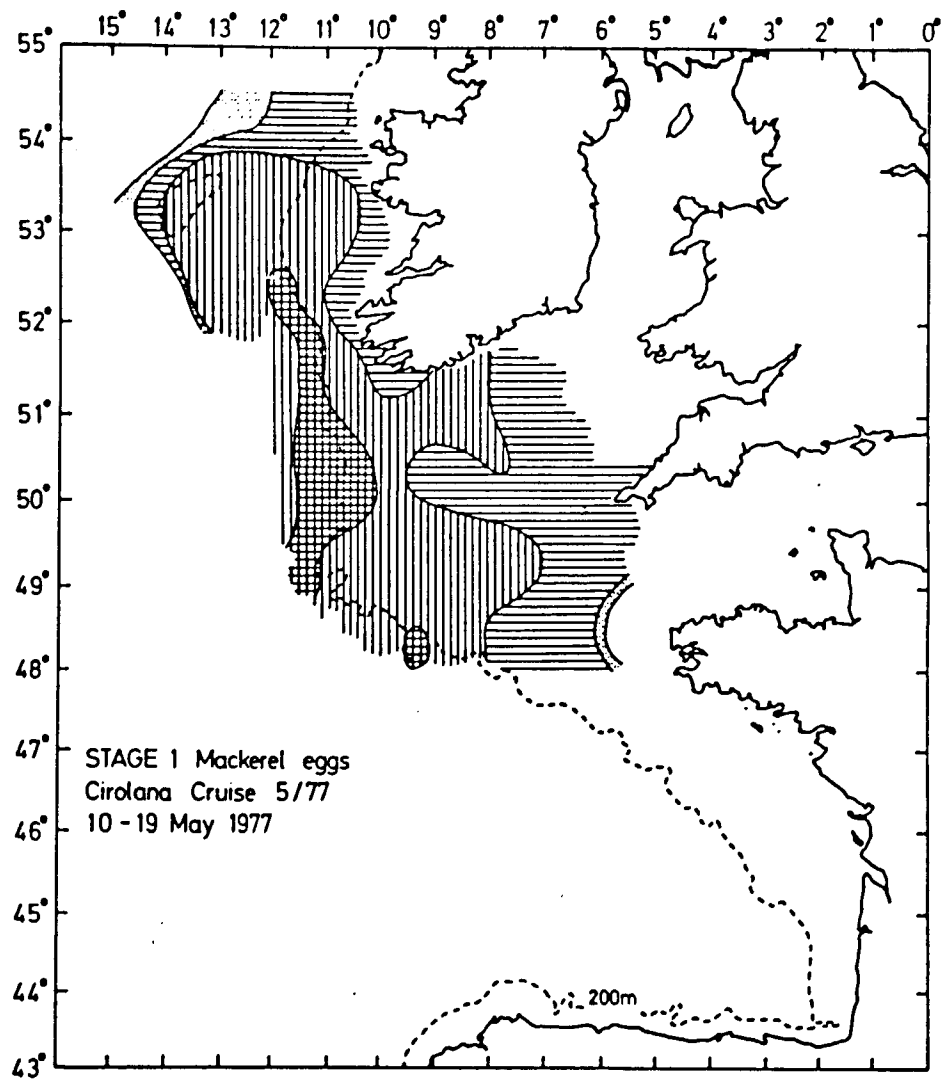


Fig. 4. 1 Cont.

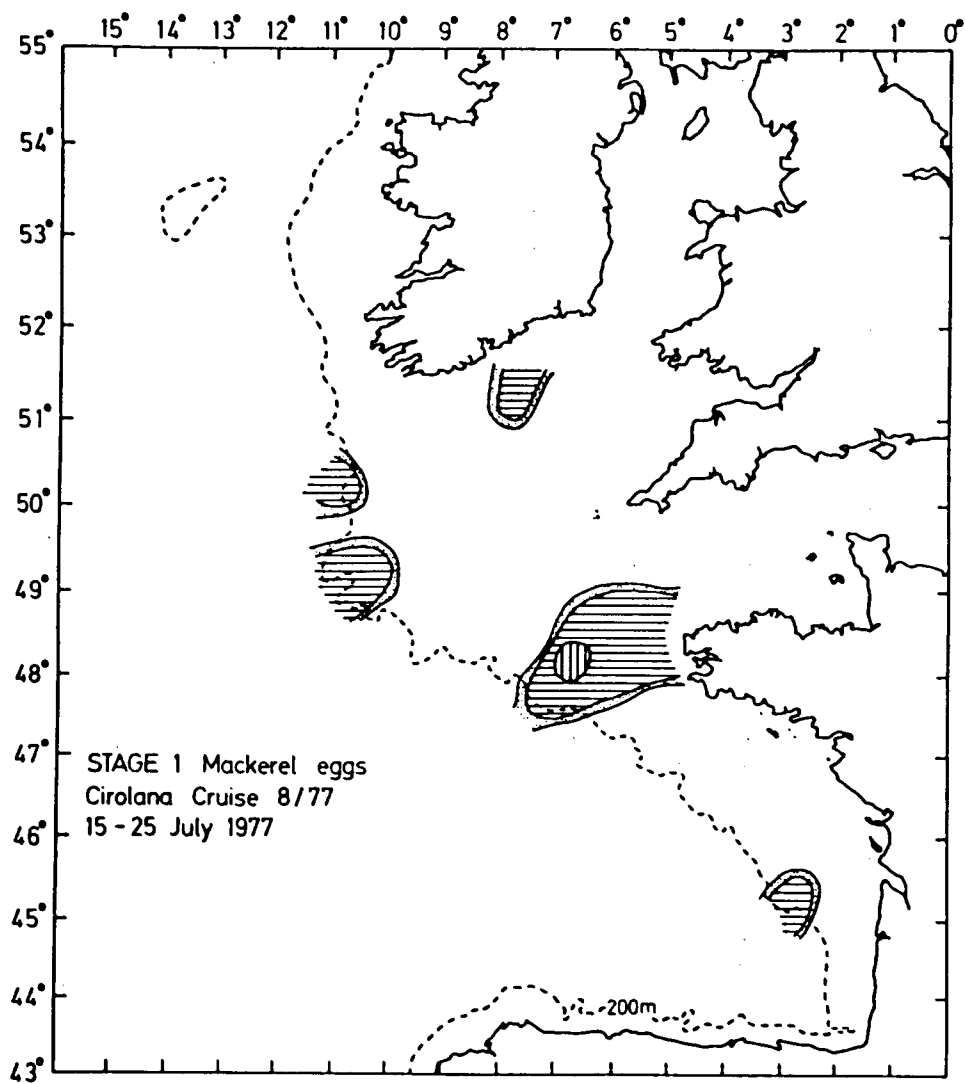


Fig. 4. 1 Cont.

Table 4.2 Egg production, no per m² per day. Western mackerel stock 1977.
Total spawning area surveyed 40.52 x 10¹⁰ m²

	CIROLANA 3/77	CIROLANA 4/77	LA PELAGIA	LA PELAGIA + CIROLANA 4/77	CIROLANA 5/77	CIROLANA 6/77	CIROLANA 8/77
	MARCH	APRIL	APRIL-MAY		MAY	JUNE	JULY
Mean, transformed data	0.96	1.46	2.87	2.00	2.67	2.64	0.18
Standard error.	0.14	0.19	0.28	0.16	0.21	0.22	0.06
Retransformed arithmetic mean	3.94	12.02	69.91	24.21	65.24	71.28	0.40
Upper confidence limit, %	32	46	75	38	52	55	13
Lower confidence limit, %	24	32	43	27	34	36	12
Total daily egg prod., x 10 ⁻¹²	1.60	4.87	10.63 ^{x)}	7.76	26.44	28.88	0.16

Total spawning season production 1.61 x 10¹⁵ eggs + 18%, - 12%

x) Bay of Biscay only, area 15.20 x 10¹⁰ m².

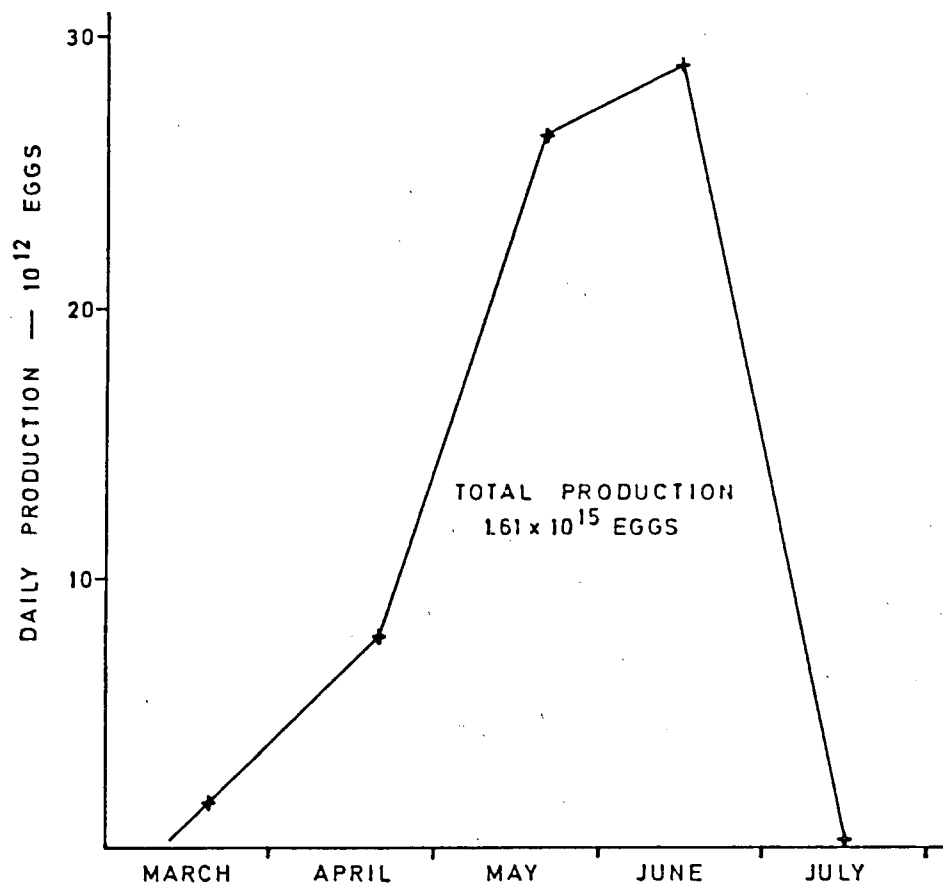


Fig. 4. 3 Egg production, no per m² per day. The Western mackerel stock.

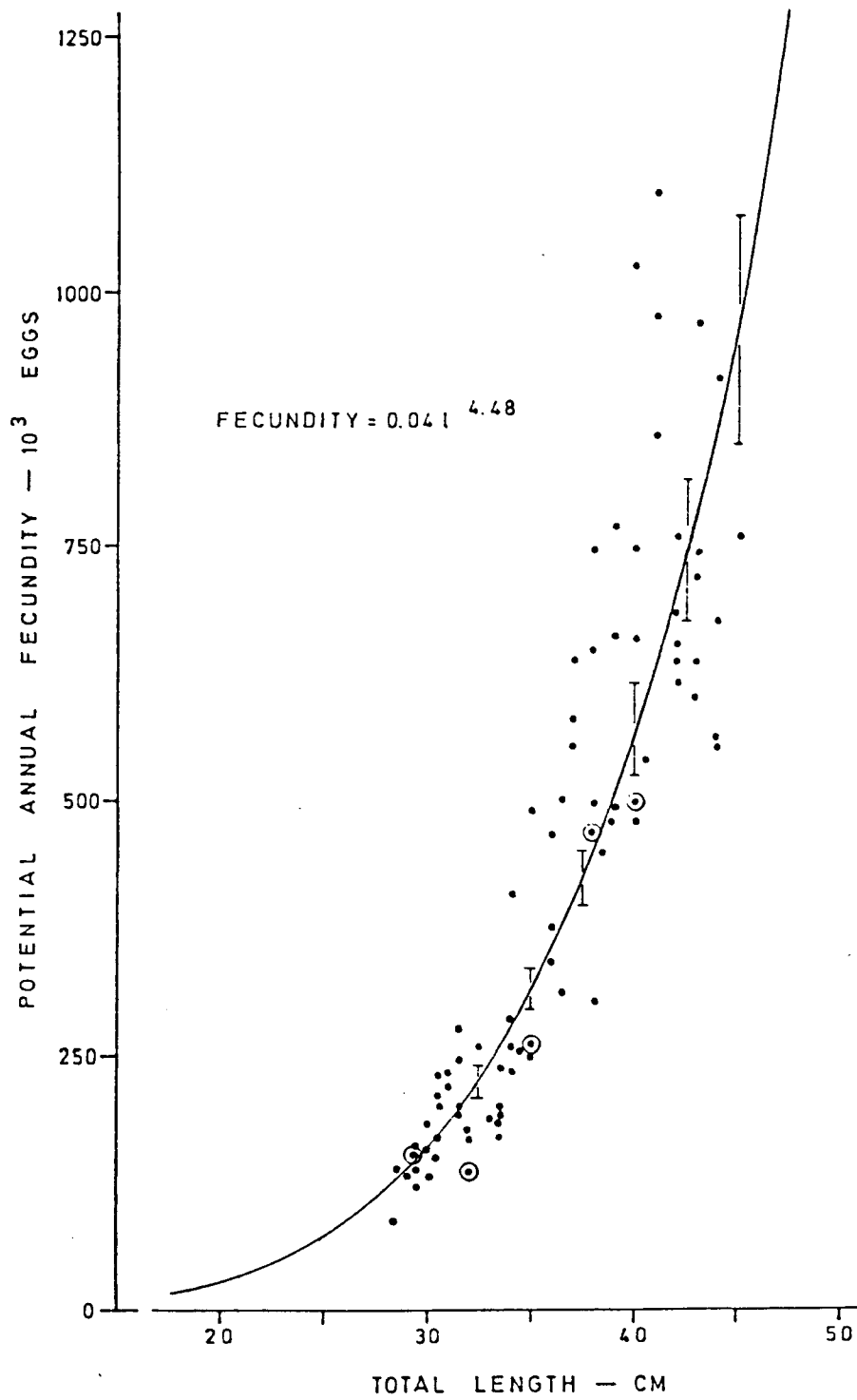


Fig. 4. 4 Fecundity of mackerel from the Western stock.

Table 5.1 Catch in number $\times 10^{-6}$ of the North Sea mackerel stock by year-classes.

Year class	1975			1976			1977
	IVa + IIIa		IV b,c	IVa + IIIa		IV b,c	IVa + IIIa
	Excl. Shetl.	Shetl.		IV b,c	IV b,c		
Pre 1968	46.4	4.6	7.2	} 55.1	} 18.9	} 57.6	} 17.0
1968	17.9	2.8	10.7				
1969	171.7	17.4	4.0	108.5	7.8	113.1	5.1
1970	20.9	2.9	4.1	14.7	5.9	14.1	4.0
1971	29.6	2.6	10.1	25.8	20.4	32.5	9.9
1972	12.4	1.9	1.9	6.6	7.6	6.6	4.9
1973	5.5	0.8	3.8	47.5	22.2	41.8	17.6
1974	7.6		4.3	60.7	12.9	48.9	14.5
1975					2.7	9.4	14.4
1976						0.7	0.6

Table 5.2 Catch in number $\times 10^{-6}$ of the Western mackerel stock by year-classes.

[illegible]

Table 5.3 Mean weight (g) at age by quarters.

\bar{w} is the overall mean, weighted by catches in recent years.

North Sea

		Age - years							
		1	2	3	4	5	6	7	> 7
Division IVa	Jan-Mar	123 ¹⁾	234	325	338	350	346	468	472
	Apr-Jun	-	206	309	362	423	437	481	553
	Jul-Sep	250 ¹⁾	334	367	393	441	455	523	588
	Oct-Dec	245	334	342	393	424	463	503	521
\bar{w}		245 ²⁾	329	363	392	438	455	520	580

1) Single fish only

2) Based on Oct-Nov only

Western area

		Age - years								
		0	1	2	3	4	5	6	7	≥ 8
Sub-area VI	Jan-Mar	no data available								
	Apr-Jun	-	-	232	281	309	345	357	422	462
	Jul-Sep	-	203	275	284	343	432	431	483	617
	Oct-Dec	-	180	286	314	327	463	415	475	625
Sub-area VII	Jan-Mar	-	58	125	177	233	246	309	356	378
	Apr-Jun	-	107	147	186	257	277	285	336	356
	Jul-Sep	61	112	183	223	256	277	317	321	392
	Oct-Dec	65	125	181	209	275	327	373	411	509
w̄		64	112	169	207	269	318	362	398	505

Table 5.4 The North Sea Mackerel stock. Catch in number with fishing mortality rates and stock sizes as derived from cohort analysis ($M = 0.15$).

		Year						
Year class		1972	1973	1974	1975	1976	1977	1978
Catch in number (10^6)	Pre 1969	105.6	169.3	98.0	89.7	73.9	74.6	
	1969	162.6	280.2	240.8	193.2	116.2	118.2	
	1970	35.6	37.6	39.9	27.8	20.6	18.1	
	1971	2.6	12.1	23.6	42.4	46.2	42.4	
	1972	-	4.5	18.7	16.2	14.2	11.5	
	1973	-	-	2.9	10.1	69.7	59.4	
	1974	-	-	-	11.9	73.6	63.4	
	1975	-	-	-	-	2.7	23.8	
	1976	-	-	-	-	-	1.3	
Total		306.4	503.7	423.9	391.3	417.1	415.7	
Fishing mortality (F)	Pre 1969	.084	.177	.140	.174	.200	.300	
	1969	.074	.166	.199	.230	.199	.300	
	1970	.104	.144	.212	.212	.227	.300	
	1971	.005	.026	.062	.144	.219	.300	
	1972	-	.030	.061	.193	.244	.300	
	1973	-	-	.006	.026	.233	.300	
	1974	-	-	-	.028	.231	.300	
	1975	-	-	-	-	.018	.200	
	1976	-	-	-	-	-	.009	
$\bar{F} \geq 3$ years		.078	.168	.164	.199	.211	.300	
Stock size at 1 Jan (10^6)	Pre 1969	1418.9	1123.3	809.8	606.1	438.4	308.8	196.9
	1969	2467.1	1972.6	1437.9	1014.2	693.7	489.3	312.0
	1970	389.6	302.3	225.3	156.9	109.3	74.9	47.8
	1971	586.3	502.2	421.0	340.5	253.7	175.5	111.9
	1972	-	162.6	135.8	99.5	70.6	47.6	30.4
	1973	-	-	502.8	430.1	360.8	245.9	156.8
	1974	-	-	-	459.3	384.2	262.4	167.3
	1975	-	-	-	-	166.8	141.0	99.4
	1976	-	-	-	-	-	(160.0)	136.5
	1977	-	-	-	-	-	-	(160.0)
Total		4861.9	4063.0	3532.6	3106.6	2477.5	1905.4	1419.0
Spawning stock (≥ 3 years)								
biomass (10^3 tons)		1471.5	1295.2	1098.5	839.3	799.3	657.5	469.4

Table 5.5 The Western Mackerel stock. Catch in number with fishing mortality rates and stock sizes as derived from cohort analysis ($M = 0.15$).

		Year						
Year class		1972	1973	1974	1975	1976	1977	1978
Catch in number (10 ⁶)	Pre 1969	507.7	582.3	567.0	1246.2	416.2	139.7	
	1969	29.4	115.5	191.8	143.8	282.0	97.7	
	1970	12.1	64.0	108.5	192.2	117.5	77.4	
	1971	12.4	49.4	123.5	306.3	276.4	123.9	
	1972	1.6	33.8	24.3	94.5	170.3	46.7	
	1973	-	-	87.0	104.0	322.3	160.2	
	1974	-	-	1.3	52.5	184.9	148.4	
	1975	-	-	-	1.0	279.5	276.1	
	1976	-	-	-	-	34.1	135.8	
	1977	-	-	-	-	-	2.0	
Total		563.2	845.0	1103.4	2140.5	2083.2	1207.9	
Fishing mortality (F)	Pre 1969	.068	.098	.124	.410	.219	.100	
	1969	.009	.041	.085	.081	.213	.100	
	1970	.005	.031	.064	.145	.117	.100	
	1971	.003	.015	.044	.138	.168	.100	
	1972	-	.025	.022	.104	.262	.100	
	1973	-	-	.027	.039	.153	.100	
	1974	-	-	-	.022	.097	.100	
	1975	-	-	-	-	.042	.050	
	1976	-	-	-	-	-	.037	
	1977	-	-	-	-	-	-	
F \geq 3 years		.050	.071	.088	.223	.184	.100	
Stock size at 1 Jan (10 ⁶)	Pre 1969	8368.0	6731.4	5253.6	3995.8	2283.0	1578.9	1229.6
	1969	3590.0	3062.6	2528.9	1998.7	1586.9	1104.2	860.0
	1970	2658.6	2277.1	1900.5	1535.1	1143.0	874.8	681.3
	1971	4280.0	3672.4	3115.0	2566.5	1924.9	1400.3	1090.6
	1972	-	1454.0	1220.1	1027.6	796.8	527.8	411.1
	1973	-	-	3532.5	2959.8	2451.0	1810.6	1410.1
	1974	-	-	-	2552.2	2148.0	1677.2	1306.2
	1975	-	-	-	-	7379.9	6092.6	4988.2
	1976	-	-	-	-	-	(4000.0)	3317.8
	1977	-	-	-	-	-	-	(1500.0)
Total		18896.6	17197.5	17550.6	16635.7	19713.5	19066.4	16794.9
Spawning stock (\geq 3 years)								
biomass (10 ³ tons)		3420.9	3651.1	4061.7	3913.0	3532.1	3212.1	3814.5

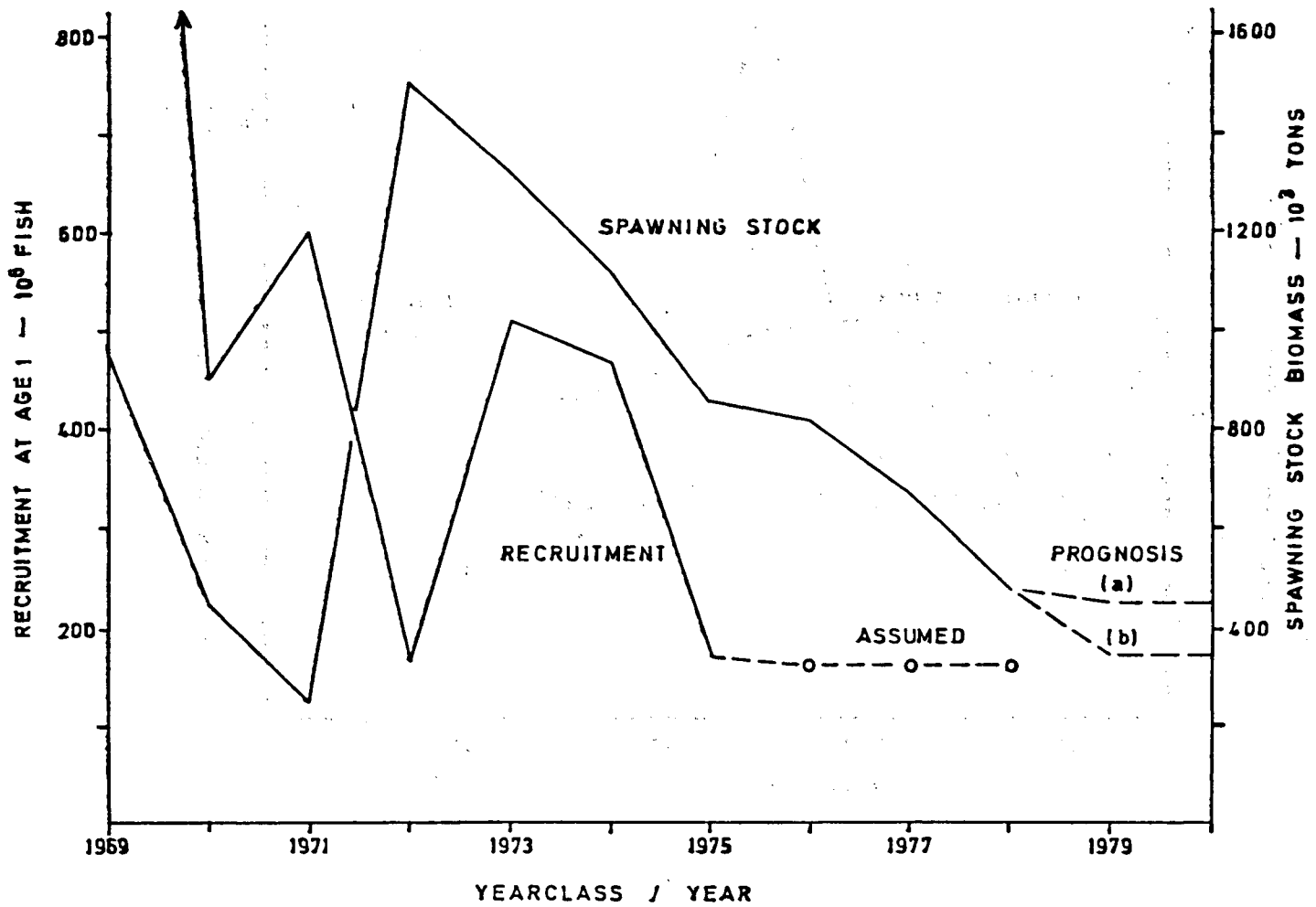


Fig. 6.1 North Sea mackerel spawning stock biomass at 1 January (age ≥ 3 years) and resulting recruitment as year class size at age 1.

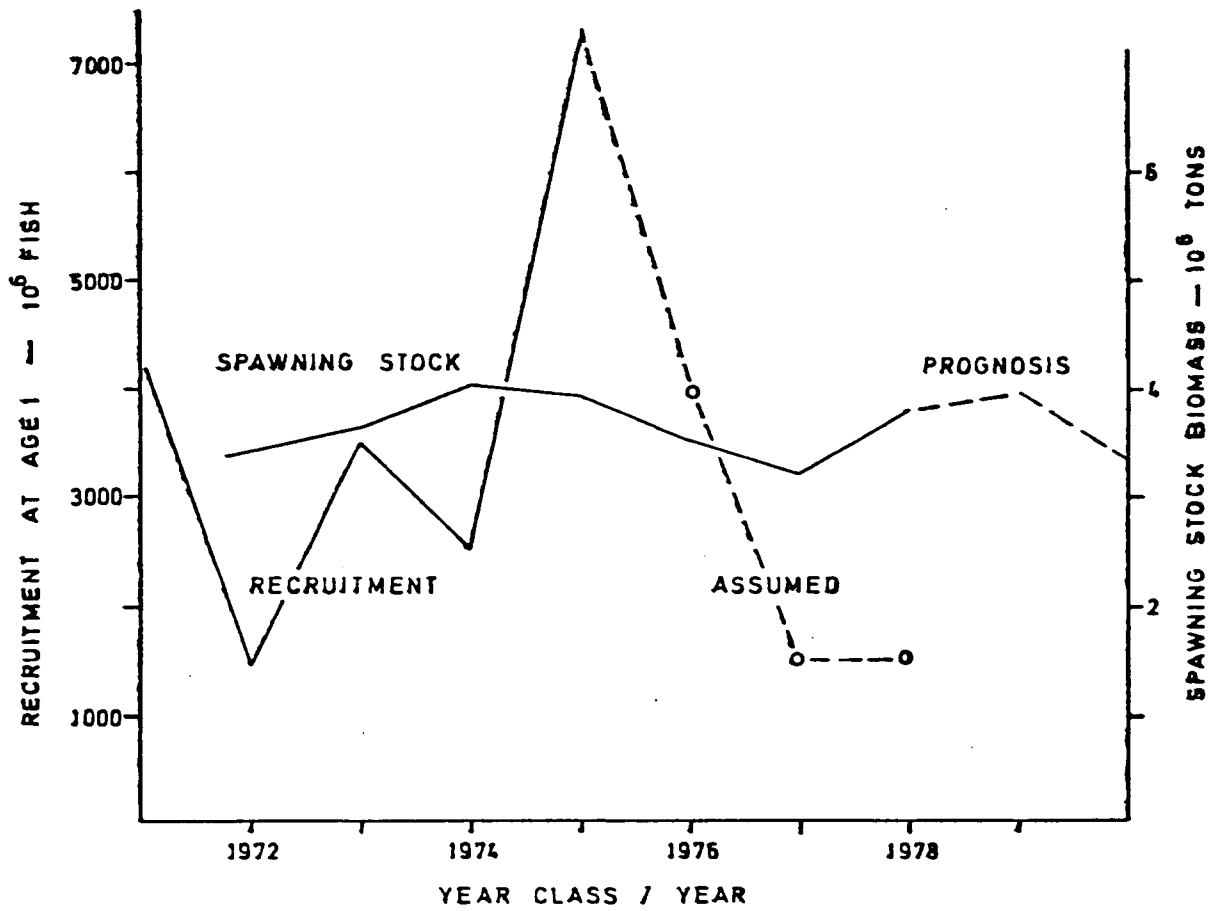


Fig. 6.2 Western mackerel spawning stock biomass at 1 Jan. (age ≥ 3 years) and resulting recruitment as year class size at age 1.

Report of the Mackerel Working Group, 1977.

ANNEX 1. SHORTCOMINGS AND GAPS IN DATA

In response to the Council's resolution, C.Res. 1977/4:24, the Mackerel Working Group identified the following gaps in the data and information required to make reliable assessments of the mackerel stocks in the northeast Atlantic.

1. Catch data and sampling

For the North Sea no information on either area or timing of catch were presented for the Faroese (41 000 tons), Swedish (3 500 tons) and USSR (2 800 tons) landings. For all these countries and Denmark (22 000 tons), no biological sampling was carried out. It was therefore impossible to raise to number at age over a quarter of the total North Sea catch with any reliability.

For the Western area, no information was available on catches by Spain (guessed to be the same as in 1976). Indeed, for the Spanish catches up to and including 1976 reported in Bulletin Statistique, it is not even possible to determine the species composition of the catch (i.e. the proportion of Scomber scombrus and Scomber colias). No sub-division into ICES sub-areas and months was possible for the Federal Republic of Germany catches, and biological sampling from the Irish catch was also inadequate for reliable raising to number at age. Since the bulk of the catch in Sub-area VIII is made by Spain, the amount of biological sampling in this area was totally inadequate.

Because it is thought that considerable amounts of mackerel do not appear in the catch statistics estimates of discards (including slipping and dumping) should be provided.

2. General biological information

To convert egg production estimates to estimates of stock size, information on the length and age composition of the spawning stock is required, and in particular the proportion of female fish at each length and age that spawn. Limited data were available, but further biological sampling is required from the main spawning areas during the main spawning season.

3. Estimates of stock and recent fishing mortality

The largest impediment to the assessment of the Western stock was the lack of any estimate of recent fishing mortality rate. This situation was very much improved in 1977 by the stock size estimate from the egg surveys. Since these surveys, however, gave a stock size estimate which was much higher than those made using catch composition and tagging data, it was felt desirable to obtain confirmatory evidence by other means. With this in mind, the Working Group considered the following possibilities:

a) Effort statistics

In aimed mackerel fisheries, these are unlikely to give valid estimates of fishing mortality, although they may enable one to judge the reliability of changes in F estimated by cohort analysis.

b) Catch per unit effort, on research vessel surveys

It was noted with interest that mackerel had been caught during bottom trawl surveys made by France in the Celtic Sea in autumn 1977. Since trawling on these surveys is not "aimed" at mackerel concentrations, they may give unbiased estimates of mortality rate and an index of the abundance of recruiting year classes, if one assumes that availability to bottom trawl remains constant. Until further surveys are completed, it is not possible to judge their usefulness in mackerel assessments, but it is recommended that further surveys be carried out in this area.

c) Acoustic estimates

Owing to the low acoustic target strength of mackerel and to the presence of other species, such as horse mackerel, in the area of distribution, the Working Group at present consider that acoustic surveys are only likely to be of value in areas where mackerel shoal independently of other species.

d) Tagging

There would be major advantages if improved tagging returns from Western area catches were available. Further investigation of external tagging and methods for retrieving of internal tags of catches destined for human consumption are required.

e) Egg surveys

The egg survey carried out in 1977 provides a fixed point for the measurement of stock size using cohort analysis. In the absence of any other reliable ways of estimating recent values of F , it is recommended that further egg surveys be made to provide further stock size estimates.

Report of the Mackerel Working Group, 1977

ANNEX 2. BIOLOGY, DISTRIBUTION, STATE OF EXPLOITATION AND DISTRIBUTION OF FISHERIES ON SHARED STOCKS

A request was received from the Chairman of the ICES Advisory Committee on Fishery Management to provide information in relation to shared stocks similar to that prepared at the 1977 Working Group meeting and subsequently presented to the Liaison Committee. This information was requested by NEAFC. Consequently, the Working Group decided to review and update, if necessary, the provisional information and data on mackerel, horse mackerel and pilchards presented as an appendix to C.M.1977/H:2. Apart from an intensive plankton survey carried out by England and France on mackerel in 1977, in general the additional information was extremely limited and the following accounts are merely presented as additions to the appendix mentioned.

MACKEREL

As already pointed out, there are generally considered to be two stocks of mackerel - the North Sea stock and the Western stock with a considerable amount of admixture between both components.

The North Sea stock

1. General biology

No new information is available about the biology of mackerel from the North Sea.

2. Exploitation and management

The fishery. The fishery in 1977 was, in general, carried out in the same way as in previous years. The total catch decreased to 269 000 tons, but even this exceeded the recommended TAC.

Stock fluctuations. The decline in stock size which has occurred in recent years continued in 1977 and the total adult stock is now estimated to be about 470 000 tons.

Fishery Regulations. No new fishery regulations have been imposed on this stock in 1977, except for a recommendation that catches in 1977 under the "standstill agreement" should not exceed those of 1976.

3. Catch statistics

The situation regarding catch statistics and the distribution of the catches remain the same as in 1977.

The Western stock

1. General biology

An extensive English and French plankton survey to collect mackerel eggs carried out during the spawning season of 1977 provided considerable additional information about the locality and distribution of the spawning areas (Lockwood, et. al, 1977). This information is detailed in the main report of the Mackerel Working Group.

2. Distribution

No new information is available about the distribution of juveniles or adults, although some French and English data should suggest that 0 and 1-group mackerel are distributed throughout the Celtic Sea and the Bay of Biscay.

3. Exploitation

The fishery. The exploitation pattern of the fishery changed dramatically in 1977 because of the absence of the USSR and other Eastern European fleets from the fishery which exploits the overwintering population in the Celtic Sea and the Bay of Biscay.

Stock fluctuations. More reliable estimates of stock size have become available as a result of the plankton survey, and from more recent evidence from the tagging experiments carried out by Norway. This indicates that the stock size is considerably larger than had been previously estimated and may be in the order of 3 million tons.

Fishery regulations. International regulations included the stand-still agreement of 1977 mentioned above, and licensing of some non EEC-countries.

4. Catch statistics

The 1977 catch, largely because of the absence of USSR vessels, decreased from 507 000 tons in 1976 to 315 000 tons in 1977. The U.K. now accounts for over 59% of the total catch.

PILCHARD (Sardina pilchardus)

1. General biology

No new information about the general biology of this species was available to the meeting, and consequently it was not possible to make any further estimates of stock size.

2. Exploitation

Apart from an updating of the catch statistics by the inclusion of the 1977 data, it was not possible to make any further comments about exploitation rates. The 1977 catch decreased slightly, from

175 000 tons in 1976 to 157 000 tons. In general, the catch has remained fairly constant since 1968.

3. Further information

The Working Group refers to a resolution (C.Res. 1977/2:30) adopted at the 65th statutory meeting of ICES which decided that a working group on pilchards and other clupeids south of the British Isles should meet in Lisbon early in 1978. The purpose of the group is to evaluate the existing knowledge of these stocks and propose an international programme of research. This group was also asked to prepare a report on the distribution of stocks in the ICES area.

HORSE MACKEREL (Trachurus trachurus)

1. General biology

No additional data were presented to the Working Group in relation to this species. Although some age, length and weight data are available from France, Norway, Poland and the U.K., this information is very limited and insufficient to make any assessment of exploitation rate or sustainable yield in Sub-Areas IV, VI, VII or VIII. More detailed data are available about the fishery exploited by the Portuguese and Spanish fleets in Division IXa.

2. Exploitation and management

The pattern of exploitation has not altered in 1976. Over 88% of the total catch in the last five years has been taken by the USSR (45%), Spain (30%) and Portugal (13%). In 1976 the heaviest catches were again taken from Sub-Areas VII and VIII which together contributed about 82% of the total catch. The amount taken in Sub-Area IV decreased from 9.0 (average 1973-1975) to 2% (Annex Table 1).

Because of the limited biological data in Sub-Area VII, and the possibility that the recent high catches there may only have resulted from an increase of fishing effort on a declining stock biomass, the Mackerel Working Group in 1977 recommended that the total annual catch should not be allowed to exceed 120 000 tons until better data become available. Similarly in Sub-Area IX the Group recommended that the annual catches should not exceed 40 000 tons. A Portuguese assessment of the fishery conducted in Div. IXa confirmed the analysis by the Working Group indicating that the stock was being heavily exploited and that the effort in recent years was about 25% above the level at which the maximum potential yield is obtained (Borges et al, 1977).

3. Stock size

The lack of scientific information makes it impossible to estimate the stock size over all the ICES areas.

4. Catch statistics

Catch statistics for the different ICES areas for the period 1966 to 1976 are given in Annex Table 2. Preliminary data for 1977 catches are not yet available for all countries. The 1976 catch (370 000 tons) is the highest recorded and has increased by over 100 000 tons on the 1975 figure. This was mainly due to increases in the Spanish and USSR catches. However, the 1977 catch will probably decrease considerably because of the withdrawal of the USSR fleet from the fishery.

Reference

Borges, F., H. Dinis and C. Monteiro 1977.

Résultats préliminaires sur la ponte, composition des tailles et état du stock du chinchard (Trachurus trachurus L) de la cote portugaise. Coun. Meet int.
Coun. Explor. Sea, 1977 (J:14).

Annex table 1. Nominal catch (tons) of horse mackerel by countries 1966-1976 in ICES Sub-areas and Divisions IIa, IIIa, IV, VI, VII, VIII, IX and X. (Data as officially reported to ICES).

Country	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Belgium	4	10	36	37	33	41	75	72	37	27	17
Denmark	-	-	4	-	-	-	-	-	-	-	-
Faroe Islands	-	-	-	-	-	-	-	5 370	1 114	158	118
France	-	-	1 830	2 479	2 768	3 039	3 603	6 549	5 525	4 969	7 620
German Dem.Rep.	-	-	-	-	-	-	-	-	49	107	215
Germany Fed.Rep.	1 532	96	1 238	1 096	966	395	175	2 891	1 720	1 480	170
Iceland	-	-	-	-	-	-	-	379	203	-	-
Netherlands	7	7	37	24	190	186	175	149	576	320	431
Norway	-	-	-	-	7 404	23 173	6 381	20 760	21 393	3 194	4 976
Poland	164	73	2 330	420	1 192	627	2 081	3 921	5 772	2 348	3 026
Portugal	53 453	62 998	74 894	48 677	62 767	57 414	63 054	45 192	50 634	45 972	50 624
Spain	47 000	53 352	62 326	85 781	98 418	26 167	82 247	113 361	70 733	83 849	111 900
Sweden	-	-	-	-	-	-	-	2	2	1	-
U.K.	214	107	104	111	121	146	221	265	1 957	636	2 147
U.S.S.R.	279	-	-	13 320	74 952	57 049	107 753	154 254	120 264	122 014	188 803
	102 653	116 643	142 799	151 945	248 811	168 237	265 765	353 165	279 979	265 075	370 047

Annex table 2. Landings (tons) of horse mackerel by Sub-areas and Divisions 1976.
Data as officially reported to ICES.

Country	IIIa	IV	VI	VII	VIII	IX	X	Total
Belgium	-	15	+	2	-	-	-	17
Faroe Islands		116	2					118
France	-	147	293	3 800	3 380	-	-	7 620
German.Dem.Rep.	-	4	105	92	14	-	-	215
Germany Fed.Rep.	-	162	5	3	-	-	-	170
Netherlands		82	69	280	-	-	-	431
Norway	44	4 842	90	-	-	-	-	4 976
Poland		11	48	2 967	-	-	-	3 026
Portugal						48 505	2 119	50 624
Spain			175	16 512	91 993	3 220	-	111 900
U.K.		11	122	2 014	-	-	-	2 147
USSR	-	3 278	3 390	150 728	30 763	644	-	188 803
Total	44	8 668	4 299	176 398	126 150	52 369	2 119	370 047