International Council for the
Exploration of the Sea



ERRATA TO C.M.1981/H:7 - Report of Mackerel Working Group

page 2 - para 2.2: delete ... "for the fishery off Cornwall"

page 6 - last line: correct: 2-group to 3-group

page 54 - Fig. 4.1: the x-axis is age not years, therefore the numbers must be moved left to align with the space not the ticks.

page 60 - Fig. 8.3: the axis indicating catch (tonnes x $10^{-3}$) should read:
Catch (tonnes x $10^{-6}$).

-o-o-o-

International Council for the
Exploration of the Sea

C.M.1981/H:7
Pelagic Fish Committee

# REPORT OF THE MACKEREL WORKING GROUP

Copenhagen, 7-14 April 1981



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ICES,
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# 1. INTRODUCTION

## 1.1. Terms of Reference

At the 68th Statutory Meeting it was decided (C.Res.1980/2:6/10) that:

the Mackerel Working Group (Chairman: M J. Guéguen) should meet at ICES headquarters from 7 to 14 April 1981 to:

(i) assess the mackerel stocks in Sub-areas II, III, IV, VI, VII, VIII and IX,

(ii) give further clarification of the biological reasoning underlying the selection of 30cm as the length below which catching mackerel is undesirable, both for the North Sea and the Western stocks,

(iii) provide the best statistics available, sub-divided by gear type and by month (or season) of catches of horse mackerel, pilchard, sprat and mackerel in the area recommended for closure in paragraph 205 of the ACFM Report of 1980,

(iv) assess the benefits to the mackerel stock of the closure proposed in the paragraph of the ACFM Report mentioned above, including data available on the length distribution of catches, the mortality per age group, by months, and by gear type and mesh sizes,

(v) assess the effects of a 40mm minimum mesh size for trawl gears for mackerel in Sub-area IV.

The Working Group was asked by the Chairman of ACFM:

to re-assess the mixing of the stocks or reinterpret the tagging data,

to try an assessment on both North Sea and Western mackerel combined.

The Group was also asked by Portugal to include the assessment of horse mackerel of ICES Divisions VIIIc and IXa in its Agenda.

## 1.2. Participation

The Group met in Copenhagen with the following participants:

| | |
|---|---|
| R.S. Bailey | United Kingdom (Scotland) |
| E. Bakken | Norway |
| M.F. Borges | Portugal |
| H. Dornheim | Federal Republic of Germany |
| A. Eltink | Netherlands |
| L.S. Gordo | Portugal |
| J.C. Guéguen (Chairman) | France |
| S.A. Iversen | Norway |
| S.H. Í. Jakupsstovu | Faroe Islands |
| S.J. Lockwood | United Kingdom (England) |
| J. Molloy | Ireland |
| S. Munch Petersen | Denmark |
| T. Westgård | Norway |

## 2. THE MACKEREL FISHERIES

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

The total landings for 1979-80 from each country fishing in this area are given in Tables 2.1 (North Sea and Skagerrak) and 2.2 (Norwegian Sea). The figures for 1980 are provisional. The total catch in the North Sea area (Sub-area IV, Divisions IIa and IIIa) in 1980 was 96 000 tonnes. This was an apparent reduction of 40% from the 1979 landings. The decrease was the result of quota management regulations, but the reduced landings still represent an excess of 100% over the maximum recommended by ACFM (50 000 tonnes).

The landings by quarters are summarised in Table 2.3. As in previous years, the bulk of the catch was taken in the third quarter of the year both in the North Sea, Skagerrak and in the Norwegian Sea.

The information on catches by area were limited and misreporting may have occurred. For these reasons, the distribution of catches could not be given in detail. However, a shift was noticed in the main fishing area from Division IVa in 1979 to southern IVa/northern IVb in 1980. No information was available on "unallocated" catches; the absence of these data will influence the validity of those assessments dependent on good catch statistics.

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

The landings by each country for the period 1970-80 are shown in Table 2.4. Some slight revisions have been made in the 1979 catches, mainly in the Spanish figures, and these have resulted in a decrease in the total catch for that year of approximately 5 000 tonnes. The provisional catch for 1980 is approximately 605 000 tonnes, compared with 601 000 tonnes in 1979. This is the highest catch ever recorded from this western area. Although the total international catch in 1980 is only slightly higher than in 1979 considerable changes have taken place in many of the national catches. The United Kingdom (England and Wales) catch decreased from 244 000 tonnes in 1979 to 151 000 tonnes, due to United Kingdom national control measures for the fishery off Cornwall. A decrease was also reported in the total French catch. Considerable increases were reported in the catches by Ireland, Denmark, the Netherlands and Faroe Islands.

In addition to the national catches, a further 107 500 tonnes (18% of the total catch) were reported to the Working Group unofficially but were not allocated on a national basis.

The TAC recommended by ACFM for the Western area (Sub-areas VI, VII and VIII) for 1980 was 330 000 tonnes. Thus, the recommended area TAC was exceeded by 83%.

The distribution of the catches by Sub-area, shown in Table 2.5, indicates that there was a small increase in the quantity taken in Sub-area VI in 1980 while there has been a corresponding decrease in the catches from Sub-areas VII and VIII. However, these figures do not reveal the considerable increase that has taken place in the catches by fleets from Ireland and the Netherlands operating in Division VIa.

The seasonal distribution of the catches (Table 2.3) shows that in Sub-area VII over 80% of the catch was taken in the first and fourth quarters of the year, as in 1979. However, in Division VIa there was an increase in the percentage of the total catch taken in the fourth quarter (62% in 1980 compared with 51% in 1979).

2.3. Divisions IXa,b

The total landings from 1972-80 from each country are given in Table 2.6. There has been an increasing trend in landings, from about 3 000 tonnes in 1972 to 7 300 tonnes in 1980. In 1978, the landings reached a peak of 7 500 tonnes and since then there has been a slight decrease. Spanish landings contribute an average of 70% of the total landings, except in 1977 when the Soviet fleet accounted for 3 000 tonnes. Portuguese landings show some fluctuations with their average catch being about 1 000 tonnes in the period 1972-80. Prior to 1972, catch data were sometimes reported as "other species". In addition, species separation from Scomber japonicus in commercial landings is not always clear. The Portuguese fishery was conducted by a fleet of 127 trawlers in 1980. The average trawler makes 112 trips of two days - on each day 3 hauls of 4.4 hrs. On a smaller scale, artisanal boats using gill nets and hook-and-line contribute to the fishery (Table 2.7). Netheir trawlers nor artisanal boats conduct a directed fishery on this species.

Annual Portuguese catches by quarter are shown in Table 2.8.

No data are available on the relationship between the Western stock and mackerel in Divisions IXa,b. For this reason the catches from Divisions IXa,b are not included in the Western stock assessment. Preliminary biological data from these Divisions are summarised below. They are at present inadequate to make an assessment.

Only Portuguese data on catch rates of trawlers are available for the period 1974-80 (Table 2.9). These show some fluctuations but there has been a downward trend in recent years.

Biological parameters are available from Portuguese data (1979) concerning northern and central areas.

a) growth parameters based on ages 1 to 8+

$K = 0.1831$

$t_o = -4.5112$

$L = 46.02$

b) Spawning takes place between the middle of March and the beginning of June, off the Portuguese coast, after individuals have completed their first year. In order to study the relationship between the mackerel from Sub-area IX and the mackerel from adjacent areas, the Working Group recommends that all countries involved in the fishery should provide and improve the data.

2.4. Discarding in 1980

2.4.1. North Sea

There was no evidence of discarding in Divisions IVa and IVb in 1980.

An investigation of discarding by Dutch trawlers showed that there was some discarding by bottom trawlers. The Dutch catch at age data were raised to include the discards, but this increase accounted for less than 1% of the international North Sea catch.

2.4.2. Western Area

No new direct observations of discarding have been made since the exercises reported in the last Working Group report (Anon. 1980a). The same raising factors as were used in 1980 were applied to the numbers at age data for those fisheries where discarding is known to occur. During the 4th quarter of 1980, the preponderance of 1978-79 year classes in the catches off Cornwall resulted in an increase in the rate of discarding in the human consumption fishery. For this quarter, a higher raising factor was applied to the English data than was used in the first quarter.

Discarding in the autumn fishery in Division VIa was limited to mackerel lost from torn nets and to those not accepted for marketing because of their quality. In total, this amounted to not more than 3% of the total landings from Division VIa and catches in numbers have been raised accordingly.

2.5. Catch Statistics

We have mentioned above the very large catches which have been reported unofficially and which have not appeared in the national catch statistics. Doubts have also been expressed by various members about the validity of national catch figures. The increasing amounts of mackerel which are caught but discarded also undermine the accuracy of catch statistics. We must, therefore, emphasize that the total estimated catches used in the VPAs for both the North Sea and Western areas must be considered with due caution. The fact must be remembered when considering the estimate of the total stock size derived from VPA and also when considering the recommended TACs for 1982. The situation is rendered even more serious because of the decline which has taken place in the size of the stocks from both areas. Because of this, the recommended TACs must therefore be considered with caution as they may be over-optimistic. The Working Group recommends that immediate steps be taken by each country to ensure that accurate catch statistics are available in future. This will entail increased cooperation between the various national organisations engaged in the collection of catch figures and an awareness by them of their responsibility in the management of these fisheries.

3. STOCK DELINEATION

A description of the problems relating to the interpretation of the tagging data was given in the 1980 Report of the Working Group (Anon. 1980a). In particular, it was difficult to interpret the observed tag densities in Division VIa in summer which were higher than those found in the North Sea in summer. This applies to both mackerel tagged southwest of Ireland and tagged in the North Sea. In addition, a high number of tags released off Ireland were returned from the North Sea, while tags from the North Sea occurred both west of the British Isles and in the English Channel.

These observations indicated that the migration pattern of the mackerel was more complex than assumed earlier. To clarify the questions, an attempt was made to establish a working hypothesis for a stock and migration concept which could give a plausible explanation to the tagging data.

As a basis, two stocks, having separate spawning areas, were assumed to exist: the North Sea stock and the Western stock. For the purpose of describing the distribution, the Western stock was considered as two components: a) a faster growing and northerly distributed component and b) a slower growing southerly component (Corten and Van de Kamp, 1978).

The migrations of the mature fish of the three components, termed "North Sea", "Western a" and "Western b", are illustrated in Figures 3.1 - 3.4 as distribution charts at four approximate periods in time: February, June, August and November.

Figure 3.1, February, represents the situation in late winter. The North Sea stock is found in the Norwegian Trench and to the west of the Shetland-Hebrides. The Western stock is distributed from Northern Ireland to the Bay of Biscay, the a-component in the northern part and the b-component in the south with an overlapping area in the Celtic Sea.

Figure 3.2, June, shows the distribution in early summer. The area of each component has expanded. The North Sea stock is found near the area of spawning, while the a-component of the Western stock occurs in Division VIa migrating northwards into the northern North Sea and the Norwegian Sea. The b-component of the Western stock also migrates to the north into Division VIa and the southern part of the North Sea.

Figure 3.3, August, shows that the distribution of mackerel is at its widest. The stocks and components overlap in distribution. Thus, the Western a-component penetrates into the northern part of the North Sea from northwest, while the Western b-component also comes into the North Sea from south.

Figure 3.4, November, shows the situation prior to the overwintering period. Part of the North Sea stock migrates to the area west of Shetland, and the rest concentrates along the western slope of the Norwegian Trench. The a-component of the Western stock retracts southwards and is found mainly to the west of the British Isles. The b-component of the Western stock moves to concentrate in the Celtic Sea area. The migrations of mackerel from and to the Celtic Sea area which are described here are basically the same as those described by Bolster (1974). The results of the Norwegian tagging experiments can now, in general, be explained on the basis of the distribution and migration pattern outlined above.

The tagging in May off Ireland is likely to give a tagged population near the northern front of the Western a-component while it is starting the migration northwards. The tagged population is likely to remain near the front until the mackerel spread out for feeding in the northern North Sea. At that time, the tagged population will be mixed with the untagged part of the Western a-component as well as the North Sea stock.

When the a-component of the Western stock leaves the North Sea in early autumn, the tagged fish will be among the last to leave.

A migration pattern such as this can explain the observed variations in tag density described in the 1979 Report of the Working Group. If the stock components of the winter catches in Division VIa were estimated by the method previously used, the data from the North Sea taggings indicated more than 100% North Sea mackerel. A similar calculation based on the taggings near Ireland indicated the reverse, i.e., more than 100% Western stock. This contradiction gave rise to serious doubts about the validity of the assessments based on tag data. In the 1980 Report of the Working Group, it was

pointed out that the observations could be explained by postulating a component of mackerel not being tagged, either in the Western area or in the North Sea.

It now seems possible to interpret the observed tag densities. The increase in density of North Sea tags observed in January/February 1979 in the northern part of Division VIa compared to that in Division IVa in summer can be explained by assuming that an untagged component of the Western stock has left the area by that time. The high density of tags from releases off Ireland in Division VIa in winter compared to that in Division IVa in summer, may result from the tagged population representing part of the Western a-component only. In winter (Figures 3.4 and 3.1), this population migrates through Division VIa and will, to a limited extent, be mixed with North Sea mackerel. In summer (Figure 3.3), the same tagged population may occur together with North Sea mackerel and other parts of the Western stock. Consequently, the density of tags from releases off Ireland will be lowered.

The distribution and migration of the stocks outlined here correspond in broad terms with the observations from the taggings, biological data and information from the fishery, but there are observations which are still not explained. Also, there may be alternative interpretations of these data. It is recognised that Western stock mackerel may be tagged in the North Sea. Mackerel of the Western a-component may occur on the tagging locations off southwest Norway in July-August, and Western b-component mackerel could conceivably migrate into the North Sea tagging area.

These problems need clarification. It is necessary to improve the data on stock identification to give a better understanding of the quantitative relationship among the migrating stock components.

For the present, the Working Group has accepted the data from the North Sea releases as representative of the North Sea stock. In the absence of other information, these data are utilized for the assessments.

## 4. MATURITY

Data are available for constructing maturity ogives only for the Western stock. Biological samples taken from commercial catches and research vessel catches in the western spawning area during the spawning season were examined and the sexual maturity of individual fish was recorded on a sclae of one to eight (Macer, 1974, 1976). Fish which were at maturity stage III (early developing) were assumed to be maturing prior to spawning in the current spawning season and fish at stage VII (spent) were assumed to have spawned in the current spawning season.

Some maturity data were available from the sampling of Dutch commercial catches on the spawning grounds during 1979 and 1980, but most data were available from the English commercial and research vessel sampling programme 1973-80. Maturity ogives constructed from these data (Figure 4.1) show that 50% of mackerel reach maturity at 28cm or as 2-group fish.

| Age | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | >10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| % Mature | 0 | 18 | 38 | 67 | 89 | 93 | 98 | 96 | 99 | 99 | 100 |

## 5. EGG SURVEYS

### 5.1. The Norwegian Egg Surveys in the North Sea in 1980

Between 17 June and 27 July, Norway surveyed the spawning area in the North Sea three times to estimate the total egg production and the size of the spawning stock. The results were reported to the meeting of ACFM last autumn. The estimate of the spawning stock is based on numbers of mackerel eggs without visible embryo. Samples were collected with a 20cm Bongo net worked 5 minutes in each of the depths 20, 15, 10 and 5m and just below the sea surface. The first cruise was carried out at approximately the same time as the surveys made in previous years. The egg index from this survey was very much the same as for last year (Anon. 1980a). This indicates that the size of the spawning stock in 1980 was of the same order as that of 1979.

The daily egg production curve is shown in Figure 5.1. This curve is based on the estimated daily egg production from the three cruises, and the spawning intensity curve obtained from daily sampling with a vertical net at a position 57°04'N 02°26'E. Assuming an egg mortality of 10% during the first day of life, the total number was estimated at $69.4 \times 10^{12}$ eggs. This is an underestimate because the Skagerrak was not surveyed. Recent investigations (Iversen, 1977) have shown that the egg production in the Skagerrak is roughly 10% of the total.

Samples from the mackerel catches in the North Sea in June-July show that the sex ratio in the spawning stock is one female per male.

The estimated spawning stock size is highly dependent upon the fecundity used. Fecundity data for the North Sea given by Borges et al. (1980) give a spawning stock of 406 000 tonnes. Applying data for the Western stock (Anon., 1979), the stock was estimated at 138 000 tonnes. Kändler (1957) gives the fecundity for some mackerel caught in the North Sea which gives a spawning stock of 90 000 tonnes. The difference between these fecundity estimates could be real, but there is a need for further fecundity investigations to clarify this.

### 5.2. Western Mackerel Stock Egg Survey

In 1977, the Western mackerel stock spawning grounds were surveyed. This survey established that spawning was concentrated along the edge of the Continental Shelf from Spain to west of Ireland during March-July. During 1980, this area was surveyed again on a total of six occasions during March-July with research vessels from England, Federal Republic of Germany, France and Scotland. A smaller scale, inshore survey was also made off the southern coast of Ireland by the Irish. In addition to the plankton samples, further biological data were collected by the research vessels and from catches of Dutch commercial vessels fishing on the spawning grounds in the spawning season.

The methods used in estimating the total egg production for the surveyed area are described by Lockwood et al. (1981) but a summary of the results is given in Table 5.1 and the production curve is shown in Figure 5.2.

Whereas a single mean fecundity estimate was made for the Western stock in 1977, the monthly Dutch length frequency data available for 1980 enabled monthly mean fecundities to be calculated. The number of female mackerel spawning during one day for each of the survey cruises was calculated from these monthly fecundity estimates and the daily production estimates, Table 5.2.

Following a thorough review of all available data, both from commercial catches and research vessel samples, the sex ratio was found to be 1:1, as in the North Sea (see section 5.1). This sex ratio was used to raise the total estimate of spawning stock (Table 5.2), and to draw the frequency distribution of spawning fish shown in Figure 5.3. The total spawning stock estimate of 6 200 x $10^6$ fish equivalent to 1.8 million tonnes was estimated by integrating the area beneath this curve.

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

### 6.1. Catch in Numbers at Age

#### 6.1.1. North Sea area

The bulk of the catches in the northern North Sea came from Danish and Norwegian purse seiners and for these catches age compositions were available. Age distribution from the Danish fishery was based on few samples which demonstrated a younger age distribution than in the Norwegian and Scottish samples. Age distribution from the Dutch catches were also available. No age compositions were available from catches taken by the Faroes, Sweden, England, France and the Federal Republic of Germany. These catches were divided according to gear and area and then numbers of mackerel caught were estimated according to available age compositions. The compositions of the Norwegian purse seine fishery were used for catches from the Faroes and Sweden. Some Scottish data for demersal trawl catches were applied for the French catches in Division IVa and Dutch data for the French catches in Division IVb. Separate age compositions for the Norwegian gill net and hook and line fishery along the western Norwegian and Skagerrak coasts were available. Catches from Sweden and the Faroes in Division IIIa were split according to Danish samples.

According to the Norwegian samples, the 1969 year class still contributes 14-25% of the catches. The age composition in Table 6.1 shows that the 1977 and 1978 year classes are extremely scarce in the catches.

#### 6.1.2. Catch in numbers of the North Sea stock

The catches of the North Sea stock in these areas are shown in Table 6.2. The Danish catches were divided between Division IVa and Division IVb as 2:1. The Swedish catches from the North Sea were assigned to Division IVa. A common age distribution was used for the Norwegian catches in both Division IVb and in the open sea part of Division IVa. A separate age distribution was applied to the Norwegian gill net catches. These were considered as pure North Sea stock as the catches were taken along the Norwegian west coast during April-October.

The total catch in numbers by age of the North Sea stock for 1980 was derived from:

$$C_{IVa\ (NS)} + C_{IVb,c} + C_{IIIa} + C_{VIa\ (NS)} + C_{IIa\ (NS)}$$

where C is the catch in numbers.

In estimating $C_{IVa\ (NS)}$, a total age composition of all catches, excluding the Norwegian coastal gill-net fishery, from Division IVa was first calculated. The North Sea stock proportion of this was then estimated using P1980 (Appendix Table 2) and to this were then added the Norwegian gill-net catches. The same proportion was applied for dividing the catch from Division IIa.

6.1.3. Western area

Although there was a small revision of the 1979 total catch in the Western area (from 605 000 tonnes reported in the previous report to 601 000 tonnes), this was not sufficiently large to justify revising catch in numbers for 1979. The numbers at age in the Western area in 1980 were estimated from sampling data provided by:

Division VIa: France, Ireland, Netherlands, Norway and Scotland

Divisions VIIa,b,c: France, Ireland, Netherlands

Divisions VIId-k: England, France, Ireland, Netherlands, Norway

Sub-area VIII: France.

In Division VIa, Faroese length compositions and age data from Faroese vessels landing in Scotland were used to allocate the Faroese catches to age groups. This age distribution was then used to allocate Danish catches to age groups. Catches made by the Federal Republic of Germany were allocated with Dutch data while remaining catches were covered by national sample data.

In Divisions VIIa,b,c, Dutch sampling data were used to allocate Dutch catches in the first half of the year but Dutch catches from the second half of the year and Federal Republic of Germany catches for the whole year were allocated with combined French and Irish data.

In Divisions VIId-k, catches made by the Federal Republic of Germany were allocated to age groups with Dutch data, Danish catches with combined English/French data. Spanish catches were assumed to be 15 000 tonnes, all taken in Sub-area VIII and allocated to ages with French sample data.

The numbers at age for each nation used in compiling the final number at age table (Table 6.3) include the estimates for "unallocated" catch and also discarded catches where appropriate. Table 6.3 also includes numbers at age of Western stock fish caught in the North Sea area.

The numbers at age caught in Division VIa were divided into North Sea and Western stock components using the method proposed by Walsh (1977). Using previous VPA estimates of fishing mortality rates, the number of tagged fish from each release still surviving in the 1978/79 winter were calculated. (This was the only season for which Norwegian tag returns from the northern part of Division VIa were available.) The proportion of the two stocks in the catches were then estimated from the ratio:

$$\frac{\text{No. of tag returns from North Sea releases in VIa}}{\text{Estimated no. of North Sea tagged fish still surviving}} \times \text{estimated no. in North Sea stock} : \frac{\text{No. of tag returns from Western releases in VIa}}{\text{Estimated no. of Western tagged fish still surviving}} \times \text{estim. no. in Western stock}$$

The values used were:

$$\frac{223}{19\,985} \times 1\,014 \times 10^6 \text{ North Sea stock: } \frac{94}{26\,246} \times 9\,571 \times 10^6 \text{ Western stock}$$

equivalent to a ratio of 25% North Sea and 75% Western.

No additional data were available for the 1979-80 or 1980-81 winter fisheries in Division VIa. This ratio was therefore applied to all age groups in the winter fisheries in Division VIa in 1980.

6.2. Mean Weight at Age (Table 6.4)

6.2.1. North Sea

The same mean weights at age were used as in the last North Sea stock assessment (Anon. 1979).

6.2.2. Western stock

For the reasons explained in 1980 (Anon. 1980), it was agreed to use the same weight at age as in previous years when calculating stock biomass. As a proportion of the 1 and 2 year old fish is now known to contribute to the spawning stock (see section 4), a mean weight at age has been calculated for those age groups in the spawning season. This has been done by applying to the mean weight at age 1 and 2 in the catch, the ratio.

$$\frac{\overline{W} \text{ at age in the stock}}{\overline{W} \text{ at age in the catch}}$$

calculated for older fish.

For the period 1972-77, the weight at age for the running plus group, formed by the pre-1969 year class, calculated for the stock assessment in 1980 (Anon. 1980a) has also been used for calculating the spawning stock biomass this year.

6.3. Assessment of the North Sea Stock

In 1980, the Working Group deferred making an assessment of the North Sea mackerel stock on the grounds that a new analysis of the tag recapture data was required. Although this analysis is not yet complete there is a need for an assessment of the stock after a gap of two years. Despite all the difficulties and inadequacies with the basic data discussed above, an assessment of the stock size was made using data from the Norwegian egg survey in 1980.

Using the catch at age data, and assuming maturity for age groups $\geq 3$, a series of VPAs were run, primarily as "exercises". From these runs, it seemed that a terminal F-value of 0.2 for the fully recruited age groups in 1980 gave a pattern in mean Fs in previous years, which was similar to those estimated in earlier VPAs (Table 6.5). The corresponding stock size figure for 1980 was about 400 000 tonnes which is of the same order as the upper estimate from egg surveys. As pointed out in section 5.1, the results of the Norwegian egg surveys in 1980 can be interpreted differently depending on the value of fecundity used. Using the fecundity for North Sea mackerel obtained by Borges et al. (1980), the spawning stock is estimated to be 800 million fish, whereas using the fecundity for Western mackerel based on a more adequate series of data, the spawning stock is estimated to be 272 million fish. These estimates would imply input values of F in 1980 of approximately 0.2 and 0.7, respectively, and very different rates of decline of the spawning stock.

Some indication of the likely value of F in 1980 can be obtained by comparing the trends in spawning stock with that shown by the indices of egg production provided by the Norwegian egg surveys since 1974 (Table 6.6). The annual variation of this index is very high which gives little reason to rely on changes between one year and the next. The trend in the values, however, is best followed by VPA runs using the lower values of input F. The large

decrease since 1978 implied by an input F of 0.7, moreover, is not supported by the egg index values. It therefore seems more likely that the spawning stock in 1980 was closer to 800 million than to 272 million. On these grounds, the VPA run using an input F of 0.2 was chosen as that most likely to represent recent changes in the stock.

The results of the VPA indicate a spawning stock of 340 000 tonnes in 1980, decreasing to 270 000 tonnes in 1981. If this assessment is correct, the spawning stock has declined every year since 1972. In nine years, it has been reduced to less than a quarter of its peak level despite the low values of F throughout this period. This is exactly what might be expected in a stock receiving very low levels of recruitment.

The reasons for these recent low levels of recruitment are not clear. In a stock declining at the present rate and in which there is little evidence of improved recruitment, the possibility of reaching a state of almost permanent depletion cannot be ruled out.

6.4. Assessment of the Western Stock

As in previous years, a VPA was carried out using the numbers at age caught in the Western area, less the estimated number of North Sea stock caught in Division VIa but with the addition of the estimated number of Western stock fish caught in Division IVa. These latter adjustments are dependent upon the mixing ratios estimated from the tagging data, which are difficult to interpret (see section 6.1.1), but as was pointed out in the previous report (Anon. 1980a), the numbers involved form only a small part of the total Western stock catch, probably less than 5%. Any errors which these adjustments may introduce will therefore have a marginal effect on the overall assessment. The catch in number for 1980 is given by Divisions in Table 6.3, and the total input to the VPA in Table 6.7.

As in previous years, there were no data available to estimate a value for the input F with which to start the VPA run. The same procedure was followed as during the last 3 years, but whereas the VPA was previously matched to the results of the 1977 Western stock egg survey, this VPA was matched to the results for the 1980 egg survey, 6 200 x $10^6$ fish. There was one variation in procedure compared with previous occasions. The VPAs carried out in 1978-80 assumed the 1977 plankton survey stock size estimate (ca. 9 000 x $10^6$ mature fish) was the stock size on 1 January. This assumption was made primarily for ease of calculation. With the new ICES VPA computer program, it is a simple matter to match the spawning stock estimate to the date of peak spawning (1 June) and run the VPA to give population estimates for 1 January, as before, and also 1 June (Table 6.8). This was the procedure adopted by this Working Group.

The proportion of M which occurred before 1 June was assumed to be proportional to the time of year, i.e., 0.4, and the proportion of F was assumed to be equal to the proportion of the total annual catch taken in the first half of the year. This was also equivalent to 0.4.

On earlier occasions, VPA runs were made assuming that all fish older than 2 years were mature, i.e., there was a knife-edge maturity at age 3. This year, the maturity ogive described for the Western stock (section 4) was included in the assessment.

A number of VPA runs were then made with different values of F until a 1980 spawning population was estimated equal to the 1980 plankton survey.

As in the past two years, the two year old fish and older were assumed to be fully exploited, and the 1 year olds only 40% exploited. The runs made with this exploitation pattern generated a 1978 year class above average, for which there is no evidence, and a 1979 year class below average, which was contrary to the evidence discussed last year (Anon. 1980a). To establish a relationship between the 1978 and 1979 year classes, and between them and the long-term mean ($3\ 000 \times 10^6$ 1 year olds), closer to that which was expected, the exploitation pattern was adjusted. By reducing F on the two year olds to about 80% of fully exploited, and increasing F on 1 year olds to 50% fully exploited, the VPA estimated recruitment figures for the 1978 and 1979 year classes which were closer to the expected, i.e., the 1978 year class is about average and the 1979 year class is above average, but not so high as indicated from the results of the VPA made in 1980. The slight increase in F on 1 year olds from 0.13 in 1979 to 0.15 in 1980 may be explained by the heavy dependance of the English fishery on the 1979 year class in the winter 1980/81 (Figure 6.1). The results of the VPA (Table 6.7) show that fishing mortality continues to rise and was about 0.30 in 1980. Values of F for other years are consistent with those estimated in earlier reports. This being so it is not surprising to find that the VPA continues to estimate the 1977 spawning stock size at about 9 000 million fish, even though it is now matched to the 1980 plankton survey results.

This analysis confirms that the 1977 year class is the weakest Western stock year class on record, i.e., 15% of the long-term mean recruitment. The 1971 year class was strong, and the 1976 year class continues to show as the strongest in recent years, although there is still the possibility that the 1979 year class may equal it.

The spawning stock VPA, and the estimates of stock biomass, are given in Table 6.8. The spawning stock biomass in 1980 was estimated to be $1.8 \times 10^6$ tonnes.

Despite the strength of the 1976 year class, the spawning stock biomass continued to decrease from its peak in 1974, when the 1971 year class was making its maximum contribution. In 1980, the estimated spawning stock biomass fell below 2.0 million tonnes for the first time, and will fall to less than half the 1974 value by the end of the year.

## 6.5. Joint Assessment of the Mackerel Stocks

Following a discussion in ACFM, the Chairman of ACFM requested the Working Group to consider assessing the two mackerel stocks jointly.

A joint assessment was discussed by the Working Group at the 1980 meeting. It was then concluded that a combined VPA would not assist in solving the main problem of estimating the size of the North Sea stock.

The limitations and advantages of a combined VPA were further discussed at the present meeting. Catch in number data for both the North Sea and the Western area were available for the years 1972-80. For a combined VPA, the annual catch could simply be added, and no assumptions and calculations of stock intermixing would be needed.

The questions of intermixing and distribution by area would, however, return when evaluating the results of a combined VPA, as most other independent assessment data relate to one or the other stock, e.g., the estimates of spawning stock size and fishing mortalities. Although the tagging results

indicate a complex migration pattern and intermixing between stocks, these and other data do not support a concept of one stock resulting from total mixing of mackerel originating from the two main spawning areas.

Furthermore, a combined VPA leading to an estimate of the size of both stocks together would not improve the basis for calculating catch prognoses and TACs. Separate TACs for the two main fishing areas are needed due to the difference in stock situation. A single TAC covering both areas could result in an exploitation of the stocks which was not proportional to the strength of these stocks, and an increase in the relative catch in the North Sea would be expected.

For these reasons, the Working Group decided against assessing the stocks jointly.

## 7. RECRUITMENT

Data from the International Young Fish Surveys in 1979 and 1980 show that the 1978 and 1979 year classes in the North Sea were very weak. This is also reflected in the age composition of the catches in 1980 (Table 6.2).

The Netherlands caught 0-group mackerel (24-28cm) in the fishery in the last quarter of 1980 in Division IVc. This, together with observations of 0-group mackerel in some Norwegian fjords for the first time for several years, could indicate that the 1980 year class is relatively strong. However, preliminary information from the Young Fish Survey this year does not support this conclusion.

## 8. CATCH FORECAST

### 8.1. Prognoses for the North Sea Stock

All available data indicate that the spawning stock is at the lowest level ever recorded. The spawning stock size of 340 000 tonnes in 1980 might be a serious overestimate (see section 6.3). Furthermore, the main fishery for mackerel in 1980 in the North Sea took place after the egg survey.

No year class of any significance compared to previous years has been produced since 1974 and the last three year classes have been extremely poor indicating serious recruitment failure.

Prognoses for the North Sea stock in 1982 were made following two sets of assumptions:

Option A: the recommended TAC for 1981 will not be exceeded

Option B: the recommended TAC for 1981 will be exceeded by 100% (i.e. 80 000 tonnes).

Each of these prognoses was made assuming 1) a continuation of recent poor recruitment, and 2) an average recruitment.

The results are summarised in the following text-tables:

| Stock at 1.1.1981 | | | Recruitment | Stock at 1.1.1982 |
|---|---|---|---|---|
| Biomass ≥ 3 y.o. = 270 000t | Option A | 1 | Low level | Biomass ≥ 3 y.o = 230 000t |
| | | 2 | Average | Biomass ≥ 3 y.o = 235 000t |
| | Option B | 1 | Low level | Biomass ≥ 3 y.o. = 205 000t |
| | | 2 | Average | Biomass ≥ 3 y.o. = 210 000t |

Prognosis B1 is shown in Figure 8.1, along with estimated stock biomass and catches over the past decade. These data show that with a continuous poor recruitment, and despite a reduction in total catches, the stock had declined continuously since 1972 to its present low level. To minimise the risk of a stock collapse, the only conclusion which may be drawn is that all fishing on the North Sea stock must stop.

8.2. Prognoses for the Western Stock

The population estimate at 1 January 1981 from the VPA has been used to start prognoses for the stock. As in 1980 (Anon. 1980a), these prognoses were made on two basic assumptions:

A) that the stock TAC of 353 000 tonnes is adhered to in 1981,

B) that the catch in 1981 is not less than 580 000 tonnes (the best estimate the Working Group could make in the continued absence of international quota enforcement).

The Working Group considers that the probability of the former assumption (Option A) being realised is negligible. However, following the request from ACFM, a stock and yield prognosis was made for the period 1980-85, assuming Option A is realised. It also assumed average recruitment (3 000 x $10^6$ 1 year olds) and a maximum fishing mortality of F = 0.15 over the period 1982-85. The results of this prognosis are shown in Figure 8.2.A.

The more realistic assumption (Option B) is the basis of the prognosis used in estimating the TAC for 1982. As in previous years, the recruitment of one year olds is assumed to be below average (1 100 x $10^6$ 1 year olds). (The reasons for this figure have been fully explained in earlier reports (Anon. 1978, 1979 and 1980a).

The results of the prognoses are presented in the text table below:

| | Recruitment | Spawning Stock at 1.1.1982 | TAC 1982 |
|---|---|---|---|
| Option A | Average | 1 819 000t | 342 000t |
| Option B | Low level | 1 532 000t | 269 000t |

Throughout the prognosis, the exploitation pattern was assumed to be the same as that applied to the terminal Fs in the VPA, i.e., 3 year olds and older fully exploited, 2 year olds approximately 80% exploited and 1 year olds 50% exploited.

In Option B, the fully exploited value of F in 1981 is 0.28, which is far in excess of the recommended level of F = 0.15, and will depress the spawning stock size to a little more than 1 million tonnes in 1985.

As in earlier years, a TAC for 1982 was calculated equivalent to F = 0.15 on the fully exploited age groups. This is equivalent to 269 000 tonnes. Assuming that this TAC and subsequent TACs are adhered to, and the pattern of fishing remains constant, the prognosis was carried through to 1985 for comparison with Option A (Figure 8.2.B).

The long-term trend in spawning stock biomasses and catches over the period from 1970 to 1985 is shown in Figure 8.3.

In last year's report (Anon. 1980a), the Working Group expressed concern about the continuing high levels of F, but assuming that F did not exceed 0.25 during 1980 and bearing in mind the presence of two strong year classes, they did not think that the stock was in imminent danger of a collapse. While no data have yet been presented to indicate an imminent stock collapse, fishing mortality did exceed the anticipated level in 1980 and shows no real sign of dropping during 1981. Even with the rather optimistic assumption that fishing mortality can be held at a level of no more than 0.15 over the period 1982-85, there is the real prospect of the stock falling below 1 million tonnes in the near future. While a stock and recruitment relationship cannot be proved, the events observed in the North Sea stock should not be ignored. The North Sea mackerel stock declined from 3 million tonnes to less than 1 million tonnes over a time scale similar to that which we see in the Western area. Following that decline, there has been a prolonged period of poor recruitment resulting in the parlous situation described above (section 8.1). Unless immediate action is taken to limit the total catches and to protect the immature fish, the Western mackerel stock could be no greater than the North Sea stock within a very few years.

Figures 8.4 and 8.5 present the forecast for the Western stock following the requirements made by ACFM.

## 9. EXPLOITATION PATTERN

### 9.1. The Effects of Closed Areas

#### 9.1.1. Sub-area VII

The implementation of a closed area southwest of the United Kingdom was proposed by the Working Group (Anon. 1979) in order to minimise the capture of young mackerel by non-selective gears when these juveniles are predominant in the fishery. The closed area proposed covered ICES Division VIIe north of 48°45'N and Division VIIf south of 50°15'N. Finally, ACFM recommended that fishing for mackerel with unselective mesh size should be banned in the area between 49°30'N and 50°30'N and between 5°W and 7°W from 15 February to 15 December.

A potential increase in the yield per recruit was expected from that measure.

The Working Group has investigated the likely benefits of the closed area. Data on age distribution in the catches have been provided by France, Netherlands and the United Kingdom for various seasons and various types of gears (Table 9.1); length distributions were provided by Netherlands for catches in the closed area and by France and the United Kingdom for the closed area and the Eastern Channel (Tables 9.2 - 9.3).

The benefits in terms of yield attributable to the closed area cannot easily be made for several reasons: migrating fish leaving the closed area can be caught in other fisheries as can be seen from the length distribution of catches in summer in the Eastern Channel (Table 9.3). Moreover, there appears to have been a change in the distribution of fish in the winter fishery off Cornwall in recent years and the large fish, which usually appear in December-January were very scarce in 1980 and catches of small fish predominated during the whole fishing season (Table 9.2 and Figure 6.1).

Because of its limited size, the closed area may offer some protection to only a small proportion of juvenile mackerel, and its benefits are not evident.

Further measures should be considered. The increase in size of the closed area to cover the whole Division VIId,e and possibly parts of Division VIIf,g and h. The measure could be met by a shift in the fishery towards the edge of the Continental Shelf, where large fish have recently been found in winter or spring. The effects of such measures have been discussed previously (Anon. 1980a)(Lockwood and Shepherd, 1980).

The implementation of a minimum landing size and its effects are discussed in section 9.3 of the present report.

9.1.2. Division VIa

Bearing in mind the occurrence of North Sea mackerel in the northern part of Division VIa in winter as outlined, and the comments on the state of the North Sea stock (section 8.1), consideration should be given to closing the winter fishery in the northern part of Division VIa.

9.1.3. Division IVc

The small quantities of mackerel caught in Division IVc (23 000 tonnes in 1980) have always been allocated to the North Sea stock for the purposes of assessment. The distributions shown in Figures 3.2 and 3.3, which are based on tagging data, suggest that these fish are probably part of the Western stock; when considering a ban on fishing on the North Sea stock, some thought should be given to exempting Division IVc from a closed area.

9.1.4. Catches of other species in the restricted area off Cornwall

As requested by the ACFM, landings of mackerel, horse mackerel, pilchard and sprat in the closed area (part of Divisions VIIe and f) are given in Table 9.4.

9.2. Effects of a 40mm Mesh Size for Trawl Gears for Mackerel in Sub-area IV

In the absence of any information on the selectivity of trawls used for catching mackerel, the Working Group felt unable to assess the real effects of a 40mm mesh size. It is thought that due to the shoaling behaviour of mackerel, the selection of such a mesh size is probably minimal.

In connection with the problem of the 30cm minimum landing size for mackerel, the Working Group recommends that the selectivity of trawls used in the mackerel fisheries should be investigated.

9.3. Minimum Landing Size

The advantages to be gained, and the problems to be encountered, with the implementation of a minimum size of 30cm were discussed at length in an earlier Working Group report (Anon. 1979). The conclusions reached then may be summarised as follows:

9.3.1. North Sea, Sub-area IV

Previous studies of North Sea mackerel have shown that the seasonal pattern of the fishery has a considerable effect on the yield and spawning stock per recruit, especially when the fishing mortality is high and the younger age groups are unprotected. The gain obtained in yield per recruit by increasing age at first capture is rather small at low levels of fishing mortality. It does, however, have a large effect on the spawning stock. Theoretically, the spawning stock would be increased by nearly 50% by increasing the age at first capture from 1 to 3 years, at a fishing mortality level of 0.2.

The existing regulation, prohibiting catching mackerel smaller than 30cm for industrial purposes, should be maintained. There is no biological justification for restricting this regulation to the industrial fishery, and to obtain full protection for the youngest age groups the present exemption of 20% for undersized fish should be reduced.

9.3.2. The Western area, Sub-area VII

An analysis of the yield and spawning biomass per recruit show that these can be improved if the present pattern of exploitation is regulated to protect the young fish.

In Sub-area VII, 3 year old mackerel are about 30cm. If the number of fish less than 30cm caught is significantly reduced, there will be a slight gain in yield in the fishery from this Sub-area of 3-6% over the range of Fs recently estimated. There will, however, be a gain of 30-50% in the spawning stock biomass, and a significantly higher gain in the yield from the fishery on the stock as a whole.

At that time (1979) over half the catch (in number) from the Western stock was taken in Sub-area VII (Anon. 1979), and most of that in the winter fishery around southwest England. It was recognised that the enforcement of a 30cm minimum size would not result in a real increase in yield or spawning stock biomass as there would probably be a serious increase in discarding. Instead, ACFM recommended a seasonally restricted area around the Cornish peninsula (Anon. 1980b) as a means of achieving some measure of protection for immature fish.

This Working Group has reconsidered the subject and concludes that there is no reason to amend their views on the 30cm minimum size regulation in the North Sea, nor the biological basis for it (Anon. 1979). There are reasons to reconsider the problem in the Western area, however.

As mentioned above, the fishery around Cornwall was the only winter fishery, prior to 1979, and individual catches contained fish of all ages and sizes. Since then, the Dutch, Federal Republic of Germany and Irish commercial fishing fleets have shown that a winter fishery may be prosecuted in western divisions of Sub-area VII. The catches made in these western divisions include very few small immature fish. Thus, there are areas where vessels may fish in winter without catching large numbers of immature mackerel, a fact which was not known in 1979. This new information suggests that a 30cm minimum size in the Western area could now be effective. Vessels fishing in winter off Cornwall, which were taking large catches including 40-60% (by number) fish less than 30cm would know that large fish were available in another area, thereby avoiding the necessity to sort and discard large numbers of fish. This was the situation in the North Sea when the 30cm minimum size regulation was first introduced there as a Norwegian national measure.

Following the introduction of a minimum size, some discarding will undoubtedly still occur and thereby reduce the potential gains directly attributable to a 30cm minimum size. The specific effect of the measure should be to shift the centre of the winter fishery away from Cornwall to areas closer to the edge of the Continental Shelf. Lockwood and Shepherd (1980), have shown that such a shift in exploitation pattern could result in higher gains in yield and spawning stock biomass than those directly attributable to the 30cm minimum size.

## 10. HORSE MACKEREL (Divisions IXa + VIIIc)

Data on horse mackerel (Trachurus trachurus L.) were presented by request for consideration to the Working Group. The following is a very brief summary of the main features.

Table 10.1 shows total Portuguese and Spanish landings by gear. Figure 10.1 presents the catches by year for both countries. It is seen that prior to 1970 (167 000 tonnes), there was an increasing trend in the landings, followed by a period (1970-76) of stability with some fluctuations. Since 1976, there has been an abrupt decrease and only 75 000 tonnes were landed in 1980.

Portuguese and Spanish data on trawl and purse seine catch rates are available from 1956 and 1975 to 1980, respectively (Table 10.2, Figure 10.2).

Prior to 1968, the trends in catch rates of Portuguese trawlers and purse seiners are similar and increasing. From 1968, the trawl catch rate showed an increase, probably due to a change in effort distribution; it reached a peak in 1972 and since then decreased sharply. The Spanish data are in close agreement with this trend and indicate a decrease in abundance.

A surplus production model (Fox, 1970) was applied (Table 10.3 and Figure 10.3) to the existing data.

The MSY obtained is about 150 000 tonnes corresponding to a cpue of 68 tonnes per Portuguese purse seiner and to an effort level equivalent to 2 200 Portuguese purse seiners. However, the 1980 total catches were 76 000 tonnes, which were attained with an effort equivalent to 5 000 Portuguese purse seiners, being more than twice the optimum effort.

These results suggest a drastic overexploitation of the stock. An assessment of the impact in the trawl fishery of mesh size changes from 40mm to 60mm and 70mm indicates that a larger mesh size in trawls would produce long-term benefits in the stock situation (Table 10.4).

Cohort analysis (Pope, 1974) results, based on 1980 catch curve data, and on four hypotheses for input Fs provide a recruitment level of about $1.2 \times 10^9$ of 0 year old fish (Table 10.5).

The Working Group also applied a yield per recruit model and estimated the MSY by fitting a Schaeffer model using trawl catch rate data during the period 1956 to 1968, when there was no apparent change in effort distribution of the trawl fleet.

The results from the two methods are in close agreement. The yield per recruit model indicates that the MSY would be attained with a fishing mortality of 0.2, whereas the present level of F is about 0.4 (Table 10.6). This indicates that the 1980 level of exploitation is more than double the optimum level. The estimated MSY (1956-1968) based on the trawl abundance index is about 130 000 tonnes, i.e., approximately the same as that estimated from the purse-seine data.

In the 1977 report (Anon. 1977), the Working Group expressed its concern about the sharp decrease in catches in Sub-area IX and commented that there was "some evidence that the exploitation pattern in that area departs widely from the optimum". On that basis, the Working Group recommended that the annual catches for this Sub-area should not be permitted to exceed 40 000 tonnes. This recommendation has not been followed and at present it is seen that for the two Divisions IXa + VIIIc, the stock situation is serious.

Although horse mackerel is one of the commercially important species in the area, our knowledge of its biology, distribution and abundance is sparse. Bearing in mind this assessment the following points should be considered:

i) the level of effort should be reduced to that equivalent of $F_{MSY}$,

ii) the improvement of the basic data on catches, effort, age and length compositions and other biological data which would increase the knowledge about the state of the stock,

iii) the participation of other countries conducting fisheries on horse mackerel in future Working Groups,

iv) the legal minimum mesh sizes should be enforced.

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Table 2.1 Nominal catch (tonnes) of MACKEREL in the North Sea, Skagerrak and Kattegat (IV and IIIa) 1970 - 1980. (Data for 1970-1979 as officially reported to ICES).

| Year / Country | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Belgium | 19 | 85 | 129 | 78 | 145 | 134 | 292 | 49 | 10 | - | - |
| Denmark | 26 753 | 17 950 | 2 023 | 7 459 | 3 890 | 9 836 | 27 988 | 21 833 | 18 068 | 19 171 | 18 649 |
| Faroe Islands | 2 134 | 3 603 | 7 551 | 11 202 | 18 625 | 23 424 | 63 476 | 42 836 | 33 911 | 28 118 | 13 393 |
| France | 4 677 | 9 061 | 6 882 | 636 | 2 254 | 2 749 | 2 607 | 2 529 | 3 452 | 3 620 | 1 881 |
| Germany, Dem.Rep. | 51 | 166 | 346 | 214 | 234 | 141 | 259 | 41 | 233 | - | - |
| Germany, Fed.Rep. | 225 | 407 | 374 | 563 | 270 | 276 | 284 | - | 284 | 211 | 56 |
| Iceland | 1 492 | 649 | 687 | 3 079 | 4 689 | 198 | 302 | - | - | - | - |
| Netherlands | 2 956 | 4 945 | 4 436 | 2 339 | 3 259 | 2 390 | 2 163 | 2 673 | 1 065 | 1 009 | 1 075 |
| Norway | 278 631 | 200 635 | 160 141 | 277 304 | 248 314 | 206 871 | 197 351 | 180 800 | 82 959 | 90 720 | 44 200 |
| Poland | 205 | 130 | 244 | 561 | 4 520 | 2 313 | 2 020 | 298 | - | - | - |
| Sweden | 4 407 | 3 163 | 4 748 | 2 960 | 3 579 | 4 789 | 6 448 | 4 012 | 4 501 | 3 935 | 1 484 |
| UK (England & Wales) | 35 | 23 | 32 | 31 | 61 | 33 | 89 | 105 | 142 | 95 | 77 |
| UK (Scotland) | 148 | 616 | 395 | 2 943 | 390 | 578 | 1 199 | 1 590 | 3 704 | 5 272 | 7 363 |
| USSR | 718 | 2 600 | 611 | 17 150 | 8 161 | 9 330 | 1 231 | 2 765 | 488 | 162 | - |
| Unallocated | | | | | | | | | | 500 | - |
| Total | 322 451 | 243 673 | 188 599 | 326 516 | 298 391 | 263 062 | 305 709 | 259 531 | 148 817 | 152 830 | 88 178 |

* Preliminary

Note: In contrast to the corresponding tables in previous years' Working Group reports 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) 1970-1980.

| Country \ Year | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Faroe Islands [1] | - | - | - | - | - | - | - | - | 283 | 6 | 795 |
| France [2] | - | 42 | - | - | - | 7 | 8 | - | 2 | - | - |
| Germany, Dem.Rep. [2] | - | - | - | - | 11 | - | - | - | - | - | - |
| Germany, Fed.Rep. [2] | - | - | - | - | - | - | - | - | 53 | 174 | - |
| Netherlands [2] | - | - | - | - | - | - | 2 | - | - | - | - |
| Norway [1] | 140 | 316 | 88 | 21 573 | 6 818 | 34 662 | 10 516 | 1 400 | 3 867 | 6 887 | 6 200 |
| UK (England & Wales) [2] | - | - | - | - | + | + | + | + | 1 | - | - |
| USSR [2] | 23 | - | - | - | - | - | - | - | - | 5 | 844 |
| Total | 163 | 358 | 88 | 21 573 | 6 829 | 34 669 | 10 526 | 1 400 | 4 206 | 7 072 | 7 839 |

1) Data provided by Working Group members

2) Data reported to ICES

3) Preliminary

Table 2.3 Landings of MACKEREL (tonnes) by quarter, 1980

| FISHING AREA | QUARTERS | | | | | TOTAL |
|---|---|---|---|---|---|---|
| | I | II | III | IV | not known | |
| IIa | | | 7 839 | | | 7 839 |
| IIIa - IV | 1 554 | 5 176 | 76 492 | 4 956 | | 88 178 |
| VI | 19 166 | 7 380 | 57 398 | 134 724 | | 218 668 |
| VII | 197 460 | 38 004 | 33 125 | 98 685 | | 367 274 |
| VIII | 353 | 1 143 | 717 | 941 | 15 654 | 18 808 |

Table 2.4 Nominal catch (tonnes) of MACKEREL in the Western Area (VI, VII, and VIII)
(Data for 1970-77 as officially reported to ICES).

| Country \ Year | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978** | 1979** | 1980* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Belgium | 8 | 2 | 1 | 3 | 7 | 17 | 10 | 1 | 1 | 3 | - |
| Denmark | - | - | - | - | - | - | 3 | 698 | 8 677 | 8 535 | 14 932 |
| Faroe Islands | - | - | - | 635 | 8 659 | 1 760 | 5 539 | 3 978 | 15 076 | 10 609 | 15 234 |
| France | 42 899 | 33 141 | 35 354 | 41 664 | 37 824 | 25 818 | 33 556 | 35 702 | 34 860 | 31 510 | 23 907 |
| Germany, Dem.Rep. | 130 | 93 | 214 | 1 733 | 2 885 | 9 693 | 4 509 | 431 | - | - | - |
| Germany, Fed.Rep. | 783 | 258 | 98 | 559 | 993 | 1 941 | 391 | 446 | 28 873 | 21 493 | 21 088 |
| Iceland | 90 | 86 | 74 | 52 | - | 21 | 10 | - | - | - | - |
| Ireland | 1 055 | 3 107 | 4 592 | 8 314 | 8 526 | 11 567 | 14 395 | 23 022 | 27 508 | 24 217 | 40 791 |
| Netherlands | 3 828 | 3 837 | 6 166 | 7 785 | 7 315 | 13 263 | 15 007 | 35 766 | 50 815 | 62 396 | 81 839 |
| Norway | - | 1 611 | - | 34 600 | 32 597 | 1 907 | 4 252 | 362 | 1 900 | 25 414 | 25 500 |
| Poland | 6 054 | 10 832 | 13 219 | 10 536 | 22 405 | 21 573 | 21 375 | 2 240 | - | 92 | - |
| Spain | 31 368 | 37 506 | 31 416 | 25 677 | 30 177 | 23 408 | 18 480 | 21 853 | 19 142 | 15 556 | 15 000 |
| Sweden | - | - | - | - | - | - | 38 | - | - | - | - |
| UK (England & Wales) | 3 374 | 4 791 | 6 923 | 13 081 | 21 132 | 31 546 | 57 311 | 132 320 | 213 344 | 244 293 | 150 598 |
| UK (N. Ireland) | 243 | 315 | 57 | 93 | 75 | 30 | 95 | 97 | 46 | 25 | - |
| UK (Scotland) | 807 | 805 | 1 412 | 5 170 | 8 466 | 16 174 | 28 399 | 52 662 | 103 671 | 103 160 | 108 372 |
| USSR | 13 555 | 36 390 | 71 249 | 65 202 | 103 435 | 309 666 | 262 384 | 16 396 | - | - | - |
| Unallocated | | | | | | | | | | 54 000 | 107 500 |
| Total, ICES members | 104 194 | 132 774 | 170 775 | 215 104 | 284 496 | 468 384 | 465 754 | 325 974 | 503 913 | 601 303 | 604 761 |
| Bulgaria | - | - | - | 4 341 | 13 558 | 20 830 | 28 195 | - | - | - | - |
| Rumania | - | - | - | - | - | 2 166 | 13 222 | - | - | - | - |
| Grand Total | 104 194 | 132 774 | 170 775 | 219 445 | 298 054 | 491 380 | 507 178 | 325 974 | 503 913 | 601 303 | 604 761 |

* Preliminary

** Working Group estimate

Table 2.5 Landings of MACKEREL (tonnes) by Sub-areas in the Western Area.

| Year | Sub-area | |
|---|---|---|
| | VI | VII + VIII |
| 1969 | 4 760 | 66 340 |
| 1970 | 3 854 | 100 340 |
| 1971 | 10 213 | 122 561 |
| 1972 | 10 013 | 157 762 |
| 1973 | 52 166 | 167 279 |
| 1974 | 64 106 | 234 081 |
| 1975 | 54 849 | 416 538 |
| 1976 | 67 785 | 439 413 |
| 1977 | 74 829 | 259 111 |
| 1978 | 151 747 | 355 487 |
| 1979 | 203 301 | 398 002 |
| 1980* | 218 603 | 386 093 |

*) Preliminary

Table 2.6 Nominal catch (tonnes) of MACKEREL on the Portuguese coast (Divisions IXa,b) (Data for 1972-1979 as officially reported to ICES)

| Country | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980* |
|---|---|---|---|---|---|---|---|---|---|
| Portugal | 753 | 1 138 | 1 621 | 1 562 | 1 806 | 1 213 | 1 082 | 743 | 1 337 |
| Spain | 2 305 | 2 334 | 3 264 | 3 345 | 2 520 | 2 935 | 6 221 | 6 280 | (6 000) |
| France | - | - | - | 1 | - | - | - | - | - |
| Poland | - | - | - | - | - | 8 | - | - | - |
| USSR | - | - | - | 44 | 466 | 2 879 | 189 | 111 | - |
| Total | 3 058 | 3 472 | 4 885 | 4 952 | 4 792 | 7 035 | 7 492 | 7 134 | 7 337 |

* Preliminary

Table 2.7 Annual catches by gear (tonnes) of MACKEREL by the Portuguese, in Divisions IXa,b.

| Gear / Year | Artisanal | Trawl | Purse Seine | Total |
|---|---|---|---|---|
| 1974 | (55) | 1 566 | - | 1 621 |
| 1975 | 198 | 1 364 | 0 | 1 562 |
| 1976 | 240 | 1 566 | 0 | 1 806 |
| 1977 | 290 | 923 | 0 | 1 213 |
| 1978 | 59 | 1 023 | 0 | 1 082 |
| 1979 | 58 | 687 | 0 | 745 |
| 1980 | 274 | 1 063 | 0 | 1 337 |

() Estimated

Table 2.8 Annual catches by quarter taken by the Portuguese trawlers in Divisions IXa,b.

| Year \ Quarter | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| 1979 | 170 | 374 | 70 | 73 | 689 |
| 1980 | 236 | 411 | 165 | 251 | 1 063 |

Table 2.9 Portuguese efforts and catch rates for trawlers in Divisions IXa,b.

| Year | Hours ($10^3$) | kg/h trawl |
|---|---|---|
| 1974 | 340 | 4.6 |
| 1975 | 350 | 3.9 |
| 1976 | 340 | 4.6 |
| 1977 | 374 | 3.4 |
| 1978 | 348 | 2.9 |
| 1979 | 380 | 1.8 |
| 1980 | 354 | 3.0 |

Table 5.1 Western MACKEREL Spawning Stock Plankton Survey, 1980.

| | ANTON DOHRN + SCOTIA 2/80 | CIROLANA 4/80 | CIROLANA 5/80 | SCOTIA 5/80 | THALASSA | CIROLANA 7/80 |
|---|---|---|---|---|---|---|
| MID CRUISE DATES | 24 March | 9 April | 6 May | 8 June | 25 June | 25 July |
| NUMBER OF SAMPLES | 118 | 94 | 103 | 113 | 143 | 100 |
| SAMPLED AREA OF SPAWNING ($km^2$) | 207 000 | 211 000 | 270 000 | 207 000 | 178 000 | 89 000 |
| DAILY PRODUCTION (Eggs x $10^{10}$) | 237.28 | 1006.09 | 558.11 | 2147.82 | 1967.48 | 24.56 |

Total Egg Production = $1.49 \times 10^{15}$

Irish Inshore Survey

| | February | March | April | May | June | July |
|---|---|---|---|---|---|---|
| Daily Production (eggs x $10^{10}$) | < < 1.0 | | 3.89 | | 28.1 | 24.4 |

Total Egg Production = $0.02 \times 10^{15}$

Table 5.2 Western MACKEREL Spawning Stock Estimate, 1980.

Production curves - see figure 5.2. - Spawning population - see figure 5.3

| | ANTON DOHRN + SCOTIA 2/80 | CIROLANA 4/80 | CIROLANA 5/80 | SCOTIA 5/80 | THALASSA | CIROLANA 7/80 |
|---|---|---|---|---|---|---|
| DAILY EGG PRODUCTION (X $10^{-10}$) | 237.28 | 1 006.09 | 558.11 | 2 447.82 | 1 967.48 | 24.56 |
| MEAN FECUNDITY | 503 863 | 522 313 | 530 711 | 456 950 | 456 950 | 363 930 |
| MATURE FEMALES (X $10^{-6}$) | 4.7 | 19.26 | 10.52 | 53.57 | 43.06 | 0.67 |
| SPAWNING STOCK (X $10^{-6}$) | 9.42 | 38.52 | 21.03 | 107.14 | 86.11 | 1.35 |

Total Spawning Stock Estimate : 6223 x $10^{6}$ fish

Table 6.1 Catch in numbers (x $10^{-6}$) for North Sea and Skagerrak in 1980.

| Year Class | IVa[1] + IIIa | IVb, c | Total IV + IIIa |
|---|---|---|---|
| pre-1970 | 25.3 | 2.7 | 28.0 |
| 1970 | 5.6 | 0.3 | 5.9 |
| 1971 | 18.7 | 0.8 | 19.5 |
| 1972 | 13.7 | 0.4 | 14.1 |
| 1973 | 17.8 | 1.4 | 19.2 |
| 1974 | 26.9 | 1.6 | 28.5 |
| 1975 | 26.2 | 1.8 | 28.0 |
| 1976 | 11.3 | 1.4 | 12.7 |
| 1977 | 2.0 | 0.1 | 2.1 |
| 1978 | 0.7 | 1.7 | 2.4 |
| 1979 | | 2.7 | 2.7 |
| 1980 | | 1.7 | 1.7 |

1) Norwegian and Danish catches from IVb and Swedish catches from the North Sea are included.

Table 6.2 Catch in numbers (x $10^{-6}$) of the North Sea stock in Sub-area IV and Divisions IIa, IIIa, and VIa in 1980.

| Year class | Divisions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | IVa | | | IVb + IVc | IIIa | VIa | IIa | Total |
| | Open area | Norwegian coast | Sum | | | | | |
| Pre-1971 | 4.6 | 6.1 | 10.7 | 10.3 | 5.3 | 4.5 | 0.9 | 31.7 |
| 1971 | 1.0 | 3.6 | 4.6 | 5.6 | 2.0 | 1.4 | 0.4 | 14.0 |
| 1972 | 1.5 | 0.7 | 2.2 | 4.0 | 1.8 | 4.3 | - | 12.3 |
| 1973 | 2.4 | 1.6 | 4.0 | 6.1 | 3.6 | 1.4 | 0.2 | 15.3 |
| 1974 | 7.9 | 3.2 | 11.1 | 8.6 | 2.9 | 1.6 | 1.7 | 25.9 |
| 1975 | 8.5 | 2.6 | 11.1 | 9.1 | 0.9 | 1.6 | 0.8 | 23.5 |
| 1976 | 6.3 | 1.2 | 7.5 | 5.0 | 0.3 | 1.2 | 0.4 | 14.4 |
| 1977 | 1.3 | | 1.3 | 0.8 | | 0.1 | 0.2 | 2.4 |
| 1978 | 0.5 | | 0.5 | 1.9 | | 3.1 | 0.1 | 5.6 |
| 1979 | | | | 2.7 | | | | 2.7 |
| 1980 | | | | 1.7 | | | | 1.7 |

Table 6.3 Catch in number (x $10^{-6}$) of the Western stock by year class.
These numbers include estimated numbers of fish discarded and unreported.

| Year Class \ Division | 1980 | | | | | Total |
|---|---|---|---|---|---|---|
| | VIa, b | VIIa,b,c | VII d-k | VIII | IVa | |
| Pre-1971 | 87.4 | 20.1 | 87.0 | 2.5 | 9.9 | 206.9 |
| 1971 | 81.9 | 9.3 | 39.9 | 1.2 | 7.3 | 139.6 |
| 1972 | 14.6 | 3.5 | 27.5 | 1.0 | 5.8 | 52.4 |
| 1973 | 53.8 | 11.2 | 84.2 | 1.9 | 7.3 | 158.4 |
| 1974 | 42.8 | 12.6 | 82.7 | 2.0 | 5.1 | 145.2 |
| 1975 | 75.9 | 14.4 | 183.2 | 3.7 | 4.8 | 282.0 |
| 1976 | 48.8 | 20.4 | 306.5 | 5.6 | - | 381.3 |
| 1977 | 5.2 | 3.2 | 62.5 | 4.3 | - | 75.2 |
| 1978 | 22.9 | 11.3 | 412.7 | 21.8 | - | 468.7 |
| 1979 | 3.0 | 0.7 | 413.2 | 67.6 | - | 484.5 |
| 1980 | - | - | 9.4 | 10.1 | - | 19.5 |
| Total | 436.3 | 106.7 | 1 708.8 | 121.7 | 40.2 | 2 413.7 |

Table 6.4 Mean weights at age used in stock assessments.

a) North Sea stock

| annual mean weight (g) | age (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | ≥ 9 |
| in spawning stock | - | 123 | 234 | 325 | 338 | 350 | 346 | 468 | 472 | 472 |
| in the catch | - | 245 | 329 | 364 | 392 | 438 | 455 | 520 | 580 | 580 |

b) Western stock

- 1969 and younger

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| in spawning stock | - | 113 | 131 | 201 | 231 | 264 | 316 | 380 | 412 | 511 | |
| in the catch | - | 137 | 150 | 241 | 311 | 334 | 398 | 410 | 503 | 511 | |

- pre 1969 year class (plus group)

| age | ≥ 4 | ≥ 5 | ≥ 6 | ≥ 7 | ≥ 8 | ≥ 9 |
|---|---|---|---|---|---|---|
| mean weight in the spawning stock | 390 | 410 | 440 | 470 | 490 | 511 |

Table 6.5 The North Sea stock - catch in numbers ($\times 10^{-6}$).

| | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 64.4 | 110.3 | 0.8 | 2.6 | 4.5 | 2.9 | 11.9 | 2.7 | 1.1 |
| 2 | 110.2 | 191.1 | 83.0 | 35.6 | 12.1 | 18.7 | 10.1 | 73.6 | 19.3 |
| 3 | 473.1 | 75.8 | 50.3 | 162.6 | 37.6 | 23.6 | 16.2 | 69.7 | 58.9 |
| 4 | 308.6 | 185.1 | 18.0 | 33.2 | 280.2 | 39.9 | 42.4 | 13.9 | 54.3 |
| 5 | 79.7 | 64.5 | 29.7 | 21.3 | 74.3 | 240.8 | 27.8 | 33.8 | 9.8 |
| 6 | 35.6 | 19.0 | 13.8 | 23.5 | 36.0 | 45.8 | 193.2 | 19.5 | 26.6 |
| 7 | 624.0 | 5.3 | 2.1 | 10.7 | 19.7 | 7.5 | 25.6 | 118.6 | 31.6 |
| 8 | 0.0 | 98.6 | 0.9 | 1.4 | 34.8 | 16.1 | 20.4 | 31.3 | 125.9 |
| 9 | 0.0 | 0.0 | 17.7 | 0.6 | 0.5 | 3.2 | 15.8 | 8.0 | 31.2 |
| 10+ | 0.0 | 0.0 | 0.0 | 11.7 | 4.0 | 25.3 | 27.9 | 17.0 | 25.0 |
| Total | 1 695.6 | 749.7 | 216.3 | 303.2 | 503.7 | 423.8 | 391.3 | 388.1 | 383.7 |
| Tonnes ($\times 10^{-3}$) | 720.3 | 286.8 | 84.0 | 117.9 | 210.5 | 187.1 | 179.3 | 173.6 | 187.7 |

| | 1978 | 1979 | 1980 |
|---|---|---|---|
| 1 | 0.0 | 2.3 | 2.7 |
| 2 | 8.2 | 0.5 | 5.6 |
| 3 | 34.7 | 11.3 | 2.4 |
| 4 | 40.8 | 21.2 | 14.3 |
| 5 | 27.9 | 33.3 | 23.5 |
| 6 | 6.0 | 14.3 | 25.9 |
| 7 | 14.2 | 4.2 | 15.3 |
| 8 | 16.1 | 9.2 | 12.3 |
| 9 | 45.7 | 2.0 | 14.0 |
| 10+ | 32.4 | 39.7 | 31.7 |
| Total | 226.0 | 138.0 | 147.7 |
| Tonnes ($\times 10^{-3}$) | 108.3 | 65.9 | 72.7 |

(continued..)

Table 6.5 ... continued

FISHING MORTALITY

| | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.05 | 0.03 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 |
| 2 | 0.24 | 0.21 | 0.03 | 0.11 | 0.03 | 0.08 | 0.02 | 0.16 | 0.07 |
| 3 | 0.60 | 0.25 | 0.07 | 0.08 | 0.15 | 0.06 | 0.08 | 0.22 | 0.17 |
| 4 | 0.87 | 0.47 | 0.08 | 0.06 | 0.17 | 0.22 | 0.14 | 0.09 | 0.26 |
| 5 | 1.24 | 0.41 | 0.12 | 0.12 | 0.17 | 0.20 | 0.22 | 0.15 | 0.08 |
| 6 | 1.11 | 1.15 | 0.14 | 0.12 | 0.29 | 0.15 | 0.24 | 0.23 | 0.16 |
| 7 | 0.99 | 0.44 | 0.33 | 0.14 | 0.14 | 0.09 | 0.11 | 0.21 | 0.65 |
| 8 | 0.00 | 0.37 | 0.12 | 0.36 | 0.83 | 0.15 | 0.33 | 0.17 | 0.34 |
| 9 | 0.00 | 0.00 | 0.10 | 0.10 | 0.20 | 0.15 | 0.20 | 0.20 | 0.25 |
| 10+ | 0.00 | 0.00 | 0.10 | 0.10 | 0.20 | 0.15 | 0.20 | 0.20 | 0.25 |
| F( 3-10) | 0.83 | 0.40 | 0.09 | 0.08 | 0.19 | 0.17 | 0.19 | 0.19 | 0.25 |

| | 1978 | 1979 | 1980 |
|---|---|---|---|
| 1 | 0.00 | 0.03 | 0.06 |
| 2 | 0.07 | 0.03 | 0.10 |
| 3 | 0.16 | 0.12 | 0.20 |
| 4 | 0.16 | 0.13 | 0.20 |
| 5 | 0.19 | 0.18 | 0.20 |
| 6 | 0.06 | 0.14 | 0.20 |
| 7 | 0.12 | 0.05 | 0.20 |
| 8 | 0.78 | 0.10 | 0.20 |
| 9 | 0.19 | 0.19 | 0.20 |
| 10+ | 0.19 | 0.19 | 0.20 |
| F( 3-10) | 0.18 | 0.14 | 0.20 |

NATURAL MORTALITY: 0.15000

(continued...)

Table 6.5 ... continued

STOCK SIZE IN NUMBERS

1 JANUARY

| | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1353.1 | 3482.5 | 439.1 | 591.7 | 327.5 | 518.4 | 649.0 | 366.9 | 160.7 |
| 2 | 551.7 | 1105.0 | 2895.2 | 377.2 | 506.9 | 277.7 | 443.5 | 547.6 | 313.3 |
| 3 | 1124.2 | 373.0 | 774.4 | 2415.0 | 291.7 | 425.0 | 221.7 | 372.3 | 403.2 |
| 4 | 567.0 | 532.4 | 251.0 | 620.0 | 1928.1 | 216.3 | 344.0 | 175.8 | 256.1 |
| 5 | 118.8 | 205.0 | 287.6 | 199.4 | 502.9 | 1400.3 | 149.3 | 256.8 | 138.5 |
| 6 | 56.4 | 29.5 | 117.0 | 220.1 | 151.9 | 364.1 | 982.6 | 102.8 | 189.8 |
| 7 | 1056.7 | 16.0 | 8.0 | 87.9 | 167.7 | 97.5 | 271.0 | 667.2 | 70.5 |
| 8 | 0.0 | 338.1 | 8.8 | 4.9 | 65.8 | 126.1 | 77.0 | 209.6 | 464.6 |
| 9 | 0.0 | 0.0 | 200.0 | 6.8 | 3.0 | 24.7 | 93.6 | 47.4 | 151.4 |
| 10+ | 0.0 | 0.0 | 0.0 | 132.2 | 23.7 | 195.2 | 165.3 | 100.7 | 121.3 |
| TOTAL | 4827.9 | 6081.4 | 4981.2 | 4655.2 | 3969.0 | 3645.3 | 3397.1 | 2847.2 | 2269.4 |
| Spawning stock biomass ($\times 10^{-3}$ t) | 1112.6 | 550.2 | 580.0 | 1249.4 | 1097.2 | 1036.3 | 866.0 | 787.0 | 712.8 |

| | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|
| 1 | 19.8 | 76.0 | 49.9 | **** |
| 2 | 137.3 | 17.1 | 63.3 | 40.4 |
| 3 | 251.8 | 110.6 | 14.2 | 49.3 |
| 4 | 292.6 | 184.6 | 84.7 | 10.0 |
| 5 | 170.2 | 214.1 | 139.3 | 59.7 |
| 6 | 110.1 | 120.7 | 153.5 | 98.1 |
| 7 | 138.8 | 89.2 | 90.7 | 108.2 |
| 8 | 31.6 | 106.3 | 72.9 | 63.9 |
| 9 | 283.7 | 12.4 | 83.0 | 51.4 |
| 10+ | 201.2 | 246.5 | 187.9 | 190.8 |
| TOTAL | 1637.1 | 1177.5 | 939.3 | |
| Spawning stock biomass ($\times 10^{-3}$ t) | 587.1 | 429.2 | 339.8 | |

Table 6.6 The North Sea Stock.

Input values of F in 1980 used in trial VPA runs, and spawning stock sizes from 1974-80 obtained from VPA and from Norwegian egg surveys.

| Input value of F in 1980 | Spawning stock (n° of 3 group and older at 1 Jan ($\times 10^{-9}$)) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Year | | | | | | |
| | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
| 0.10 | 3.0 | 2.6 | 2.3 | 2.3 | 2.1 | 1.7 | 1.5 |
| 0.20 | 3.0 | 2.3 | 1.9 | 1.8 | 1.5 | 1.2 | 0.8 |
| 0.30 | 2.9 | 2.2 | 1.8 | 1.6 | 1.2 | 0.8 | 0.6 |
| 0.50 | 2.7 | 2.1 | 1.7 | 1.5 | 1.1 | 0.7 | 0.4 |
| 0.60 | 2.7 | 2.1 | 1.7 | 1.4 | 1.0 | 0.6 | 0.3 |
| 0.70 | 2.7 | 2.1 | 1.6 | 1.4 | 1.0 | 0.6 | 0.3 |
| Index of spawning stock from Norwegian egg surveys (55°-61°N) | 5.89 | 15.68 | 5.79 | 3.79 | 1.87 | 3.08 | 3.26 |

Table 6.7 The Western MACKEREL stock. Catch in number with fishing mortality rates and stock sizes derived from cohort analysis (M = 0.15)

| | Year / Age | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|---|
| Catch in number x $10^{-6}$ | 0 | 1.6 | 0.0 | 1.3 | 1.0 | 34.2 | 2.0 | 10.3 | 79.5 | 19.5 |
| | 1 | 12.4 | 33.8 | 87.0 | 52.5 | 279.4 | 153.5 | 31.3 | 351.1 | 484.5 |
| | 2 | 12.1 | 49.4 | 24.3 | 104.0 | 184.9 | 289.5 | 563.8 | 61.6 | 468.7 |
| | 3 | 29.4 | 64.0 | 123.5 | 94.5 | 322.3 | 154.0 | 425.0 | 602.5 | 75.2 |
| | 4 | 507.7 | 115.5 | 108.5 | 306.3 | 170.6 | 166.0 | 243.7 | 365.5 | 381.3 |
| | 5 | ↓ | 582.3 | 191.8 | 192.2 | 288.8 | 51.0 | 258.3 | 217.2 | 282.0 |
| | 6 | | ↓ | 567.0 | 143.8 | 118.6 | 140.0 | 71.9 | 233.1 | 145.2 |
| | 7 | | | ↓ | 1 246.2 | 279.7 | 64.4 | 86.8 | 151.9 | 158.4 |
| | 8 | | | | ↓ | 438.8 | 89.4 | 56.7 | 154.2 | 52.4 |
| | 9 | | | | | ↓ | 158.5 | 83.2 | 70.5 | 139.6 |
| | 10+ | | | | | | ↓ | 210.8 | 263.7 | 206.9 |
| | Total | 563.2 | 845.0 | 1 103.4 | 2 140.5 | 2 117.3 | 1 268.3 | 2 106.9 | 2 485.7 | 2 413.7 |
| Fishing Mortality | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 | 0.01 |
| | 1 | 0.00 | 0.02 | 0.03 | 0.02 | 0.08 | 0.04 | 0.07 | 0.13 | 0.15 |
| | 2 | 0.01 | 0.01 | 0.02 | 0.04 | 0.09 | 0.10 | 0.19 | 0.17 | 0.25 |
| | 3 | 0.01 | 0.04 | 0.04 | 0.09 | 0.15 | 0.10 | 0.20 | 0.30 | 0.30 |
| | 4 | 0.06 | 0.05 | 0.08 | 0.13 | 0.23 | 0.10 | 0.22 | 0.25 | 0.30 |
| | 5 | ↓ | 0.09 | 0.11 | 0.19 | 0.17 | 0.09 | 0.21 | 0.29 | 0.30 |
| | 6 | | ↓ | 0.12 | 0.11 | 0.17 | 0.11 | 0.18 | 0.28 | 0.30 |
| | 7 | | | ↓ | 0.37 | 0.30 | 0.12 | 0.16 | 0.31 | 0.30 |
| | 8 | | | | ↓ | 0.20 | 0.14 | 0.14 | 0.22 | 0.30 |
| | 9 | | | | | ↓ | 0.10 | 0.18 | 0.25 | 0.30 |
| | 10+ | | | | | | 0.10 | 0.18 | 0.25 | 0.30 |

| | | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stock in number at 1 January x $10^{-6}$ | 0 | 1 865 | 4 205 | 3 044 | 4 673 | 4 936 | 619 | 3 520 | 4 429 | 2 110 | - |
| | 1 | 4 449 | 1 604 | 3 619 | 2 619 | 4 021 | 4 217 | 531 | 3 020 | 3 739 | 1 100 |
| | 2 | 2 081 | 3 817 | 1 349 | 3 034 | 2 205 | 3 202 | 3 487 | 428 | 2 275 | 2 770 |
| | 3 | 2 782 | 1 780 | 3 240 | 1 139 | 2 515 | 1 727 | 2 488 | 2 480 | 311 | 1 525 |
| | 4 | 8 843 | 2 367 | 1 473 | 2 674 | 892 | 1 867 | 1 344 | 1 749 | 1 578 | 198 |
| | 5 | ↓ | 7 141 | 1 931 | 1 167 | 2 018 | 610 | 1 453 | 931 | 1 167 | 1 006 |
| | 6 | | ↓ | 5 607 | 1 484 | 827 | 1 470 | 478 | 1 012 | 601 | 744 |
| | 7 | | | ↓ | 4 302 | 1 144 | 602 | 1 136 | 345 | 656 | 383 |
| | 8 | | | | ↓ | 2 553 | 727 | 458 | 837 | 217 | 418 |
| | 9 | | | | | ↓ | 1 791 | 543 | 342 | 578 | 138 |
| | 10+ | | | | | | ↓ | 1 375 | 1 280 | 856 | 915 |
| | Total | 20 020 | 20 914 | 20 262 | 21 091 | 21 112 | 16 832 | 16 813 | 16 854 | 14 088 | |
| Spawning Stock | | 11 326 | 11 680 | 12 048 | 11 638 | 10 442 | 9 952 | 9 625 | 8 606 | 7 144 | |

Table 6.8 The Western MACKEREL stock. Stock in number at 1 June and spawning biomass derived from cohort analysis.

| Age \ Year | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 756 | 3 960 | 2 866 | 4 400 | 4 635 | 582 | 3 311 | 4 139 | 1 979 |
| 1 | 4 185 | 1 496 | 3 373 | 2 445 | 3 671 | 3 908 | 487 | 2 696 | 3 316 |
| 2 | 1 955 | 3 575 | 1 260 | 2 815 | 2 000 | 2 895 | 3 043 | 377 | 1 938 |
| Stock in number at 1 June 3 | 2 608 | 1 650 | 3 001 | 1 033 | 2 233 | 1 562 | 2 161 | 2 070 | 260 |
| 4 | 8 118 | 2 182 | 1 342 | 2 390 | 767 | 1 689 | 1 161 | 1 488 | 1 318 |
| 5 | 0 | 6 483 | 1 738 | 1 017 | 1 778 | 554 | 1 257 | 782 | 975 |
| 6 | 0 | 0 | 5 043 | 1 337 | 728 | 1 326 | 420 | 851 | 502 |
| 7 | 0 | 0 | 0 | 3 491 | 954 | 540 | 1 005 | 287 | 548 |
| 8 | 0 | 0 | 0 | 0 | 2 215 | 647 | 408 | 722 | 181 |
| 9 | 0 | 0 | 0 | 0 | 0 | 1 621 | 476 | 292 | 483 |
| 10+ | 0 | 0 | 0 | 0 | 0 | 0 | 1 205 | 1 091 | 715 |
| Total | 18 621 | 19 346 | 18 623 | 18 928 | 18 980 | 15 323 | 14 933 | 14 793 | 12 216 |
| Spawning Stock | 10 469 | 10 704 | 10 950 | 10 103 | 9 150 | 9 001 | 8 407 | 7 307 | 6 017 |

| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977-81 |
|---|---|---|---|---|---|---|
| 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 1 | 0.113 | 0.113 | 0.113 | 0.113 | 0.113 | 0.113 |
| 2 | 0.131 | 0.131 | 0.131 | 0.131 | 0.131 | 0.131 |
| Mean weight at age of spawning stock 3 | 0.201 | 0.201 | 0.201 | 0.201 | 0.201 | 0.201 |
| 4 | 0.380 | 0.251 | 0.251 | 0.251 | 0.251 | 0.251 |
| 5 | | 0.410 | 0.264 | 0.264 | 0.264 | 0.264 |
| 6 | | | 0.440 | 0.316 | 0.316 | 0.316 |
| 7 | | | | 0.470 | 0.380 | 0.380 |
| 8 | | | | | 0.490 | 0.412 |
| 9 | | | | | | 0.511 |
| 10+ | | | | | | 0.511 |

Proportions of Maturity

| Age | 1972-81 |
|---|---|
| 0 | 0.000 |
| 1 | 0.180 |
| 2 | 0.380 |
| 3 | 0.670 |
| 4 | 0.890 |
| 5 | 0.930 |
| 6 | 1.000 |
| 7 | 1.000 |
| 8 | 1.000 |
| 9 | 1.000 |
| 10+ | 1.000 |

Stock Biomass (x $10^{-3}$t)

| | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 |
|---|---|---|---|---|---|---|---|---|---|
| Total | 4 338 | 4 175 | 4 164 | 3 784 | 4 019 | 3 424 | 3 053 | 2 731 | 2 323 |
| Spawning Stock | 3 394 | 3 457 | 3 480 | 3 176 | 3 314 | 2 666 | 2 562 | 2 258 | 1 786 |

Table 9.1 Western MACKEREL age distribution inside the closed area in Sub-area VII in 1980 (in percent).

| Year class | Purse seine | | Trawl | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 Jan 15 Febr. | 15 Nov 31 Dec. | 1 Jan 15 Feb. | Febr. | March | April | October | 15 Nov 31 Déc. |
| 1980 | - | 1.05 | - | - | - | - | - | 0.52 |
| 79 | 0.52 | 51.92 | 0.79 | 0.05 | 0.70 | 0.27 | 70.80 | 27.72 |
| 78 | 31.91 | 21.99 | 22.77 | 15.19 | 22.83 | 36.17 | 17.91 | 29.14 |
| 77 | 5.30 | 1.93 | 5.49 | 3.01 | 5.22 | 22.58 | 1.69 | 2.78 |
| 76 | 22.96 | 10.39 | 24.31 | 23.59 | 22.03 | 17.04 | 5.70 | 15.26 |
| 75 | 14.31 | 5.39 | 15.08 | 15.04 | 13.64 | 8.27 | 3.63 | 8.16 |
| 74 | 6.28 | 1.63 | 6.41 | 12.55 | 11.00 | 3.21 | - | 2.61 |
| 73 | 5.85 | 1.07 | 6.01 | 9.03 | 9.02 | 3.21 | 0.20 | 1.08 |
| 72 | 2.51 | 0.31 | 2.56 | 3.22 | 0.50 | 2.22 | - | 0.55 |
| 71 | 2.65 | 0.24 | 2.62 | 4.49 | 5.04 | 1.36 | - | 0.49 |
| ≤ 70 | 6.54 | 0.46 | 9.75 | 11.13 | 7.31 | 4.57 | - | 1.07 |

Table 9.2 Western MACKEREL length distribution in percent inside the closed area in 1980.

| length | Pelagic trawl | | | | | | Purse seine | |
|---|---|---|---|---|---|---|---|---|
| | JAN | FEB | MARCH | APRIL | OCT. | 15 NOV/ 31 DEC | JAN | 15 NOV/ 31 DEC |
| 20 | 0.04 | 0.02 | | - | - | 0.05 | 0.14 | 0.06 |
| 21 | 0.64 | 0.02 | 0.26 | - | 0.09 | 0.10 | 0.28 | 0.21 |
| 22 | 0.07 | - | 0.31 | 0.16 | 1.23 | 0.60 | 0.14 | 1.40 |
| 23 | 0.14 | 0.01 | 0.02 | - | 7.31 | 2.24 | 0.69 | 5.49 |
| 24 | 0.07 | 0.07 | 0.22 | 0.16 | 15.18 | 4.37 | 0.69 | 10.09 |
| 25 | 1.40 | 0.54 | 0.38 | 1.00 | 11.77 | 7.20 | 1.10 | 10.30 |
| 26 | 4.66 | 2.83 | 5.05 | 4.84 | 9.75 | 5.75 | 2.25 | 8.43 |
| 27 | 8.50 | 3.69 | 5.24 | 4.51 | 9.28 | 6.99 | 2.75 | 8.21 |
| 28 | 7.61 | 3.36 | 6.76 | 4.40 | 10.58 | 8.29 | 4.95 | 8.67 |
| 29 | 6.40 | 4.13 | 4.90 | 2.92 | 9.93 | 11.10 | 4.40 | 10.00 |
| 30 | 11.74 | 8.02 | 9.26 | 6.52 | 8.09 | 10.28 | 7.15 | 8.38 |
| 31 | 14.69 | 13.37 | 14.27 | 14.87 | 5.82 | 12.57 | 7.98 | 9.52 |
| 32 | 11.86 | 10.82 | 13.25 | 16.95 | 3.37 | 10.71 | 10.73 | 6.94 |
| 33 | 7.21 | 8.08 | 9.36 | 9.13 | 1.00 | 6.85 | 12.10 | 5.14 |
| 34 | 5.11 | 7.65 | 6.70 | 7.20 | 0.61 | 4.29 | 6.33 | 2.87 |
| 35 | 3.44 | 7.23 | 4.50 | 2.59 | | 3.01 | 6.60 | 1.71 |
| 36 | 2.91 | 6.64 | 5.74 | 2.86 | | 1.77 | 2.61 | 0.86 |
| 37 | 2.11 | 6.56 | 3.78 | 5.87 | | 1.42 | 4.68 | 0.78 |
| 38 | 2.40 | 5.43 | 3.46 | 4.15 | | 0.93 | 5.50 | 0.52 |
| 39 | 2.18 | 4.04 | 2.90 | 4.93 | | 0.64 | 5.76 | 0.34 |
| 40 | 2.02 | 3.30 | 1.25 | 2.33 | | 0.25 | 4.54 | 0.03 |
| 41 | 0.95 | 2.26 | 1.56 | 2.85 | | 0.27 | 4.81 | 0.04 |
| 42 | 0.46 | 1.15 | 0.64 | 1.04 | | 0.12 | 3.03 | 0.07 |
| 43 | 0.36 | 0.68 | 0.20 | 0.26 | | 0.07 | 1.51 | 0.02 |
| 44 | 0.14 | 0.10 | | | | 0.01 | 0.96 | 0.06 |
| 45 | 0.19 | | | 0.26 | | 0.05 | 0.28 | |
| 46 | - | | | | | | 0.28 | |
| 47 | 0.07 | | | | | | | |

Table 9.3 Western MACKEREL length distribution in percent outside the closed area in 1980.

| length | Western Channel (VIIe) January | Eastern Channel (VIId) 2 quarter | Eastern Channel (VIId) 3 quarter |
|---|---|---|---|
| | Purse seine | Trawl | Trawl |
| 18 | | 0.25 | |
| 19 | | 2.21 | |
| 20 | 0.02 | 11.05 | 0.46 |
| 21 | 0.02 | 14.50 | 4.68 |
| 22 | 0.09 | 11.30 | 14.75 |
| 23 | 0.45 | 3.44 | 12.21 |
| 24 | 0.51 | 1.72 | 8.76 |
| 25 | 1.25 | 1.72 | 6.99 |
| 26 | 3.14 | 6.88 | 6.68 |
| 27 | 5.81 | 11.06 | 4.99 |
| 28 | 8.73 | 11.30 | 7.37 |
| 29 | 8.20 | 8.35 | 9.98 |
| 30 | 7.56 | 3.68 | 8.37 |
| 31 | 9.07 | 1.23 | 5.61 |
| 32 | 10.52 | 1.47 | 2.61 |
| 33 | 7.78 | 0.98 | 1.69 |
| 34 | 6.12 | 1.72 | 0.77 |
| 35 | 3.97 | 0.98 | 0.54 |
| 36 | 5.75 | 2.46 | 0.54 |
| 37 | 4.79 | 0.98 | 0.61 |
| 38 | 4.59 | 1.96 | 0.54 |
| 39 | 4.09 | 0.25 | 0.38 |
| 40 | 3.93 | 0.25 | 0.69 |
| 41 | 0.04 | - | 0.38 |
| 42 | | 0.25 | 0.23 |
| 43 | | | |
| 44 | | | |
| 45 | | | 0.08 |
| 46 | | | 0.08 |

Table 9.4 Landings (tonnes) of mackerel, horse mackerel, sprat and pilchard in closed area in Divisions VIIe and f by month and gear, in 1980.

MACKEREL

| Rectangle[x] | Purse-seine England 1 | 2 | 3 | 4 | Norway 1 | 2 |
|---|---|---|---|---|---|---|
| Jan. | 1 024 | 2 301 | 457 | 6 784 | 5 500 | 8 600 |
| Feb. | 280 | 467 | 2 227 | 9 988 | 0 | 0 |
| Nov. | 0 | 102 | 0 | 0 | 0 | 0 |
| Dec. | 0 | 0 | 118 | 225 | 0 | 0 |

| | Hand-line England 2 | 4 |
|---|---|---|
| Jan. | 355 | 0 |
| Feb. | 203 | 5 |
| Mar. | 236 | 0 |
| Apr. | 159 | 0 |
| May | 2 | 0 |
| Jun. | 460 | 0 |
| Jul. | 264 | 0 |
| Aug. | 132 | 0 |
| Sep. | 430 | 0 |
| Oct. | 0 | 0 |
| Nov. | 879 | 8 |
| Dec. | 0 | 0 |

| Rectangle[x] | Midwater trawl England 1 | 2 | 3 | 4 | Midwater trawl Germany,F.R. All rectangles | France All rectangles | Netherlands[1] All rectangles |
|---|---|---|---|---|---|---|---|
| Jan. | 1 724 | 5 517 | 862 | 7 453 | 0 | 5 853 | 0 |
| Feb. | 563 | 2 521 | 4 131 | 11 242 | 0 | 6 214 | 7 277 |
| Mar. | 0 | 0 | 0 | 0 | 82 | 2 184 | 5 650 |
| Apr. | 0 | 0 | 0 | 0 | 0 | 182 | 0 |
| Oct. | 0 | + | + | + | 5 | 0 | 2 894 |
| Nov. | 178 | 492 | 853 | 1 668 | 0 | 0 | 0 |
| Dec. | 355 | 1 001 | 246 | 4 362 | 0 | 0 | 0 |

x) Rectangles:
1. 50° - 50°30'N 6° - 7°W
2. 50° - 50°30'N 5° - 6°W
3. 49°30' - 50°N 6° - 7°W
4. 49°30' - 50°N 5° - 6°W

1) No data on Dutch catches of horse mackerel, pilchard and sprat.

(continued)

Table 9.4 cont'd.

HORSE MACKEREL

| Rectangle[x)] | Purse-seine England 1 | 2 | 3 | 4 | | Midwater trawl England 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|---|
| Jan. | 0 | 0 | 0 | 30 | Jan. | 0 | 0 | 7 | 7 |
| Feb. | 0 | 0 | 0 | 35 | Feb. | 0 | 1 | 31 | 23 |
| Dec. | 0 | 0 | 110 | 0 | Aug. | 0 | 1 | 0 | 3 |
| | | | | | Sep. | 0 | 1 | 0 | 4 |
| | | | | | Oct. | 0 | 0 | 0 | 2 |
| | | | | | Dec. | 28 | 0 | 33 | 41 |

| Rectangle[x)] | PILCHARD All gears England 1 | 2 | 3 | 4 | | SPRAT Purse-seine England 2 | Midwater trawl England 2 | 4 |
|---|---|---|---|---|---|---|---|---|
| Jan. | 0 | 92 | 0 | 100 | Jan. | 27 | 0 | 0 |
| Feb. | 0 | 0 | 0 | 65 | Feb. | 0 | 110 | 15 |
| Nov. | 0 | 0 | 0 | 86 | | | | |

Table 10.1 Annual landings of HORSE MACKEREL (tonnes), by countries and fisheries, in ICES Divisions IXa and VIIIc.

| Year | Portugal | | | | Spain | | | | Portugal and Spain |
|---|---|---|---|---|---|---|---|---|---|
| | Trawl | Seine | Artisanal | Total | Trawl | Seine | Artisanal | Total | Total |
| 1956 | 1 989 | 33 882 | 2 300 | 38 171 | | | | - | - |
| 1957 | 1 396 | 39 362 | 2 600 | 43 358 | | | | - | - |
| 1958 | 1 516 | 35 285 | 2 300 | 39 101 | | | | - | - |
| 1959 | 2 470 | 37 020 | 2 500 | 41 990 | | | | - | - |
| 1960 | 4 000* | 35 638 | 2 500 | 42 138 | | | | - | - |
| 1961 | 4 400* | 42 102 | 3 000 | 49 502 | | | | - | - |
| 1962 | 7 231 | 46 345 | 3 400 | 56 976 | | | | 53 202 | 110 178 |
| 1963 | 6 593 | 54 267 | 3 900 | 64 760 | | | | 53 420 | 118 180 |
| 1964 | 8 983 | 55 693 | 4 100 | 68 776 | | | | 57 365 | 126 141 |
| 1965 | 4 033 | 54 327 | 4 745 | 63 105 | | | | 52 282 | 115 377 |
| 1966 | 5 582 | 44 725 | 7 118 | 57 425 | | | | 47 000 | 104 425 |
| 1967 | 6 726 | 52 643 | 7 279 | 66 648 | | | | 53 351 | 119 999 |
| 1968 | 11 427 | 61 985 | 7 252 | 80 664 | | | | 62 326 | 142 990 |
| 1969 | 19 839 | 36 373 | 6 275 | 58 983 | | | | 85 781 | 144 744 |
| 1970 | 32 475 | 29 392 | 7 079 | 68 946 | | | | 98 418 | 167 364 |
| 1971 | 32 309 | 19 050 | 6 108 | 57 467 | | | | 75 349 | 132 816 |
| 1972 | 45 452 | 28 515 | 7 066 | 81 033 | | | | 82 247 | 163 280 |
| 1973 | 28 354 | 10 737 | 6 406 | 45 497 | | | | 114 878 | 160 375 |
| 1974 | 29 907 | 14 966 | 3 198 | 48 071 | | | | 78 105 | 126 176 |
| 1975 | 26 786 | 10 149 | 6 556 | 43 491 | | | | 85 688 | 129 179 |
| 1976 | 26 836 | 16 833 | 5 372 | 49 041 | 89 197 | 26 291 | 376* | 115 864 | 164 905 |
| 1977 | 26 440 | 16 847 | 8 054 | 51 341 | 74 469 | 31 431 | 376 | 106 276 | 157 617 |
| 1978 | 23 411 | 4 561 | 4 071 | 32 043 | 80 121 | 14 945 | 376 | 95 442 | 127 475 |
| 1979 | 19 331 | 2 906 | 4 740 | 26 977 | 48 518 | 7 428 | 376 | 56 322 | 83 299 |
| 1980 | 15 179* | 4 575 | 5 378 | 25 132 | 41 261 | 9 064* | 376 | 50 701 | 75 833 |

*Estimated

Table 10.2 The ' e MACKEREL fishery in ICES Divisions VIIIc-IXa.
Effo. nd catch rates of trawlers and purse seiners, by cou. .

| Year | PORTUGAL | | | | SPAIN | | | |
|---|---|---|---|---|---|---|---|---|
| | Effort | | C.P.U.E. | | Effort | | C.P.U.E. | |
| | Trawl | Seine | Trawl | Seine | Trawl | Seine | Trawl | Seine |
| | (1 000 h) | No. boats | kg/h | t/seiner | (1 000 h) | No. boats | kg/h | t/seiner |
| 1956 | 111.4 | 387 | 17.8 | 87.6 | | | | |
| 1957 | 100.6 | 388 | 13.8 | 101.5 | | | | |
| 1958 | 128.9 | 280 | 11.8 | 126.0 | | | | |
| 1959 | 157.8 | 446 | 15.7 | 83.0 | | | | |
| 1960 | 166.1 | 374 | 24.1 | 95.3 | | | | |
| 1961 | 189.6 | 442 | 23.2 | 95.3 | | | | |
| 1962 | 213.0 | 386 | 33.9 | 120.1 | | | | |
| 1963 | 176.5 | 384 | 37.4 | 141.3 | | | | |
| 1964 | 185.0 | 391 | 48.6 | 142.4 | | | | |
| 1965 | 184.2 | 394 | 21.9 | 137.9 | | | | |
| 1966 | 174.1 | 385 | 32.1 | 116.2 | | | | |
| 1967 | 206.1 | 385 | 32.6 | 136.7 | | | | |
| 1968 | 217.1 | 389 | 52.6 | 159.3 | | | | |
| 1969 | 232.2 | 384 | 85.4 | 94.7 | | | | |
| 1970 | 257.2 | 386 | 126.3 | 76.2 | | | | |
| 1971 | 290.0 | 341 | 111.4 | 55.9 | | | | |
| 1972 | 280.9 | 288 | 161.8 | 99 0 | | | | |
| 1973 | 369.3 | 253 | 76.8 | 42.4 | - | - | - | - |
| 1974 | 340 * | 236 | 88.0 | 63.4 | - | - | - | - |
| 1975 | 350 * | 241 | 76.5 | 42.1 | 969 | - | 88.5 | - |
| 1976 | 340 * | 237 | 78.9 | 71.0 | 1 102 | 189 | 105.1 | 139.4 |
| 1977 | 374 * | 235 | 70.7 | 71.7 | 1 582 | 209 | 67.2 | 150.4 |
| 1978 | 348 * | 243 | 67.3 | 18.8 | 1 194 | 211 | 79.9 | 70.8 |
| 1979 | 380 * | 283 | 50.9 | 10.3 | 1 114 | 211 | 50.6 | 35.2 |
| 1980 | 354 * | 282 | 42.9 | 16.2 | 733 | 211 | 56.3 | 41.9 |

* Estimated

Table 10.3 The Horse MACKEREL fishery in ICES Divisions VIIIc- IXa
Catch, C.P.U.E., effort and 3 years running mean effort.

(1) C.P.U.E. of the Portuguese purse seiners,

(2) Effort expressed in number of Portuguese purse seiners.

| Year | Total catch (tonnes) | C.P.U.E. (1) | Estimated Effort (2) | Mean Effort K = 3 |
|---|---|---|---|---|
| 1 962 | 110 178 | 120.1 | 917.4 | - |
| 1 963 | 118 180 | 141.3 | 836.4 | - |
| 1 964 | 126 141 | 142.4 | 885.8 | 879.9 |
| 1 965 | 115 377 | 137.9 | 836.7 | 853.0 |
| 1 966 | 104 425 | 116.2 | 898.7 | 873.7 |
| 1 967 | 119 999 | 136.7 | 877.8 | 871.1 |
| 1 968 | 142 990 | 159.3 | 897.6 | 891.4 |
| 1 969 | 144 744 | 94.7 | 1 528.4 | 1 101,3 |
| 1 970 | 167 364 | 76.2 | 2 196.4 | 1 540,8 |
| 1 971 | 132 816 | 55.9 | 2 376,0 | 2,033.6 |
| 1 972 | 163 280 | 99.0 | 1 649,3 | 2 073.9 |
| 1 973 | 160 375 | 42.4 | 3 782.4 | 2.602,6 |
| 1 974 | 126 176 | 63.4 | 1 990,1 | 2 473.9 |
| 1 975 | 129 179 | 42.1 | 3 068,4 | 2 947.0 |
| 1 976 | 164 905 | 71.0 | 2 322,6 | 2 450.4 |
| 1 977 | 158 560 | 71.7 | 2 211,4 | 2 534.1 |
| 1 978 | 127 475 | 18.8 | 6 780,6 | 3 771.5 |
| 1 979 | 83 299 | 10.3 | 8 087.3 | 5 693.1 |
| 1 980 | 75 833 | 16.2 | 4 681 | 6 516.3 |

Table 10.4 Horse MACKEREL in ICES Divisions VIIIc-IXa. Immediate losses and long term gains in the trawl fishery for changes in mesh size from 40 mm to 60 and 75 mm, and for a range of exploitation rates.

| Change of mesh from 40 mm to 60 mm | | | |
|---|---|---|---|
| F | E | Immediate Losses | Long Term Gains |
| 0.07 | 0.25 | - 22.3 | - 3.0 |
| 0.20 | 0.50 | - 22.3 | + 18.9 |
| 0.43* | 0.6825* | - 22.3 | + 39.0 |
| 0.6 | 0.75 | - 22.3 | + 47.2 |

| Change of mesh from 40 mm to 75 mm | | | |
|---|---|---|---|
| F | E | Immediate Losses | Long Term Gains |
| 0.07 | 0.25 | - 57.3 | - 35.3 |
| 0.2 | 0.50 | - 57.3 | - 2.0 |
| 0.43* | 0.6825* | - 57.3 | + 32.7 |
| 0.6 | 0.75 | - 57.3 | + 48.4 |

*Exploitation level in 1980.

Table 10.5 Input data and results of cohort analysis (Pope 1974) using the 1980 catch curve as synthetic cohort, for several hypothesis of F (M = 0.2).

| Age | | 0 | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|---|
| Age Distribution | Catch in numbers x $10^{-3}$ | 50 622 | 317 967 | 95 239 | 45 924 | 43 809 | 62 755 | 44 233 | 11 802 | 0.677 |
| Fishing Mortality | 1 HYP | 0.040 | 0.374 | 0.181 | 0.124 | 0.168 | 0.385 | 0.517 | 0.249 | 0.02 |
| | 2 HYP | 0.045 | 0.437 | 0.224 | 0.160 | 0.226 | 0.588 | 1.168 | 1.281 | 0.20 |
| | 3 HYP | 0.046 | 0.443 | 0.228 | 0.164 | 0.232 | 0.612 | 1.298 | 2.017 | 0.60 |
| | $F_{80}$ | 0.046 | 0.442 | 0.228 | 0.163 | 0.231 | 0.607 | 1.269 | 1.797 | 0.43 |
| Population (No. x $10^{-3}$) | 1 HYP | 1 127.40 | 317.97 | 635.31 | 433.97 | 313.75 | 217.24 | 121.07 | 59.10 | 37.11 |
| | 2 HYP | 1 266.50 | 991.11 | 523.74 | 342.63 | 238.96 | 156.01 | 70.94 | 18.06 | 4.11 |
| | 3 HYP | 1 254.30 | 981.10 | 515.55 | 335.92 | 233.47 | 151.51 | 67.26 | 15.05 | 1.64 |
| | $F_{80}$ | 1 256.70 | 983.06 | 517.15 | 337.23 | 234.55 | 152.39 | 67.98 | 15.63 | 2.12 |

Table 10.6 - Estimates of Yield per recruit, over a range of values of F

($K = 0.1625$ ; $W_\infty = 1\ 140$ g ; $M = 0.2$ ; $t_o = -1$ ; $t_r = 1$)

| F | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Y/R (g) | 54.6 | 76.7 | 85.1 | 87.0 | 86.0 | 83.6 | 80.7 | 77.6 | 74.6 | 71.7 | 69.0 | 66.4 |

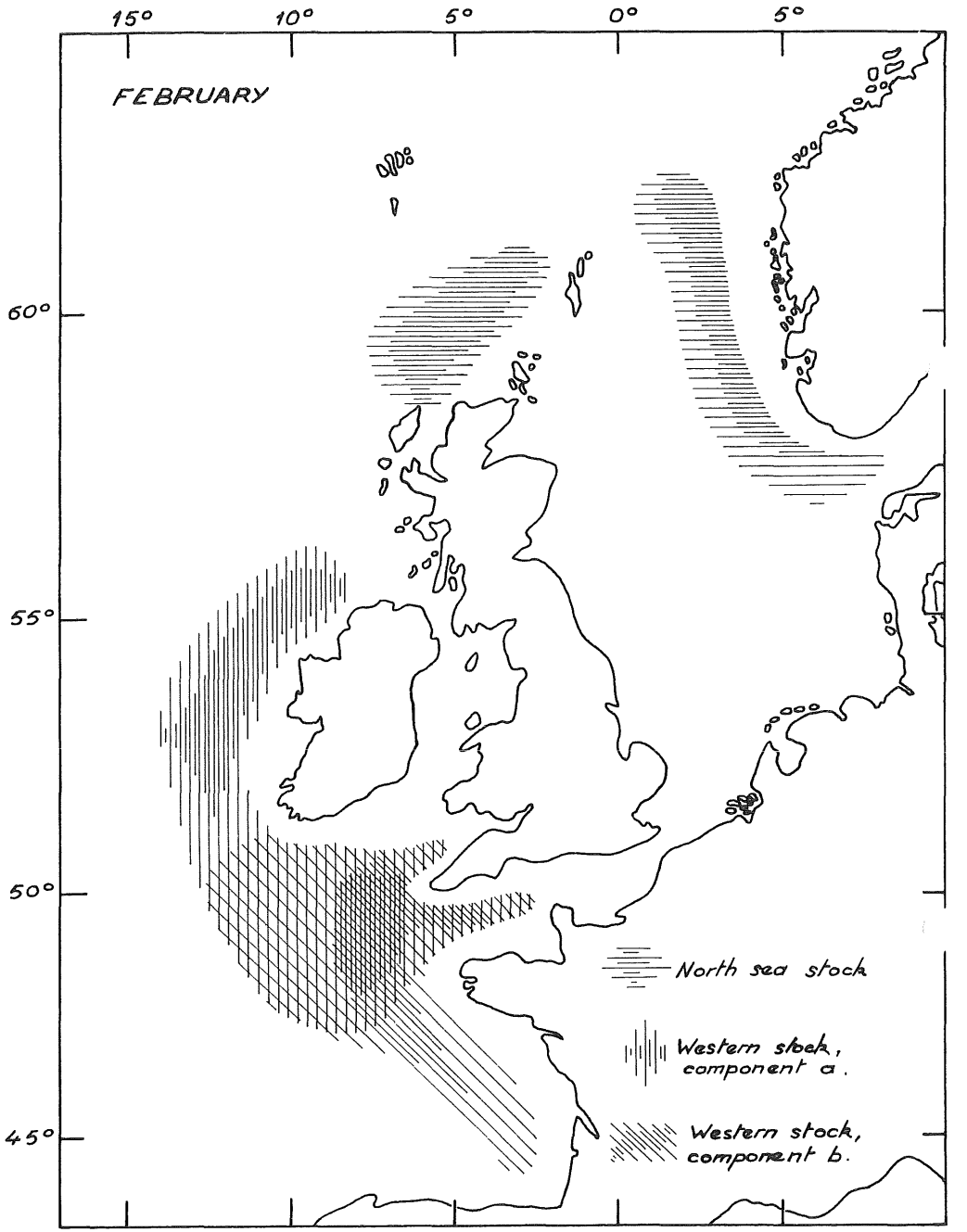



Figure 3.1. Chart showing putative distribution of MACKEREL in February.

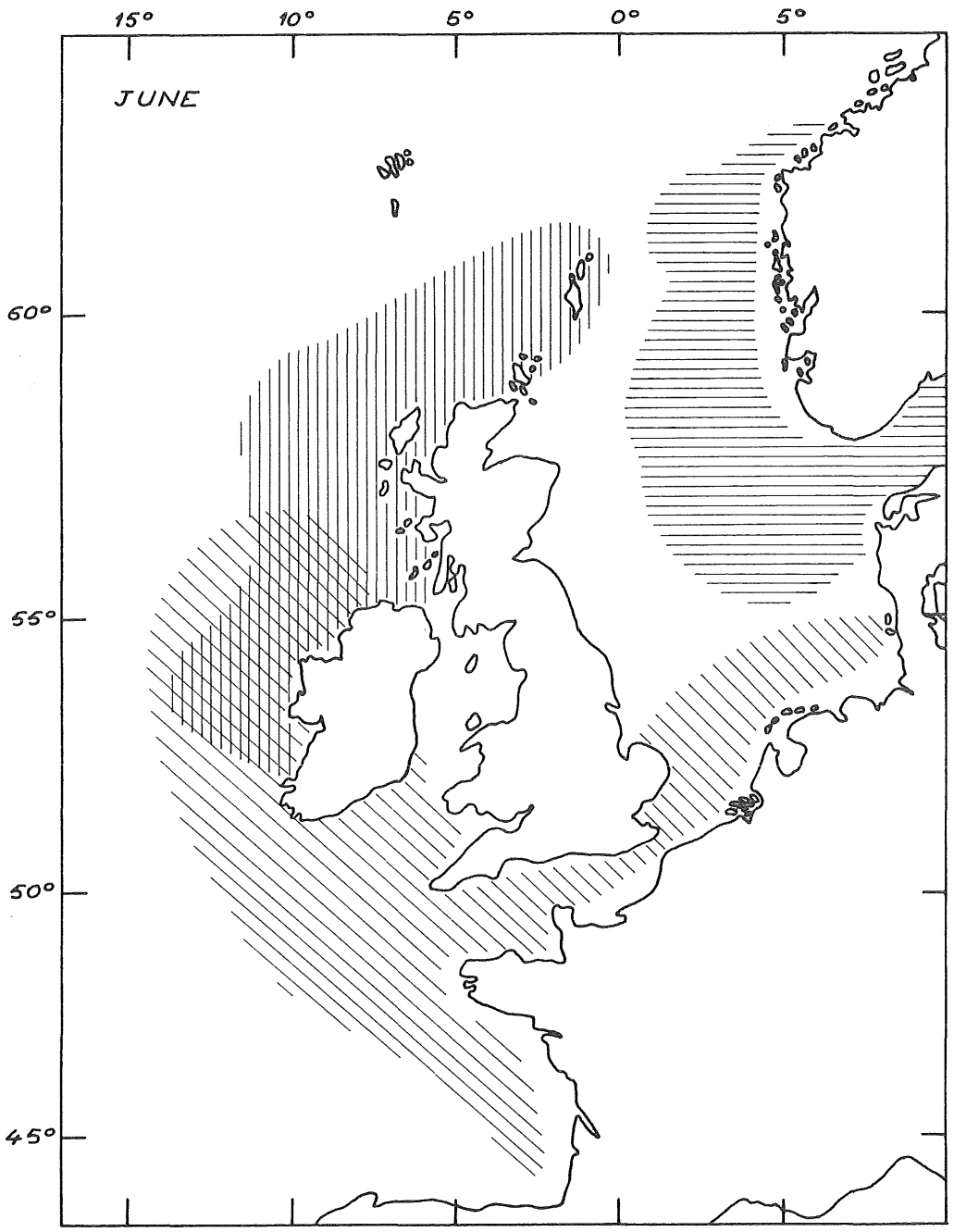



Figure 3.2. Chart showing putative distribution of MACKEREL in June.

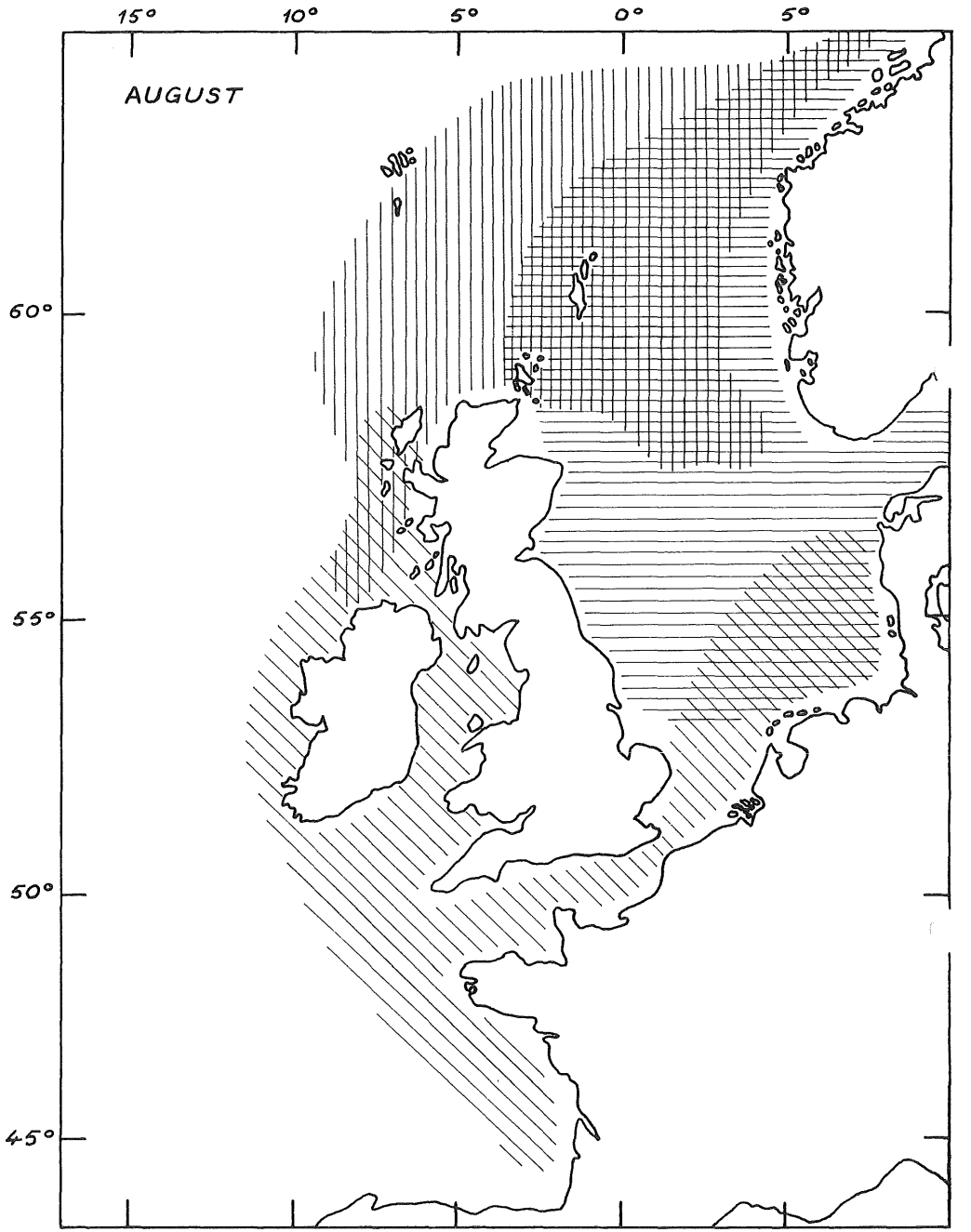



Figure 3.3. Chart showing putative distribution of MACKEREL in August.

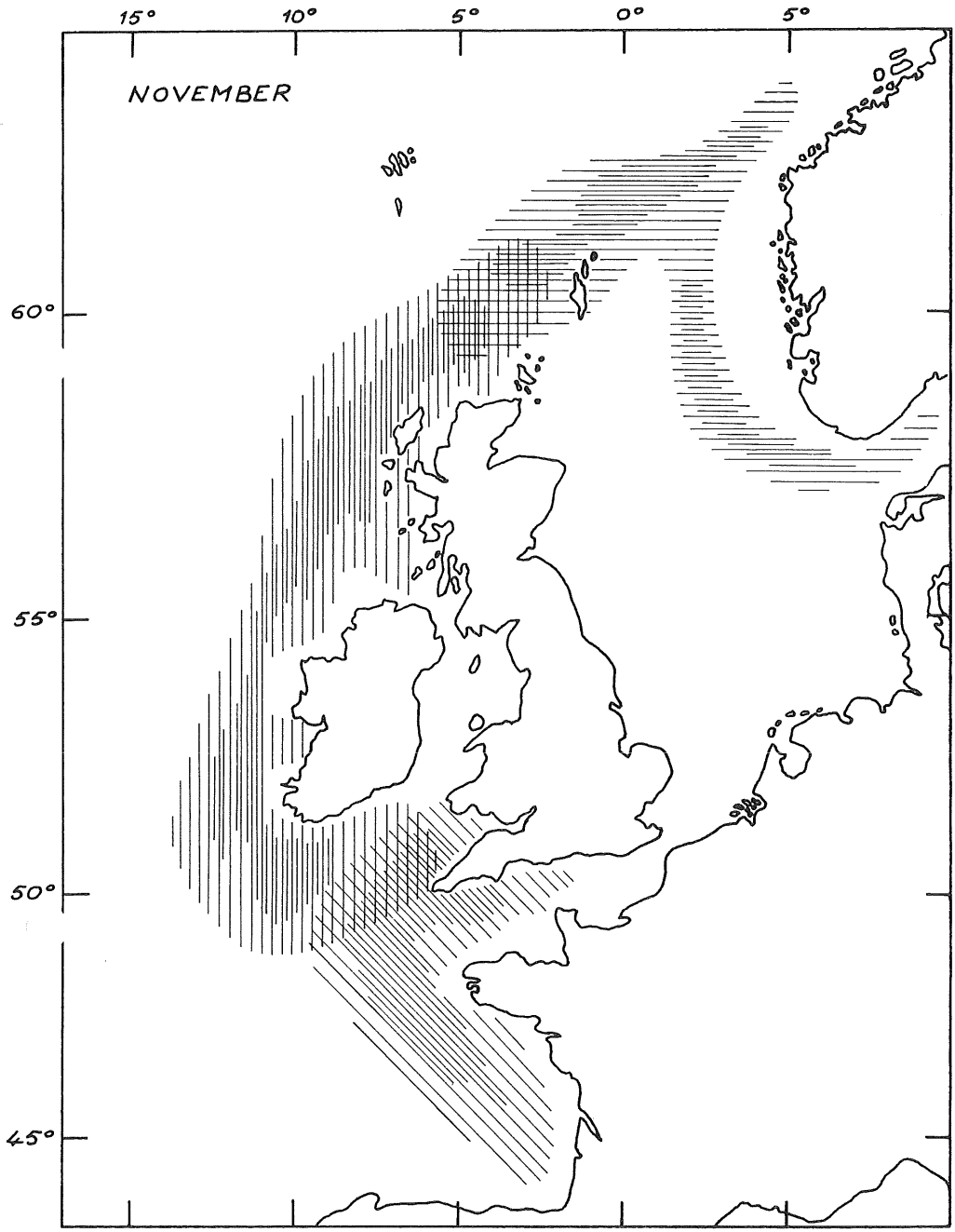
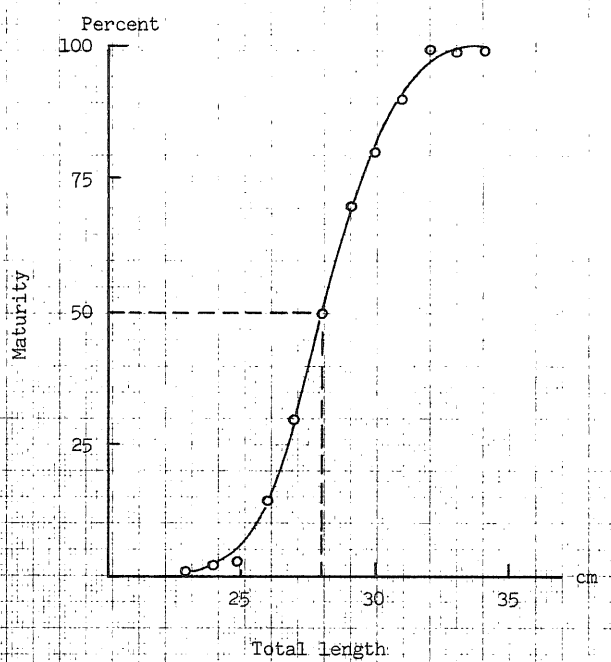
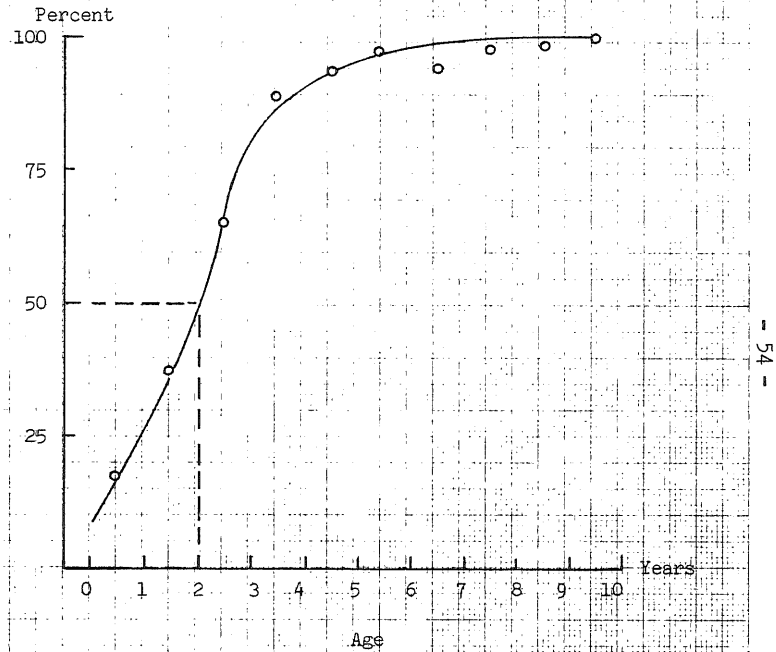



Figure 3.4. Chart showing putative distribution of MACKEREL in November.

Figure 4.1 Maturity length and maturity age ogives (fitted by eye).



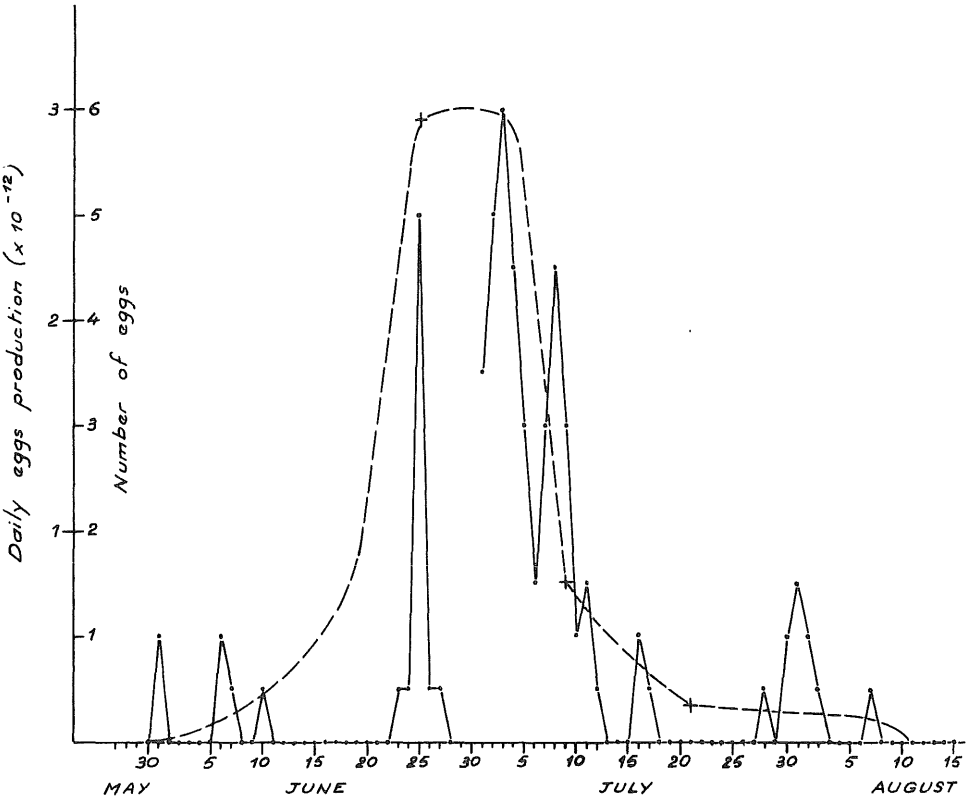



Figure 5.1. Norwegian egg surveys in the North Sea in 1980 (the egg production curve is based on the three surveys (+) and daily egg sampling from a fixed position).

Figure 5.2 Western MACKEREL stock. Egg production curve, March-July 1980.

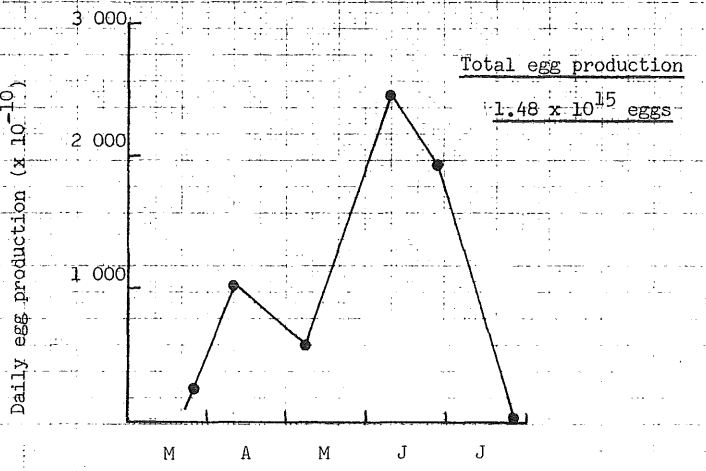



Figure 5.3 Western MACKEREL spawning stock size, March-July 1980

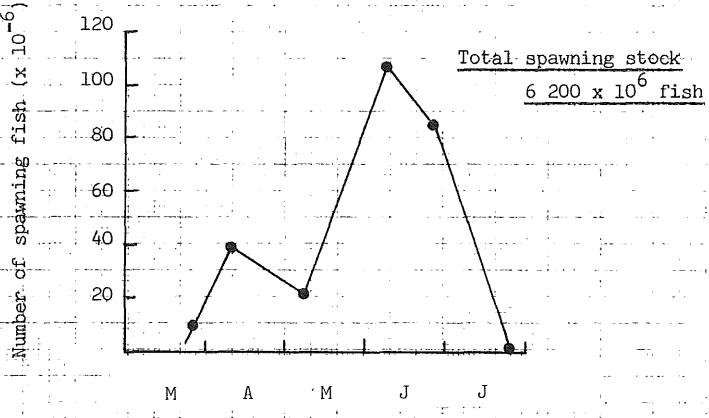


Figure 6.1 Length frequency distributions of MACKEREL caught during the English winter fishery off Cornwall.

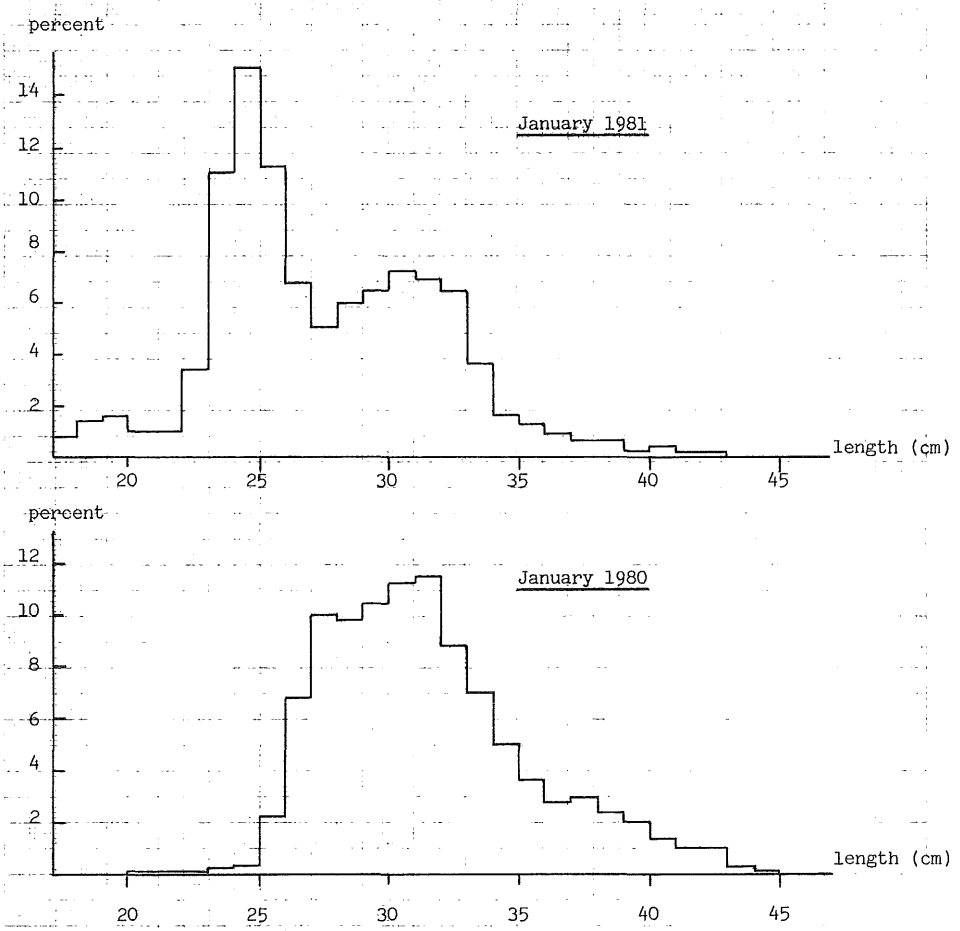
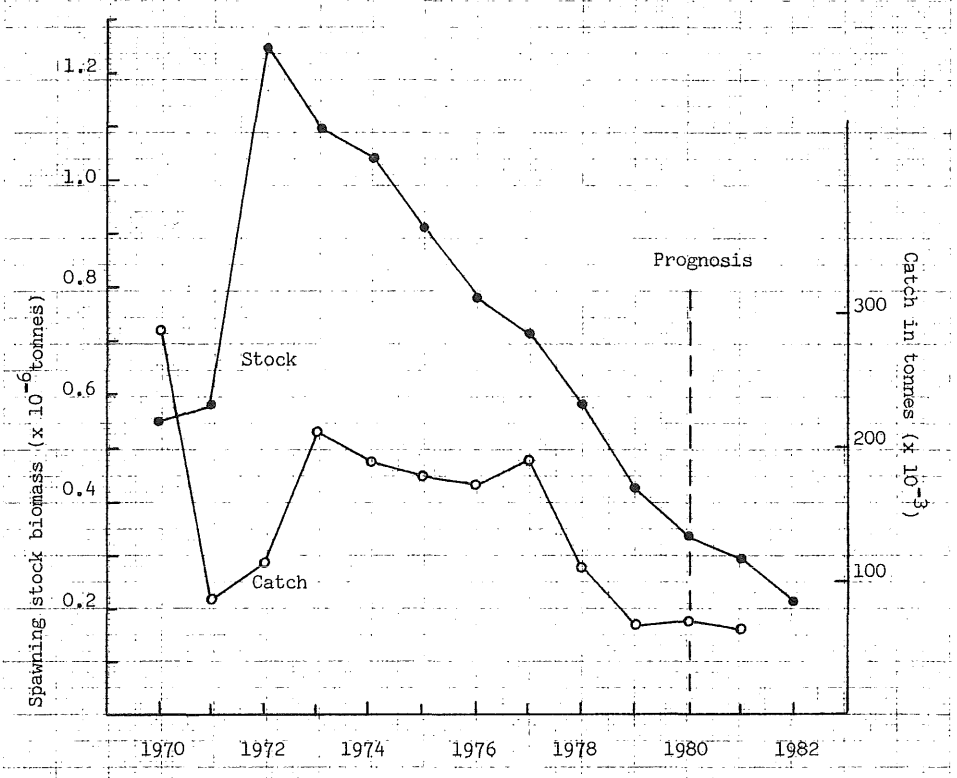


Figure 8.1 North Sea MACKEREL.
Data from cohort analysis. Prognosis with low recruitment and 1981 TAC exceeded.

Spawning stock ≥ 3 years at 1 January.



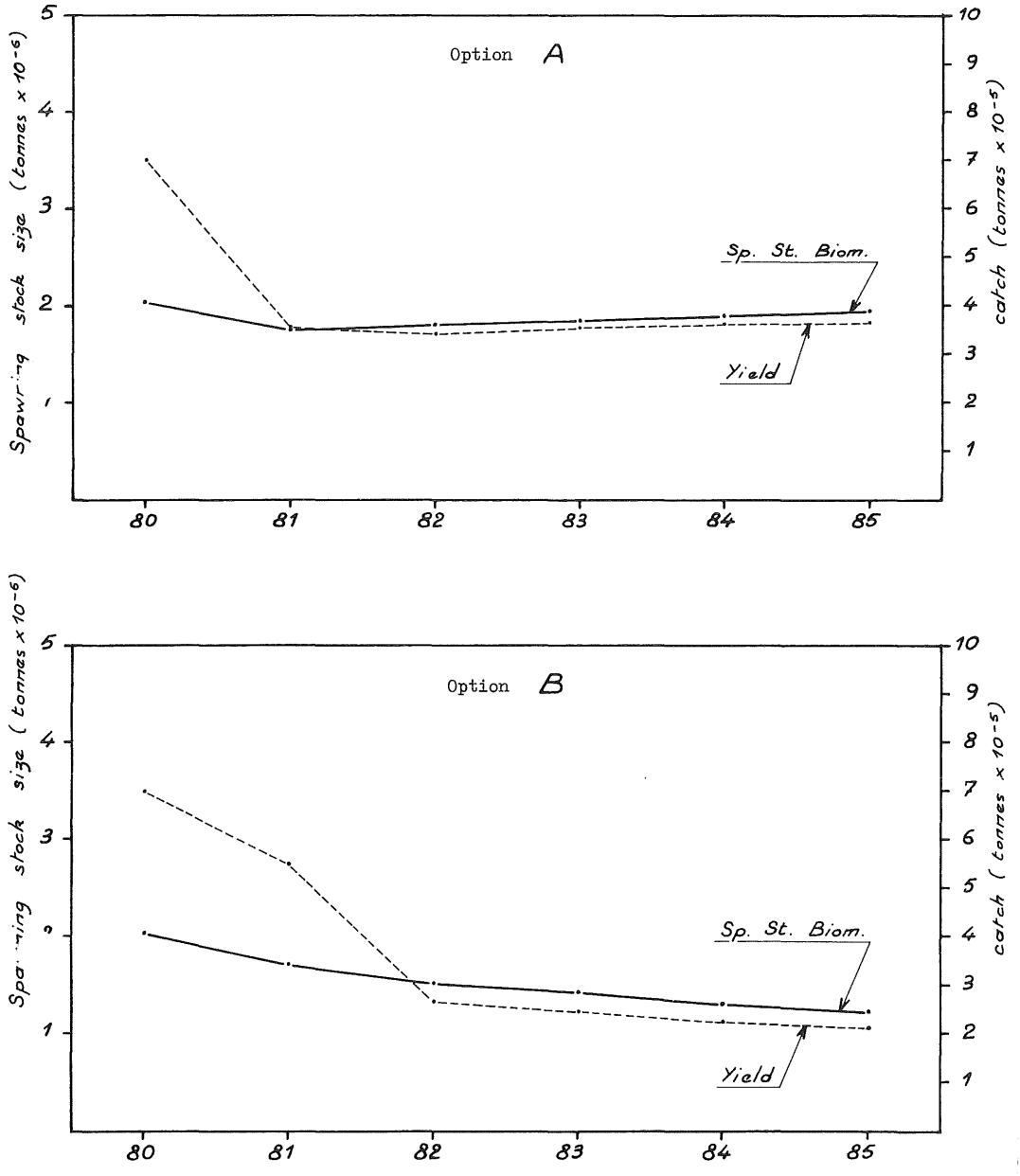
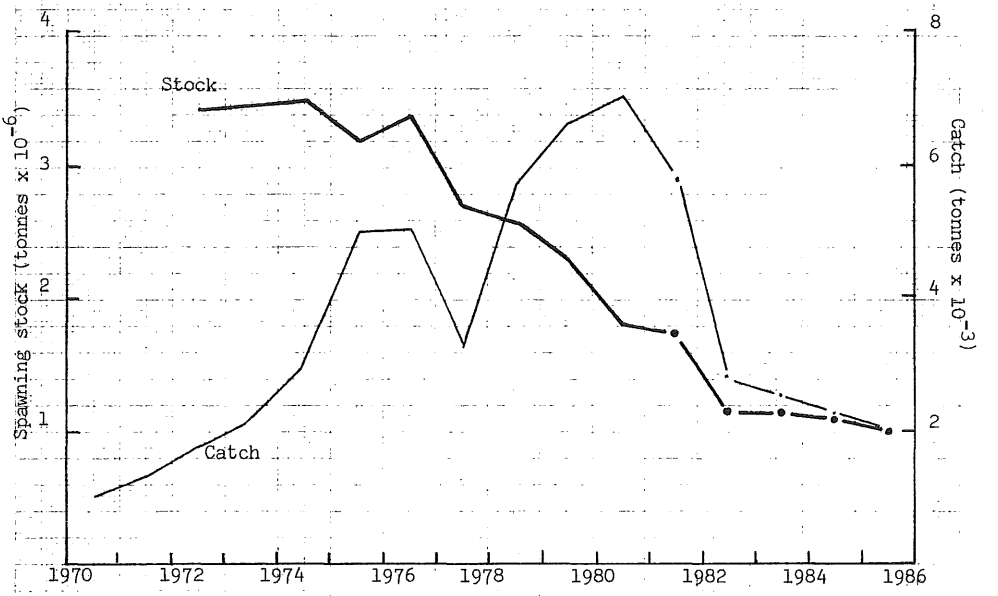



FIG. 8.2.—WESTERN STOCK PROGNOSIS.

Figure 8.3 Western MACKEREL.
Long term trend in spawning stock and catches.
Prognosis with low recruitment and TAC exceeded in 1981.



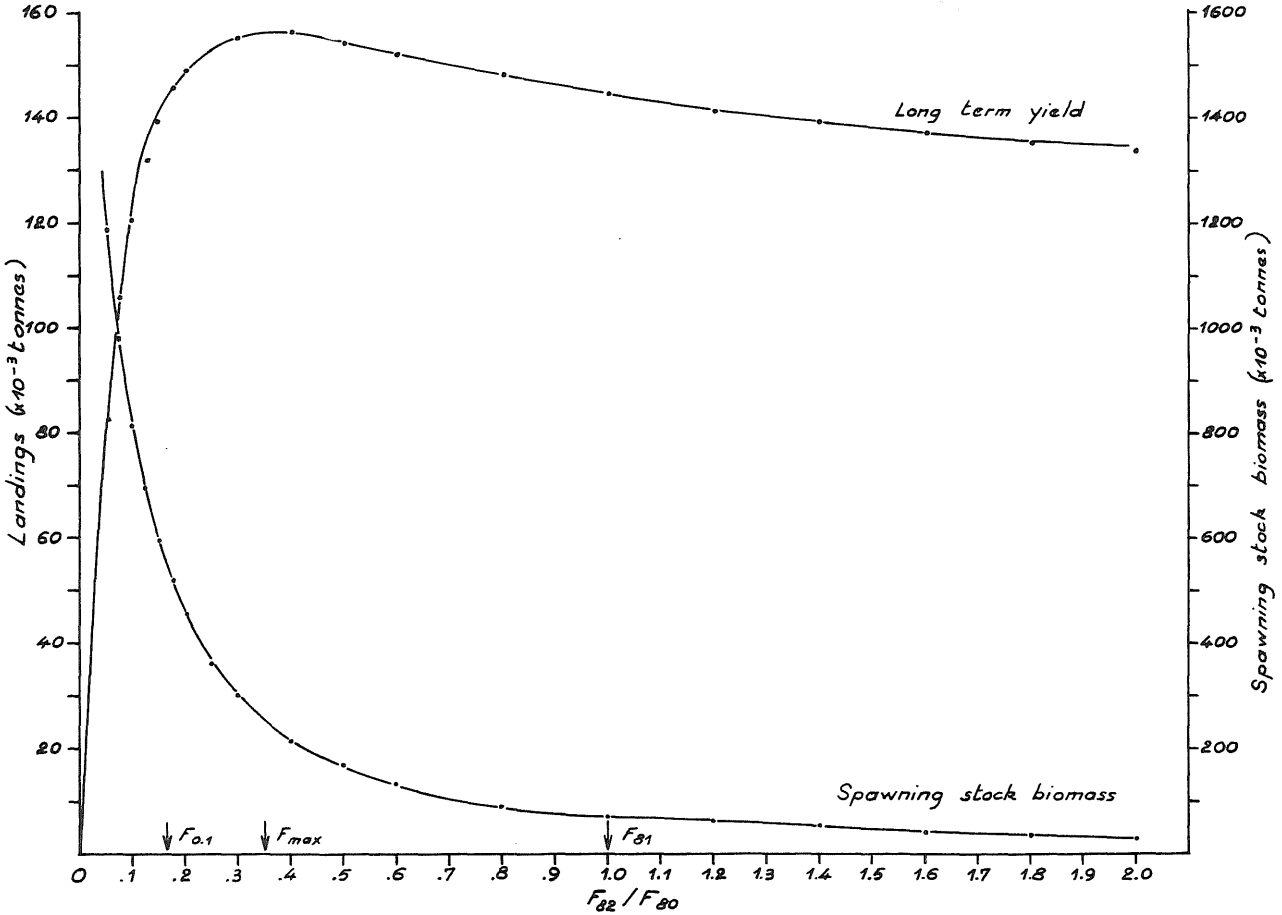



Fig. 8.4.— Predictions for Western mackerel.

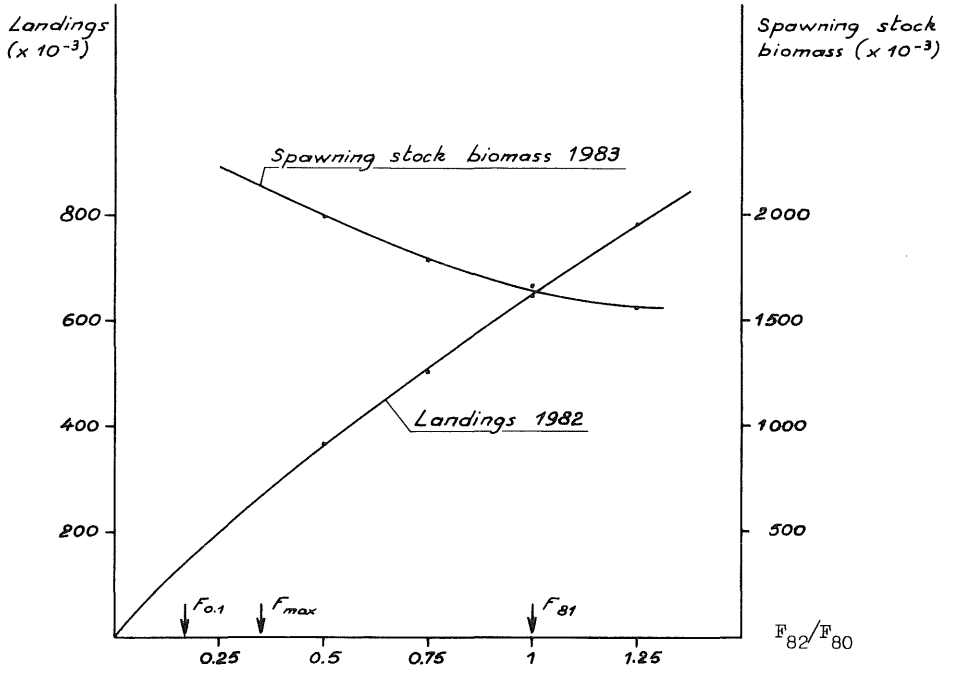



Fig. 8.5.— Predictions for Western mackerel.

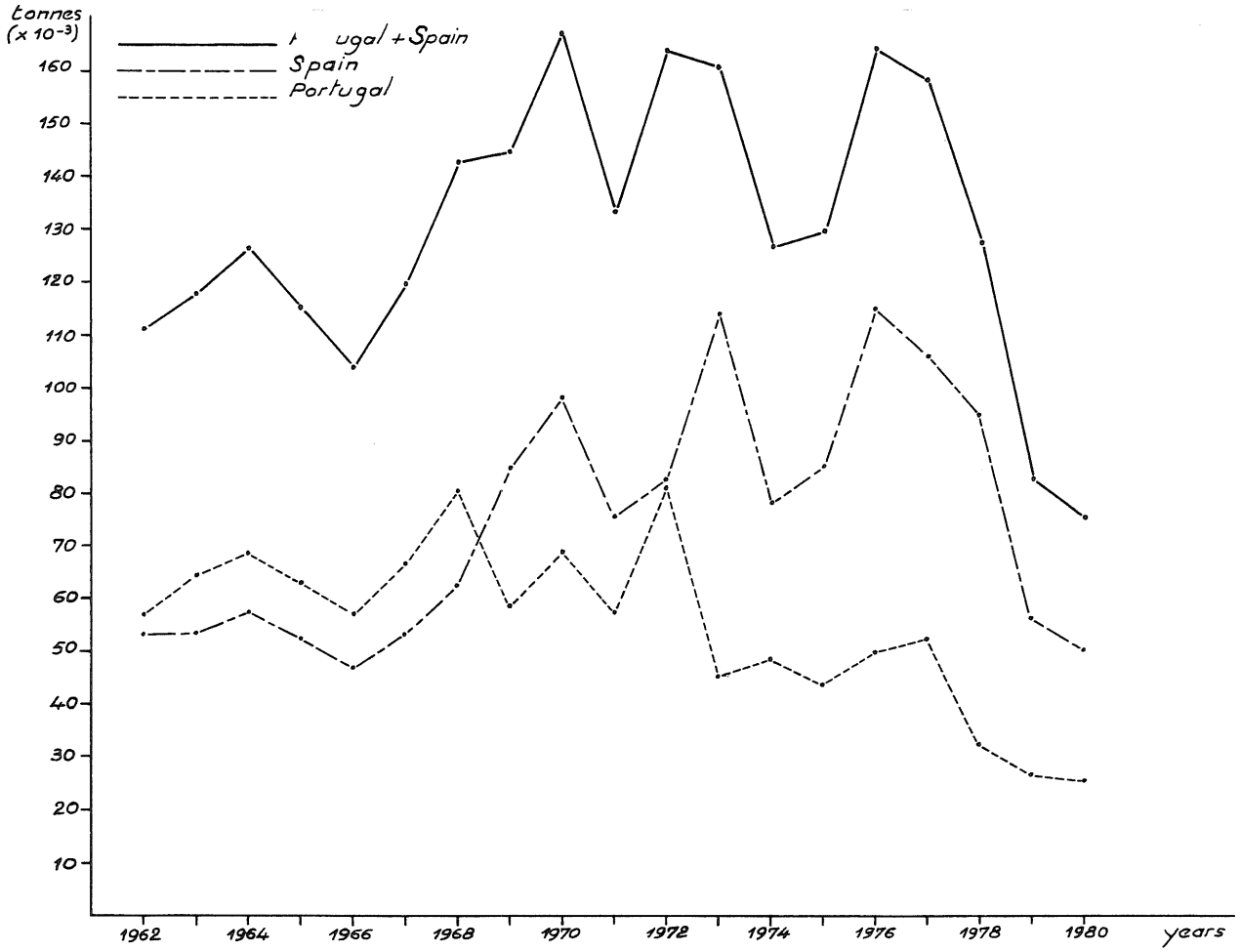



Figure 10.1. Portuguese and Spanish landings of HORSE MACKEREL from Divisions VIIIc-IXa.

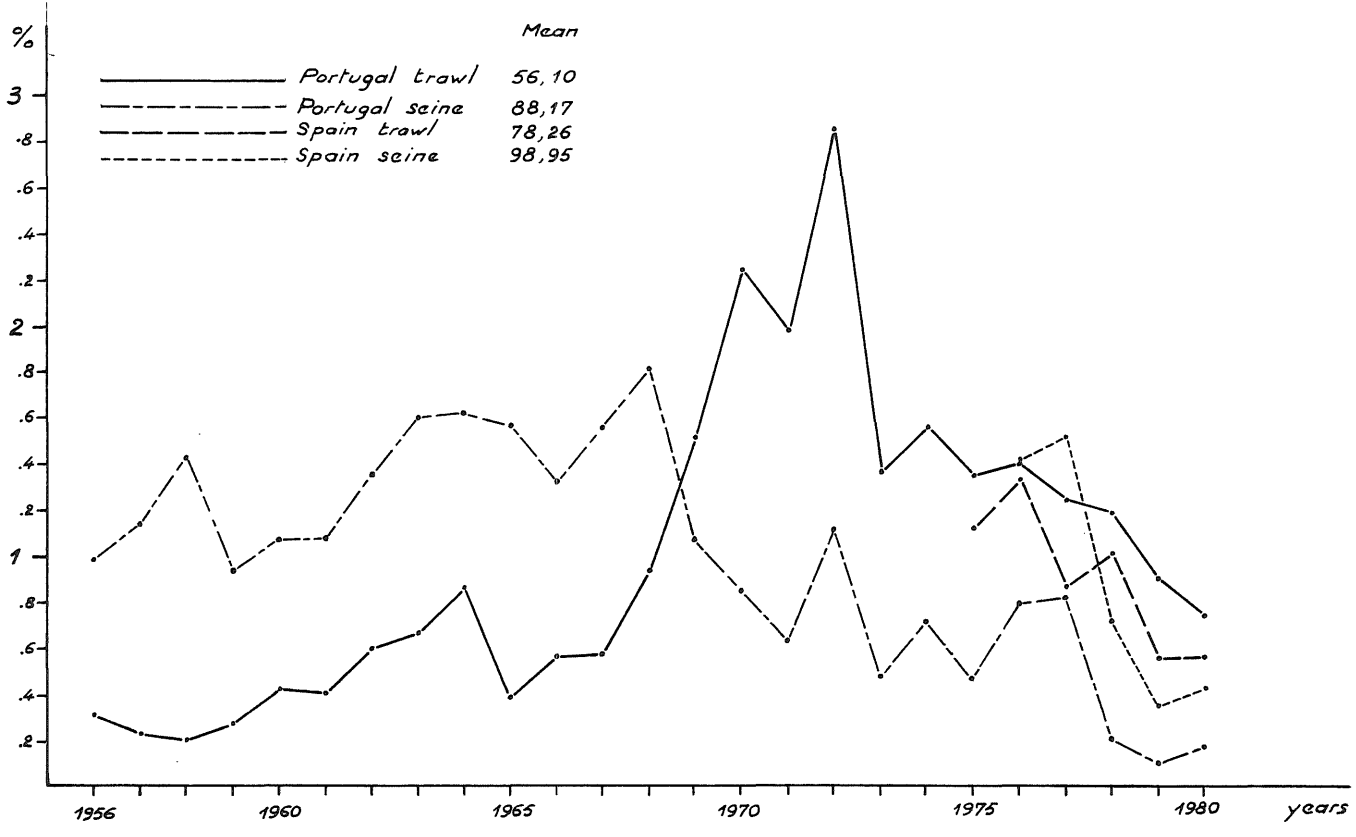



Figure 10.2. HORSE MACKEREL fishery in Divisions VIIIc and IXa. Fluctuations of the abundance index of purse seiners and trawlers around the mean.

Figure 10.3 se MACKEREL in ICES Divisions VIIIc-IXa
Production model (FOX)

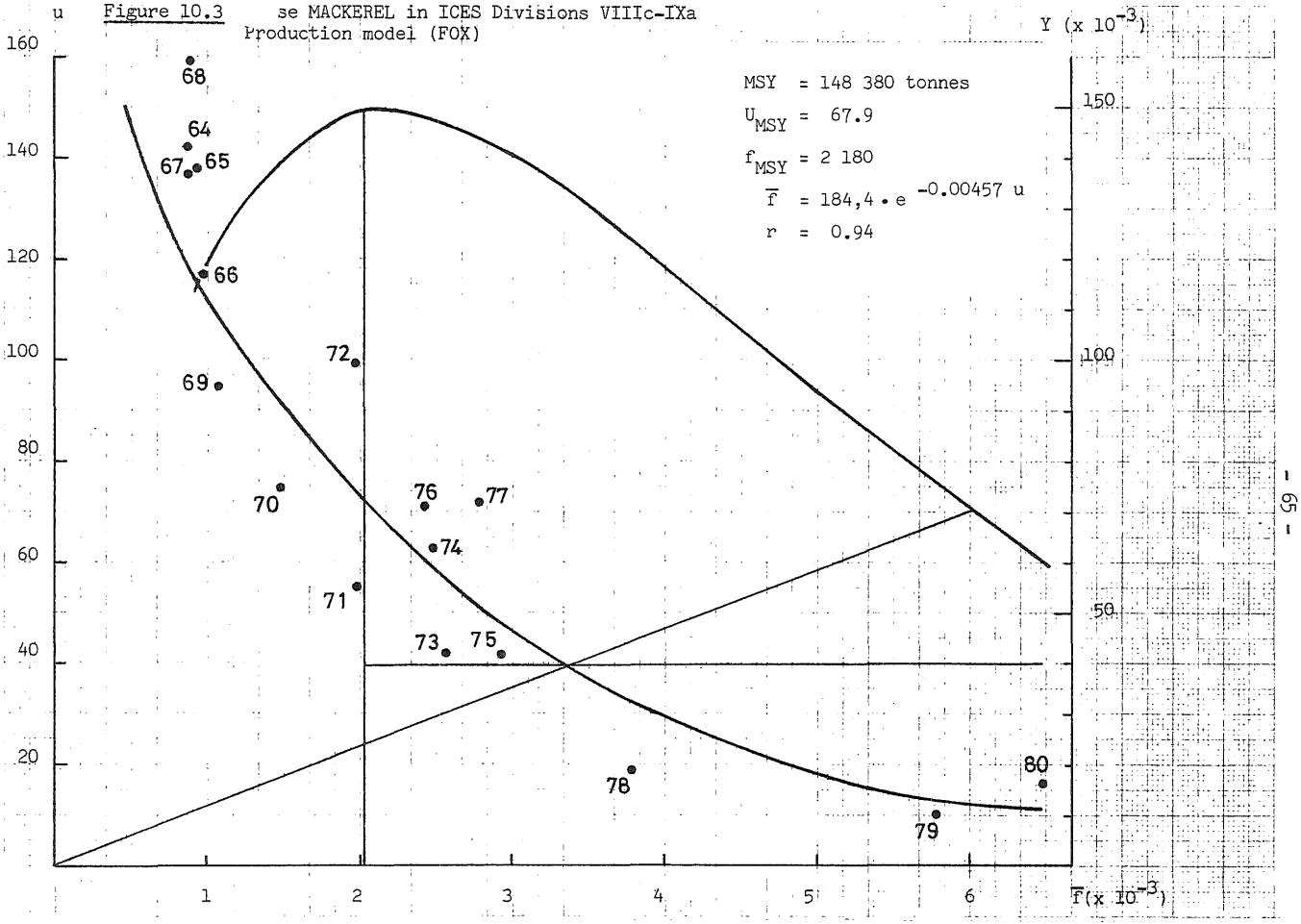
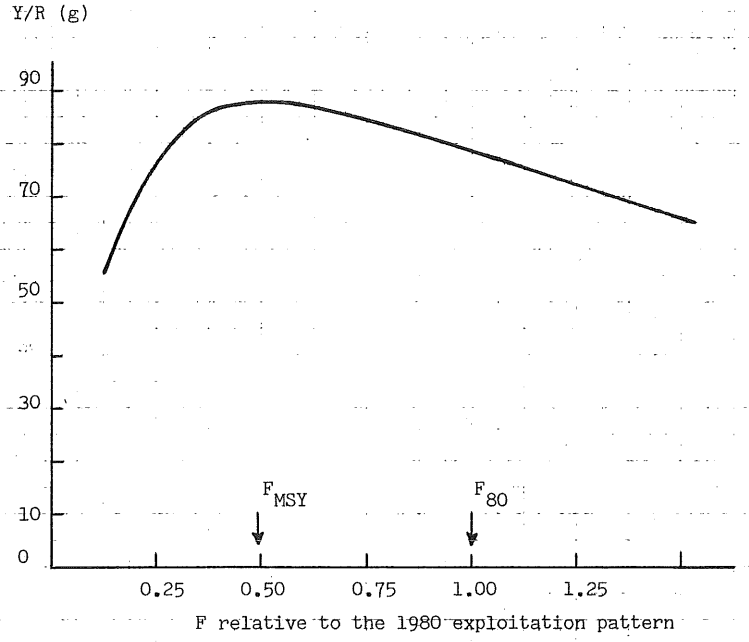


Figure 10.4 Horse MACKEREL in ICES Divisions VIIIc-IXa
Yield per recruit curve.



APPENDIX

Application of the Norwegian Tagging Data

The Norwegian tagging data including the recaptures from 1980 are given in Table 1 (North Sea stock releases). Although the 1980 recapture data is to be considered preliminary, the data has been used for:

1. Splitting the North Sea landings in a N.S. Stock component and a Western Stock component in Divisions IVa and IIa
2. Rough estimates of survival rates.

1. Method of splitting the landings

Let: $p_j = \frac{P_{J(NS)}}{P_{J(NS)} + P_{J(W)}}$ = proportion of North Sea stock in total landings from Sub-area IVa in year j.

$p_j$ is estimated from the tagging data. Assuming this estimate to be valid, we consider now only tagging data related to the North Sea stock, and apply the formula (Anon. 1979)

$$P_{j+1} = P_j \cdot \frac{\frac{\sum r_{ij+1}}{P_{j+1}}}{\frac{\sum r_{ij}}{P_j}} = P_j \cdot \Delta_{j+1/j} \qquad (1)$$

Where $\sum r_{ij}$ and $\sum r_{ij+1}$ are the recaptures during years j and j+1 from releases of all years prior to year j.

$\Delta_{j+1/j}$ is conceived as an estimate of the change in density of North Sea tags from year j to j+1 (Thus if $\Delta_{j+1/j} < 1$ a further dilution of the North Sea stock component has occurred).

Table 2 shows the estimated $p_j$ for the years 1976-1979. It is seen, that for each age group a $p_j$ is estimated. However, this was not possible for 1980. The formula (1) has been applied to split the 1980 landings by

a) $\Delta_{1980/1979} = \frac{\frac{47}{19.5}}{\frac{100}{41.9}} = 1.01$

b) using the proportions ($p_j$) given for each age group in 1979, estimates of $p_{1980}$ are obtained as:

$$p_{1980} = p_{1979} \cdot 1.01 \simeq p_{1979}$$

However, the estimate of $\Delta_{1980/79}$ is for all year classes combined, and to use this combined with last years (1979) $p_j$ it is necessary to assume, that either $\Delta_{1980/79}$ is the same for all age groups or that the errors in assuming such is negligible compared with the errors due to low tag returns in 1980, Table 2.

Estimation of survival rates

In order to assess whether the tagging data could be used for assessing any trends in recent years fishing mortalities, estimates of survival rates were made. However, as the recaptures are only registered in the Norwegian industrial landings, the number of recaptures for each year i were raised by the factor (see Table 3 and 4):

$$\frac{\text{(North Sea landing) year}_i}{\text{(Norwegian Industrial landing) year}_i}$$

Two methods (models) were applied.

Notation:

$R_i$ = number of released (tagged) fish in year i
$r_i$ = total number of recaptures from $R_i$
$m_i$ = total number of recaptures in year i
$T_i$ = total number of recaptures in year i and later of all releases from year 1 to i ($T_1 = R_1$)
$z_i$ = the group of tagged fish, which were caught before year i (being tagged), not caught in year i, but subsequently caught
note: $z_i = T_i - R_i$

1. Robson-method (Ricker, 1975)
The survival rate is estimated as (for year i to i+1):

$$s_i = \frac{R_{i+1}}{R_i} \cdot \frac{r_i}{r_{i+1}} \cdot \frac{T_{i+1} - R_{i+1}}{T_i}$$

2. Jolly & Seber method (Seber 1973)

The formulas are derived in the following way:
Just after the i'th release of tagged fish two groups of tagged fish are present in the population:

a) The $R_i$ just released, of which $r_i$ are subsequently caught;
b) The $M_i - m_i$ previously tagged fish, which were not caught during year i. Of these $z_i$ are caught subsequently.

Assuming equal probability of recapture for those two groups, we have:

$$\frac{Z_i}{M_i - m_i} = \frac{r_i}{R_i} \quad \text{and} \quad \hat{M}_i = \frac{R_i \cdot z_i}{r_i} + m_i$$

and the survival rate is

$$S_i = \frac{\hat{M}_{i+1}}{\hat{M}_i - m_i + R_i}$$

Table 5 shows the estimated survival rates. As can be seen, the two models give very similar paterns, which is not surprising, because although the assumptions underlying the two models differ, the application of the data is similar. However, the estimated survival rates for the years 1973-78 did not provide any basis for input values of F's in a VPA.

References:

Ricker, W.E., 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bulletin of the Fisheries Research Board of Canada, No. 191. pp. 382.

Seber, G.A.F., 1973. The estimation of animal abundance and related parameters. Griffin. pp. 506.

Appendix Table 1. Number of tags returned (r) in total Norwegian industrial landings (P), x $10^{-3}$ tonnes. Releases (N) in the North Sea. Recaptures in the Shetland area (Sh), in the northeastern North Sea (NS) and in the northern part of Division VIa near Rona (R). All year classes included.

| Release | | 1969 | | | 1970 | | | 1971 | | | 1972 | | | 1973 | | | 1974 | | | | 1975 | | | 1976 | 1977 | 1978 | 1978/79 | 1979 | 1980[1] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | N | Sh | NS | Sum | Sh | NS | Sum | Sh | NS | Sum | Sh | NS | Sum | Sh | NS | Sum | Sh | NS | R | Sum | Sh | NS | Sum | | | | R | | |
| 1969 | 1 187 | 19 | 547 | 566 | 16 | 198 | 230 | 50 | 6 | 56 | 4 | 5 | 9 | 22 | 2 | 24 | 8 | 7 | 2 | 17 | 2 | 5 | 7 | 6 | 3 | 0 | 0 | 0 | 0 |
| 1970 | 3 505 | | | | 2 | 476 | 478 | 34 | 19 | 53 | 9 | 30 | 39 | 31 | 47 | 78 | 17 | 22 | 14 | 53 | 4 | 31 | 35 | 19 | 19 | 3 | 3 | 1 | 0 |
| 1971 | 9 305 | | | | | | | 1 | 154 | 155 | 57 | 145 | 255 | 142 | 285 | 427 | 86 | 128 | 90 | 304 | 22 | 173 | 195 | 109 | 95 | 19 | 9 | 6 | 1 |
| 1972 | 11 818 | | | | | | | | | | 0 | 178 | 178 | 143 | 489 | 632 | 113 | 269 | 195 | 577 | 35 | 334 | 369 | 198 | 203 | 33 | 16 | 4 | 3 |
| 1973 | 7 277 | | | | | | | | | | | | | 0 | 441 | 441 | 61 | 274 | 129 | 464 | 35 | 323 | 358 | 148 | 153 | 28 | 10 | 7 | 5 |
| 1974 | 4 493 | | | | | | | | | | | | | | | | 7 | 303 | 110 | 420 | 13 | 193 | 206 | 89 | 124 | 17 | 11 | 2 | 2 |
| 1975 | 9 995 | | | | | | | | | | | | | | | | | | | | 0 | 674 | 674 | 229 | 302 | 45 | 27 | 19 | 4 |
| 1976 | 1 763 | | | | | | | | | | | | | | | | | | | | | | | 50 | 62 | 14 | 7 | 5 | 5 |
| 1977 | 7 094 | | | | | | | | | | | | | | | | | | | | | | | | 202 | 41 | 38 | 28 | 8 |
| 1978 | 12 173 | | | | | | | | | | | | | | | | | | | | | | | | | 76 | 102 | 28 | 19 |
| 1979 | 11 991 | | | | | | | | | | | | | | | | | | | | | | | | | | | 0 | 12 |
| 1980 | 5 676 | | | | | | | | | | | | | | | | | | | | | | | | | | | | 2 |
| P | | 237.0 | 314.0 | 551.0 | 89.0 | 195.4 | 274.4 | 166.6 | 23.8 | 190.4 | 91.7 | 51.4 | 143.1 | 195.0 | 109.7 | 304.7 | 158.0 | 59.0 | 37.2 | 254.2 | 103.9 | 113.5 | 217.4 | 175.7 | 137.3 | 36.9 | 14.9 | 41.9 | 19.5 |

1) Preliminary figure.

Appendix Table 2. Estimates of proportion of North Sea stock in Norwegian industrial landings ($p_j$) in Division IVa.

| Year class | $p_j$ | | | | ~ | |
|---|---|---|---|---|---|---|
| | 1976 | 1977 | 1978 | 1979 | | 1980 |
| pre-1969 | 0.33 | 0.58 | 0.38 | 0.24 | | 0.24 |
| 1969 | 0.48 | 0.77 | 0.53 | 0.33 | | 0.33 |
| 1970 | 0.60 | 0.66 | 0.63 | 0.40 | | 0.40 |
| 1971 | 0.15 | 0.31 | 0.19 | 0.12 | | 0.12 |
| 1972 | 0.26 | 0.54 | 0.33 | 0.21 | | 0.21 |
| 1973 | 1.00 | 0.95 | 0.39 | 0.25 | | 0.25 |
| 1974 | | 1.00 | 0.64 | 0.61 | | 0.61 |
| 1975 | | | 1.00 | 0.64 | | 0.64 |
| 1976 | | | | 1.00 | | 1.00 |
| 1977 | | | | | | 1.00 |

Appendix Table 3. Norwegian industrial catch and total international catch in the North Sea

| Year | N Norwegian industrial catch, IV+IIIa+IIa | T International total catch IV+IIIa+IIa | T/N | N/T |
|---|---|---|---|---|
| 1969 | 551.0 | 739.2 | 1.34 | .75 |
| 1970 | 274.4 | 322.5 | 1.18 | .85 |
| 1971 | 190.4 | 243.7 | 1.28 | .78 |
| 1972 | 143.1 | 188.6 | 1.32 | .76 |
| 1973 | 304.7 | 348.1 | 1.14 | .88 |
| 1974 | 254.2 | 305.2 | 1.20 | .83 |
| 1975 | 217.4 | 297.7 | 1.37 | .73 |
| 1976 | 175.7 | 316.2 | 1.80 | .56 |
| 1977 | 137.3 | 260.9 | 1.90 | .53 |
| 1978 | 36.9 | 153.0 | 4.15 | .24 |
| 1979 | 14.9 | 158.5 | 10.64 | .09 |
| 1980 | 19.5 | 88.2 | 4.52 | .22 |

Appendix Table 4. Tagging data. Returns in Norwegian industrial catches, raised to total international catch. IVa + II + IIa. Year of release excluded.

| Year of release | N ($R_i$) | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | $\Sigma r_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | 4 187 | 270 | 72 | 12 | 27 | 20 | 10 | 11 | 6 | 0 | 0 | 0 | 428 |
| 1970 | 3 505 | | 68 | 51 | 89 | 64 | 48 | 34 | 36 | 12 | 11 | 0 | 413 |
| 1971 | 9 305 | | | 337 | 487 | 365 | 267 | 196 | 180 | 79 | 64 | 5 | 1 980 |
| 1972 | 11 818 | | | | 720 | 692 | 506 | 356 | 386 | 137 | 43 | 14 | 2 854 |
| 1973 | 7 277 | | | | | 557 | 490 | 266 | 291 | 116 | 74 | 23 | 1 817 |
| 1974 | 4 493 | | | | | | 282 | 160 | 236 | 71 | 21 | 9 | 779 |
| 1975 | 9 995 | | | | | | | 412 | 574 | 187 | 202 | 18 | 1 393 |
| 1976 | 1 763 | | | | | | | | 118 | 58 | 53 | 23 | 252 |
| 1977 | 7 094 | | | | | | | | | 170 | 298 | 36 | 504 |
| 1978 | 12 173 | | | | | | | | | | 298 | 86 | 384 |
| 1979 | 11 991 | | | | | | | | | | | 54 | 54 |
| | $m_i$ | 270 | 140 | 400 | 1 323 | 1 698 | 1 603 | 1 435 | 1 827 | 830 | 1 064 | 268 | |

Appendix Table 5. Estimates of survival rates

| Year | Survival rates | | Z | | F* | |
|---|---|---|---|---|---|---|
| | Robson | J & S | Robson | J & S | Robson | J & S |
| 1969 | 0.32 | 0.38 | 1.13 | 0.96 | 0.98 | 0.81 |
| 1970 | 0.41 | 0.45 | 0.89 | 0.80 | 0.74 | 0.65 |
| 1971 | 0.73 | 0.77 | 0.31 | 0.26 | 0.16 | 0.11 |
| 1972 | 0.70 | 0.77 | 0.36 | 0.26 | 0.21 | 0.21 |
| 1973 | 0.98 | 1.06 | - | - | - | - |
| 1974 | 0.79 | 0.86 | 0.23 | 0.15 | 0.08 | 0 |
| 1975 | 0.64 | 0.69 | 0.44 | 0.37 | 0.29 | 0.22 |
| 1976 | 0.81 | 0.89 | 0.21 | 0.12 | 0.06 | - |
| 1977 | 1.16 | 1.16 | - | - | - | - |
| 1978 | 1.17 | 1.20 | - | - | - | - |

*M = 0.15