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REPORT OF THE MACKEREL WORKING GROUP

Copenhagen, 6-13 September 1983

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REPORT OF THE MACKEREL WORKING GROUP

1. INTRODUCTION

1.1 Terms of Reference

At the 70th Statutory Meeting in Copenhagen, it was decided (C.Res.1982/2:5:12) that the Mackerel Working Group (Chairman: Dr J Guéguen) should meet at ICES headquarters from 6 to 13 September 1983 to:

- " (i) assess catch options for the mackerel stocks in Sub-areas II, III, IV, VI, VII, VIII and IX inside safe biological limits,
- (ii) continue the examination of the relationship between Sub-area IX mackerel and the Western area stock (Sub-areas VI-VIII),
- (iii) assess the state of the horse mackerel in Sub-areas VII, VIII and IX,
- (iv) review which data are available in the Working Group files for evaluating density dependence in the parameters of the models used in fish stock assessment,
- (v) specify deficiencies in data required for assessments."

In addition, the Group was asked by ACFM to give further information on the frequency of juvenile mackerel in commercial fisheries in the Celtic Sea broken down by statistical rectangles and month in order to advise on the delineation of the closed area in that zone.

Following a comment by ACFM, the Working Group decided to modify the presentation of its report and to present the results for each stock separately.

1.2 Participation

The Group met in Copenhagen with the following participants:

E Bakken	Norway
A Eltink	Netherlands
A Farina	Spain
J C Guéguen (Chairman)	France
S A Iversen	Norway
S J Lockwood	United Kingdom (England/Wales)
J Molloy	Ireland
A Saville	United Kingdom (Scotland)
P Sparre	Denmark
T Westgård	Norway

Mr K Hoydal, ICES Statistician, also attended the meeting.

2. ALLOCATION OF MACKEREL CATCHES TO STOCKS

2.1 Allocation of Catches in Divisions IIa, IVa and VIa to Stocks

The allocation of fish caught in Divisions IIa, IVa and VIa was made by the following percentages:

		<u>Divisions</u>		
		<u>IIa</u>	<u>IVa</u>	<u>Vla</u>
1981:	North Sea stock	52	100	75
	Western stock	48	0	25
1982:	North Sea stock	35	100	25
	Western stock	65	0	75

The reasoning behind these percentages is given below.

#### Division IIa

The percentages are derived from age composition data, and are calculated by the method described in Appendix A. The percentages, by age groups, are given in Table 2.1. It should be noted that most of the estimated mixing factors "x" (the fraction of North Sea stock in the catch) fall within the expected range,  $0 \leq x \leq 1$ .

These results are not supported by Norwegian tagging experiments, the results of which are given in Table 2.2 for 1981-83, but the 1982 returns can be summarized as follows:

	Number of releases 1970-81	Number of recaptures in Div.IIa during 1982 (but not including any released in 1982)	Spawning stock in 1982
North Sea area	89 336	6	$352 \times 10^6$
Celtic Sea area	124 674	39	$7\ 786 \times 10^6$

The estimate of the proportion of North Sea stock ( $P_{NS}$ ) in the catches follows the method described earlier (Anon., 1981):

$$P_{NS} = \frac{\frac{6 \times 352}{89336} + \frac{39 \times 7786 \times y}{124674}}{\frac{6 \times 352}{89336} + \frac{39 \times 7786 \times y}{124674}}$$

where y is the fraction of the Western stock with which the fish tagged off Ireland mix. The value calculated for  $P_{NS}$  varies with the value assumed for y:

y	1	$\frac{1}{2}$	$\frac{1}{4}$	1/8	1/16
$P_{NS}$	0.01	0.02	0.04	0.08	0.15

These results are based on very few recaptures and should, therefore, be treated with reservation. As fish tagged in the North Sea may include Western stock fish, these values of  $P_{NS}$  may be overestimates.

#### Division VIa

It is assumed that all fish taken in the Minches, west of Scotland, and off northwest Ireland are of the Western stock. Fish taken in the winter (Rona) fishery north of 58°30'N (Butt of Lewis) may be of either stock.

Applying the method described in Appendix A to the age composition data from the Rona fishery, it was calculated that in 1981 100% of the catch were of the North Sea stock, whereas in 1982 100% were from the Western stock (Table 2.1). As Norwegian tag returns show that some fish from the Western stock remained in the Rona area in 1981, and some fish of the North Sea stock remained there in 1982, the Working Group could not accept these results. Following careful consideration of the problem it was decided to allocate 25% to the Western stock in 1981, and 25% to the North Sea stock in 1982. These figures should, however, be treated with reservation as they are not based on calculations.

The value of 25% chosen as the percentage North Sea stock in the 1982 catches is within the range of possible values calculated from the limited number of Norwegian tag returns (Table 2.2). Using this method of analysis (as applied to catches in Division IIA, above) the chosen value of 75% North Sea stock in the 1981 catch appears to be an over-estimate.

y	1	$\frac{1}{2}$	$\frac{1}{4}$	1/8	1/16
1981	0.12	0.21	0.35	0.52	0.68
1982	0.11	0.20	0.34	0.50	0.67

These results are based on very few tag returns.

## 2.2 Division IXa

Although previous Working Groups (Anon., 1981, 1982) have considered the stock composition of mackerel from Division IXa, it has not been possible, because of lack of adequate data, to decide whether catches from this area should be included in the assessment of the Western stock. No additional data were presented to this meeting which would clarify the situation. Consequently, the Working Group, as in previous assessments, has not included catches from Division IXa with those which have been taken from what is considered as the Western stock.

## 3. MACKEREL - NORTH SEA AREA

### 3.1 North Sea Area (Sub-area IV, Divisions IIA and IIIa) Fisheries in 1982

Total landings for the years 1973-82 by country are shown in Table 3.1.A (North Sea, Skagerrak and Kattegat) and in Table 3.1.B (Norwegian Sea). ACFM recommended no TAC in 1982, but a TAC was agreed between EEC and Norway for the North Sea, Skagerrak and Kattegat and set at 25 000 tonnes. Total landings from the North Sea, Skagerrak and Kattegat amounted to 33 800 tonnes, of which 81% were taken by Norway. In Division IIIa 4 500 tonnes were taken, and in the North Sea 28 200 tonnes. Landings from Division IIA amounted to 37 420 tonnes, the highest landings on record, 92% of which were taken by Norway. The landings in 1982 from Division IIA represent a 50% increase compared to 1981, which may be explained by a reduction in the limits on industrial fishing by Norwegian vessels in 1982.

The total catch of the North Sea stock in 1982 was estimated at 56 000 tonnes. The landings by quarters are summarized in Table 3.1.C. As in previous years, the bulk of the catch was taken in the third quarter of the year.

### 3.2 Catch in Numbers and Weight at Age

#### 3.2.1 Catch in numbers

In the Norwegian Sea (Division IIA) Norway caught 92% of the total 1982 catch of 37 000 tonnes.

Catches taken by Poland and Denmark were allocated to numbers at age according to Norwegian data. The catches of USSR, all taken in the third quarter, were allocated to numbers at age according to data in a paper prepared for the ICES Statutory Meeting in 1983 by Seliverstova (C.M.1983/H:25). Norway took 70% of the 1982 catches in Division IIIa. The Norwegian catches were taken in the Skagerrak, and age compositions in these catches were applied to the Danish and Swedish catches.

In the northern North Sea (Division IVa) 90% of the 1982 catches were taken by the Norwegian drifters and purse seiners (Figure 3.1). Norwegian and Scottish age composition data were applied for allocating catches taken by Denmark, France, England and Sweden into numbers at age.

In the central North Sea (Division IVb) 90% of the 1982 catches were taken by Norway and the Netherlands. Age compositions from these catches were applied when allocating the catches from France, Federal Republic of Germany, England and Belgium to numbers at age.

The Dutch vessels caught about 25% of the total 1982 catch in the southern part of the North Sea (Division IVc). Catches taken by France, England and Belgium were allocated to numbers at age according to Dutch age composition data.

Table 3.2.B shows the catch in numbers in the Norwegian Sea, Skagerrak and Kattegat, and the North Sea. The 11+ group was split in accordance with Norwegian age compositions for all the areas. In Division IVc no data were available for splitting the 11+ group. This was split in accordance with Norwegian data for Division IVb.

No 0-group mackerel were caught in 1982.

#### Revision of 1981 data

The landings of mackerel in 1981 are given in Table 3.1.A. Revisions were made in the preliminary 1981 data given in the previous Working Group report (Anon., 1982) for some countries. Most revisions were small, but new information revealed that the landings by the United Kingdom (Scotland) were about 7 000 tonnes higher than the previously reported catch.

In the previous assessment when calculating catch in number, the Scottish landings were allocated as 2 686 tonnes in Division IVc and 2 993 tonnes in Division IVb. According to the new information, the total Scottish catch of 10 575 tonnes were taken in Division IVb. Consequently, a revision was made in the catch in numbers at age for 1981 according to age compositions of Scottish catches from Division IVb.

Faroese catches in Division VIa in 1981 were also revised from about 19 000 tonnes previously reported to about 9 000 tonnes. Calculated catch in numbers by age was adjusted accordingly, and part of the catch allocated to the North Sea stock (Section 2.1).

The revisions outlined above were incorporated in Tables 3.2.A and 3.2.C.

### 3.2.2 Weight at age

Mean weight at age data applied were the same as last year's. They are given in Table 3.4.A.

### 3.3 Stock Assessment

#### 3.3.1 Egg surveys in the North Sea

During the period 24 May - 31 July 1982 one Dutch and four Norwegian surveys were carried out to estimate the mackerel egg production. Two



limited surveys were carried out by a Scottish vessel in the central part of the spawning area: 9-24 June and 26-27 June. In addition to egg sampling they carried out acoustic investigations on the spawning stock.

An estimate of the total egg production in the North Sea was based on the Dutch and Norwegian surveys. These data were supplemented by daily plankton samples of two Norwegian oil installations, "Ekofisk" (56°34'N, 03°08'E) and "Cod" (57°04'N, 02°26'E), to establish the spawning intensity at these two locations. The methods for sampling and estimating total egg production were the same as those applied earlier (Iversen, 1981), except that the Dutch used a Gulf III sampler. The total egg production was estimated at  $110 \times 10^{12}$  eggs, which is 10% higher than that given by Iversen and Eltink (1983, in press). The explanation for this is given in Appendix B. This is more than twice that estimated for 1981 (Iversen, 1982). The large difference in estimated egg production between 1981 and 1982 might, to some extent, be explained by the lack of data prior to 10 June 1981. Although little is known about confidence limits of such egg production estimates, the fecundity/weight relationship  $F = 560 \times W^{1.14}$  is close to linear (W in g) (Iversen and Adoff, 1983, in press) in the range of fish weights investigated. This relationship gives a spawning stock of 165 000 tonnes. The sex ratio applied is 1:1 (Iversen, 1981).

### 3.3.2 Assessment of the North Sea stock

In 1981, the catches taken in Division VIa during the 1980 winter (Rona) fishery north of 58°30'N (Butt of Lewis) were apportioned to stocks according to the proportions calculated from Norwegian tagging data (Anon., 1981). In 1982, these catches were re-allocated entirely to the North Sea stock on the basis of age composition and analyses of parasite infestation rates. Norwegian tagging data were not used (Anon., 1982). During the past year it has become clear that the allocation between stocks, using parasite infestation rates, is subject to a large sampling variance. It was, therefore, decided to re-adopt the stock allocation of the 1980 catches, which was calculated in 1981.

Recent analysis of Norwegian biological samples from June-August 1960-81 revealed that 74% of the 2 year old mackerel, which appeared in the catches, were sexually mature. By comparing fishing mortalities for II-group mackerel with the fishing mortalities for the III-group the year after, when they are fully recruited to the spawning stock, it seems that about 50% of the II-group mackerel are available to the fishery. Assuming that only the spawning component of the stock is available in the fishery, maturity ogive for the North Sea stock was estimated:

Age:	1	2	3+
Proportion of maturity:	0	0.37	1.0

This new maturity ogive was incorporated in the cohort analysis and in the stock prognosis.

The North Sea mackerel egg survey in 1982 estimated a spawning stock biomass of about 165 000 tonnes (Appendix B). The terminal fishing mortality rates for 1982 were adjusted until the VPA calculated approximately the same biomass. The results of the VPA for the period 1975-82 are shown in Table 3.3.A-C. Results from earlier years are given in Anon. (1982) and in Figure 3.2.A.

### 3.3.3 Analysis of recruitment (1969-82) in the North Sea stock

The number of 1 year old recruits as estimated by VPA (Table 3.3.C.) are shown, with the spawning stock biomass which produced them, in Figure 3.3.C. As pointed out in earlier reports (Anon., 1981, 1982), the last strong year class was that spawned in 1969. During the early 1970s there was a period of relatively stable, but low, recruitment, followed by a clear trend of declining recruitment to the end of the decade. Provisional VPA estimates for 1980 and 1981 year classes show a slight improvement over year classes in the late 1970s, but they are still insufficient to support a fishery, or even to create any significant growth in stock.

Some relationships between North Sea mackerel production and recent 1 year old recruitment estimates have been examined by Lockwood (1983). Part of his analysis is reproduced here. From the stock in number estimated by VPA (Table 3.3.C) it is possible to calculate the number of 1 year old recruits ( $R_m$ ), which must join the stock each year to equal the losses due to natural mortality in the previous year:

$$R_m = N(1 - e^{-M}).$$

When the VPA estimate of 1 year old recruits ( $R_1$ ) is greater than  $R_m$ , the stock in number increases and vice versa. An index of the estimated recruitment ( $R_1$ ) relative to  $R_m$  was calculated by:

$$I = \frac{R_1 - R_m}{R_m}$$

The annual indices for the period 1969-81 are shown in Figure 3.3.B. The negative values, which predominated throughout the 1970s, show that there was insufficient production to maintain a stable stock. Even if there had been no fishery, the stock in number would have declined by more than 35% over the period 1971-80. While the 1980 and 1981 year classes appear strong in relative terms and show that the stock still has some capacity for growth, it cannot be ignored that absolute recruitment is still very low.

### 3.4 Forecasts for the North Sea Stock

#### 3.4.1 Recruitment

In the previous report of the Working Group (Anon., 1982), an analysis of annual landings of young mackerel from coastal areas off southern Norway was presented. This indicated that the number of recruits from the 1980 year class as 1 year olds was somewhat higher than the recruitment of the immediately preceding year classes.

This has been confirmed by sampling of catches from the North Sea in 1982. In the cohort analysis (Section 3.3.2.), the F on 2 year olds in 1982 was set at 0.10 resulting in an estimate of the 1980 year class in 1981 of  $229 \times 10^6$  fish. This is about half the number of the 1974 year class as 1 year olds ( $543 \times 10^6$  fish). However, the analysis of the landings of young mackerel indicated that the 1974 and the 1980 year classes appear to be of equal strength (Anon., 1982).

At present very little information is available on the 1981 year class. This year class was not present in landings of young mackerel on the Norwegian coast, although some research vessel catches from Division IVa in June contained mackerel of the 1981 year class.

Preliminary results of the International Young Fish Survey in February 1983 showed that young mackerel were present in the western part of Division IVa. The number per haul was higher than in 1982.

Although these observations could indicate that the 1981 year class might provide some recruitment, Walsh (1977) found only a weak correlation between these survey catch rates and VPA recruitment estimates. Therefore, it was decided to carry out the prognosis by applying a year class strength of  $20 \times 10^6$  fish as 1 year olds for the 1981 year class. This recruitment corresponds to the lowest level previously estimated by VPA.

The same low recruitment was assumed for the 1982 year class for which there is no information.

### 3.4.2 Recruitment

The input parameters for the catch forecasts of the North Sea mackerel stock are given in Table 3.4.A. Stock numbers by age on 1 January 1983 were obtained from the cohort analysis (Table 3.3.C). The reference exploitation pattern was that of 1982.

The weights at age in catch and stock are retained from previous years. As outlined in Section 3.3.2 the proportion of mature fish at age 2 was changed from 0 to 0.37.

Table 3.4.B shows a series of stock and catch predictions for 1984-85. All predictions were made on the assumption that the catch of mackerel from the North Sea stock in 1983 will amount to 65 000 tonnes. This was estimated by the Working Group on the basis of national catches in 1982, information for 1983 at the time of the meeting, and information on fisheries management for 1983.

On this basis the spawning stock size at the time of spawning in 1983 is about 150 000 tonnes. This is about 10% less than estimated from the egg surveys for 1982. Preliminary results of Norwegian egg surveys in 1983 indicate an egg production similar to that of 1982.

Recruitment as 1 year old in 1983 and 1984 was set at the low level of  $20 \times 10^6$  fish.

As seen from Table 3.4.B four forecasts are given under different management options for 1984.

A continued fishery in 1984, giving catches of 65 000 tonnes as estimated for 1983, would result in a stock biomass of about 60 000 tonnes at 1 January 1985. This stock would be too low to sustain a continued fishery unless recruitment is much higher than assumed in these calculations.

The winter fishery of North Sea mackerel north of  $58^{\circ}30'N$  in Division VIa is discussed in Section 2.1 and in the previous report of the Working Group (Anon., 1982, Section 6.2.2). A closure of the mackerel fishery in this area during winter (1 November - 1 April) would reduce the  $F$  on the North Sea stock. The effect of such a closure in 1984 was assessed by estimating a reduction in  $F$  which would have taken place if this fishery had been closed in 1982 and applying a proportional reduction to the  $F_{(3-13)}$  for 1984 given in the first option. This  $F$  for 1984 is then 0.57. On the assumption that the rate of stock mixing in 1984 is the same as in 1982, fishing closure would result in a stock biomass of 68 000 tonnes at the beginning of 1985, i.e., about 17% higher than maintaining the status quo.

A fishery at an  $F$  of 0.15 would result in a stock biomass of 98 000 tonnes at 1 January 1985. No fishery of North Sea mackerel in 1984 would result in a biomass of 112 000 tonnes at 1 January 1985.

Figure 3.3 shows predicted catch on spawning stock size at various levels of  $F$  in 1984.

The continuing low level of stock and recruitment still support the Working Group's earlier view that "the fishery on the North Sea stock must be closed at the earliest opportunity" (Anon., 1982).

#### 4. MACKEREL - WESTERN AREA

##### 4.1 The Fishery in 1982 (Sub-areas VI, VII and VIII)

The landings by each country for the 10-year period 1973-82 are shown in Table 4.1.A. The 1981 figures have been revised and decreased by about 6 500 tonnes. The total estimated landings for 1982 is 596 000 tonnes, which is slightly lower than the 1981 catch of 610 000 tonnes.

The 1982 Western stock TAC recommended by ICES was 270 000 tonnes. The catch from this stock was estimated to be 609 000 tonnes.

As in 1981, considerable landings (19% of the total) could not be allocated to any particular country, and this figure is given in Table 4.1.A as 'unallocated'. The major catches were recorded by the United Kingdom, Netherlands and Ireland, who together took over 80% of the allocated landings. Considerable decreases were recorded in the landings recorded by Faroes, France, and the Federal Republic of Germany. However, as stated in the 1982 report of the Working Group, the catch table should not be taken as a true record of the total catch taken by some countries, because of the problem of mis-reporting of catches.

The distribution of the catches by Sub-area and by quarter are shown in Tables 4.1.B and 3.1.C. The percentage of the total catch taken in Division VIa was 57% and was approximately the same as that in 1981. This catch was taken mainly in the fourth quarter. About 40% of the total catch was taken in Division VII, and this was mainly taken in the first quarter. Although the catches from Division VII were mainly from the winter fishery off Cornwall, increased catches were recorded from Division VIIj (southwest of Ireland) by Dutch and Irish fleets.

#### 4.2 Catch in Numbers and Weight at Age in the Western Area

##### 4.2.1 Catch in numbers

###### Division VIa

The catches taken in this Division in 1982 by Ireland, Netherlands, Norway and Scotland were sampled for age. The catches by these countries amounted to about 85% of the total international catch. To estimate the total catch in numbers the catches by Denmark and Faroes were raised using Norwegian data, English catches using Scottish data, Northern Irish catches using Irish data and Federal Republic of Germany catches using Dutch data.

A revision had to be made to the catch in numbers at age taken in this Division in 1981, because of a catch of 4 153 tonnes taken by Northern Ireland, which was not included in the 1982 report. This was converted to numbers at age using Irish sampling data. A further revision was made because of the overestimation of the Faroese catch in the previous report (see Section 3.2.1 above).

A notable feature of the Division VIa catches in 1982 was the much higher representation of younger fish than in previous years. As can be seen in Tables 4.2.A and 4.2.B catches of 1 year olds were about 10 times higher, and those of 2 year olds about 4 times higher than in 1981. The catches in weight were very similar in these years. The VPA would not suggest that the year classes concerned

are strong (Table 4.3.C). Although this high representation of younger fish was apparent in all fisheries in Division VIa, it was particularly marked in the North Rona fishery in the first and last quarters of the year.

#### Sub-areas VII and VIII

Numbers at age data for Divisions VIIa,b and c were provided by Ireland and the Netherlands. French catches were raised to numbers at age by the Dutch age distributions and German catches of the fourth quarter were raised by Dutch data of the fourth quarter.

In Divisions VIId-k all fishing nations provided sampling data except Denmark, whose catches were raised by English data, and the Federal Republic of Germany, whose catches were raised to numbers at age by Dutch sampling data.

Numbers at age data for Divisions VIIla and b were provided by France, and for Division VIIlc by Spain.

Sampling data were supplied by countries which accounted for more than 95% of the catch in these Sub-areas.

#### Catch in numbers in 1983

To use the spawning stock estimate from the 1983 egg surveys in the VPA (see Section 4.3.1), it was necessary to estimate the catch in numbers per age group caught in the Western areas in the first half of 1983. Preliminary estimates of national catches during this period were provided for all countries with appreciable mackerel fisheries in the area amounting to about 194 000 tonnes. Age data were available from Irish sampling in Division VIa and Divisions VIIb,j, and from English sampling in Division VIIe. Catches by all countries fishing in these Divisions were raised to these data. No age sampling data were available for catches taken in Sub-area VIII, but these amounted to only 7% of the total. These catches were raised to the combined total of the Divisions, in which sampling data were available. The resulting estimates of catch in numbers at age, given in Table 4.2.C, must be considered as preliminary.

#### 4.2.2 Weight at age (Table 4.4.A)

The mean weights at age in the stock previously used were compared with Dutch mean weights at age in the catches in the second quarter on the spawning grounds in Division VIIj. They were in good agreement, therefore no change was made. No change was needed in the mean weights at age in the catch given in last year's report (Anon., 1982).

#### 4.3 Stock Assessment

##### 4.3.1 Egg surveys

A preliminary report of the 1983 egg survey of the Western mackerel stock (Appendix C) was presented to the Working Group. The main results from this survey were that the total daily egg production was  $1.44 \times 10^{15}$  eggs, and the spawning population was  $7\ 200 \times 10^6$  mature fish. This estimate of egg production is about the same as that which was estimated in 1980 ( $1.46 \times 10^{15}$  eggs), but presumably due to changes in the stock structure they were produced by more fish ( $6\ 200 \times 10^6$  mature fish, in 1980). On the basis of earlier prognoses of stock biomass for 1983 (Anon., 1982), the Working Group anticipated a fall in stock size and concomitant fall in the egg production. However, they noted the report's comments (Appendix C) on increased

sampling effort and spawning ground coverage in 1983, compared with 1980 and 1977, and accepted the main findings from the 1983 plankton survey as being the best estimate of the Western mackerel spawning stock size.

#### 4.3.2 Virtual Population Analysis of the Western Stock

In running the VPA, the Working Group had a choice of two options which they could follow. The first of these was not to incorporate any 1983 data, on the grounds that the plankton survey stock size estimate and catch data were provisional. The second option was to incorporate the 1983 data and thereby present the most up-to-date assessment possible. As a first step both procedures were followed.

Using data no more recent than December 1982, a VPA was run along the same lines as has been adopted in recent years (Anon., 1981, 1982), i.e., the terminal values of fishing mortality rate for 1982 were varied until the VPA estimated a spawning stock in 1980 approximately the same as that estimated by the plankton survey in 1980 ( $6\ 200 \times 10^6$ ). This procedure estimated a fishing mortality rate for 1982 of  $F = 0.26$  on fully recruited age groups. This was approximately the same as the value forecast ( $F = 0.24$ ) in 1982, assuming the catch in 1982 was about 600 000 tonnes (Anon., 1982). The pattern of fishing mortalities by age groups for years preceding 1982 was broadly the same as that found in earlier VPAs (Anon., 1981, 1982).

For the second VPA run, incorporating provisional 1983 data, it was necessary to estimate the number of mature fish at 1 January 1983 from the spawning stock estimate. This was done by raising the spawning stock in number ( $7\ 200 \times 10^6$  fish at spawning time) by that part of natural mortality which occurs before the peak of spawning ( $(M = 0.15) \times 0.4$ ) and adding the estimated number of mature fish caught during the first half of 1983 ( $615 \times 10^6$ ) (See Section 4.2). Thus, the mature population on 1 January 1983 was estimated to be  $8\ 250 \times 10^6$  fish. This population was estimated by VPA when a fishing mortality value for 1982 of  $F = 0.18$  was used, but this estimated a spawning stock in 1980, which was 30% higher than previously used as the reference point. By increasing the fishing mortality rate for 1982 to  $F = 0.19$ , the estimated mature stock at 1 January 1983 was reduced to  $7\ 859 \times 10^6$ , and the estimated spawning stock for 1980 was reduced to within about 25% of the previous reference value.

After considering the three VPA print-outs it was agreed that, although the 1983 data were provisional, no significant revisions could be foreseen, and, therefore, the most up-to-date assessment should be adopted. However, ever mindful of the need for caution when making significant revisions to assessments, it was decided to adopt the more conservative of the two VPAs using the 1983 data, i.e., that which underestimated the stock in 1983 but was within 25% of the 1980 stock estimate. This VPA is reproduced for the years 1976-82 in Tables 4.3 A - C. The limited amount of information for the period 1972-75 can be found in earlier reports (Anon., 1981).

As might be expected, a change in the assessment, which results in an increase in stock size in recent years, will also result in a decrease in estimated fishing mortality rate. However, while this assessment, presented in Tables 4.3 A-C, estimates a spawning stock in 1980 about 25% greater than previously estimated, there is less than 5% change in the fishing mortality. In years earlier than 1978 there are effectively no changes in estimates of either fishing mortality or stock.

As with the VPA assessment made in 1982, the highest mean fishing mortality rates were estimated for 1979 and 1980. In earlier years it has been difficult to relate values of  $F$  with catch in weight as

catch weight were only presented by area. In Table 4.3.A the SOP catches are given. These catches include the estimated discards, previously only recorded in the catch in number tables. It can now be seen that the high estimates of F were made in those years when the total catches were high.

#### 4.4 Forecasts for the Western Stock

##### 4.4.1 Recruitment

No quantitative estimate of the recruitment of the 1982 year class as 1 year olds in 1983 was available. Nevertheless, some indications from the commercial fisheries suggest that this year class is likely to be a poor one. For that reason, and to be on the cautious side, the Working Group decided to set the 1982 year class strength at  $1\ 000 \times 10^6$  fish, which is among the lowest on record.

##### 4.4.2 Prognoses

At the time the Working Group met, some unofficial information was available about the catches of Western mackerel in the first 6 months of 1983. On the basis of these catches, and in the absence of any agreed TAC, the Working Group assumed that a largely unregulated fishery would continue throughout 1983, and that the total annual catches would reach 650 000 tonnes. Stock forecasts were run on this assumption. All parameters used in making the forecasts are summarized in Table 4.4.A, and the results are presented in Table 4.4.B and in Figure 4.1.

The continued absence of effective international management measures through to 1985 might result in a continued catch of  $650 \times 10^3$  tonnes in 1984, which would reduce the 1985 spawning stock biomass to about  $1\ 460 \times 10^3$  tonnes, which would be the lowest level on record. If the fishing mortality in 1984 was reduced to the level corresponding to F<sub>0.1</sub> (i.e., a reduction of 13% over the present level of F), a catch of  $463 \times 10^3$  tonnes would be taken, resulting in a spawning stock biomass of  $1\ 676 \times 10^3$  t. This would also be the lowest on record and represents about 45% of the level in the early 1970s.

The concern expressed by this Working Group on previous occasions (Anon., 1982) is as strong now as it was then, and the urgency for effective conservation measures should not be underestimated.

#### 4.5 Closed Area in the Celtic Sea

Further information on the distribution of juvenile mackerel in the Celtic Sea was obtained by sampling landings made in England, Ireland and the Netherlands. The number of fish per sample, which were less than 30 cm total length, were calculated as a percentage of the total number of fish in the sample. These data were combined and are shown by ICES statistical rectangles by months, January 1982 to April 1983, in Figure 4.2. The Working Group estimated that total catch taken from this area was 60 000 tonnes in 1982 and 85 000 tonnes in the first half of 1983.

As shown in earlier reports (Anon., 1981, 1982) the catches made around Cornwall were predominantly of juvenile fish. Only during the early winter, 1982-83, did juvenile fish contribute less than 50% of the catch in number from any individual rectangle, but even in this period the majority of fish caught in the area was less than 30 cm.

During the winter 1981-82 there was an appreciable amount of fishing activity west of 5°W, but during the winter of 1982-83 virtually all mackerel fishing effort was concentrated in the western English Channel, east of 5°W. Some fishing occurred south of 49°30'N, but as in previous years most of it was north of this latitude. Samples taken during the

period September 1982 to April 1983 show quite clearly that juvenile mackerel form a major part of catches taken throughout the northern half of ICES Division VIIe. For these reasons, efforts to introduce measures to minimise catches of juvenile fish in the area must continue. Any suggestions that the eastern boundary of the closed area, or "Mackerel box", should be further west than 2°West should be looked at very critically. The Working Group recommends that, on mackerel criteria alone the eastern boundary should be fixed at 2°W.

During 1982 and early 1983 mackerel fishing west of 7°W was concentrated on the main spawning grounds between the Great Sole Bank and southwest of Ireland, Division VIIj. Dutch samples taken from this area during the spawning season contained considerably less than 50% juvenile fish. Only during the summer months, when the total quantities being caught in the area are small, do the numbers of juvenile fish exceed 50% of the total Irish samples.

No further information was available by statistical rectangle for the area W of 7°W than was given in last year's report (Anon., 1982).

5. MACKEREL IN SUB-AREA IX

5.1 The Fishery in 1982

The total catches of mackerel taken from Sub-area IX are shown in Table 5.1.1. The 1982 figure is provisional, but the catch taken by Spain appears to have declined considerably.

5.2 Biological Information

The only data presented to the Working Group were a length frequency distribution of Portuguese catches in 1982. This shows that the catches were composed of 68% immature fish (Jorge and Gordo, 1982).

6. HORSE MACKEREL

6.1 Landings of Horse Mackerel - Sub-areas IV and VI, VII, VIII and IX

Sub-areas IV and VI

The total landings in Sub-area IV, given in Table 6.1.A for the period 1974-82, have not risen above 10 000 tonnes since 1974, and the 1982 landings are at about the same level as in 1981. There is no directed fishery in this area.

The catches in Sub-area VI for the period 1974-82 are given in Table 6.1.B. There is no directed fishery in this area. Some revisions have been made to the table with a lower catch in 1981.

Sub-area VII

Total landings in Sub-area VII are given in Table 6.1.C for the period 1974-82. Some revisions have been made, which have resulted in a decrease for 1981. The preliminary estimate of the catches in 1982 indicate that they are about the same level as in 1981. About 15 000 tonnes were caught as mature fish in Division VIIj.

Sub-area VIII

Total landings in Sub-area VIII are given in Table 6.1.D for the period 1974-82. There has been a continuous decrease since 1977 from 125 000 tonnes to about 23 000 tonnes in 1982.



#### Sub-area IX

Total landings are given in Table 6.1.D for 1974-82. Total landings in 1982 remained the same as in 1981.

### 6.2

#### Biological Data

Very few biological data were available to the Working Group. Very limited catch in number at age data were presented by England and the Netherlands for Sub-areas IV, VII and VIII. More data were supplied by Portugal and Spain for Division VIIIc and Sub-area IX. These data did not add significantly to those presented last year and, therefore, the Working Group could make no further advance with an assessment (see Section 7.2 of the 1982 Report).

The limited English and Dutch data available for fitting growth curves were compared with that described by Farina (in press) for Division VIIIc.

One explanation of difference in growth curves could be differences in ageing techniques. It was therefore agreed that before publishing comparative growth data, those involved should exchange otoliths and compare their ageing results.

No horse mackerel egg data from the 1983 mackerel plankton survey were available at this meeting, but it is hoped that they will be ready for the meeting to be held in Lowestoft in February 1984 (Appendix C).

### 7.

#### DENSITY DEPENDENCE AND DEFICIENCIES IN DATA

#### 7.1

##### Density Dependence

The Working Group was asked to review the existing data on parameters, which may be dependent on stock density. No data were presented during the meeting which would enable this to be done. Ideally, the data required would be a long series of stock size estimates, together with a similar series of data on e.g. mean lengths, weights, age at 1st maturity, etc. Although the required data were not available at the meeting and stock size estimates may not be available for a sufficient number of years, particularly for the Western stock, relevant data may exist at various national laboratories which would enable this subject to be examined more carefully.

It was therefore agreed that members of the Working Group would attempt to extract the relevant data from their data files at home and present them as working documents at the 1984 meeting of the Working Group.

#### 7.2

##### Deficiencies in Data

#### 7.2.1

##### Mackerel

The Working Group again considered the deficiencies in the data necessary to make accurate assessments. Considerable doubt still surrounds the official landing catch statistics provided by some countries - both in regard to species composition and quantity. These points, together with the large amounts of unallocated catches, have been commented upon in detail in Anon., 1982. The Working Group would again emphasize the absolute necessity of obtaining accurate information about quantity, composition and origin of catches - including discards.

There has been no improvement in the basic data required, as outlined in Anon., 1982. For both the North Sea and the Western stock assessments, information is particularly lacking about:

- 1) Stock separation in Divisions IIa, IVa and parts of VIa
- 2) Estimates of F in the most recent year
- 3) Recruitment indices.

Age distribution of the catches is also lacking for certain countries, e.g., the Federal Republic of Germany, the Faroes, and Denmark which take substantial quantities of the total landings.

#### 7.2.2 Horse mackerel

Due to the lack of biological information on spawning areas and spawning seasons as well as on fecundity it is not possible to determine the stock relationship between Sub-areas VI, VII, VIII and IX. There is also considerable difficulty in obtaining accurate age compositions both because of the lack of adequate samples and difficulties in interpreting otoliths.

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Table 2.1 Stock mixing factor (x) for catches in Divisions IIA and VIIa  
For explanation on the method see Appendix A.

AGE	$x = (r - \bar{r}) / (\bar{a} - \bar{r})$ $\bar{x}$ = weighted mean		$r$ = weighting factor			
	NORTH SEA <sup>a)</sup> SPAWNERS	WESTERN <sup>a)</sup> SPAWNERS	Catches, Division IIA <sup>b)</sup>		Catches Divs. VIIa, Rona <sup>c)</sup>	
	p %	q %	r %	x	r %	x
1981						
3	2	18	1.1	1.06	1.6	1.03
4	1	1	0.7	-	1.0	-
5	5	17	3.6	1.12	2.6	1.20
6	8	19	12.5	0.59	6.2	1.16
7	17	8	14.0	0.67	6.5	-0.17
8	6	12	16.8	-0.86	8.8	0.53
9	4	2	6.6	2.30	4.9	1.45
10	57	25	44.7	0.62	68.6	1.36
			$\bar{x} = 0.52$		$\bar{x} = 1.00^h)$ (1.22) <sup>h)</sup>	
1982	d)	e)	f)		g)	
3	3.0	22.2	13.7	0.44	24.3	-0.005
4	6.5	12.8	13.6	-0.22	18.8	-1.12
5	1.5	0.6	3.0	2.67	2.2	1.78
6	7.5	11.3	9.0	0.61	13.9	-0.56
7	7.0	13.6	9.1	0.68	12.8	0.12
8	13.5	6.6	10.5	0.57	8.3	0.25
9	2.5	8.2	9.2	-0.18	6.2	0.36
10	58.5	23.2	31.8	0.24	13.5	-0.27
			$\bar{x} = 0.35$		$\bar{x} = 0.00^h)$ (-0.22) <sup>h)</sup>	

a) Anon.(1982), Table 4.2

b) Derived from Norwegian samples, July-Sept.1981

c) " " " " 1st and 4th quarter 1981

d) " " " " Division IVb May 1982

e) " " Dutch samples Division VIIj April-June 1982

f) " " Norwegian and Soviet (Seliyerstova,1983) samples, July-August 1982

g) " " Norwegian samples, 1st and 4th quarter 1982

h) Rounded value, true mean in brackets

Table 2.2 Results of the Norwegian tagging experiments (Tag returns from Norwegian landings to selected factories 1981-83)

RELEASES			RECAPTURES							
			Norwegian Sea			North Sea	Via			
			1981	1982	1983	1982	1981	1982	Q4	1983
						Q1	Q1	Q4	Q1	
OFF SOUTHWEST IRELAND	Year	No								
	1970	4 540								
	71	5 000								
	72	5 086								
	73	8 205								
	74	10 028								
	75	10 003								
	76	9 474								
	77	14 032	2	4	1			1	1	
	78	18 169	3	5		1			1	
	79	20 173	3	7	1			3		1
	80	9 992	2	4				2	1	
	81	9 972		5	3				1	
	82	10 065		5	3	1				3
83	13 400			12						
Sum		148 139	10	39	20	2	11	3	0	4
IN THE NORTH SEA	1970	3 505								
	71	9 350								
	72	11 818								
	73	7 277								
	74	4 493								
	75	9 995								
	76	1 763								
	77	7 094								
	78	12 173								
	79	11 991	2	2	2	1	4	1	1	
	80	5 678		1	3	1	3	1		1
	81	4 199			1	1	2	3		
	82	13 164			5	2				11
	83	9 216								
Sum		111 716	2	6	10	6	20	6	1	13

Table 3.1.A Nominal catch (tonnes) of MACKEREL in the North Sea, Skagerrak and Kattegat (IV and IIIa) 1973-1982 (Data for 1973-1976 as officially reported to ICES. Data from 1977 onwards were submitted by Working Group members).

Country \ Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982*
Belgium	78	145	134	292	49	10	10	5	55	102
Denmark	7 459	3 890	9 836	27 988	21 833	18 068	19 171	13 234	9 982	2 027
Faroe Islands	11 202	18 625	23 424	63 476	42 836	33 911	28 118	14 770	-	-
France	636	2 254	2 749	2 607	2 529	3 452	3 620	2 238	3 755	2 420
Germany, Dem.Rep.	214	234	141	259	41	233	-	-	-	-
Germany, Fed.Rep.	563	270	276	284	-	284	211	56	59	73
Iceland	3 079	4 689	198	302	-	-	-	-	-	-
Ireland							-	738	733	-
Netherlands	2 339	3 259	2 390	2 163	2 673	1 065	1 009	853	1 706	390
Norway	277 304	248 314	206 871	197 351	180 800	82 959	90 720	44 781	28 341	27 612
Poland	561	4 520	2 313	2 020	298	-	-	-	-	-
Sweden	2 960	3 579	4 789	6 448	4 012	4 501	3 935	1 666	2 446	654
UK (England & Wales)	31	61	33	89	105	142	95	76	6 520	16
UK (Scotland)	2 943	390	578	1 199	1 590	3 704	5 272	9 514	10 575	44
USSR	17 150	8 161	9 330	1 231	2 765	488	162	-	-	-
Unallocated							500		3 216	450
Total	326 516	298 391	263 062	305 709	259 531	148 817	152 823	87 931	67 388	33 788

\*) Preliminary

Note: In contrast to the corresponding tables in Working Group reports for years prior to 1982, the catches do not include catches taken in Sub-area IIA.

Table 3.1.B. Nominal catches (tonnes) of MACKEREL in the Norwegian Sea  
(Division IIa), 1973-1982.

Country	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 <sup>3)</sup>
Denmark <sup>2)</sup>								-	801	1 008
Faroe Isl. <sup>1)</sup>	-	-	-	-	-	283	6	270	-	-
France <sup>2)</sup>	-	-	7	8	-	2	-	-	6	-
German, Dem. Rep. <sup>2)</sup>	-	11	-	-	-	-	-	-	51	-
Germany, F.R. <sup>2)</sup>	-	-	-	-	-	53	174	2	-	-
Netherlands <sup>2)</sup>	-	-	-	2	-	-	-	-	-	-
Norway <sup>1)</sup>	21 573	6 818	34 662	10 516	1 400	3 867	6 887	6 618	12 941	34 540
Poland	-	-	-	-	-	-	-	-	-	231
UK(Engl. & Wales) <sup>1)</sup>	-	+	+	+	+	1	-	-	255	-
UK(Scotland) <sup>2)</sup>	-	-	-	-	-	-	-	296	968	-
USSR <sup>3)</sup>	-	-	-	-	-	-	5	1 450	3 640	1 641
Total	21 573	6 829	34 669	10 526	1 400	4 206	7 072	8 340	18 662	37 420

1) Data provided by WG members.

2) Data reported to ICES.

3) Preliminary.

Table 3.1.C. Quarterly catches of mackerel in 1982

	I	II	III	IV	Not known	Total
IIa	-	100	37 300	+	-	37 400
IIIa	+	1 100	2 600	200	600	4 500
IVa	200	3 500	21 800	2 100	600	28 200
VI	35 900	7 100	53 500	244 400	-	340 900
VII	149 500	41 200	15 500	31 600	-	237 800
VIII	6 700	8 500	900	1 000	-	17 100
IX	-	-	-		4 400	4 400

Table 3.2.A. MACKEREL. 1981 catches in numbers ( $\times 10^{-6}$ ) by age group and by area (Norwegian Sea (Division IIa), North Sea (Divisions IVa,b,c) and Skagerrak and Kattegat (Division IIIa)). North Sea stock.

Year class	Age	Divisions			
		IIa <sup>1)</sup>	IVa <sup>2)</sup>	IVb,c <sup>3)</sup>	IIIa <sup>2)</sup>
1980	1	-	0.6	1.6	1.7
1979	2	-	0.8	4.8	0.4
1978	3	0.3	3.0	7.9	0.4
1977	4	0.2	0.3	0.7	0.2
1976	5	0.8	3.2	8.6	0.5
1975	6	2.9	4.3	11.3	0.8
1974	7	3.3	5.5	9.0	2.3
1973	8	3.9	2.9	5.9	0.6
1972	9	1.5	1.5	2.9	0.4
1971	10	2.7	2.3	3.9	0.4
1970	11	0.8	0.6	0.9	0.3
1969	12	4.4	5.7	9.7	2.6
1968	13	1.1	0.9	0.3	0.2
1967	14	1.0	1.3	0.5	0.2
≥1966	≥15	0.4	0.9	0.3	0.1
Total		23.2	33.8	68.3	11.1

1) From 1982 meeting work sheets.

2) From Table 4.1 and Table 4.3 of 1982 WG Report (IVa+IIIa - IIIa)

3) From Table 4.3 of 1982 WG Report.



Table 3.2.B MACKEREL. 1982 catch in numbers ( $\times 10^{-3}$ ) by age group and by area (Norwegian Sea (Division IIa), the North Sea (Divisions IVa,b,c) and Skagerrak and Kattegat (Division IIIa)). North Sea stock.

Year class	Age	Divisions				
		IIa	IVa	IVb	IVc	IIIa
1982	0	-	-	-	-	-
1981	1	-	400.0	2.2	432.8	2 068.4
1980	2	2 056.9	5 285.2	59.7	522.0	5 921.0
1979	3	7 667.1	5 444.0	431.0	565.0	856.0
1978	4	7 651.0	3 785.0	413.7	637.5	262.7
1977	5	1 693.7	1 023.0	196.8	137.0	48.9
1976	6	5 072.8	2 583.0	670.1	938.1	381.2
1975	7	5 128.6	3 231.0	885.9	456.3	441.7
1974	8	5 922.0	4 660.0	864.3	236.2	466.6
1973	9	5 142.9	2 153.0	853.9	324.7	189.7
1972	10	2 077.5	1 574.0	424.9	172.7	132.8
1971	11	4 696.2	1 625.0	427.5	173.8	161.2
1970	12	2 040.3	957.0	342.5	139.2	327.1
1969	13	5 824.3	4 933.0	864.0	351.2	536.3
1968	14	2 310.1	750.0	359.3	146.1	25.0
1967	15	549.0	519.0	148.1	60.2	10.0
1966	16	180.0	167.0	48.9	19.9	25.0
1965	17	34.5	21.0	16.7	6.8	0
≥1964	≥18	160.2	0	16.7	6.8	0
Σ		58 207.2	39 110.2	7 026.2	5 326.1	11 853.6

Table 3.2.C. Catch in numbers ( $\times 10^{-6}$ ) of the North Sea stock in 1981, by age group.

Year class	Age	D I V I S I O N S				Sum
		IIa	IIIa + IVa	IVb,c	VIa	
1980	1	-	2.3	1.6	+	3.9
1979	2	-	1.2	4.8	0.1	6.1
1978	3	0.2	3.4	7.9	0.5	12.0
1977	4	0.1	0.5	0.7	0.1	1.4
1976	5	0.6	3.7	8.6	0.6	13.5
1975	6	1.0	5.1	11.3	1.3	18.7
1974	7	2.	7.8	9.0	1.7	20.6
1973	8	0.7	3.5	5.9	1.9	12.0
1972	9	0.5	1.9	2.9	1.3	6.6
1971	10	0.7	2.7	3.9	1.4	8.7
1970	11	0.6	0.9	0.9	0.8	3.2
1969	12	4.4	8.3	9.7	4.8	27.2
1968	13	0.4	1.1	0.3	0.8	2.6
1967	14	0.5	1.5	0.5	0.7	3.2
≥ 1966	≥15	0.4	1.0	0.3	0.5	2.2
TOTAL		12.2	44.9	68.3	16.5	141.9

Table 3.2.D MACKEREL. Catch in numbers ( $\times 10^{-3}$ ) of the North Sea stock in 1982 by age groups.

Yea Class	Age Years	DIVISIONS						
		IVa	IIa	IVb	IVc	IIIa	VIa	TOTAL
1982	0	-		-	-	-	-	
1981	1	400.0		2.2	432.8	2 068.4	372	3 275.4
1980	2	5 285.2	2 056.9	59.7	522.0	5 921.0	3 263	17 107.8
1979	3	5 444.0	589.6	431.0	565.0	865.0	5 561	13 446.6
1978	4	3 785.0	1 277.4	413.7	637.5	262.5	4 295	10 671.3
1977	5	1 023.0	294.8	196.8	137.0	48.9	496	2 196.5
1976	6	2 583.0	1 473.9	670.1	938.1	381.2	3 169	9 215.3
1975	7	3 231.0	1 375.7	885.9	456.3	441.7	2 930	9 320.6
1974	8	4 660.0	2 653.1	864.3	236.2	466.6	1 907	10 787.2
1973	9	2 153.0	491.3	853.9	324.7	189.7	1 405	5 417.6
1972	10	1 574.0	589.6	424.9	172.7	132.8	509	3 403.0
1971	11	1 625.0	1 768.7	427.5	173.8	161.2	789	4 945.2
1970	12	957.0	1 277.4	342.5	139.2	327.1	187	3 230.2
1969	13	4 933.0	6 878.4	864.0	351.2	536.3	1 384	14 946.9
1968	14	750.0	393.1	359.3	146.1	25.0	109	1 782.5
1967	15	519.0		148.1	60.2	10.0		
1966	16	167.0	589.6	48.9	19.9	25.0		1 779.7
1965	17	21.0		16.7	6.8	0	124	
≥1964	≥18	0		16.7	6.8	0		
Σ		39 110.2	21 709.4	7 026.2	5 326.3	11 853.6	26 500	111 525.7

Table 3.3.A VIRTUAL POPULATION ANALYSIS

MACKEREL IN THE NORTH SEA (FISHING AREAS IV, VIA AND IIA)

CATCH IN NUMBERS

UNIT: MILLIONS

	1975	1976	1977	1978	1979	1980	1981	1982
1	11.9	2.7	1.1	0.0	2.3	2.7	3.9	3.3
2	10.1	73.6	19.3	8.2	0.5	5.6	6.1	17.1
3	16.2	69.7	58.9	54.7	11.3	2.4	12.0	13.4
4	42.4	13.9	54.3	40.8	21.2	14.3	1.4	10.7
5	27.8	33.8	9.8	27.9	35.3	23.5	13.5	2.2
6	193.2	19.5	26.6	6.0	14.3	25.9	18.7	9.2
7	25.6	118.6	31.6	14.2	4.2	15.3	20.6	9.3
8	20.4	31.3	125.9	16.1	9.2	12.3	12.0	10.8
9	15.8	8.0	31.2	45.7	2.0	14.0	6.6	5.4
10	5.0	9.0	8.3	14.6	27.0	3.5	8.7	3.4
11	0.5	4.0	8.8	5.5	5.2	19.3	3.2	4.9
12	0.2	0.5	4.5	5.5	2.0	3.8	27.2	3.2
13	22.2	0.1	0.8	2.9	2.0	1.3	2.6	14.9
14	0.0	3.4	0.1	0.6	1.2	1.6	3.2	1.8
15+	0.0	0.0	2.5	3.2	2.3	2.2	2.2	1.8
TOTAL	391.3	388.1	383.7	225.9	138.0	147.7	141.9	111.4

SUM OF PRODUCTS UNIT: THOUSAND TONNES

SOP	182	175	189	110	68	75	74	55
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Table 3.3.B VIRTUAL POPULATION ANALYSIS

MACKEREL IN THE NORTH SEA (FISHING AREAS IV, VIA AND IIA)

FISHING MORTALITY COEFFICIENT UNIT: Year<sup>-1</sup> NATURAL MORTALITY COEFFICIENT = 0.15

	1975	1976	1977	1978	1979	1980	1981	1982
1	0.02	0.01	0.01	0.00	0.03	0.04	0.02	0.02
2	0.03	0.19	0.09	0.07	0.03	0.09	0.11	0.10
3	0.13	0.28	0.22	0.22	0.13	0.19	0.26	0.37
4	0.18	0.14	0.34	0.22	0.19	0.23	0.16	0.37
5	0.18	0.21	0.14	0.28	0.26	0.32	0.33	0.37
6	0.25	0.18	0.24	0.11	0.21	0.31	0.43	0.37
7	0.17	0.23	0.46	0.18	0.10	0.34	0.41	0.37
8	0.29	0.30	0.38	0.42	0.16	0.44	0.46	0.37
9	0.28	0.16	0.51	0.22	0.08	0.37	0.42	0.37
10	0.16	0.24	0.24	0.45	0.18	0.18	0.39	0.37
11	0.08	0.18	0.37	0.24	0.27	0.18	0.24	0.37
12	0.28	0.10	0.30	0.40	0.12	0.30	0.40	0.37
13	0.76	0.21	0.22	0.31	0.23	0.10	0.33	0.37
14	0.00	0.23	0.32	0.24	0.19	0.28	0.36	0.37
15+	0.00	0.23	0.32	0.24	0.19	0.28	0.36	0.37
( 3-13)W	0.23	0.23	0.32	0.24	0.19	0.28	0.37	0.37

Table 3.3.C VIRTUAL POPULATION ANALYSIS

MACKEREL IN THE NORTH SEA (FISHING AREAS IV, VIA AND IIA)

STOCK SIZE IN NUMBERS UNIT: MILLIONS

BIOMASS TOTALS UNIT: THOUSAND TONNES

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: 0.100  
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.400

	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	544.0	280.7	145.8	20.4	85.0	73.2	228.7	179.4*****	
2	371.1	457.2	239.1	124.5	17.5	71.7	60.5	193.3	151.4
3	146.3	310.1	325.5	187.9	99.5	14.6	56.0	46.4	150.5
4	271.5	110.9	202.5	225.7	129.7	75.2	10.4	37.1	27.6
5	179.0	194.4	82.6	124.2	156.5	92.0	51.5	7.6	22.0
6	930.5	128.3	136.1	62.0	81.1	104.0	57.5	31.9	4.5
7	179.6	622.4	92.4	92.6	47.8	56.6	65.6	32.2	19.0
8	88.0	130.9	426.1	50.4	66.5	37.3	34.6	37.4	19.2
9	69.0	56.9	83.8	250.6	28.6	48.8	20.8	18.7	22.3
10	35.3	44.8	41.5	43.4	173.4	22.7	29.1	11.8	11.1
11	7.1	25.8	30.2	28.1	25.9	124.3	16.3	17.0	7.0
12	0.9	5.6	16.5	17.9	19.1	15.7	89.1	11.1	10.1
13	44.3	0.6	4.4	11.8	10.3	14.6	10.0	51.6	6.6
14	0.0	17.8	0.4	3.0	7.5	7.0	11.3	6.2	30.7
15+	0.0	0.0	9.8	16.1	14.3	9.7	7.8	6.2	7.4
TOTAL NO	2866.5	2386.3	1838.6	1258.4	960.8	766.8	749.2	688.1	
SPS NO	1924.8	1673.8	1409.0	1067.2	799.4	594.7	438.3	352.9	
TOT. BIOM	1139.8	966.1	783.3	573.7	446.8	360.0	300.3	249.4	
SPS BIOM	899.7	770.2	652.7	504.4	396.1	306.6	225.7	167.1	

Table 3.4.A. Input for catch forecasts, North Sea MACKEREL ( $M = 0.15$ )

Age	Stock Number in 1983 ( $\times 10^{-6}$ )	Reference Fishing Pattern (= $F_{82}$ )	Weight at Age in Catch	Weight at Age in Stock at 1 Jan.	Weight at age at Spawning	Maturity Ogive
1	20.0	0.05	.245	.123	.180	0
2	151.4	0.27	.329	.234	.275	0.37
3	150.5	1.0	.363	.325	.330	1
4	27.6	1.0	.392	.335	.415	1
5	22.0	1.0	.438	.350	.460	1
6	4.5	1.0	.455	.346	.495	1
7	19.0	1.0	.520	.468	.525	1
8	19.2	1.0	.580	.472	.550	1
9	22.3	1.0	.585	.505	.565	1
10	11.1	1.0	.610	.535	.590	1
11	7.0	1.0	.635	.560	.610	1
12	10.1	1.0	.655	.585	.630	1
13	6.6	1.0	.670	.605	.645	1
14	30.7	1.0	.675	.615	.650	1
15+	7.4	1.0	.685	.650	.675	1

Table 3.4.B Forecasts of stock biomasses and catches of the North Sea MACKEREL stock.  
Basic parameters are given in Table 3.4.A. Stock biomasses at 1 January and catch in tonnes  
x 10<sup>-3</sup>. Spawning stock biomass at the time of spawning are given in parenthesis.

1982		1983				Management option for 1984	1984				1985	
Total land- ings	$F(3-13)$	Stock biomass	Spawn. stock biom.	$F(3-13)$	Total land- ings		Stock biom.	Spawn. stock biom.	$F(3-13)$	Total land- ings	Stock biomass	Spawn. stock biom.
55	0.37	178	153(152)	0.50	65	Maintain catch level	119	114(112)	0.75	65	58	53
						Close V1a North, winter		(114)	0.57	53	68	63
						$F_{84} \approx F_{0.1}$		(116)	0.15	17	98	93
						No fishing		(121)	0	0	112	107

Weights in 1 000 tonnes



Table 4.1.A. Nominal catch (tonnes) of MACKEREL in the western area (VI, VII and VIII)  
(Data for 1973-1977 as officially reported to ICES)

Country \ Year	1973	1974	1975	1976	1977	1978**	1979**	1980**	1981 (**)	1982** (**)
Belgium	3	7	17	10	1	1	3	-	-	+
Denmark	-	-	-	3	698	8 677	8 535	14 932	13 464	15 100
Faroe Islands	635	8 659	1 760	5 539	3 978	15 076	10 609	15 234	9 070	11 100
France	41 664	37 824	25 818	33 556	35 702	34 860	31 510	23 907	14 829	9 500
Germany, Dem.Rep.	1 733	2 885	9 693	4 509	431	-	-	-	-	-
Germany, Fed.Rep.	559	993	1 941	391	446	28 873	21 493	21 088	29 221	11 500
Iceland	52	-	21	10	-	-	-	-	-	-
Ireland	8 314	8 526	11 567	14 395	23 022	27 508	24 217	40 791	92 271	109 700
Netherlands	7 785	7 315	13 263	15 007	35 766	50 815	62 396	91 081	88 117	67 200
Norway	34 600	32 597	1 907	4 252	362	1 900	25 414	25 500	21 610	19 000
Poland	10 536	22 405	21 573	21 375	2 240	-	92	-	1	-
Spain	25 677	30 177	23 408	18 480	21 853	19 142	15 556	15 000	11 469	15 600
Sweden	-	-	-	38	-	-	-	-	-	-
UK (England & Wales)	13 081	21 132	31 546	57 311	132 320	213 344	244 293	150 598	75 722	82 900
UK (N. Ireland)	93	75	30	95	97	46	25	-	4 153	9 600
UK (Scotland)	5 170	8 466	16 174	28 399	52 662	103 671	103 160	108 372	109 153	130 000
USSR	65 202	103 435	309 666	262 384	16 396	-	-	-	-	-
Unallocated							54 000	98 258	140 322	114 700
Total, ICES members	215 104	284 496	468 384	465 754	325 974	503 913	601 303	604 761	609 402	595 900
Bulgaria	4 341	13 558	20 830	28 195	-	-	-	-	-	-
Rumania	-	-	2 166	13 222	-	-	-	-	-	-
Grand Total	219 445	298 054	491 380	507 178	325 974	503 913	601 303	604 761	609 402	595 900

\* Preliminary

\*\* Working Group estimate

+ Includes S. japonicus

Table 4.1.B. Landings of MACKEREL (tonnes) by  
Sub-areas in the Western area.

Year	Sub-area		
	VI	VII and VIII	IX
1969	4 760	66 340	n.a.
1970	3 854	100 340	n.a.
1971	10 213	122 561	n.a.
1972	10 013	157 762	3 387
1973	52 166	167 279	3 969
1974	64 136	234 081	5 593
1975	64 849	416 538	5 634
1976	67 765	439 413	5 581
1977	74 829	259 111	7 565
1978	151 747	355 487	7 965
1979	203 301	398 002	7 462
1980	218 663	386 093	4 640
1981	335 082	274 320	9 565
1982*	340 962	255 031	4 396

\* Preliminary

Table 4.2.A. Catch in numbers by age group ( $\times 10^{-3}$ ) of the Western stock in 1981.

Age	Divisions and Sub-area					TOTAL
	IIa + IVa	VIa	VIIa-c	VIIId-k	VIII	
0				5 052	33 295	38 347
1	-	7 612	647	210 921	46 847	266 027
2	-	40 592	20 047	424 561	21 033	506 233
3	123	26 180	14 603	176 262	6 662	223 830
4	78	8 333	2 012	18 493	2 521	31 437
5	402	56 464	21 976	91 159	3 270	173 271
6	1 397	74 888	14 129	62 514	2 232	155 160
7	1 565	54 869	8 041	29 639	1 090	95 204
8	1 878	63 880	16 237	28 163	1 567	111 725
9	738	19 430	3 115	7 609	1 002	31 894
10+	4 996	218 613	29 296	61 664	6 378	320 947

Table 4.2.B. Catch in numbers by age group ( $\times 10^{-3}$ ) of the western stock in 1982.

Year Class	D I V I S I O N S					Total
	IIa	VIa	VIIa-c	VIId-k	VIIIa-c	
1982 0	-	-	0	1 674	291	1 965
1981 1	-	75 160	232	129 718	4 717	209 827
1980 2	-	156 569	1 680	284 854	5 055	448 158
1979 3	4 984	166 095	4 434	310 515	6 711	492 739
1978 4	4 973	77 442	6 120	90 917	2 816	182 268
1977 5	1 066	9 262	966	11 428	1 351	24 073
1976 6	3 297	64 277	4 931	61 469	2 553	136 527
1975 7	3 334	57 021	4 787	38 982	5 639	109 763
1974 8	3 849	45 109	4 707	25 588	4 461	83 714
1973 9	3 343	49 279	5 768	26 923	2 987	88 300
Pre-1973 10 <sup>+</sup>	11 617	145 934	17 408	75 188	12 030	262 177
TOTAL	36 463	846 148	51 033	1 057 256	48 611	2 039 511

Table 4.2.C. Western stock.

Catches in numbers ( $\times 10^{-3}$ ) of the Western stock (Jan. - June 1983)

Year class	1982	1981	1980	1979	1978	1977	1976	1975	1974	<1974
Numbers ( $10^{-3}$ )	8 282	343 597	200 639	180 350	37 052	12 213	29 415	20 903	19 477	47 059

Table 4.3.A VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

CATCH IN PUMBERS UNIT: MILLIONS

	1976	1977	1978	1979	1980	1981	1982
0	34.2	2.0	10.3	79.5	19.5	38.3	2.0
1	279.4	153.5	31.3	551.1	484.5	266.0	209.8
2	184.9	289.5	563.8	61.6	468.7	506.2	448.2
3	322.3	154.0	425.0	602.5	75.2	223.8	492.7
4	170.6	166.0	243.7	365.5	381.3	31.4	182.3
5	288.8	51.0	258.3	217.2	282.0	173.3	24.0
6	118.6	140.0	71.9	233.1	145.2	155.2	136.5
7	279.7	64.4	151.9	86.8	158.4	95.2	109.8
8	438.8	89.4	56.7	154.2	52.4	111.7	83.7
9	0.0	158.5	83.2	70.5	139.6	31.9	88.3
10+	0.0	0.0	210.8	263.7	206.9	320.9	262.2
TOTAL	2117.3	1268.3	2106.9	2485.7	2413.7	1953.9	2039.5

Catch in weight ( $t \times 10^{-3}$ )

SUM OF PRODUCTS UNIT: THOUSAND TONNES

SOP	682	381	628	767	803	677	707
Nominal	507	326	504	606	605	610	596

Table 4.3.B VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

FISHING MORTALITY COEFFICIENT

UNIT: Year<sup>-1</sup>

NATURAL MORTALITY COEFFICIENT = 0.15

	1976	1977	1978	1979	1980	1981	1982
0	0.01	0.00	0.00	0.01	0.01	0.01	0.01
1	0.07	0.04	0.06	0.13	0.10	0.08	0.10
2	0.07	0.09	0.16	0.16	0.25	0.14	0.19
3	0.11	0.07	0.18	0.27	0.29	0.17	0.19
4	0.19	0.07	0.15	0.21	0.26	0.18	0.19
5	0.15	0.08	0.15	0.19	0.24	0.17	0.19
6	0.15	0.09	0.14	0.19	0.17	0.19	0.19
7	0.27	0.11	0.13	0.23	0.18	0.16	0.19
8	0.19	0.12	0.13	0.18	0.20	0.17	0.19
9	0.00	0.09	0.15	0.22	0.23	0.17	0.19
10+	0.00	0.09	0.15	0.22	0.23	0.17	0.19
( 3- 8)W	0.16	0.09	0.15	0.22	0.23	0.17	0.19

Table 4.3.0 VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

STOCK SIZE IN NUMBERS UNIT: MILLIONS

BIOMASS TOTALS UNIT: THOUSAND TONNES

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: 0.400  
PROPORTION OF ANNUAL M BEFORE SPAWNING: 0.400

	1976	1977	1978	1979	1980	1981	1982	1983
0	5285.0	634.1	5568.4	6222.9	4109.6	2796.1	216.4	*****
1	4475.9	4517.2	545.9	3061.8	5282.4	3519.1	2371.2	184.4
2	2890.0	3593.7	3745.8	439.2	2510.4	4098.1	2782.6	1846.7
3	3234.2	2316.2	2825.1	2702.6	321.0	1555.5	3058.9	1980.6
4	1084.3	2485.4	1851.0	2038.5	1769.6	206.9	1131.8	2177.3
5	2295.0	758.3	1985.5	1367.7	1416.7	1170.8	149.0	805.6
6	871.5	1708.2	605.4	1470.0	976.4	958.7	847.5	106.1
7	1278.5	657.6	1340.6	454.8	1049.7	706.1	631.7	603.2
8	2772.9	842.0	506.4	1013.3	311.0	757.0	519.7	485.2
9	0.0	1980.9	642.0	583.4	729.6	219.3	548.2	369.9
10+	0.0	0.0	1626.7	1434.0	1081.3	2205.8	1627.9	1548.9
TOTAL NO	24187.4	19493.6	19240.7	20537.9	19357.6	18193.3	13934.9	10068
SPS NO	10712.1	10777.7	10300.8	8979.5	7855.6	8258.0	7785.9	7200
TOT. BIOM	4533.7	4419.6	4177.5	3802.9	3543.2	3730.5	3423.6	2955
SPS BIOM	3163.6	3156.4	3147.2	2790.7	2391.4	2590.3	2394.0	2178

Plankton survey estimates  
Ref. Section 4.3.1



Table 4.4.A. Input data used in the forecasts for the Western Stock

Age	Stock in nb in 1983 ( $\times 10^{-6}$ )	Fishing pattern	Weight at age in the catch	Weight at age in the stock	Maturity ogive
1	1 000	0.53	0.131	0.113	0.18
2	1 847	1.0	0.248	0.131	0.38
3	1 981	1.0	0.283	0.201	0.67
4	2 177	1.0	0.343	0.251	0.89
5	806	1.0	0.373	0.264	0.93
6	106	1.0	0.455	0.316	1.0
7	603	1.0	0.497	0.380	1.0
8	485	1.0	0.508	0.412	1.0
9	370	1.0	0.539	0.511	1.0
10 <sup>+</sup>	1 549	1.0	0.573	0.511	1.0

Proportion of F before spawning = 0.4.

Mean weights at age used in calculating SB and SSB were those at 1 January

Table 4.4.B Forecasts for the Western Stock - (Basic parameters are given in Table 4.4.A) catches and stock biomasses are given in tonnes  $\times 10^{-3}$

1982		1983				Management option for 1984	1984				1985		
Total land- ings *	$\bar{F}(3-8)$	Stock biomass	Spawn. stock biom.	$\bar{F}(3-8)$	Total land- ings		Stock biom.	Spawn. stock biom.	$\bar{F}(3-8)$	Total land- ings	Stock biomass	Spawn. stock biom.	
609	0.19	2 955	2 178	0.20	650	No fishing	2 476	2 041	0	0	2 515	2 124	
						$F_{84} = F_{83}$			1 884	0.20	534	2 087	1 610
						maintain total land.			1 847	0.25	650	1 994	1 463
						$F_{84} = F_{0.1}$			1 906	0.17	463	2 144	1 676

\* Includes landings taken from outside the western area  
excludes landings of N sea stock from within the western area  
Spawning stock biomass are estimated at 1 June and stock biomass are estimated at 1 January  
Weights in 1 000 tonnes

Table 5.1 Nominal catch (tonnes) of MACKEREL in Sub-area IX - 1973-1982

Country	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 <sup>WE</sup>
Portugal	1 635	2 329	2 224	2 595 <sup>WE</sup>	1 743 <sup>WE</sup>	1 555 <sup>WE</sup>	1 071 <sup>WE</sup>	1 921 <sup>WE</sup>	3 108 <sup>WE</sup>	3 600
Spain	2 334	3 264	3 345	2 520	2 935	6 221	6 280	2 719	2 111 <sup>WE</sup>	796
France	-	-	1	-	-	-	-	-	-	-
Poland	-	-	-	-	8	-	-	-	-	-
USSR	-	-	44	466	2 879	189	111	-	-	-
Total	3 969	5 593	5 614	5 581	7 565	7 965	7 462	4 640	5 219	4 396

\* Preliminary

<sup>WE</sup> Working Group estimate

Table 6.1.A. Landings of HORSE MACKEREL in Sub-area IV, by country (in tonnes)

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982*
Belgium	34	23	15	14	15	9	8	34	7
Denmark	-	-	-	63	1 543	496	199	3 576	1 616
Faroe Islands	772	156	116	130	3	-	260	-	2 327
France	582	140	147	325	182	221	292	2	570
German Dem. Rep.	-	-	4	-	-	-	-	-	-
Germany Fed.Rep.	686	696	162	2	1 993	376	+	139	30
Iceland	203	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	1 161	412	-
Netherlands	576	173	82	223	106	88	101	355	559
Norway	20 713	2 174	4 842	450	1 037	199	119	2 292	7
Poland	62	-	11	6	-	-	-	-	-
Spain	-	-	-	-	-	-	-	-	-
Sweden	2 <sup>a)</sup>	+	-	-	... b)	+	-	-	-
U.K.(Engl.&Wales	5	3	11	22	36	23	11	15	6
U.K. (Scotland)	1 222	2	+	4	5	+	-	-	-
U.S.S.R.	5 894	6 566	3 278	87	-	-	-	-	-
TOTAL	30 751	9 933	8 668	1 326	4 920	1 412	2 151	6 825	5 122

\* ) Preliminary

a) Includes IIIa

b) Included in IIIa

Table 6.1.B. Landings of HORSE MACKEREL in Sub-area VI, by country (in tonnes)

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982*
Belgium	-	-	+	-	-	-	-	-	-
Denmark	-	-	-	-	-	443	734	341	2 785
Faroe Islands	342	2	2	-	-	-	-	-	-
France	-	-	293	113	91	151	45	454	4
Ireland	-	-	-	-	59	-	-	-	-
Germany, Fed. Rep.	209	263	5	-	-	155	5 550	10 212	2 114
Netherlands	-	106	69	19	114	6 910	2 365	100 <sup>a)</sup>	50 <sup>a)</sup>
Norway	627	869	90	-	-	-	-	5	-
Poland	1 067	479	48	-	-	-	-	-	-
Spain	400	150	175	147	91	20	-	-	-
U.K. (Engl. & Wales)	14	6	37	40	44	73	9	5	+
U.K. (Scotland)	41	187	85	105	9	39	1	17	83
U.S.S.R.	780	1 210	3 390	246	-	-	-	-	-
TOTAL	3 521	3 379	4 299	670	408	7 791	8 724	11 134	5 036

\* Provisional

a) Estimated from biological sampling

Table 6.1.C. Landings of HORSE MACKEREL in Sub-area VII, by country (in tonnes)

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982*
Belgium	3	4	2	1	1	3	+	1	1
Denmark	-	-	-	-	2 104	4 287	5 045	3 099	877
France	2 466	2 443	3 800	2 448	3 564	4 407	1 983	2 800	2 314
German Dem. Rep.	8	-	92	45	-	-	-	-	-
Germany, Fed.Rep.	825	521	3	308	2 923	5 333	2 289	1 079	12
Ireland	-	-	-	1 133	3 388	-	-	16	-
Netherlands	-	41	280	2 088	10 556	25 174	23 002	25 000 <sup>a)</sup>	27 500 <sup>a)</sup>
Norway	16	-	-	-	29	959	394	-	-
Poland	4 643	1 869	2 967	640	61	-	-	-	-
Spain	12 315	10 890	17 124	483	516	676	50	234	104
U.K.(Engl.&Wales)	675	438	2 014	1 343	2 918	2 686	12 933	2 520	2 670
U.K.(Scotland)	-	-	-	-	-	-	1	-	-
U..S.S.R.	95 650	101 393	150 728	20 366	-	-	-	-	-
TOTAL	116 601	117 599	177 010	28 855	26 060	43 525	45 697	34 746	33 478

\* Provisional

a) Estimated from biological sampling

Table 6.1.D. Landings of HORSE MACKEREL in Sub-areas VIII and IX, by country (in tonnes)

Country	1974	1975	1976	1977	1978	1979	1980	1981	1982** *
<u>Sub-area VIII</u>									
Denmark	-	-	-	-	-	127	-	-	-
France	2 477	2 386	3 380	4 881	3 643	4 240	3 361	3 711	3 073
German Dem.Rep.	-	-	14	-	-	-	-	-	-
Netherlands	-	-	-	-	19	-	-	-	-
Spain	62 836	72 916	95 401	104 812	80 139	42 766	34 134	36 362	19 610
U.K. (Engl. & Wales)	-	-	-	-	-	22	-	+	1
U.S.S.R.	925	11 436	30 763	15 213	3	-	-	-	-
TOTAL	66 238	86 738	129 558	124 906	83 804	47 155	37 445	40 073	22 684
<u>Sub-area IX</u>									
Poland	-	-	-	168	-	-	-	-	-
Portugal	48 071	43 491	49 041	51 341	32 043	26 977	25 132	26 032	29 494
Spain	2 954	1 882	3 339	981	14 787	12 880	11 679	12 120	8 840
U.S.S.R.	-	422	644	14 898	381	250	-	-	-
TOTAL	51 025	45 795	53 024	67 388	47 211	40 107	36 811	38 152	38 334

\*\* ) Provisional

**Figure 3.1** MACKEREL. Norwegian catches July-September 1981 and 1982 (coastal fishery excluded). 1000 tonnes. Data provided by the Institute of Marine Research, Bergen, Norway.

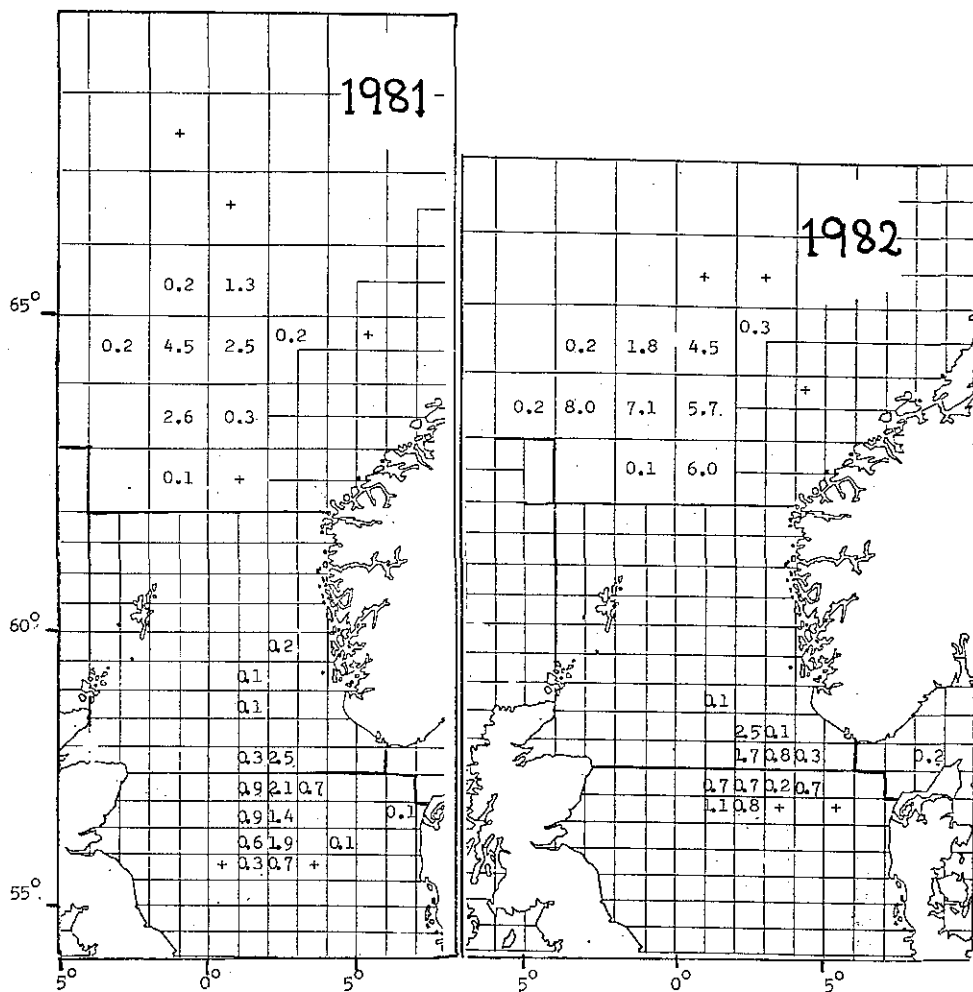
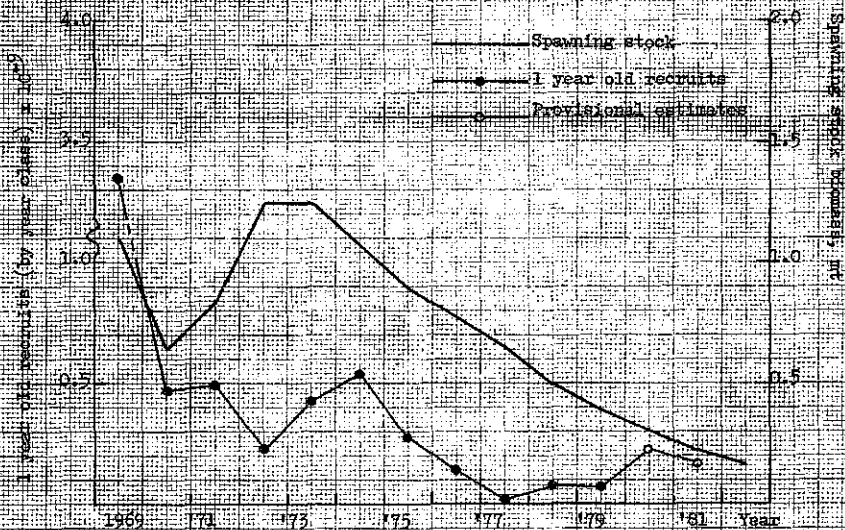


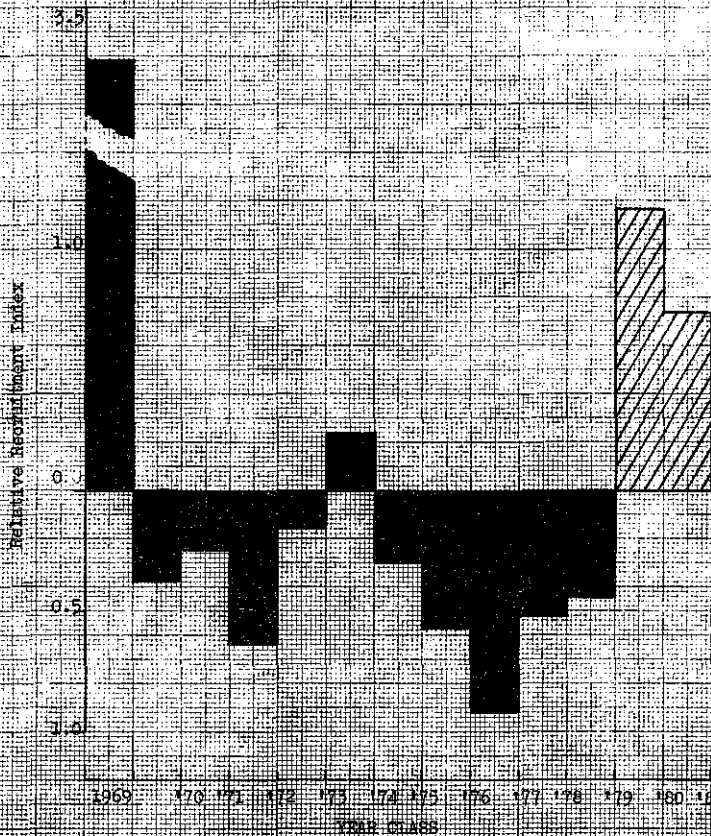


Figure 3.2.4 Spawning stock biomass and 1 year old recruitment 1969-81. Recruits are shown by year classes.



NP: Recruitment estimates for 1960 and 1981 are provisional

Figure 2-2.B. YPA estimates of 1 year old recruitment relative to the number necessary to maintain a stable stock in number, assuming  $M=0.15$ .



YPA recruitment estimates for 1980 and 1981 are provisional

Figure 3.3

## FISH STOCK SUMMARY

(Stock) MACKEREL - NSRA

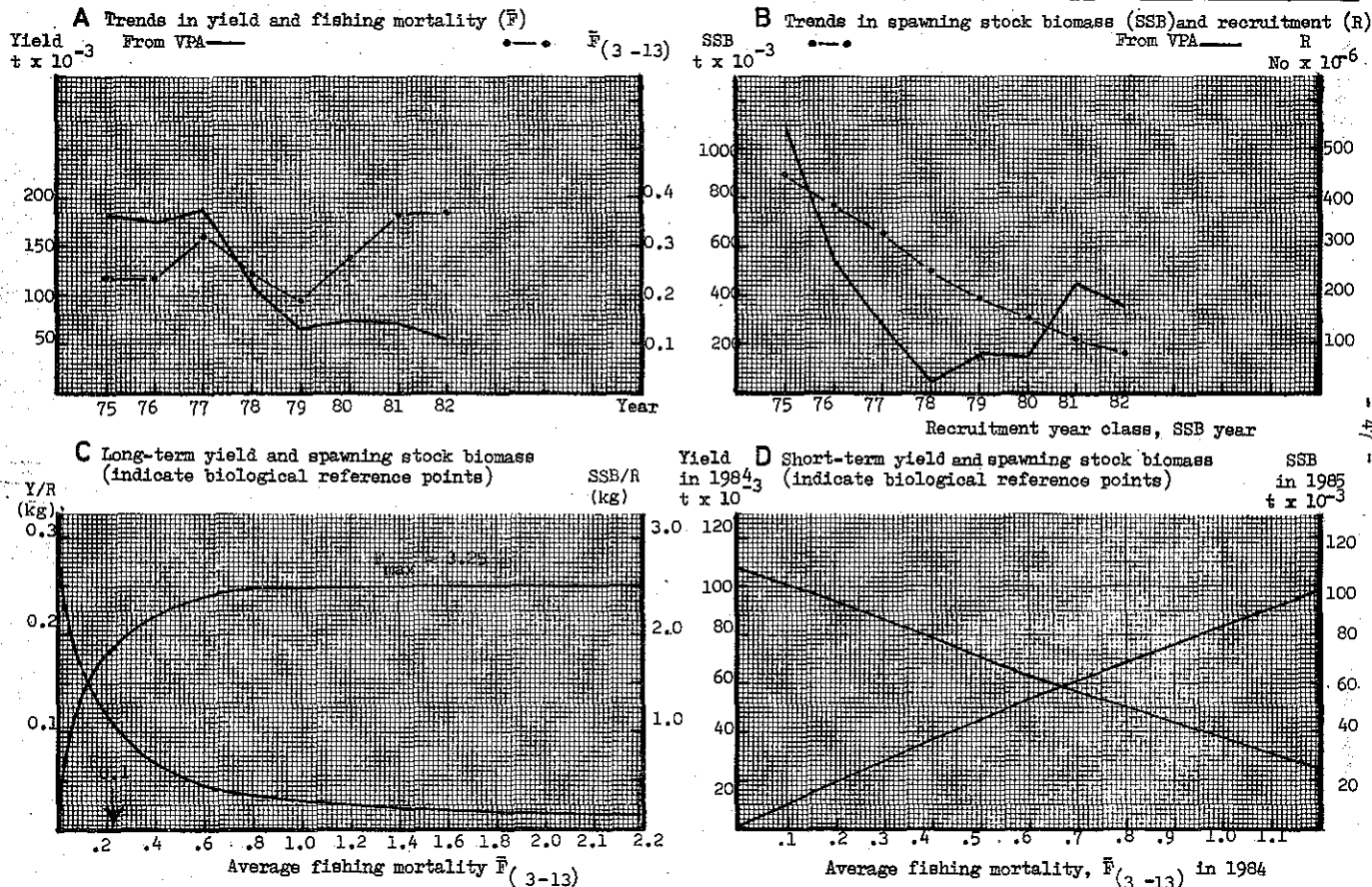


Figure 4.1

## FISH STOCK SUMMARY

(Stock) Mackerel western

A Trends in yield and fishing mortality ( $\bar{F}$ )Yield  
 $t \times 10^{-3}$  $\bar{F}_{(3-8)}$ SSB  
 $t \times 10^{-6}$ 

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

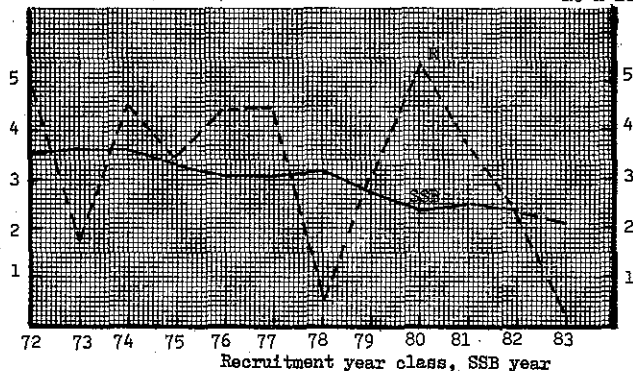
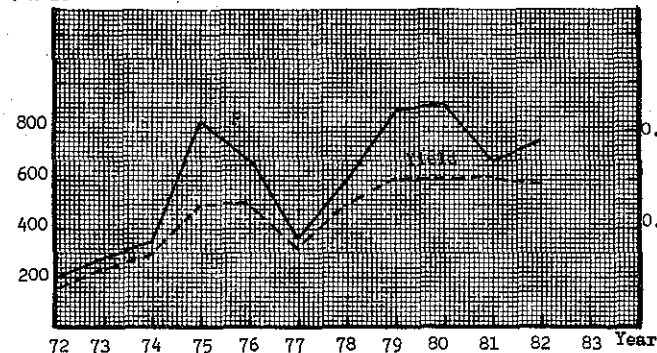
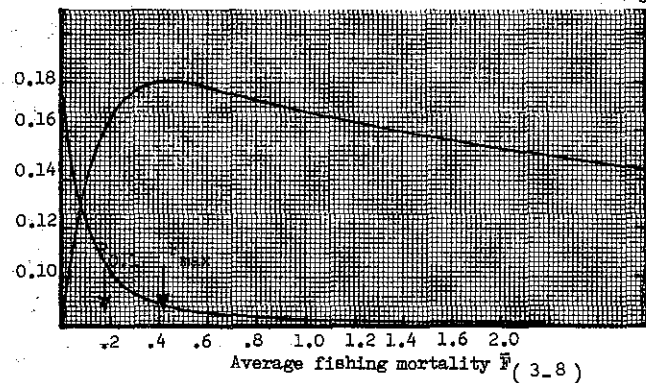
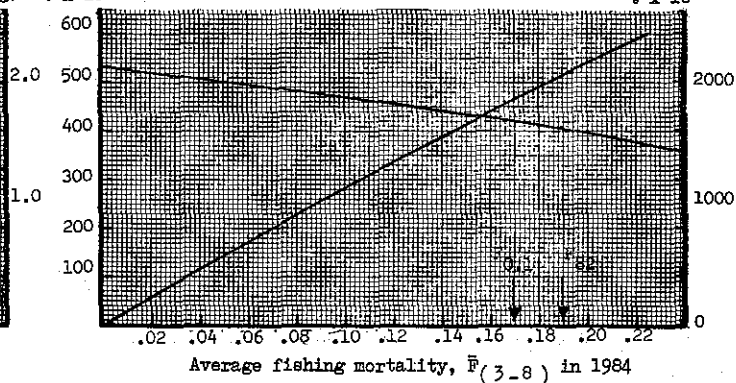
R  
 $No \times 10^{-9}$ C Long-term yield and spawning stock biomass  
Yield/R (indicate biological reference points)  
(kg)SSB/R  
(kg)D Short-term yield and spawning stock biomass  
Yield in 198 (indicate biological reference points)  
 $t \times 10$ SSB  
in 1985  
 $t \times 10^{-3}$ 

Figure 4.2 The percentage frequency of MACKEREL less than 30 cm total length in the Celtic Sea fisheries January 1982 -February 1982. The small digits in the corner of each statistical rectangle give the number of samples taken in the rectangle.

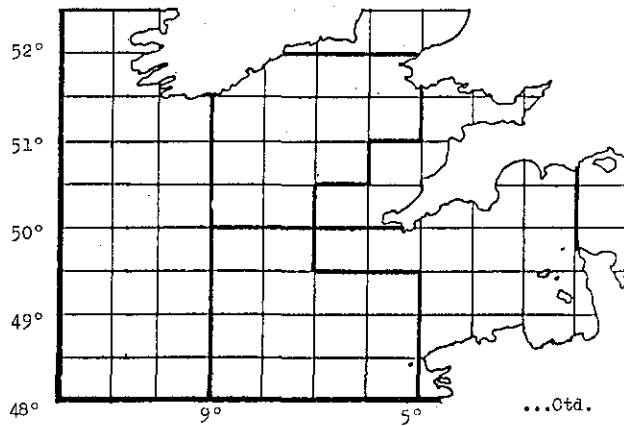
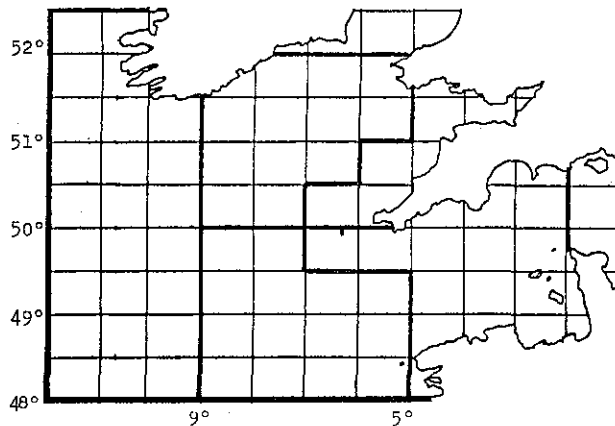
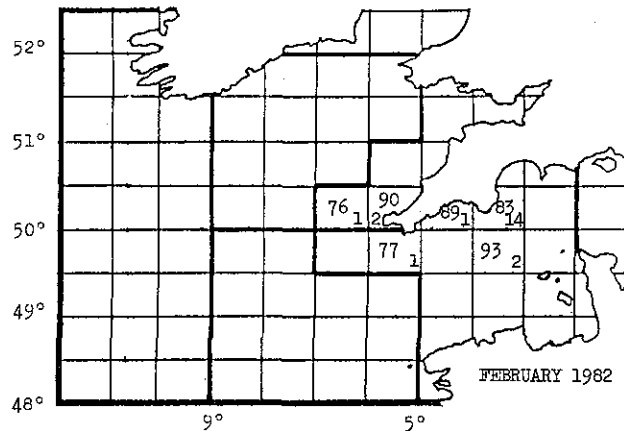
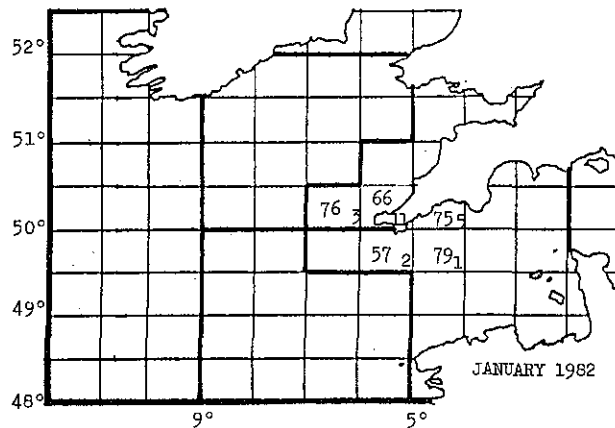


Figure 4.2 contd. The percentage frequency of MACKEREL less than 30 cm September 1982-December 1982. The small digits in the corner of each statistical rectangle give the number of samples taken in the rectangle.

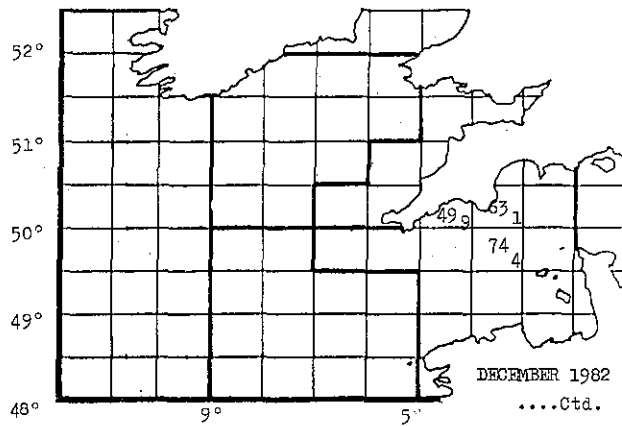
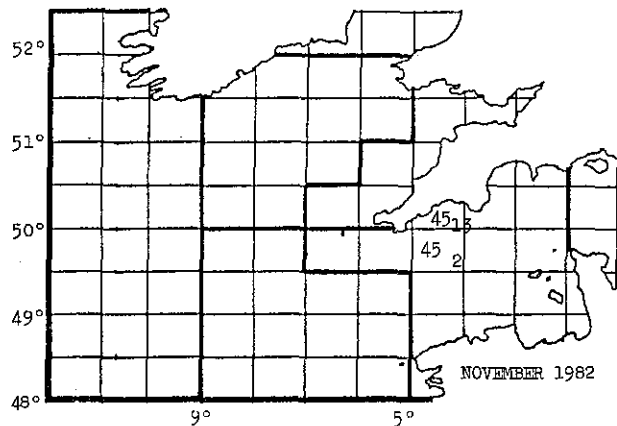
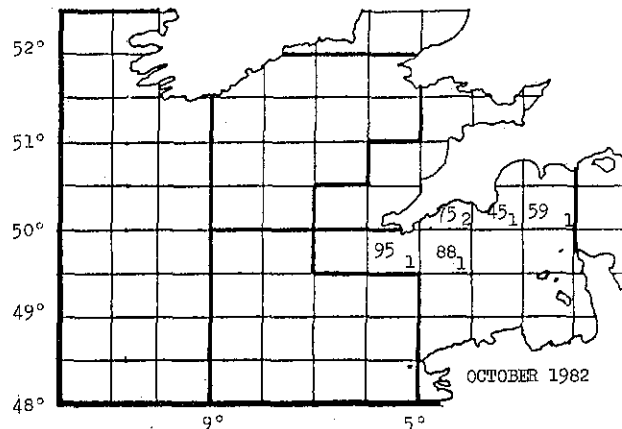
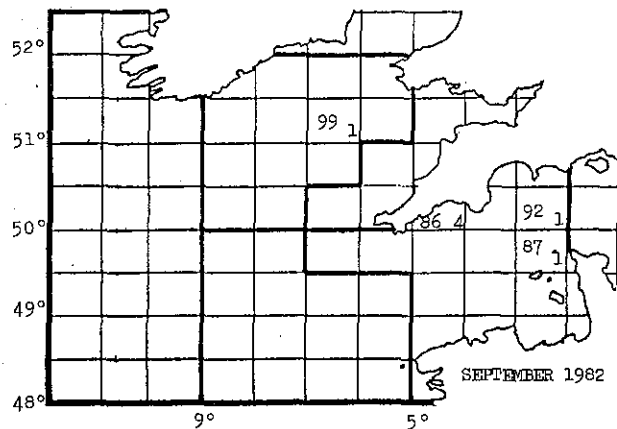
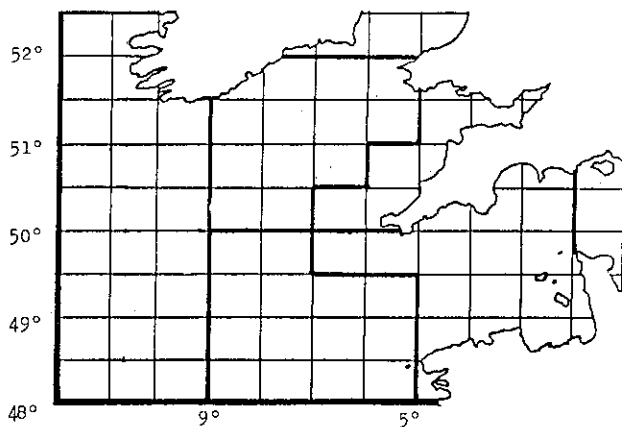
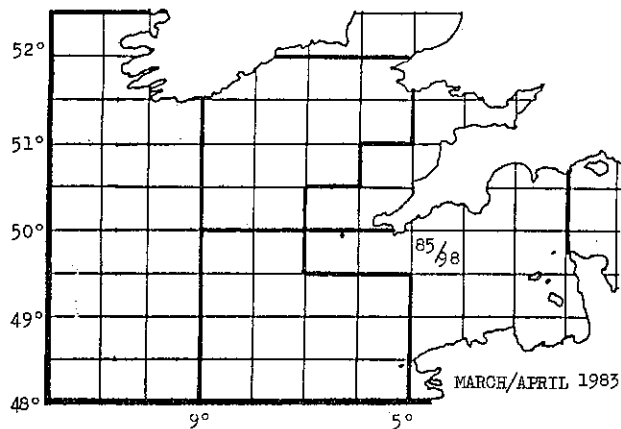
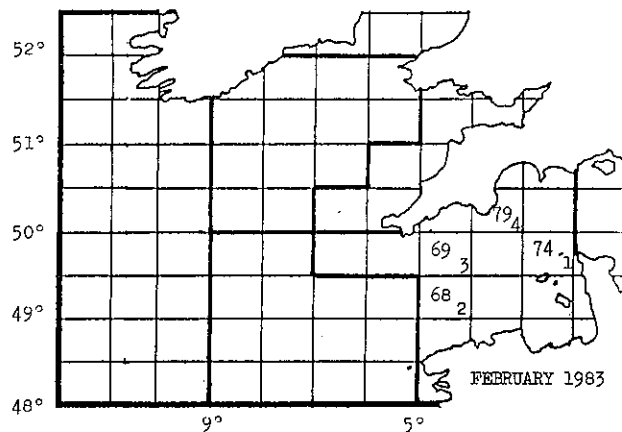
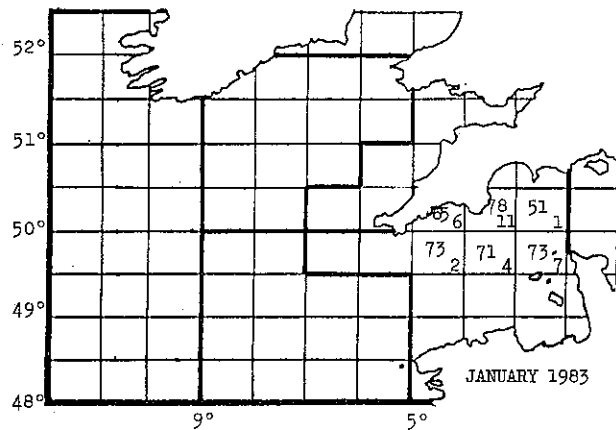


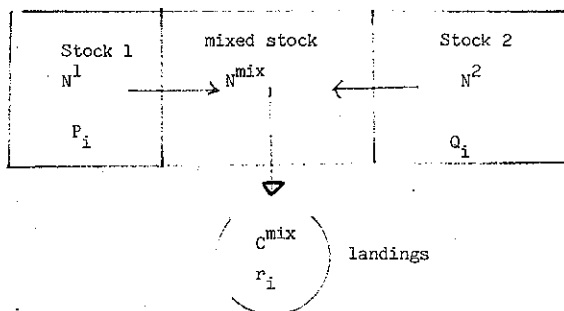
Figure 4.2 contd. The percentage frequency of MACKEREL less than 30 cm January - April 1983.  
The small digits in the corner of each statistical rectangle give the number of samples taken in the rectangle.



# APPENDIX A

## Method used to allocate a Mixed Catch to Stock Components

The system considered consists of two stocks which originate from two areas and mix in a third area where they are fished.



Let  $N^j$  = total number of fish (all age groups) in area  $j$ ,  $j = 1, 2$

$P_i N^1$  = stock number in age group  $i$ , in stock 1, before mixing

$Q_i N^2$  = stock number in age group  $i$ , in stock 2, before mixing.

All fish in the area of mixing are assumed to come from either stock 1 or stock 2. Before mixing, there are no fish in the area of mixing.

Let  $\theta_j$  be the fraction of fish migrating from area  $j$  to the area of mixing.

Thus, the total stock numbers after mixing become

$$N^{mix} = \theta_1 N^1 + \theta_2 N^2$$

we assume that the same fractions of all age groups migrate i.e.,

$$N_i^{mix} = \theta_1 N^1 P_i + \theta_2 N^2 Q_i$$

We assume that fishing mortality remains constant for all age groups, i.e. there is a constant factor  $S$ , so that the numbers caught in the area of mixing become

$$C_i^{mix} = S N_i^{mix}$$

for all age groups.

Thus

$$C_i^{mix} = S \theta_1 N^1 P_i + S \theta_2 N^2 Q_i$$

Let  $C^{mix} = \sum_i C_i^{mix}$ , the total number caught in the area of mixing and let

$$r_i = \frac{C_i^{mix}}{C^{mix}}$$

then



$$r_i = \frac{S\theta_1 N^1}{C^{mix}} p_i + \frac{S\theta_2 N^2}{C^{mix}} q_i \quad (1)$$

Because  $\sum_i r_i = 1.0$ ,  $\sum_i p_i = 1.0$  and  $\sum_i q_i = 1.0$   
we have:

$$\frac{S\theta_1 N^1}{C^{mix}} + \frac{S\theta_2 N^2}{C^{mix}} = 1.0$$

If we rename  $x = \frac{S\theta_1 N^1}{C^{mix}}$  then

$$1-x = \frac{S\theta_2 N^2}{C^{mix}}$$

and equation (1) can be rewritten

$$r_i = x p_i + (1-x) q_i \quad (2)$$

Assume that,  $r_i$ ,  $p_i$  and  $q_i$  are known,  
then equation (2) can be solved for  $x$

$$x = \frac{r_i - q_i}{p_i - q_i} \quad (3)$$

If all assumptions given above were fulfilled, and if the estimates of  $r_i$ ,  $p_i$  and  $q_i$  were without sampling errors equation (3) would hold for all age groups. As this is not the case when considering real data, we use the average over age groups as an estimate for  $x$

$$\hat{x} = \frac{1}{n} \sum_{i=1}^n \frac{r_i - q_i}{p_i - q_i}$$

The split of  $C^{mix}$  into stock components is estimated by

$$C^1 = \hat{X}C^{mix} \quad \text{and} \quad C^2 = (1-\hat{X})C^{mix}$$

and the numbers in each age groups in the mixed catch are estimated by

$$\hat{C}_i^1 = p_i \cdot \hat{X} C^{mix} \quad \text{and} \quad \hat{C}_i^2 = q_i \cdot (1-\hat{X}) C^{mix}$$

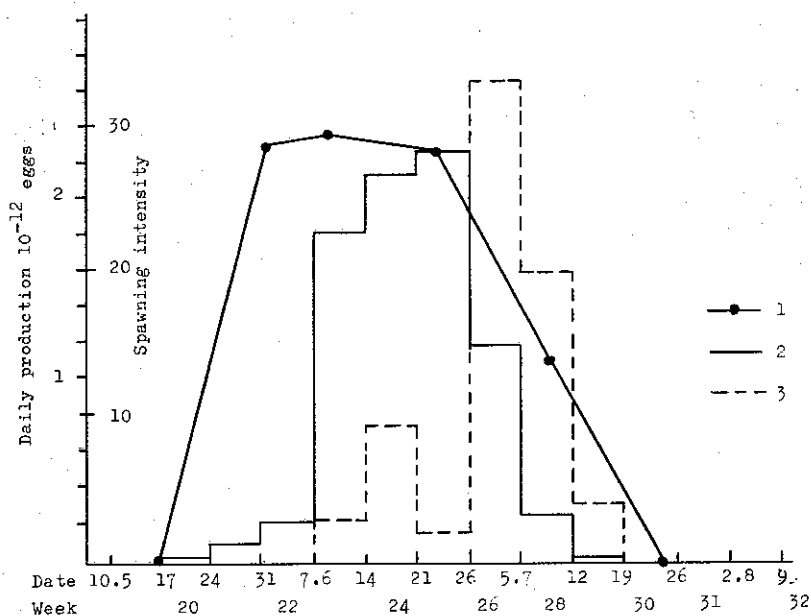
The assumption being that the age distribution of the catch taken in the mixing area equals that of the original stock.

APPENDIX B

North Sea Egg Surveys

The total egg production estimate for the North Sea given by Iversen and Eltink (1983, in press) is underestimated at about 10%. In that paper, the age of the eggs is based on Danielssen and Iversen (1977), and the average surface temperature for the spawning area for each survey. If the temperature varies appreciably within the spawning area, this will bias an estimate based on an average temperature. This was the situation at the time of the Dutch survey. During the Norwegian surveys the temperature was more stable in each case. The criteria of eggs to be used are different for the Dutch and Norwegian investigations. The Dutch use the same system as applied for egg surveys on the Western stock (Lockwood, Nichols and Dawson, 1981). The Norwegian stage used at the temperature range encountered are about 25% older than those classified by the Dutch. If this is taken into account and also applying a more representative temperature for Sub-areas, the total egg production is estimated at  $110 \times 10^{12}$  eggs (App.B, Figure 1).

A document prepared by Walsh et al. (C.M.1982/H:49) for the ICES Statutory Meeting in 1982, using the same egg survey data, also suffered from the defect discussed above, that the egg stage durations used were inconsistent between surveys. In that case the correction required would be much higher but in the opposite direction. Accordingly, the Working Group decided not to use this estimate.



Appendix B. Figure 1 The egg production curve based on the Dutch and the four Norwegian surveys in 1982 (1). The spawning intensities of mackerel at "Ekofisk" (2) and "Cod" (3) in 1982.

APPENDIX C

Preliminary Report on the 1983 Plankton Survey to Estimate the  
Western Mackerel Spawning Stock Size

An informal meeting of representatives of some laboratories participating in the 1983 mackerel egg survey was held at ICES headquarters on 5 September 1983. Those attending were:

S Coombs, IMER, England  
A Eltink, RIVO, Netherlands  
J Guéguen, ISTEPM, France  
S Lockwood, MAFF, England  
A Saville, DAFS, Scotland.

Although no representative of the Federal Republic of Germany attended the meeting, the data from their sampling in March-April were available for inclusion in the assessment.

As on previous occasions, the survey was carried out between March and July in the Bay of Biscay, Celtic Sea and west of Ireland (Appendix C, Figure 1). Six ships participated in a total of 10 cruises. The cruises were arranged so that, as far as possible, there was always one ship on the spawning ground, and at the peak of spawning (late May to early June) there were two ships on the spawning ground. This procedure ensured more intense coverage than on previous occasions. Whereas in 1977 and 1980 sampling was generally limited to alternate rows of stations, liaison between scientists in charge of conservative cruises in 1983 ensured that virtually all stations within the main grid were sampled. Thus, the total daily stage 1 mackerel egg production estimates were made with very few interpolated values for unsampled rectangles.

Daily egg production estimates (and interpolations for unsampled rectangles) were made following the same procedures as those used in 1980 (Lockwood et al., 1981). The daily egg production rate per  $m^2$  in each  $\frac{1}{2}^\circ \times \frac{1}{2}^\circ$  rectangle was raised by the area of the rectangle. The daily egg production rate for the entire survey area was estimated by the sum of all the rectangle estimates within the main survey area (App.C., Fig.1). Four total production estimates were made; these are given in App.C, Table 1 and are shown in App.C, Fig.2. The estimates for 1 April and mid-May were made by combining data from two cruises, "Anton Dohrn" + "Cirolana 1", and "Scotia" 1 + "Tridens 1" respectively. The peak production estimate was made using the results from "Cirolana 2" + "Tridens 2" + "Scotia 2" + "Challenger".

On the northern and southern extremities of the grid this often utilised two observations per rectangle, but in the important central sector, over the Great Sole Bank (between  $48^\circ 30'$  and  $50^\circ N$ ) there were four observations per rectangle. The production estimate for July is a minimum estimate, as "Thalassa 1" did not manage complete coverage of the grid. Data from "Thalassa 2" were not ready in time for this meeting.

The total egg production estimate for the Western mackerel stock in 1983 was:  $1.44 \times 10^{15}$  stage 1 eggs.

The egg production estimate was converted to spawning stock following the procedures adopted in 1980 (Lockwood et al., 1981). Using length frequency information from the Dutch commercial fishery and trawl hauls made by the research vessels during the plankton survey, the mean length of mature fish (28 cm and larger) was calculated. Separate mean lengths were calculated to correspond with each production estimate, plus one for mid-April based on

Dutch commercial data only. Mean fecundity was calculated from these mean lengths by the relationship:

$$F = 8.8 L^{3.02}$$

The fecundity estimates, their corresponding egg production estimates and spawning stock estimates are given in App.C, Table 1. The total number of spawning fish was estimated by area under the spawning stock curve shown in App.C, Figure 3.

The 1983 Western mackerel spawning stock estimate was 7200 million mature fish.

These estimates of total egg production and spawning stock size are almost the same as those made in 1980. A brief discussion of these results was held in view of recent VPA assessments, which estimated a decline in spawning stock size over the period 1980-82 (Anon., 1982). It was noted, however, that this, the third Western mackerel plankton survey, was the most comprehensive to date and, therefore, might result in estimates which were not minimum estimates as was previously the case, particularly for the 1977 data.

It was agreed at this meeting that stage 1 mackerel egg data from each research vessel cruise should be sent to all other participants, so that each has a complete set of data. Dr Lockwood is to prepare a paper, presenting these results for the 1984 Statutory Meeting of ICES.

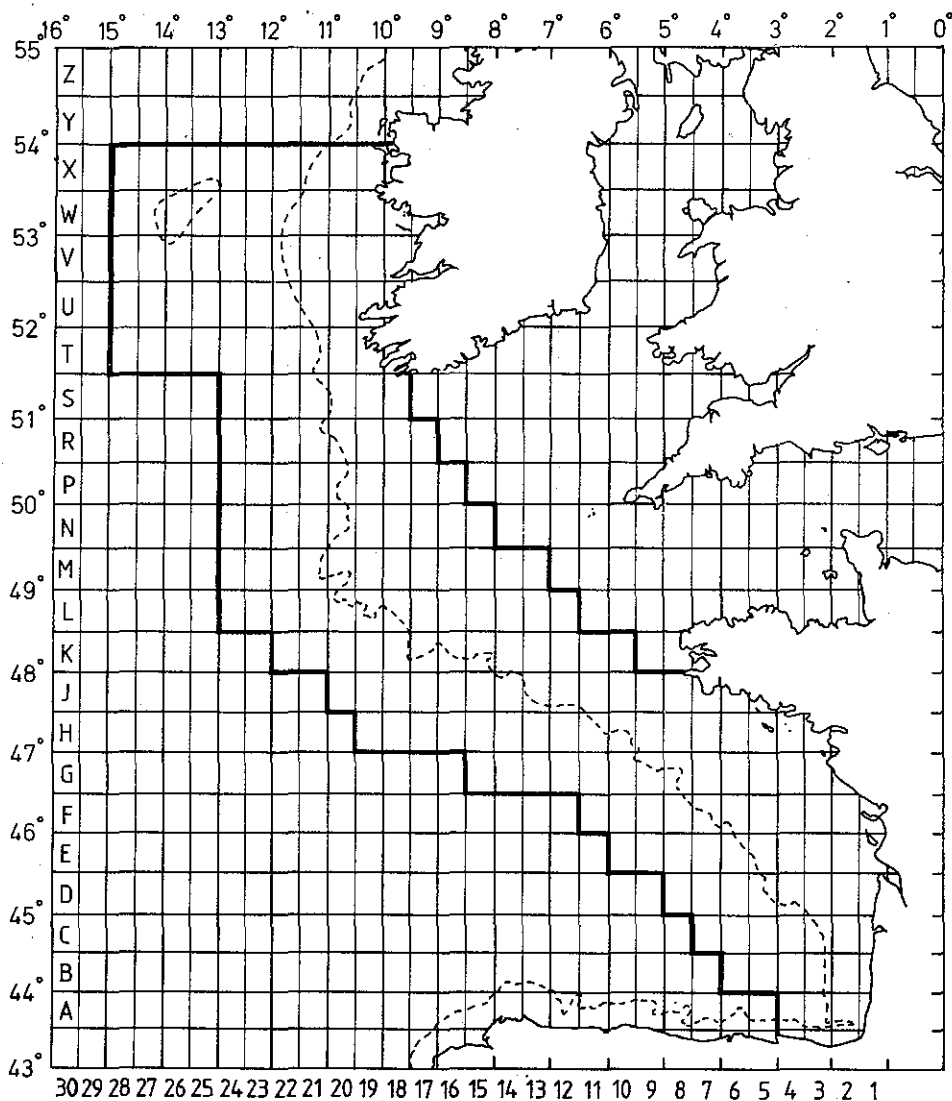
It was also agreed that a second meeting should be held at which not only the mackerel egg data will be considered, but all data collected during the course of this survey. The meeting will be convened by Dr Lockwood and will be held at the Fisheries Laboratory, Lowestoft, probably 8-10 February incl. 1984. Informal papers for discussion will be invited from anyone who has an interest in these surveys, or on related work in the Western mackerel stock spawning area.

App.C, Table 1. Western mackerel stock, monthly stage 1 egg production estimates (shown in App.C, Fig.2), mean lengths of mature fish, mean fecundities and spawning population, by months, March-July 1983.

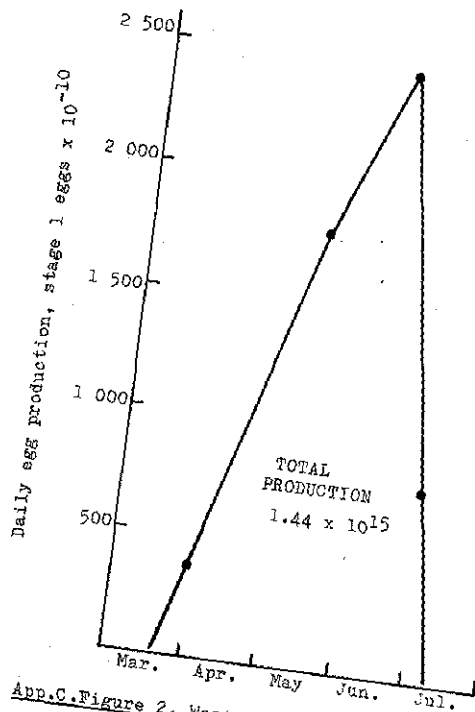
Cruises \ Month	1 April	Mid-April	Mid-May	June	July
	Anton Dohrn + Cirolana 1	Commercial data	Scotia 1 + Tridens 1	Cirolana 2 + Tridens 2 + Scotia 2 + Challenger	Thalassa 1
Sr.I egg production $P \times 10^{-10}$	380	(900) <sup>x)</sup>	1 775	2 457	777
Mean length mature fish L cm	33.4	35.6	36.0	34.6	- ?
Mean fecundity, F	351 720	426 500	441 000	391 500	391 500
Mature fish $\times 10^{-6}$ ((P/F) $\times$ 2)	21.6	42.2	80.5	125.6	39.7

x) From curve in App.C., Figure 2.

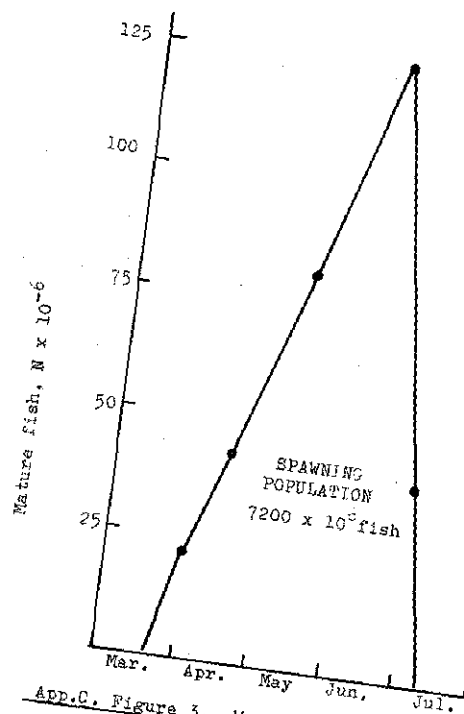
App.C., Figure 1. The Western Mackerel spawning area. Samples were taken at the centre of each  $\frac{1}{2}^{\circ} \times \frac{1}{2}^{\circ}$  rectangle within the bold line.







App.C. Figure 2. Western mackerel stock, stage I egg production March-July 1983.



App.C. Figure 3. Western mackerel stock spawning population, March-July 1983.

