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Exploration of the Sea

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REPORT OF THE MACKEREL WORKING GROUP

Copenhagen, 14 - 21 April 1982

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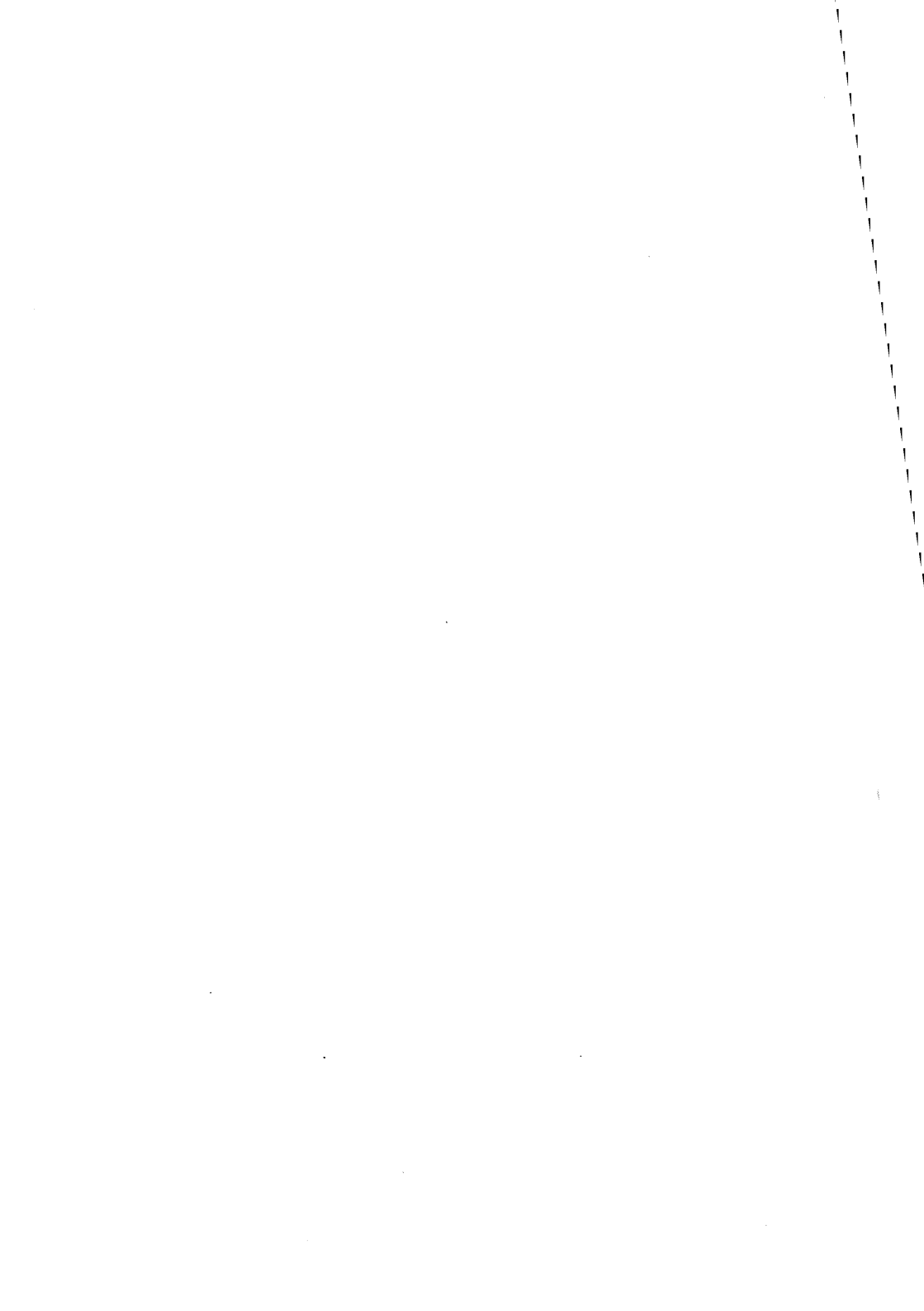


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REPORT OF THE MACKEREL WORKING GROUP

1. INTRODUCTION

1.1 Terms of Reference

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

- (i) assess the state of the mackerel stocks in Sub-areas II, III, IV, VI, VII, VIII and IX and provide management options for 1983,
- (ii) assess the effects of a 40 mm minimum mesh size for trawl gears for mackerel,
- (iii) examine the relationship between Sub-area IX mackerel and the Western area stock (Sub-areas VI-VIII),
- (iv) consider the data base for doing assessments of horse mackerel, with particular reference to Sub-areas VII, VIII and IX,
- (v) specify deficiencies in data required for assessments.

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

1.2 Participation

The Group met in Copenhagen with the following participants:

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

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

2. THE MACKEREL FISHERIES

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

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

represent an excess of about 100% on the maximum recommended by ACFM for 1981 (40 000 tonnes).

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

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

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

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

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

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

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

2.3 Divisions IXa, b

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

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

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

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

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

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

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

2.4 Catch Statistics

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

3. EGG SURVEYS

3.1 The Norwegian Egg Surveys in the North Sea in 1981

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

The size of the spawning area was about 20% less in 1981 than in 1980. The egg production curve based on the four surveys is shown in Figure 3. The total egg production in the North Sea was estimated to be 44×10^{12} eggs. The shape of the spawning curve is uncertain during the beginning of the season due to lack of data. The shape of the curve prior to the first survey would influence the egg production estimate. Daily plankton samples from stand-by vessels in the oil fields, 'Ekofisk' (56°34'N, 03°08'E) and 'Cod' (57°04'N, 02°26'E), demonstrate that spawning started during the last week of May, and that the intensity of spawning was rather low during the first 2-3 weeks. Therefore, the suggested shape of the production curve prior to the first survey (Figure 3) may overestimate rather than underestimate the egg production. However, 'Cod' and 'Ekofisk' are situated on the Western border of the

spawning area, and the spawning intensity as observed here may, therefore, not be representative for the total spawning area.

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

3.2 Western Mackerel Stock Egg Survey

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

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

4. CATCH IN NUMBERS, MORTALITIES AND STOCK SIZE

4.1 Catch in Numbers at Age

4.1.1 The North Sea and adjacent areas

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

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

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

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

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

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

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

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

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

North Sea stock

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

Division IIIa

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

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

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

Divisions IVa,b,c and IIIa

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

Division VIa

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

4.1.2 Western area

Division VIa

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

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

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

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

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

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

Sub-areas VII and VIII

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

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

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

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

Sub-area IX

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

4.2 Mean Weight at Age

4.2.1 North Sea stock

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

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

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

4.2.2 Western stock

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

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

Mean weights at age in the catch (g)

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

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

4.3 Stock Assessments

4.3.1 Assessment of the North Sea stock

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

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

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

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

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

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

To produce an SSB reduction of 25% from 1980 to 1981, a 50% increase in \bar{F} in 1981 compared to 1980 was required. Taking the various sources of errors and bias involved in the SSB estimation from egg surveys into

consideration, the 25% reduction in SSB was believed to be a reasonable approximation to the findings of the 1980 and 1981 Norwegian egg surveys. Spawning stock biomass in 1980 was estimated to be 495 000 tonnes and 373 000 tonnes in 1981, the lowest on record.

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

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

4.3.2 Assessment of the Western stock

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

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

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

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

In view of the apparent shift in the major overwintering ground from around the Cornish Peninsula to the west of Ireland and the uncertainty

concerning the resultant effect on the Cornish fishery catch rates and age composition in 1981, most members of the Working Group were unwilling to accept the above approaches as a basis for estimating F in 1981.

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

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

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

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

- 5. CATCH FORECAST
- 5.1 Recruitment
- 5.1.1 North Sea stock

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

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

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

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

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

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

5.1.2 Western stock

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

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

5.2 Prognosis

5.2.1 North Sea stock

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

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

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

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

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

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

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

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

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

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

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

5.2.2 Western stock

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

A total of 18 stock/catch forecasts were made (Table 5.4a,b), 9 assuming average recruitment, and 9 assuming a low level of recruitment, and using the input data presented in Table 5.3. The same 9 management options were run in each case. These ranged from the assumption that the current absence of effective international

control measures would continue through to 1985 ('free fishing') to the overoptimistic view that the fishery will be controlled at $F = 0.15$ from 1983 onwards. An $F = 0.15$ was recommended in previous reports and is approximately $F_{0.1}$.

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

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

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

6. ADDITIONAL CONSERVATION MEASURES

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

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

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

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

6.2 The Effects of Closed Areas and Closed Seasons

6.2.1 Divisions VIIe,f

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

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

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

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

6.2.2 Division VIa

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

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

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

7. HORSE MACKEREL

7.1 Catch Statistics

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

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

International catch data (Table 7.1).

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

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

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

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

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

7.2 The Horse Mackerel Fisheries

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

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

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

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

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

7.3 Biological Sampling and Results

7.3.1 Length compositions

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

Length distributions from groundfish survey records during August/September 1981 in the North Sea are bi-modal at 7 cm (0-group) and 31 cm in Divisions IVb and c. A somewhat smaller sample from Division IVa had a single mode at 37 cm. The artisanal fishery in

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

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

7.3.2 Mean weight at age and raised age/length keys

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

7.3.3 Maturity, sex ratio and growth parameters

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

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

7.4 Egg Surveys

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

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

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

observed for mackerel (Figure 7.3).

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

7.5 Mortality Estimates

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

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

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

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

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

7.6 Mesh Selectivity Data

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

Area	Mesh size (mm)	L ₅₀ (cm)	Selection factor	L ₇₅ -L ₂₅ (cm)
Robles <i>et al.</i> 1980 VIIIc, IXa	61	28.90	4.74	6.3
Robles <i>et al.</i> 1980 VIIIc, IXa	74	33.98	4.59	5.3
Eltink 1981 VIIe	67	27.6	4.1	2.7

7.7 Yield per Recruit in ICES Divisions VIIIc and IXa

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

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

7.8 Reliability of Data Base

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

8. DEFICIENCIES IN DATA ON MACKEREL AND HORSE MACKEREL

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

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

- a) the stock separation in Divisions IIa, IVa and part of VIa should be further investigated (i.e., extension of parasite studies, external tagging programmes, meristic characters...);
- b) estimates of F: further work should be carried out to calculate estimates of F, which could be used in stock assessments, e.g. work on cpue in non-directed fisheries, on research vessel surveys;
- c) recruitment: at present data on recruitment on which to base the catch forecasts are negligible. Investigations should be made on nursery areas of mackerel to get abundance indices of incoming year classes.

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

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

9. SAFE BIOLOGICAL LIMITS

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

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

In previous reports of the Working Group (Anon., 1980), the data available for both the North Sea and Western stocks were analysed from this viewpoint. No clear evidence of a stock/recruitment relationship was found for either stock. In the case of the Western stock, this lack of evidence can perhaps be given some credence, because recruitment to this stock has shown relatively little variation in the short period

for which adequate data are available, despite an appreciable decline in spawning stock biomass. Caution should be exercised, however, in accepting any management policy, which will reduce this spawning stock to an even lower level, because a stock-induced decline in recruitment is unlikely to be detected for several years after the stock has been reduced beyond the critical level.

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

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

Country \ Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981*
Belgium	129	78	145	134	292	49	10	10	5	55
Denmark	2 023	7 459	3 890	9 836	27 988	21 833	18 068	19 171	13 234	9 716
Faroe Islands	7 551	11 202	18 625	23 424	63 476	42 836	33 911	28 118	14 770	-
France	6 882	636	2 254	2 749	2 607	2 529	3 452	3 620	2 238	3 212
Germany, Dem.Rep.	346	214	234	141	259	41	233	-	-	-
Germany, Fed.Rep.	374	563	270	276	284	-	284	211	56	1 167
Iceland	687	3 079	4 689	198	302	-	-	-	-	-
Ireland								-	738	-
Netherlands	4 436	2 339	3 259	2 390	2 163	2 673	1 065	1 009	853	1 714
Norway	60 141	277 304	248 314	206 871	197 351	180 800	82 959	90 720	44 781	28 822
Poland	244	561	4 520	2 313	2 020	298	-	-	-	-
Sweden	4 748	2 960	3 579	4 789	6 448	4 012	4 501	3 935	1 666	2 020
UK (England & Wales)	32	31	61	33	89	105	142	95	76	6 520
UK (Scotland)	395	2 943	390	578	1 199	1 590	3 704	5 272	9 514	3 133
USSR	611	17 150	8 161	9 330	1 231	2 765	488	162	-	-
Unallocated								500		3 216
Total	188 599	326 516	298 391	263 062	305 709	259 531	148 817	152 840	87 931	59 575

*)Preliminary

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

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

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

1) Data provided by Working Group Members

2) Data reported to ICES

3) Preliminary

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

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

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

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

* Preliminary

***) Working Group estimate

+ Includes S japonicus

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

Year	Sub-area		
	VI	VII and VIII	IX
1969	4 760	66 340	n.a.
1970	3 854	100 340	n.a.
1971	10 213	122 561	n.a.
1972	10 013	157 762	3 387
1973	52 166	167 279	3 969
1974	64 136	234 081	5 593
1975	64 849	416 538	5 634
1976	67 765	439 413	5 581
1977	74 829	259 111	7 565
1978	151 747	355 487	7 965
1979	203 301	398 002	7 462
1980	218 663	386 093	4 640
1981 [⊛]	341 712	274 320	9 565

⊛ Preliminary

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

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

x) Preliminary

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

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

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

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

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

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

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

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

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

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

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

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

Catch in numbers (10^{-6})								
	1975	1976	1977	1978	1979	1980	1981	
1	11.9	2.7	1.1	0.0	2.3	2.7	3.9	
2	10.1	73.6	19.5	8.2	0.5	14.9	6.4	
3	16.2	69.7	58.9	34.7	11.3	2.7	12.7	
4	42.4	13.9	54.3	40.8	21.2	18.0	2.3	
5	27.8	33.8	9.8	27.9	33.3	28.3	15.0	
6	193.2	19.5	26.6	6.0	14.5	30.7	22.8	
7	25.6	118.6	31.6	14.2	4.2	19.5	25.4	
8	20.4	31.3	125.9	16.1	9.2	9.2	16.0	
9	15.8	8.0	31.2	45.7	2.0	18.2	11.0	
10	5.0	9.0	8.3	14.6	27.0	5.0	10.5	
11	0.5	4.0	8.8	5.5	5.2	27.6	7.0	
12	0.2	0.5	4.5	5.5	2.0	5.4	42.2	
13	22.2	0.1	0.8	2.9	2.0	1.8	6.7	
14	0.0	3.4	0.1	0.6	1.2	2.3	5.5	
15+	0.0	0.0	2.5	3.2	2.5	3.1	2.9	
TOTAL	391.3	388.1	383.7	225.9	138.0	189.4	190.3	

Fishing mortalities (M = 0.15)									
	1975	1976	1977	1978	1979	1980	1981	1976-1980	
1	0.02	0.01	0.01	0.00	0.03	0.05	0.05	0.02	
2	0.02	0.16	0.07	0.06	0.03	0.23	0.15	0.11	
3	0.09	0.22	0.17	0.16	0.11	0.23	0.30	0.18	
4	0.16	0.10	0.25	0.16	0.13	0.24	0.50	0.18	
5	0.15	0.17	0.09	0.18	0.18	0.24	0.30	0.17	
6	0.20	0.14	0.18	0.07	0.13	0.24	0.30	0.15	
7	0.13	0.17	0.34	0.13	0.06	0.24	0.30	0.19	
8	0.21	0.22	0.26	0.27	0.11	0.17	0.30	0.21	
9	0.24	0.11	0.33	0.13	0.05	0.33	0.30	0.19	
10	0.17	0.19	0.15	0.24	0.10	0.15	0.30	0.17	
11	0.08	0.19	0.28	0.14	0.12	0.14	0.30	0.17	
12	0.22	0.09	0.33	0.27	0.06	0.17	0.30	0.18	
13	0.74	0.16	0.20	0.34	0.14	0.07	0.30	0.18	
14	0.00	0.22	0.22	0.22	0.22	0.22	0.30	0.22	
15+	0.00	0.22	0.22	0.22	0.22	0.22	0.30	0.22	
F (3-14),U	0.20	0.17	0.23	0.19	0.12	0.20	0.30		
F (3-14),W	0.18	0.17	0.23	0.16	0.12	0.21	0.30		

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

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

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

[#] Fitted estimate

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

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

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

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

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

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

Stock size in numbers (10^{-6}) at 1 January. Biomass: thousand tonnes.								
	1975	1976	1977	1978	1979	1980	1981	1982
0	4748	4628	580	2919	4142	2960	3457*****	
1	2832	4086	3952	497	2503	3492	2529	2940
2	3351	2389	3258	3259	399	1829	2557	1931
3	1154	2788	1885	2536	2284	286	1150	1731
4	2956	906	2101	1480	1790	1410	177	778
5	1146	2261	622	1655	1048	1203	865	120
6	1443	809	1679	488	1185	702	779	586
7	4302	1109	586	1315	354	805	475	528
8	0	2553	696	445	991	224	550	321
9	0	0	1791	517	331	711	146	373
10+	0	0	0	1309	1256	1009	1488	1084
TOTAL	21931	21527	17150	16419	16263	14630	14173	
SPAWN. ST.	11997	10890	10413	9957	8798	7339	6598	
Total stock biom. 1 Jun. 1-10+	3584	3419	3535	3130	2763	2438	2242	
SSB 1 Jun.	2925	2673	2780	2649	2346	1962	1771	

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

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

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

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

*at 1 January

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

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

*Recruitment "Average" $2\ 550 \times 10^6$ at 1 year old

"Low" $1\ 100 \times 10^6$ at 1 year old

Proportion of F before spawning = 0.4

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

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

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

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

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

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

*) Preliminary

a) Includes IIIa

b) Included in IIIa

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

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

*Provisional

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

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

*Provisional

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

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

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

*)Working Group estimate

**)Provisional

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

Table 7.5 Raised length composition for HORSE MACKEREL - Division VIIe - (Nb X 10⁻³)

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

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

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

Gear CLASSES	PORTUGAL - 1981			Spain 1981			Portugal & Spain			TOTAL
	Trawl	Purse- seine	Arti- sanal	Trawl	Purse- seine	Artisa- nal 1980	Trawl	Purse- seine	Arti- sanal	
7	0	0	0	0	0	0	0	0	0	0
8	21	0	0	0	0	0	21	0	0	21
9	371	0	0	0	0	0	371	0	0	371
10	1943	57	73	27	2337	0	1970	2394	73	4439
11	4142	1276	34	0	4045	0	4142	5322	34	9499
12	4600	3970	184	688	3056	0	5288	7027	184	12500
13	7610	7956	511	1206	944	0	8816	8900	511	18228
14	20595	2957	3164	776	13980	0	21371	16937	3164	41473
15	24569	2796	7980	456	41761	0	25025	44558	7980	77563
16	13235	4264	6536	2360	68239	0	15596	72504	6536	94637
17	7888	1690	8383	3330	65092	0	11219	66782	8383	86385
18	4383	1005	4635	4146	37715	7	8530	38721	4643	51894
19	1904	613	2966	4141	38974	0	6045	39587	2966	48599
20	1340	660	2152	2719	73543	4	4059	74204	2157	80421
21	1279	998	2018	2105	72375	7	3384	73373	2026	78784
22	900	2255	1964	843	1776	4	1744	20012	1969	23726
23	637	3175	2066	676	2427	22	1313	5602	2089	9005
24	520	2688	1061	623	5214	35	1144	7902	1096	10144
25	347	1378	864	1051	1798	188	1399	3176	1053	5629
26	262	450	779	2330	89	84	2592	540	863	3997
27	308	416	413	3304	224	89	3613	640	502	4756
28	472	359	150	4108	0	90	4581	359	241	5182
29	1102	731	482	5824	89	130	6926	821	613	8361
30	2553	995	907	10870	0	184	13423	995	1091	15510
31	3773	1578	1174	13203	0	112	16976	1578	1286	19841
32	4098	1553	1078	13301	0	123	17400	1553	1201	20155
33	3778	1291	1349	10596	0	99	14374	1291	1448	17115
34	3412	1032	1640	10196	0	76	13608	1032	1717	16358
35	2507	927	1099	7502	0	49	10010	927	1148	12087
36	1677	1040	1432	5655	0	28	7333	1040	1461	9834
37	1145	760	1002	4103	0	39	5248	760	1041	7050
38	618	578	1085	2898	0	35	3517	578	1120	5216
39	344	331	422	1244	0	46	1588	331	469	2389
40	149	220	148	746	0	20	896	220	169	1285
41	28	81	61	12	0	4	41	81	65	188
42	8	9	119	26	0	2	35	9	121	166
43	0	0	16	22	0	0	22	0	16	39
44	6	0	23	3	0	3	9	0	27	36
45	0	0	54	0	0	0	0	0	54	54
46	0	0	3	0	0	0	0	0	3	3
47	0	0	3	0	0	0	0	0	3	3
TOTAL	122541	50105	58048	121105	449669	1492	243646	499774	59541	802952
Total Weight	13376	5957	6699	28776	19330	376	42152	25287	7075	74514

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

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

Table 7.9 HORSE MACKEREL in Sub-areas VIII and IX a.

Length and age structure of the catch and mean weight at age in 1980. (Numbers x 10⁻³)

Age \ Length	0	I	II	III	IV	V	VI	VII	VIII	IX*
.7	09									
8	22									
9	371									
10	2961	1478								
11	5120	4379								
12	8001	3700								
13	11393	6836								
14	13147	26958	1369							
15	2327	71669	5568							
16	9042	79117	5678							
17	2419	74378	3589							
18		37907	13908							
19		21044	26730	826						
20		18094	48735	11339	2252					
21		7405	39392	30883	1024					
22		359	9704	13310	356					
23			2413	5466	1126					
24			3956	4950	1238					
25			1126	3152	1351					
26			428	1999	1143	428				
27				1584	2378	794				
28				943	1415	2824				
29				928	3102	2475	1547	309		
30				884	2652	8220	3552	204		
31					5139	8810	5516	376		
32					5502	9150	4273	1229		
33						5203	5956	5203	753	
34						2846	5693	4269	2127	1423
35						1342	2683	4701	2019	1342
36							2459	4307	2459	610
37							705	1283	1283	3780
38							349	1043	3474	349
39									597	1792
40									551	734
41										180
42										167
43										39
44										36
45										54
46										3
47										3
TOTAL	56412	353484	160596	76264	28678	42092	32733	22921	13263	10520
\bar{L}_t	12,76	16,28	19,19	22,05	27,97	31,15	32,72	34,44	36,20	37,11
\bar{W} stock	4	24	66	124	195	274	356	436	515	580
\bar{W} catch	16,99	35,37	58,01	80,11	100,20	249,15	288,87	337,02	394,15	421,91

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

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

Age Length	0	I	II	III	IV	V	VI	VII	VIII	IX
7										
8										
9										
10	2471	1217								
11	6877	5858								
12	17896	7670								
13	20397	12303								
14	10162	20837	962							
15	1757	53894	3							
16	9525	80013	5715							
17	2611	75103	9606							
18		35010	12949							
19		9918	12886	461						
20		3597	9527	2187	468					
21		1022	5378	4216	140					
22		121	3310	4540	121					
23			2086	4726	973					
24			3458	4327	1082					
25			1725	4829	2069					
26			857	4006	2291	857				
27				2186	3282	1096				
28				4466	2199	4389				
29				315	3060	2441	1526	305		
30				579	1736	5380	2325	132		
31					2678	4591	2875	196		
32					4134	6875	3210	924		
33						6692	7660	6692	969	
34						3791	7582	5687	2832	1896
35						1888	3777	6618	2841	1888
36							3231	5661	3231	801
37							3999	1818	1818	5355
38							370	1005	3681	370
39									800	2399
40									621	827
41										138
42										91
43										4
No. Otoliths	91	357	218	174	84	92	60	36	28	25
Total	71696	306563	68462	34438	24233	38000	33555	29038	16793	13769
\bar{L}_t	13.19	15.98	19.32	23.88	28.10	31.19	33.26	34.56	36.16	36.88
\bar{W} stock	4	24	66	124	195	274	356	436	515	588
\bar{W} cap	18.77	33.44	59.20	111.99	182.73	250.11	303.46	340.56	390.24	414.10

Table 7.11 Biological parameters of HORSE MACKEREL by countries.

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

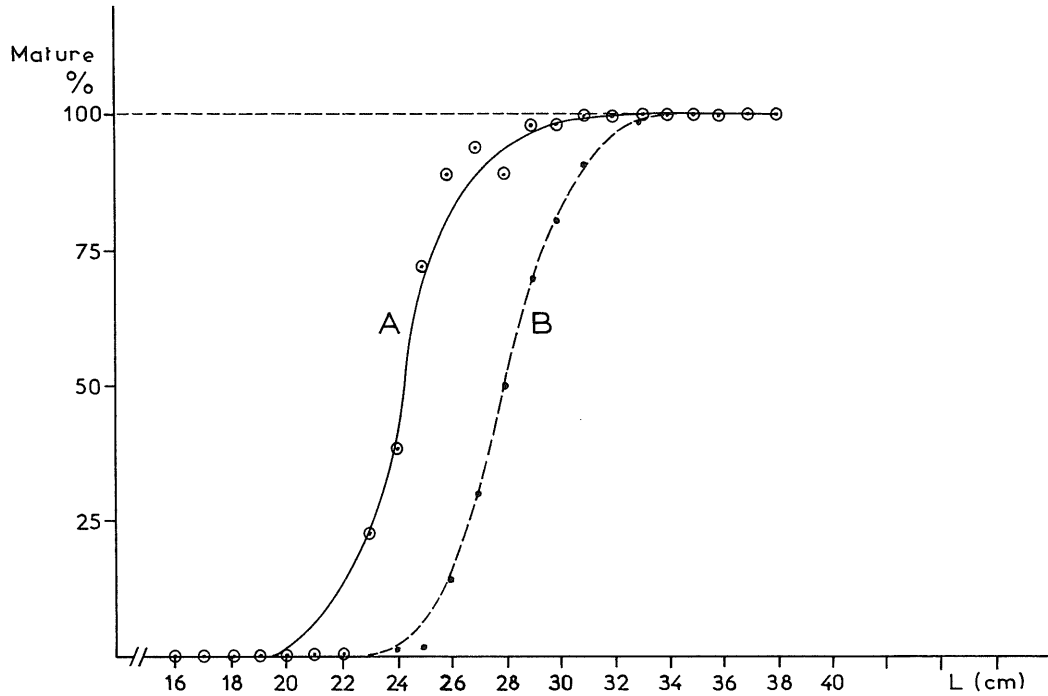


Figure 2.1 .—Maturity-ogives of mackerel

A.mackerel from the occidental coast of Portugal

B.mackerel from the western stock

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

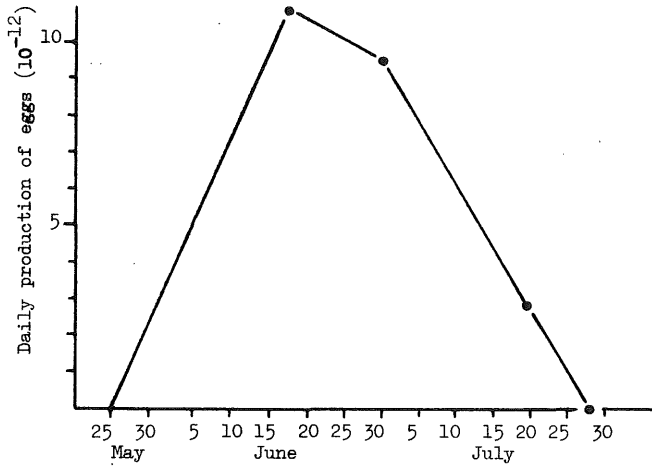


Figure 4.1.a. North Sea MACKEREL.
Trends in spawning stock size at beginning of spawning, based
on VPA.

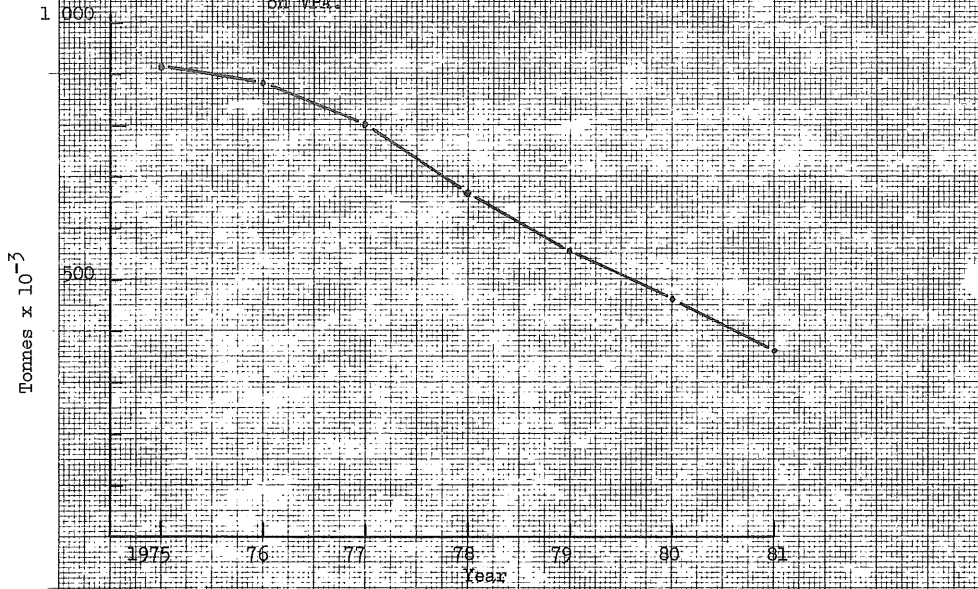


Figure 4.1.b. Trends in fishing mortalities from VPA for North Sea MACKEREL
older than 3 years.

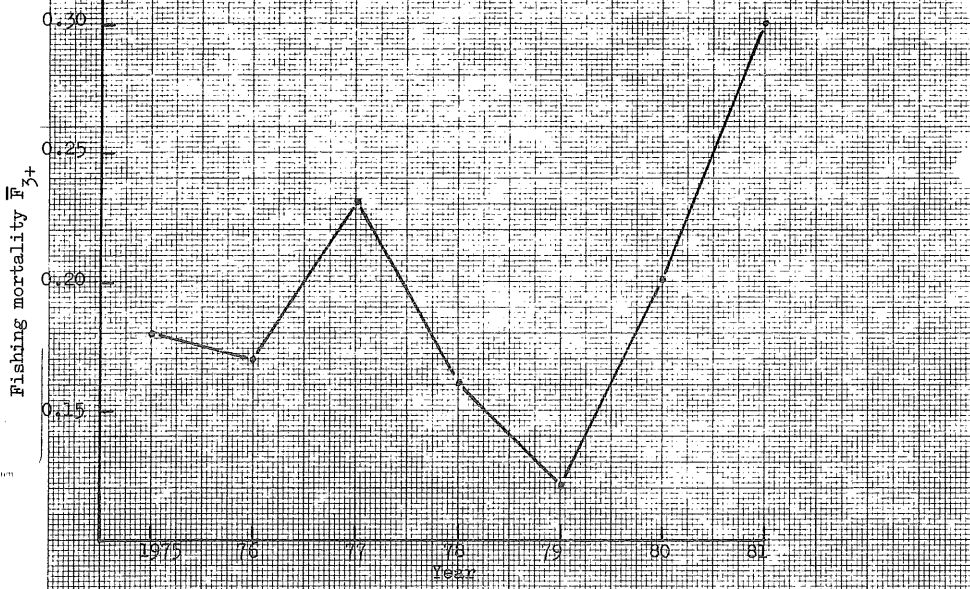


Figure 4.1.c. Trends in recruitment of 1-year-old North Sea MACKEREL (VFA).

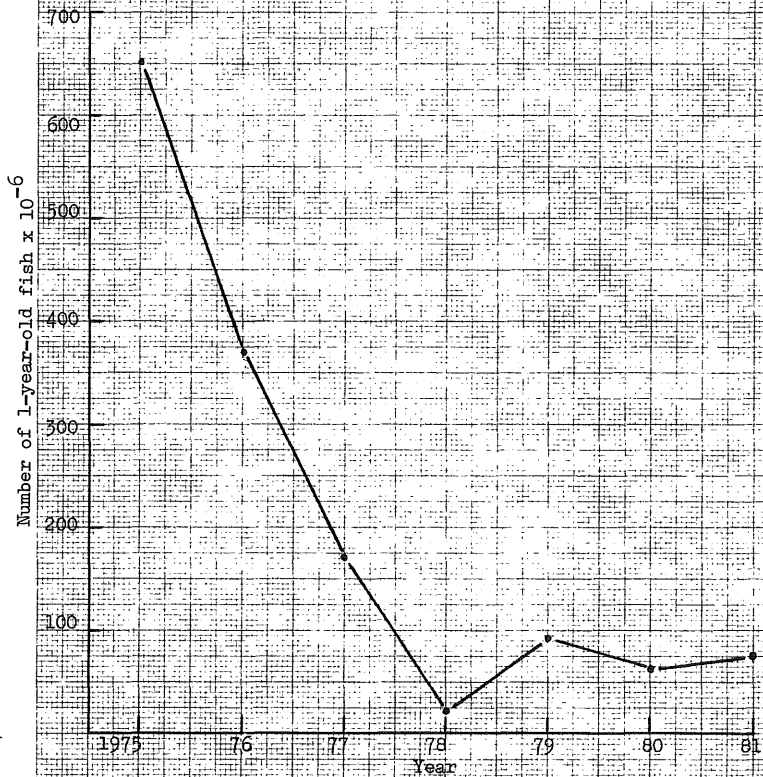


Figure 4.2.a. Western MACKEREL stock.
Spawning stock biomass (1 June).

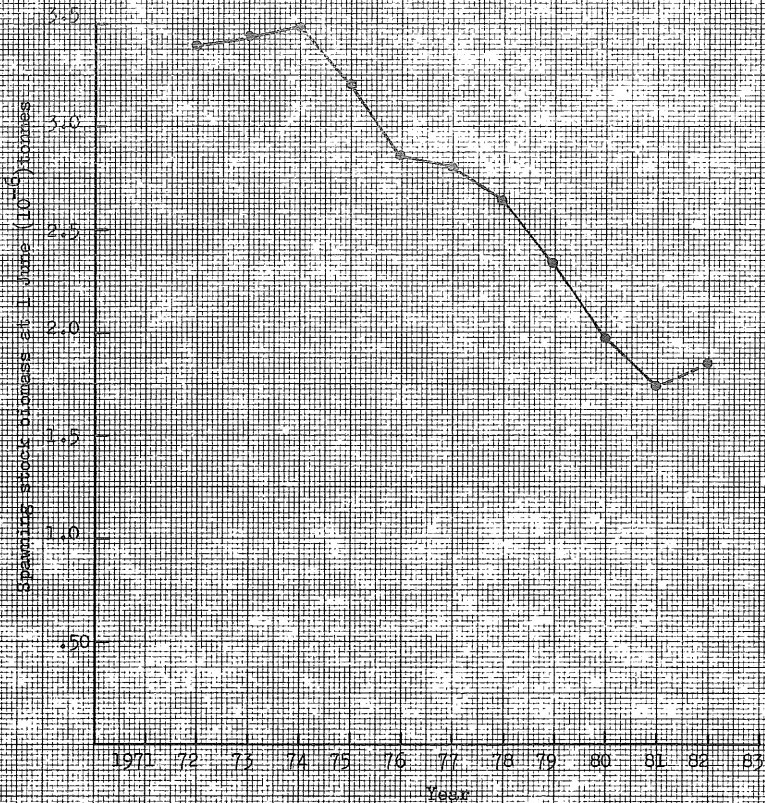


Figure 4.2.b. Western MACKEREL stock,
F and catch in numbers.

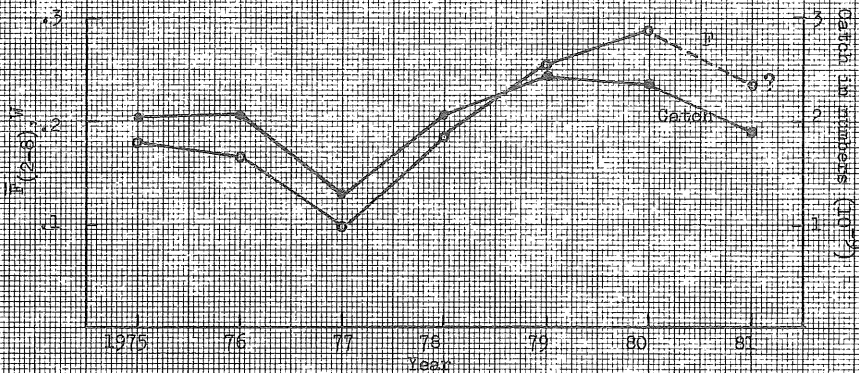


Figure 4.2.c. Western MACKEREL stock.
Recruitment as 1-group fish.

Recruitment as 1-group
(millions)

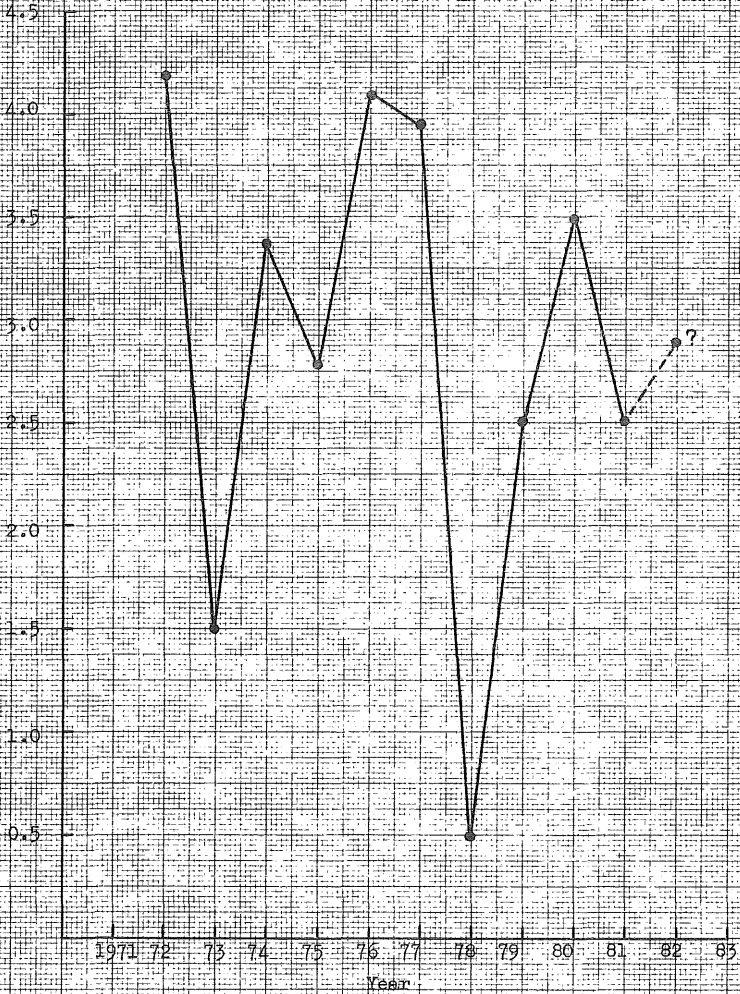


Figure 5.1. Western MACKEREL stock. Western spawning stock biomass and 1-year-old recruitment estimated by cohort analysis. Dates refer to year of spawning. '+' is the geometric mean of observations.

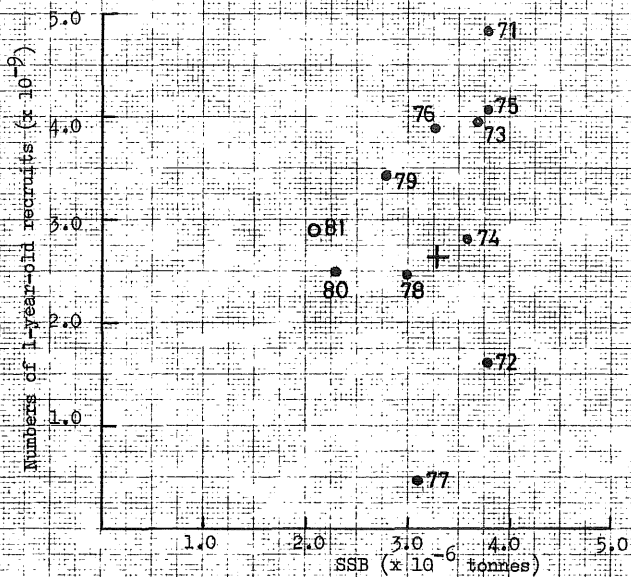


Figure 5.2. North Sea MACKEREL.
 Catch prediction for 1983. $F_{82} = 0.46$.
 Proportion of F before spawning = 0.1.
 Weight at age in the catch from text table in Section 4.2.1.

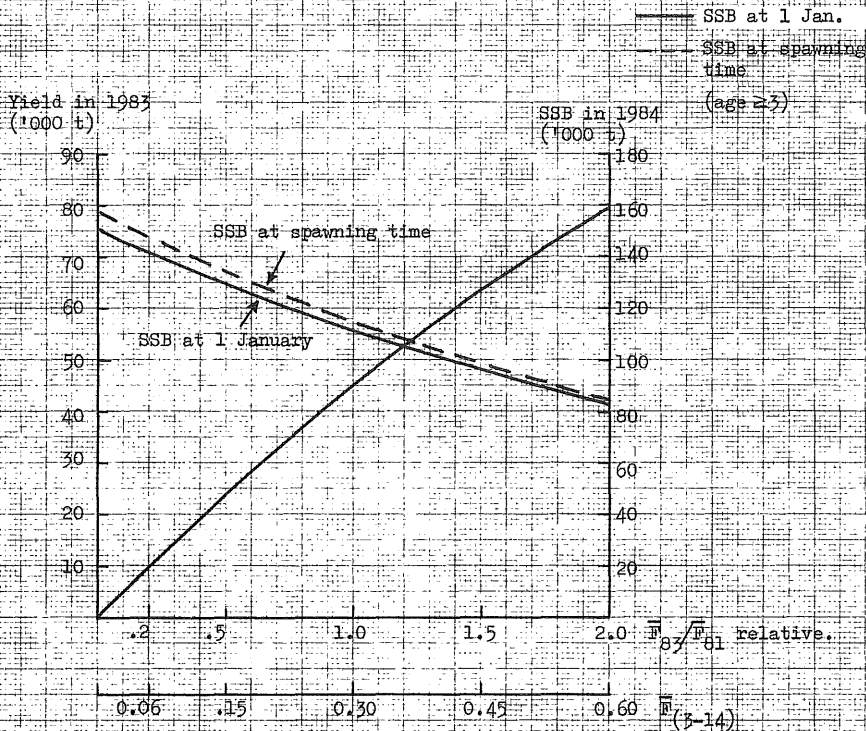


Figure 5.3. Western HAKEBREW stock.
Yield in 1983 and spawning stock biomass in 1984 (1 June) at a range of fishing mortality rates relative to F_{81} (= 1.0).
Recruitment = low.

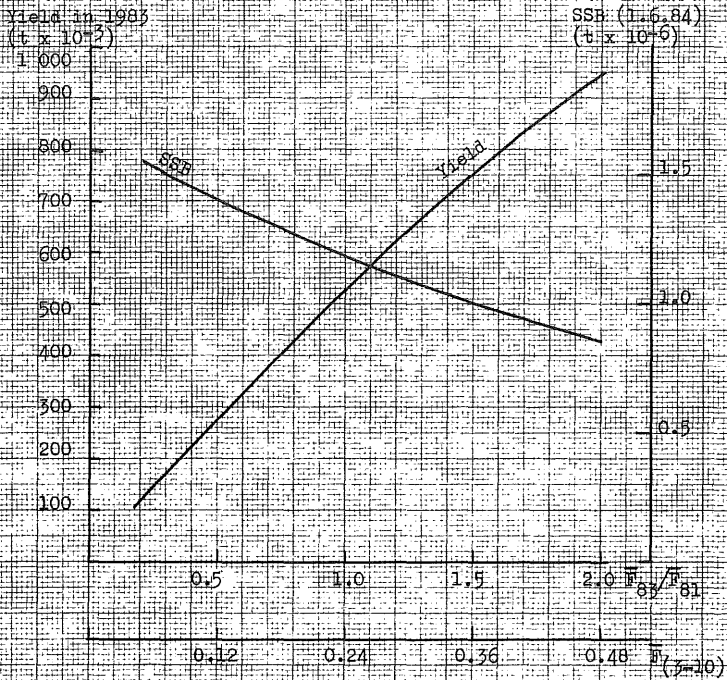
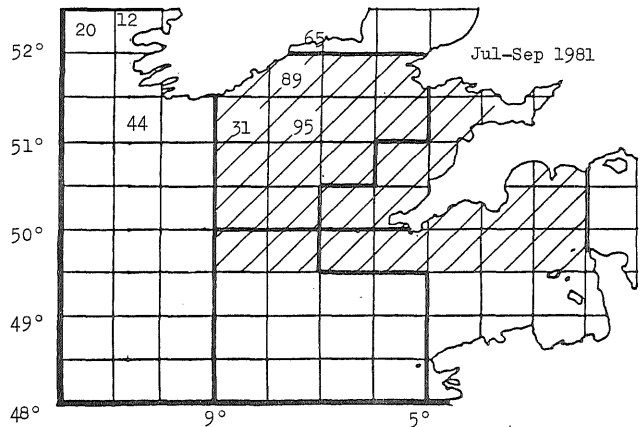
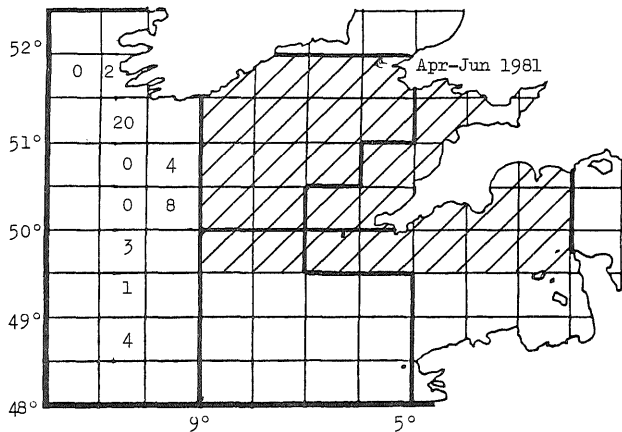
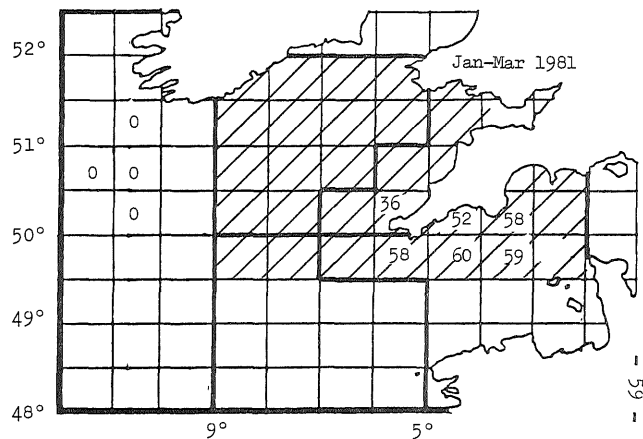
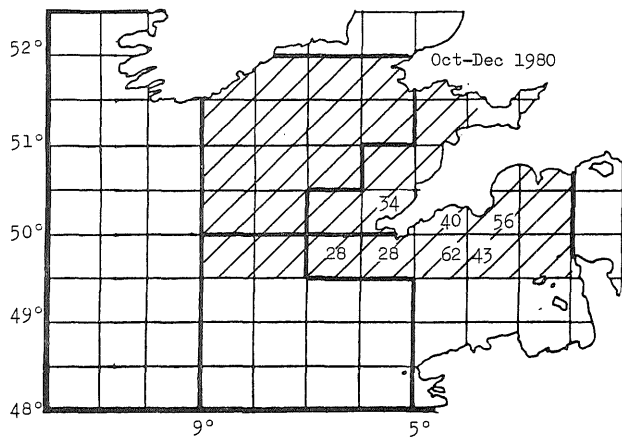


Figure 6.1. The percentage frequency of mackerel less than 30 cm total length in the Celtic Sea fisheries, October-December 1980 January-March 1982. Suggested closure (see text) in shaded area. ICES division border lines indicated.



/Continued

Figure 6.1. (Continued).

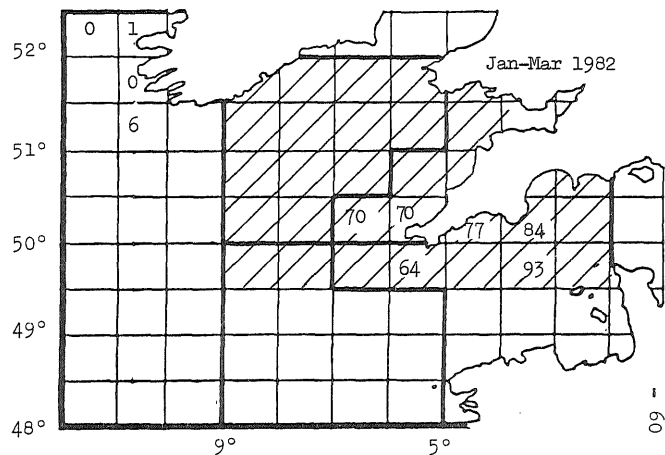
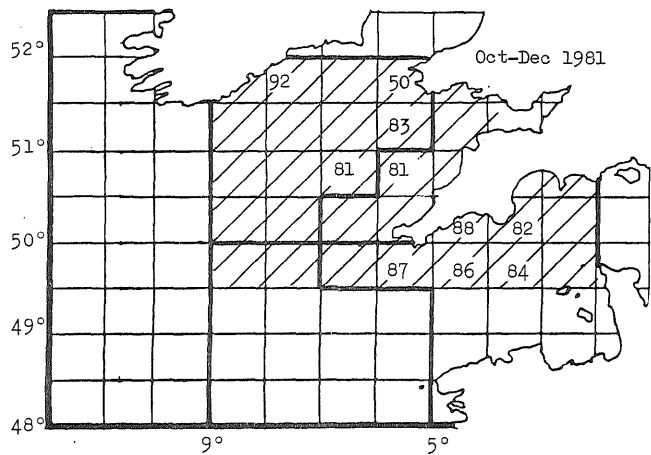


Figure 6.2. The percentage frequency of mackerel less than 30 cm total length in December and January. Data for January 1981 are separated into purse seine and pelagic trawl. Suggested closure (see text) in shaded area.

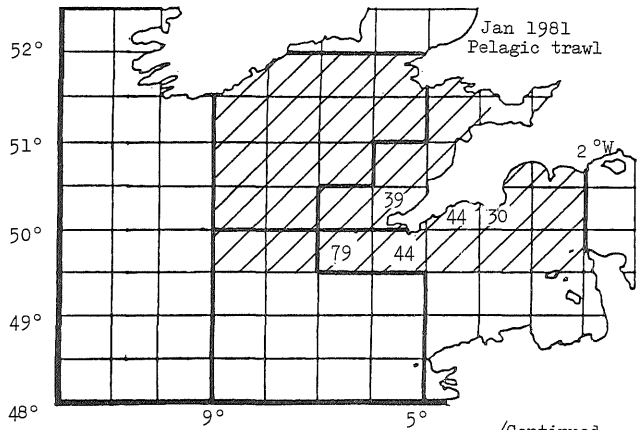
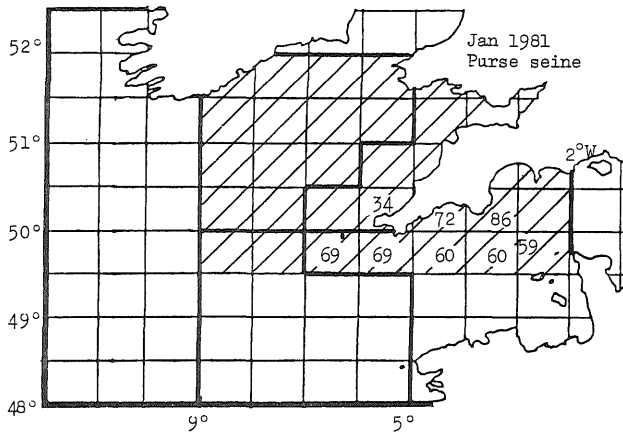
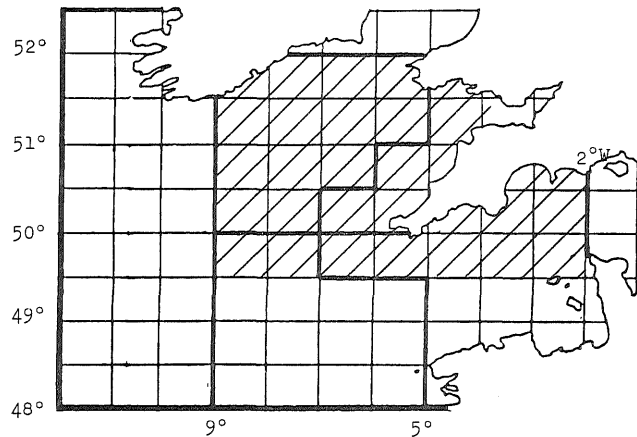
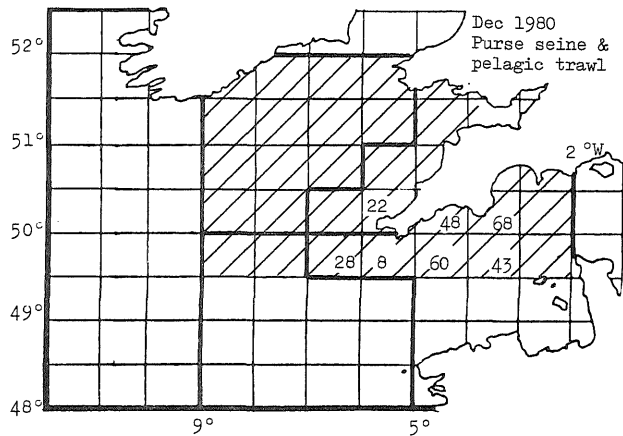


Figure 6.2. (Continued).

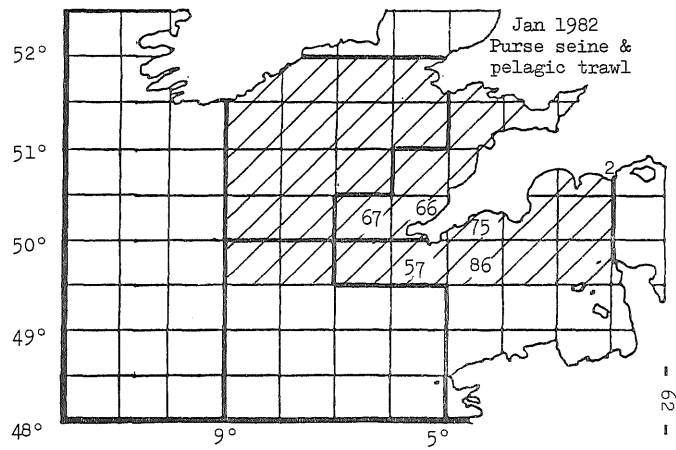
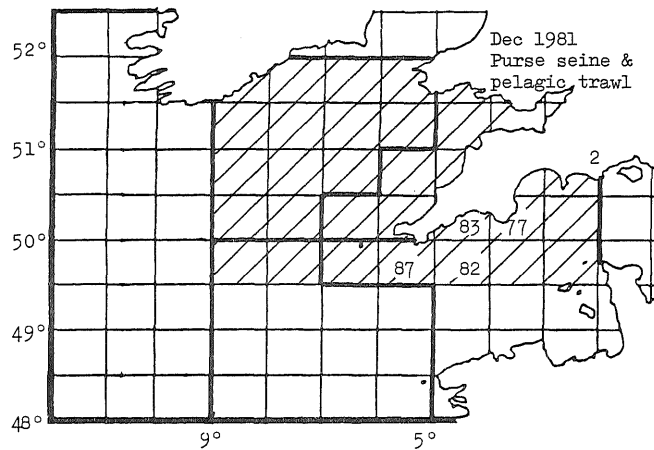


Figure 7.1. Maturation cycle of *FORSE MACKREI* on Portuguese coast for both sexes.

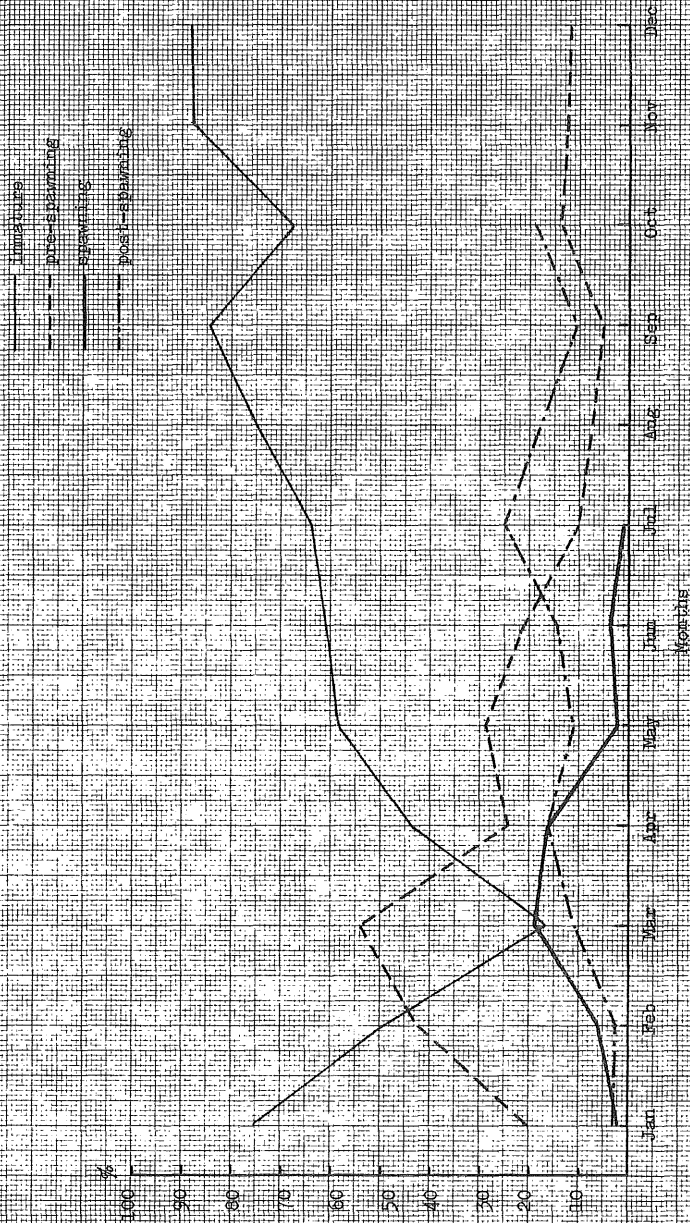
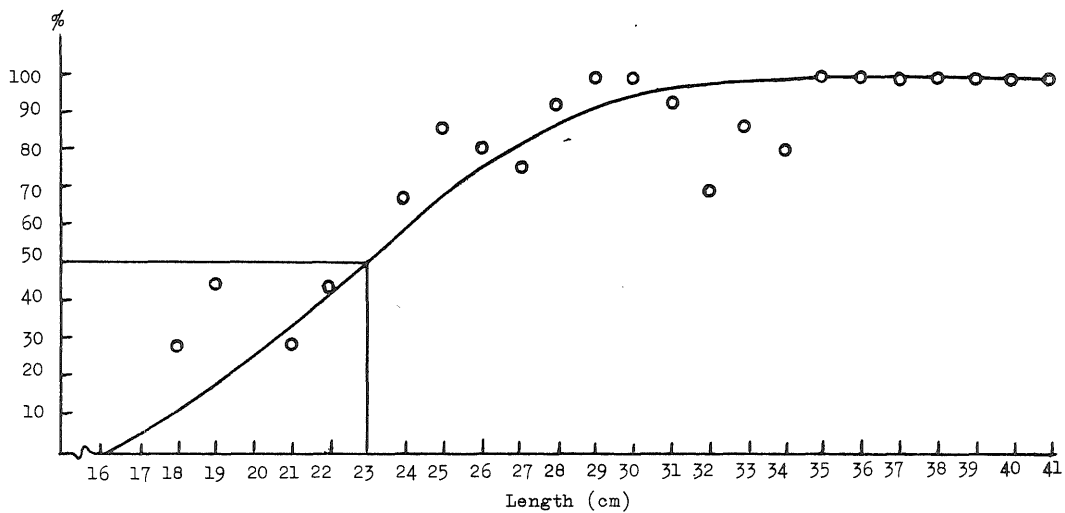


Figure 7.2. Maturity ogive of HORSE MACKEREL (Portuguese coast) (both sexes).



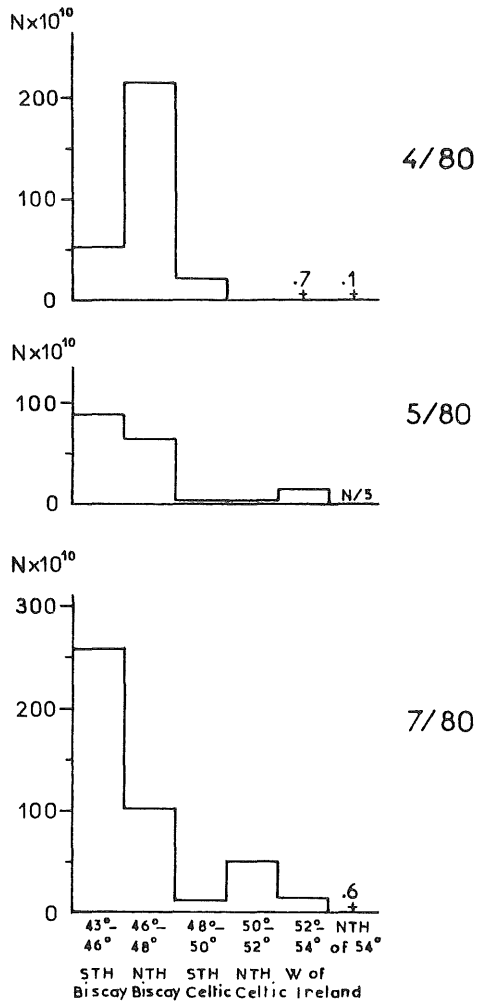


Fig.7.3.—Horse mackerel: intensity of spawning in the areas surveyed by R.V. Cirolana in 1980 (nb of eggs $\times 10^{10}$)

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

Ages 1-4 $y = 13.455 - 0.834x$ $r = 0.996$
5-6 $y = 12.267 - 0.515x$ $r = 0.966$
1-6 $y = 12.405 - 0.360x$ $r = 0.896$

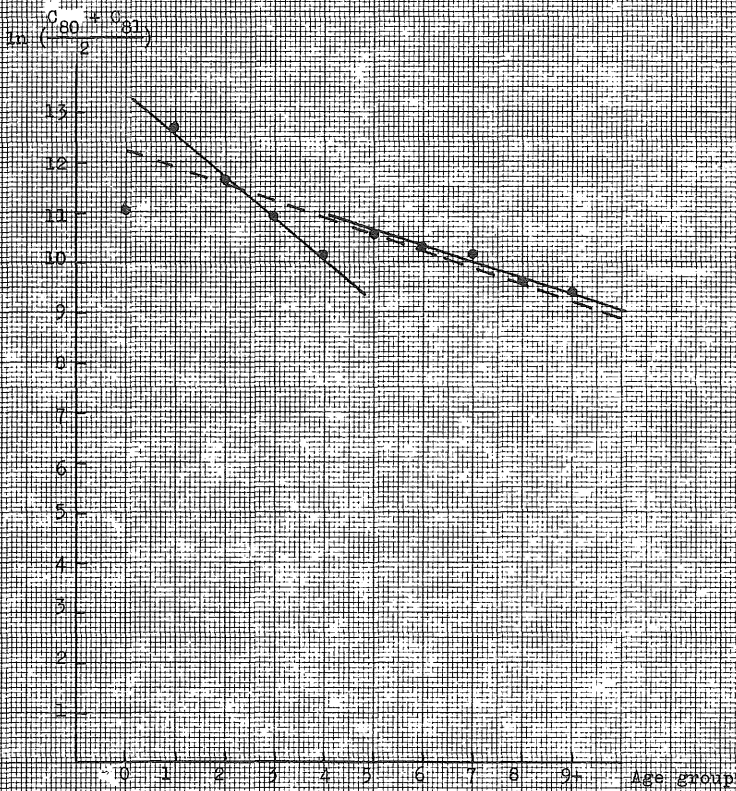
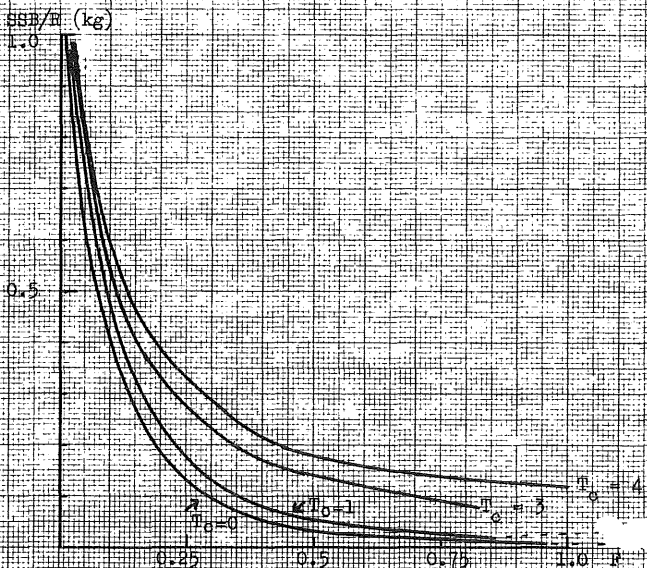
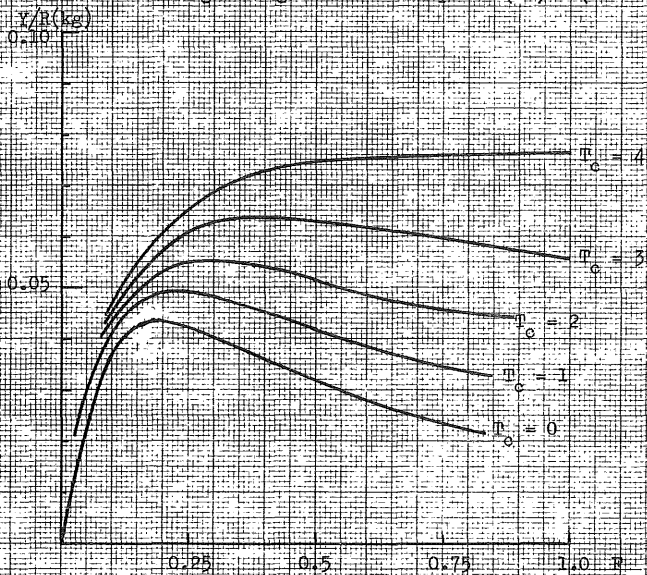


Figure 7.15. HORSER MACKEREL in Sub-areas VIII and IX.
Yield per recruit and spawning stock biomass (SSB) per recruit
for a range of ages at first capture (t_c). ($M = 0.2$)



APPENDIX A

APPLICATION OF THE NORWEGIAN TAGGING DATA

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

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

2. Estimation of Survival Rates

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

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

3. Model for Estimating Survival Rates

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

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

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

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

An estimator of θ_i is

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

where

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

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

Let M_i = number of tags recovered in year i

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

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

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

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

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

and the estimator of β_i becomes

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

An estimate of S_i is

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

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

inserting (2) into (3) gives

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

and inserting (2) into (4) gives

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

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

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

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

and

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

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

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

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

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

Appendix A, Table 1

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

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

*Appendix Table 2 1981 Working Group Report

Appendix A, Table 2

North Sea MACKEREL

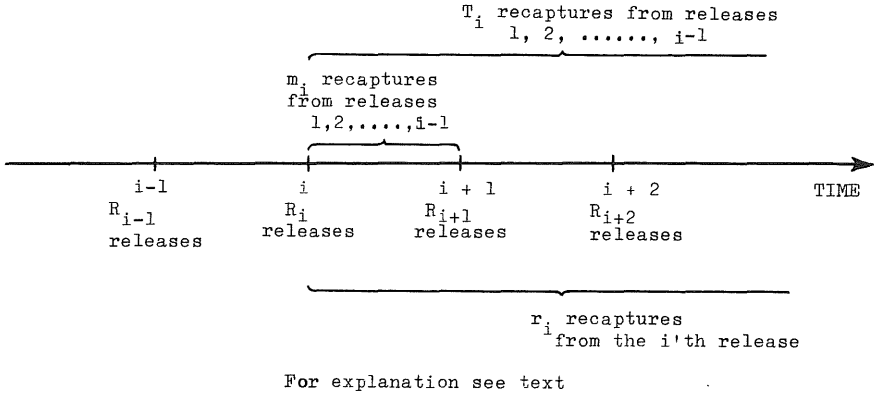
Norwegian tagging data. Recaptures excluding recaptures from the year of tagging

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

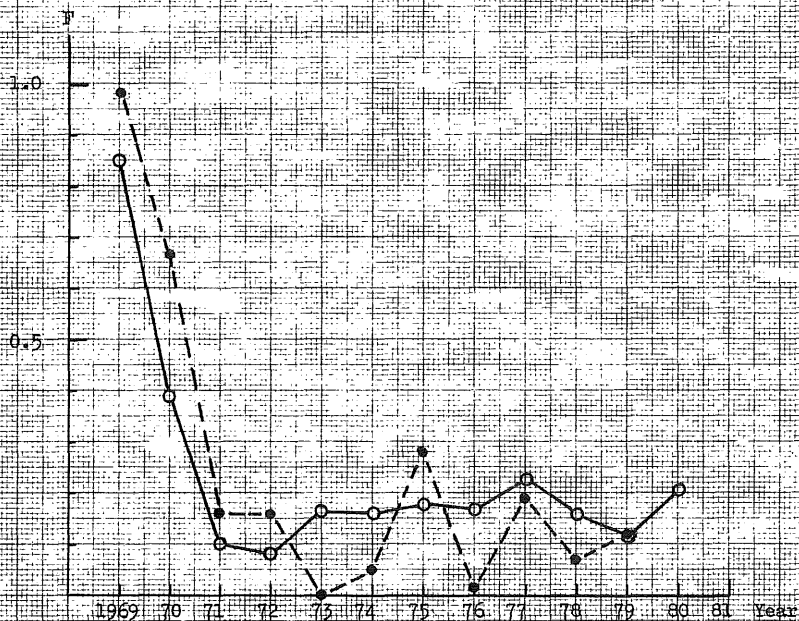
Appendix A, Table 3 North Sea MACKEREL
Estimates of survival rates and F
Norwegian tagging data

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

Appendix A, Figure 1.



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



● — ● Average F estimated from Norwegian tagging data
○ — ○ F_{3-14} (weighted) estimated from VPA

APPENDIX B

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Finally we get :

$$C_{80,10} = 31.7 \times 0.11 = 3.5$$

$$C_{80,11} = 31.7 \times 0.61 = 19.3$$

$$C_{80,12} = 31.7 \times 0.12 = 3.8$$

$$C_{80,13} = 31.7 \times 0.04 = 1.3$$

$$C_{80,14} = 31.7 \times 0.05 = 1.6$$

$$C_{80,15+} = 31.7 \times 0.07 = \underline{2.2}$$

Total 31.7
