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International Council for the Exploration of the Sea

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# REPORT OF THE MACKEREL WORKING GROUP

Copenhagen, 14 - 21 April 1982

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# REPORT OF THE MACKEREL WORKING GROUP

## 1. INTRODUCTION

### 1.1 Terms of Reference

At the 69th Statutory Meeting in Woods Hole, USA, it was decided (C.Res.1981/2:27:10) that the Mackerel Working Group (Chairman: M J Guéguen) should meet at ICES headquarters 14-21 April 1982 to:

(i) assess the state of the mackerel stocks in Sub-areas II, III, IV, VI, VII, VIII and IX and provide management options for 1983,

(ii) assess the effects of a 40 mm minimum mesh size for trawl gears for mackerel,

(iii) examine the relationship between Sub-area IX mackerel and the Western area stock (Sub-areas VI-VIII),

(iv) consider the data base for doing assessments of horse mackerel, with particular reference to Sub-areas VII, VIII and IX,

(v) specify deficiencies in data required for assessments.

In addition, the Group was asked by ACFM to consider the situation in recent years regarding the effects of areas/seasonal closures.

### 1.2 Participation

The Group met in Copenhagen with the following participants:

| | |
|---|---|
| E Anderson | USA |
| E Bakken | Norway |
| M F Borges | Portugal |
| D Eaton | United Kingdom (England & Wales) |
| A Eltink | Netherlands |
| A G Garces | Spain |
| L S Gordo | Portugal |
| J C Guéguen (Chairman) | France |
| S A Iversen | Norway |
| S J Lockwood | United Kingdom (England & Wales) |
| J Molloy | Ireland |
| J Moores | Canada |
| S Munch-Petersen | Denmark |
| A Saville | United Kingdom (Scotland) |
| P Sparre | Denmark |

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

## 2. THE MACKEREL FISHERIES

### 2.1 North Sea Area (Sub-area IV, Divisions IIa and IIIa)

Total landings for the years 1972-81 by country are shown in Table 2.1 (North Sea and Skagerrak) and Table 2.2 (Norwegian Sea). The landings from the North Sea and Skagerrak during 1981 apparently decreased by about 30% compared to 1980, while the landings from the Norwegian Sea increased by about 100%. Norway and USSR account for most of the landings from Division IIa, and the fishery has shown a more northern distribution in 1981 than in previous years. The total landings represent an excess of about 100% on the maximum recommended by ACFM for 1981 (40 000 tonnes).

It must be emphasized, however, that the information on total landings and landings by area has become less reliable in recent years. Information on 'unallocated' catches was presented.

The landings by quarters are summarized in Table 2.3. As in previous years, the bulk of the catch was taken in the third quarter of the year.

2.2 The Western Area (Sub-areas VI, VII and VIII)

The landings by each country for the 10-year period 1972-81 are shown in Table 2.4. Some slight revisions have been made in the 1980 figures, but these have not altered the total catch. The total catch for 1981 is over 616 000 tonnes, compared with 605 000 tonnes for 1980, and is the highest recorded catch for the Western area.

The most important feature of the catch table is the continued increase in the amount of mackerel, which cannot be allocated to any particular country. Over 22% of the total recorded landings in 1981 are 'unallocated'. A considerable increase took place in the catch recorded by Ireland, and, to a lesser extent, by the Federal Republic of Germany. The catch recorded by the United Kingdom (England and Wales) decreased substantially, while the catch recorded by France also decreased. However, the catch table must not be used as an indication of the total catches taken by some countries because of the presence of 'unallocated catches'.

The TAC recommended by ACFM for the Western area (Sub-area VI, VII and VIII) for 1981 was either 333 000 tonnes or 350 000 tonnes, depending on whether the fishery was allowed in the North Sea. Due to the absence of any international management agreement this TAC was not implemented.

The distribution of the catches by Sub-area and by quarter are shown in Tables 2.5 and 2.3. Since 1979, the proportion of the total catch taken in Sub-area VI has increased each year, and in 1981 it constituted over 55%. The increased catches in this area have been taken mainly in the third and fourth quarters. The percentage of the total catch taken in Sub-area VII amounted in 1981 to 42%. This catch was again taken mainly in the first and fourth quarters (i.e., in the Cornwall fishery), although the percentage of the total catch taken in this fishery decreased in 1981. These changes, evident in the distribution of the fishery in 1981, are broadly in agreement with those suggested by the previous Working Group to improve the exploitation pattern.

2.3 Divisions IXa, b

In the Working Group report for 1981 (Anon., 1981) it was explained that species separation between *Scomber scombrus* and *Scomber japonicus* is not always made in commercial catch statistics in Portugal and Spain. During 1981, the reported catch of Atlantic mackerel in Portugal was found to be underestimated by 43%. It was assumed that this was true throughout the period 1972-81, and the Portuguese catch figures were corrected on this assumption. These revised figures are given, with the catches by other nations, in Table 2.6.

In 1981 the total international catch in this area reached 9 600 tonnes, the highest figure ever recorded and more than twice the catch in 1980. This increase occurred despite neither Portugal nor Spain are pursuing a directed fishery.

The data, which are currently available for comparing the mackerel in Division IXa and those of the Western stock, are limited. Gordo *et al.*(1982)

have summarized the length, weight and growth from the Portuguese fishery, but these data alone are insufficient to make stock separation (cf. Kästner, 1977; Corten and van de Kamp, 1978; Anon., 1981).

There appears to be a clear difference in the maturation rate of mackerel off the Portuguese coast compared to those in the Celtic Sea. Off Portugal, 50% maturity occurs at a mean length of 24 cm, while in the Celtic Sea the fish are 28 cm before 50% reach first maturity (see Figure 2.1).

From plankton and fishing surveys, carried out in recent years, it is known that there is a significant mackerel spawning in the Bay of Biscay, and 0-group mackerel (probably from the main Biscay spawning area) recruit to the north coast of Spain. Whether or not there is also recruitment of these fish to the west coast of the Iberian Peninsula is not known. If they do, the mackerel in Division IXa, or at least part of them, are of the Western stock. If there is a separate spawning and an associated 0-group recruitment along this coast, the stock may be a separate management unit. As a first step towards clarifying this situation, additional information on spawning, recruitment, and migration should be collected.

The continued omission of the mackerel catches in Division IXa from the Western stock assessment should not be interpreted as an implicit acceptance of a separate stock. The Working Group reserves its position but has continued the Western assessment on the basis followed in earlier years.

## 2.4 Catch Statistics

The previous Working Group (Anon., 1981) drew attention to the under-reporting of catches by a number of countries. This shortcoming undermines the basis of the stock assessment and as a result may lead to an overestimate of the stock biomass and hence the TAC. The situation for the Western stock area in 1981 has undoubtedly deteriorated further. Even allowing for 'unallocated' catches, the total reported catch of 616 000 tonnes may be considerably underestimated. As a result, the Working Group would again recommend that any stock estimate should be treated with extreme caution. Every measure should be taken to ensure the collection of accurate catch figures.

# 3. EGG SURVEYS

## 3.1 The Norwegian Egg Surveys in the North Sea in 1981

Four Norwegian surveys were carried out in the North Sea during the period 10 June - 27 July to estimate the mackerel egg production in 1981. The methods used for the egg sampling and estimating production were the same as those applied in 1981 (Iversen, 1981).

The size of the spawning area was about 20% less in 1981 than in 1980. The egg production curve based on the four surveys is shown in Figure 3. The total egg production in the North Sea was estimated to be $44 \times 10^{12}$ eggs. The shape of the spawning curve is uncertain during the beginning of the season due to lack of data. The shape of the curve prior to the first survey would influence the egg production estimate. Daily plankton samples from stand-by vessels in the oil fields, 'Ekofisk' (56°34'N, 03°08'E) and 'Cod' (57°04'N, 02°26'E), demonstrate that spawning started during the last week of May, and that the intensity of spawning was rather low during the first 2-3 weeks. Therefore, the suggested shape of the production curve prior to the first survey (Figure 3) may overestimate rather than underestimate the egg production. However, 'Cod' and 'Ekofisk' are situated on the Western border of the spawning area, and the spawning intensity as observed here may, therefore, not be representative for the total spawning area.

The estimated egg production in the North Sea in 1981 was about 30% lower than the estimated production in 1980, indicating a similar reduction in spawning stock biomass.

### 3.2 Western Mackerel Stock Egg Survey

During 1981, plankton survey work was limited to a single survey of the area west of Ireland by the Federal Republic of Germany in April-May, and a survey of the Celtic Sea in May by England.

A full plankton survey to estimate the Western mackerel stock is being planned for 1983. This survey will be essential, as the 1980 results will be of limited value due to the convergence in the cohort analysis.

## 4. CATCH IN NUMBERS, MORTALITIES AND STOCK SIZE

### 4.1 Catch in Numbers at Age

#### 4.1.1 The North Sea and adjacent areas

Landings from the central and southern North Sea (Divisions IVb and c) amounted to about 30 000 tonnes, of which about half were covered by data on age composition from Norway, Netherlands and Scotland. Data from the Norwegian purse-seine fishery in the third quarter were applied to Danish landings of that quarter. The Dutch data were mainly from the fishery by trawl covering the second, third and fourth quarters. These data were used for Danish landings except in the third quarter, and for the English and French landings. No information was available on the mackerel fishery by the Federal Republic of Germany, Sweden and Belgium, and the overall age distribution in the third quarter was applied to the landings of these countries.

In the northern North Sea (Division IVa) about 65% of the catch was taken by Norway by gill nets and purse seines. Age compositions were available for these fisheries and also from Scotland and the Netherlands. The Norwegian data relating to the offshore fishery were used for landings by France and England. A minor Swedish catch was added to the accumulated annual catch in number by age.

Landings from the Skagerrak and Kattegat (Division IIIa) amounted to about 6 400 tonnes, of which 65% was taken by Norway. A combined age distribution of Norwegian catches by gill net and purse seine in the third quarter was used for landings by Denmark and Sweden.

In the Norwegian Sea (Division IIa) about 75% of the catch was taken by Norwegian purse seiners in July-August. Age composition of these catches were available.

Length and age distribution data from the USSR catches were available. The length distribution of these catches were the same as for the Norwegian catches. However, there were differences in the age distributions. Due to a greater data basis, the Norwegian age distributions were applied also to the USSR catches.

Since there was no information on gear, time or area of fishing by Denmark, United Kingdom (England), or the German Democratic Republic, the combined Norwegian data were applied.

Table 4.1 shows the catch in numbers by age for the North Sea and the Skagerrak (Divisions IVa, IIIa, IVb and c).

In 1981, no catch of 0-group mackerel was recorded. 1-group mackerel (1980 year class) occurred in catches taken in the southern North Sea (Division IVc) in the autumn. About 400 tonnes of young mackerel, mainly 1-group, were fished in the Norwegian fjords during summer and autumn. The total catch of 1-group mackerel was found to be $3.9 \times 10^6$ individuals. This is somewhat higher than in the previous 5 years.

No discarding of mackerel is known to take place in the North Sea stock catches.

North Sea stock

In previous years, catches in the northern North Sea, the Norwegian Sea and to the West of Scotland have been split between the North Sea stock and the Western stock on the basis of proportions calculated from tag returns. At present, the number of tags returned are insufficient for quantitative evaluations. However, the returns from known positions of catches in 1981 support the concept of stock intermixing, which has been used for previous assessments. It seems reasonable to follow the system adopted earlier, and this requires the catches taken in Divisions IVa, IIa and VIa to be split between stocks. On the basis of information on migration, age compositions and fishing areas, the Working Group decided to split the catches as follows:

Division IIa

Calculations of stock mixing in Division IIa from a very limited number of tag returns were presented in a working document to ACFM at its meeting in November 1981, and to the Mackerel Working Group at the present meeting. The results showed a very low proportion (6-25%) of mackerel from the North Sea stock.

The proportion applied to catches in this area in 1980, as estimated from observed changes in tag densities, corresponded to an overall proportion of about 40% North Sea stock.

In view of the uncertainties associated with the tag results due to the low number of returns, the Working Group decided to apply the same stock proportions as in the preceding year, i.e., those used for catches in 1980 in Divisions IIa and IVa (Appendix A.).

Divisions IVa,b,c and IIIa

As in previous years, it was assumed that part of the catch in Division IVa came from the Western stock. This is also indicated by tag returns in 1981. The stock proportions applied to catch in Division IIa were also used for Division IVa. Catches taken in Divisions IVb,c and IIIa were accounted as 100% North Sea stock.

Division VIa

The catch in number from the North Sea stock in Division VIa is described in Section 4.1.2.

4.1.2 Western area

Division VIa

In Division VIa catches taken by France, the Federal Republic of Germany, Ireland, Netherlands, Norway, and Scotland were covered by national age sampling, and those of Denmark were converted to numbers per age group from one sample derived from Danish sampling and additional ones taken from Danish landings in Scottish ports.

Faroese catches, for which no samples were available, were converted to numbers per age by using Norwegian data from the same time period as the two fleets fished in the same area using the same gear. English catches were similarly converted using Scottish data from the same quarters as those in which the English catches had been taken.

In previous reports it has been pointed out that catches taken in the first and fourth quarter in the northern part of Division VIa contain a high proportion of fish belonging to the North Sea stock. In 1981 (Anon., 1981) the Working Group used a method, based on tag returns, proposed by Walsh (1977), for estimating this proportion, and as a result allocated only 25% of the catch in numbers from the winter fisheries to the North Sea stock.

This year the Working Group felt that the matter should be re-examined, as the technique for estimating the proportion using tagging data could lead to erroneous results, a) because of the low numbers of tag returns on which it was based, b) because it was based only on the returns in the winter of 1978/79, and c) because it assumes that the mackerel tagged in a very small area of the total distribution of the Western stock are uniformly distributed throughout the entire stock.

Additional data were available on this subject at the 1982 meeting from the work on differences in parasite infestation rates in the two stocks (McKenzie, 1981), and sampling of catches from this fishery in the winter of 1981/82. This sampling would suggest that in that period the catches from the relevant area were very predominantly North Sea stock. The age distributions of catches taken from this fishery in 1981/82 were also compared with age distributions of drift-net catches taken in the spawning area of the North Sea stock in June, and with those from the Dutch fishery on the Western stock spawning grounds in April-July (Eltink, 1982). The results are given in Table 4.2. These data would strongly suggest that the stock composition in this winter fishery in 1981 was heavily dominated by the North Sea stock.

On these grounds it was decided that all of the catches taken in the fisheries in the Butt of Lewis - North Rona area in the first and last quarter of 1981 should be allocated to the North Sea stock. In the light of the dubiety about the technique used last year to make this allocation, it was decided to revise the stock allocation made in relation to the 1980 data, on the same basis.

## Sub-areas VII and VIII

Numbers at age data for Divisions VIIa,b and c were provided by Ireland, Netherlands and France (first and second quarters only). United Kingdom and French (third and fourth quarters) catches were raised to numbers at age by the Irish age distributions.

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

As in previous years, the Spanish catches in Sub-area VIII were distributed to age groups by the French age distributions.

The numbers given in Table 4.4 include reported, unallocated landings, and also estimates for discards where these are significant (Anon.,1980).

## Sub-area IX

The total catches in numbers at age in Sub-area IX were estimated from Portuguese sampling data (Table 4.5).

4.2 Mean Weight at Age

4.2.1 North Sea stock

In the VPA runs this year, the 10+ group was split in 10, 11, 12, 13, 14 and older than 14 years mackerel (see Section 4.3.1). Weight at age data for these age groups were available for the last 2 years, from Norwegian observations.

Mean weight for age groups 8-15+ for the first three quarters was plotted and smoothed weight at age curves were fitted by eye. The weights(g) at age as obtained from the three curves are listed in the text table below. The weights for the first 7 age groups in the first and third quarters are the same as those applied previously:

| Age | 1st quarter (wt. in stock) | 2nd quarter (wt. in spawn. stock) | 3rd quarter (wt. in catch) |
|---|---|---|---|
| 1 | 123 | 180 | 245 |
| 2 | 234 | 275 | 329 |
| 3 | 325 | 330 | 363 |
| 4 | 338 | 415 | 392 |
| 5 | 350 | 460 | 438 |
| 6 | 346 | 495 | 455 |
| 7 | 468 | 525 | 520 |
| 8 | 472 | 550 | 580 |
| 9 | 505 | 565 | 585 |
| 10 | 535 | 590 | 610 |
| 11 | 560 | 610 | 635 |
| 12 | 585 | 630 | 655 |
| 13 | 605 | 645 | 670 |
| 14 | 615 | 650 | 675 |
| ≥15 | 650 | 675 | 685 |

4.2.2 Western stock

Recent changes, which have taken place in the distribution of commercial fisheries particularly in the last two years, are likely to have resulted in appreciable changes in the mean weights at age in the catches compared to those used in previous assessments. Accordingly, it was decided that those values ought to be re-estimated.

This was done, using estimated mean weights at age for each quarter of 1981 provided by England, Ireland and Scotland. The values provided by these countries were weighted by the catches they took in that quarter to provide quarterly mean weights at age. The quarterly mean weights at age were then weighted by the total catches taken in that quarter to estimate annual mean weights at age in the catch for the Western stock, The values derived in this way are given in the text table below, together with the corresponding values used in previous reports for comparison.

Mean weights at age in the catch (g)

| Age | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ≥10 |
|---|---|---|---|---|---|---|---|---|---|---|
| New values | 131 | 248 | 283 | 343 | 373 | 455 | 497 | 508 | 539 | 573 |
| Previous values | 137 | 158 | 241 | 314 | 334 | 398 | 410 | 503 | 511 | 511 |

The new values have been used in all catch forecasts for the Western stock given in Section 5 of this report.

## 4.3 Stock Assessments

### 4.3.1 Assessment of the North Sea stock

Due to difficulties in detecting the ring structure of mackerel otoliths from fish older than 10 years, a 10+ group has been used in the VPA input in previous years. However, as the 10+ group in recent years showed up as a dominant component of the total catch, it was decided to attempt to split the 10+ group into the ages 10-15+. Further, from Norwegian samples, estimates for these age groups were available for the years 1980-81.

For 1981, the estimates of numbers caught in age groups 10-15+ were based on Norwegian samples. For the year classes 1960-68 the number caught in age groups 10-15+ were estimated as described in Appendix B. To test the method, the estimates based on Norwegian samples in 1980 were compared to those in Appendix B.

Catch in number 1980 (x $10^{-6}$)

| Age | Method of App.B | Norwegian samples |
|---|---|---|
| 10 | 3.5 | 3.5 |
| 11 | 19.3 | 19.6 |
| 12 | 3.8 | 3.2 |
| 13 | 1.3 | 2.1 |
| 14 | 1.6 | 0.9 |
| 15+ | 2.2 | 0.7 |
| Total | 31.7 | 30.0 |

Because the Norwegian samples in 1980 were considered not to be fully representative for the entire catch, it was decided to use the estimates based on the Appendix B method. Catch at age data are shown in Table 4.3. From Norwegian egg surveys, a spawning stock biomass reduction of about 30% from 1980 to 1981 was estimated.

Input Fs for 1981 were chosen so that a spawning stock biomass reduction of about 30% from 1980 to 1981 was produced. The fishing pattern was the same as that used in last year's assessment, except for the 1 group, which was given a value to produce a stock number of 93 x $10^6$ 1 group in 1981 (see Section 5.1).

To produce an SSB reduction of 25% from 1980 to 1981, a 50% increase in $\bar{F}$ in 1981 compared to 1980 was required. Taking the various sources of errors and bias involved in the SSB estimation from egg surveys into consideration, the 25% reduction in SSB was believed to be a reasonable approximation to the findings of the 1980 and 1981 Norwegian egg surveys. Spawning stock biomass in 1980 was estimated to be 495 000 tonnes and 373 000 tonnes in 1981, the lowest on record.

Further, the input F for 1981 was calibrated to produce an average F (for ages 3-14 weighted by stock numbers) for 1979 of 0.12, the estimate of F based on Norwegian tagging experiments (cf. Appendix A). F for the oldest age group was given the value of 0.22 for all years, and M = 0.15 was used for all age groups.

VPA results are shown in Table 4.6 and in Figure 4.1.a,b,c.

### 4.3.2 Assessment of the Western stock

The building-up of the age structure in the catch in 1981 has been fully explained in Section 4.1.2. For 1980, an adjustment of the catch at age data was made to take account of the new split of the catch made in Division VIa between the North Sea and the Western stocks. This resulted in an overall decrease of about 2.5% for 2 year olds and older.

Several approaches for estimating the input F in 1981 were examined. The first was an attempt to predict F in 1981 for individual age groups (4-10) based on linear regression for individual year classes between fishing effort and F from a previous VPA (Anon., 1981). A fishing effort series applicable to the total catch from the Western stock was generated for 1973-81, based on the cpue from the English winter handline fishery at Cornwall (Table 4.7) (Dawson, 1979). For each age group fully recruited to the fishery, the total effort estimate for that particular year was considered to apply. For each age group partially recruited to the fishery, only that fraction of the effort estimate for the year in question proportional to the partial recruitment coefficient (i.e., ratio between F at age to weighted mean F for ages 100% recruited) was considered to apply. The Cornish cpue values exhibited a 70% decrease from 1973 to 1982, with the downward trend being continuous except for an increase in 1980-81, which was succeeded by the low series in 1982. Assuming the 1981 cpue value not to be indicative of stock abundance due to the apparent changes, which have occurred during the last several years in the migration of large fish towards the Cornish Peninsula in December-January, a corrected cpue value for 1981 consistent with the downward trend observed in the other years was employed to produce an effort value for 1981 for the purpose of predicting F in 1981 for the various year classes. (The 'corrected' value was estimated by fitting an exponential curve to the time series, less the 1981 data.) Values of $R^2$ = 0.8 - 1.0 were derived for the various linear regressions. These estimates of F and the resulting stock estimate are summarized in Table 4.8.

A second approach for estimating F in 1981 was to calculate values of Z at each age as the difference in the $\log_e$ of the catch in numbers (total stock) of adjacent age groups in 1980 and 1981 and then subtract M (0.15) from each estimate. These estimates are also given in Table 4.8.

An additional estimate of F of 0.48 for ages 2 and older (Table 4.8) in 1981 was derived from the difference in $\log_e$ of the catch in numbers at ages 2-8 in 1980 and ages 3-9 in 1981. With 0.48 as an input F in 1981, a 1980 spawning stock at 1 June of 3 700 x $10^6$ was estimated from VPA. Although a confidence interval was not calculated for the 1980 egg survey estimate of spawning stock size (6 200 x $10^6$ fish), some, and possibly all, of the above estimates ranging between 3 700 x $10^6$ and 4 900 x $10^6$ fish (Table 4.8) are within the probable confidence interval.

In view of the apparent shift in the major overwintering ground from around the Cornish Peninsula to the west of Ireland and the uncertainty concerning the resultant effect on the Cornish fishery catch rates and age composition in 1981, most members of the Working Group were unwilling to accept the above approaches as a basis for estimating F in 1981.

Finally, the Working Group followed the same procedure as in previous years, and trial runs of VPA were made to match the 1980 value of the spawning stock at the date of peak spawning (1 June): 6 200 x $10^6$ fish. In the absence of any new information, no change has been made in the maturity ogive used in 1981 (Anon., 1981). The possibility of the selection pattern for 2 year old fish and older being dome-shaped was discussed by the Group, but due to the importance of the confidence limits, which exist on the yearly values, there is no strong evidence that this is the case, and a full recruitment was finally adopted for 2 year olds and older. A partial recruitment of 0.05 and 0.5 of the fully recruited was assumed for 0-and 1-group fish, respectively. An adjustment of the input values of F for 9 and 10+ group fish in 1981 was made to obtain a stock size for 9 and 8 year old fish in 1980 compatible with the level of the 10+ group calculated for 1981.

The mean value of F of 0.235 for fully recruited age groups in 1981, which is needed to match the 1980 spawning stock calculated from the egg surveys, is about 20% lower than in 1980 but does not conflict with what is known of the fishery. Fleets, which exploit the West of the British Isles (Divisions VIIb,c, VIa) are catching larger and heavier fish, which results in an increased yield with a lower number of fish caught. The mortality on 1- and 3-year old fish remained constant in 1979 and 1980, but the mortality on 2-year olds increased by 72% in 1980. The mortality on fully recruited age groups in 1980 (Figure 4.2.b) was the highest on record since 1975 and far above the level of 0.15, which was recommended for the Western stock. A full set of F values is given in Table 4.9.

Concerning recruitment, the 1979 year class, although being 25% above the long-term averages, does not appear as an outstanding one, as was previously assumed. The 1980 year class may be below the average, and this, together with the considerable weakness of the 1977 year class, gives some concern for the stock, if the exploitation continues at its level of the last 3 years (see Figure 4.2a and c).

The age structure of the stock for the period 1975-81 is given in Table 4.9. The stock biomass has decreased rather steadily by about 9% each year since 1977 and is reduced to 50% of its 1974 level, as was forecast by the Working Group in 1981 (Anon., 1981). According to what was previously said about the probable underestimation of catches and the absolute reliance on the 1980 egg survey for estimating terminal F, the actual drop in the stock may well be considerably greater.

# 5. CATCH FORECAST

## 5.1 Recruitment

### 5.1.1 North Sea stock

In the previous report of the Working Group (Anon., 1981), it was pointed out that observations on catch of 0-group mackerel in 1980 might indicate that the 1980 year class was stronger than the preceding ones.

An analysis of data on landings of young mackerel from fjord areas of southern Norway seems to give some support to the previous assumptions of the 1980 year class being relatively strong in that area.

The data are presented in the text table below, giving landings of young mackerel of a commercial size group classified as 5-12 mackerel per kg. This includes both the 0- and 1-group, but a major part of the catch is taken during the period June-August before the 0-group appears. Hence, the landings can be assumed to be dominated by the 1-group. The landings are given for the total coastal area (T) north of 62°N and for a coastal stretch in the western part of the Skagerrak (A), where on average about 40% of the total is taken.

| | Landings (tonnes) | |
|---|---|---|
| Year | Area A | Total T |
| 1968 | 45 | 514 |
| 1969 | 54 | 184 |
| 1970 | 798 | 1 531 |
| 1971 | 5 | 149 |
| 1972 | 277 | 285 |
| 1973 | 10 | 58 |
| 1974 | 1 | 65 |
| 1975 | 190 | 436 |
| 1976 | + | 273 |
| 1977 | + | 1 |
| 1978 | 0 | + |
| 1979 | 0 | 0 |
| 1980 | 6 | 21 |
| 1981 | 123 | 411 |

The data indicate that stronger year classes are noticed in this fishery, e.g., the 1969, 1971, and 1974 year classes. A ranking of year class strength by these data relate well with the ranks observed by the number as 3-year old mackerel in the stock determined by the VPA (Table 4.6). On this basis, the number of recruits from the 1980 year class as 1-year olds was assumed to be somewhat higher than the recruits from previous year classes.

Based on this indication, the size of the 1980 year class was set at $93 \times 10^6$ fish, which is the geometric mean of the number of recruits (1 year old) for the period 1976-80, as given by the VPA. Subsequent year class strength was set at $20 \times 10^6$, the lowest level on record.

### 5.1.2 Western stock

The estimated recruitment of 1-year old mackerel to the Western stock is shown with estimated spawning stock biomass in Figure 5.1. It appears that despite the 40% reduction in spawning stock biomass over the period 1975-80, the recruitment has not yet been adversely affected.

While direct recruitment indices are not currently available, comparisons between research vessel cruises in the Celtic Sea area in December 1979 and 1981 suggest that the 1981 year class will not be as strong as the 1979 year class.

## 5.2 Prognosis

### 5.2.1 North Sea stock

Table 5.2 shows a series of stock and catch predictions made on the basis of estimated stock size at 1 January 1982, assumed exploitation pattern, weight at age and maturity as given in Table 5.1.

All predictions were made on the assumption that the catch of mackerel from the North Sea stock in 1982 will amount to 105 000 tonnes. This quantity was estimated by the Working Group members on the basis of national catches in 1981, reported catches in the first months of 1982, and information on fisheries management for 1982.

The prognoses were calculated assuming a continued low level of recruitment (as 1 year olds) in 1982, 1983 and 1984. The recruitment was set at 20 x $10^6$ recruits equal to the lowest recruitment estimated by the VPA (1977 year class in 1978). This low recruitment was felt to be indicative of the poor recruitment in recent years.

As seen from Table 5.2, six forecasts are given under different management options.

A continued fishery giving catches of about 105 000 tonnes as estimated for 1981 and assumed also for 1982 will result in a collapse of the stock in 1984 (catch being higher than stock size). If the fishery continues at the rate of exploitation corresponding to the estimated catch in 1982 ($F = 0.46$), the spawning stock biomass is predicted to decline to about 100 000 tonnes in 1984.

By reducing the fishing mortality in 1983 to 0.30 as estimated for 1981, the spawning stock biomass in 1984 will become 17% higher than that obtained if F is kept at 0.46.

In Section 4.1.2 an outline is given of the fishery on mackerel of the North Sea stock in the northern part of Division VIa in winter. A possible management option is to close the fishery to preserve the stock. For this reason, a prediction of the likely effect of such a closure was made. The reduction in fishing mortality resulting from a closure was estimated on the basis of the catch in number in 1981 in Division VIa (Table 4.3) as part of the total catch of the North Sea stock. The proportion, 83.2/190.3, was applied to the F of 0.46 in 1982, giving Fs of about 0.2 for 1983 and 1984. This allows a comparison to be made between the management options marked "VIa closure" and "$F_{83} = F_{82}$, $F_{84} = F_{82}$" in Table 5.2.

A reduction of the fishing mortality in 1983 and 1984 to half that of 1981 results in an F of 0.15 corresponding approximately to $F_{0.1}$. Even at this low F, the spawning stock is reduced to 130 000 tonnes in 1984, a reduction to nearly half the level of 1982.

Even without any fishery in 1983 and 1984, the stock will continue to decline if recruitment remains at the assumed low level. The predicted spawning stock biomass in 1984 is about 150 000 tonnes.

In Figure 5.2 is shown predicted catch and spawning stock size at various Fs in 1983.

The only conclusion, which can be safely drawn from these results, assuming low recruitment, is that fishery on the North Sea stock must be closed at the earliest possible opportunity (see also Section 9).

### 5.2.2 Western stock

As in previous years, the Working Group assumed no management in 1982 and made their best estimate of the total catch with continued "free fishing". They estimated that the catch in 1982 may reach 750 000 tonnes.

A total of 18 stock/catch forecasts were made (Table 5.4a,b), 9 assuming average recruitment, and 9 assuming a low level of recruitment, and using the input data presented in Table 5.3. The same 9 management options were run in each case. These ranged from the assumption that the current absence of effective international control measures would continue through to 1985 ('free fishing') to the overoptimistic view that the fishery will be controlled at F = 0.15 from 1983 onwards. An F = 0.15 was recommended in previous reports and is approximately $F_{0.1}$.

The effects of all these options are shown in Figure 5.3.

With low recruitment and free fishing during 1982-83, the spawning stock biomass will be reduced to no more than 0.7 million tonnes in 1984. If fishing during 1982 is not more intense than during 1981 (F = 0.24), and recruitment is average, then the stock may be close to 1.2 million tonnes.

Whichever fishing mortality is realized in the next 2-3 years, it must be fully appreciated that the stock will fall to considerably less than half the highest spawning stock estimate in the past decade. It is already 35% below the 10-year average stock level. There has been a continued decline since the mid-1970s, and unless positive management and conservation measures (see Section 6) are introduced and enforced, as a matter of urgency, this stock could well collapse within a very few years.

## 6. ADDITIONAL CONSERVATION MEASURES

### 6.1 Effects of a 40 mm Minimum Mesh Size for Trawl Gears for Mackerel

In 1981 the Mackerel Working Group was asked to assess the effects of a 40 mm cod end mesh size on mackerel trawl fisheries (Anon., 1981). During December 1981, mesh selectivity experiments were carried out off Cornwall by the Dutch research vessel "Tridens", using a pelagic trawl fitted with a trouser cod end.

A total of 14 hauls, which caught mackerel, were made with 40 mm and 70 mm mesh cod ends, and a further two hauls included mackerel where 50 mm were compared to 40 mm. Of these 16 hauls, 13 caught over 200 kg of mackerel (plus other species) and there was very little selectivity. Two hauls made with catches equivalent to 5 t/h (which are very poor catch rates by commercial standards) show no signs of selectivity. Only one haul, with a catch rate equivalent to 0.11 t/h was valid for calculating the selectivity factor, which was estimated to be 5.3.

The 50% retention length for the 40 mm cod end will be 21 cm, assuming full selection. These experiments show, however, that with catch rates, which would be of interest in the commercial fishery, there is no solution. This supports previous conclusions made by the Working Group (Anon., 1981) that controlling minimum mesh sizes has no conservation value in the commercial mackerel fisheries. This infers that using a minimum mesh size of 80 mm in the mackerel fishery would also have no conservation value.

### 6.2 The Effects of Closed Areas and Closed Seasons

#### 6.2.1 Divisions VIIe,f

The "Mackerel box" around the Cornish Peninsula, which was recommended by ACFM, is between 5° and 7°W and 49°30' to 50°30'N. The eastern boundary of this area (5°W) is 3° further west than was originally recommended by this Working Group (Anon., 1979).

In Figure 6.1, the percentage frequencies of mackerel less than 30 cm total length in the commercial fisheries (Dutch, English and Irish) are shown by statistical rectangles, by quarters October-December 1980 to January-March 1982. These distributions show quite clearly that the eastern boundary of the restricted area should be moved to 2°W.

Mackerel catches north of 49°30'N and between 2° and 5°W contain immature ( < 30 cm) mackerel just as often as they do between 5° and 7°W. The data available for the fourth quarter of 1981 suggest that a further northward extension of the restricted area should be considered. Consideration should also be given to the prohibition of fishing for mackerel between 49°30'N and 52°N and from 2°W to 9°W (shaded area in Figures 6.1 and 6.2).

On the basis of the selectivity data presented by the Netherlands, the Working Group wishes to reiterate its original recommendation that there should be no fishing for mackerel with non-selective gears permitted within the restricted area during the closed season. Indeed, on the basis of the frequency of mackerel less than 30 cm during December-January 1980/81 and 1981/82 (Figure 6.2), serious consideration should be given to closing the area around Cornwall permanently to purse-seining and trawling for mackerel. Such a closure would be in line with earlier recommendations for improving the exploitation pattern on the Western stock (Anon., 1980; Lockwood and Shepherd, 1980).

### 6.2.2 Division VIa

In the ACFM report for 1979 it was recommended that the fishery for mackerel in Division VIa should be prohibited from 1 November to 1 April in that part of the Division north of 56°N. This recommendation was based on evidence that the catches taken in that part of Division VIa in winter were composed predominantly of mackerel belonging to the North Sea stock and they were in poor condition at that time. In the light of the depleted state of the North Sea stock, it was considered an inefficient use of the resource to take a considerable proportion of the limited catches which could be taken from the stock under these conditions. This recommendation has never been acted upon by the management bodies.

The desirability of enforcing this recommendation has, however, increased in subsequent years; partly because the North Sea mackerel stock has continued to decline to progressively lower levels, and partly because the proportion of the total catch in numbers of this stock taken in the northern part of Division VIa in this winter fishery has progressively increased. This proportion was 29% in 1980 and 44% in 1981. The Mackerel Working Group would accordingly suggest that this recommendation should be repeated by ACFM, with a modification only of the southern boundary of the area proposed for closure. A closure of the whole of the area north of 56°N would seem unduly restrictive in view of the fact that the winter fishery in question does not extend so far south. The Mackerel Working Group would suggest that the southern boundary of the closed area should be set at 58°N.

The likely effects of this on spawning stock biomass and yields in 1983 and 1984, on the assumption it is introduced by 1 January 1983, are shown in Table 5.2.

## 7. HORSE MACKEREL

### 7.1 Catch Statistics

Doubts exist concerning reporting of horse mackerel catches from all Sub-areas, and it is hoped that accuracy of reporting will be improved in subsequent years.

7.1.1 Horse mackerel - Sub-areas IV, VI, VII, VIII and Division IXa

International catch data (Table 7.1).

Sub-area IV. The total catch has declined dramatically since the cessation of fishing in the area by the USSR and Norway in the mid-1970s. The present catch levels of about 3 000 tonnes represent by-catch in other fisheries.

Sub-area VI (Table 7.2). There has been an increase in the area since the mid-1970s from about 4 000 tonnes per annum to the present level of 10 000 tonnes in 1981.

Sub-area VII (Table 7.3). There is a difficulty in assessing trends because of misreporting of catches in recent years, which were taken in the Sub-area VII fishery.

Sub-area VIII (Table 7.4). Catches appear to have stabilized around 40 000 tonnes following the decline from a peak of 130 000 tonnes in 1976, after which time the USSR ceased fishing in EEC waters.

Division IXa (Table 7.4). Landings reached a peak of 67 000 tonnes in 1977 (which included 15 000 tonnes taken by the USSR), since when there has been a decline to the present level of 40 000 tonnes. Catch data from Spain and Portugal have been revised since the 1981 meeting of the Working Group.

7.2 The Horse Mackerel Fisheries

7.2.1 United Kingdom fishery in Sub-areas IV, VI and VII

Catches from Sub-areas IV and VI remain minimal: below 50 tonnes per annum since 1971. The catch in Sub-area VII has dropped sharply from a peak of 13 000 tonnes in 1980 to 2 520 tonnes in 1981, of which 90% was taken in the Start Point (Div.VIIe)winter fishery.A first attempt at establishing a directed fishery for horse mackerel in this area was unsuccessful, despite the presence of overwintering shoals, due to bad weather and marketing difficulties. Indications are that another attempt will be made to establish the fishery during the 1982-83 winter season.

7.2.2 Spanish and Portuguese fisheries in Sub-area VIII and Division IXa

Spanish catches account for 93% of the landings in Sub-area VIII and combined Spanish/Portuguese catches for total landings in Division IXa in 1981.

Catches by gear and catch rates were presented in 1981 (Anon., 1981). In 1981, the combined catch from Sub-areas VIII and IX totalled 75 000 tonnes, and catch rates show a decreasing trend for all gears. Research cruises carried out during the last three years seem to indicate a concomittant decrease in the stock abundance index from 1980 to 1981.

7.3 Biological Sampling and Results

7.3.1 Length compositions

Length compositions of the catches by gear for the fisheries in Sub-area VIII and Divisions VIIe and IXa are given in Tables 7.5-7.7.

Length distributions from groundfish survey records during August/September 1981 in the North Sea are bi-modal at 7 cm (O-group) and 31 cm in Divisions IVb and c. A somewhat smaller sample from Division IVa had a single mode at 37 cm. The artisanal fishery in

Divisions VIIIc and IXa shows a change from older fish (mode 36 cm) in 1980 to younger fish (mode 17 cm) in 1981. From the length compositions for Divisions VIIIc and IXa (Tables 7.6, 7.7) it can be seen that there is a reduction in the catch by numbers between the 22 cm and 29 cm groups, corresponding with the length at 50% maturity (23 cm, 2-3 years old). This has been a constant feature of the catch compositions in the Portuguese/Spanish fishery since data were first collected in 1976.

The winter fishery in Division VIIe was bi-modal at 21 cm and 27-28 cm (Table 7.5). Age compositions of the catch show a predominance of 2 year old fish corresponding with lengths in the range 17-23 cm from mean age at length data.

7.3.2 Mean weight at age and raised age/length keys

Summaries of these data are presented in Table 7.8. Because of uncertainties about the reliability of ageing techniques for horse mackerel, it was felt by the Working Group that horse mackerel age/length keys presented for 1981 could not be used.

7.3.3 Maturity, sex ratio and growth parameters

Maturity stages during the year in Division IXa are presented in Figure 7.1. It shows an extended spawning season from January to June, with a peak during March and April. Indications are that the spawning is later in Sub-areas VII and VIII. Fish, which are not mature, make the largest part of the catch over the whole year.

The maturity ogive (Figure 7.2) shows 50% maturity at 23 cm. Observed sex ratio throughout the year were 1:1. The same results were obtained using combined data from Sub-areas VI, VII and VIII for 1979-81 inclusive. Estimates of growth parameters obtained by different countries are summarized in Table 11.

7.4 Egg Surveys

Horse mackerel eggs picked out from samples taken during the Western mackerel stock egg survey cruises in June 1977 and April, May and July 1980, have been worked up, and an attempt made to estimate the horse mackerel SSB, using the same methods as applied to the mackerel egg surveys (Lockwood, Nichols and Dawson, 1981; Lockwood *et al.*, 1981).

The fecundity estimate applied was the mean fecundity estimated over all lengths as given by Macer (1972). A 1:1 sex ratio was assumed as indicated by available data. The observed mean length of 32.9 cm on the spawning grounds, giving a mean weight of 300 g, was used to raise the spawning stock numbers to biomass in 1977. For 1980, a mean length of 32.0 was derived from all available data relating to the spawning grounds at the time of the surveys, giving a mean weight of 271 g, using 1981 weight at length data.

The June 1977 sample covered the Celtic Sea area only, and by extrapolation of the egg production curve to the beginning of March and the end of July (the duration of the mackerel spawning), a spawning stock biomass estimate of $1.53 \times 10^6$ tonnes was obtained. This can be compared with the SSB estimate of $1.4 \pm 0.4 \times 10^6$ tonnes obtained from a trawling survey (Nazaroff *et al.*, 1978).The 1980 samples, covering the continental shelf edge from Division VIIIc east of 3°W to Division VIa (55°00'N), gave an estimated SSB of $0.593 \times 10^6$ tonnes. The greatest intensity of spawning was observed in Division VIIIb. The bulk of the observed spawning occurred south of 49°N, and the peak of spawning was probably later than was observed for mackerel (Figure 7.3).

The results available to the Working Group from egg surveys can only provide very general estimates of horse mackerel spawning stock biomass, probably no better than an indication of the order of magnitude. Outstanding samples from the 1980 egg surveys should be processed as a matter of priority, and the results made available to the 1983 Working Group meeting.

## 7.5 Mortality Estimates

7.5.1 The estimates of spawning stock biomass given in Section 7.4 would infer that fishing mortality rates could be estimated for 1977 and 1980 from the catch data for these years. This has not been done, because the Working Group felt that little confidence could be placed on the recorded catch data from the relevant Sub-areas.

Using the observed age composition of the United Kingdom fishery in Division VIIe in 1981, and assuming full recruitment to the fishery to occur at age 3, Z was estimated from the relative proportions of the 3-9 and 4-10 year old fish. The estimate of Z obtained was 0.3.

### 7.5.2 Estimation of mortality on horse mackerel in Sub-area VIII and Div. IXa

A catch curve was constructed, utilizing data available from Sub-area VIII and Division IXa combined for 1980 and 1981 (Tables 7.9-7.10). These data (Figure 7.4) indicated a higher exploitation rate on age groups 1-4 than on age groups 5-8. However, due to problems associated with ageing and the absence of a rationale to explain the phenomenon, the Working Group feels that a more detailed analysis should be performed to substantiate this relationship.

The data available on length composition indicate that the current catch is composed primarily of young fish, caught mainly by trawl and purse seine. The heavy exploitation upon this component of the stock seriously reduces the number of fish available for recruitment to the spawning stock.

## 7.6 Mesh Selectivity Data

Selectivity experiments on horse mackerel have been conducted in ICES Divisions VIIIc and IXa (Robles *et al.*, 1980), and more recently in the Celtic Sea by the Netherlands (Eltink, unpubl.data). Experimental data are given in the text table below.

| | Area | Mesh size (mm) | $L_{50}$ (cm) | Selection factor | $L_{75}-L_{25}$ (cm) |
|---|---|---|---|---|---|
| Robles *et al.* 1980 | VIIIc, IXa | 61 | 28.90 | 4.74 | 6.3 |
| Robles *et al.* 1980 | VIIIc, IXa | 74 | 33.98 | 4.59 | 5.3 |
| Eltink 1981 | VIIe | 67 | 27.6 | 4.1 | 2.7 |

## 7.7 Yield per Recruit in ICES Divisions VIIIc and IXa

Yield per recruit model, considering different ages at first catch and a range of Fs was applied. The following input parameters were used: M = 0.2, and weight at age in the catch and in the stock given in Table 7.9.

The results given in Figure 7.5 suggest that there is a potential for increase in both yield and spawning stock biomass per recruit, if the age of first capture is raised to 4 years. This objective should be achieved by directing effort away from areas of high juvenile abundance and also by the immediate enforcement of the legitimate minimum mesh size in trawl fisheries.

7.8 Reliability of Data Base

The data base is very weak for carrying out any quantitative assessment other than the general conclusion that the exploitation pattern requires drastic modifications in Divisions VIIIc and IXa.

8. DEFICIENCIES IN DATA ON MACKEREL AND HORSE MACKEREL

The reliability of national catch statistics officially reported to ICES has been commented upon in Section 2.4.

For North Sea and Western stock mackerel, three other points need being mentioned:

a) the stock separation in Divisions IIa, IVa and part of VIa should be further investigated (i.e., extension of parasite studies, external tagging programmes, meristic characters...);

b) estimates of F: further work should be carried out to calculate estimates of F, which could be used in stock assessments, e.g. work or cpue in non-directed fisheries, on research vessel surveys;

c) recruitment: at present data on recruitment on which to base the catch forecasts are negligible. Investigations should be made on nursery areas of mackerel to get abundance indices of incoming year classes.

For horse mackerel, during the time available to the Working Group it was not possible to fully investigate the data already available or which could be prepared for stock assessments. Therefore, the Group felt it useful that an ad hoc group should be set up to work out the inventory of existing data and specify the points which need improvement.

As pointed out in Section 7.3.2, problems exist in age determination of horse mackerel and hence in the calculation of the age structure of catches. The Working Group, therefore, recommends that a workshop on interpretation of horse mackerel otoliths reading should be convened.

9. SAFE BIOLOGICAL LIMITS

The Working Group was asked by the Chairman of ACFM to evaluate whether predicted catches were within "safe biological limits".

The primary consideration in this must be, whether a predicted catch is likely to reduce the spawning stock below the level at which future recruitment will be adversely affected or will accentuate the situation, where potential recruitment is thought to be already affected by the spawning capacity of the stock.

In previous reports of the Working Group (Anon., 1980), the data available for both the North Sea and Western stocks were analysed from this viewpoint. No clear evidence of a stock/recruitment relationship was found for either stock. In the case of the Western stock, this lack of evidence can perhaps be given some credence, because recruitment to this stock has shown relatively little variation in the short period for which adequate data are available, despite an appreciable decline in spawning stock biomass. Caution should be exercised, however, in accepting any management policy, which will reduce this spawning stock to an even lower level, because a stock-induced decline in recruitment is unlikely to be detected for several years after the stock has been reduced beyond the critical level.

The situation in the North Sea stock is very different. In that case, the longer series of data would point to this stock having been maintained, even in periods of high stock size and low exploitation, by very large year classes at infrequent intervals with low recruitment in intervening years (Hamre, 1980). In that situation, a very long series of data would be necessary to demonstrate stock-induced recruitment failure. In the case of this stock, no major year class has recruited since that spawned in 1969, and the spawning stock is now only about 12% of that in the early 1960s. Under these circumstances, although a clear relationship between stock and recruitment cannot be demonstrated, it would seem likely that the long period of more than ten years without the production of a really strong year class is a result of serious stock depletion. The primary consideration of management must, therefore, be to rebuild the stock, as quickly as possible, to a much higher level.

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Table 2.1 Nominal catch (tonnes) of MACKEREL in the North Sea, Skagerrak and Kattegat (IV and IIIa) 1972-1981 (Data for 1972-1976 as officially reported to ICES. Data from 1977 onwards were submitted by Working Group members).

| Country \ Year | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981* |
|---|---|---|---|---|---|---|---|---|---|---|
| Belgium | 129 | 78 | 145 | 134 | 292 | 49 | 10 | 10 | 5 | 55 |
| Denmark | 2 023 | 7 459 | 3 890 | 9 836 | 27 988 | 21 833 | 18 068 | 19 171 | 13 234 | 9 716 |
| Faroe Islands | 7 551 | 11 202 | 18 625 | 23 424 | 63 476 | 42 836 | 33 911 | 28 118 | 14 770 | - |
| France | 6 882 | 636 | 2 254 | 2 749 | 2 607 | 2 529 | 3 452 | 3 620 | 2 238 | 3 212 |
| Germany, Dem.Rep. | 346 | 214 | 234 | 141 | 259 | 41 | 233 | - | - | - |
| Germany, Fed.Rep. | 374 | 563 | 270 | 276 | 284 | - | 284 | 211 | 56 | 1 167 |
| Iceland | 687 | 3 079 | 4 689 | 198 | 302 | - | - | - | - | - |
| Ireland | | | | | | | | - | 738 | - |
| Netherlands | 4 436 | 2 339 | 3 259 | 2 390 | 2 163 | 2 673 | 1 065 | 1 009 | 853 | 1 714 |
| Norway | 160 141 | 277 304 | 248 314 | 206 871 | 197 351 | 180 800 | 82 959 | 90 720 | 44 781 | 28 822 |
| Poland | 244 | 561 | 4 520 | 2 313 | 2 020 | 298 | - | - | - | - |
| Sweden | 4 748 | 2 960 | 3 579 | 4 789 | 6 448 | 4 012 | 4 501 | 3 935 | 1 666 | 2 020 |
| UK (England & Wales) | 32 | 31 | 61 | 33 | 89 | 105 | 142 | 95 | 76 | 6 520 |
| UK (Scotland) | 395 | 2 943 | 390 | 578 | 1 199 | 1 590 | 3 704 | 5 272 | 9 514 | 3 133 |
| USSR | 611 | 17 150 | 8 161 | 9 330 | 1 231 | 2 765 | 488 | 162 | - | - |
| Unallocated | | | | | | | | 500 | | 3 216 |
| Total | 188 599 | 326 516 | 298 391 | 263 062 | 305 709 | 259 531 | 148 817 | 152 840 | 87 931 | 59 575 |

*)Preliminary

Note: In contrast to the corresponding tables in Working Group reports for years prior to 1981, the catches do not include catches taken in Sub-area IIa.

Table 2.2 Nominal catches (tonnes) of MACKEREL in the Norwegian Sea (Division IIa) 1972-1981

| Country \ Year | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981[3)] |
|---|---|---|---|---|---|---|---|---|---|---|
| Denmark[2)] | | | | | | | | | - | 806 |
| Faroe Islands[1)] | - | - | - | - | - | - | 283 | 6 | 270 | - |
| France[2)] | - | - | - | 7 | 8 | - | 2 | - | - | 4 |
| Germany, Dem.Rep.[2)] | - | - | 11 | - | - | - | - | - | - | 51 |
| Germany, Fed.Rep.[2)] | - | - | - | - | - | - | 53 | 174 | 2 | - |
| Netherlands[2)] | - | - | - | - | 2 | - | - | - | - | - |
| Norway[1)] | 88 | 21 573 | 6 818 | 34 662 | 10 516 | 1 400 | 3 867 | 6 887 | 6 618 | 12 220 |
| UK (England & Wales)[1)] | - | - | + | + | + | + | 1 | - | - | 255 |
| USSR[3)] | - | - | - | - | - | - | - | 5 | 1 450 | 3 640 |
| Total | 88 | 21 573 | 6 829 | 34 669 | 10 526 | 1 400 | 4 206 | 7 072 | 8 340 | 16 976 |

1) Data provided by Working Group Members

2) Data reported to ICES

3) Preliminary

Table 2.3 Landings of Mackerel (tonnes) by quarter. 1981

| Fishing Area | Quarters | | | | Not known | TOTAL |
|---|---|---|---|---|---|---|
| | I | II | III | IV | | |
| IIa | - | - | 16 976 | - | - | 16 976 |
| IIIa-IV | 1 866 | 5 724 | 46 330 | 1 607 | 4 048 | 59 575 |
| VI | 24 331 | 9 002 | 95 222 | 213 157 | - | 341 712 |
| VII | 118 623 | 49 795 | 24 966 | 65 915 | | 259 299 |
| VIII | 658 | 1 079 | 1 005 | 810 | 11 469 | 15 021 |
| IX | 855 | 549 | 864 | 840 | 6 457 | 9 565 |

Table 2.4  Nominal catch (tonnes) of MACKEREL in the western area (VI, VII and VIII)
(Data for 1972-1977 as officially reported to ICES)

| Country \ Year | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978** | 1979** | 1980** | 1981* **) |
|---|---|---|---|---|---|---|---|---|---|---|
| Belgium | 1 | 3 | 7 | 17 | 10 | 1 | 1 | 3 | - | - |
| Denmark | - | - | - | - | 3 | 698 | 8 677 | 8 535 | 14 932 | 13 464 |
| Faroe Islands | - | 635 | 8 659 | 1 760 | 5 539 | 3 978 | 15 076 | 10 609 | 15 234 | 19 799 |
| France | 35 354 | 41 664 | 37 824 | 25 818 | 33 556 | 35 702 | 34 860 | 31 510 | 23 907 | 14 829 |
| Germany, Dem.Rep. | 214 | 1 733 | 2 885 | 9 693 | 4 509 | 431 | - | - | - | - |
| Germany, Fed.Rep. | 98 | 559 | 993 | 1 941 | 391 | 446 | 28 873 | 21 493 | 21 088 | 29 221 |
| Iceland | 74 | 52 | - | 21 | 10 | - | - | - | - | - |
| Ireland | 4 592 | 8 314 | 8 526 | 11 567 | 14 395 | 23 022 | 27 508 | 24 217 | 40 791 | 92 271 |
| Netherlands | 6 166 | 7 785 | 7 315 | 13 263 | 15 007 | 35 766 | 50 815 | 62 396 | 91 081 | 88 117 |
| Norway | - | 34 600 | 32 597 | 1 907 | 4 252 | 362 | 1 900 | 25 414 | 25 500 | 21 610 |
| Poland | 13 219 | 10 536 | 22 405 | 21 573 | 21 375 | 2 240 | - | 92 | - | 1 |
| Spain+ | 31 416 | 25 677 | 30 177 | 23 408 | 18 480 | 21 853 | 19 142 | 15 556 | 15 000 | 11 469 |
| Sweden | - | - | - | - | 38 | - | - | - | - | - |
| UK (England & Wales) | 6 923 | 13 081 | 21 132 | 31 546 | 57 311 | 132 320 | 213 344 | 244 293 | 150 598 | 75 722 |
| UK (N. Ireland) | 57 | 93 | 75 | 30 | 95 | 97 | 46 | 25 | - | - |
| UK (Scotland) | 1 412 | 5 170 | 8 466 | 16 174 | 28 399 | 52 662 | 103 671 | 103 160 | 108 372 | 109 153 |
| USSR | 71 249 | 65 202 | 103 435 | 309 666 | 262 384 | 16 396 | - | - | - | - |
| Unallocated | | | | | | | | 54 000 | 98 258 | 140 322 |
| Total, ICES members | 170 775 | 215 104 | 284 496 | 468 384 | 465 754 | 325 974 | 503 913 | 601 303 | 604 761 | 616 032 |
| Bulgaria | - | 4 341 | 13 558 | 20 830 | 28 195 | - | - | - | - | - |
| Rumania | - | - | - | 2 166 | 13 222 | - | - | - | - | - |
| Grand Total | 170 775 | 219 445 | 298 054 | 491 380 | 507 178 | 325 974 | 503 913 | 601 303 | 604 761 | 616 032 |

* Preliminary

**) Working Group estimate

\+ Includes *S japonicus*

Table 2.5 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* | 341 712 | 274 320 | 9 565 |

* Preliminary

Table 2.6 Nominal catch (tonnes) of Mackerel in Sub-area IX

| Country | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 x) |
|---|---|---|---|---|---|---|---|---|---|---|
| Portugal | 1 082 | 1 635 | 2 329 | 2 244 | 2 595 | 1 743 | 1 555 | 1 071 | 1 921 | 3 108 |
| Spain | 2 305 | 2 334 | 3 264 | 3 345 | 2 520 | 2 935 | 6 221 | 6 280 | 2 719 | 6 457 |
| France | - | - | - | 1 | - | - | - | - | - | - |
| Poland | - | - | - | - | - | 8 | - | - | - | - |
| USSR | - | - | - | 44 | 466 | 2 879 | 189 | 111 | - | - |
| Total | 3 387 | 3 969 | 5 593 | 5 634 | 5 581 | 7 565 | 7 965 | 7 462 | 4 640 | 9 565 |

x) Preliminary

Table 4.1 Catch in numbers (x $10^{-6}$) for North Sea and Skagerrak in 1981

| Year class | IVa + IIIa | IVb,c | Total IV and IIIa |
|---|---|---|---|
| pre-1967 | 1.2 | 0.2 | 1.4 |
| 1967 | 1.8 | 0.4 | 2.2 |
| 1968 | 1.3 | 0.2 | 1.5 |
| 1969 | 9.5 | 7.3 | 16.8 |
| 1970 | 1.0 | 0.7 | 1.7 |
| 1971 | 3.2 | 2.9 | 6.1 |
| 1972 | 2.1 | 2.7 | 4.8 |
| 1973 | 4.0 | 4.3 | 8.3 |
| 1974 | 8.1 | 7.8 | 15.9 |
| 1975 | 5.6 | 9.3 | 14.9 |
| 1976 | 3.8 | 7.2 | 11.0 |
| 1977 | 0.5 | 0.6 | 1.1 |
| 1978 | 3.4 | 7.3 | 10.7 |
| 1979 | 1.2 | 4.8 | 6.0 |
| 1980 | 2.3 | 1.6 | 3.9 |
| 1981 | - | - | |

Table 4.2 Percentage age compositions of catches in the winter fisheries in the northern part of Division VIa compared with those in the North Sea and Western Stock spawning grounds in 1981

| Age | Div. VIa (north) | | Western Spawning Stock | Div. IVb |
|---|---|---|---|---|
| | Feb. | Nov. | | June |
| 1 | 0 | 0 | 1 | 0 |
| 2 | 1 | 0 | 15 | + |
| 3 | 6 | 1 | 15 | 2 |
| 4 | 0 | 1 | 1 | 1 |
| 5 | 7 | 2 | 14 | 5 |
| 6 | 8 | 6 | 16 | 8 |
| 7 | 10 | 6 | 7 | 17 |
| 8 | 7 | 9 | 10 | 6 |
| 9 | 4 | 5 | 2 | 4 |
| 10 | 8 | 11 | 8 | 6 |
| 11 | 8 | 3 | | 5 |
| 12 | 32 | 37 | | 36 |
| 13 | 2 | 10 | 13 | 3 |
| 14 | 4 | 6 | | 4 |
| ≥15 | 3 | 3 | | 3 |
| No. of otoliths | 95 | 198 | 950 | 480 |

Table 4.3 Catch in numbers (x $10^{-6}$) of the North Sea stock in Sub-area IV and Divisions IIa, IIIa and VIa in 1981

| Year Class | Divisions | | | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | IVa | | | IVb + IVc | IIIa | VIa | IIa | |
| | Open Area | Norwegian Coast | Sum | | | | | |
| pre-1967 | 0.1 | 0.7 | 0.8 | 0.2 | 0.1 | 1.7 | 0.1 | 2.9 |
| 1967 | 0.2 | 1.0 | 1.2 | 0.4 | 0.2 | 3.5 | 0.2 | 5.5 |
| 1978 | 0.1 | 0.7 | 0.8 | 0.2 | 0.2 | 5.2 * | 0.3 | 6.7 |
| 1979 | 1.0 | 3.8 | 4.8 | 7.3 | 2.6 | 26.0 | 1.5 | 42.2 |
| 1970 | 0.1 | 0.4 | 0.5 | 0.7 | 0.3 | 5.2 | 0.3 | 7.0 |
| 1971 | 0.1 | 1.6 | 1.7 | 2.9 | 0.4 | 5.2 | 0.3 | 10.5 |
| 1972 | 0.2 | 0.7 | 0.9 | 2.7 | 0.4 | 6.7 | 0.3 | 11.0 |
| 1973 | 0.5 | 1.5 | 2.0 | 4.2 | 0.6 | 8.2 | 1.0 | 16.0 |
| 1974 | 1.8 | 3.1 | 4.9 | 7.8 | 2.3 | 8.4 | 2.0 | 25.4 |
| 1975 | 1.7 | 2.2 | 3.9 | 9.3 | 0.8 | 6.9 | 1.9 | 22.8 |
| 1976 | 1.8 | 1.6 | 3.4 | 7.2 | 0.5 | 3.1 | 0.8 | 15.0 |
| 1977 | 0.1 | 0.2 | 0.3 | 0.6 | 0.2 | 1.0 | 0.2 | 2.3 |
| 1978 | 1.7 | 1.3 | 3.0 | 7.3 | 0.4 | 1.7 | 0.3 | 12.7 |
| 1979 | 0.8 | + | 0.8 | 4.8 | 0.4 | 0.4 | 0 | 6.4 |
| 1980 | 0.6 | 0 | 0.6 | 1.6 | 1.7 | + | 0 | 3.9 |
| 1981 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*) Distributed on age groups as catch of North Sea stock in Division IIa

Table 4.4 Catch in numbers (x $10^{-3}$) of the Western stock by year class in 1981. These numbers include estimated number of fish discarded and unreported.

| Year Class | Divisions | | | | | Total |
|---|---|---|---|---|---|---|
| | IIa+IVa | VIa | VIIa-c | VIId-k | VIIIa-c | |
| Pre-1972 | 12 300 | 207 653 | 29 296 | 61 664 | 6 378 | 317 291 |
| 1972 | 2 000 | 17 380 | 2 115 | 7 609 | 1 002 | 31 106 |
| 1973 | 4 300 | 59 159 | 16 237 | 28 163 | 1 567 | 109 426 |
| 1974 | 2 400 | 53 108 | 8 041 | 29 639 | 1 090 | 94 278 |
| 1975 | 1 900 | 74 111 | 14 129 | 62 514 | 2 232 | 154 886 |
| 1976 | - | 55 560 | 21 976 | 91 159 | 3 270 | 171 965 |
| 1977 | - | 12 187 | 2 012 | 18 493 | 2 521 | 35 213 |
| 1978 | - | 30 954 | 14 603 | 176 262 | 6 662 | 228 481 |
| 1979 | - | 42 460 | 20 047 | 424 561 | 21 033 | 508 101 |
| 1980 | - | 7 596 | 647 | 210 921 | 46 847 | 266 011 |
| 1981 | - | - | - | 5 052 | 33 295 | 38 347 |
| Total | 22 900 | 560 168 | 130 103 | 1 116 037 | 125 894 | 1 955 105 |

Table 4.5 Catch in numbers (x $10^{-3}$) in Sub-area IX from pre-1972 to 1981

| Year class | Numbers | Percentage |
|---|---|---|
| Pre-1972 | 74 | 0.21 |
| 1973 | 17 | 0.05 |
| 1974 | 31 | 0.09 |
| 1975 | 69 | 0.20 |
| 1976 | 85 | 0.24 |
| 1977 | 210 | 0.60 |
| 1978 | 1 219 | 3.45 |
| 1979 | 3 988 | 11.30 |
| 1980 | 13 651 | 38.68 |
| 1981 | 15 944 | 45.18 |

Table 4.6. North Sea MACKEREL stock.
Catch in numbers with fishing mortalities and stock in numbers by cohort analysis, from VPA.
M = 0.15.

Catch in numbers ($10^{-6}$)

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|
| 1 | 11.9 | 2.7 | 1.1 | 0.0 | 2.3 | 2.7 | 3.9 |
| 2 | 10.1 | 73.6 | 19.3 | 8.2 | 0.5 | 14.9 | 6.4 |
| 3 | 16.2 | 69.7 | 58.9 | 34.7 | 11.3 | 2.7 | 12.7 |
| 4 | 42.4 | 13.9 | 54.3 | 40.8 | 21.2 | 18.0 | 2.3 |
| 5 | 27.8 | 33.8 | 9.8 | 27.9 | 33.3 | 28.3 | 15.0 |
| 6 | 193.2 | 19.5 | 26.6 | 6.0 | 14.3 | 30.7 | 22.8 |
| 7 | 25.6 | 118.6 | 31.6 | 14.2 | 4.2 | 19.5 | 25.4 |
| 8 | 20.4 | 31.3 | 125.9 | 16.1 | 9.2 | 9.2 | 16.0 |
| 9 | 15.8 | 8.0 | 31.2 | 45.7 | 2.0 | 18.2 | 11.0 |
| 10 | 5.0 | 9.0 | 8.3 | 14.6 | 27.0 | 5.0 | 10.5 |
| 11 | 0.5 | 4.0 | 8.8 | 5.5 | 5.2 | 27.6 | 7.0 |
| 12 | 0.2 | 0.5 | 4.5 | 5.5 | 2.0 | 5.4 | 42.2 |
| 13 | 22.2 | 0.1 | 0.8 | 2.9 | 2.0 | 1.8 | 6.7 |
| 14 | 0.0 | 3.4 | 0.1 | 0.6 | 1.2 | 2.3 | 5.5 |
| 15+ | 0.0 | 0.0 | 2.5 | 3.2 | 2.3 | 3.1 | 2.9 |
| TOTAL | 391.3 | 388.1 | 383.7 | 225.9 | 138.0 | 189.4 | 190.3 |

Fishing mortalities (M = 0.15)

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1976-1980 |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.02 | 0.01 | 0.01 | 0.00 | 0.03 | 0.05 | 0.05 | 0.02 |
| 2 | 0.02 | 0.16 | 0.07 | 0.06 | 0.03 | 0.23 | 0.15 | 0.11 |
| 3 | 0.09 | 0.22 | 0.17 | 0.16 | 0.11 | 0.23 | 0.30 | 0.18 |
| 4 | 0.16 | 0.10 | 0.25 | 0.16 | 0.13 | 0.24 | 0.30 | 0.18 |
| 5 | 0.15 | 0.17 | 0.09 | 0.18 | 0.18 | 0.24 | 0.30 | 0.17 |
| 6 | 0.20 | 0.14 | 0.18 | 0.07 | 0.13 | 0.24 | 0.30 | 0.15 |
| 7 | 0.13 | 0.17 | 0.34 | 0.13 | 0.06 | 0.24 | 0.30 | 0.19 |
| 8 | 0.21 | 0.22 | 0.26 | 0.27 | 0.11 | 0.17 | 0.30 | 0.21 |
| 9 | 0.24 | 0.11 | 0.33 | 0.13 | 0.05 | 0.33 | 0.30 | 0.19 |
| 10 | 0.17 | 0.19 | 0.15 | 0.24 | 0.10 | 0.15 | 0.30 | 0.17 |
| 11 | 0.08 | 0.19 | 0.28 | 0.14 | 0.12 | 0.14 | 0.30 | 0.17 |
| 12 | 0.22 | 0.09 | 0.33 | 0.27 | 0.06 | 0.17 | 0.30 | 0.18 |
| 13 | 0.74 | 0.16 | 0.20 | 0.34 | 0.14 | 0.07 | 0.30 | 0.18 |
| 14 | 0.00 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.30 | 0.22 |
| 15+ | 0.00 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.30 | 0.22 |
| F( 3-14),U | 0.20 | 0.17 | 0.23 | 0.19 | 0.12 | 0.20 | 0.30 | |
| F( 3-14),W | 0.18 | 0.17 | 0.23 | 0.16 | 0.12 | 0.21 | 0.30 | |

Stock size in numbers ($10^{-6}$) at 1 January - Biomass units tonnes x $10^{-3}$

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| 1 | 653 | 368 | 171 | 19 | 92 | 60 | 93 | ********** |
| 2 | 459 | 551 | 314 | 146 | 17 | 77 | 49 | 77 |
| 3 | 200 | 386 | 406 | 253 | 118 | 14 | 53 | 37 |
| 4 | 317 | 157 | 267 | 295 | 185 | 91 | 10 | 34 |
| 5 | 214 | 233 | 123 | 180 | 216 | 140 | 62 | 6 |
| 6 | 1160 | 158 | 169 | 96 | 129 | 155 | 94 | 40 |
| 7 | 227 | 820 | 118 | 121 | 77 | 98 | 105 | 60 |
| 8 | 117 | 172 | 596 | 72 | 91 | 63 | 66 | 67 |
| 9 | 81 | 82 | 119 | 397 | 48 | 70 | 46 | 42 |
| 10 | 34 | 55 | 63 | 74 | 299 | 39 | 43 | 29 |
| 11 | 7 | 24 | 39 | 47 | 50 | 233 | 29 | 28 |
| 12 | 1 | 6 | 17 | 25 | 35 | 38 | 175 | 18 |
| 13 | 45 | 1 | 5 | 11 | 17 | 28 | 28 | 111 |
| 14 | 0 | 18 | 1 | 3 | 7 | 13 | 23 | 18 |
| 15+ | 0 | 0 | 14 | 17 | 13 | 17 | 12 | 22 |
| TOTAL | 3514 | 3031 | 2422 | 1757 | 1394 | 1136 | 888 | |
| SPAWN. ST. | 2403 | 2113 | 1937 | 1592 | 1285 | 999 | 745 | |
| Total Biomass | 1095 | 1057 | 893 | 706 | 571 | 484 | 381 | |
| SSB | 908 | 883 | 798 | 670 | 556 | 458 | 358 | |

Table 4.7 Catch per unit effort (tonnes/1 000 hook hours) in the Cornish winter handline fishery

| Winter | CPUE |
|---|---|
| 1972/73 | 5.02 |
| 1973/74 | 4.81 |
| 1974/75 | 3.33 |
| 1975/76 | 3.20 |
| 1976/77 | 2.18 |
| 1977/78 | 2.31 |
| 1978/79 | 1.51 |
| 1979/80 | 2.11 |
| 1980/81 | 3.24 (1.52)* |
| 1981/82 | 1.50 |

* Fitted estimate

Table 4.8 Alternative levels of F in 1981 with resultant spawning stock numbers in 1980 and spawning stock biomass in 1981

| | Method* | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Age 2 | 0.24 | 0.25 | 0.60 | 0.48 |
| 3 | 0.24 | 0.28 | 0.60 | 0.48 |
| 4 | 0.24 | 0.30 | 0.60 | 0.48 |
| 5 | 0.24 | 0.48 | 0.65 | 0.48 |
| 6 | 0.24 | 0.45 | 0.45 | 0.48 |
| 7 | 0.24 | 0.37 | 0.28 | 0.48 |
| 8 | 0.24 | 0.26 | 0.22 | 0.48 |
| 9 | 0.26 | 0.41 | 0.37 | 0.48 |
| 10+ | 0.26 | 0.41 | 0.37 | 0.48 |
| Spawning stock 1 June 1980 ($10^{-6}$ fish) | 6.200 | 4 900 | 4 500 | 3 700 |
| Spawning biomass 1 June 1981 ($10^{-3}$ tonnes) | 1 771 | 1 222 | 1 161 | 919 |

* Method 1: from VPA output
Method 2: from cpue series
Method 3: $\log_e$ difference of adjacent age groups in 1980 and 1981
Method 4: $\log_e$ difference at ages 2-8 in 1980 and ages 3-9 in 1981

<u>Table 4.9</u>. Western MACKEREL stock.
Catch in numbers with fishing mortalities and stock in numbers estimated by cohort analysis, from VPA. M = 0.15.

Catch in numbers ($10^{-6}$)

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 34 | 2 | 10 | 80 | 20 | 38 |
| 1 | 53 | 279 | 154 | 31 | 351 | 485 | 266 |
| 2 | 104 | 185 | 290 | 564 | 62 | 460 | 508 |
| 3 | 95 | 322 | 154 | 425 | 603 | 75 | 229 |
| 4 | 306 | 171 | 166 | 244 | 366 | 377 | 35 |
| 5 | 192 | 289 | 51 | 258 | 217 | 277 | 172 |
| 6 | 144 | 119 | 140 | 72 | 233 | 140 | 155 |
| 7 | 1246 | 280 | 64 | 152 | 87 | 154 | 94 |
| 8 | 0 | 439 | 89 | 57 | 154 | 51 | 109 |
| 9 | 0 | 0 | 159 | 83 | 71 | 136 | 31 |
| 10+ | 0 | 0 | 0 | 211 | 264 | 193 | 317 |
| Total | 2141 | 2117 | 1268 | 2107 | 2486 | 2367 | 1955 |

Fishing mortalities (M = 0.15)

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|
| 0 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 | 0.01 | 0.01 |
| 1 | 0.02 | 0.08 | 0.04 | 0.07 | 0.16 | 0.16 | 0.12 |
| 2 | 0.03 | 0.09 | 0.10 | 0.21 | 0.18 | 0.31 | 0.24 |
| 3 | 0.09 | 0.13 | 0.09 | 0.20 | 0.33 | 0.33 | 0.24 |
| 4 | 0.12 | 0.23 | 0.09 | 0.19 | 0.25 | 0.34 | 0.24 |
| 5 | 0.20 | 0.15 | 0.09 | 0.18 | 0.25 | 0.28 | 0.24 |
| 6 | 0.11 | 0.17 | 0.09 | 0.17 | 0.24 | 0.24 | 0.24 |
| 7 | 0.37 | 0.32 | 0.13 | 0.13 | 0.31 | 0.23 | 0.24 |
| 8 | 0.00 | 0.20 | 0.15 | 0.15 | 0.18 | 0.28 | 0.24 |
| 9 | 0.00 | 0.00 | 0.10 | 0.19 | 0.26 | 0.23 | 0.26 |
| 10+ | 0.00 | 0.00 | 0.10 | 0.19 | 0.26 | 0.23 | 0.26 |
| $F_{(2-8)},W$ | 0.18 | 0.17 | 0.10 | 0.19 | 0.26 | 0.29 | 0.24 |
| $F_{(3-8)},W$ | 0.22 | 0.18 | 0.10 | 0.18 | 0.27 | 0.29 | 0.24 |

Stock size in numbers ($10^{-6}$) at 1 January. Biomass: thousand tonnes.

| | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|---|---|---|---|
| 0 | 4748 | 4628 | 580 | 2919 | 4142 | 2960 | 3457 | ********** |
| 1 | 2832 | 4086 | 3952 | 497 | 2503 | 3492 | 2529 | 2940 |
| 2 | 3351 | 2389 | 3258 | 3259 | 399 | 1829 | 2557 | 1931 |
| 3 | 1154 | 2788 | 1885 | 2536 | 2284 | 286 | 1150 | 1731 |
| 4 | 2956 | 906 | 2101 | 1480 | 1790 | 1410 | 177 | 778 |
| 5 | 1146 | 2261 | 622 | 1655 | 1048 | 1203 | 865 | 120 |
| 6 | 1443 | 809 | 1679 | 488 | 1185 | 702 | 779 | 586 |
| 7 | 4302 | 1109 | 586 | 1315 | 354 | 805 | 475 | 528 |
| 8 | 0 | 2553 | 696 | 445 | 991 | 224 | 550 | 321 |
| 9 | 0 | 0 | 1791 | 517 | 331 | 711 | 146 | 373 |
| 10+ | 0 | 0 | 0 | 1309 | 1236 | 1009 | 1488 | 1084 |
| TOTAL | 21931 | 21527 | 17150 | 16419 | 16263 | 14630 | 14173 | |
| SPAWN. ST. | 11997 | 10890 | 10413 | 9957 | 8798 | 7339 | 6598 | |
| Total stock biom. 1 Jun. 1-10+ | 3584 | 3419 | 3535 | 3130 | 2763 | 2438 | 2242 | |
| SSB 1 Jun. | 2925 | 2673 | 2780 | 2649 | 2346 | 1962 | 1771 | |

Table 5.1 Input for catch forecasts. North Sea MACKEREL ($M = 0.15$)

| Age | Stock Number in 1982 (x 10-6) | Reference Fishing Pattern (= $F_{81}$) | Weight at Age in Catch | Weight at Age in Stock at 1 Jan. | Maturity Ogive |
|---|---|---|---|---|---|
| 1 | 20.0 | 0.046 | .245 | .123 | 0 |
| 2 | 76.7 | 0.15 | .329 | .234 | 0 |
| 3 | 36.6 | 0.3 | .363 | .325 | 1 |
| 4 | 33.5 | 0.3 | .392 | .335 | 1 |
| 5 | 6.1 | 0.3 | .438 | .350 | 1 |
| 6 | 39.6 | 0.3 | .455 | .346 | 1 |
| 7 | 60.2 | 0.3 | .520 | .468 | 1 |
| 8 | 67.0 | 0.3 | .580 | .472 | 1 |
| 9 | 42.2 | 0.3 | .585 | .505 | 1 |
| 10 | 29.0 | 0.3 | .610 | .535 | 1 |
| 11 | 27.7 | 0.3 | .635 | .560 | 1 |
| 12 | 18.5 | 0.3 | .655 | .585 | 1 |
| 13 | 111.4 | 0.3 | .670 | .605 | 1 |
| 14 | 17.7 | 0.3 | .675 | .615 | 1 |
| 15+ | 22.2 | 0.3 | .685 | .650 | 1 |

Table 5.2 Forecasts of stock and catch of the North Sea MACKEREL stock
Basic parameters are given in Table 5.1. Spawning stock 3+
Stock biomass and catch in tonnes x 10-3 and recruitment as number x $10^{-6}$

| 1982 | | | | | 1983 | | | | | | 1984 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock* Biomass | Spawning* Stock Biomass | Recruit-ment | $\bar{F}_{(3-14)}$ | Catch | Management Options | Stock* Biomass | Spawning* Stock Biomass | Recruit-ment | $\bar{F}_{(3-14)}$ | Catch | Management Options | Stock* Biomass | Spawning* Stock Biomass | Recruit-ment | $\bar{F}_{(3-14)}$ | Catch |
| 275 | 255 | 20 | 0.46 | 105 | Maintain catch level | 169 | 163 | 20 | 0.90 | 105 | as 1983 | - | - | 20 | >20 | 105 |
| 275 | 255 | 20 | 0.46 | 105 | $F_{83}=F_{82}$ | 169 | 163 | 20 | 0.46 | 65 | $F_{84}=F_{82}$ | 102 | 96 | 20 | 0.46 | 38 |
| 275 | 255 | 20 | 0.46 | 105 | $F_{83}=F_{81}$ | 169 | 163 | 20 | 0.3 | 45 | $F_{84}=F_{81}$ | 118 | 112 | 20 | 0.3 | 31 |
| 275 | 255 | 20 | 0.46 | 105 | VIa closure | 169 | 163 | 20 | 0.2 | 32 | VIa closure | 130 | 124 | 20 | 0.2 | 24 |
| 275 | 255 | 20 | 0.46 | 105 | $F_{83}=0.5F_{81}$ | 169 | 163 | 20 | 0.15 | 24 | $F_{84}=0.5F_{81}$ | 136 | 130 | 20 | 0.15 | 19 |
| 275 | 255 | 20 | 0.46 | 105 | No fishery | 169 | 163 | 20 | 0 | 0 | No fishery | 157 | 151 | 20 | 0 | 0 |

*at 1 January

Table 5.3 Input data used in forecasts for the Western MACKEREL Stock

| Age | Stock in Number in 1982 (x 10-6) | Fishing Pattern /1981 | Weight at Age in Catch | Weight at Age in Stock at 1 Jan. | Maturity Ogive |
|---|---|---|---|---|---|
| 1 | * | 0.5 | 0.131 | 0.113 | 0.18 |
| 2 | 1 931 | 1.0 | 0.248 | 0.131 | 0.38 |
| 3 | 1 731 | 1.0 | 0.283 | 0.201 | 0.67 |
| 4 | 770 | 1.0 | 0.343 | 0.251 | 0.89 |
| 5 | 120 | 1.0 | 0.373 | 0.264 | 0.93 |
| 6 | 586 | 1.0 | 0.455 | 0.316 | 1.0 |
| 7 | 528 | 1.0 | 0.497 | 0.380 | 1.0 |
| 8 | 321 | 1.0 | 0.508 | 0.412 | 1.0 |
| 9 | 373 | 1.0 | 0.539 | 0.511 | 1.0 |
| 10+ | 1 084 | 1.0 | 0.573 | 0.511 | 1.0 |

*Recruitment "Average" 2 550 x $10^6$ at 1 year old
"Low" 1 100 x $10^6$ at 1 year old

Proportion of F before spawning = 0.4

Table 5.4a Forecasts for the Western stock assuming low recruitment - basic parameters are given in Table 5.3. Spawning stock according to maturity ogive. Catches and stock biomass in tonnes x $10^{-3}$.

| 1982 | | | | | 1983 | | | | | 1984 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock Biomass 1 Jan. | Spawning Stock Biomass 1 June | $\bar{F}_{(2-10)}$ | Catch | Management Options | Stock Biomass 1 Jan. | Spawning Stock Biomass 1 June | $\bar{F}_{(2-10)}$ | Catch | Management Options | Stock Biomass 1 Jan. | Spawning Stock Biomass 1 June | $\bar{F}_{(2-10)}$ | Catch |
| 2 215 | 1 500 | 0.33 | 750 | Free fishing | 1 725 | 1 130 | 0.46 | 750 | Free fishing | 1 200 | 685 | 0.75 | 750 |
| | | | | $F_{83}=F_{max}$ | | 1 140 | 0.43 | 710 | $F_{84}=F_{max}$ | 1 235 | 800 | .43 | 505 |
| | | | | $F_{83}=F_{82}$ | | 1 190 | 0.33 | 570 | $F_{83}=F_{82}$ | 1 345 | 920 | 0.33 | 440 |
| | | | | $F_{83}= 0.8\ F_{82}$ | | 1 255 | 0.19 | 350 | $F_{84}=0.8F_{82}$ | 1 520 | 1 110 | 0.19 | 310 |
| | | | | $F_{83}\approx F_{0.1}$ | | 1 275 | 0.15 | 280 | $F_{84}\approx F_{0.1}$ | 1 575 | 1 175 | 0.15 | 260 |
| 2 215 | 1 555 | 0.24 | 570 | $F_{83}=F_{max}$ | 1 870 | 1 245 | 0.43 | 770 | $F_{83}=F_{max}$ | 1 325 | 870 | 0.43 | 540 |
| | | | | $F_{83}=F_{81}$ | | 1 345 | 0.24 | 470 | $F_{84}=F_{81}$ | 1 565 | 1 130 | 0.24 | 390 |
| | | | | $F_{83}=0.8F_{81}$ | | 1 370 | 0.19 | 380 | $F_{84}=0.8F_{81}$ | 1 635 | 1 210 | 0.19 | 330 |
| | | | | $F_{83}\approx F_{0.1}$ | | 1 395 | 0.15 | 305 | $F_{83}\approx F_{0.1}$ | 1 695 | 1 275 | 0.15 | 275 |

Table 5.4b Forecasts for Western stock assuming average recruitment - basic parameters are given in Table 5.3. Spawning stock according to mautrity ogive. Catches and stock biomass on tonnes x $10^{-3}$.

| 1982 | | | | | 1983 | | | | | 1984 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock Biomass 1 Jan. | Spawning Stock Biomass 1 June | $F_{(2-10)}$ | Catch | Management Options | Stock Biomass 1 Jan. | Spawning Stock Biomass 1 June | $F_{(2-10)}$ | Catch | Management Options | Stock Biomass 1 Jan. | Spawning Stock Biomass 1 June | $F_{(2-10)}$ | Catch |
| 2 380 | 1 540 | 0.33 | 750 | Free fishing | 2 050 | 1 250 | 0.38 | 750 | Free fishing | 1 735 | 980 | 0.46 | 750 |
| | | | | $F_{83}=F_{max}$ | | 1 210 | 0.43 | 830 | $F_{84}=F_{max}$ | 1 650 | 930 | 0.43 | 675 |
| | | | | $F_{83}=F_{82}$ | | 1 260 | 0.33 | 665 | $F_{84}=F_{82}$ | 1 780 | 1 060 | 0.33 | 590 |
| | | | | $F_{83}=0.8F_{82}$ | | 1 330 | 0.19 | 405 | $F_{84}=0.8F_{82}$ | 1 985 | 1 275 | 0.19 | 405 |
| | | | | $F_{83}\approx F_{0.1}$ | | 1 350 | 0.15 | 330 | $F_{84}\approx F_{0.1}$ | 2 050 | 1 345 | 0.15 | 335 |
| 2 380 | 1 580 | 0.24 | 590 | $F_{83}=F_{max}$ | 2 180 | 1 315 | 0.43 | 890 | $F_{84}=F_{max}$ | 1 745 | 1 000 | 0.43 | 715 |
| | | | | $F_{83}=F_{81}$ | | 1 418 | 0.24 | 540 | $F_{83}=F_{81}$ | 2 025 | 1 290 | 0.24 | 510 |
| | | | | $F_{83}=0.8F_{81}$ | | 1 450 | 0.19 | 440 | $F_{84}=0.8F_{81}$ | 2 105 | 1 375 | 0.19 | 430 |
| | | | | $F_{83}\approx F_{0.1}$ | | 1 470 | 0.15 | 350 | $F_{83}\approx F_{0.1}$ | 2 175 | 1 450 | 0.15 | 355 |

Table 7.1 Landings of HORSE MACKEREL in Sub-area IV, by country (in tonnes)

| Country | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981* |
|---|---|---|---|---|---|---|---|---|---|
| Belgium | 69 | 34 | 23 | 15 | 14 | 15 | 9 | 8 | 34 |
| Denmark | - | - | - | - | 63 | 1 543 | 496 | 199 | 509 |
| Faroe Islands | 3 649 | 772 | 156 | 116 | 130 | 3 | - | 260 | ? |
| France | 225 | 582 | 140 | 147 | 325 | 182 | 221 | 292 | 397 |
| German Dem. Rep. | - | - | - | 4 | - | - | - | - | - |
| Germany Fed.Rep. | 1 735 | 686 | 696 | 162 | 2 | 1 993 | 376 | + | 28 |
| Iceland | 373 | 203 | - | - | - | - | - | - | - |
| Ireland | - | - | - | - | - | - | - | 1 161 | ? |
| Netherlands | 148 | 576 | 173 | 82 | 223 | 106 | 88 | 101 | 100 |
| Norway | 16 765 | 20 713 | 2 174 | 4 842 | 450 | 1 037 | 199 | 119 | 2 250 |
| Poland | 260 | 62 | - | 11 | 6 | - | - | - | - |
| Spain | - | - | - | - | - | - | - | - | - |
| Sweden | 2 a) | 2 a) | + | - | - | ... b) | + | - | - |
| U.K.(Engl.&Wales | 20 | 5 | 3 | 11 | 22 | 36 | 23 | 11 | 15 |
| U.K. (Scotland) | - | 1 222 | 2 | + | 4 | 5 | + | - | - |
| U.S.S.R. | 18 743 | 5 894 | 6 566 | 3 278 | 87 | - | - | - | - |
| TOTAL | 41 989 | 30 751 | 9 933 | 8 668 | 1 326 | 4 920 | 1 412 | 2 151 | ? |

*) Preliminary

a) Includes IIIa

b) Included in IIIa

Table 7.2 Landings of HORSE MACKEREL in Sub-area VI, by country (in tonnes)

| Country | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981* |
|---|---|---|---|---|---|---|---|---|---|
| Belgium | - | - | - | + | - | - | - | - | - |
| Denmark | - | - | - | - | - | - | 443 | 734 | 341 |
| Faroe Islands | 1 681 | 342 | 2 | 2 | - | - | - | - | - |
| France | - | - | - | 293 | 113 | 91 | 151 | 45 | 16 |
| Ireland | - | - | - | - | - | 59 | - | - | - |
| Germany, Fed. Rep. | 101 | 209 | 263 | 5 | - | - | 155 | 5 550 | 9 925 |
| Netherlands | - | - | 106 | 69 | 19 | 114 | 6 910 | 2 385 | 4 000 |
| Norway | 3 909 | 627 | 869 | 90 | - | - | - | - | - |
| Poland | 694 | 1 067 | 479 | 48 | - | - | - | - | - |
| Spain | 5 851 | 400 | 150 | 175 | 147 | 91 | 20 | - | - |
| U.K. (Engl.& Wales) | 19 | 14 | 6 | 37 | 40 | 44 | 73 | 9 | 7 |
| U.K.(Scotland) | - | 41 | 187 | 85 | 105 | 9 | 39 | 1 | 17 |
| U.S.S.R. | 93 | 780 | 1 210 | 3 390 | 246 | - | - | - | - |
| TOTAL | 12 559 | 3 521 | 3 379 | 4 299 | 670 | 408 | 7 791 | 8 724 | 14 306 |

*Provisional

Table 7.3 Landings of HORESE MACKEREL in Sub-area VII, by country (in tonnes)

| Country | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981* |
|---|---|---|---|---|---|---|---|---|---|
| Belgium | 3 | 3 | 4 | 2 | 1 | 1 | 3 | + | - |
| Denmark | - | - | - | - | - | 2 104 | 4 287 | 5 045 | 3 099 |
| France | 2 768 | 2 466 | 2 443 | 3 800 | 2 448 | 3 564 | 4 407 | 1 983 | 1 585 |
| German Dem. Rep. | 8 | 8 | - | 92 | 45 | - | - | - | - |
| Germany, Fed.Rep. | 1 055 | 825 | 521 | 3 | 308 | 2 923 | 5 333 | 2 289 | 414 a) |
| Ireland | - | - | - | - | 1 133 | 3 388 | - | - | - |
| Netherlands | 1 | - | 41 | 280 | 2 088 | 10 556 | 25 174 | 23 002 | 40 000 |
| Norway | - | 16 | - | - | - | 29 | 959 | 394 | - |
| Poland | 2 967 | 4 643 | 1 869 | 2 967 | 640 | 61 | - | - | - |
| Spain | 16 695 | 12 315 | 10 890 | 17 124 | 483 | 516 | 676 | 50 | - |
| U.K.(Engl.&Wales) | 226 | 675 | 438 | 2 014 | 1 343 | 2 918 | 2 686 | 12 933 | 2 541 |
| U.K.(Scotland | - | - | - | - | - | - | - | 1 | - |
| U..S.S.R. | 107 588 | 95 650 | 101 393 | 150 728 | 20 366 | - | - | - | - |
| TOTAL | 131 311 | 116 601 | 117 599 | 177 010 | 28 855 | 26 060 | 43 525 | 45 697 | 48 439 |

*Provisional

a) August-December catch estimates based on information from fishing vessels.

Table 7.4 Landings of HORSE MACKEREL in Sub-areas VIII and IX, by country (in tonnes)
(Data for 1973 to 1980 as officially reported to ICES)

| Country | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981** |
|---|---|---|---|---|---|---|---|---|---|
| Sub-area VIII | | | | | | | | | |
| Denmark | - | - | - | - | - | - | 127 | - | - |
| France | 3 556 | 2 477 | 2 386 | 3 380 | 4 881 | 3 643 | 4 240 | 3 361 | 3 143 |
| German Dem.Rep. | - | - | - | 14 | - | - | - | - | - |
| Netherlands | - | - | - | - | - | 19 | - | - | - |
| Spain* | 96 561 | 62 836 | 72 916 | 95 401 | 104 812 | 80 139 | 42 766 | 34 134 | 36 362 |
| U.K.(Engl.&Wales) | - | - | - | - | - | - | 22 | - | + |
| U.S.S.R | 1 120 | 925 | 11 436 | 30 763 | 15 213 | 3 | - | - | - |
| TOTAL | 101 237 | 66 238 | 86 738 | 129 558 | 124 906 | 83 804 | 47 155 | 37 445 | 39 405 |
| Sub-area IX | | | | | | | | | |
| Poland | - | - | - | - | 168 | - | - | - | - |
| Portugal* | 45 497 | 48 071 | 43 491 | 49 041 | 51 341 | 32 043 | 26 977 | 25 132 | 26 032 |
| Spain* | 1 622 | 2 954 | 1 882 | 3 339 | 981 | 14 787 | 12 880 | 11 679 | 12 120 |
| U.S.S.R. | - | - | 422 | 644 | 14 898 | 381 | 250 | - | - |
| TOTAL | 47 119 | 51 025 | 45 795 | 53 024 | 67 388 | 47 211 | 40 107 | 36 811 | 38 152 |

*)Working Group estimate

**)Provisional

| cm | JAN - MAR VIIe commercial data trawl | JAN - MAR VIIe commercial data purse seine | JAN - MAR VIIe commercial data total | JAN - MAR VIIe research (trawl) total | OCT - DEC VIIe commercial data trawl | OCT - DEC VIIe commercial data purse seine | OCT - DEC VIIe commercial data total | OCT - DEC VIIe research (trawl) total | 1st and 4th quarters combined VIIe commercial data trawl | 1st and 4th quarters combined VIIe commercial data purse seine | 1st and 4th quarters combined VIIe commercial data total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | | | | | | | + | | | |
| 7 | | | | | | | | + | | | |
| 8 | | | | | | | | 0,01 | | | |
| 9 | | | | | | | | 0,08 | | | |
| 10 | | | | | | | | 0,6 | | | |
| 11 | | | | | | | | 0,6 | | | |
| 12 | | | | 0,03 | | | | 0,5 | | | |
| 13 | | | | | | | | 0,08 | | | |
| 14 | | | | | | | | 0,1 | | | |
| 15 | 35,1 | | 35,1 | | 117,4 | | 117,4 | 0,1 | 152,5 | | 152, 5 |
| 16 | 105,3 | | 105,3 | 0,06 | 426,3 | | 426,3 | 0,9 | 531,6 | | 531,6 |
| 17 | 421,2 | | 421,2 | 0,09 | 691,8 | 3,1 | 694,9 | 3,5 | 1 113,0 | 3,1 | 1 116,1 |
| 18 | 421,2 | | 421,2 | 0,06 | 1 215,0 | 3,1 | 1 218,1 | 2,7 | 1 636,2 | 3,1 | 1 639,3 |
| 19 | 596,8 | | 596,8 | | 1 130,7 | | 1 130,7 | 1,0 | 1 727,5 | | 1 727,5 |
| 20 | 421,2 | | 421,2 | | 1 526,3 | | 1 526,3 | 1,9 | 1 947,5 | | 1 947,5 |
| 21 | 386,1 | 10,7 | 396,8 | 0,09 | 2 743,6 | 12,3 | 2 755,9 | 2,8 | 3 129,7 | 23,0 | 3 152,7 |
| 22 | 105,3 | | 105,3 | 0,06 | 1 633,4 | 24,7 | 1 658,1 | 2,1 | 1 738,7 | 24,7 | 1 763,4 |
| 23 | 105,3 | | 105,3 | 0,15 | 1 868,2 | 37,0 | 1 905,2 | 1,2 | 1 973,5 | 37,0 | 2 010,5 |
| 24 | 245,7 | 54,4 | 300,1 | 0,2 | 620,1 | 21,6 | 641,7 | 0,4 | 865,8 | 76,0 | 941,8 |
| 25 | 386,1 | 188,0 | 574,1 | 0,7 | 67,0 | 12,3 | 79,3 | 0,3 | 453,1 | 200,3 | 653,4 |
| 26 | 351,0 | 516,7 | 867,7 | 1,2 | 67,0 | 21,6 | 88,6 | 0,2 | 418,0 | 538,3 | 956,3 |
| 27 | 315,9 | 708,3 | 1 024,2 | 1,3 | 174,1 | 49,3 | 223,4 | 0,3 | 490,0 | 757,6 | 1 247,6 |
| 28 | 351,0 | 700,6 | 1 051,6 | 1,3 | 79,5 | 64,7 | 144,2 | 0,4 | 430,5 | 765,3 | 1 195,8 |
| 29 | 280,8 | 415,3 | 696,1 | 1,0 | 37,6 | 43,2 | 80,8 | 0,3 | 318,4 | 458,5 | 776,9 |
| 30 | 105,3 | 239,0 | 344,3 | 1,0 | 37,6 | 18,5 | 56,1 | 0,4 | 142,9 | 257,5 | 400,4 |
| 31 | | 130,8 | 130,8 | 0,3 | 72,1 | 18,5 | 90,6 | 0,2 | 72,1 | 149,3 | 221,4 |
| 32 | 70,2 | 39,9 | 110,1 | 0,2 | 53,3 | 6,2 | 59,5 | 0,3 | 123,5 | 46,1 | 169,6 |
| 33 | | 25,4 | 25,4 | 0,3 | 31,3 | 9,2 | 40,5 | 0,3 | 31,3 | 34,6 | 65,9 |
| 34 | 35,1 | 10,7 | 45,8 | 0,06 | 43,9 | | 43,9 | 0,2 | 79,0 | 10,7 | 89,7 |
| 35 | | | | 0,06 | 6,3 | | 6,3 | 0,09 | 6,3 | | 6,3 |
| 36 | | | | 0,09 | 12,5 | | 12,5 | 0,1 | 12,5 | | 12,5 |
| 37 | | 10,7 | 10,7 | | 6,3 | | 6,3 | 0,1 | 6,3 | 10,7 | 17,0 |
| 38 | | 10,7 | 10,7 | | 3,1 | | 3,1 | + | 3,1 | 10,7 | 13,8 |
| 39 | | 10,7 | 10,7 | | 6,3 | | 6,3 | 0,04 | 6,3 | 10,7 | 17,0 |
| 40 | | | | | | | | 0,01 | | | |
| 41 | | | | | | | | | | | |
| 42 | | | | | | | | + | | | |
| TOTAL | 4 738,6 | 3 071,9 | 7 810,5 | 8,25 | 12 670,7 | 345,3 | 13 016 | 21,8 | 17 409,3 | 3 417,2 | 20 826,5 |

Table 7.5 Raised length composition for HORSE MACKEREL - Division VIIe - (Nb X $10^{-3}$)

Table 7.6 Raised length composition for HORSE MACKEREL by gears and country in 1980 in Sub-areas VIII and IXa. Unit:1 000 ind.

| | Portugal 1980 | | | Spain 1980 | | | Portugal & Spain | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gear Classes | Trawl | Purse-Seine | Arti-sanal | Trawl | Purse-Seine | Arti-sanal | Trawl | Purse-seine | Arti-sanal | TOTAL |
| 7 | 84 | - | - | - | - | - | 84 | - | - | 84 |
| 8 | 589 | 3 | - | - | - | - | 589 | 3 | - | 592 |
| 9 | 1359 | 39 | - | - | - | - | 1359 | 39 | - | 1399 |
| 10 | 1265 | 163 | - | - | 2258 | - | 1265 | 2422 | - | 3688 |
| 11 | 8434 | 395 | - | - | 3906 | - | 8434 | 4301 | - | 12735 |
| 12 | 22238 | 160 | - | 239 | 2927 | - | 22477 | 3087 | - | 25565 |
| 13 | 31507 | 276 | 2 | 253 | 335 | - | 31761 | 611 | 2 | 32375 |
| 14 | 24975 | 635 | 12 | 159 | 6272 | - | 25135 | 6908 | 12 | 32056 |
| 15 | 20090 | 3804 | 14 | 1438 | 33232 | - | 21528 | 37036 | 14 | 58580 |
| 16 | 12470 | 12618 | 8 | 8169 | 61986 | - | 20639 | 74605 | 8 | 95253 |
| 17 | 7284 | 7104 | 92 | 11926 | 60920 | - | 19210 | 68025 | 92 | 87328 |
| 18 | 5899 | 9116 | 192 | 3432 | 29310 | 7 | 9331 | 38426 | 200 | 47958 |
| 19 | 6673 | 5756 | 182 | 2501 | 7952 | - | 9174 | 13708 | 182 | 23065 |
| 20 | 7975 | 2712 | 155 | 1991 | 2775 | 4 | 9966 | 5488 | 160 | 15616 |
| 21 | 6588 | 1814 | 171 | 1058 | 1114 | 7 | 7646 | 2929 | 179 | 10755 |
| 22 | 3728 | 1346 | 143 | 2110 | 758 | 4 | 5838 | 2104 | 148 | 8092 |
| 23 | 2733 | 1139 | 155 | 2531 | 1203 | 22 | 5264 | 2343 | 178 | 7786 |
| 24 | 1509 | 1127 | 160 | 4615 | 1419 | 35 | 6124 | 2546 | 195 | 8867 |
| 25 | 883 | 979 | 173 | 5823 | 573 | 188 | 6707 | 1552 | 362 | 8622 |
| 26 | 1216 | 853 | 210 | 5557 | 89 | 84 | 6774 | 942 | 294 | 8011 |
| 27 | 847 | 639 | 280 | 4519 | 188 | 89 | 5366 | 828 | 370 | 6564 |
| 28 | 653 | 555 | 325 | 6428 | - | 90 | 7082 | 555 | 416 | 8053 |
| 29 | 888 | 306 | 386 | 6442 | 94 | 130 | 7330 | 400 | 516 | 8247 |
| 30 | 1573 | 521 | 743 | 7128 | - | 184 | 8702 | 521 | 927 | 10151 |
| 31 | 2115 | 286 | 898 | 6928 | - | 112 | 9043 | 286 | 1010 | 10340 |
| 32 | 3171 | 443 | 940 | 10463 | - | 123 | 13635 | 443 | 1063 | 15142 |
| 33 | 4235 | 461 | 1367 | 15849 | - | 99 | 20084 | 461 | 1466 | 22012 |
| 34 | 4558 | 409 | 1453 | 15289 | - | 76 | 19847 | 409 | 1530 | 21787 |
| 35 | 3553 | 626 | 1727 | 11055 | - | 49 | 14609 | 626 | 1777 | 17013 |
| 36 | 2554 | 425 | 1850 | 8066 | - | 28 | 10620 | 425 | 1879 | 12925 |
| 37 | 1888 | 527 | 2550 | 5283 | - | 39 | 7172 | 527 | 2290 | 9989 |
| 38 | 82 | 493 | 1593 | 3322 | - | 35 | 3405 | 493 | 1628 | 5527 |
| 39 | 402 | 162 | 941 | 1646 | - | 46 | 2049 | 162 | 987 | 3199 |
| 40 | 115 | 106 | 738 | 465 | - | 20 | 580 | 106 | 759 | 1447 |
| 41 | 55 | 17 | 103 | 57 | - | 4 | 113 | 17 | 108 | 238 |
| 42 | 3 | 2 | 126 | 3 | - | 2 | 7 | 2 | 128 | 138 |
| 43 | 2 | 2 | 69 | 16 | - | - | 19 | 2 | 69 | 91 |
| 44 | - | - | - | - | - | 3 | - | - | 3 | 3 |
| TOTAL | 194211 | 56036 | 17473 | 154777 | 217320 | 1492 | 348989 | 273357 | 18966 | 641313 |
| Total Weight | 15179 | 4575 | 5378 | 36489 | 8948 | 376 | 51136 | 13524 | 5754 | 70945 |

Table 7.7 Raised length composition for HORSE MACKEREL by gears and country in 1981. Sub-areas VIII and IXa. Unit: 1 000 ind.

| | PORTUGAL - 1981 | | | Spain 1981 | | | Portugal & Spain | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Gear CLASSES | Trawl | Purse-seine | Arti-sanal | Trawl | Purse-seine | Artisa-nal 1980 | Trawl | Purse-seine | Arti-sanal | TOTAL |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 21 | 0 | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 21 |
| 9 | 371 | 0 | 0 | 0 | 0 | 0 | 371 | 0 | 0 | 371 |
| 10 | 1943 | 57 | 73 | 27 | 2337 | 0 | 1970 | 2394 | 73 | 4439 |
| 11 | 4142 | 1276 | 34 | 0 | 4045 | 0 | 4142 | 5322 | 34 | 9499 |
| 12 | 4600 | 3970 | 184 | 688 | 3056 | 0 | 5288 | 7027 | 184 | 12500 |
| 13 | 7610 | 7956 | 511 | 1206 | 944 | 0 | 8816 | 8900 | 511 | 18228 |
| 14 | 20595 | 2957 | 3164 | 776 | 13980 | 0 | 21371 | 16937 | 3164 | 41473 |
| 15 | 24569 | 2796 | 7980 | 456 | 41761 | 0 | 25025 | 44558 | 7980 | 77563 |
| 16 | 13235 | 4264 | 6536 | 2360 | 68239 | 0 | 15596 | 72504 | 6536 | 94637 |
| 17 | 7888 | 1690 | 8383 | 3330 | 65092 | 0 | 11219 | 66782 | 8383 | 86385 |
| 18 | 4383 | 1005 | 4635 | 4146 | 37715 | 7 | 8530 | 38721 | 4643 | 51894 |
| 19 | 1904 | 613 | 2966 | 4141 | 38974 | 0 | 6045 | 39587 | 2966 | 48599 |
| 20 | 1340 | 660 | 2152 | 2719 | 73543 | 4 | 4059 | 74204 | 2157 | 80421 |
| 21 | 1279 | 998 | 2018 | 2105 | 72375 | 7 | 3384 | 73373 | 2026 | 78784 |
| 22 | 900 | 2255 | 1964 | 843 | 1776 | 4 | 1744 | 20012 | 1969 | 23726 |
| 23 | 637 | 3175 | 2066 | 676 | 2427 | 22 | 1313 | 5602 | 2089 | 9005 |
| 24 | 520 | 2688 | 1061 | 623 | 5214 | 35 | 1144 | 7902 | 1096 | 10144 |
| 25 | 347 | 1378 | 864 | 1051 | 1798 | 188 | 1399 | 3176 | 1053 | 5629 |
| 26 | 262 | 450 | 779 | 2330 | 89 | 84 | 2592 | 540 | 863 | 3997 |
| 27 | 308 | 416 | 413 | 3304 | 224 | 89 | 3613 | 640 | 502 | 4756 |
| 28 | 472 | 359 | 150 | 4108 | 0 | 90 | 4581 | 359 | 241 | 5182 |
| 29 | 1102 | 731 | 482 | 5824 | 89 | 130 | 6926 | 821 | 613 | 8361 |
| 30 | 2553 | 995 | 907 | 10870 | 0 | 184 | 13423 | 995 | 1091 | 15510 |
| 31 | 3773 | 1578 | 1174 | 13203 | 0 | 112 | 16976 | 1578 | 1286 | 19841 |
| 32 | 4098 | 1553 | 1078 | 13301 | 0 | 123 | 17400 | 1553 | 1201 | 20155 |
| 33 | 3778 | 1291 | 1349 | 10596 | 0 | 99 | 14374 | 1291 | 1448 | 17115 |
| 34 | 3412 | 1032 | 1640 | 10196 | 0 | 76 | 13608 | 1032 | 1717 | 16358 |
| 35 | 2507 | 927 | 1099 | 7502 | 0 | 49 | 10010 | 927 | 1148 | 12087 |
| 36 | 1677 | 1040 | 1432 | 5655 | 0 | 28 | 7333 | 1040 | 1461 | 9834 |
| 37 | 1145 | 760 | 1002 | 4103 | 0 | 39 | 5248 | 760 | 1041 | 7050 |
| 38 | 618 | 578 | 1085 | 2898 | 0 | 35 | 3517 | 578 | 1120 | 5216 |
| 39 | 344 | 331 | 422 | 1244 | 0 | 46 | 1588 | 331 | 469 | 2389 |
| 40 | 149 | 220 | 148 | 746 | 0 | 20 | 896 | 220 | 169 | 1285 |
| 41 | 28 | 81 | 61 | 12 | 0 | 4 | 41 | 81 | 65 | 188 |
| 42 | 8 | 9 | 119 | 26 | 0 | 2 | 35 | 9 | 121 | 166 |
| 43 | 0 | 0 | 16 | 22 | 0 | 0 | 22 | 0 | 16 | 39 |
| 44 | 6 | 0 | 23 | 3 | 0 | 3 | 9 | 0 | 27 | 36 |
| 45 | 0 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 54 | 54 |
| 46 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| 47 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| TOTAL | 122541 | 50105 | 58048 | 121105 | 449669 | 1492 | 243646 | 499774 | 59541 | 802962 |
| Total Weight | 13376 | 5957 | 6699 | 28776 | 19330 | 376 | 42152 | 25287 | 7075 | 74514 |

Table 7.8 Mean weight and mean length at age for HORSE MACKEREL in ICES Divisions VIIe, VIIIc and IXa

| Age | 1981 Division VIIe | | | | 1981 Divisions VIIIc and IXa combined | | | | 1980 Divisions VIIIc and IXa combined | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nos of otoliths read | Raised total nos in catch x $10^{-3}$ | Catch $\bar{l}$(cm) | Catch $\overline{wt}$(g) | Nos of otoliths read | Raised total nos in catch x $10^{-3}$ | Catch $\bar{l}$(cm) | Catch $\overline{wt}$(g) | Nos of otoliths read | Raised total nos in catch x $10^{-3}$ | Catch $\bar{l}$(cm) | Catch $\overline{wt}$(g) |
| 0 | 37 | 13 | 18.3 | 14.0 | 91 | 56 404 | 12.8 | 17.0 | 91 | 71 706 | 13.2 | 18.8 |
| 1 | 68 | 46 | 19.2 | 46.5 | 357 | 353 481 | 16.3 | 35.4 | 357 | 306 558 | 16.0 | 33.4 |
| 2 | 113 | 85 | 21.0 | 87.1 | 218 | 166 596 | 19.2 | 58.0 | 218 | 68 261 | 19.3 | 59.2 |
| 3 | 48 | 18 | 25.5 | 138.1 | 174 | 76 267 | 22.1 | 88.1 | 174 | 34 438 | 23.9 | 112.0 |
| 4 | 49 | 14 | 27.2 | 168.4 | 84 | 28 679 | 28.0 | 180.2 | 84 | 24 235 | 28.1 | 182.7 |
| 5 | 32 | 12 | 28.1 | 197.5 | 92 | 42 094 | 31.2 | 249.2 | 92 | 38 002 | 31.2 | 250.1 |
| 6 | 11 | 2 | 28.7 | 230.5 | 60 | 32 733 | 32.7 | 288.9 | 60 | 33 555 | 33.3 | 303.5 |
| 7 | 19 | 6 | 29.8 | 260.8 | 36 | 22 926 | 34.4 | 337.0 | 36 | 29 039 | 34.6 | 340.6 |
| 8 | 22 | 5 | 30.9 | 260.7 | 28 | 13 263 | 36.3 | 394.2 | 28 | 16 794 | 36.2 | 390.2 |
| 9 | 31 | 1 | 32.9 | 270.3 | - | - | - | - | - | - | - | - |
| (9+) | - | - | - | - | 25 | 10 521 | 37.1 | 421.9 | 25 | 13 769 | 36.9 | 414.1 |
| 10 | 25 | 1 | 33.0 | 278.9 | - | - | - | - | - | - | - | - |
| (10+) | 27 | 7 | 33.4 | 286.7 | - | - | - | - | - | - | - | - |
| TOTALS | 482 | 210 | - | - | 1 165 | 802 964 | - | - | 1 165 | 636 357 | - | - |

Table 7.9 HORSE MACKEREL in Sub-areas VIII and IX a.
Length and age structure of the catch and mean weight
at age in 1980. (Numbers x $10^{-3}$)

| Length \ Age | 0 | I | II | III | IV | V | VI | VII | VIII | IX* |
|---|---|---|---|---|---|---|---|---|---|---|
| .7 | 09 | | | | | | | | | |
| 8 | 22 | | | | | | | | | |
| 9 | 371 | | | | | | | | | |
| 10 | 2961 | 1478 | | | | | | | | |
| 11 | 5120 | 4379 | | | | | | | | |
| 12 | 8001 | 3700 | | | | | | | | |
| 13 | 11393 | 6836 | | | | | | | | |
| 14 | 13147 | 26958 | 1369 | | | | | | | |
| 15 | 2327 | 71669 | 3568 | | | | | | | |
| 16 | 9842 | 79117 | 5678 | | | | | | | |
| 17 | 2419 | 74378 | 3589 | | | | | | | |
| 18 | | 37987 | 13908 | | | | | | | |
| 19 | | 21044 | 26730 | 826 | | | | | | |
| 20 | | 18094 | 48735 | 11339 | 2252 | | | | | |
| 21 | | 7485 | 39392 | 30883 | 1024 | | | | | |
| 22 | | 359 | 9704 | 13310 | 356 | | | | | |
| 23 | | | 2413 | 5466 | 1126 | | | | | |
| 24 | | | 3956 | 4950 | 1238 | | | | | |
| 25 | | | 1126 | 3152 | 1351 | | | | | |
| 26 | | | 428 | 1999 | 1143 | 428 | | | | |
| 27 | | | | 1584 | 2378 | 794 | | | | |
| 28 | | | | 943 | 1415 | 2824 | | | | |
| 29 | | | | 928 | 3102 | 2475 | 1547 | 309 | | |
| 30 | | | | 884 | 2652 | 8220 | 3552 | 201 | | |
| 31 | | | | | 5139 | 8810 | 5516 | 376 | | |
| 32 | | | | | 5502 | 9150 | 4273 | 1229 | | |
| 33 | | | | | | 5203 | 5956 | 5203 | 753 | |
| 34 | | | | | | 2846 | 5693 | 4269 | 2127 | 1423 |
| 35 | | | | | | 1342 | 2683 | 4701 | 2019 | 1342 |
| 36 | | | | | | | 2459 | 4307 | 2459 | 610 |
| 37 | | | | | | | 705 | 1283 | 1283 | 3780 |
| 38 | | | | | | | 349 | 1043 | 3474 | 349 |
| 39 | | | | | | | | | 597 | 1792 |
| 40 | | | | | | | | | 551 | 734 |
| 41 | | | | | | | | | | 188 |
| 42 | | | | | | | | | | 167 |
| 43 | | | | | | | | | | 39 |
| 44 | | | | | | | | | | 36 |
| 45 | | | | | | | | | | 54 |
| 46 | | | | | | | | | | 3 |
| 47 | | | | | | | | | | 3 |
| TOTAL | 56412 | 353484 | 160596 | 76264 | 28678 | 42092 | 32733 | 22921 | 13263 | 10520 |
| $l_t$ | 12.76 | 16.28 | 19.19 | 22.05 | 27.97 | 31.15 | 32.72 | 34.44 | 36.20 | 37.11 |
| $\bar{W}$ stock | 4 | 24 | 66 | 124 | 195 | 274 | 356 | 436 | 515 | 588 |
| $\bar{W}$ cat. | 16.99 | 35.37 | 58.01 | 88.11 | 180.20 | 249.15 | 288.87 | 337.02 | 394.15 | 421.91 |

Table 7.10 HORSE MACKEREL in Sub-areas VIII and IXa.

Length and age structure of the catch and mean weight at age in 1981 (Numbers x 10-3)

| Age / Length | 0 | I | II | III | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | 2471 | 1217 | | | | | | | | |
| 11 | 6877 | 5858 | | | | | | | | |
| 12 | 17896 | 7670 | | | | | | | | |
| 13 | 20397 | 12303 | | | | | | | | |
| 14 | 10162 | 20837 | 962 | | | | | | | |
| 15 | 1757 | 53834 | 3 | | | | | | | |
| 16 | 9525 | 80013 | 5715 | | | | | | | |
| 17 | 2611 | 75103 | 9606 | | | | | | | |
| 18 | | 35010 | 12949 | | | | | | | |
| 19 | | 5918 | 12886 | 461 | | | | | | |
| 20 | | 3597 | 9527 | 2187 | 468 | | | | | |
| 21 | | 1022 | 5378 | 4216 | 140 | | | | | |
| 22 | | 121 | 3310 | 4540 | 121 | | | | | |
| 23 | | | 2086 | 4726 | 973 | | | | | |
| 24 | | | 3458 | 4327 | 1082 | | | | | |
| 25 | | | 1725 | 4829 | 2069 | | | | | |
| 26 | | | 857 | 4006 | 2291 | 857 | | | | |
| 27 | | | | 2186 | 3282 | 1096 | | | | |
| 28 | | | | 1466 | 2199 | 4389 | | | | |
| 29 | | | | 315 | 3060 | 2441 | 1526 | 305 | | |
| 30 | | | | 579 | 1736 | 5380 | 2325 | 132 | | |
| 31 | | | | | 2678 | 4591 | 2875 | 196 | | |
| 32 | | | | | 4134 | 6875 | 3210 | 924 | | |
| 33 | | | | | | 6692 | 7660 | 6692 | 969 | |
| 34 | | | | | | 3791 | 7582 | 5687 | 2832 | 1896 |
| 35 | | | | | | 1888 | 3777 | 6618 | 2841 | 1888 |
| 36 | | | | | | | 3231 | 5661 | 3231 | 801 |
| 37 | | | | | | | 399 | 1818 | 1818 | 5355 |
| 38 | | | | | | | 370 | 1005 | 3681 | 370 |
| 39 | | | | | | | | | 800 | 2399 |
| 40 | | | | | | | | | 621 | 827 |
| 41 | | | | | | | | | | 138 |
| 42 | | | | | | | | | | 91 |
| 43 | | | | | | | | | | 4 |
| No.Otoliths | 91 | 357 | 218 | 174 | 84 | 92 | 60 | 36 | 28 | 25 |
| Total | 71696 | 306563 | 68462 | 34438 | 24233 | 38000 | 33555 | 29038 | 16793 | 13769 |
| $\bar{l}_t$ | 13,19 | 15,98 | 19,32 | 23,88 | 28,10 | 31,19 | 33,26 | 34,56 | 36,16 | 36,88 |
| $\bar{W}$ stock | 4 | 24 | 66 | 124 | 195 | 274 | 356 | 436 | 515 | 588 |
| $\bar{W}$ cap | 18,77 | 33,44 | 59,20 | 111,99 | 182,73 | 250,11 | 303,46 | 340,56 | 390,24 | 414,10 |

Table 7.11 Biological parameters of HORSE MACKEREL by countries.

| | France | | Portugal | England | | |
|---|---|---|---|---|---|---|
| | | | | Div.VIIe | Sub-area VIII | Div.VII b,c,j,k |
| a | 0.158 (≤ 23) | $6.3\ 10^{-3}$ (>23 cm) | $8.0 \cdot 10^{-3}$ | 0.0055 | - | - |
| b | 1.83 | 3.08 | 3.0087 | 3.1103 | - | - |
| k | 0.20 | | 0.1625 | 0.435 | 0.5033 | 0.583 |
| to | -0.59 | | - 1.0242 | + 1.235 | + 0.955 | 0.21 |
| $L\infty$ | 44.88 | | 51.74 | 37.0 | 35.6 | 34.1 |
| $W\infty$ | 772.08 | | 1140.00 | 414.9 | 368.0 | 321.9 |
| No. weighted | 3 207 | | 884 | 458 | - | |
| No. measured | 1 704 | | 884 | 497 | 167 | 70 |
| Method | scales | | otoliths | otoliths | otoliths | otoliths |
| Date | Oct-Nov 75 and Ap-May 76 | | Jan-Dec 76 | Jan-March and Oct-Dec 81 | Jan,March and May 1981 | |
| Length range | 8-44 | | 9-43 | 6-42 | 11-43 | |

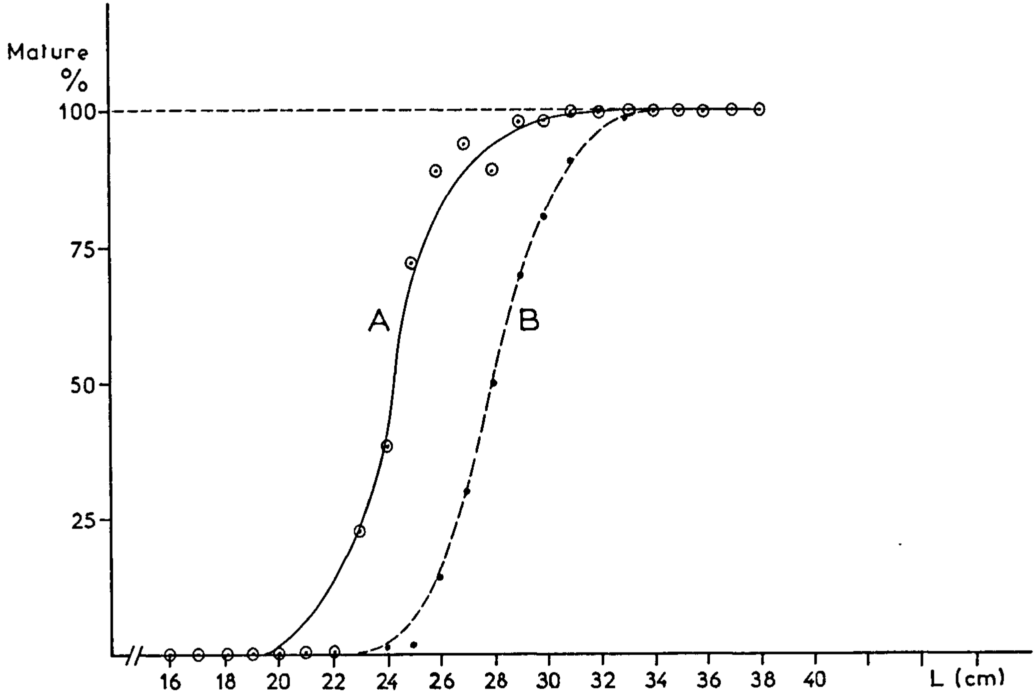



Figure 2.1 .— Maturity-ogives of mackerel

A. mackerel from the occidental coast of Portugal

B. mackerel from the western stock

Figure 3. Norwegian mackerel egg surveys in the North Sea in 1981. Egg production curve based on the four surveys (+) in 1981.

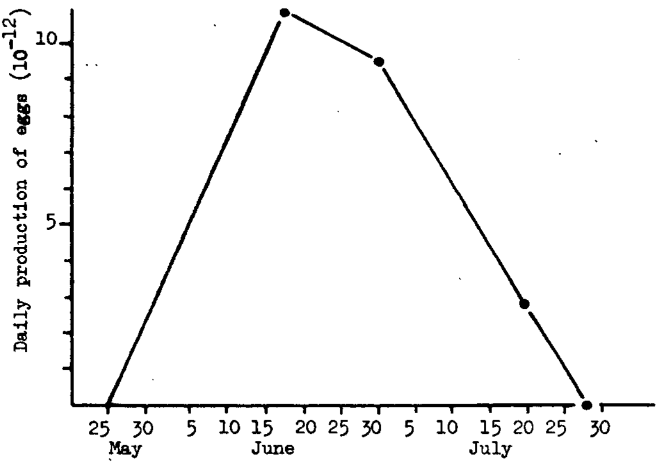


Figure 4.1.a. North Sea MACKEREL.
Trends in spawning stock size at beginning of spawning, based on VPA.

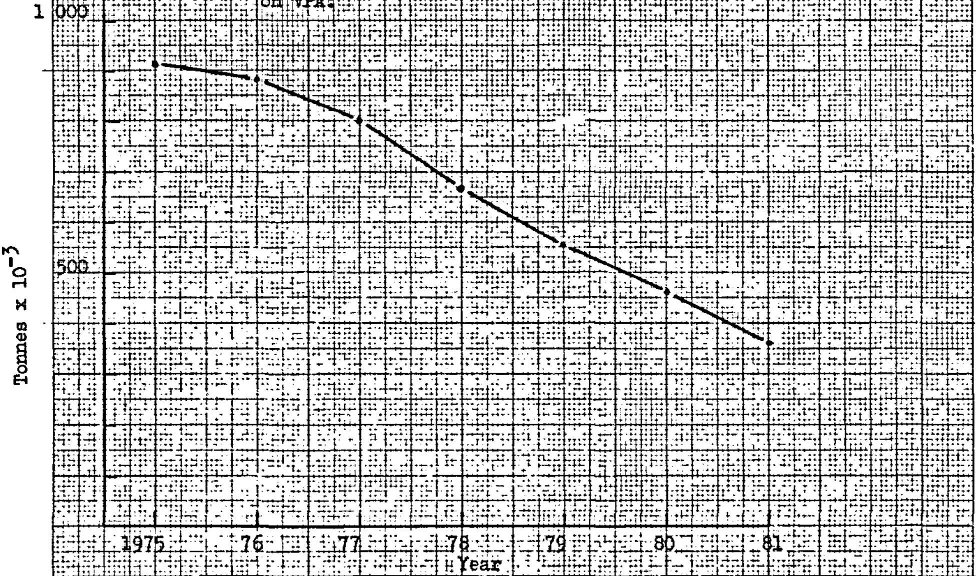



Figure 4.1.b. Trends in fishing mortalities from VPA for North Sea MACKEREL older than 3 years.

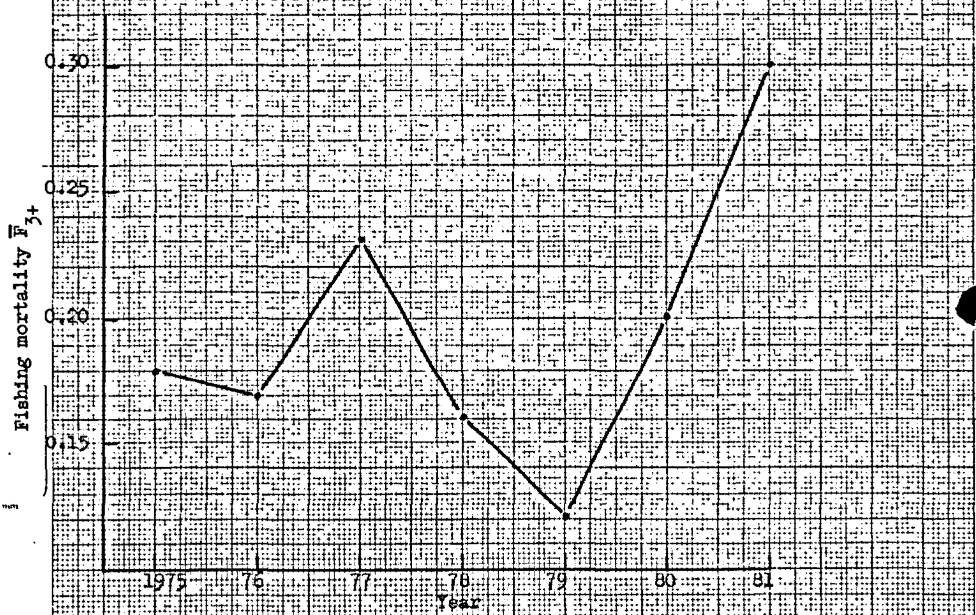


Figure 4.1.c. Trends in recruitment of 1-year-old North Sea MACKEREL (VPA).

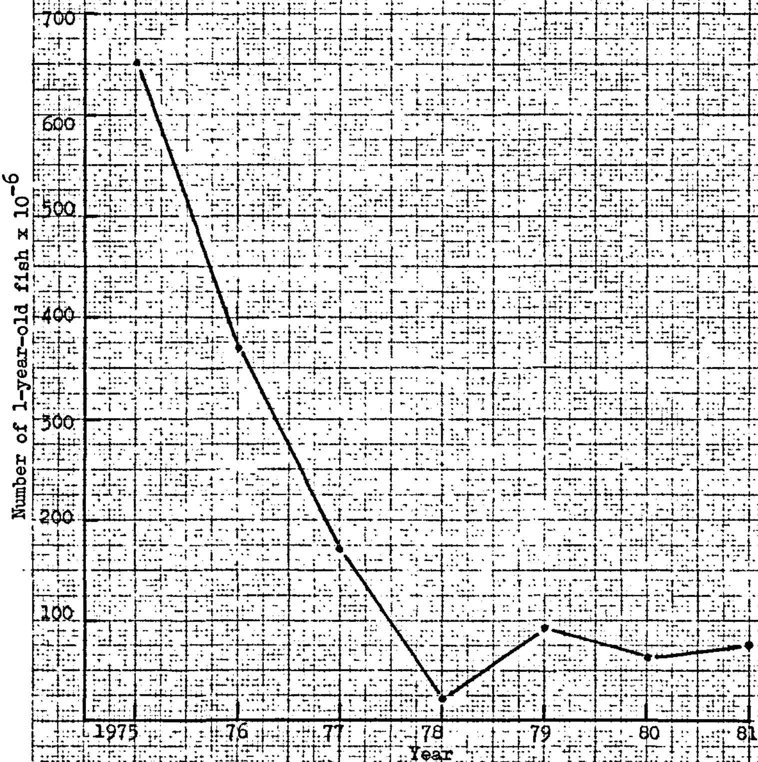


Figure 4.2.a. Western MACKEREL stock.
Spawning stock biomass (1 June).


Figure 4.2.b. Western MACKEREL stock.
F and catch in numbers.

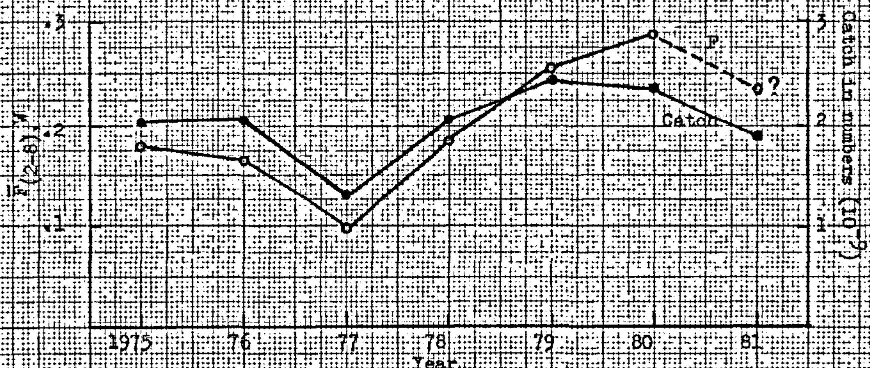


Figure 4.2.c. Western MACKEREL stock.
Recruitment as 1-group fish.

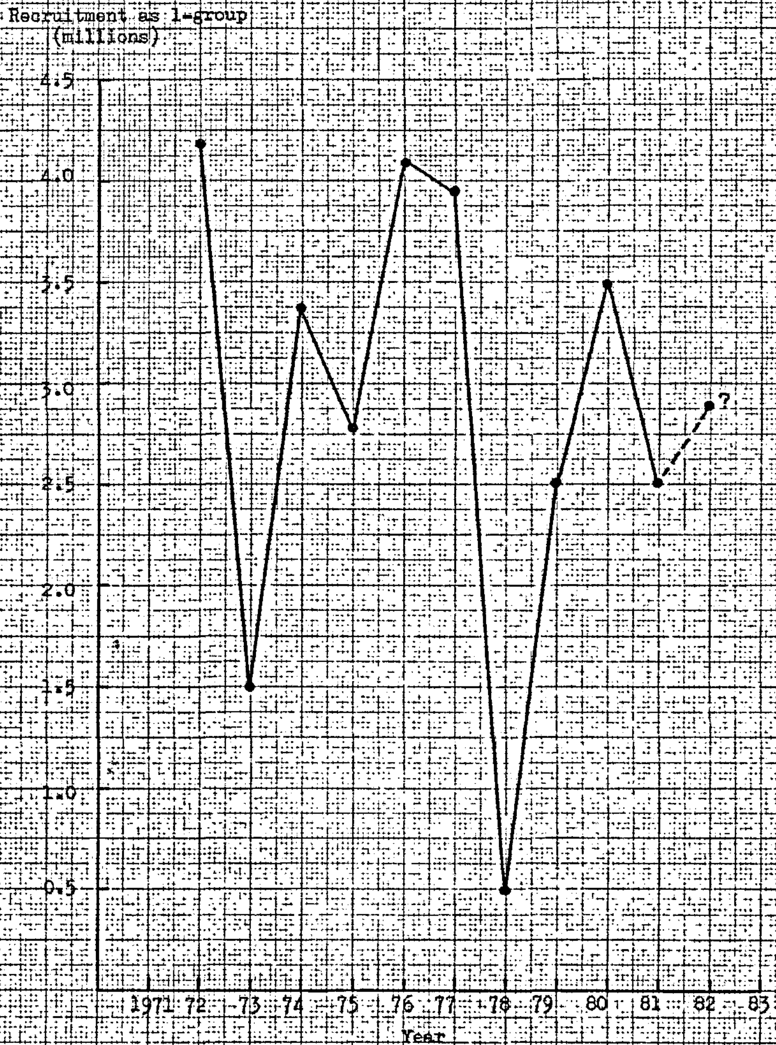


Figure 5.1. Western MACKEREL stock.
Western spawning stock biomass and 1-year-old recruitment estimated by cohort analysis. Dates refer to year of spawning. '+' is the geometric mean of observations.

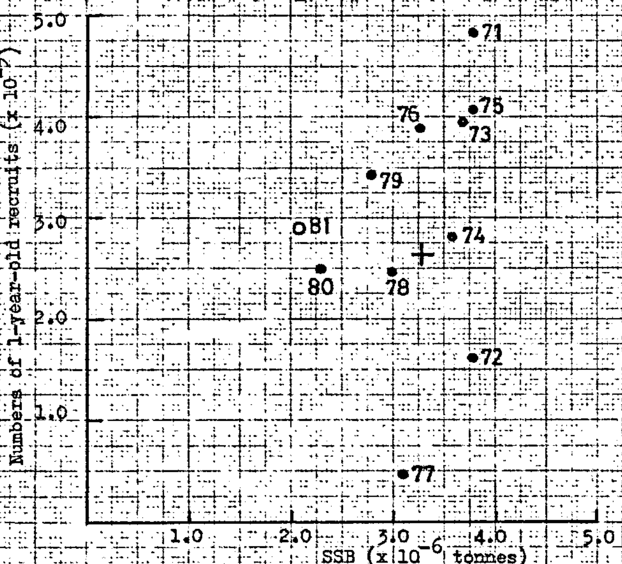


Figure 5.2. North Sea MACKEREL.
Catch prediction for 1983. $F_{82} = 0.46$.
Proportion of F before spawning = 0.1.
Weight at age in the catch from text-table in Section 4.2.1.

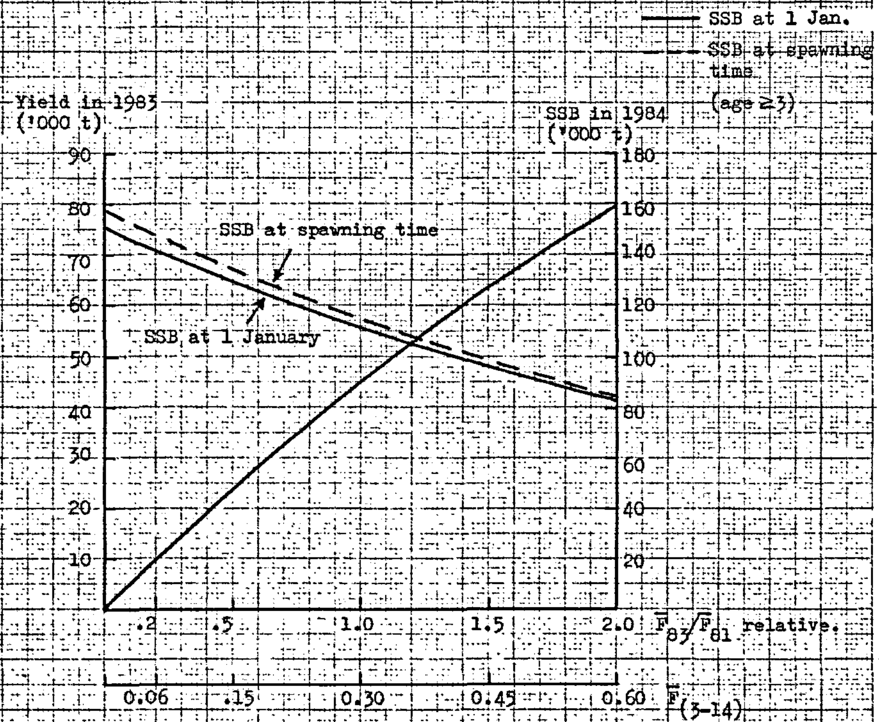


Figure 5.3. Western MACKEREL stock.
Yield in 1983 and spawning stock biomass in 1984 (1 June) at a range of fishing mortality rates relative to $F_{81}$ (= 1.0).
Recruitment - low.

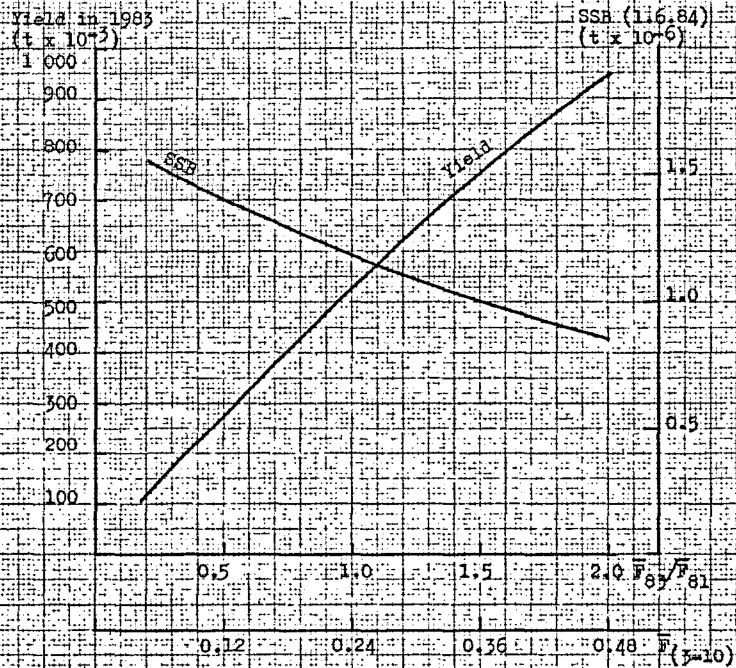
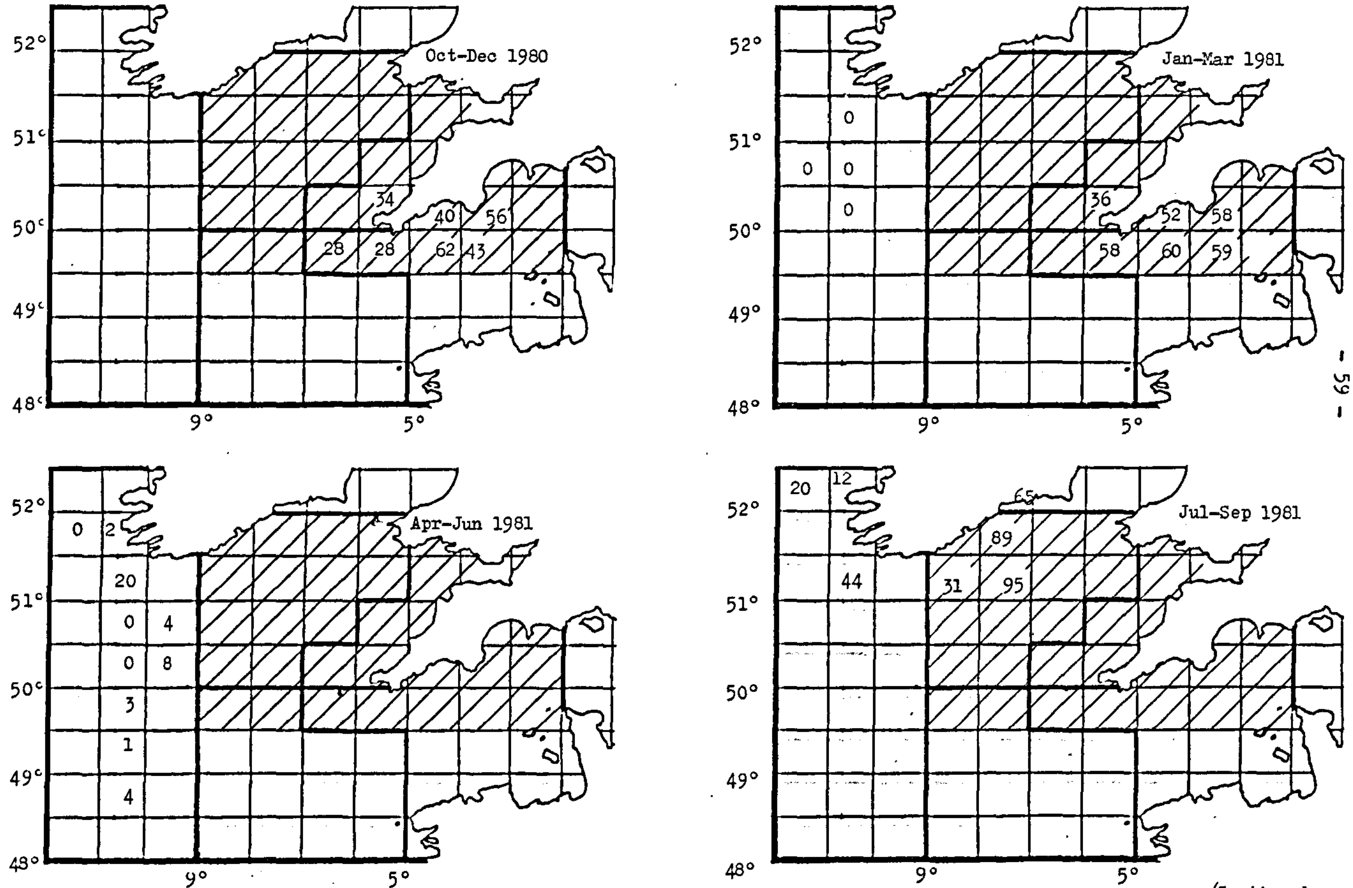


Figure 6.1. The percentage frequency of mackerel less than 30 cm total length in the Celtic Sea fisheries, October-December 1980 to January-March 1982. Suggested closure (see text) in shaded area. ICES division border lines indicated.






/Continued

Figure 6.1. (Continued).

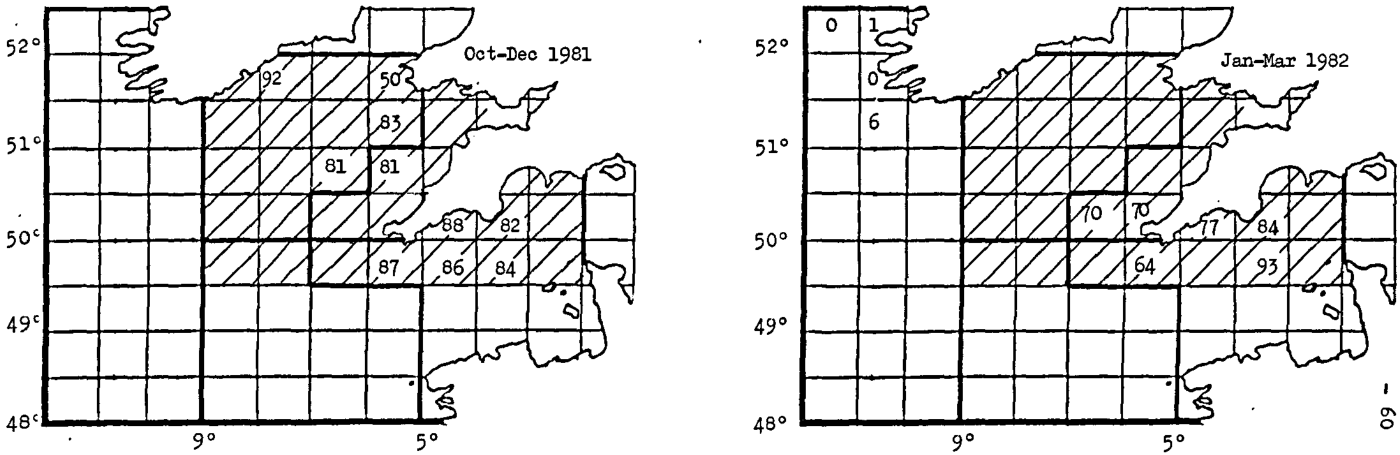
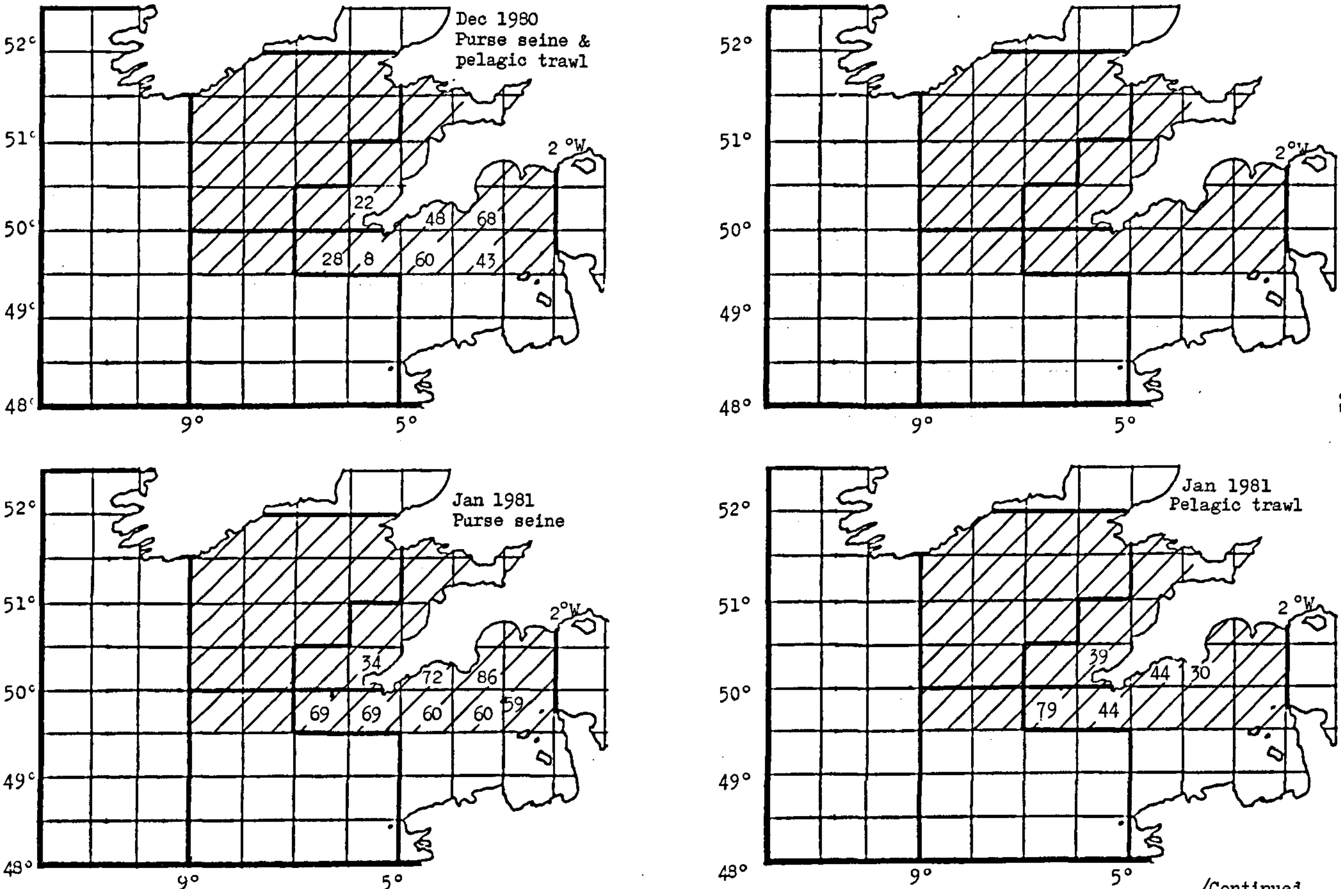
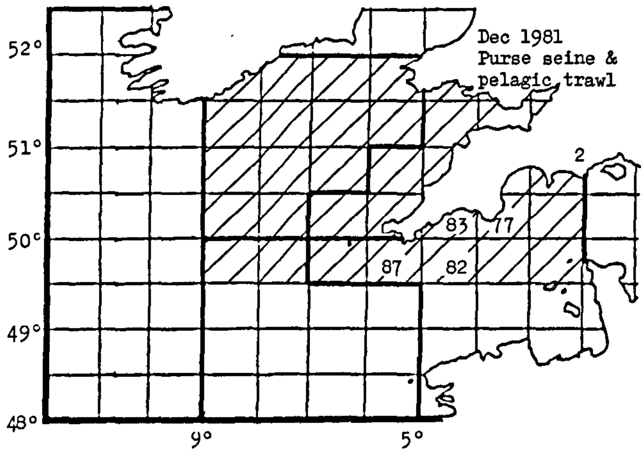


Figure 6.2. The percentage frequency of mackerel less than 30 cm total length in December and January. Data for January 1981 are separated into purse seine and pelagic trawl for comparison. Suggested closure (see text) in shaded area.




/Continued

Figure 6.2. (Continued).



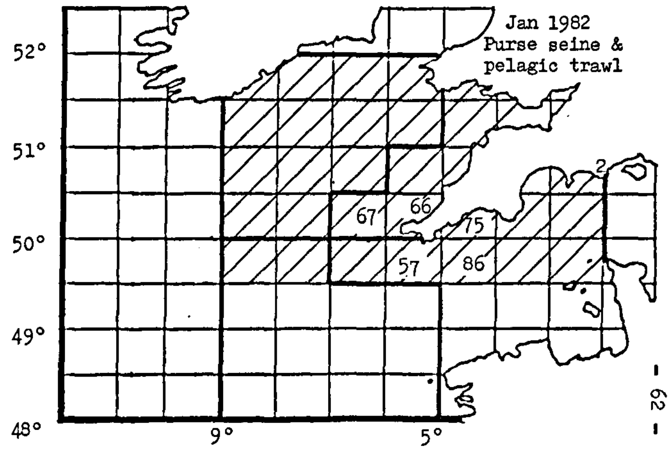



Figure 7.1. Maturation cycle on HORSE MACKEREL on Portuguese coast for both sexes.

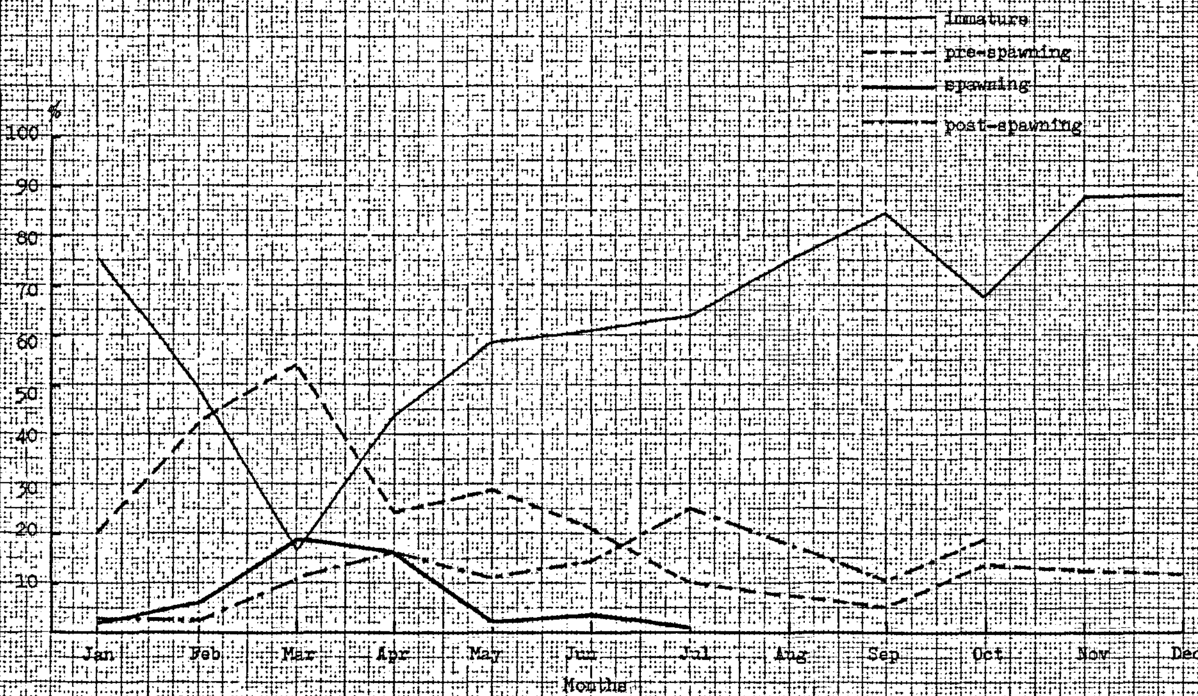
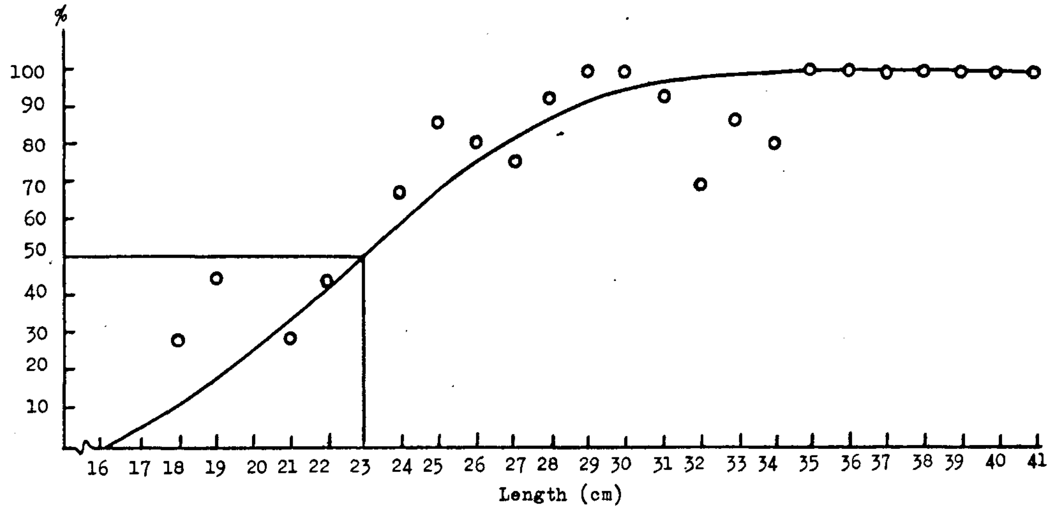


Figure 7.2. Maturity ogive of HORSE MACKEREL (Portuguese coast) (both sexes).



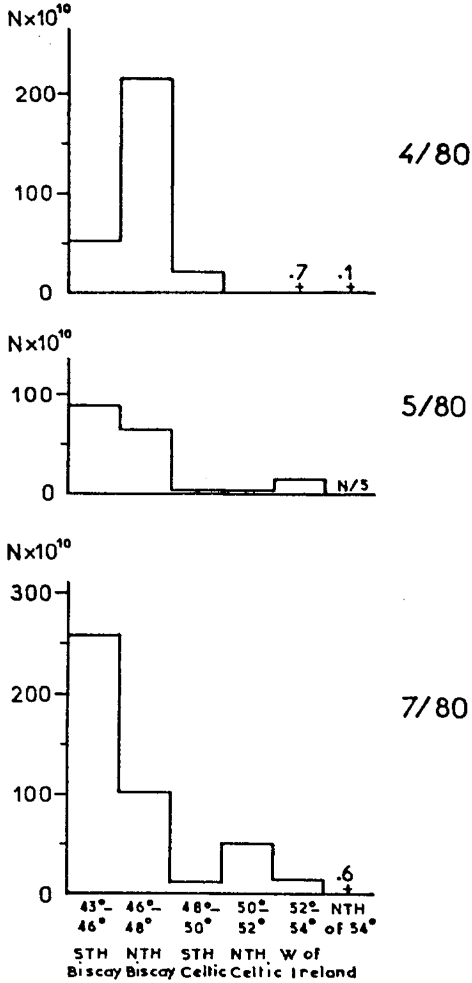



Fig. 7.3.—Horse mackerel: intensity of spawning in the areas surveyed by R.V. Cirolana in 1980 (nb of eggs $\times 10^{10}$)

Figure 7.4. HORSE MACKEREL in Sub-area VIII and Division IXa.

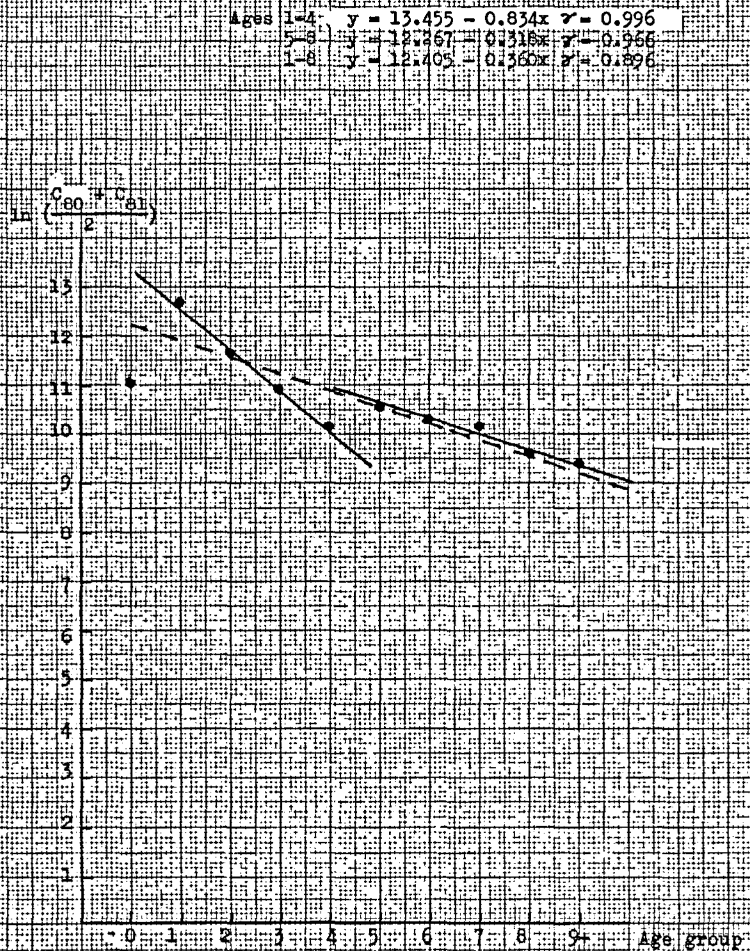
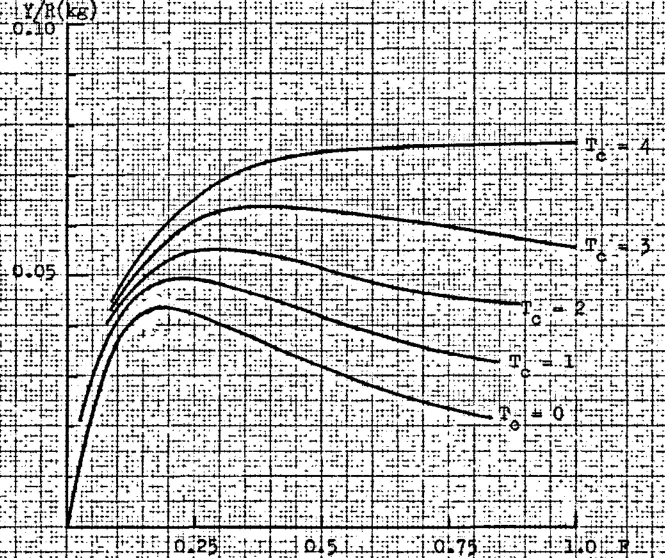
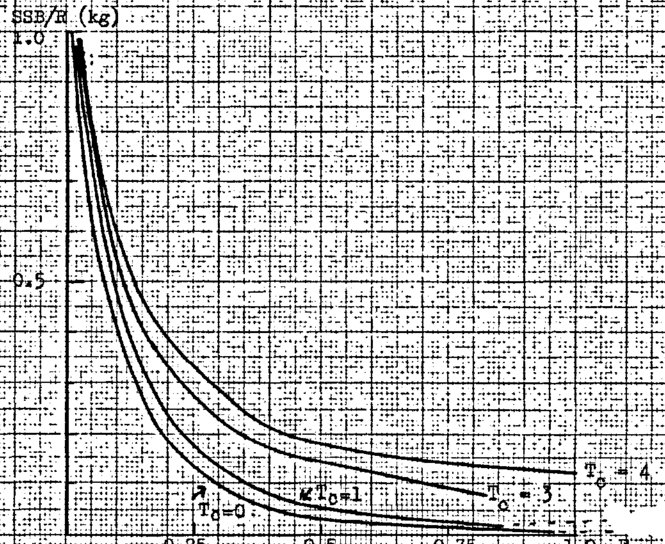


Figure 7.5. HORSE MACKEREL in Sub-areas VIII and IX.
Yield per recruit and spawning stock biomass (SSB) per recruit for a range of ages at first capture (tc). (M = 0.2)



APPENDIX A

## APPLICATION OF THE NORWEGIAN TAGGING DATA

### 1. Splitting the North Sea and Norwegian Sea landings into stock components

The low number of recaptures in 1981 from the Norwegian tagging experiments has rendered the 1981 data too scanty for splitting the North Sea and Norwegian Sea landings into North Sea and Western stock components. Therefore, the North Sea stock proportion of the landings (catch in numbers) from Divisions IVa and IIa was estimated using the $P_{1980}$ (Anon. 1981, Appendix), assuming that all age groups $\leqslant 5$ belonged to the North Sea stock (Appendix Table 1).

### 2. Estimation of Survival Rates

In a working document presented to the Working Group the Norwegian tagging data had been updated to 1981 containing the total number of reported recaptures from all countries. Excluding recaptures of tags released within the same year, the data are shown in Appendix Table 2. The survival rates were estimated using the Robson-model described below.

Appendix Table 3 shows the estimated survival rates and the corresponding values of F (assuming M = 0.15). The F-values should be considered averages of all age groups included in the tagging experiments ($\geqslant 3$). For comparison with the VPA result, see Appendix A, Figure 2.

### 3. Model for Estimating Survival Rates

In the following the tagged fish are assumed to be released at the beginning of the year.

To obtain an estimate of $S_i$, the survival rate in year i, two "working variables" are introduced (Seber, 1973).

$\beta_i$ = the probability that a tag is recovered in; year i, given that the fish is alive at the beginning of year i.

$\theta_i$ = the probability that a tag is recovered in one of the years i, i + 1, i + 2,.... given that the fish is alive at the beginning of year i.

An estimator of $\theta_i$ is

$$\hat{\theta}_i = \frac{r_i}{R_i} \qquad (1)$$

where

$r_i$ = the numbers of tags recovered from the i'th release (see Appendix Figure)

$r_i$ = number of tagged fish released at the i'th release.

Let $M_i$ = number of tags recovered in year i

and $T_i$ = total number of tags recovered in years i, i + 1, i + 2,... from releases 1 to i.

Given that, a tag is recovered in one of the years i, i + 1, i + 2,... the probability that it is recovered in year i is

$$\frac{M_i}{T_i}$$

The probability that a tagged fish alive at the beginning of year i is recovered in year i, thus becomes

$$\frac{M_i}{T_i}\ \theta_i$$

and the estimator of $\beta_i$ becomes

$$\hat{\beta}_i = \frac{M_i}{T_i}\hat{\theta}_i \qquad (2)$$

An estimate of $S_i$ is

$$\hat{S}_i = \frac{\hat{\theta}_i - \hat{\beta}_i}{\hat{\theta}_{i+1}} \qquad (3)$$

i.e.

$$\hat{S}_i = \frac{\left(\text{the probability that a tag is recovered in one of the years i +1, i + 2,..., given that the fish was alive at the beginning of year } \boxed{i}\right)}{\left(\text{the probability that a tag is recovered in one of the years i + 1, i + 2,... given that the fish was alive at the beginning of year } \boxed{i + 1}\right)}$$

inserting (2) into (3) gives

$$\hat{S}_i = \frac{T_i - M_i}{T_i}\ \frac{\hat{\theta}_i}{\hat{\theta}_{i+1}} \qquad (4)$$

and inserting (2) into (4) gives

$$\hat{S}_i = \frac{T_i - M_i}{T_i}\ \frac{r_i}{R_i}\ \frac{R_{i+1}}{r_{i+1}} \qquad (5)$$

The first year after release, the tagged fish may not have mixed totally into the stock over the entire area, and to take this into account, recaptures from the first year after release were excluded from the analysis.

If we exclude recaptures in year i from releases at the beginning of year i, $M_{ii}$, we get

$$\frac{M_i - M_{ii}}{T_i - r_i} = \left(\begin{array}{l}\text{probability of being recovered in one of the}\\ \text{years } i,\ i+1,\ i+2,\ldots \text{ when released in}\\ \text{years } 1,\ 2,\ldots\ i-1, \text{ given that the tag is recovered}\end{array}\right)$$

and

$$\frac{r_i - M_{ii}}{R_i} = \hat{\hat{\theta}}_i = \left(\begin{array}{l}\text{probability of being recovered in years } i+1,\\ i+2,\ldots \text{ when released in year } i, \text{ given that}\\ \text{the fish is alive at the beginning of year } i\end{array}\right)$$

$$\hat{\hat{\beta}}_i = \frac{M_i - M_{ii}}{T_i - r_i}\,\hat{\hat{\theta}}_i$$

inserting $\hat{\hat{\theta}}_i$ and $\hat{\hat{\beta}}_i$ into (3) gives

$$\hat{\hat{S}}_i = \frac{(T_i - r_i) - (M_i - M_{ii})}{T_i - r_i} \times \frac{r_i - M_{ii}}{R_i} \times \frac{R_{i+1}}{r_{i+1} - M_{i+1,\,i+1}} \qquad (6)$$

Thus $\hat{\hat{S}}_i$ is an estimator of survival rate when recaptures in the year of release are excluded from the analysis.

Appendix A, Table 1

Proportions of North Sea MACKEREL in catches of Divisions IIa and IVa (except Norwegian coastal gill net fishery)

| Year class | Applied for 1980* | 1981 |
|---|---|---|
| pre-1969 | 0.24 | 0.24 |
| 1969 | 0.33 | 0.33 |
| 1970 | 0.40 | 0.40 |
| 1971 | 0.12 | 0.12 |
| 1972 | 0.21 | 0.21 |
| 1973 | 0.25 | 0.25 |
| 1974 | 0.61 | 0.61 |
| 1975 | 0.64 | 0.64 |
| 1976 | | |
| 1977 | 1.00 | |
| 1978 | | 1.00 |
| 1979 | | |
| 1980 | | |

*Appendix Table 2   1981 Working Group Report

Appendix A, Table 2 North Sea MACKEREL

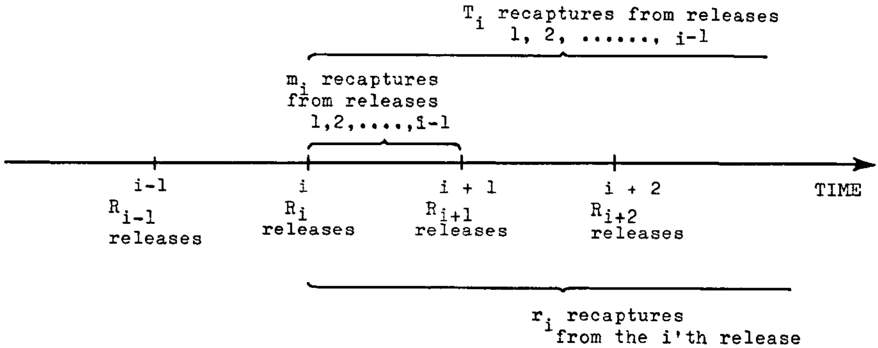
Norwegian tagging data. Recaptures excluding recaptures from the year of tagging

| Year | Recaptures / $R_i$ | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | $r_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 4 187 | 226 | 58 | 12 | 26 | 19 | 7 | 8 | 3 | 0 | 1 | 2 | 1 | 363 |
| 1970 | 3 505 | | 62 | 52 | 83 | 58 | 38 | 26 | 21 | 9 | 6 | 0 | 0 | 355 |
| 1971 | 9 305 | | | 272 | 456 | 337 | 214 | 158 | 118 | 36 | 32 | 8 | 1 | 1 632 |
| 1972 | 11 818 | | | | 677 | 632 | 412 | 280 | 239 | 74 | 35 | 18 | 7 | 2 374 |
| 1873 | 7 277 | | | | | 496 | 387 | 210 | 182 | 46 | 40 | 15 | 4 | 1 380 |
| 1974 | 4 493 | | | | | | 233 | 141 | 146 | 31 | 26 | 11 | 3 | 591 |
| 1975 | 9 995 | | | | | | | 403 | 355 | 97 | 78 | 26 | 9 | 968 |
| 1976 | 1 763 | | | | | | | | 76 | 32 | 29 | 11 | 4 | 152 |
| 1977 | 7 094 | | | | | | | | | 119 | 105 | 34 | 14 | 272 |
| 1978 | 12 173 | | | | | | | | | | 248 | 55 | 51 | 354 |
| 1979 | 11 991 | | | | | | | | | | | 85 | 51 | 136 |
| 1980 | 5 676 | | | | | | | | | | | | 30 | 30 |
| $m_i$ | | 226 | 120 | 336 | 1 242 | 1 542 | 1 291 | 1 226 | 1 140 | 444 | 600 | 265 | 175 | |

Appendix A, Table 3 North Sea MACKEREL
Estimates of survival rates and F
Norwegian tagging data

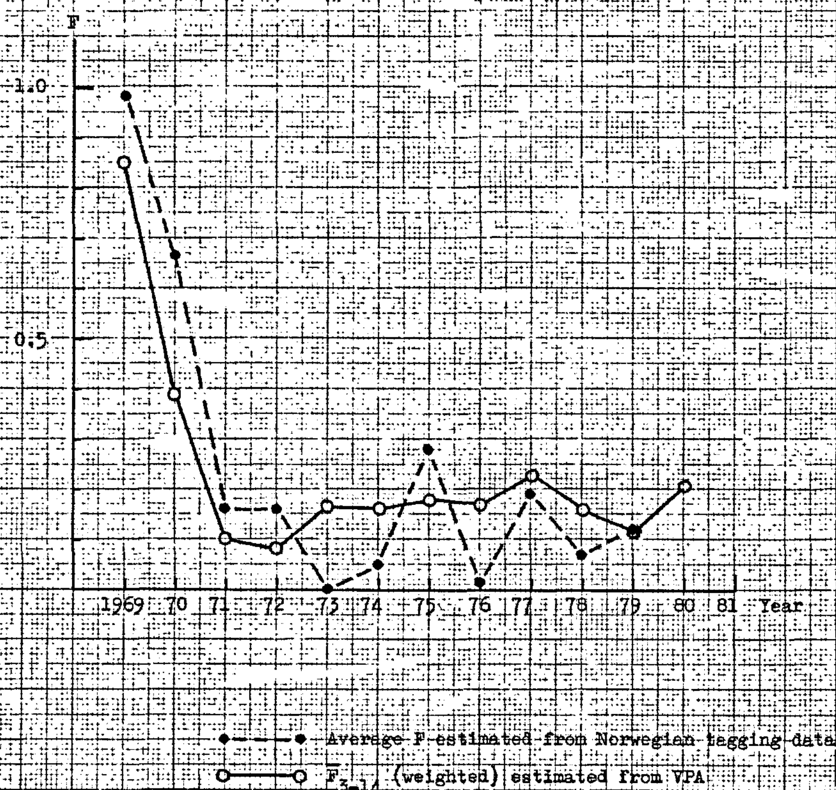
| Year | Survival rates | F |
|---|---|---|
| 1969 | 0.32 | 0.99 |
| 1970 | 0.44 | 0.67 |
| 1971 | 0.73 | 0.16 |
| 1972 | 0.73 | 0.16 |
| 1973 | 0.91 | - |
| 1974 | 0.82 | 0.05 |
| 1975 | 0.65 | 0.28 |
| 1976 | 0.85 | 0.01 |
| 1977 | 0.71 | 0.19 |
| 1978 | 0.80 | 0.07 |
| 1979 | 0.76 | 0.12 |

<u>Appendix A, Figure 1.</u>




For explanation see text

Appendix A, Figure 2. North Sea MACKEREL.
Comparison of average F estimated from tagging data and VPA.



## APPENDIX B

## ESTIMATION OF NUMBERS CAUGHT IN AGE GROUPS 10-15+ OF NORTH SEA MACKEREL

The idea is to calculate the relative strengths of the year classes from the catch in numbers, and then to apply these relative strengths to split the 10+ group from last year's VPA input tables into age groups 10-15+.

For the estimation of relative year class strength only age groups 4-9 were applied, these age groups being considered under full exploitation and well covered by otolith samples.

As an example, the estimation of catches of age groups 10-15+ in 1980 is given below. R(y/y-1) designates the relative strength of year class y to year class y-1 derived from the catch numbers. For the six year classes in question we get

$$R(70/69)=\frac{1}{4}\left(C_{74.4}/C_{74.5}+C_{75.5}/C_{75.6}+C_{76.6}/C_{76.7}+C_{77.7}/C_{77.8}\right)$$

$$=\frac{1}{4}(39.9/240.8+27.8/193.2+19.5/118.6+31.6/125.9) = 0.177$$

$$R(69/68)=\frac{1}{4}\left(C_{73.4}/C_{73.5}+C_{74.5}/C_{74.6}+C_{75.6}/C_{75.7}+C_{76.7}/C_{76.8}\right)$$

$$=\frac{1}{4}(280.2/74.3+240.8/45.8+193.2/25.6+118.6/31.3) = 5.09$$

$$R(68/67)=\frac{1}{4}(33.2/21.3+74.3/36.0+45.8/7.5+25.6/20.4) = 2.75$$

$$R(67/66)=0.95$$

$$R(66/65)=1.95$$

$$R(65/64)=5.37$$

where catch numbers are taken from Table 6.5 of the 1981 Working Group report.

And the relative strengths of all six year classes combined are derived:

| | | % | Age |
|---|---|---|---|
| R(70/69) x ............................x R(65/64) | = 24.65 | 11 | 10 |
| R(69/68) x ....................x R(65/64) | =139.25 | 61 | 11 |
| R(68/67) x .............x R(65/64) | = 27.36 | 12 | 12 |
| R(67/66)x ........x R(65/64) | = 9.95 | 4 | 13 |
| R(66/65)R(65/64) | = 10.47 | 5 | 14 |
| R(65/64) | = 5.37 | 2 | 15 |
| Sum | =217.05 | 95 | |
| Sum/0.95 | =228.5 | | |
| | | 5 | 16+ |

The 16+ group is assigned the relative strength of 5% (approx. = exp(-7 x 0.4)).

Finally we get :

$$C_{80.10} = 31.7 \times 0.11 = 3.5$$

$$C_{80.11} = 31.7 \times 0.61 = 19.3$$

$$C_{80.12} = 31.7 \times 0.12 = 3.8$$

$$C_{80.13} = 31.7 \times 0.04 = 1.3$$

$$C_{80.14} = 31.7 \times 0.05 = 1.6$$

$$C_{80.15+} = 31.7 \times 0.07 = \underline{2.2}$$

Total 31.7