https://doi.org/10.17895/ices.pub.19260869

International Council for the Exploration of the Sea

C.M.1985/Assess:7

REPORT OF THE MACKEREL WORKING GROUP

Copenhagen, 18-27 February 1985

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1 INTRODUCTION

1.1 Terms of Reference

At the 72nd Statutory Meeting in Copenhagen it was decided (C.Res.1984/2:4:2) that the Mackerel Working Group (Chairman: Dr E D Anderson) should meet at ICES headquarters from 18 February to 27 February 1985 to:

i) evaluate data on the rate of mixing between the North Sea and Western stock of mackerel in Divisions IIa-Vb, IVa, and VIa,

ii) assess catch options for the mackerel stocks in Subareas II, III, IV, V, VI, VII, and VIII inside safe biological limits in 1986,

iii) analyse the discrepancy between the egg survey and VPA estimates of the North Sea stock and review past practice when making assumptions on recruitment levels used in the forecasts,

iv) specify data required to assess the effect of the closed area for mackerel off southwest England (Cornish box) in preparation for the review of the regulations scheduled for 1986.

In addition, the Assessment Working Groups dealing with North Sea roundfish, herring, industrial species, mackerel, and saithe have been requested to:

i) provide quarterly catch at age and mean weight at age data as input for the Multispecies VPA for the period 1974 to 1984 and as far as possible for earlier years back to 1963 for the North Sea,

ii) evaluate the evidence for natural mortality for the oldest age groups,

iii) assess the effects of applying the estimates of total natural mortality calculated by the Multispecies Working Group.

The Working Groups dealing with saithe and mackerel have also been requested to:

iv) provide advice to the Multispecies Working Group on the geographical distribution of mackerel and saithe by age group and quarter, and on the proportion of these which could be predators on the North Sea prey species.

1.2 Participation

The Working Group met in Copenhagen with the following participants:

E D Anderson (Chairman)	USA
E Bakken	Norway
A Eltink	Netherlands
E Kirkegaard	Denmark
S J Lockwood	UK (England & Wales)
J Molloy	Ireland
A Saville	UK (Scotland)
T Westgård	Norway

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

2 STOCK DISTRIBUTION AND MIXING

2.1 Review of Information on Stocks

As a preliminary step to reviewing data on mixing rates, the Working Group had previously agreed to review all available data on stock identification and mixing. Working documents were presented on growth characteristics, biological tags, and conventional tagging returns.

The conventional tagging data were limited almost entirely to external tag returns from releases prior to 1976 (published data summarised in Working Document by S. Lockwood). Only a few (relative to the total numbers) internal tag returns were included where reasonably reliable recapture positions were known. As on earlier occasions, it was accepted that these data indicate two principal annual migrations. During the spring and summer, there was a move away from the Celtic Sea northwards, towards Divisions VIa and northern IVa and eastwards towards Divisions VIId, IVb and IVc. During autumn, a return migration to the Celtic Sea area was apparent. The second migration appeared to result in a movement of fish from the Kattegat, Skagerrak, central and northern North Sea toward an overwintering area along the Norwegian Rinne. Taken alone, these data indicated two, well-separated overwintering areas, one in the northern North Sea and the other in the Celtic Sea area. Combined with the knowledge that there are also two major spawning grounds in the Celtic Sea and northern North Sea, there was apparent, if not conclusive, evidence for two stocks.

It had been hoped that a thorough analysis of all the internal tagging results from Norwegian experiments would have been presented at this meeting, but it is hoped that such results will be made available in the future.

Examination of mean length at age in samples taken during spring off southwest Ireland and southwest Norway, showed a consistent difference in size (K. Sunnanå, Working Doc.). The North Sea fish were always larger than Celtic Sea fish, except for the 0/1-group fish, which were the same in both areas. Despite these consistent differences in mean length at age, these data were not accepted as reliable indicators of stock differences. The earlier spawning season in, and migrations from, the Celtic Sea area could result in underestimating mean length at age relative to North Sea fish sampled at the same time. However, the same bias is unlikely to occur in measurements of otolith L_1 in multi-aged samples taken concurrently from different areas. In this case it is assumed that the earlier spawning season in the Celtic Sea area will result in a larger mean L_1 compared with fish spawned in the North Sea.

Dawson (1983 and Working Doc.) found that, during the spring of 1979 and 1982, the Celtic Sea sample mean L_1 was significantly larger than North Sea samples. It was concluded that such differences can only be maintained in a multi-age stock if the two spawning areas, North Sea and Celtic Sea, are occupied by separate spawning populations. Thus, these data support the hypothesis that there are two stock , but the Working Group could not see any practical application of the method to measure stock mixing.

The cestode, Grillotia angeli, has been identified as a biological tag, with characteristic infestation levels in North Sea mackerel and Celtic Sea mackerel (MacKenzie and Mehl, 1984). Initially, there were indications that this 'tag' might provide estimates of mixing rates. Recently the potential value of this 'tag' has diminished as a much reduced proportion of Celtic Sea fish of year classes 1977 and younger are infested with Grillotia. The nematode, Anisakis, might also be used as a diagnostic stock character. Results presented by A. Eltink in a Working Document show that the parasite load is higher in the mackerel from the central and northern North Sea than in Celtic Sea fish, but it is doubtful that the differences are sufficient to give reliable estimates of stock mixing.

Immuno-genetics (tissue typing) have been used successfully for separating a number of fish species, stocks and races, but it seems unlikely that it will help with mackerel stock separation in the forseeable future. In a review of published and unpublished data, Jamieson (MS. in prep.) concludes that there is genetic homogeneity of mackerel throughout the North Atlantic.

Jamieson's conclusion does not conflict with the hypothesis that the Celtic Sea area and North Sea are occupied by separate spawning stocks. The weight of evidence currently available indicates that the stocks are separate, there is no significant mixing at spawning time, but their separation has not yet been shown to be genetic. Thus, the Working Group decided to continue with their previous approach to the mackerel assessment, i.e., separate assessments will be made for a North Sea stock and for a Western stock. Where the two stocks are known to mix in Divisions IIa, northern IVa, and northern VIa, the stock ratios will be calculated from the frequency of internal tag returns from the Norwegian releases off Ireland in spring and Norway in summer (see Section 2.3).

2.2 Recent Shifts in Distribution

In recent years, the Working Group has been aware of changes in the seasonal distribution of Western mackerel, some of which have direct implications on the assessments. These changes have affected the assessment of the Western stock winter fishery

(Anon., 1982) and the distribution of juvenile fish from the Western stock (Anon., 1984a). Following further discussions, the Working Group agreed that in recent years there has been a progressive change in the overwintering distribution of mature fish. These shifts cannot yet be described in quantitative terms, but, on the basis of personal knowledge of and observations by Working Group members, a succession of changes related to the main centres of the winter fishery in recent years was established (Figure 2.1). These changes have direct implications for the assessments as they affect the mixing ratios in northern Division VIa.

The forerunner of the current Western stock winter fishery was the Cornish handline fishery. Throughout the 1950s and early 1960s, this was a summer fishery; in 1966 it continued through the autumn and on into 1967. This fishery continued as a year round fishery throughout the 1970s and into the early 1980s. In the early 1970s, Soviet trawlers also began fishing mackerel south of Cornwall in winter.

By the late 1970s, there was a slight westward shift in the main centre of the UK winter fishery away from Eddystone Bay to the area around the Lizard and Land's End peninsula. In this period,the fleet fishing in this area outside UK fishing limits changed from predominantly non-EEC nations to exclusively EEC nations.

From the late 1970s to the present, there has been a pro- gressive movement of the main winter fishery westward and northward away from the area around the Cornish peninsula. In the period 1981-82, the factory trawler fleets worked off the southeast coast of Ireland and along the entire west coast of Ireland. From about 1982 to 1984, the main winter fishing activity took place between northwest Ireland and west of the outer Hebrides. Over the last winter, 1984-85, the main fishing activity by trawlers and purse seiners has been to the north and west of Cape Wrath.

While the greater part of the winter fishery since 1980 has taken place to the west of the British Isles, some fishing has continued in the western English Channel. The quantities of fish involved have been relatively small, and they are distributed much further south of the Cornish peninsula than was the case in the 1970s.

Thus, in recent years, the winter distribution has reverted to that observed in the 1950's, as described by Nédélec (1958).

Over the same period that the winter distribution has been changing, there have been changes also in the UK autumn fishery in the Minches. In the early-to-mid- 1970s, the Minch fishery began in late summer and continued through the autumn (August-October inclusive). As the season progressed, the fishery moved from the north Minch to the south Minch and then out toward Ireland. By 1980, the timing of the fishery was later and restricted almost entirely to the northern Minch. In the autumn of 1984, there was effectively no Minch fishery at all. In 1984, as the shoals moved south from their summer fishing grounds in Divisions IIa and northern IVa, they followed the edge of the continental shelf and remained north of about 58^0N to the end of the year.

In addition to the changes in the autumn and winter fisheries, there have been variations in the distribution of the main summer fishery in recent years (Figure 2.1). By comparison, these variations are less significant than the shift in winter distributions and, to some extent, they have been influenced by management measures controlling the southern limit of Norwegian fishing effort. In common with the other shifts, however, these variations have implications for the assessments as they affect the mixing rates between the stocks.

With significant changes in seasonal distributions, it is clear that the stock mixing ratios for each season's fishery must be calculated on an annual basis. Furthermore, while the methods adopted to calculate the mixing ratios must be consistent from year to year, it is clear that the calculated mixing rates may vary considerably. In Divisions IIa and IVa, these variations may possibly fluctuate year by year, but the pattern of change in Division VIa described above suggests that large fluctuations there are less likely than gradual change. Prior to 1980, the Working Group estimated that much higher percentages of overwintering fish in northern Division VIa were North Sea stock, whereas now there is about 10 percent. This change may be accounted for in part by the shift in the winter distribution of Western fish.

At present, the Working Group has no firm evidence to suggest that there has been any significant change in the annual migration path nor a shift in the spawning distributions of either stock. The distributions found in 1977, 1980, and 1983 were all the same, differing only in total egg production. However, the possibility of shifts in spawning distributions cannot be overlooked and will be drawn to the attention of the Ad hoc Working Group on Mackerel Egg Surveys by the Chairman (Dr S J Lockwood).

It has already been recorded that in recent years there has been a shift in the distribution of Western stock juveniles (1 and 2 year olds) towards Division VIa (Anon., 1984a). This shift appears to be well established now. It can be demonstrated by comparing the ratios of Division VIa and Western stock catches of juveniles with the ratios of Division VIa and Western stock total catches (Table 2.1 and Figure 2.2).

As the proportion of the total Western stock catch taken in Division VIa increased, there has been a tendency for the catch of juveniles to increase proportionately. In 1982, however, there was a dramatic change and the proportion of juvenile fish caught in Division VIa increased at a relatively higher rate than the increase in total catch taken in Division VIa. This new trend was maintained in 1983 and 1984 despite the weak 1982 and 1983 year classes.

The evidence for a northward shift in the distribution of juvenile fish is further reinforced by the recorded catch of 0.5 x 10^6 O-group mackerel from Division VIa (Table 4.3). O-group catches of this magnitude are without precedent in this Division.

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

As in 1983, the Norwegian tagging data were the only data available to the Working Group on which to base a quantitative estimate of mixing ratios. The data are given in Table 2.2 as numbers of tagged mackerel released and tags returned.

Calculations of mixing ratios were carried out as in previous years. It was assumed that mackerel tagged southwest of Ireland and off southern Norway were "pure" Western and North Sea stock, respectively, and that the tagged fish were distributed randomly within each stock. Fish tagged in the year of return were excluded from the calculations.

The proportion of mackerel from the North Sea stock in the various fisheries was calculated as follows:

$$p = \frac{n_{NS}}{n_{NS} + n_W} = \frac{\dfrac{r_{NS} \cdot N_{NS}}{m_{NS}}}{\dfrac{r_{NS} \cdot N_{NS}}{m_{NS}} + \dfrac{r_W \cdot N_W}{m_{IR}}}$$

NS and W - indicate North Sea and Western stock, respectively
n - number of mackerel present in the area
r - number of tags returned
m - number of mackerel tagged
N - stock size.

Stock size numbers were taken from the VPA tables in the previous report (Anon., 1984a) as age 3 and older at 1 January 1984 (no. x 10^{-6}):

North Sea stock	533.4
Western stock	7,403.5

2.3.1 Division IIa

Notwithstanding the omission of current year's releases from the assessment, it is worth noting that 8 mackerel tagged off Ireland in May 1984 were recaptured in Division IIa in the July-August fishery (Table 2.2). On the basis of the equation above, the proportion, p, of mackerel from the North Sea stock in catches from Division IIa was calculated to have been 0.10. This proportion is somewhat higher than that estimated for the 1983 catches ($p = 0.06$), but equal to the value of 0.10 decided by the Working Group to be applied for each of the years 1981, 1982 and 1983.

The Working Group decided to apply the value of 0.10 for the North Sea stock component in the Division IIa catches in 1984. This proportion was used for the estimated catch in number of age 3 and older. All fish of age 1 and 2 were assumed to be from the North Sea stock.

A catch of 920 tonnes was taken in Division Vb in 1984. This catch was split by stock applying $p = 0.10$ as used for Division IIa.

2.3.2 Division IVa

In 1984, 12 tags were returned from a fishery in August-September in the northeastern part of Division IVa. Uncertainties exist about the fishing locations of some of the recaptures, but the calculated proportion of North Sea mackerel, 0.07, seemed representative of catches taken north of 59^0N. The estimate was based on a low number of tags, but shifts in the Norwegian fishery during July-October 1984 indicated a migration of mackerel from an area at about 64^0N southwards into the northeastern part of the North Sea. Hence, the estimated proportion just north and south of the Sub-area border at 62^0N latitude should be similar. A set of age distributions from Division IIa and the northern part of Division IVa in 1983 and 1984 also seemed to indicate similarities between the two fishing areas in 1984, in contrast to 1983.

The Working Group decided to apply the proportion 0.10 to catches taken in Division IVa north of 59^0N. The catch in this area was 3,000 tonnes. The rest of the catch in Division IVa, 26,482 tonnes, was mainly taken in the southern part, nearer Division IVb, and this catch was assumed to be all North Sea stock.

Catches taken in Division IVa by Norway in a coastal fishery by gill nets and hook and line in May-October and all catches from Division IIIa were assumed to be entirely North Sea mackerel as in previous years.

For 1981-83, all catches in Division IVa were assumed to be 100% North Sea stock, since the bulk of the catch was taken in the southern part close to Division IVb where mixing would not be expected.

2.3.3 Division VIa

As in previous years, mixing of the two stocks in Division VIa was assumed to occur only in the area north of 58^0N in the periods January-March and October-December.

Tag recaptures from three fisheries in this area were available a) by Scotland, first quarter, b) by Scotland, fourth quarter and c) by Norway, fourth quarter (Table 2.2). The following proportions of North Sea mackerel were estimated:

a)	0.10,
b)	0.09,
c)	0.12,
a+b+c)	0.11.

The Working Group decided to apply a rounded value of 0.10 for the catches of mackerel 3 years and older as was used for the 1983 catches.

All age 1 and 2 fish and catches taken in the 2nd and 3rd quarters together with catches taken south of 58^{0}N in Division VIa were assumed to be from the Western stock.

3 NORTH SEA AND NORWEGIAN SEA AREAS

3.1 The Fishery in 1984

Total landings for 1975-84 by countries are shown in Table 3.1 for the North Sea, Skagerrak and Kattegat (Sub-area IV and Division IIIa) and in Table 3.2 for the Norwegian Sea (Division IIa). The catch in 1983 was revised according to updated reports, and the recorded catch was increased by 4,617 tonnes in Sub-area IV and Division IIIa and by 74 tonnes in Division IIa.

ACFM had recommended that "... fishing in the North Sea should be closed..." in 1984, but the EEC and Norway agreed to a TAC of 31,300 tonnes for the two parties in Sub-area IV and Division IIIa. It was also accepted that Sweden continued its traditional fishery in Division IIIa.

The total landings from these areas were 39,300 tonnes, of which 70% was taken by Norway and 25% by Denmark.

The catch in Division IIa in 1984 was 94,000 tonnes, nearly twice that of 1983 and the highest catch on record. Norway took 88% of the total. The record catch was due to increased Norwegian landings resulting from some national fisheries restrictions of earlier years being lifted and from mackerel occurring closer to the coast. There is no agreed TAC for Division IIIa.

About 900 tonnes were reported from Division Vb, and this was included in Table 3.2.

The quarterly distribution of the catches by Sub-areas and Divisions is shown in Table 3.3. The total catch of the North Sea stock in 1984 was estimated at about 72,400 tonnes (Table 3.5).

3.2 Catch in Numbers

3.2.1 1984 data

As in 1983, Danish vessels fishing in Division IIa occupied the same area and time period as the Norwegian fleet; consequently, Danish catches were allocated into numbers at age using Norwegian data. There was a minor Soviet catch in the area which was also divided into numbers using Norwegian data.

In Division IIIa, the Swedish catch was allocated into quarters of the year using the combined Norwegian and Danish data. The Swedish catch was allocated to age groups in the 2nd quarter using Norwegian data and in the 3rd quarter using combined Norwegian and Danish data.

In Division IVa, the catches from the Netherlands, England and Scotland were split into age groups using Danish data. Division IVa was split into Division IVa north and Division IVa south of 59^0N, and 1,500 tonnes of the Norwegian catch and 500 tonnes of the Danish catch were taken in Division IVa north. The mackerel taken in Division IVa north were assumed to be of the same age composition as those taken in Division IIa in the same time period.

In Division IVb, the catch taken by the Federal Republic of Germany was allocated to age groups in the 2nd quarter using samples from the Netherlands and in the 3rd quarter using Danish samples. Ninety percent of the combined Division IVb+c Danish catch was estimated to have been taken in Division IVb.

The Belgian and Danish catches in Division IVc were allocated to age groups using Dutch data.

In Division Vb in the 3rd quarter of the year, there were catches taken by the Faroes, Denmark and USSR. These catches were considered to have the same age distribution as the catches taken in Division IIa in the 3rd quarter.

The catch at age in Sub-area IV and Divisions IIa, IIIa, and Vb is shown in Table 3.4.

The estimation of the age composition of the Division VIa catch is given in Section 4.3.1, and the proportions of the part of it taken north of 58^0N during the winter fishery allocated to the North Sea stock is described in Section 2.3.3.

3.2.2 Revision of the 1983 data

In Division VIa in 1983, the Faroese data were revised upwards by 5,506 tonnes, 10% of which was allocated to the North Sea stock with an age distribution equal to the Norwegian catch in that area.

3.2.3 Weight at age

The changes in the distribution of the North Sea mackerel fisheries in the last year are likely to have changed the mean weights at age in the catches compared to those used in previous assessments. It was decided to estimate new values for 1984 and compare them with the values used in previous years.

The estimated mean weights at age for each division and quarter of 1984 provided by Ireland (VIa), Scotland (IVa and VIa), the Netherlands (IVb, IVc and VIa), Norway (IIa, IIIa, IVa and VIa) and Denmark (IIIa, IVa and IVb) were used. The values for each age group were weighted by the catches in number taken by the different countries to provide quarterly mean weights at age. The quarterly mean weights at age were weighted by the catch in number taken in that quarter at each age to estimate annual mean weights at age. The values are given in the text table below together with the values used in previous years. A sum of products check on these data indicates that the new estimates are a better represention of the mean weights at age in the catch in 1984 than are the previous values.

Mean weights at age (kg)

Age	Catch (New values)	Catch (Previous values)
1	.178	.245
2	.334	.329
3	.383	.363
4	.398	.392
5	.425	.438
6	.489	.455
7	.577	.520
8	.553	.580

Age	Catch (New values)	Catch (Previous values)
9	.633	.585
10	.657	.610
11	.653	.635
12	.682	.655
13	.662	.670
14	.727	.675
15+	.755	.685

Catch (tonnes)	SOP New values (tonnes)	SOP Previous values (tonnes)
72 375	72 018	69 598

Mean weights at age of the stock on 1 January and at the time of spawning were unchanged from those used in last year's assessment.

3.2.4 Spawning stock biomass estimate from the egg survey in 1984

The egg survey in the North Sea in 1984 was more extensive than earlier surveys. Five vessels from four countries participated occupying a total of 627 plankton stations during six surveys. Based on the surveys, two separate egg production estimates were presented to the Working Group. The estimates were in good agreement and it was decided to use an egg production estimate of 88.5 x 10^{12} eggs giving a spawning stock estimate of 133,000 tonnes. The estimates given to the Working Group were preliminary and a full report from the survey will be presented to a meeting in Lowestoft later this year (C.Res. 1984/2:11). After that meeting, it is possible that the egg survey estimate may be modified. The 1984 egg production estimate is about half of the 1983 estimate, but given that the 95% confidence limits are about ±30%, this does not necessarily imply a 50% decrease in the spawning stock biomass.

3.2.5 Exploitation pattern

A separable virtual population analysis (SVPA) (Pope and Shepherd, 1982; Anon., 1983) was used, as in last year's analysis (Anon., 1984a), to estimate the exploitation pattern of the fishery on the North Sea stock. A data set of ages 2-13 during 1977-84, a terminal F reference age of 3 years, and a terminal S of 1.80 at age 13 were used as the basis for estimating the exploitation pattern. The value for S of 1.80 was chosen to level out the exploitation pattern on ages 8 and older. This value is considerably higher than that used in the previous assessment (Anon., 1984a), but was considered by the Working Group to be a more accurate characterisation of the data.

The coefficient of variation (CV) of the log catch data was 24% and only ten (13%) of the 77 log catch ratio residuals in the data set were in excess of the recommended level of 2 $\log_e$ (1 + CV/100) (Table 3.6). The only consistent pattern exhibited by the excessive residuals was for the weak 1977 year class, which can be explained by normal sampling errors in assigning catch in numbers to this year class.

The exploitation pattern at ages 1-14 in 1984 from the extended analysis of the SVPA (using terminal populations option) was used to factor the terminal F in 1984 for the conventional VPA, as this pattern provides the best fit to the 1984 catch data.

Age	1	2	3	4	5	6	7
S	0.00	0.35	1.00	1.07	1.48	1.54	2.69

Age	8	9	10	11	12	13	14
S	1.88	1.48	1.67	1.66	2.52	1.82	1.59

These results indicate full recruitment to the fishery at about age 5 in 1984 with a fluctuating pattern at ages 5-14. This constitutes a slight change from the previous assessment of this stock (Anon., 1984a) where 100% recruitment was estimated from SVPA to have occurred at age 4 in 1983.

3.2.6 Fishing mortality and stock size

A VPA for the North Sea stock was made using the same maturity ogive and mean weight at age of the spawning stock at the time of spawning (Table 3.11) as used in the 1984 assessment (Anon., 1984a). The exploitation pattern for the terminal year (Section 3.2.5) and the input F values for the oldest true age group (14 years) in years prior to 1984 were obtained from the extended analysis of the final SVPA run.

None of the egg survey estimates of spawning stock biomass in 1982, 1983 and 1984 were considered to be more reliable than the others. Therefore, the terminal F values for 1984 were adjusted so that the sum of squares of the percent deviation between the spawning stock estimates determined from the VPA and those based on egg surveys (190,000, 240,000 and 133,000 tonnes, respectively) was minimized. In this way, each egg survey estimate was given approximately equal weighting in estimating the 1984 F. This resulted in substantially lower spawning stock estimates in 1982 and 1983 than in the VPA in the previous report (Anon., 1984a). The estimates of the spawning stock biomass from the VPA and the egg surveys in 1982, 1983 and 1984 are shown in Figure 3.1. The confidence limits of the spawning stock estimates are at least ±30% which is the approximate 95% confidence limits of the egg production estimates (Iversen and Westgård, 1984). It is seen from Figure 3.1 that all the VPA spawning stock estimates are within these confidence limits.

The results of the VPA for 1969-84 are given in Tables 3.7 - 3.9 and Figure 3.2. The $\bar{F}_{3-13}$ for 1984 was 0.51 compared to 0.29 in 1983, nearly an 80% increase in fishing mortality. The 1984 $\bar{F}_{3-13}$ was the highest observed since 1969. $\bar{F}$ values in virtually all years have been in excess of $F_{0.1} = 0.17$. Spawning stock biomass at the time of spawning in 1984 was estimated to be about 159,000 tonnes in the VPA, compared to 133,000 tonnes based on egg survey results. Results of the VPA indicated that spawning stock biomass was fairly stable during 1982-84 at an average of 163,000 tonnes. However, spawning stock biomass has undergone an 87% decline from a recent high of 1.2 million tonnes in 1973. Table 3.10 indicates the level of consistency of recent assessments of the North Sea mackerel stock. Estimates of both $\bar{F}$ and stock biomass in given years from different assessments have fluctuated primarily because the VPA each year was 'tuned' to a new egg survey estimate of spawning stock biomass. As indicated above, these estimates have been characterised by rather wide confidence limits. In contrast to previous assessments, the present VPA was 'tuned' taking into account three consecutive egg survey estimates. If this practice is continued in future assessments, there is likely to be greater consistency with the 1985 results than with those in preceding years.

3.2.7 Recruitment

The number of recruits at age 1 estimated from VPA is given in Table 3.9 and Figure 3.2. Catches of 1-year-olds have declined since 1981 (1980 year class) and, in 1984, very few 1-year-olds occurred in the catches (Table 3.5). The number of 2-year-olds was also very low, and they accounted for only 2% of the total catch in number, compared to about 15% in 1982 and 1983. This indicates that both the 1983 and the 1982 year classes are very poor.

Records of landings of young mackerel from fjord areas of southern Norway have been shown to give some indication of year-class strength (Anon., 1982). Data from the fishery in 1983 and 1984 indicate that the 1983 year class is very weak, while the 1982 year class, on the basis of these data, might seem somewhat stronger.

Data from the International Young Fish Survey (IYFS) have been shown to be of little value as an indicator of year-class strength, except for the extremely strong year classes. The Working Group examined the available IYFS data and concluded that they could not be used to assess recruitment for the recent years.

A young fish survey in the German Bight area has been carried out annually by the Netherlands in October-November since 1980 using a GOV-trawl. Mackerel <20cm in length, assumed to be O-group, were caught only in the 1984 survey. This could indicate that the 1984 year class was stronger than the preceding ones. The surveys, however, failed to indicate the 1980 and 1981 year classes to be abundant, although catch data (VPA) now show them to be the strongest in recent years. Furthermore, the 1984 year class did not appear in industrial catches from the North Sea. For these reasons, the Working Group concluded that the 1984 year class must be considered minimal for the purpose of calculating stock prognoses (Section 3.3).

3.3 Forecasts for the North Sea Stock

3.3.1 Exploitation pattern

The average exploitation pattern determined by the SVPA for the period 1977-84 was adopted for the catch and stock forecasts and the yield-per-recruit analysis. This pattern indicated 100% recruitment to the fishery at ages 8 and older (Table 3.11), compared to 100% recruitment at ages 5 and older in 1984 (see Section 3.2.5). The pattern assumed in the present forecast was considered by the Working Group to be more appropriate than that used previously. The change was primarily the result of selecting a higher terminal S at age 13 in the present SVPA (1.80) than in the previous SVPA (1.00).

3.3.2 Recruitment for the stock prognosis

Indices of recruitment were discussed in Section 3.2.7. It was concluded that both the 1983 and the 1984 year classes should be considered weak. It was, therefore, decided to carry out the prognosis assuming a strength of 20 x 10^6 fish at age 1 for the 1983 and 1984 year classes. Considering the pattern of generally poor recruitment in recent years,the same assumption was made for the 1985 and 1986 year classes. The recruitment level used is equivalent to the strength of the 1978 year class, the poorest year class on record (and also equal to the 1982 year class as estimated by the current VPA).

3.3.3 Catch and stock predictions

The input parameters for the catch forecasts of the North Sea stock are given in Table 3.11.

The weights at age in the catch were obtained smoothing the observed 1984 values given in Section 3.2.3. The maturity ogive as well as the weights at age in the stock and at time of spawning were those used in the previous assessment (Anon., 1984a). The stock size in numbers in 1985 was obtained from the VPA (Table 3.9), except the number of 2-year-olds (1983 year class) which was estimated assuming a recruitment at age 1 of 20 x 10^6 fish and no catch in 1984.

A catch of 75,000 tonnes of mackerel from the North Sea stock in 1985 was used in the forecasts. This value was based on information on catch quotas agreed to by the EEC and Norway, and on assumed ratios of stock mixing in Divisions IIa and VIa equal to those applied to catches in 1984. It was further assumed that catches in Division IIa in 1985 would remain at the 1984 level, and that about 20,000 tonnes of North Sea mackerel would be caught in Division VIa during the winter of 1985. On this basis, the estimated catch of North Sea stock mackerel was:

Division IIa	9,500 tonnes
Divisions IIIa + IVa-c	45,500 tonnes
Division VIa	20,000 tonnes
Total	75,000 tonnes

Table 3.12 shows a series of stock and catch predictions for 1985-87.

The estimated catch of 75,000 tonnes in 1985 results in a total stock biomass in 1985 of 94,000 tonnes and in 1986 of 22,000 tonnes.

A continued fishery in 1986 to yield a catch of 75,000 tonnes is obviously impossible. Maintaining F at the 1985 level of about 1.35 will bring the stock very near the point of extinction. Even an F_{86} value equal to $F_{0.1}$ (0.17) would result in a further decline in the stock biomass. No fishing on North Sea mackerel in 1986 might result in a biomass of 34 000 tonnes at 1 January 1987, a slight increase from 1986.

From the forecast, it is clear that the only way the North Sea mackerel stock can be preserved is by closing the fishery or by having recruitment that will be substantially higher than assumed.

4 WESTERN AREA

4.1 The Fishery in 1984 (Sub-areas VI, VII, and VIII)

The landings by each country are shown in Table 4.1 for the 10-year period 1975-84. The figures for 1984 are preliminary and the 1983 figures have been revised resulting in a decrease of approximately 20,000 tonnes for the year. This revision was mainly caused by a reduction in the catches attributed to N.Ireland. The total landings for 1984 were approximately 482,000 tonnes including a provisional estimate of 12,500 and 15,000 tonnes for France and Spain, neither of which supplied data to the Working Group. This annual total represents a decrease of about 77,300 tonnes (13%) from 1983 and is the lowest landing figure since 1977. Table

4.1 also shows the estimated amount of mackerel which was caught but subsequently discarded. This figure is about the same as in 1983. Again, as in recent years, considerable quantities of mackerel (about 13% of the total landed catch) could not be attributed to any country and were considered as unallocated.

Considerable decreases took place in the catches of most of the countries involved in the fishery, particularly in the catches of Denmark, Federal Republic of Germany, Ireland, Netherlands and the UK (England & Wales). On the other hand, substantial increases were recorded in the catches of Norway and the UK (Scotland). These changes appear to have been caused by increased enforcement measures together with a change in the distribution of the fishery (see Section 2.2).

The catches by Sub-areas are shown in Table 4.2. Over 60% of the total catches were taken in Division VIa, and the importance of the fishery in this area has increased consistently each year since 1976 when it amounted to only 12% of the total.

The distribution of the catches by sub-area and quarters is shown in Table 3.3.

The quarterly catches in Division VIa were again divided into catches taken north and south of 58^0N in order to give an indication of the importance of the North Rona fishery. Catches in this area during 1984 amounted to over 273,000 tonnes which is about 89% of the total catch from Division VIa. The corresponding figure for 1983 was about 53%. About 93% of the total catch taken in the northern part of Division VIa was taken in the fourth quarter, while over 86% of the catch in the southern part of the Division was taken in the first and second quarters. The quarterly catches taken in Sub-area VII indicate that only about 7% was taken in the fourth quarter compared with 27% in 1983, this reduction being the result of the decrease in the fishery off Cornwall.

4.2 Discarded Catches and Unallocated Landings in the Western Area Fisheries

As reported in 1984, discarding no longer appears to be the problem that it was 6 years earlier. Factors contributing to this improvement include the shift of the winter fishery away from the area around the Cornish peninsula, and the lifting of UK individual boat quota restrictions in the latter part of 1984. Inevitably there is still some discarding associated with vessel processing at sea, but this was thought to represent less than 2.5% of the total Western area landings. An estimate of total discards was included in the assessment.

Just as there has been a reduction in the level of discarding, there has also been a reduction in the 'unallocated' catches. The total of 62,900 tonnes 'unallocated' represents 13% of the Western area landings (a reduction of 4% from 1983). Most of this mackerel was misreported as horse mackerel.

4.3 Catch in Numbers

4.3.1 1984 data

Division VIa

The catches taken in Division VIa in 1984 by Ireland, Netherlands, Federal Republic of Germany, Norway and Scotland were sampled for age. The catches by these countries amounted to 95% of the total international catch in this Division. Of the remaining catches, those by the Faroe Islands were raised using Norwegian data and those by Northern Ireland were raised using data from Ireland during the relevant periods. As in 1983, all age 1-2 fish were allocated to the Western stock and 10% of all older age groups caught north of 58°N during the first and fourth quarters were allocated to the North Sea stock (see Section 2.3.3.).

In contrast to 1982 and 1983, the number of 1 and 2- year-old fish in the catches was low. However, this probably reflects the weakness of these year classes. The catch in numbers at age in 1984 in the Division is shown in Table 4.3. and those allocated to the Western stock are given in Table 4.4. Discards were estimated to account for less than 1% of the total.

Divisions VIIa-c

Number-at-age data were supplied by Ireland and the Netherlands. These two nations accounted for over 99% of the total catch reported. The small English catch in the Irish Sea was allocated to age groups using age distribution data from an English research vessel survey. The catch in numbers at age from these Divisions in 1984 is shown in Tables 4.3 and 4.4.

It was estimated that about 4% of the total catch of 66 x 10^6 fish was discarded.

Divisions VIId-k

Numbers at age were supplied by England, the Netherlands, Ireland and the Federal Republic of Germany. These catches accounted for 95% of the total in these Divisions. The age distribution of the English first quarter catch was applied to the Danish catches in Division VIId+e. The age distribution of the Dutch fourth quarter catch in Division VIId was applied to English catches in that quarter. The assumed French catches taken in Divisions VIId-k during the whole year were allocated to age groups using the combined 1984 age distribution from the other countries in Divisions

VIId-k.

The catch in numbers at age from these Divisions in 1984 is shown in Tables 4.3 and 4.4.

Discards were estimated to account for about 7% of the total catch of 597 x 10^6 fish.

Divisions VIIIa-c

No data were supplied for these areas.

The assumed French and Spanish catches taken in Divisions VIIIa-c during the whole year were allocated to age groups using the annual age distribution from Divisions VIId-k. The assumed catch in numbers at age for these Divisions is shown in Tables 4.3 and 4.4.

Nothing is known about discarding in these Divisions.

4.3.2 Revision of the 1983 data

The catch in weight taken in Division VIa north of 58^0N during the winter of 1983 was increased by approximately 5,400 tonnes because of an unallocated catch which was not included in last year's data. In addition, the catch taken in Division VIa by Northern Ireland in 1983 was revised downwards from 18,400 tonnes to 810 tonnes. The corrected catch in numbers at age for the Western stock in 1983 is included in Table 4.7.

4.3.3 Splitting of the 10+ age group into 10 and 11+

At its 1984 meeting, the Working Group agreed to provide age compositions for the Western stock to age 15+ (Anon., 1984a). Age compositions determined for 1984 catches at this meeting were to age 15+, but most countries did not bring sufficient data to permit the extension of ages beyond 10+ in previous years. It was therefore decided to extend the catch in numbers at age only to 11+ this year and to extend it further next year towards the objective of 15+.

Previously, only catches from 1979 to 1983 were assigned ages to 10+. The catch in numbers of these 10+ age groups was split into 10 and 11+ age groups using the ratio between the 9 and 10+ age groups of the previous year. The resulting 10 and 11+ age compositions for 1979-83 were in close agreement with actual age compositions of catches from Ireland, England and the Netherlands in the respective years.

4.3.4 Weight at age

Mean weights at age in the stock at spawning time were estimated for 1984 by using samples from Dutch commercial freezer trawlers in Division VIIj in March, April and May, from an English research vessel in Division VIIj+h in March and from the Irish commercial fishery in Division VIIj in April. These data were smoothed by fitting a curve by eye and rounding them to the nearest 5 grammes (Table 4.11).

Those countries which supplied age compositions of the catches in 1984 also supplied mean weights at age for those catches. Weighted (by catch in numbers) mean weights at age were determined from all the catches from the Western stock. These are shown in Table 4.11. The sum of products (SOP) and the actual catch for 1984 differed by less than 1%.

These new stock and catch mean weights at age were used in the predictions for 1985 and 1986.

4.3.5 Maturity at age

It is 5 years since the maturity ogive currently in use was formulated. Recent studies of mackerel maturation question some of the detail (Eltink, 1984). It was not possible to construct a new maturity ogive at this meeting. Therefore, this Working Group requests the Mackerel Egg Production Workshop, which will meet in June 1985, to examine the data from those countries which have fisheries on the spawning grounds and in juvenile areas. It is important that these maturity data should be examined by sex, age, month and Divisions.

4.4 Assessment of the Western Stock

4.4.1 Spawning stock biomass estimates from plankton surveys

Studies of the mackerel spawning in the Celtic Sea continued in 1984 but were limited in time and area. The most recent spawning stock estimate is still that made following the international survey undertaken in 1983: 6 985 x 10^6 mature fish (Anon., 1984b). The estimate for 1980 was 7 310 x 10^6 mature fish.

4.4.2 Catch per unit effort from the Cornish handline fishery

In the third quarter of each year, there is a small handline fishery for mackerel in the coastal waters around Cornwall. Over the period 1976 to 1984, the annual catch in the fishery has been between 500 and 1,500 tonnes. In 1984, catch-per-unit effort data from the fishery were used to estimate terminal $\bar{F}_{2-10}$ for running a VPA, which was in close agreement with the VPA 'tuned' to the 1983 egg survey stock estimate (Anon., 1984a). Total international effort on the Western stock was estimated from the stock catch and cpue series (Table 4.5). A first fit estimate of $\bar{F}_{2-10}$ for 1984 was made with a functional linear regression of $\bar{F}_{2-10}$ for 1973-1983 (taken from Anon., 1984a) against the international effort (Figure 4.1A). An iterative procedure was then followed running SVPAs to derive an exploitation pattern for a new VPA from which $\bar{F}_{2-10}$ values were taken for a new regression. This iteration was continued until convergence was achieved between the regression estimate of $\bar{F}_{2-10}$ for 1984 and the terminal $\bar{F}$ value used in VPA. This final set of values is given in Table 4.5 and the regression shown in Figure 4.1B. The VPA from which these F values was taken calculated a spawning stock in number for 1983 of $9,255 \times 10^6$, about 32% higher than the most recent egg survey estimate ($6,985 \times 10^6$).

When this method was used in 1984, it estimated a spawning stock size in 1983 only 10% greater than the egg survey method. There was no obvious reason why the results obtained this year differed so much. In the light of shifts in Western stock distribution, described earlier, it may be that the apparent relationship found last year was purely fortuitous. Clearly, further study of the stock relationships and these cpue data is necessary before they can be used with confidence for estimating terminal F values.

4.4.3 Exploitation pattern

SVPA was used to estimate the exploitation pattern of the fishery on the Western mackerel stock. A data set of ages 1-10 during 1978-84, a terminal F reference age of 3 years, and a terminal S of 0.80 at age 10 were found to be the most suitable for estimating the exploitation pattern. The coefficient of variation

(CV) of the log catch data was 16% and only five (9%) of the 54 log catch ratio residuals in the data set were in excess of the recommended level of 2 $\log_e$ (1 + CV/100) (Table 4.6). The excessive residuals occurred at the youngest and oldest ages in the data set, but followed no specific pattern and suggested no problems with the catch in numbers at age.

The exploitation pattern at ages 1-10 in 1984 from the extended analysis of the SVPA (using terminal populations option) was used to factor the terminal F for 1984 for the conventional VPA, as this pattern provides the best fit to the 1984 catch data:

Age	1	2	3	4	5	6	7	8	9	10
S	0.31	0.71	1.00	0.89	0.68	0.61	0.90	0.51	0.50	0.57

These results indicated a dome-shaped exploitation pattern in 1984 with a maximum (100% recruitment) at age 3 followed by a decline to a relatively stable level at ages 8 and older at around 50% of the maximum. The exploitation pattern assumed for 1983 in the previous assessment (Anon., 1984a) indicated the same basic pattern as above, but with a maximum at age 2 instead of age 3. This relatively minor change probably reflects natural changes, but it may also reflect management measures in Divisions VIIe+f.

4.4.4 Fishing mortality and stock size

A conventional VPA was run using the output of the separable VPA (see Section 4.4.3) as input for the F values at the oldest true age (10) during 1977-83 and for the F values at ages 1-10 in 1984. The F values in 1984 were adjusted according to the pattern estimated by the SVPA by trial and error until they produced a spawning stock size at spawning time in 1983 equivalent to that calculated from results of the egg survey in 1983 (6 985 x 10^6). The result was $\bar{F}_{3-10}$ = 0.26 in 1984 compared to 0.23 in 1983 (Table 4.8). The 1984 $\bar{F}_{3-10}$ was the highest observed to date in the Western stock (1972-84). All $\bar{F}_{3-10}$ values during 1979-84 have exceeded $F_{0.1}$

Results of the VPA for 1972-84 are given in Tables 4.7-4.9 and Figure 4.2. The estimated spawning stock size at spawning time in 1984 was 5,502 x 10^6 fish, a 21% decrease from 1983. Spawning stock biomass has undergone a fairly steady decline from about 3.9 million tonnes in 1973 to an estimated 1.8 million tonnes in 1984, the lowest level on record. The decrease since 1978 amounted to 44%.

The spawning stock size calculated for 1980 by the VPA was only 6% higher than that estimated by the egg survey in that year, easily within the likely confidence interval of the survey estimate. In addition, the 1977 spawning stock estimate from the VPA was only 5% lower than the estimate based on the egg survey that year.

The consistency of this assessment with those of past years is indicated in Table 4.10. The estimates of $\bar{F}$ and stock biomass for recent years (1981-84) from the last several assessments (1982-85) have been quite consistent mainly because they have all (except for the 1982 assessment) been tuned to the results of the 1983 egg survey estimate. The greatest change between the current results and those from the 1984 assessment pertained to 1981.

The $\bar{F}_{3-10}$ in was 18% higher in the 1985 (current) assessment than in the 1984 assessment. This was due mainly to the splitting of the large catch in number at the 10+ age group in 1981 to 10 and 11+ age groups. Results of the SVPA in the previous assessment (Anon., 1984a) had implied an F of 0.17 at the 10+ group in 1981. Current results of the SVPA implied an F of 0.27 at the 10 and 11+ groups in 1981. This increase in F resulted in a reduction in stock size and biomass at those ages which accounted for nearly

70% of the difference in stock biomass estimates in 1981 between the 1984 and 1985 assessments.

4.4.5 Recruitment

As noted on earlier occasions, there are no established data or criteria for quantifying recruitment levels in the Western mackerel stock. The absence of O-group mackerel from research vessel samples collected from Divisions VIId-k and VIIIa,b,c during November-December 1982 and 1983 was interpreted as indicating very weak year classes (Anon, 1984a). These year classes continue to be noticeable for their relative absence from the catches, which suggests that the research vessel observations are reliable "presence" or "absence" indicators at least. On this basis, the 1984 year class is "present". In December 1984, O-group mackerel were widely distributed in Divisions VIIe,h,k and VIIIa,b. They were not recorded in Divisions VIIg,j. However, O-group mackerel were recorded in appreciable numbers (0.5×10^6) in the commercial catches from Division VIa. This has not happened before, even when total catch tonnages in that Division were higher.

Without knowing the absolute size of the 1984 year class, the Working Group is confident that it is stronger than both the 1982 and 1983 year classes. A research vessel survey in January 1985 also caught 1984 year-class mackerel in Division VIa in much higher numbers than the preceeding five year classes in comparable surveys at that age.

4.5 Forecasts for the Western Stock

4.5.1 Exploitation pattern

The average exploitation pattern by the SVPA for the period 1978-84 was adopted for the catch and stock forecasts and the yield-per-recruit analysis. This pattern indicated 100% recruitment at age 3 followed by a decline to a stable level of 85% at ages 6 and older (Table 4.10).

In the previous report of the Working Group (Anon., 1984a), it was mentioned that management measures were implemented in November 1983 in the Celtic Sea to reduce the catch of age 1-2 mackerel. It was also indicated, however, that age 1-2 fish will still be vulnerable to fishing in areas outside of the closed area in Sub-area VII because of an apparent northerly shift in distribution of young fish of the Western stock. The effect of this shift is considered by the Working Group to result in no appreciable change in the exploitation pattern on young fish in the next 3 years from that observed during the 1978-84 period.

4.5.2 Recruitment for the stock prognosis

As noted earlier (Section 4.4.2), the Working Group does not have any quantitative estimates of the 1984 year-class strength, except that it is confident that this year class is stronger than both the 1982 and 1983 year classes.

Mindful of criticisms made within ACFM in recent years of the Working Group's propensity for assuming low recruitment levels, the Working Group reviewed this subject once more. The options considered were AM and GM mean 1-year-old recruitment calculated from the VPA values and a "low" value. The low value was calculated from $\exp(\bar{x} - 1.4s)$ (Anon., 1980) where $\bar{x}$ is the GM 1-year-old recruitment for 1972-83. These three values were:

AM	$3\ 400 \times 10^6$
GM	$2\ 770 \times 10^6$
Low	0.903×10^6

From the 12-year time series, 1-year-old recruitment was less than the AM in five years, less than the GM in three years and less than the "low" value in 1978 and 1983. On the basis of this comparison, there appears to be little reason for choosing between either the GM or the "low" value, except that the "low" value represents a more cautious and conservative level. At this stage, the Working Group chose to continue with the "low" value, rounded up to $1,000 \times 10^6$, for inclusion in the stock prognosis.

The Working Group wishes to point out that due to the low exploitation and percentage maturity of 1-group fish, the recruitment level has comparatively little influence on the stock prognosis.

4.5.3 Catch and stock projections

The Working Group assumed that, in the light of the improved enforcement of national quotas within the EEC in 1984, the agreed TAC of 409,500 for the Western area in 1985 would be overshot only to a minor extent. To this catch, however, must be added catches of the Western stock taken in Divisions IIa + Vb for which there are no agreed TACs. As explained in Section 3.4.3., the catch in these Divisions, in 1985 was assumed to be 95,000 tonnes of which, as in 1984, 90% was estimated to be from the Western stock. On this basis, the entire catch from the Western stock in 1985 was estimated to be about 500,000 tonnes.

A series of forecasts was run assuming that level of catch in 1985 using the input parameters given in Table 4.11. Stock numbers at age at 1 January 1985 were taken from the VPA output (Table 4.9), except for the 1984 year class which was set at $1,000 \times 10^6$ as explained in Section 4.4.5.

The closed area around Cornwall was not fully enforced in 1984, and its likely future effect in modifying the exploitation pattern cannot currently be quantified. In the light of the low recruitment levels used in the predictions, and the evidence for greater exploitation of juvenile fish in recent years in Division VIa, it was assumed that it will have no effect on the exploitation pattern in 1985 and 1986. Because of the low recruitment levels in these years, this assumption will have little effect on the catch and spawning stock biomass predictions.

The results of the predictions are given in Table 4.12. The $\bar{F}_{3-10}$ required to take the assumed catch of 500,000 tonnes in 1985 is 0.31 which is about 20% higher than the 1984 level. Maintaining this catch in 1986 would require an $\bar{F}_{3-10}$ of 0.41 and would reduce the spawning stock biomass to about 800,000 tonnes in 1987.

Fishing at the $\bar{F}_{0.1}$ level in 1986 would result in a catch in that year of 240,000 tonnes, and if maintained in 1987 would result in a spawning stock biomass of 1 million tonnes in that year.

It should be noted that even a complete ban on fishing in 1986 and 1987 would still result in a reduction in the spawning stock biomass of about 25% from 1984 to 1987. This is due to the weak recruitment by the 1982 and 1983 year classes and, to a minor extent, to the assumption that the 1984 year class is low. The Working Group felt concerned about the low levels of spawning stock biomass predicted for 1986 and 1987, even under the most rigorous management. It also felt it advisable to point out that, as long as unrestricted fishing is allowed to continue in Division IIa, catches of the order of 80 000 tonnes are likely to be taken from the Western stock even if no fishing is allowed in the Western areas. This aspect of the current management regime, therefore, has a considerable effect on the management options open for the Western stock.

5 CLOSED AREA OFF SOUTHWEST ENGLAND

The EEC introduced restrictions on mackerel fishing in a large part of Divisions VIIe,f, the so-called "Box" around Cornwall. Directed fishing for mackerel by trawling, purse seining, and other types of active netting is prohibited. The restrictions will be in force until 31 December 1986. This Working Group anticipates that at some time before that date, the EEC will ask advice from ACFM about future conservation measures in the Cornwall area. The Working Group discussed what data they might collect prior to the next meeting to help ACFM formulate their advice.

The Working Group assumed that they will be asked to assess the effect that the restricted area has had on the Western stock, particularly with respect to immature fish. There will be three main problems when trying to make such an assessment. The first is related to the short period the "Box" has been in force, the second is a consequence of the weak 1982 and 1983 year classes, and the third is the apparent northerly shift in distribution of young fish.

By February 1986, the "Box" will have been a restricted area for mackerel fishing for 26 months. However, from November 1983 to December 1984, only purse seining and pelagic trawling were prohibited. Directed fishing with demersal trawls and demersal seines was permitted through 31 December 1984. Thus, by February 1986, there will only be a 14-month period when the "Box" has been fully in force.

The intention of the "Box" has always been to protect immature fish, defined for simplicity as mackerel less than 30 cm. In recent years, these fish have comprised over 50% by number of the catches around Cornwall. In the last two years, however, the percentage immature fish has fallen dramatically but not due to any conservation measure. The fall in the proportion of immature fish is a direct consequence of the weak 1982 and 1983 year classes. Under these circumstances, the Working Group anticipates certain difficulties in assessing the conservation benefits.

One aspect of the assessment of the "Box" in which the Working Group believes it can make a positive contribution is in describing total Western stock juvenile mackerel distribution. When the limits of the "Box" were first defined, it was known that a major part of the total juvenile Western catch was taken in the area. Changes in Western stock distribution described above (Section 2.2) indicate the possibility that the Cornwall "Box" is no longer such an important nursery area. To elucidate this aspect of stock distribution, Working Group members agreed to direct a part of the research vessel time at their disposal in the forthcoming year to mapping juvenile mackerel distribution. Whenever possible, these distributions should be quantified in absolute terms.

6 DATA REQUESTED BY MULTISPECIES WORKING GROUP

The Mackerel Working Group was requested to provide some data on the North Sea mackerel stock for use by the Multispecies Working Group (see Section 1.1). Information was provided on catch in numbers at age, mean weight at age, and geographical distribution on a quarterly basis. The Working Group had no evidence to justify separate estimates of natural mortality for the oldest ages groups and did not assess the effects of applying the estimates of total natural mortality calculated by the Multispecies Working Group.

6.1 Catch at Age by Quarters

Data on catch at age by quarters were not readily available since the Mackerel Working Group had not compiled such data by stock. Catch-at-age data for the North Sea stock had been calculated on an annual basis only, and they were, in part, derived by applying estimated ratios of stock mixing for catches in various fishing areas. For these reasons, the requested data had to be reconstructed.

The Working Group decided that this should be done from the annual catch in number by age as given in Table 3.10 of the 1984 report of the Working Group (Anon., 1984a). The catch for each year was split by quarters on the basis of recorded catch in weight in each quarter for the relevant divisions. The same quarterly proportion was applied to all age groups. It was recognized that this method had shortcomings, but since a major part of the fishery on the stock occurred in the third and fourth quarters, the Working Group considered that the resulting data would be likely to suffice for the purpose of the Multispecies VPA.

Results were prepared for the period 1972-84, and a more detailed description of the data used for splitting by quarters in each of the years is given in the Appendix of the present report. Tables of estimated quarterly catch at age are given in the Appendix (App. Tables 1-13).

There was no catch-by-quarter data available for years prior to 1972 to permit this analysis to be extended further.

6.2 Mean Weight at Age by Quarter

A table of estimated quarterly mean weights at age in the catches is given in the Appendix (App. Table 14). All the values are from previous Working Group reports:

Values given in	Used for Years	Quarters
WG Report 1975 (Anon., 1975)	1972-76	2-4
WG Report 1980 (Anon., 1980)	1977-83	1
WG Report 1980 (Anon., 1980)	1978-80	2-4
WG Report 1982 (Anon., 1982)	1981-83	2-4
WG Report 1985	1984	1-4

The quarterly mean weight-at-age values which were used, with the exception of 1984, were not annually observed values, but were smoothed means based on weight-at-age data for more than one year.

6.3 Stock Distribution by Quarters

Part of the North Sea mackerel stock occurs outside of the North Sea area (Divisions IVa-c and IIIa) at certain times of the year: in the northern part of Division VIa in the first and fourth quarters and in Division IIa in the third quarter. This stock distribution will have an impact on predation in the North Sea estimated by the Multispecies VPA. The Working Group, therefore, made an attempt to estimate the stock distribution by quarters of immature and mature North Sea mackerel for the Multispecies assessments. Data were not available to quantify the distribution, and the estimates had to be based on the general knowledge of migrations (Anon., 1981).

This information is provided as two charts (App. Figures 1-2) showing the distribution, by ICES areas, separately for the immature and the mature part of the North Sea stock.

7 DEFICIENCIES IN DATA

The Working Group again considered the deficiencies in the data used to make assessments. These deficiencies have been considered at each meeting of the Working Group since 1982.

7.1 Catch Statistics

The situation with respect to catch statistics is very much the same as in previous years. Accurate information is still lacking as to the location of many of the catches reported by various countries accounting for a substantial portion of the landings. No information was available about French and Spanish catches. There is still a considerable number of countries which do not supply age distribution for their catches. Lack of information from both the above aspects present major problems when distributing the reported catches into the appropriate stock. Although some decrease has taken place in both the amounts of the total catch which could not be attributed to any particular country and in the amounts considered as "discards", it must again be pointed out that the accuracy of the assessments depends greatly on the accuracy of the total catch data.

7.2 Ageing

The North Sea stock utilises individual age groups up to age 14 and then a 15+ age group. At present, the Western stock assessment utilises age groups only to 11+, but the Working Group intends extending the age range in this assessment as soon as sufficient data are available. To this end, it is essential that all routine ageing of mackerel identifies individual age groups at least to 14 years of age.

To investigate the consistency between nations in ageing mackerel to 14 years, it was agreed that Wendy Dawson (UK) should coordinate an otolith exchange programme (Anon., 1984a). This exchange is taking place and, at the time of this Working Group meeting, 409 otoliths from four areas had been read by England, Federal Republic of Germany, Ireland, Netherlands, and Scotland (readings from Norway and Denmark were not available in time for this meeting). A preliminary analysis of the ageing by these five nations showed that there is a high level of agreement at ages less than 10 years, but the variability increases considerably at older ages. It was also noted that the level of agreement between nations varied with the area from which otoliths originated. Highest agreement is being found in the samples from west of Ireland.

7.3 Other Data

Section 2 of this report discusses in detail the information available on the recent changes in the distribution of the fisheries and the methods which have been used to try to distinguish different stocks. As has been stated, accurate assessments also depend on the distribution of the catches to the appropriate stocks. Considerably more work is needed before this problem will be solved. Information is also required which may explain the changes which have occurred in the distributions of the adult and juvenile components. It is important to establish whether these changes are still in progress or whether the stock distributions will become established as they are at present. Information which may help in this respect may come from environmental and hydrographical studies.

There are still deficiencies in the basic biological material about the stocks during spawning time. New data are required about fecundity, maturity ogives and mean weight at age for the spawning populations and should be collected at the time of each egg survey.

Again, as has been repeatedly pointed out, the prognoses of spawning stocks depend greatly on the recruitment levels used. Apart from some research vessel surveys and an examination of the numbers of juveniles in the commercial catches, there is no quantitative information about recruitment. Additional surveys which would indicate the distribution and abundance of recruiting year classes as 0 and 1-group fish are urgently needed.

The Working Group recommends that a thorough analysis of the Norwegian tagging data be conducted and that the models currently being used for this analysis be refined.

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Table 2.1 Catch in number of juvenile fish (1 and 2 year olds) and total catch from Division VIa and the Western stock to calculate relative catch ratios illustrating the shift of young fish towards Division VIa

Juvenile catch number from WG report of year:	Year of catch	1 and 2 year old fish			Total catch		
		Div. VIa a $\times 10^{-6}$	West. stock W $\times 10^{-6}$	a/W x100	Div. VIa a $\times 10^{-6}$	West. stock W $\times 10^{-6}$	a/W x100
1977	1972	0.1	24.5	0.4	29.8	563.2	5.3
1977	1973	0.8	83.2	1.0	57.3	845.0	6.8
1977	1974	1.5	111.3	1.3	72.8	1 103.4	6.6
1978	1975	12.1	156.5	7.7	678.7	2 141.5	31.7
1978	1976	8.0	464.3	1.7	158.9	2 117.3	7.5
1980	1977	13.9	433.0	3.2	166.3	1 268.3	13.1
1980	1978	2.2	595.1	0.4	309.3	2 106.9	14.7
1980	1979	2.4	412.7	0.6	433.6	2 485.7	17.4
1981	1980	25.9	953.2	2.7	436.3	2 413.7	18.1
1984	1981	48.5	772.5	6.3	603.5	1 996.5	30.2
1984	1982	212.6	638.9	33.3	805.0	2 012.3	40.0
1984	1983	209.4	756.3	27.7	860.2	2 146.6	40.1
1985	1984	24.5	96.3	25.4	754.7	1 596.0	47.3

Table 2.2 Results of Norwegian tagging experiments. Tag returns are from Norwegian landings to selected factories, 1981-1984, and returns by Scotland in the 1st quarter (1QSc) and 4th quarter (4QSc) 1984.

RECAPTURES

	RELEASES		Norwegian Sea				North Sea		DIVISION VIa, north							
									1981	1984		1983		1984		
	Year	No.	1981	1982	1983	1984	1982	1984	4Q	1Q	4Q	1Q	4Q	4Q	1QSc	4QSc
O	1970	4 540				1										
F	1971	5 000							1							
F	1972	5 086		1		1										
	1973	8 205														
S	1974	10 028		4		1			1	1						
O	1975	10 003													1	
U	1976	9 474		3		1			1					2		
T	1977	14 032	2	4	1	2			2						2	
H	1978	18 169	3	5	2	8	1	1	1					1		
	1979	20 173	3	7	1	5			3			1			2	1
I	1980	9 992	2	4		4			2	1				3	1	2
R	1981	9 972		5	3	5		1		1			3	7	2	
E	1982	10 065		5	5	5	1	1				3	3	4	3	1
L	1983	13 400			16	25		3					2	12	11	4
A	1984	14 512				8		1						13		2
D	Sum	162 651	10	39	38	66	2	7	11	3	0	4	8	42	22	10
	1970	3 505														
I	1971	9 350												1	1	
N	1972	11 818				1				1				1		
	1973	7 277				2						1				1
T	1974	4 493				1									1	
H	1975	9 995				1	1		2							
E	1976	1 763		1											1	
	1977	7 094							2							
N	1978	12 173		2		5		2	7	1	1		1			
O	1979	11 991	2	2	2	8	1		4					2	2	
R	1980	5 678		1	3	5	1		3	1			1	2		
T	1981	4 199			2	3	1		2	3				2	4	
H	1982	16 164			7	16	2	1				11	1	19	9	3
	1983	9 216				26		2					5	13	8	4
S	1984	13 587												4		1
E D	Sum	125 303	2	6	14	68	6	5	20	6	1	12	8	44	26	•9

Table 3.1 Nominal catch (tonnes) of MACKEREL in the North Sea, Skagerrak and Kattegat (IV and IIIa) 1975-1984 (Data for 1975-1976 as officially reported to ICES. Data from 1977 onwards were submitted by Working Group members).

Country / Year	1976	1977	1978	1979	1980	1981	1982	1983	1984*
Belgium	292	49	10	10	5	55	102	93	67
Denmark	27,986	21,833	18,068	19,171	13,234	9,982	2,034	11,285	*10,088
Faroe Islands	63,476	42,836	33,911	28,118	1,770	-	720	-	-
France	2,607	2,529	3,452	3,620	2,238	3,755	3,041	2,248	-
German, Dem.Rep.	259	41	233	-	-	-	-	-	-
Germany, Fed.Rep.	284	-	284	211	56	59	28	10	87
Iceland	302	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	738	733	-	-	-
Netherlands	2,163	2,673	1,065	1,009	853	1,706	390	96	* 340
Norway	197,351	180,800	82,959	90,720	44,781	28,341	27,612	24,464	27,311
Poland	2,020	298	-	-	-	-	-	-	-
Sweden	6,448	4,012	4,501	3,935	1,666	2,446	692	1,903	1,151
UK (Engl.& Wales)	89	105	142	95	76	6,520	28	16	2
UK (Scotland)	1,199	1,590	3,704	5,272	9,514	10,575	28	4	13
USSR	1,231	2,765	488	162	-	-	-	-	-
Unallocated + discards	-	-	-	500	-	3,216	450	96	202
Total	305,709	259,531	148,817	152,823	87,931	67,388	35,125	40,215	39,261

* Preliminary

Note: In contrast to the corresponding tables in Working Group reports for years prior to 1982, the catches do not include catches taken in Division IIa.

Table 3.2 Nominal catches (tonnes) of MACKEREL in the Norwegian Sea (Division IIa), 1975-1984.

Country / Year	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984*
Denmark[2]						-	801	1,008	10,427[3]	11,787[4]
Faroe Islands[1]	-	-	-	283	6	270	-	180	-	138
France[2]	7	8	-	2	-	-	6	8	-	-
Fed. Rep. of Germany[2]	-	-	-	-	-	-	51	-	5	-
German Dem. Rep.[2]	-	-	-	53	174	2	-	-	-	-
Netherlands[2]	-	2	-	-	-	-	-	-	-	-
Norway[1]	34,662	10,516	1,400	3,867	6,887	6,618	12,941	34,540	38,453	82,005
Poland	-	-	-	-	-	-	-	231	-	-
UK (England & Wales)[1]	+	+	+	1	-	-	255	-	-	-
UK (Scotland)[2]	-	-	-	-	-	296	968	-	-	-
USSR[3]	-	-	-	-	5	1,450	3,640	1,641	65	5
Total	34,669	10,526	1,400	4,206	7,072	8,340	18,662	37,608	48,950	93,935

1 Data provided by Working Group members

2 Data reported to ICES

3 Includes 1,497 tonnes caught in Division Vb

4 Includes 920 tonnes caught in Division Vb

* Preliminary

Table 3.3 Quarterly catches of MACKEREL in 1984 by division.

Division	I	II	III	IV	Not known	Total
IIa	-	100	92,100	800		93,000
IIIa	+	1,400	3,200	100		4,700
IVa-c	-	900	31,400	2,300		34,600
Vb	-	-	900	-		900
VIa N.of 58^0	13,800	600	4,000	254,700		273,100
VIa S.of 58^0	25,000	4,800	700	4,100		34,600
VII	110,700	41,300	4,200	12,300		168,500
VIII	700	1,100	600	800	15,000	18,200

Table 3.4 MACKEREL catch in numbers ($x\ 10\ x^{-3}$) by age group for the North Sea (Divisions IVa, b, c) the Norwegian Sea (Division IIa), the Skagerrak (Division IIIa), and Division Vb in 1984.

Year Class	Age	Divisions							Total
		IIa	IIIa	IVa N of 59°	IVaS S of 59°	IVb	IVc	Vb	
1983	1	-	-	-	-	-	17	-	17
1982	2	448	608	14	1,105	726	102	4	3,007
1981	3	59,094	4,357	1,906	20,595	4,365	587	584	91,488
1980	4	37,982	2,692	1,225	12,949	2,199	343	376	57,766
1979	5	27,536	904	888	5,842	1,084	199	272	36,725
1978	6	17,013	505	549	3,590	255	97	168	22,177
1977	7	1,856	133	60	756	226	48	18	3,097
1976	8	7,167	372	231	1,806	148	185	71	9,980
1975	9	8,026	151	259	2,076	204	76	79	10,871
1974	10	6,582	366	212	2,466	158	124	65	9,973
1973	11	3,837	129	124	1,089	107	97	38	5,421
1972	12	1,665	73	54	985	156	39	16	2,988
1971	13	2,435	65	79	760	73	45	24	3,481
1970	14	-	18	-	320	58	28	-	424
≤1969	15+	5,769	278	186	2,091	72	213	57	8,666
Total		179,410	10,651	5,787	56,430	9,831	2,200	1,772	266,081
Tonnes		93,014	4,715	3,000	26,482	4,185	932	920	133,248

Table 3.5 MACKEREL catch in numbers ($x\ 10^{-3}$) by age group for the North Sea stock in 1984

Year class	Age	Divisions							Total
		IIa	IIIa	IVa	IVb	IVc	Vb	VIa	
1983	1	-	-	-	-	17	-	-	17
1982	2	448	608	1 119	726	102	4	-	3 007
1981	3	5 909	4 357	20 786	4 365	587	58	25 805	61 867
1980	4	3 798	2 692	13 071	2 199	343	38	14 837	36 978
1979	5	2 754	904	5 931	1 084	199	27	8 725	19 624
1978	6	1 701	505	3 645	255	97	17	3 491	9 711
1977	7	186	133	762	226	48	2	1 339	2 696
1976	8	717	372	1 829	148	185	7	2 257	5 515
1975	9	803	151	2 102	204	76	8	1 762	5 106
1974	10	658	366	2 487	158	124	6	1 450	5 249
1973	11	384	129	1 101	107	97	4	1 288	3 110
1972	12	167	73	990	156	39	2	356	1 783
1971	13	244	65	768	73	45	2	689	1 886
1970	14	-	18	320	58	28	-	398	822
≤1969	15+	577	278	2 110	72	213	6	957	4 213
Total		18 346	10 651	57 021	9 831	2 200	181	63 354	161 584
Tonnes		9 301	4 715	26 782	4 185	932	92	26 368	72 375

Table 3.6. Input parameters and log catch ratio residuals from the separable VPA for the North Sea mackerel stock. Residuals in $\boxed{}$ are in excess of the recommended level of 2 $\log_e$ (1 + CV/100).

```
NATURAL MORTALITY =    .150
      TERMINAL F =    .440
      TERMINAL S =   1.800

      REFERENCE AGE (FOR UNIT SELECTION) IS  3

      NO. OF ITERATIONS CHOSEN IS   30
      MINIMUM DIFFERENCE BETWEEN ITERATIONS IS 10**-5

   ITERATION    SSQ
      1       38.4356
     28        7.0302

 APPROX. COEFF. VARIATION OF CATCH DATA =  24.2 %
```

YEAR	1977	1978	1979	1980	1981	1982	1983	1984
F(I)	.2251	.1930	.1257	.2086	.2035	.2027	.2205	.4400

AGE	2	3	4	5	6	7	8	9	10	11	12	13
S(J)	.3423	1.0000	1.1049	1.4190	1.4050	1.6622	2.1688	1.7027	1.9542	1.7719	2.1698	1.8000

LOG CATCH RATIO RESIDUALS

	77/78	78/79	79/80	80/81	81/82	82/83	83/84	
2/ 3	.049	.078	-.262	.043	-.164	.182	.075	.003
3/ 4	-.057	-.154	.046	$\boxed{.489}$	-.097	-.257	.031	.001
4/ 5	.352	-.323	.291	-.048	$\boxed{-.756}$	.274	.209	.000
5/ 6	-.120	-.149	.366	-.176	.034	.319	-.274	.000
6/ 7	.173	-.296	.202	.054	$\boxed{.533}$	.116	$\boxed{-.781}$	.001
7/ 8	.242	-.177	$\boxed{-.773}$	.078	$\boxed{.490}$	-.045	.166	.001
8/ 9	.052	$\boxed{.941}$	$\boxed{-.616}$	.002	-.110	-.212	-.055	.002
9/10	.213	-.205	-.368	.213	.202	-.104	.053	.003
10/11	-.386	.050	.292	-.195	.102	-.047	.187	.003
11/12	-.039	.325	$\boxed{.545}$	-.430	-.348	-.159	.109	.003
12/13	$\boxed{-.476}$	-.084	.281	-.028	.116	-.067	.261	.002
	.002	.005	.005	.004	.002	.001	.000	.019

Table 3.7. VIRTUAL POPULATION ANALYSIS

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

CATCH IN NUMBERS UNIT: millions

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	64.4	110.3	.8	2.6	4.5	2.9	11.9	2.7	1.1	.0	2.3	2.7
2	110.2	191.1	83.0	35.6	12.1	18.7	10.1	73.6	19.3	8.2	.5	5.6
3	473.1	75.8	50.3	162.6	37.6	23.6	16.2	69.7	58.9	34.7	11.3	2.4
4	308.6	185.1	18.0	33.2	280.2	39.9	42.4	13.9	54.3	40.8	21.2	14.3
5	79.7	64.5	29.7	21.3	74.3	240.8	27.8	33.8	9.8	27.9	33.3	23.5
6	35.6	19.0	13.8	23.5	36.0	45.8	193.2	19.5	26.6	6.0	14.3	25.9
7	624.0	5.3	2.1	10.7	19.7	7.5	25.6	118.6	31.6	14.2	4.2	15.3
8	.0	98.6	.9	1.4	34.8	16.1	20.4	31.3	125.9	16.1	9.2	12.3
9	.0	.0	17.7	.6	.5	3.2	15.8	8.0	31.2	45.7	2.0	14.0
10	.0	.0	.0	11.7	.0	.5	5.0	9.0	8.3	14.6	27.0	3.5
11	.0	.0	.0	.0	4.0	.3	.5	4.0	8.8	5.5	5.2	19.3
12	.0	.0	.0	.0	.0	24.5	.2	.5	4.5	5.5	2.0	3.8
13	.0	.0	.0	.0	.0	.0	22.2	.1	.8	2.9	2.0	1.3
14	.0	.0	.0	.0	.0	.0	.0	3.4	.1	.6	1.2	1.6
15+	.0	.0	.0	.0	.0	.0	.0	.0	2.5	3.2	2.3	2.2
TOTAL	1695.6	749.7	216.3	303.2	503.7	423.8	391.3	388.1	383.7	225.9	138.0	147.7

	1981	1982	1983	1984
1	3.9	3.0	.1	.0
2	6.0	14.3	17.0	3.0
3	11.5	15.5	28.3	61.9
4	1.1	9.7	16.6	37.0
5	12.5	2.0	6.8	19.6
6	17.4	7.7	1.0	9.7
7	17.8	7.6	5.5	2.7
8	10.5	8.3	6.5	5.5
9	5.4	5.3	5.0	5.1
10	7.5	3.0	4.3	5.2
11	2.2	3.6	1.8	3.1
12	20.4	2.2	3.2	1.8
13	1.8	8.6	1.2	1.9
14	2.5	1.7	8.0	.8
15+	1.5	1.3	1.8	4.2
TOTAL	122.0	93.[illegible]	107.1	161.5

Table 3.8. VIRTUAL POPULATION ANALYSIS

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

FISHING MORTALITY COEFFICIENT UNIT: Year-1 NATURAL MORTALITY COEFFICIENT = .15

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	.025	.011	.009	.000	.025	.021	.018	.012	.004	.000
2	.030	.202	.092	.077	.028	.073	.055	.081	.079	.151
3	.137	.277	.233	.225	.138	.174	.200	.187	.217	.427
4	.195	.158	.340	.238	.197	.245	.106	.245	.294	.456
5	.204	.223	.151	.277	.294	.328	.330	.270	.256	.630
6	.282	.203	.259	.123	.211	.368	.407	.329	.199	.658
7	.171	.264	.549	.203	.113	.345	.439	.294	.390	1.148
8	.385	.307	.465	.567	.166	.518	.398	.355	.415	.801
9	.285	.241	.536	.288	.117	.445	.426	.338	.354	.630
10	.190	.246	.397	.487	.260	.292	.429	.420	.475	.714
11	.123	.217	.380	.470	.302	.283	.284	.356	.452	.708
12	.325	.165	.379	.409	.293	.355	.512	.479	.560	1.076
13	.810	.252	.405	.423	.240	.297	.268	.398	.494	.778
14	.000	.253	.405	.570	.292	.291	1.436	.410	.746	.680
15+	.000	.253	.405	.570	.292	.291	1.438	.410	.746	.680
(3-13)W	.255	.251	.359	.273	.217	.334	.366	.284	.266	.511
(3- 8)U	.229	.239	.333	.272	.190	.330	.313	.280	.295	.687

Table_3.9. VIRTUAL POPULATION ANALYSIS

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

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: thousand tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .100
PROPORTION OF ANNUAL M BEFORE SPAWNING: .400

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	514.7	277.1	138.7	22.5	101.3	142.5	252.8	282.0	26.8	20.0	20.0
2	370.4	432.0	236.0	118.4	19.3	85.0	120.1	196.7	240.0	23.0	17.2
3	136.2	309.5	303.6	135.3	94.3	16.2	68.0	97.8	156.1	190.8	17.0
4	256.5	102.2	202.0	207.0	127.4	70.7	11.7	47.9	69.9	108.2	107.1
5	162.2	181.6	75.1	123.7	140.5	90.0	47.6	9.1	32.3	44.8	59.0
6	844.7	113.9	125.1	55.6	80.7	90.2	55.8	29.5	6.0	21.5	20.5
7	175.1	548.6	30.0	83.1	42.3	56.3	53.7	32.0	18.3	4.2	9.6
8	68.5	127.0	362.6	39.8	53.4	32.5	34.3	29.8	20.5	10.6	1.1
9	68.5	40.1	30.4	196.1	19.4	41.7	16.7	19.6	16.0	11.7	4.1
10	31.0	44.3	27.1	40.5	126.5	14.8	23.0	9.4	12.2	10.9	5.3
11	4.6	22.1	29.6	15.7	21.4	84.0	9.5	12.9	5.3	6.5	4.6
12	.8	3.5	15.3	17.6	8.5	13.6	54.5	6.2	7.8	2.9	2.8
13	42.6	.5	7.6	9.0	10.0	5.4	6.2	28.1	3.3	3.7	.9
14	.0	16.3	.3	1.5	5.1	6.8	3.5	5.4	16.2	1.7	1.5
15+	.0	.0	8.0	7.7	9.7	9.3	2.1	4.1	3.7	9.1	4.7
TOTAL NO	2675.8	2218.7	1686.9	1123.5	864.9	759.1	741.5	810.7	636.2	469.7	
SPS NO	1772.7	1534.0	1273.7	941.2	692.5	513.7	374.0	371.6	420.2	369.6	
TOT.BIOM	1956.0	886.4	708.4	501.0	380.8	323.6	270.9	261.9	230.6	184.5	
SPS BIOM	825.6	699.7	585.4	436.2	336.4	258.1	188.7	162.1	168.3	158.9	

Table 3.10 Consistency of estimates of fishing mortality and stock biomass for the North Sea MACKEREL stock

Year of Catch / Assessment	$\bar{F}$ (3-10)				Spawning stock biomass				Total biomass			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1982	0.30	-	-	-	358	-	-	-	381	-	-	-
1983	0.37	0.37	-	-	226	167	-	-	300	249	-	-
1984	0.29	0.23	0.24	-	236	207	213	-	327	322	282	-
1985	0.37	0.28	0.29	0.51	189	162	168	159	271	262	231	182

Table 3.11 Input data for catch forecasts, North Sea MACKEREL stock (M=0.15)

Age	Stock in number in 1985 (x 10^{-6})	Fishing pattern	Weight at age in the catch (kg)	Weight at age at spawning (kg)	Weight at age 1 Jan (kg)	Maturity ogive
1	20.0	0.03	0.180	0.180	0.123	0.00
2	17.2	0.18	0.330	0.275	0.234	0.37
3	17.0	0.51	0.375	0.330	0.325	1.00
4	107.1	0.57	0.395	0.415	0.335	1.00
5	59.0	0.73	0.430	0.460	0.350	1.00
6	20.5	0.72	0.475	0.495	0.346	1.00
7	9.6	0.85	0.540	0.525	0.468	1.00
8	1.1	1.00	0.580	0.550	0.472	1.00
9	4.1	1.00	0.610	0.565	0.505	1.00
10	5.3	1.00	0.640	0.590	0.535	1.00
11	4.6	1.00	0.660	0.610	0.560	1.00
12	2.8	1.00	0.680	0.630	0.585	1.00
13	0.9	1.00	0.700	0.645	0.605	1.00
14	1.5	1.00	0.715	0.650	0.615	1.00
15+	4.7	1.00	0.730	0.675	0.650	1.00

Recruitment at age 1: 1985 20 x 10^6
1986 20 x 10^6
1987 20 x 10^6

Catch in 1985: 75 000 tonnes

Table 3.12 Forecasts of stock biomasses and catches for the North Sea MACKEREL stock. Basic parameters are given in Table 3.11. Stock biomass and catch is in tonnes x 10^{-3}. Spawning stock biomass is at the time of spawning.

1984		1985				Management option for 1985	1986				1987	
Total landings	$\bar{F}_{(3-13)}$	Stock biomass	Spawn. stock biomass	$\bar{F}_{(3-13)}$	Total landings		Stock biomass	Spawn. stock biomass	$\bar{F}_{(3-13)}$	Total landings	Stock biomass	Spawn. stock biomass
72.4	.69	94	90	1.50	75	Maintain catch level	31	22	-	(75)	-	-
						$F_{86} = F_{85}$		27	1.50	23	15	10
						$F_{86} = F_{0.1}$		30	0.18	5	30	28
						No fishing		30	0	0	34	33

Table 4.1 Nominal catch (tonnes) of MACKEREL in the western area (VI, VII and VIII) (Data for 1975-77, as officially reported to ICES)

Country / Year	1975	1976	1977	1978 **	1979 **	1980 **	1981 **	1982 **	1983 **	1984* **
Belgium	17	10	1	1	3	3	-		+	-
Denmark	-	3	698	8 677	8 535	14 932	13 464	15 100	15 000	200
Faroe Islands	1 760	5 539	3 978	15 076	10 609	15 234	9 070	10 500	9 500	9 200
France	25 818	33 556	35 702	34 860	31 510	23 907	14 829	12 300	11 000	12 500
German Dem. Rep.	9 693	4 509	431	-	-	-	-	-	-	-
Germany, Fed.Rep.	1 941	391	446	28 873	21 493	21 088	29 221	11 200	23 000	11 200
Iceland	21	10	-	-	-	-	-	-	-	-
Ireland	11 567	14 395	23 022	27 508	24 217	40 791	92 271	109 700	110 000	84 100
Netherlands	13 263	15 007	35 766	50 815	62 396	91 081	88 117	67 200	83 100	54 100
Norway	1 907	4 252	362	1 900	25 414	25 500	21 610	19 000	19 900	34 700
Poland	21 573	21 375	2 240	-	92	-	1	-	-	-
Spain+	23 408	18 480	21 853	19 142	15 556	15 000	11 469	15 600	10 400	15 000
Sweden	-	38	-	-	-	-	-	-	-	-
UK (England + Wales)	31 546	57 311	132 320	213 344	244 293	150 598	75 722	82 900	62 000	30 000
UK (N. Ireland)	30	95	97	46	25	-	4 153	9 600	800	1 100
UK (Scotland)	16 174	28 399	52 662	103 671	103 160	108 372	109 153	147 400	120 100	167 200
USSR	309 666	262 384	16 396	-	-	-	-	-	-	-
Unallocated					54 000	98 258	140 322	97 300	96 000	62 900
Total, ICES Members	468 384	465 754	325 974	503 913	601 303	604 761	609 402	597 800	560 800	482 200
Bulgaria	20 830	28 195	-	-	-	-	-	-	-	-
Rumania	2 166	13 222	-	-	-	-	-	-	-	-
Discard	-	-	-	50 700	60 600	21 600	42 300	24 900	11 300	12 100
GRAND TOTAL	491 380	507 178	325 974	554 613	661 903	626 361	651 702	622 700	572 100	494 300

* Preliminary
**) Working Group Estimate
\+ Includes S japonicus

Table 4.2 Catches of MACKEREL (tonnes) by Sub-areas in the Western area. Discards not estimated prior to 1978

Year	Sub - areas					
	VI			VII and VIII		
	Landings	Discards	Catch	Landings	Discards	Catch
1969	4 800	-	4 800	66 300	-	66 300
1970	3 900	-	3 900	100 300	-	100 300
1971	10 200	-	10 200	122 600	-	122 600
1972	10 000	-	10 000	157 800	-	157 800
1973	52 200	-	52 200	167 300	-	167 300
1974	64 100	-	64 100	234 100	-	234 100
1975	64 800	-	64 800	416 500	-	416 500
1976	67 800	-	67 800	439 400	-	439 400
1977	74 800	-	74 800	259 100	-	259 100
1978	151 700	15 200	166 900	355 500	35 500	391 000
1979	203 300	20 300	223 600	398 000	39 800	437 800
1980	218 700	6 000	324 700	386 100	15 600	401 700
1981	335 100	2 500	337 600	274 300	39 800	314 100
1982	340 400	4 100	344 500	257 800	20 800	278 600
1983	315 100	22 300	317 400	245 400	9 000	254 400
1984*	306 100	1 600	307 700	176 100	10 500	186 600

* Preliminary

Table 4.3 MACKEREL catch in numbers (x 10^{-3}) by age group for the Western area (Sub-areas VI, VII and VIII in 1984)

Year class	Age	Divisions VIa North 58^0 Winter	VIa Remainder	VIIa-c	VIId-k	VIIIa-c	Total
1984	0	-	395	58	49	6	508
1983	1	4 985	3 868	1 978	5 252	640	16 723
1982	2	13 031	2 640	501	56 515	6 890	79 577
1981	3	258 048	28 420	21 649	244 203	29 772	582 092
1980	4	148 368	23 493	19 031	119 304	14 545	324 741
1979	5	87 254	19 249	8 829	82 516	10 060	207 908
1978	6	34 909	5 419	5 183	24 327	2 966	72 804
1977	7	13 388	1 895	1 281	1 326	162	18 052
1976	8	22 572	4 339	1 447	19 403	2 366	50 127
1975	9	17 617	1 994	2 147	12 069	1 471	35 298
1974	10	14 495	2 701	913	7 658	934	26 701
1973	11+	36 885	8 686	3 051	24 471	2 984	76 077
Total		651 552	103 099	66 068	597 093	72 796	1 490 608
Tonnes		268 524	39 220	19 763	148 740	18 134	494 381

Table 4.4 MACKEREL catch in numbers (x 10^{-3}) by age group for the Western stock in 1984.

Year class	Age	Divisions							Total
		IIa	IVa	Vb	VIa	VIIa-c	VIId-k	VIIIa-c	
1984	0				395	58	49	6	508
1983	1				8 853	1 978	5 252	640	16 723
1982	2				15 671	501	56 515	6 890	79 577
1981	3	53 185	1 715	526	260 663	21 649	244 203	29 772	611 713
1980	4	34 184	1 103	338	157 021	19 031	119 304	14 545	345 526
1979	5	24 782	799	245	97 778	8 829	82 516	10 060	225 009
1978	6	15 312	494	151	37 798	5 183	24 327	2 966	86 231
1977	7	1 670	54	16	13 944	1 281	1 326	162	18 453
1976	8	6 450	208	64	24 654	1 447	19 403	2 366	54 592
1975	9	7 223	233	71	17 849	2 147	12 069	1 471	41 063
1974	10	5 924	191	59	15 747	913	7 658	934	31 426
≤1973	11+	12 334	399	121	41 883	3 051	24 471	2 984	85 243
Total		161 064	5 196	1 591	692 256	66 068	597 093	72 796	1596 064
Tonnes		83 713	2 700	828	281 376	19 763	148 740	18 134	555 254

Table 4.5 The relationship between total international effort, measured in terms of Cornish handline effort (Q3 cpue) and F_{2-10} calculated by VPA.

Year	Western stock* catch t x 10^{-3}	Cornish handline Q3 cpue t/10^{-5} Hook hrs	Total Int. effort f Hook hrs x 10^{-8}	1984 WG VPA $\bar{F}_{2-10}$	Iterated VPA $\bar{F}_{2-10}$
1973	319	94	3.39	0.06	0.050
1974	411	272	1.51	0.08	0.069
1975	862	157	5.49	0.17	0.144
1976	682	196	3.48	0.15	0.131
1977	381	170	2.24	0.09	0.079
1978	628	82	7.66	0.16	0.143
1979	767	105	7.30	0.21	0.193
1980	804	107	7.51	0.23	0.200
1981	664	95	6.99	0.17	0.149
1982	648	93	6.97	0.19	0.154
1983	625	83	7.53	0.24	0.174
1984	555	73	7.60	0.214+	0.180++

* 1973-80. VPA SOP values
\+ Functional regression estimate
++ Functional regression estimate = VPA $\bar{F}_{2-10}$

Table 4.6. Input parameters and log catch ratio residuals from the separable VPA for the Western mackerel stock. Residuals in $\boxed{}$ are in excess of the recommended level of $2 \log_e (1 + CV/100)$.

```
NATURAL MORTALITY =   .150
       TERMINAL F =   .257
       TERMINAL S =   .800

       REFERENCE AGE (FOR UNIT SELECTION) IS  3

       NO. OF ITERATIONS CHOSEN IS   30
       MINIMUM DIFFERENCE BETWEEN ITERATIONS IS 10**-5

    ITERATION    SSQ
       1       10.3956
      25        2.1158

 APPROX. COEFF. VARIATION OF CATCH DATA =  16.3 %
```

YEAR	1978	1979	1980	1981	1982	1983	1984
F(I)	.1735	.2383	.2480	.2065	.2257	.2509	.2570

AGE	1	2	3	4	5	6	7	8	9	10
S(J)	.3785	.8289	1.0000	.9553	.8746	.8384	.8731	.8441	.8409	.8000

LOG CATCH RATIO RESIDUALS

	78/79	79/80	80/81	81/82	82/83	83/84	
1/ 2	.146	.240	.276	.099	$\boxed{-.600}$	-.095	.005
2/ 3	.100	$\boxed{-.343}$	$\boxed{.382}$	-.024	-.093	-.016	.005
3/ 4	.074	.064	.261	-.116	-.111	-.166	.003
4/ 5	.008	-.162	.148	-.097	-.005	.107	.000
5/ 6	.053	.042	.004	-.041	-.089	.026	-.002
6/ 7	-.155	.109	-.110	.173	.196	-.214	-.001
7/ 8	-.056	.152	-.257	-.117	.144	.136	.002
8/ 9	-.226	-.219	-.134	.047	$\boxed{.356}$	.202	.005
9/10	.060	.121	$\boxed{-.565}$	.081	.267	.021	.006
	.004	.004	.005	.005	.004	.002	.023

Table_4.7. VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

CATCH IN NUMBERS UNIT: millions

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1.6	.0	1.3	1.0	34.2	2.0	10.3	79.5	19.5	38.3	2.0	.0
1	12.4	33.8	87.0	52.5	279.4	153.5	31.3	351.1	484.5	266.1	203.0	43.6
2	12.1	49.4	24.3	104.0	184.9	289.5	563.6	61.6	468.7	506.4	455.9	712.7
3	29.4	64.0	123.5	94.5	322.3	154.0	425.0	602.5	75.2	225.1	483.6	444.6
4	507.7	115.5	108.5	306.3	170.6	166.0	243.7	365.5	381.3	31.7	164.1	391.6
5	.0	582.3	191.8	192.2	288.8	51.0	258.3	217.2	282.0	174.8	24.7	130.4
6	.0	.0	567.0	143.8	118.6	140.0	71.9	233.1	145.2	158.5	136.6	20.2
7	.0	.0	.0	1246.2	279.7	64.4	151.9	86.8	158.4	99.5	108.6	91.3
8	.0	.0	.0	.0	433.3	89.4	56.7	154.2	52.4	116.6	84.5	70.9
9	.0	.0	.0	.0	.0	158.5	83.2	70.5	139.6	35.3	87.0	47.1
10	.0	.0	.0	.0	.0	.0	210.8	74.6	43.6	138.7	24.4	48.9
11+	.0	.0	.0	.0	.0	.0	.0	189.1	163.3	205.5	237.9	145.3
TOTAL	563.2	845.0	1103.4	2140.5	2117.3	1268.3	2106.9	2485.7	2413.7	1996.5	2012.3	2146.6

	1984
0	.5
1	16.7
2	79.6
3	611.7
4	345.5
5	225.0
6	86.2
7	18.5
8	54.6
9	41.1
10	31.4
11+	85.2
TOTAL	1596.0

Table 4.8. VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

FISHING MORTALITY COEFFICIENT   UNIT: Year-1   NATURAL MORTALITY COEFFICIENT = .15

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
0	<.001	.007	.003	.003	.015	.005	.003	.003	.000	<.001
1	.018	.072	.038	.061	.136	.114	.077	.051	.090	.097
2	.031	.077	.094	.182	.136	.255	.159	.165	.239	.222
3	.078	.119	.081	.185	.283	.274	.177	.212	.240	.314
4	.105	.187	.079	.166	.227	.276	.166	.203	.257	.280
5	.133	.129	.074	.160	.210	.259	.185	.181	.205	.212
6	.099	.155	.061	.135	.200	.200	.214	.205	.209	.192
7	.322	.269	.112	.112	.225	.192	.194	.211	.194	.284
8	.000	.169	.122	.129	.150	.195	.200	.238	.196	.161
9	.000	.000	.031	.151	.222	.187	.185	.213	.191	.158
10	.000	.000	.000	.139	.186	.197	.270	.178	.169	.178
11+	.000	.000	.000	.139	.186	.197	.270	.178	.169	.178
(2-10)W	.156	.144	.067	.161	.221	.237	.165	.195	.231	.255
(3- 8)U	.131	.171	.091	.148	.216	.233	.190	.208	.216	.240

Table 4.9. VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

STOCK SIZE IN NUMBERS UNIT: millions

BIOMASS TOTALS UNIT: thousand tonnes

ALL VALUES, EXCEPT THOSE REFERRING TO THE SPAWNING STOCK ARE GIVEN FOR 1 JANUARY; THE SPAWNING STOCK DATA REFLECT THE STOCK SITUATION AT SPAWNING TIME, WHEREBY THE FOLLOWING VALUES ARE USED: PROPORTION OF ANNUAL F BEFORE SPAWNING: .400
PROPORTION OF ANNUAL M BEFORE SPAWNING: .400

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	5013.5	5154.9	658.3	3408.8	5684.1	4500.9	5146.6	630.2	275.7	5384.6	********
1	3165.5	4314.2	4405.2	564.7	2976.1	4818.7	3855.9	4394.2	545.8	194.3	4634.1
2	3704.6	2675.0	3454.6	3649.4	457.1	2230.7	3699.1	3072.4	3594.1	429.4	151.8
3	1351.7	3092.2	2132.0	2705.4	2619.6	336.4	1492.1	2715.4	2241.2	2434.9	296.0
4	3316.5	1075.9	2363.2	1692.4	1935.5	1698.3	220.1	1076.0	1890.1	1513.2	1551.0
5	1236.2	2571.0	763.3	1880.3	1251.3	1328.1	1109.5	160.1	756.0	1265.0	987.6
6	1633.9	886.2	1945.7	514.0	1379.5	859.0	382.6	793.3	115.0	530.1	384.8
7	4853.3	1273.2	655.1	1545.0	462.0	971.8	605.1	613.1	556.5	80.3	376.6
8	.0	3026.8	337.5	502.5	1139.2	317.4	690.0	428.8	427.3	394.6	52.0
9	.0	.0	2199.3	638.1	380.0	880.9	224.7	486.1	291.0	302.2	287.1
10	.0	.0	.0	1746.2	472.2	261.9	627.1	160.8	337.9	206.9	222.1
11+	.0	.0	.0	.0	1197.0	981.1	932.1	1567.7	1004.2	561.4	553.5
TOTAL NO	24275.2	24070.5	19417.1	19006.9	19963.7	19191.1	19485.8	16104.2	11984.9	13301.9	
SPS NO	11858.0	11000.2	10220.0	10274.6	9018.7	7739.4	7254.1	7817.4	6977.4	5502.2	
TOT.BIOM	5070.9	4655.4	4508.8	4370.8	3950.9	3531.6	3328.4	3537.9	3030.9	2469.7	
SPS BIOM	3688.5	3312.9	3273.5	3286.1	2954.4	2455.4	2205.0	2337.2	2097.3	1859.4	

Table 4.10 Consistency of estimates of fishing mortality and stock biomass for the North Sea MACKEREL stock

Year of catch / Assessment	$\bar{F}_{(3-10)}$				SPS Biomass				Total Biomass			
	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984
1982	0.24	-	-	-	1 177	-	-	-	2 242	-	-	-
1983	0.17	0.19	-	-	2 590	2 394	-	-	3 730	3 424	-	-
1984	0.17	0.19	0.22	-	2 705	2 421	2 153	-	3 863	3 599	3 037	-
1985	0.20	0.21	0.23	0.26	2 205	2 337	2 097	1 839	3 532	3 328	3 538	3 031

Table 4.11 Input data for catch forecasts, Western MACKEREL stock (M = 0.15).

Age	Stock in no. in 1985 (x 10^{-6})	Fishing pattern	Weight at age in catch 1984	Weight at age at spawn-ing	Maturity ogive
0	-	-	0.069	-	-
1	1 000.0	0.38	0.137	0.090	0.18
2	151.8	0.83	0.176	0.175	0.38
3	296.0	1.00	0.294	0.240	0.67
4	1 531.0	0.96	0.324	0.285	0.89
5	987.6	0.87	0.341	0.330	0.93
6	880.8	0.85	0.429	0.370	1.00
7	376.6	0.85	0.538	0.405	1.00
8	52.0	0.85	0.468	0.435	1.00
9	289.1	0.85	0.561	0.465	1.00
10	222.1	0.85	0.619	0.490	1.00
11+	553.5	0.85	0.636	0.535	1.00

Recruitment at age 1: 1985 1 000 x 10^6
1986 1 000 x 10^6
1987 1 000 x 10^6

Catch in 1985: 500 000 tonnes

Table 4.12 Forecast of stock biomass and catch for the Western MACKEREL stock. Basic input parameters are given in Table 4.11. Stock biomass and catch in tonnes x 10^{-3} Spawning stock biomass at time of spawning.

1984		1985				Management option for 1986	1986				1987	
Catch	$\bar{F}_{(3-10)}$	Stock biomass	Spawn. stock biomass+	$\bar{F}_{(3-10)}$	Total land- ings		Stock biomass	Spawn. stock biomass+	$\bar{F}_{(3-10)}$	Total land- ings	Stock biomass	Spawn. stock biomass+
555	0.24	1.990	1.528	0.28	500*	Maintain catch level	1 598	1 150	0.37	500*	1 228	803
						$F_{86} = F_{85}$	1 598	1 191	0.28	388	1.328	954
						$F_{85} = F_{0.1}$	1 598	1 244	0.16	240	1 460	1 106
						$F_{85} = M$	1 598	1 257	0.15	220	1 493	1 125
						No fishing	1 598	1 323	0	0	1 676	1 365

+ Spawning stock biomass estimated at 1 June.

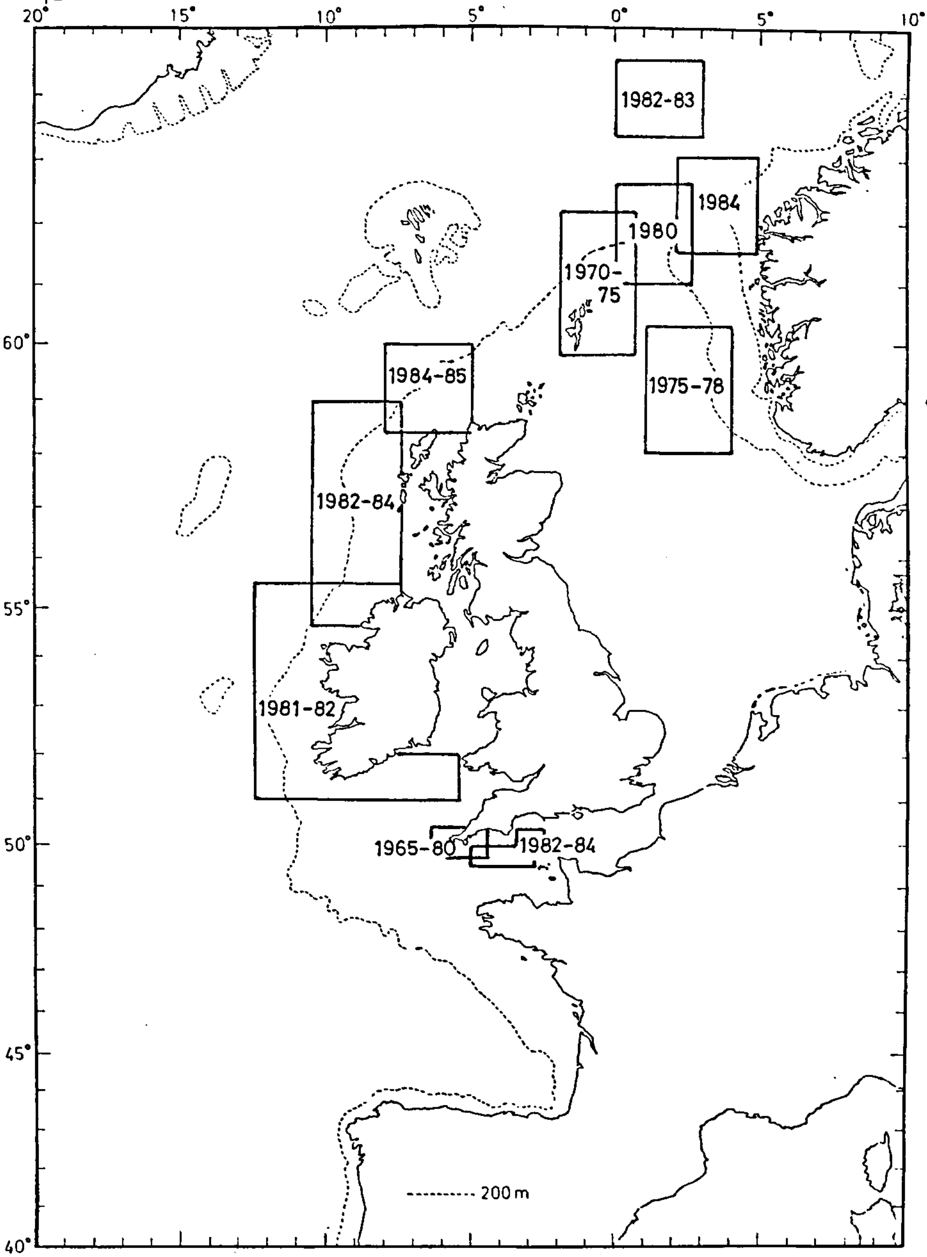


Figure 2.1. Shifts in the position of the main Western stock fisheries during summer north and east of Shetland and during winter south and west of the British Isles.

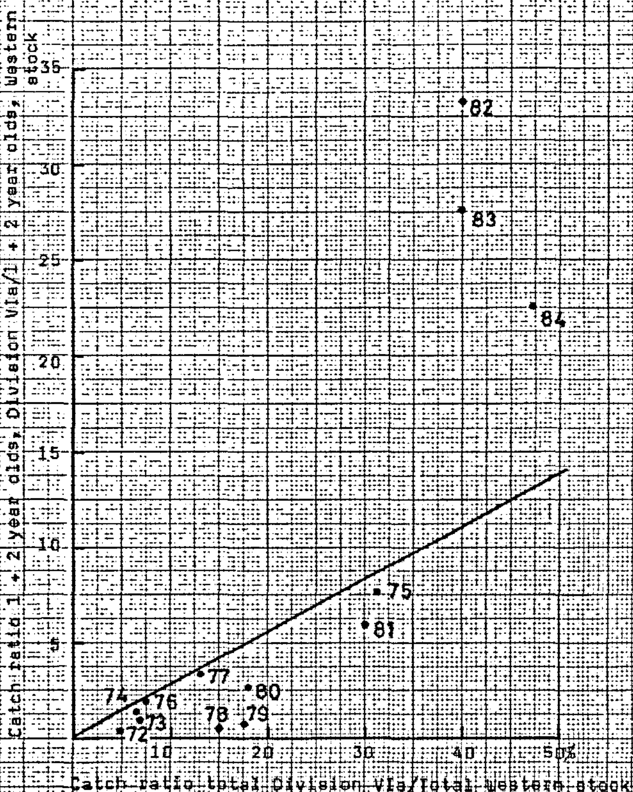


Figure 2.2. The relationship between the juvenile fish (1 + 2 year olds) in Division VIa catches relative to juvenile fish in the Western stock catches and the total Division VIa catch relative to the total Western stock catch. The straight line is drawn (not fitted) to delimit the distribution of observations up to, and including, 1981.

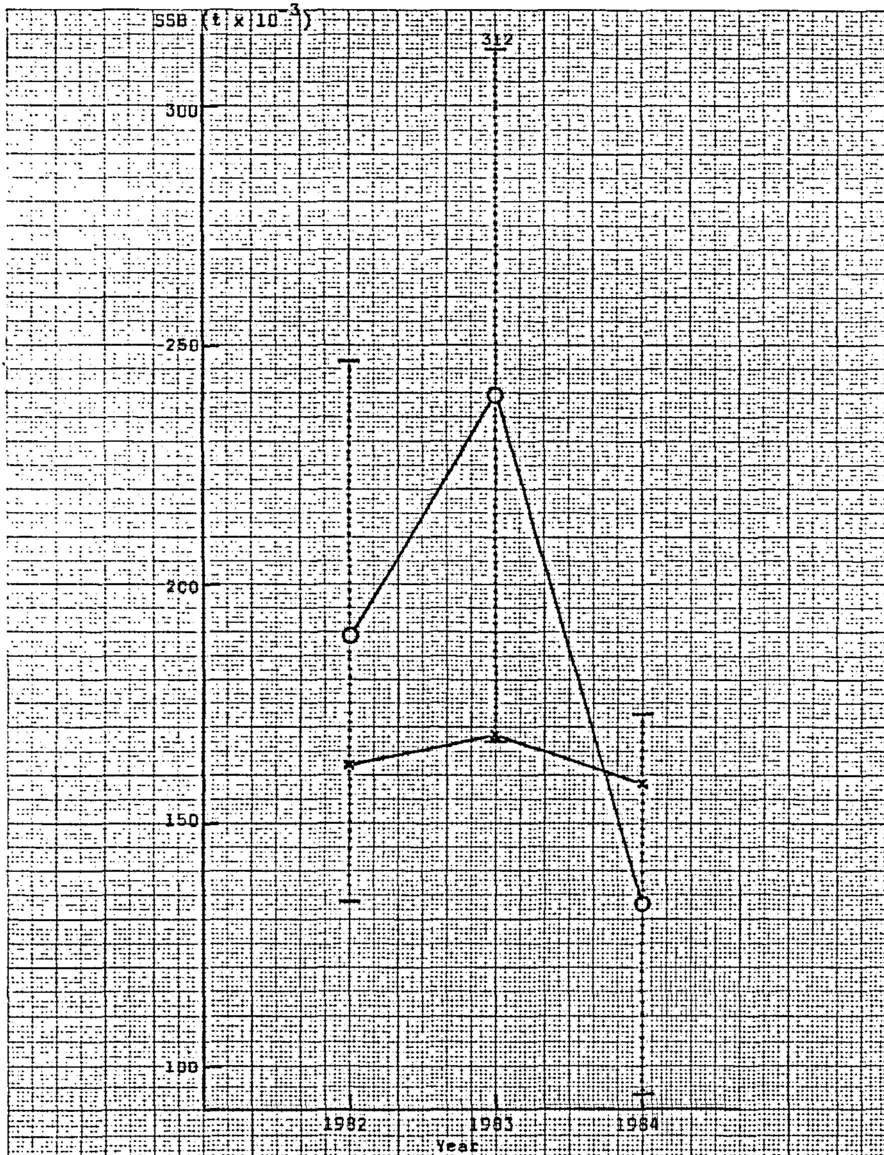


Figure 3.1. Spawning stock biomass for the North Sea mackerel stock for 1982-84 as estimated from egg production estimates (o——o) and from the VPA (x——x). Vertical bars reflect the ± 30% error limits around the spawning stock estimates from the egg surveys.

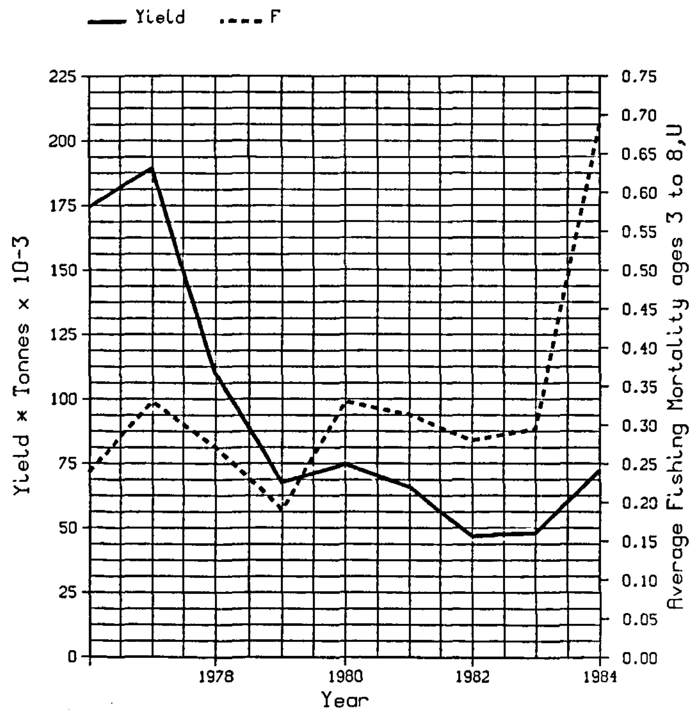
FISH STOCK SUMMARY

STOCK: Mackerel North Sea

6-3-1985

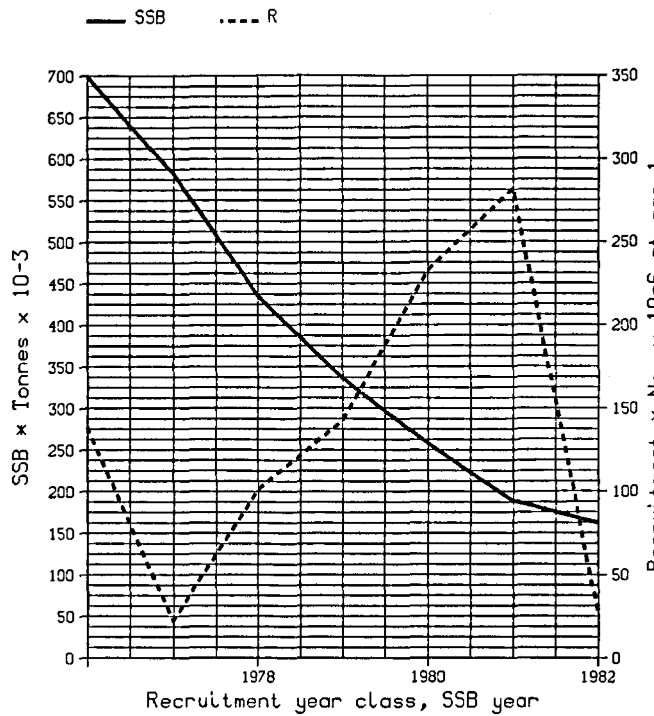
Figure 3.2.

Trends in yield and fishing mortality (F)



A

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



B

Continued..

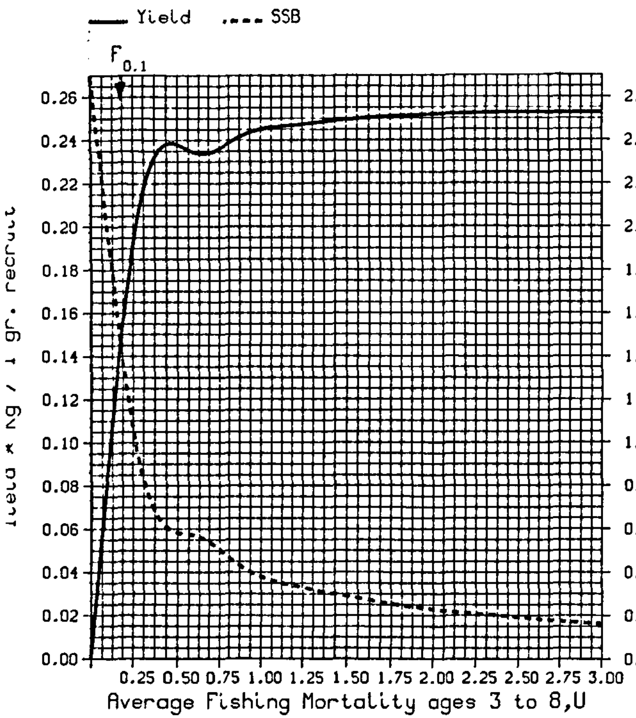
FISH STOCK SUMMARY

STOCK: Mackerel North Sea

6-3-1985

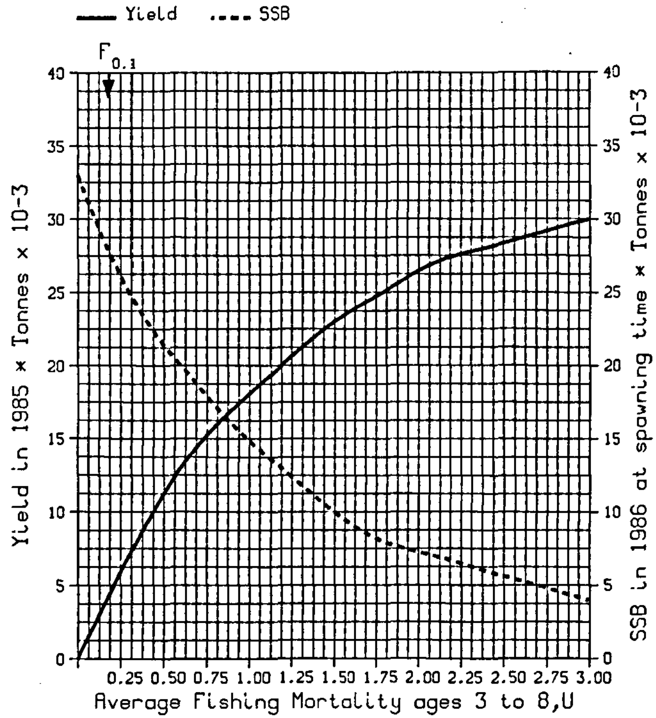
Figure 3.2. (Continued)

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



D

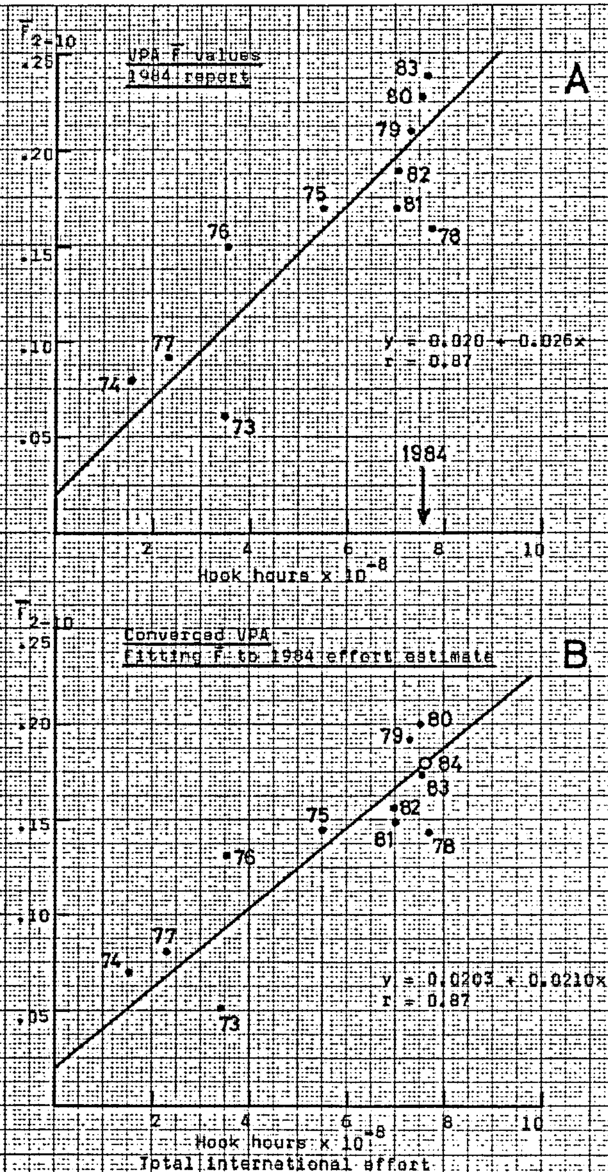


Figure 4.1. Relationship between total international effort, measured in terms of Cornish handline effort (3Q cpue) and $\bar{F}_{2-10}$: a) using terminal F values from VPA 1973-83 in Anon. (1984) and b) the converged VPA incorporating 1984 effort data.

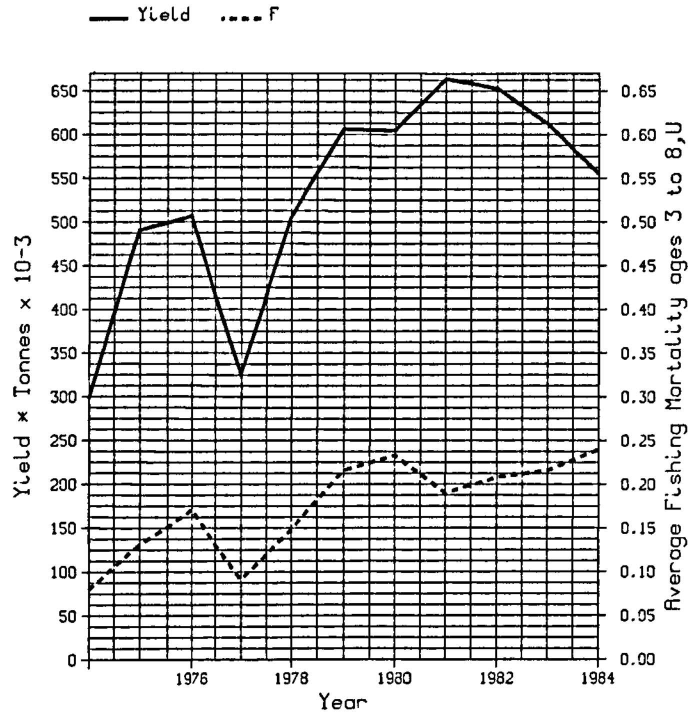
FISH STOCK SUMMARY

STOCK: Western Mackerel

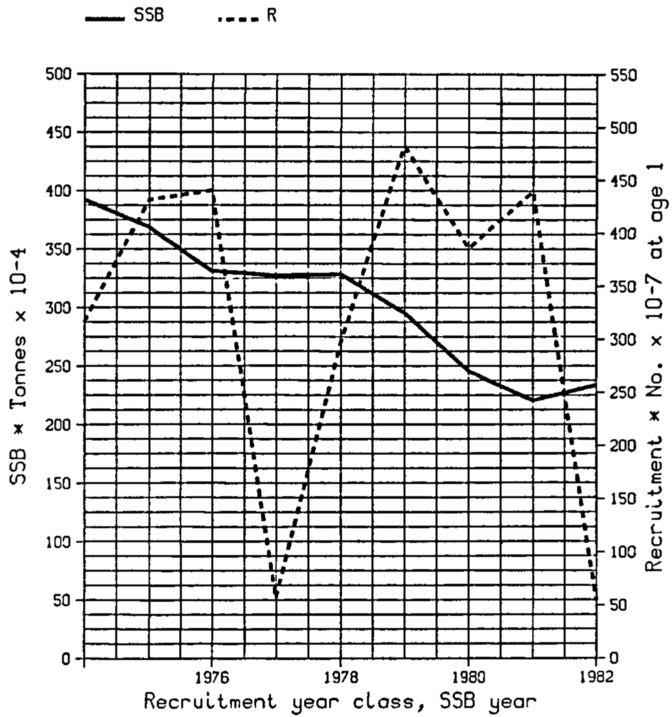
5-3-1985

Figure 4.2.

Trends in yield and fishing mortality (F)



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



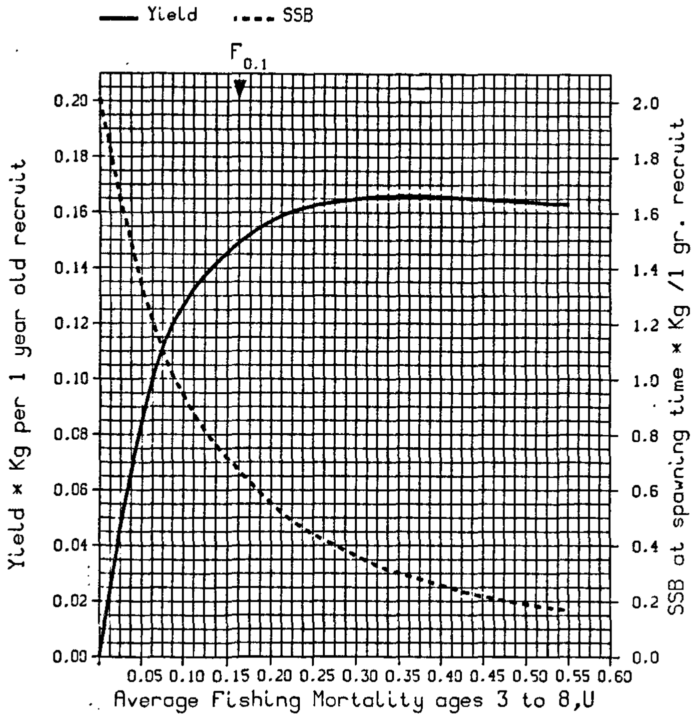
B

/Continued

FISH STOCK SUMMARY
STOCK: Western Mackerel
5-3-1985

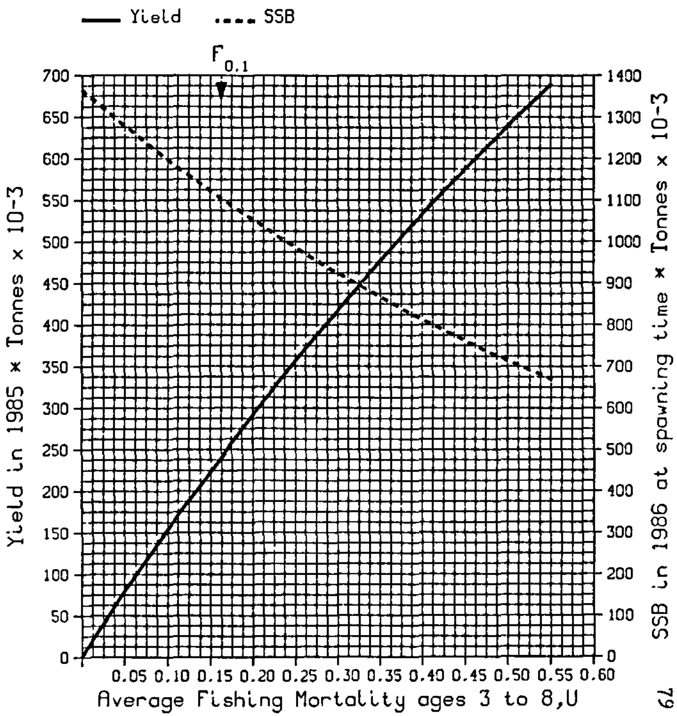
Figure 4.2 (Continued)

Long term yield and spawning stock biomass (kg)



C

Short-term yield and spawning stock biomass



D

Data for the Multispecies Working Group

Data requested by the Multispecies Working Group are given in Appendix Tables 1-13 (catch at age by quarters) and Appendix Table 14 (mean weight at age by quarters) for the years 1972-84.

The sources of the data and the calculation procedures are outlined below. For all years, the annual catch in number by age were obtained from Anon. (1984a, Table 3.10).

1972

The catch of mackerel in 1972 by ICES Divisions and quarters was reported in Anon. (1975, Table 3a). Sums of catches in tonnes for Divisions IVa-c and IIIa by quarters were used to split the total catch in number (303.2×10^6) into quarters. Catches not specified to period were excluded.

	Quarter				
	I	II	III	IV	Total
Tonnes	311	8 562	117,488	36,401	161,762
%	0.2	5.3	72.1	22.4	

These percentages were applied to the catch in number by age and the results are given in App. Table 1.

1973

The catch of mackerel in 1973 by quarters was reported in Anon. (1975, Table 2.1.3). Percentage catch by quarters was calculated for 1972.

	Quarter				
	I	II	III	IV	Total
Tonnes	3,614	9,081	276,625	71,012	360,332
%	1.0	2.5	76.8	19.7	

The results are given in App. Table 2.

1974

The catch of mackerel in 1974 by ICES Divisions and periods was reported in Anon. (1975, Table 2.1.4). The sums of catches in tonnes for Divisions IVa-c and IIIa by quarters were used to split the total catch in number (3,177.5 x 10^6) into quarters. Catches not specified to period were excluded.

	Quarter				Total
	I	II	III	IV	
Tonnes	1,830	7,937	205,828	60,736	276,331
%	0.6	2.9	74.5	22.0	

These percentages were applied to the catch in number by age and the results are given in App. Table 3.

1975

Catches of mackerel in 1975 by quarters are given in Anon. (1976, Table 2.1.5) and the percentage catch by quarters was calculated as for 1974.

	Quarter				Total
	I	II	III	IV	
Tonnes	1,426	15,723	107,732	122,204	247,085
%	0.6	6.3	43.6	49.5	

The results are given in App. Table 4.

1976

Data on catches of mackerel by quarters were not available for 1976. According to records of the fishery, catches in Sub-area IV and Division IIIa were dominated by the Norwegian and Faroes fisheries, accounting for 260,800 tonnes, or 85% of the total. These fisheries took place in the Shetland area, i.e. to the northeast (July) and east (August-September) of Shetland. Later (October), about 40,000 tonnes were taken off southwestern Norway.

The following catches and percentages by quarters were assumed:

	Quarter				Total
	I	II	III	IV	
Tonnes	2,000	5,000	200,000	56,000	263,085
%	1	2	76	21	

The resulting catch in number by age and quarters are given in App. Table 5.

1977

Landings of mackerel (tonnes) by quarters in 1977 were given in Anon. (1978, Table 2.3). Catch in number by age from Division IVa had been allocated to the North Sea and Western stocks using proportions derived from tagging data applied to the yearly catch. A major part of the catch was taken in Division IVa.

Percentage catch by quarter was calculated from catches reported in Sub-area IV and Division IIIa as given in Table 2.3 referred to above.

	Quarter				Total
	I	II	III	IV	
Tonnes	713	7,540	194,215	20,131	222,599
%	0.3	3.4	87.3	9.0	

Results are given in App. Table 6.

1978

Catch in number by quarter for the North Sea stock of mackerel was available from the files of the Mackerel Working Group:

Quarter	Catch in number, x 10^{-3}
I	2,748.7
II	11,647.1
III	235,119.1
IV	8,074.8
Total	257 589.7

This total, however, is higher than that used in the VPA. The origin of the discrepancy could not be identified, and it was decided to apply quarterly percentages as derived from the above data to the total catch in number used for the VPA (225.9 x 10^6):

	Quarter			
	I	II	III	IV
%	1.1	4.5	91.3	3.1

The results are given in App. Table 7.

1979

Landings of mackerel (tonnes) by quarters in 1979 were given in Anon. (1980, Table 2.3) as a sum for Sub-area IV and Division IIIa (also including 5 470 tonnes from Division IIa). A total of 101 705 tonnes was taken in Division IVa and about 36% of this quantity was allocated to the North Sea stock. All Division VIa catches were assumed to be of the Western stock.

On this basis, the proportions of the catch by quarter for the North Sea stock were calculated from Table 2.3.

	Quarter				Total
	I	II	III	IV	
Tonnes	21	5,506	140,250	7,525	153,302
%	0	4	91	5	

Results are given in App. Table 8.

1980

Landings of mackerel (tonnes) by quarters in 1980 for the different areas were given in Anon. (1981, Table 2.3.) Catches taken in Divisions IIa, IVa, and VIa were of mixed stock origin and various mixing ratios had therefore been applied to split the catches.

On the basis of these ratios and the reported landings, the following catches in tonnes by quarters and percentages were estimated for the North Sea stock:

	Quarter				
Division	I	II	III	IV	Total
IIa IIIa + IVa VIa	 699 4,791	 2,329 	3,529 34,492 	 2,230 33,681	
Tonnes	5,490	2,329	38,020	35,911	81,750
%	6.7	2.9	46.5	43.9	

The estimated catches in number by age and quarter are given in App. Table 9.

1981

Landings of mackerel (tonnes) by quarter in 1981 were given in Anon. (1981, Table 2.3) Catches in Division IIa and Division VIa north from the first and fourth quarters, had been allocated to the North Sea and Western stocks by applying mixing ratios from tagging results.

The catch of North Sea mackerel taken in the various areas by quarters was estimated from Table 2.3 and the overall mixing ratios applied directly to the catch in tonnes.

	Quarter				
Division	I	II	III	IV	Total
IIa IIIa + IVa-c VIa, north	 2,002 592	 6,141 	1,696 49,708 	 1,724 3,809	
Tonnes	2,594	6,141	51,404	5,533	65,672
%	3.9	9.4	78.3	8.4	

These percentages were applied to catch in number by age, App. Table 10.

1982

Quarterly catches of mackerel (tonnes) in 1982 by areas were reported in Anon. (1984c, Table 3.1.C) As in preceding years, catches in Division IIa and Division VIa were allocated to stock by applying estimated mixing ratios.

The following catches in tonnes by quarters were estimated:

	Quarter				
Division	I	II	III	IV	Total
IIa		10	3,730		
IIIa		1,100	3,200	200	
IVa-c	200	3,500	22,400	2,100	
VIa, north	867			6,680	
Tonnes	1,067	4,610	29,330	8,980	43,987
%	2.4	10.5	66.7	20.4	

The percentages were applied to total catch in number by age (93.8 x 10^6) and the results are given in App. Table 11.

1983

Quarterly catches of mackerel (tonnes) in 1983 were reported in Table 3.3 of the 1984 Mackerel Working Group report (Anon., 1984). Based on this and the stock mixing ratios as outlined above, the following catches in tonnes were estimated:

	Quarter				
Division	I	II	III	IV	Total
IIa			4,850	30	
IIIa		300	4,800	400	
IVa-c	100	1,900	26,700	1,400	
VIa, north	1,470	-	-	11,820	
Tonnes	1,570	2,200	36,350	13,650	53,770
%	3	4	68	25	

The sums by area are somewhat different from those given in Anon. (1984a, Table 3.7) as regards Division VIa north.

The percentages given above were applied to the catch in number. The results are given in App. Table 12.

1984

Catch in number by age and quarter for the North Sea stock of mackerel for 1984 was compiled by the Working Group at the 1985 Meeting.

The sources of data are described in the main part of the present report.

The calculated number by quarters are given in App. Table 13.

App. Table 1 Catch in number by age by quarter North Sea stock of mackerel 1972 Number x 10^6

Age	I	II	III	IV	Total
1	+	0.1	1.9	0.6	2.6
2	0.1	1.9	25.7	7.9	35.6
3	0.3	8.6	117.3	36.4	162.6
4	0.1	1.8	23.9	7.4	33.2
5	+	1.1	15.4	4.8	21.3
6	0.1	1.2	16.9	5.3	23.5
7	+	0.6	7.7	2.4	10.7
8	-	0.1	1.0	0.3	1.4
9	-	0.1	0.4	0.1	0.6
10+	+	0.6	8.5	2.6	11.7
Total	0.6	16.1	218.6	67.8	303.2

App. Table 2 Catch in number by age by quarter North Sea mackerel stock 1973 Number x 10^6

Age	I	II	III	IV	Total
1	+	0.1	3.5	0.9	4.5
2	0.1	0.3	9.3	2.4	12.1
3	0.4	0.9	28.9	7.4	37.6
4	2.8	7.0	215.2	55.2	280.2
5	0.7	1.9	57.1	14.6	74.3
6	0.4	0.9	27.6	7.1	36.0
7	0.2	0.5	15.1	3.9	19.7
8	0.3	0.9	26.7	6.9	34.8
9	-	-	0.4	0.1	0.5
10	-	-	-	-	-
11+	+	0.1	3.1	0.8	4.0
Total	4.9	12.6	386.9	99.3	503.7

App. Table 3 Catch in number by age by quarter North Sea stock of mackerel 1974 Number x 10^6

Age	I	II	III	IV	Total
1	2.5	13.2	337.6	99.7	453.2
2	1.1	5.4	137.5	40.6	184.6
3	2.0	9.9	254.6	75.2	341.7
4	1.5	7.0	180.4	53.2	242.1
5	7.9	38.2	982.7	290.2	1 319.0
6	1.6	8.0	204.4	60.3	274.3
7	0.6	2.9	74.2	21.9	99.6
8	0.7	3.3	84.8	25.1	113.9
9	0.3	1.5	38.1	11.2	51.1
10	0.1	0.2	6.5	1.9	8.7
11	-	0.1	1.1	0.3	1.5
12+	0.5	2.6	65.4	19.3	87.8
Total	19.0	92.3	2 367.3	698.9	3 177.5

App. Table 4 Catch in number by age by quarter North Sea stock of mackerel 1975 Number x 10^6

Age	I	II	III	IV	Total
1	0.1	0.7	5.2	5.9	11.9
2	0.1	0.6	4.4	5.0	10.1
3	0.1	1.0	7.1	8.0	16.2
4	0.2	2.7	18.5	21.0	42.4
5	0.2	1.7	12.1	13.8	27.8
6	1.2	12.2	84.2	95.6	193.2
7	0.1	1.6	11.2	12.7	25.6
8	0.1	1.3	8.9	10.1	20.4
9	0.1	1.0	6.9	7.8	15.8
10	+	0.3	2.2	2.5	5.0
11	-	+	0.3	0.2	0.5
12	-	-	0.3	0.1	0.2
13	0.1	1.4	9.7	11.0	22.2
14 15+					
Total	2.3	24.5	170.8	193.7	391.3

App. Table 5 Catch in number by age by quarter North Sea stock of mackerel 1976 Number x 10^6

Age	I	II	III	IV	Total
1	+	0.1	2.1	0.5	2.7
2	0.7	1.5	55.9	15.5	73.6
3	0.7	1.4	53.0	14.6	69.7
4	0.1	0.3	10.6	2.9	13.9
5	0.3	0.7	25.7	7.1	33.8
6	0.2	0.4	14.8	4.1	19.5
7	1.2	2.4	90.1	24.9	118.6
8	0.3	0.6	23.8	6.6	31.3
9	0.1	0.1	6.1	1.7	8.0
10	0.1	0.2	6.8	1.9	9.0
11	0.1	0.1	3.0	0.8	4.0
12	+	+	0.4	0.1	0.5
13	+	+	0.1	+	0.1
14+	+	0.1	2.6	0.7	3.4
Total	3.8	7.9	295.0	81.4	388.1

App. Table 6 Catch in number by age by quarter North Sea stock of mackerel 1977 Number x 10^6

Age	I	II	III	IV	Total
1	+	+	1.0	0.1	1.1
2	0.1	0.7	16.8	1.7	19.3
3	0.2	2.0	51.4	5.3	58.9
4	0.2	1.8	47.4	4.9	54.3
5	+	0.3	8.6	0.9	9.8
6	0.1	0.9	23.2	2.4	26.6
7	0.1	1.1	27.6	2.8	31.6
8	0.4	4.3	109.9	11.3	125.9
9	0.1	1.1	27.2	2.8	31.2
10	+	0.3	7.2	0.8	8.3
11	+	0.3	7.7	0.8	8.8
12	+	0.2	3.9	0.4	4.5
13	+	+	0.7	0.1	0.8
14	-	+	0.1	+	0.1
15+	+	0.1	2.2	0.2	2.5
Total	1.2	13.1	334.9	34.5	383.7

App. Table 7 Catch in number by age by quarter North Sea stock of mackerel 1978 Number x 10^6

Age	I	II	III	IV	Total
1	-	-	-	-	-
2	0.1	0.4	7.5	0.2	8.2
3	0.4	1.5	31.7	1.1	34.7
4	0.4	1.8	37.3	1.3	40.8
5	0.3	1.2	25.5	0.9	27.9
6	0.1	0.3	5.4	0.2	6.0
7	0.2	0.6	13.0	0.4	14.2
8	0.2	0.7	14.7	0.5	16.1
9	0.5	2.1	41.7	1.4	45.7
10	0.2	0.7	13.3	0.4	14.6
11	0.1	0.2	5.0	0.2	5.5
12	0.1	0.2	5.0	0.2	5.5
13	0.1	0.1	2.6	0.1	2.9
14	+	0.1	0.5	+	0.6
15+	0.1	0.1	2.9	0.1	3.2
Total	2.8	10.0	206.1	7.0	225.9

App. Table 8 Catch in number by age by quarter North Sea stock of mackerel 1979 Number x 10^6

Age	I	II	III	IV	Total
1	-	0.1	2.1	0.1	2.3
2	-	+	0.5	+	0.5
3	-	0.4	10.3	0.6	11.3
4	-	0.8	19.3	1.1	21.2
5	-	1.3	30.3	1.7	33.3
6	-	0.6	13.0	0.7	14.3
7	-	0.2	3.8	0.2	4.2
8	-	0.4	8.4	0.4	9.2
9	-	0.1	1.8	0.1	2.0
10	-	1.1	24.6	1.3	27.0
11	-	0.2	4.7	0.3	5.2
12	-	0.1	1.8	0.1	2.0
13	-	0.1	1.8	0.1	2.0
14	-	+	1.1	0.1	1.2
15+	-	0.1	2.1	0.1	2.3
Total	-	5.5	125.6	6.9	138.0

App. Table 9 Catch in number by age by quarter North Sea stock of mackerel 1980 Number x 10^6

Age	I	II	III	IV	Total
1	0.2	0.1	1.2	1.2	2.7
2	0.4	0.2	2.6	2.4	5.6
3	0.2	0.1	1.1	1.0	2.4
4	1.0	0.4	6.6	6.3	14.3
5	1.6	0.7	10.9	10.3	23.5
6	1.7	0.8	12.0	11.4	25.9
7	1.0	0.5	7.1	6.7	15.3
8	0.6	0.2	3.9	3.7	8.4
9	0.9	0.4	6.5	6.2	14.0
10	0.2	0.1	1.6	1.6	3.5
11	1.3	0.5	9.0	8.5	19.3
12	0.2	0.1	1.8	1.7	3.8
13	0.1	+	0.6	0.6	1.3
14	0.1	0.1	0.7	0.7	1.6
15+	0.1	0.1	1.0	1.0	2.2
Total	9.6	4.3	66.6	63.3	143.8

App. Table 10 Catch in number by age by quarter North Sea stock of mackerel 1981 Number x 10^6

Age	I	II	III	IV	Total
1	0.2	0.4	3.0	0.3	3.9
2	0.2	0.6	4.7	0.5	6.0
3	0.4	1.1	9.0	1.0	11.5
4	+	0.1	0.9	0.1	1.1
5	0.5	1.2	9.8	1.0	12.5
6	0.7	1.6	13.6	1.5	17.4
7	0.7	1.7	14.0	1.5	17.9
8	0.4	1.0	8.2	0.9	10.5
9	0.2	0.5	4.2	0.5	5.4
10	0.3	0.7	5.9	0.6	7.5
11	0.1	0.2	1.7	0.2	2.2
12	0.8	1.9	16.0	1.7	20.4
13	0.1	0.2	1.4	0.1	1.8
14	0.1	0.2	1.9	0.2	2.4
15+	0.1	0.1	1.2	0.1	1.5
Total	4.8	11.5	95.5	10.2	122.0

App. Table 11 Catch in number by age by quarter North Sea stock of mackerel 1982 Number x 10^6

Age	I	II	III	IV	Total
1	0.1	0.3	2.0	0.6	3.0
2	0.3	1.5	9.6	2.9	14.3
3	0.4	1.6	10.3	3.2	15.5
4	0.2	1.0	6.5	2.0	9.7
5	0.1	0.2	1.3	0.4	2.0
6	0.2	0.8	5.1	1.6	7.7
7	0.2	0.8	5.0	1.6	7.6
8	0.2	0.9	5.5	1.7	8.3
9	0.1	0.6	3.5	1.1	5.3
10	0.1	0.3	2.0	0.6	3.0
11	0.1	0.4	2.4	0.7	3.6
12	0.1	0.2	1.5	0.4	2.2
13	0.2	0.9	5.7	1.8	8.6
14	+	0.2	1.1	0.4	1.7
15+	+	0.1	0.9.	0.3	1.3
Total	2.3	9.8	62.4	19.3	93.8

App. Table 12 Catch in number by age by quarter North Sea stock of mackerel 1983 Number x 10^6

Age	I	II	III	IV	Total
1	+	+	0.1	+	0.1
2	0.5	0.7	11.5	4.2	16.9
3	0.8	1.2	19.1 0.3)*	7.0	28.4
4	0.5	0.7	11.1 0.2)*	4.1	16.6
5	0.2	0.3	4.6	1.7	6.8
6	+	+	0.7	0.3	1.0
7	0.2	0.2	3.7	1.4	5.5
8	0.2	0.3	4.4	1.6	6.5
9	0.1	0.2	3.4	1.2	4.9
10	0.1	0.2	2.9	1.1	4.3
11	0.1	0.1	1.2	0.4	1.8
12	0.1	0.1	2.2	0.8	3.2
13	+	+	0.8	0.3	1.2
14	0.2	0.3	5.4	2.0	7.9
15+	0.1	0.1	1.2	0.4	1.8
Total	3.1	4.4	72.3	26.5	106.9

*Added due to adjusted catch data.
[The sums by age differ slightly from those of Table 3.10 due to roundings]

App. Table 13 Catch in number by age by quarter North Sea stock of mackerel 1984 Number x 10^6

Age	I	II	III	IV	Table
1	0	0	0	+	0
2	0	0.3	2.7	+	3.0
3	1.2	0.7	34.8	25.2	61.9
4	1.1	1.1	20.5	14.3	37.0
5	0.8	0.3	10.0	8.5	19.6
6	0.4	0.2	5.7	3.4	9.7
7	0.1	0.1	1.1	1.4	2.7
8	0.2	0.3	2.6	2.4	5.5
9	0.1	0.1	2.9	2.0	5.1
10	0.1	0.3	3.2	1.6	5.2
11	0.1	0.1	1.4	1.5	3.1
12	+	0.1	1.2	0.5	1.8
13	0.1	0.2	0.8	0.8	1.9
14	+	0.2	0.1	0.5	0.8
15+	0.1	0.4	2.5	1.2	4.2
Total	4.3	4.4	89.5	63.3	161.5

App. Table 14 Weight at age in the catch from the North Sea stock

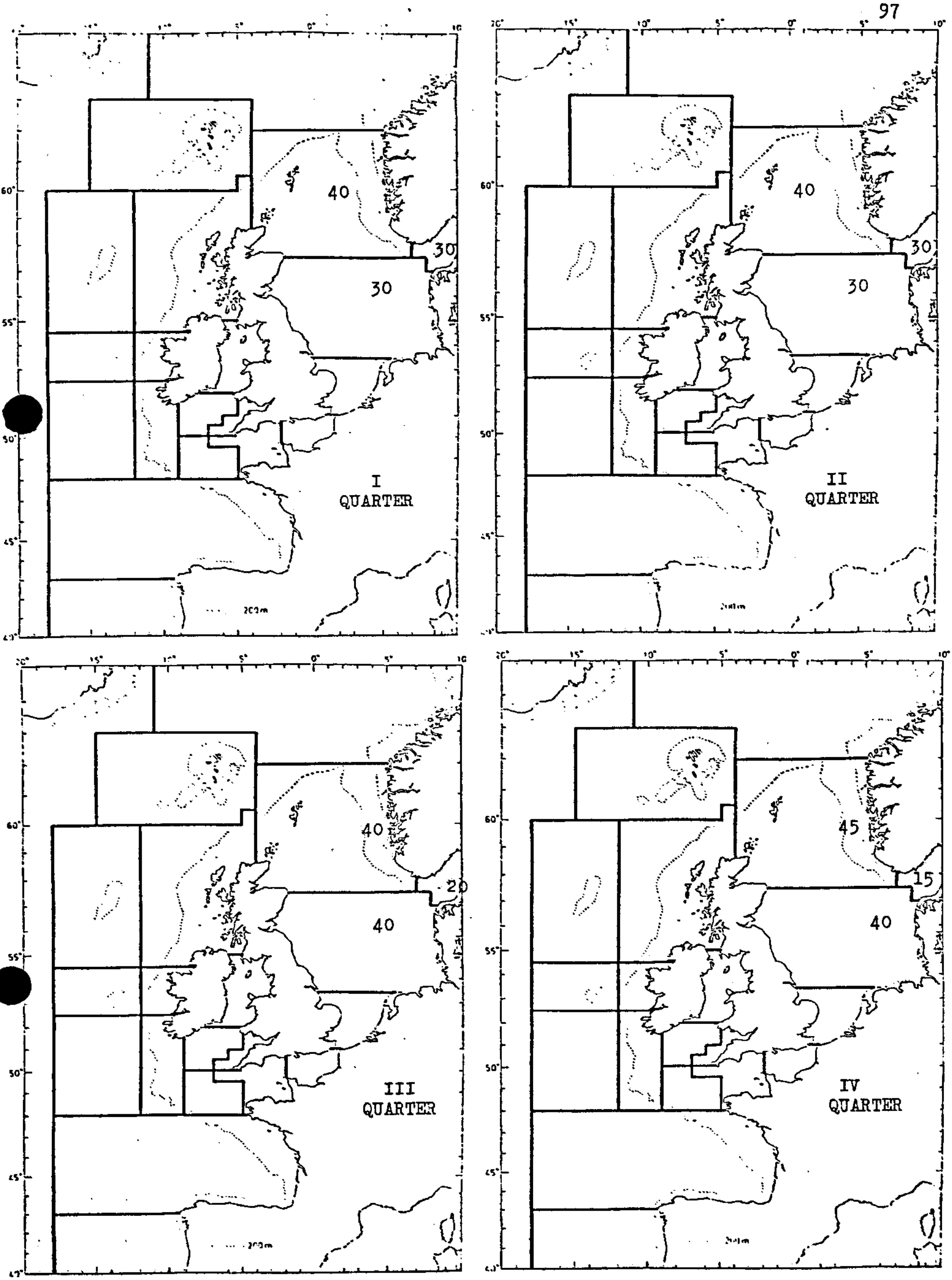
Year	1972-76				1977				1978			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Age 0	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	.217	.252	.123	-	.250	.245	.123	-	-	.201
2	-	.340	.315	.377	.234	.206	.334	.334	.234	.318	.384	.303
3	-	.404	.371	.450	.325	.309	.367	.342	.325	.306	.323	.273
4	-	.385	.372	.401	.338	.362	.393	.393	.338	.332	.401	.411
5	-	.423	.414	.449	.350	.423	.441	.424	.350	.361	.480	.479
6	-	.470	.478	.497	.346	.437	.455	.463	.346	.355	.459	.434
7	-	.477	.474	.477	.468	.481	.523	.503	.468	.417	.486	.495
8	-	.520	.481	.523	.472	.553	.588	.521	.472	.405	.533	.441
9	-	.489	.508	.561	-	-	-	-	.505	.510	.536	.516
10	-	.640	.576	.566	-	-	-	-	.535	.567	.651	.603
11+	-	.601	.636	.661	-	-	-	-	-	-	-	-

App. Table 14 (cont'd)

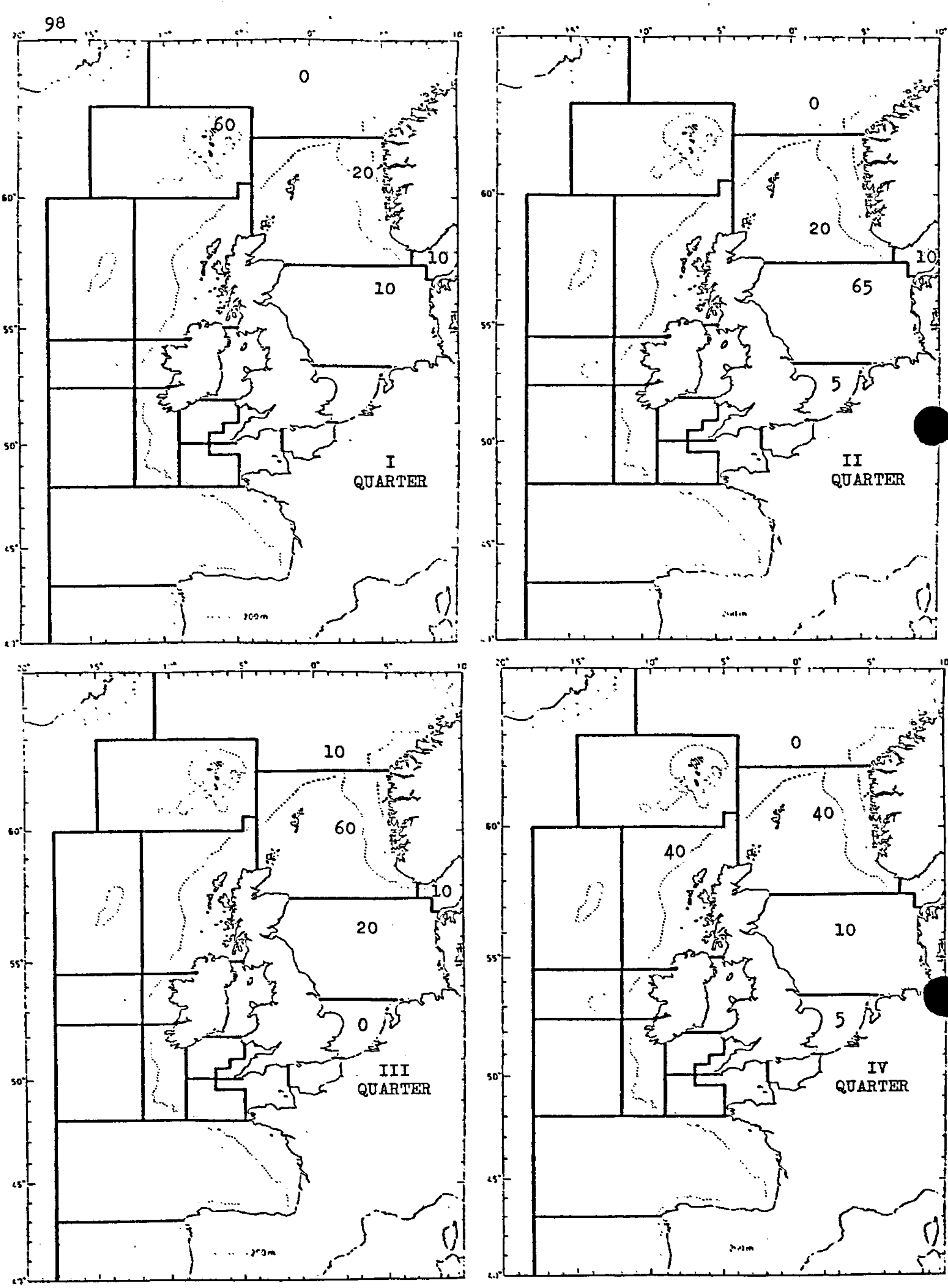
Year	1979				1980				1981			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Age 0	-	-	-	-	-	-	-	-	-	-	-	-
1	.123	-	-	.201	.123	-	-	.201	.123	.180	.245	-
2	.234	.318	.384	.303	.234	.318	.384	.303	.234	.275	.329	-
3	.325	.306	.323	.273	.325	.306	.323	.273	.325	.330	.363	-
4	.338	.332	.401	.411	.338	.332	.401	.411	.338	.415	.392	-
5	.350	.361	.480	.479	.350	.361	.480	.479	.350	.460	.438	-
6	.346	.355	.459	.434	.346	.355	.459	.434	.346	.495	.455	-
7	.468	.417	.486	.495	.468	.417	.486	.495	.468	.575	.520	-
8	.472	.405	.533	.441	.472	.405	.533	.441	.472	.550	.580	-
9	.505	.510	.536	.516	.505	.510	.536	.516	.505	.565	.585	-
10	.535	.567	.651	.603	.535	.567	.651	.603	.535	.590	.610	-
11	-	-	-	-	-	-	-	-	.560	.610	.637	-
12	-	-	-	-	-	-	-	-	.585	.630	.655	-
13	-	-	-	-	-	-	-	-	.605	.645	.670	-
14	-	-	-	-	-	-	-	-	.615	.650	.685	-
15+	-	-	-	-	-	-	-	-	.650	.675	.685	-

App. Table 14 (cont'd)

Year	1982				1983				1984			
Quarter	1	2	3	4	1	2	3	4	1	2	3	4
Age 0	-	-	-	-	-	-	-	-	-	-	-	.083
1	.123	.180	.245	.196	.123	.180	.245	.231	-	-	-	.270
2	.234	.275	.329	.243	.234	.275	.329	.268	.199	.346	.349	.349
3	.325	.330	.363	.303	.325	.330	.363	.317	.263	.385	.401	.377
4	.335	.415	.392	.375	.335	.415	.392	.377	.296	.488	.415	.392
5	.350	.460	.438	.465	.350	.460	.438	.443	.310	.499	.452	.420
6	.346	.495	.455	.455	.346	.495	.455	.472	.362	.570	.512	.489
7	.468	.525	.520	.536	.468	.525	.520	.503	.400	.628	.548	.577
8	.472	.550	.580	.595	.472	.550	.580	.578	.416	.630	.564	.562
9	.505	.565	.585	.561	.505	.565	.585	.610	.513	.736	.653	.615
10	.535	.590	.610	.588	.535	.590	.610	.599	.534	.643	.660	.683
11	.560	.610	.637	.596	.560	.610	.637	-	.494	.598	.666	.653
12	.585	.630	.655	.682	.585	.630	.655	.616	.556	.662	.692	.708
13	.605	.645	.670	.687	.605	.645	.670	.670	.572	.606	.683	.662
14	.615	.650	.675	.666	.615	.650	.675	.760	.648	.746	.772	.721
15+	.650	.675	.685	.746	.650	.675	.685	.716	.652	.644	.791	.746



App. Figure 1. Approximate quarterly distribution(% , numbers), of the immature North Sea mackerel stock. Percentages are not derived from quantitative observations and are intended only for use by the Multispecies Working Group as indications of average distribution by area and time during the period 1972-84.



App. Figure 2. Approximate quarterly distribution (%, numbers) of the mature North Sea mackerel stock. Percentages are not derived from quantitative observations and are intended only for use by the Multispecies Working Group as indications of average distribution by area and time during the period 1972-84.