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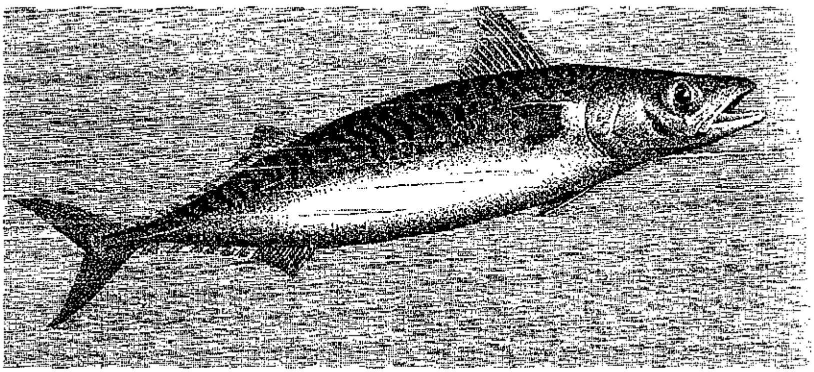

Report of the Mackerel Working Group

Copenhagen 24 april - 2 May

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1 INTRODUCTION

1.1 Terms of Reference

At the 77th Statutory Meeting in The Hague it was decided (C.Res. 1989/2:4:14) that the Mackerel Working Group (Chairman: E. Kirkegaard) should meet at ICES Headquarters from 24 April - 2 May 1990 to:

1) assess the status of and provide catch options for 1991 within safe biological limits for the mackerel stocks and management units in Sub-areas II-IX;

2) update the quantitative description of the distribution and relative abundance of juvenile mackerel by season and by as fine an area breakdown as possible, and re-evaluate possible management measures to limit the catches of juvenile mackerel;

3) for mackerel in Divisions VIIIc and IXa, consider possible fishery closures by area and season which could be introduced to reduce the exploitation of juveniles;

4) provide quarterly catch-at-age and catch and stock mean weight-at-age data and information on the relative distribution at different ages by quarter for North Sea mackerel for 1989 as input for the multispecies VPA, and provide information on the likely level of Western stock mackerel which are seasonally present in the North Sea;

5) define distribution areas of high priority for recruitment surveys.

1.2 Participants

The Working Group met in Copenhagen with the following participants:

W.A. Dawson	UK (England)
A. Eltink	Netherlands
P. Hopkins	UK (Scotland)
S.A. Iversen	Norway
E. Kirkegaard (Chairman)	Denmark
A.I. Krysov	USSR
P. Lucio	Spain
J. Molloy	Ireland
I.G. Priede (part-time	UK (Scotland)
D.A. Vasilyev	USSR
J. Watson (part-time)	UK (Scotland)

2 BIOMASS ESTIMATES FROM EGG SURVEYS

2.1 Review of the Mackerel/Horse Mackerel Egg Production Workshop

The Mackerel/Horse Mackerel Egg Production Workshop was held at the Fisheries Laboratory in Lowestoft, England from 29 January - 2 February 1990. The purpose of this meeting was to complete the analysis of the western mackerel/horse mackerel egg survey data for 1989, to estimate the rate of atresia, to prepare estimates of spawning stock size, and to compare the methodology used to estimate the spawning stock size from the total fecundity and the batch fecundity methods (Anon., 1990a).

The results from this Mackerel/Horse Mackerel Egg Production Workshop concerning mackerel are reviewed below.

General Aspects

Samples taken from the middle of the spawning area show mackerel spawning may occur throughout the 24-hour period. It is not confined to any time of the night or day.

New egg stage duration experiments have confirmed that the temperature regression for stage 1 eggs remains valid. Following fixation, the proportion of eggs identified as stage 1 remained the same, but the proportions at later stages were altered.

The results of a comparison of egg staging between countries showed that there is a wide variation in stage identification of stages 1a, 1b, 3, 4, and 5, with less variation for stage 2. The most important result was that stage 1 eggs (i.e., stages 1a and 1b combined), which are currently used by the Working Group for the determination of total egg production, were fairly accurately identified by all countries, with a variation of -7% to +10% from the overall mean.

North Sea Egg Survey

In 1989 the spawning area of mackerel in the North Sea was covered once at peak spawning time by a Norwegian research vessel. If this represents the peak of spawning, and it is assumed that the shape of the production curve was the same as in previous years, the estimated egg production is in the range of 34-56 x 10^{12} eggs. Assuming the curve to have the same shape as in 1989, the egg production corresponds to a spawning stock biomass of 53,000 t. In 1990, the Netherlands, Denmark, and Norway will carry out a North Sea egg survey for mackerel.

Western Egg Survey in 1989

The results for the first period (April) indicate an unusually high egg production. The Workshop regarded this as suspect, because it is about 8 times the production observed in previous years' surveys. Because no reason was found to reject the data provided, they were presented in the report in two ways by including and excluding the first survey. However, important information concerning the validity of the egg production estimate of the first coverage became available after this Workshop meeting. On 6 March 1990, when most participants of this Workshop met in Aberdeen for the meeting on "EC Batch Fecundity Method for Mackerel", it was agreed that the egg production of the first coverage should be rejected based on the information presented. The working document containing the arguments for rejecting the first survey was attached to the Workshop report as an appendix.

The total stage 1 egg production estimate for each survey period was plotted against the mid-cruise data to give a production curve based on only four points as shown in Figure 2.1 (revised from Anon., 1990a). In addition, production curves were calculated for the area north, east, and south of the standard area. The values for each area are presented in Table 2.1 (revised from

Anon., 1990a).

Using the data from periods 2 to 5, a total seasonal production of 1.41×10^{15} stage eggs is obtained for the standard area. Including the areas north, east, and south of the standard area increase the estimated by 6% to 1.50×10^{15} (Table 2.2). Spawning is also thought to occur to the west of the standard area but it is unlikely that much egg production was missed.

Two previous estimates of total potential fecundity have been made for the western mackerel stock in 1977 and in 1986. In 1989, a similar study was undertaken jointly by MAFF and DAFS in conjunction with Aberdeen University. The provisional results were used for calculating preliminary stock size estimates.

Atresia

As recommended by a previous workshop, further work was carried out to estimate atresia. Approximately one third of all ovaries examined contained atretic eggs. The model used by the workshop implies that atresia could be between 8% and 16% of the potential fecundity.

2.2 Application of the Batch Fecundity Method to the Western Mackerel Stock

"Under the terms of study contract No. DG XIV/B/1-1989/2 between the Commission of the European Communities and the University of Aberdeen, research is being carried out on the evaluation of the batch fecundity method for assessment of stocks of pelagic spawning fishes. The preliminary results of this research are presented in this section but do not necessarily reflect the opinion of the Commission of the European Commmunities and do not prejudice its future attitude in this field. The text of these Sections (2.2 and 2.3) may be reproduced, in whole or in part, quoting the source."

Organization

The Batch Fecundity programme was conducted in parallel with the ICES 1989 Assessment of the Spawning Stock Biomass of the Western Mackerel Stock using the total fecundity method (Watson and Priede, WD 1990, and Anon., 1990a). Under the batch fecundity method, biomass (B) is calculated as:

$$B = \frac{E_d}{F_{bw}\ S\ r} \qquad (1)$$

where E_d = estimated number of eggs.
F_{bw} = estimated batch fecundity per gramme fish weight.
S = spawning fraction.
and r = proportion of fish that are female, i.e. sex ratio.

E_d was derived as a subset of the data collected for the total fecundity method. In order to obtain estimates of F_{bw} and S, a trawl survey was undertaken of the spawning stock from 23 May to 12 June which is in the middle of the spawning season.

Fish at maturity stages 2-6 (Walsh, Appendix 1 in Watson and Priede, WD 1990) were selected at random from each of 51 trawl hauls, giving a total of 1,330 ovaries for histological analysis to determine the daily spawning fraction of the adult population (S). Ovaries with hydrated oocytes were selected for determination of batch fecundity F_{bw}. A total of 298 ovaries proved suitable for this analysis.

Figure 2.2 shows the area covered by the egg survey from 23 May to 12 June. For the purposes of biomass calculation, the area is divided into 3 sections.

Results

Total daily egg production corresponding to each statistical rectangle is shown in Figures 2.3 and 2.4. At this time, egg production was greatest off the west coast of Ireland extending westward towards the Porcupine Bank. These data were integrated to give daily egg production estimates for each section (Table 2.3).

Fecundity per gram (Fb_w) was estimated from a regression through the origin of batch size on fish weight for each sector. The estimates are given in Table 2.3.

There is a systematic change in batch fecundity with a decrease from south to north. It is assumed that this corresponds to a decrease in spawning output of individual fish as they move north during the spawning season (Watson and Priede, WD 1990).

The spawning fraction (S) was assumed to be equal to the proportion of fish with ovaries containing migratory nucleus stage oocytes. This assumes that the duration of the migratory nucleus stage is 24 hours. This is a provisional assumption, prior to completion of captive spawning experiments in Aberdeen. Such experiments will give more precise information on the stage duration, but evidence available to date indicates that the error in this assumption is no greater than 20%. The estimated spawning fractions are given in Figure 2.5. These were averaged over each section.

The spawning fraction also declined systematically from south to north suggesting that fish spawn every 1.6 days in the south, every 3 days in the centre, and every 5.5 days in the north. This may correspond to a northern migration of spawning fish.

For the purposes of biomass estimation, the sex ratio was assumed to be 1:1. Estimated biomass is given in Table 2.3

The total biomass of 2.352×10^6 t corresponds to a hypothetical population of fish, all with hydrated oocytes. A correction factor of 0.930 gives the biomass assuming all stage 3 (pre-spawning) fish as 2.220×10^6 t. This is directly comparable with the total fecundity method biomass estimate which is also based on pre-spawning fish (Table 2.6).

Conclusions

75% of the variance in the batch fecundity biomass estimate is derived from the egg production estimate. The precision of the new method is, therefore, limited by the egg survey rather than any intrinsic problems with our understanding of fish fecundity.

The batch method gives a higher estimate of biomass than the total fecundity method; 2.22 and 1.87 million t, respectively. This may be attributable to loss of eggs by the fish during the spawning season, so that the realised total fecundity is less than the pre-determined potential fecundity.

The mean batch fecundity of the overall population is 53.05 egg/g and the mean overall spawning interval is 2.92 days (Watson and Priede, WD 1990). To generate the observed egg production over the whole spawning season, each fish must spawn 23 batches requiring 67 days on the spawning ground. Using mean batch fecundity and spawning interval for the overall population, the net loss of eggs through atresia would need to be about 16% to account for this difference.

The EC-funded study contract has shown that the batch fecundity method can be applied to stocks of mackerel. The estimation of stock size using the batch fecundity method requires extensive sampling of the adult stock and this provides additional information on stock structure and distribution. This information is presented in Section 2.3.

2.3 Additional Information

The trawl survey provided fishery-independent information on the age structure of the stock in the survey area. An overall age composition was obtained from a weighted combination of the age compositions of individual hauls. Details of the method are documented in Watson & Priede (WD 1990). By clustering the hauls according to the similarities of age composition and grouping hauls in the same cluster which were geographically adjacent, sub-divisions of the survey area were defined. The age composition within each sub-division was then calculated as the mean of the hauls within the sub-division, weighted by catch rate. The age composition over the whole survey area was calculated as the mean of the sub-divisions, weighted by sub-division area and mean catch rate. The resulting estimate of the overall age composition is shown in Table 2.4. A comparison with the VPA estimate of age structure is given in Section 5.4.

Also shown in Table 2.4 are the proportions mature at age. All fish aged 3 years and older were found to be mature (Maturity stages 2-6). The proportions mature at ages 1 and 2 were calculated, using the same survey area sub-divisions as those used to calculate age compositions. The proportions of 1- and 2-year-olds which were immature males, immature females, mature males and mature females were calculated for each haul. The proportions over the whole survey area were found by combining the hauls in the same way as for the overall age composition, this time using the respective catch rates of 1- and 2-year-olds. This analysis indicated that 4% of males and less than 1% of females were mature at age 1. At age 2, 86% of males and 93% of females were mature. Maturity at age is discussed more fully in section 5.4.2.

2.4 Biomass Estimates

North Sea area

The total egg productions and spawning stock biomass estimates, as derived from the North Sea egg surveys, are listed by year in Table 2.5. The spawning stock estimate of 53,000 t in 1989 is based on only one coverage at peak spawning time and seems an increase of over 40% of the estimate of 37,000 t in 1988, but the stock is still at a very low level.

Western areas

The spawning stock biomass of mackerel as derived from the western egg surveys and as estimated by the traditional total fecundity method is 2.01 million t in 1989, which is an increase of 16% compared to the spawning stock biomass of 1.73 million t in 1986 estimated by the same method (Table 2.6).

The spawning stock biomass estimates by the traditional total fecundity method do not include a correction for atresia, which might possibly increase the spawning stock biomass values by 8-16% (see Section 2.1). Neither is it corrected for de novo vitellogenesis which might reduce the spawning stock biomass, although it does not seem to be significant.

The spawning stock biomass estimated by the batch fecundity method, which is not affected by atresia and de novo vitellogenesis, was estimated at 2.40 million t in 1989 (Table 2.6). The estimate of the total fecundity method is 16% lower than the spawning stock biomass as estimated by the batch fecundity method. The estimates of both methods appear to be in good agreement. The difference might be attributed to atresia.

The Working Group decided to use only the spawning stock biomass estimates from the total fecundity method for tuning the VPA, because only these data are available from previous egg surveys. The estimates were not corrected for atresia. The Working Group recommends that the comparison between the total fecundity method and the batch fecundity method should be repeated in 1992.

3 STOCK DISTRIBUTION AND MIXING

3.1 Revised Distribution of 1987 and 1988 Fisheries

The distribution of the fisheries for the first to fourth quarters has been revised for 1987 and 1988 to include the USSR catches. These are presented in Figures 3.1 and 3.2, respectively.

3.2 Distribution of Mackerel Fisheries in 1989

As for 1987 and 1988, the officially reported distribution of catches could not be taken as a reliable guide to where mackerel were actually caught in all areas and seasons (Anon., 1988a, 1989a). However, some flexibility to fish parts of the TAC for the western area east of the 4°W line enabled a catch allocation to be given within Division IVa to some EEC countries. This resulted in a mixture of accurate and inaccurate landing statistics. Those from the North Sea are presumed to be accurate while substantial inaccuracies exist in Division VIa data for the fourth quarter.

Catches taken in the first and fourth quarters from Division VIIe were reported as being caught to the south of the mackerel box, wherease it is thought that they came mainly from inside the box.

The quarterly distributions of the fisheries in 1989, as estimated by the Working Group, are shown in Figures 3.3A-D. These were was very similar to the distribution of the fisheries in 1988 (Anon., 1989a).

<u>First quarter</u>

In the first quarter (Figure 3.3A), catches were taken along the edge of the continental shelf to the west of the British Isles, off Ireland, and in the western Channel. The fishing area was much the same as in 1987 and 1988. Most of the catch was taken by trawlers. During the first quarter, the mackerel migrate from north to south through Divisions VIa and VIIb,c. The fishery reflects the migration from the northern area to the main spawning area.

In Division VIIIc, fishing was mainly on adult mackerel. The highest catches were taken in the eastern part of Division VIIIc. In Division IXa, fishing was mainly on 1-group mackerel.

<u>Second quarter</u>

In the second quarter (Figure 3.3B), the main catches in the Western area were taken south of Ireland in the spawning area. The fishing area was the same as in previous years. The catches north of Ireland were mainly taken as by-catch in the herring fishery. Another mackerel fishery in the second quarter took place off the coast of southwest Norway and in the Skagerrak. A small quantity was taken, mainly by drift nets and as by-catch in trawl fisheries.

In Divisions VIIIc, the fishery in the second quarter was similar to that in the first quarter. However, more than 50% of the catches by number in Division IXa consisted of 0-group mackerel.

<u>Third quarter</u>

In the third quarter (Figure 3.3C), the major fishery took place in the southeastern part of Division IIa and in the eastern part of Division IVa. The fishing area was very similar to that in 1988. Most of the catches were taken by purse seiners. Small by-catches were recorded in the southern and central North Sea.

In the eastern and central parts of Division VIIIc, the catches decreased to almost zero. Only in the western part of Division VIIIc and in Division IXa were there significant catches, which consisted mainly of 0-group mackerel.

<u>Fourth quarter</u>

In the fourth quarter of 1989 (Figure 3.3D), the main fishery shifted southwards from Division IIa to Division IVa. Although there are uncertainties about the exact fishing locations, it seems that most of the catches in this quarter were taken around the Shetlands, the majority being taken to the east. In addition to the Shetland area fishery, smaller quantities were taken off northwest Ireland, off Cornwall and Divisions IIIa and IVb,c. The catches taken off Cornwall still contain a high proportion of juveniles.

In Divisions VIIIc and IXa, the fishery in the fourth quarter was rather similar to that in the third quarter.

3.3 Review of Information on the Adult Stocks

The migration and area distribution of Western mackerel was reviewed at the second meeting of the joint EEC-Norwegian Scientific Group which took place in Brussels in 1989 (Anon., 1990b). The Group was asked to update the information on the stock and catch distributions described in their first report (Anon., 1989b).

The second report describes the spawning areas, the distribution of various age groups and the migration pattern from both fishery data and fishery-independent data. The distribution of the juveniles is described in Section 3.4. During the period 1981-1988 an increasing proportion of mackerel was taken outside the western areas. Figures 3.3A-D show that the catches taken in 1989 were consistent with this trend, which is probably caused by a northward shift in distribution of the western mackerel outside the spawning season. The results from research vessel surveys indicate that the total distribution of mackerel may be more widespread than indicated by the fisheries and that the distribution of commercial catches may not always reflect the precise distribution of the stock.

The report reviewed several sources of data on mackerel migrations. These included ICES Mackerel Working Group reports, fishery data and tagging results. Attention was paid to changes in migration pattern in recent years in relation to the shifts in distribution. Adult western stock mackerel migrate between areas of overwintering, spawning and feeding. While minor changes in distribution of the western spawning area have been observed since the egg surveys began in 1977, the overall area has remained unchanged. However, the overwintering area has gradually moved northwards and the feeding area further eastwards during the later half of the 1980s. In the report, the changes in the migration pattern from the late 1970s through to the late 1980s are illustrated.

The current distribution and migration pattern of western mackerel suggests that in late summer they are probably distributed over a wide area in Division IVa. The fisheries indicate that a major part of the mackerel stock follows a migration route across the northern part of Division IVa, probably north of 59^0 - 60^0. Mackerel now occur further east in the southeastern part of Division IIa and the eastern part of Division IVa than in the early 1980s, during the third quarter. The return migration to the spawning area now appears to start somewhat later than in earlier years. It should be noted, however, that the distribution and migration of mackerel in the feeding area seems to vary substantially, although the migration starts from a consistent spawning area. Additional information became available this year on the distribution of the adult stock at the peak of spawning (see Section 2.3). The fishing survey together with the batch fecundity method demonstrated that adult mackerel were present throughout the western area in May/June. Age groups 2 to 5 occurred throughout the area while the older fish, mainly the 1980 and 1981 year classes, were concentrated towards the southern Celtic Sea around the shelf edge. The current migration pattern adult mackerel are now thought to follow is illustrated in Figure 3.4.

The very low size of the North Sea stock and the mixing with mackerel from the Western stock in the third and fourth quarters makes it difficult to determine the distribution and migration of the North Sea mackerel. At present, this is not known with any precision outside the spawning season. The distribution of the adults at the time of spawning is shown by the Stage I egg distribution (Anon., 1990a; Iverson et al., 1989).

The migration pattern of the mackerel from Divisions VIIIc and IXa is still unknown.

3.4 Juvenile Distribution

The migration and area distribution of the juvenile mackerel was also reviewed at the second meeting of the joint EEC-Norwegian Scientific Group (Anon., 1990b). The apparent changes in the distribution of juvenile Western mackerel since about 1981 have also been discussed in earlier Working Group reports (Anon., 1985, 1986, 1987a, 1988a, 1989a). After 1981, there was a tendency for the catches of both juveniles and adults to increase proportionally in Division VIa. This proportion could not be calculated on the same area basis in 1987, 1988 and 1989, because of misreporting of catches. However, if the proportion is calculated from officially-reported catches in the northern area, the concentration of juveniles in the north remains high. In addition to the changes in distribution of the juveniles in the catches, the proportions of both first winter and second winter fish from the recent survey have increased in recent years and have increased dramatically in the surveys carried out in 1989 and in the first quarter of 1990 (see Section 4.2).

The distribution of the juvenile year classes is given in more detail in Figures 3.5-3.8, which show the catch rates for research vessel surveys.

The occurrence of the 1987, 1988, and 1989 year classes expressed as a percentage (number) of the catches taken in the commercial fishery in each ICES division in 1989 is shown in Figure 3.9. The Working Group has once again been asked to give the distribution and relative abundance of juvenile mackerel by season in as fine an area breakdown as possible. Therefore, the occurrence of the 1987, 1988 and 1989 year classes is also expressed in the same way by rectangle in Figures 3.10 - 3.13.

The juvenile migration and distribution is summarised in Figure 3.14.

Since 1985 acoustic surveys have been carried out in the Skagerrak and Kattegat, and the central and northern North Sea in July-August. These surveys have demonstrated that large amounts of 1- and 2-group mackerel have been present each year in the investigated area. In 1989, Denmark carried out a survey in the Skagerrak and the central North Sea (Kirkegaard, WD90), while Norway covered the northern part of the North Sea (Aglen WD 90). Both surveys demonstrated that the 1987 year class was highly abundant in the investigated area (about 1,600 millions) particularly in the northern North Sea. The 1988 year class, however, was poorly represented in the area (about 200 millions). The 0-group (1989 year class) was observed for the first time in these surveys in the western central North Sea.

Data from the International Young Fish Survey in the first quarter 1990 indicate that the 1989 year class is the strongest observed in the North Sea since the early 1970s (Table 3.1 and Walsh, WD90). The high index was due to high abundances in some statistical rectangles in the western central North Sea.

3.4.1 The 1989 year class

Fourth quarter 1989

Research vessel surveys during this quarter were undertaken by Scotland, France and the Netherlands and covered most of the Western area and the southern North Sea. The highest concentrations were found to the northwest of Ireland, along the shelf edge in ICES Division VIIj, and in north and central Biscay. A large concentration was also found in the eastern part of Division IVb (Anon., 1990b, Figure 3.5).

The 1989 year class was more wide-spread in the commercial catches than usual. They were present in Divisions VIId,e,g, IVc, and also to the north of Scotland in Division VIa (Figures 3.10 to 3.13).

The year class was present in the second quarter and very abundant in the third and fourth quarters of 1989 in Division IXa and the western part of Division VIIIc.

First quarter 1990

Research vessel surveys were undertaken by England, Scotland, and the Federal Republic of Germany in the Western area during this quarter. The highest concentrations were observed around the Cornish peninsula in Division VIIe, to the southwest of Ireland, and especially to the west of Scotland. The IYFS also provided additional information on the distribution of the 1989 year class in the North Sea. An unusually high concentration was observed in the western North Sea, off the northeast coast of England. High abundances of 1-group fish in the North Sea during the first quarter have not been observed since 1971. The survey carried out by the Federal Republic of Germany was directed mainly towards the shelf edge and, therefore, these data were not included in the distribution and abundance charts (Figures 3.5 and 3.9) or in the recruit index. However, on this survey, high concentrations of the 1989 year class were observed in Division VIIe also and to the west of Ireland.

The combined fourth quarter 1989 and first quarter 1990 distribution is presented in Figure 3.5

3.4.2 The 1988 year class

Fourth quarter 1988 and first quarter 1989

The revised distribution of the 1988 year class during this period is presented in Figure 3.6 and includes additional information that was not available to the Working Group in 1989. Large concentrations were found in the Western Channel, off the Britany peninsular, to the south and northwest of Ireland and in the Celtic Sea towards the shelf edge. No high concentrations were observed in the North Sea.

The 1988 year class was only present in the commercial catches in the first quarter of 1989 in Division IXa and the western parts of Division VIIIc (Figures 3.9 and Figure 3.10).

Second quarter 1989

The 1988 year class was present in the Western area during a research vessel survey carried out in May/June 1989. The survey covered most of the Western area except Divisions VIIe,f and Sub-area VIII. The 1988 year class comprised 15% by number of the catches. This age composition is compared with the VPA in Section 5.4.3.

This year class was only present in the catches to the west and northwest of Ireland, and in Division IXa and Divisions VIIIa-c. None were taken in the North Sea (Figure 3.9).

Third quarter 1989

The only research vessel data available for the third quarter in the Western area was from the Dutch egg survey cruise in the Celtic Sea, however, the 1988 year class was not present. During the Danish acoustic survey in July/August in the North Sea and Skagerrak, 16% of the estimated stock in number was the 1988 year class.

It was also well represented (40%) in the commercial catches in Divisions VIIb, VIIj and VIIIc and IXa. They were also present in the catches from Divisions VIa and IIIa (Figure 3.9).

Fourth quarter 1989 and first quarter 1990

The revised distribution of the 1988 year class during this period is illustrated in Figure 3.7. The largest concentrations were found in Division VIIe, and to the northwest of Ireland and west of Scotland.

The 1988 year class was represented in the fishery in all areas except Division IVb (Figure 3.9).

3.4.3 The 1987 year class

Fourth quarter 1988 and first quarter 1989

Additional information on the distribution of the 1987 year class was made available to the Working Group for the period October 1988-March 1989 and is illustrated in Figure 3.8. Very high concentrations were found in Division VIIe. It was also abundant to the south of Ireland and west of Scotland. No concentrations were observed in the North Sea.

Large numbers of the 1987 year class were present in the catches in all areas (Figure 3.9).

Second quarter 1989

The 1987 year class was well represented in the May/June research vessel survey which covered the Western area. Almost 30% of the catch in number consisted of the 1987 year class.

The 1987 year class was also present in the Western area commercial catches (Figure 3.9).

Third quarter 1989

No research vessel data were available for the third quarter in the Western area. Large quantities of the 1987 year class were found in the North Sea during the acoustic survey in July-August in the eastern part of the North Sea, Skagerrak, and Kattegat. This year class was well represented in the catches in Divisions IVa,b and IIa and VIa (Figure 3.9).

Fourth quarter

The 1987 year class was well represented in the commercial catches, with 25% being taken from the main fishery, Divisions IVa, VIa (Figure 3.9).

4 RECRUITMENT SURVEYS

4.1 Recruit Indices

The method used for predicting year-class strength from combined research vessel surveys during the first and fourth quarters was the one described by Dawson *et al*. (1988) which was also the same method used in the 1988 assessment (Anon., 1989a). A potential disadvantage of this method is that the annual indices are based upon individual surveys in different months using different types of bottom trawl. However, because most of the western area is covered by the surveys, the indices are less likely to be affected by fluctuations within the distribution than other methods which utilize the data as independent sets, e.g., RCRTINX2 method. Another potential problem with this method is that the recruit indices may be driven by a few very high values because of the shoaling nature of the fish. In an attempt to remove this source of bias, the recruit indices were also examined by calculating trimmed means (e.g., excluding single highest and lowest value). However, treating the data in this way did not improve correlation and, therefore, this method was not used.

The recruit indices were calculated using the 1989 and first quarter 1990 research vessel data. The 1988/1989 recruit index used by the 1989 Working Group was revised to include the first quarter 1989 data and exclude an anomalously high value. All the survey data for the 1989/1990 season were available for this year's assessment. The recruit index was plotted against the number of 1- and 2-groups calculated from the VPA and is presented in Section 5.4.3.

4.2 High Priority Areas for Recruitment Surveys

In the terms of reference, the Mackerel Working Group was asked to define distribution areas of high priority for recruitment surveys. In accordance with this, all the survey data for the Western area were examined (1981-1990) (Walsh, WD1990). In each year, the rectangles contributing 95% of the index value were found and pooled over all years. The high abundance areas were indicated as either 1) a catch of >500 fish/hour in any year or

2) catches of >100 fish /hour in two different years. The abundance indices of the first- and second-winter fish were combined to give this overall distribution. These priority rectangles are shown in Figure 4.1. The Working Group recommends replicate samples to be taken in these high priority rectangles. However, the distribution of first- and second-winter mackerel has been shown to be very variable (Anon.,1986, 1987a, 1988a, 1989a, 1990b), and the overall survey area should not be reduced. There has either been an increase in abundance or a northward shift in distribution towards the more northern range of their distribution around northwest Ireland and to the west of Scotland in recent years. Table 4.1 shows the recruit indices calculated for the first- and second-winter fish both south and north of 52°30'N. These figures demonstrate an increase in abundance in the northern area from 1984 onwards. The ratio of fish in the northern area is particularly high for 1989.

4.3 Future Recruit Surveys - Western Areas

The Working Group has stressed in this and other recent reports the importance of obtaining accurate information about the strength of the recruiting year classes as early as possible.

The Mackerel Egg and Recruitment Workshop, which met in Aberdeen in 1988, discussed this problem in detail and made a number of recommendations about future surveys (Anon., 1988b). In general it was recommended that future surveys should be standardized and carried out along similar lines to the North Sea International Young Fish Survey.

At present, a number of countries, the Netherlands, Ireland, UK (Northern Ireland), UK (Scotland), UK (England and Wales), and more recently France and the Federal Republic of Germany, carry out young fish surveys for various species throughout the Western areas.

While some of these surveys are coordinated as far as mackerel is concerned, it is clear that a far greater amount of information could be obtained if all surveys could be standardized and coordinated on an international basis. Apart from obtaining recruit indices for mackerel, it is felt that coordinated surveys could obtain valuable information on the abundance and distribution of other important commercial species such as herring, horse mackerel, hake, megrim, and monkfish. Such information would render the surveys much more cost-effective at a time when some countries are reducing their pelagic research programmes.

The Working Group would, therefore, strongly recommend that a planning group should be established by ICES which would study all existing fish surveys carried out in the Western areas, with a view to establishing a proper standardized international survey which would obtain recruitment indices for as many species as possible.

5 NORTH SEA, NORWEGIAN SEA, AND WESTERN AREAS (SUB-AREA IV), DIVISIONS IIIa, IIa, AND Vb, SUB-AREAS VI AND VII, AND DIVISIONS VIIIa,b,d,e

5.1 The Fishery 1989

The nominal catches in the North Sea, Skagerrak,and Kattegat and the Norwegian Sea and off the Faroes (Divisions IIa and Vb) are given in Tables 5.1 and 5.2. The catches in these areas increased by 21,455 t (8.6%) compared to 1988, thus continuing the trend of recent years. Misreporting is known to have occurred, and the catches by area as given in Table 5.1 and 5.2 are, therefore, inaccurate.

The catches that could not be allocated to any country decreased considerably compared to 1988 and 1987. The catches reported from the Western area (Sub-areas VI, VII, and Divisions VIIIa,b,d,e) are shown in Table 5.3. The landing figures for 1989 are preliminary and are mainly based on data submitted by Working Group members. The total catch from these areas was reported to be 293,200 t, which is a considerable reduction since 1988 (377,000 t). However, it must be pointed out that this figure, as in 1986, 1987 and 1988, includes considerable quantities of mackerel which were reportedly taken in the northern part of Division VIa, but were in fact taken east of 4^{0}W in Division IVa. It was estimated that the amount misreported in this way totalled 92,200 t, which is a reduction of about 50% compared to 1988 (180,000 t). In 1986 and 1987, the misreported catches were estimated at 148,000 t and 117,000 t, respectively. The reduction in misreported catches in 1989 from this area was caused by changes in management regimes, in that a larger part of the TAC than in previous years, was allowed to be fished east of 4^{0}W.

The estimated catch by quarter for the various Sub-areas and Divisions are given in Table 5.4. This table is based on information provided by Working Group members. As in previous years, the major part of the catches were taken in Division VIa during the first quarter, in the northern part of Division IVa during the third and fourth quarters, and in the southeastern part of Division IIa during the third quarter.

The overall catches were reduced by about 65,000 t compared to 1988, due to a decrease of about 30,000 t in each of the two Divisions IIa and IVa.

5.1.1 Discards

The Working Group has had estimates of discards of mackerel for only one fleet for the years 1988 and 1989. The quantities of mackerel estimated to have been discarded in those years were 5,800 t and 4,900 t, respectively, and obviously this must be considered as a minimum quantity and probably a substantial under-estimate (Table 5.5). Estimates of quantities of mackerel discarded during the 1978 to 1982 period ranged from 21,000 t to 60,000 t, but this was at a time when fishing was permitted in the area around Cornwall. Recent working groups have again warned about the possible increase in discards of young mackerel.

The problem of discards has generally been confined to juvenile mackerel. However, a further problem could develop with the increasing importance of the fishery for horse mackerel, particularly in Sub-areas VI and VII. Quantities of mackerel are now taken as a by-catch in this fishery but, because they have been taken together with the horse mackerel, they are invariably in poor condition and are unfit for human consumption and may consequently be discarded. A similar problem appears to exist in the fisheries in Divisions VIIIa-e and IXa, and this was discussed in detail by the 1989 Working Group.

Therefore, the Working Group would again like to draw attention to the importance of collecting as much information as possible about the quantitites of discards in all the fisheries throughout the Western area. This information can only be reliably obtained by placing observers on board the commercial vessels, not only during the main mackerel fishing season, but also throughout other mackerel fisheries.

5.1.2 Catch in numbers in 1989

The catch in numbers and mean weight at age by quarter for Divisions IIa, IVa and Vb, IIIa, IV,b,c, VIa,b, VIIa,d-h, VIIb,c,j, k, VIIIa,b,d,e are shown in Table 5.6.

Table 5.7 shows the quarters for which sampling data are provided by division and country, together with the total catch and the percentage sampled. Catches for which there were no sampling data were corrected to numbers at age using appropriate quarterly data. Only countries providing sampling data are included in the table.

The total catch in number for the Western stock estimated as the sum of catches in all areas given in Table 5.6 are given in Table 5.12.

Sampling Intensity of Catches

The Working Group examined the level of sampling carried out in 1989 for the different areas. The data, which are summarised in Table 5.8, are based on the details submitted by each country to the administrative report of the Pelagic Fish Committee. It was considered advisable to examine the sampling levels because of the recent changes in the distributions of the fisheries and because of the reduced level of pelagic research reported by some countries. The Working Group felt that, for these two reasons, some catches which had previously been well sampled, might not be adequately covered.

The data indicate the numbers of commercial samples that have been taken from each area, together with the numbers of fish measured and aged. However, although the numbers of samples shown are those that have been obtained from commercial catches, the numbers of fish measured and aged are based on a combination of research vessel and commercial samples. Therefore, the data do not give a proper indication of the sampling level of the commercial catches. In addition, the level of samples obtained from research vessels was particularly high in 1989 because of the samples collected during the egg surveys.

An examination of the sampling details obtained from the 1985 administrative report of the Pelagic Fish Committee enabled a rough comparison to be made between the sampling levels for both years in relation to the landings. It would appear that:

Division IIa Landings have increased by 10% since 1985. The number of samples has also increased although the actual number of fish measured appears to have decreased.

Division IIIa Landings have doubled since 1985, but the number of samples appears to be at a very low level.

Sub-area IV Landings have increased by a factor of six, but the number of commercial samples appears to have remained at about the same level as that in 1985.

Sub-area VI Landings are only about 1/3 of the 1985 level and commercial samples appear to be about half.

Sub-area VII Landings are about the same level, but the number of commercial samples has dropped very significantly.

Sub-areas VIII and IX Landings in these areas appear to be at about the same level as in 1985, but the actual number of samples appears to be very high in comparison with other areas.

In general, it appears that all the important fisheries are covered by sampling programmes. This is also shown in Table 5.7, which demonstrates the percentage of the total catch which is covered by age distributions. However, although the actual number of samples obtained from the commerical fleets are known for each area, it has not been possible to obtain any information about the size or quality of the actual samples. The Working Group discussed the sampling techniques in use by various countries as a result of which it was decided that a more detailed analysis of the various national sampling programmes should be undertaken at the next meeting of the Working Group. It was also decided that the various catches in numbers at age table should in future indicate the numbers of fish aged and measured.

5.1.3 Revision of catch data from previous years

At this Working Group meeting, USSR data were available for catch in numbers and average weight for the different age groups for Divisions IIa and Vb for the period 1984-1989. In previous years, Norwegian data from these areas were used to split the USSR catches into number per age groups. A comparison of the 1988 age structure of the USSR and Norwegian catches showed that they were rather similar. However, the USSR average weights in catches were 9.2% lower than the Norwegian ones. This will increase the catches in number for Division IIa by 2% and the overall catches of Western fish by 0.2%. The Working Group, therefore, decided not to alter the catch in numbers for 1988. Since the USSR catches for the previous years were only 15-65% of the 1988 figure, catches in number were not altered for the period 1984-1987.

For other countries there were no revisions of catch data as given in Anon. (1989a).

5.1.4 Length composition

The 1988 length distributions were revised as a result of revisions of the Spanish length distributions, and the length distribution of the pelagic trawlers of the USSR was included.

The 1989 annual length compositions by fleet were provided by Denmark, Ireland, Netherlands, Norway, UK (England and Scotland), Spain, and the USSR.

These length distributions were available for all the major fishing fleets, and a coverage of about 80% of the total landings was obtained both in 1988 and in 1989.

The length distributions by country per year for each fleet [numbers ('000) of fish per cm length group) are shown in Tables 5.9 and 5.10 for 1988 and 1989, respectively.

5.2 Allocation of Catches to Stock

As for the catches in 1987 and 1988 (Anon., 1989a), the Working Group was not able to split the 1989 catches by stocks.

The Working Group decided to allocate all mackerel caught in 1989 to the Western stock. This was also done last year for the 1988 catches (Anon., 1989a). Including a small catch of North Sea fish in the Western stock will have very little influence on the assessment of the Western stock, since the North Sea stock is less than 3% of the size of the Western spawning stock.

Based on spawning stock size estimates from egg surveys in the North Sea in 1986 and 1988, the average total mortality rate was estimated to be 0.21 (Anon., 1989a) This low mortality rate corresponds to a catch in the order of 2,000-5,000 t per year. In 1988, the Working Group assumed a catch of the North Sea stock of 3,000 t (Anon., 1989a). Since the fishery in 1989 was carried out similarly both in area and time as in 1988, the Working Group assumed a similar catch of North Sea mackerel in 1989.

5.3 Assessment of the North Sea Stock

5.3.1 The state of the North Sea stock

During the period 16-27 June 1989, the spawning area of mackerel in the North Sea was surveyed once by Norway (See Section 2.1). This period usually represents the peak of the spawning. If this period represents the peak in 1989 and the spawning curve had the same shape as in 1981-1984 or 1986, the estimated egg production was in the range 34-56 x 10^{12} eggs. If the spawning curve in 1989 had the same shape as in 1988, the egg production was estimated at 36 x 10^{12} corresponding to a spawning stock size of 53,000 t (Anon. 1990a). This indicates an increase in the spawning stock from 37,000 t in 1988 (Iversen _et al_., 1989) to 53,000 t in 1989. However, the spawning stock in the North Sea is still considered to be at an extremely low level.

During the egg survey only a few mackerel were caught, so there are, therefore, very few data on the age composition of the North Sea spawning stock. The age structure is considered to be the same as in 1988. The increase in spawning stock might be due to the 1987 year class.

5.4 Assessment of the Western Stock

5.4.1 Mean weight at age

Mean weight at age in the catch

Mean weights at age in the catches by quarter in 1989 were provided by Scotland (Divisions VIa and IVa), England (Divisions VIId,e,f), Ireland (Divisions VIa and VIIb,j), Norway (Divisions IIa, IIIa and IVa), Denmark (Divisions IVa and IIIa), USSR (Divisions IIa, Vb), the Netherlands (Divisions IVa,b,c, VIa, VIIb,d,e,f,j), and Spain (Division VIIIb).

Weighted (by number) mean catch weight-at-age estimates were made by divisions by quarter and by division by year for catches from the Western and North Sea area. These are shown in Table 5.6 by division, but Divisions VIIb,c,j,k, and Divisions VIIa,d-h and also Divisions VIIIa,b,d,e were combined. The mean weights at age in the catch are given in Table 5.14.

Mean weight at age in the stock

Mean weights at age of the spawning stock at spawning time were estimated for 1989 by using samples from Dutch commercial freezer trawlers in Division VIIj in March, April and May. These weights (in kg) are shown in Table 5.13 (1-year-olds are rarely taken in samples; therefore, a constant weight of 0.070 kg was assumed for all years for this age group).

5.4.2 Maturity at age

Estimates of maturity at age can have a large influence on estimated spawning stock biomass. The 1987 year class is thought to be relatively large, so this is particularly true for the estimate of stock size in 1989.

The previous large year class was that of 1984, and during the 1986 egg survey it was found that the proportion mature was less than the 60% assumed in the maturity ogive. This information, together with a much lower number of 2-year-olds on the spawning grounds than expected and a lower-than-average growth rate, resulted in a revision of the estimate of the proportion mature to 20%.

Sampling carried out during the trawl survey in 1989 indicated that 93% of the 1987 year class were mature on the spawning grounds (Section 2.3). The age composition estimated from the same survey agrees closely with that from the VPA (Section 5.4.3), and does not suggest that there were fewer 2-year-olds on the spawning ground than expected. A proportion of these fish is likely to show abortive maturation, but in the absence of new information there are no grounds for revising the figure of 60% mature for this year class.

5.4.3 Fishing mortality and tuning of the VPA

In 1988, the Working Group decided that future assessments should use catch-at-age data extended to include a 15+ group. In 1989, the Working Group suggested that this should be done by increasing the data by one age group each year, because ageing to 15+ was thought to be unreliable for the years prior to the Age

Determination Workshop held in Lowestoft in June 1987. The catch-at-age data currently extend to a 12+ age group, and the present Working Group questioned both the reliability of age readings beyond this, and the advantages of further extending the number of ages. It was, therefore, decided to abandon attempts to include older age groups.
Separable VPAs were run to examine the exploitation pattern, all years prior to 1984 downweighted. Choosing a reference age of 5 and a terminal S of 1, the results of the SVPA suggested an almost flat exploitation pattern over the age range 5 - 11 (Table 5.11).

Using a reference age of 5 and terminal S of 1, SVPAs were run using a range of fishing mortalities. Each run of the SVPA was used to calculate a VPA with input F values based on the terminal populations. The terminal fishing mortality chosen was the one which minimized the squared residuals between the VPA estimates of SSB, and those of the series of egg surveys in 1977, 1980, 1983, 1986, and 1989. The first two egg survey results are suspect. The coverage in 1977 was sparse, and an anomalously low estimate of egg production during one period of the 1980 survey resulted in a revision of the final estimate (Anon., 1981). The residuals were, therefore, also calculated excluding the 1980 survey and excluding both the 1977 and 1980 surveys.

The results are shown in Figure 5.1. Both curves show a minimum at approximately F = .275. The curves excluding the 1980 egg survey and excluding both the 1977 and 1980 egg surveys are almost indistinguishable, but including the 1980 result raises the curve. This illustrates that the VPA has converged by 1980, and the tuning is almost wholly dependent on the latest 3 egg surveys. It also suggests that the 1980 egg survey is an overestimate, and perhaps should not have been revised to exclude the period with low egg production.

The input data and the results of the VPA, using a terminal fishing mortality of 0.275 in the separable VPA, are shown in Tables 5.12-5.16 and in Figures 5.7A and B. Spawning stock biomasses from the VPA and from the egg surveys are plotted in Figure 5.2. The spawning stock biomass in 1989 is estimated to have been 1.93 million t, that in 1988 2.01 million t, or about 17% higher than that estimated in last year's assessment. However, the VPA results suggest the 1987 and 1988 year classes may be weaker than previously assumed. The net result is that spawning stock biomass in 1989 is close to that predicted, but not because of any increase in biomass since 1988.

The age composition in 1989 indicated by the VPA is compared with that estimated during the trawl survey of the stock from 23 May - 12 June 1989 in Figure 5.3 (see Section 2.3).

5.4.4 Forecast for the Western stock

The 1989 Mackerel Working Group defined three levels of recruitment for prediction purposes. Predicted recruitment of strong and weak year classes was taken to be the geometric means of recent strong and weak year classes, respectively, with an intermediate value between these two. This was thought to be realistic, given the tendency for recruitment to be either very strong or very weak in recent years. The present Working Group adopted the same method. The geometric mean of the 1982, 1983, 1985, and 1986 year classes was used as a value of weak recruitment. For strong recruitment, the 1979, 1980, 1981, and 1984 year classes were used. The resulting recruitment values are shown in the text table below:

Level	0-group	1-group
Strong	6300	5400
Intermediate	3900	3300
Weak	1400	1200

Recruitment of 0-group fish in 1990, 1991, and 1992 was assumed to be intermediate.

For the 1989 and 1988 year classes, the recruit survey indices (see Section 4.1) were used to select the appropriate level of recruitment. The recruitment indices, together with the numbers of 1-group and 2-group estimated from the VPA, are presented in Table 5.17. The indices and VPA values for years up to and including 1987 were used to calculate regressions through the origin in order to predict the strengths of the 1988 and 1989 year classes (Figures 5.4-5.5). The regressions are summarized below:

Age group	Regression equation	Correlation coefficient
First-winter juveniles	$y = 38.8x$	$r = 0.92$
Second-winter juveniles	$y = 22.9x$	$r = 0.60$

The regression for the second-winter fish is considered to be unreliable and was, therefore, not used for the prediction.

Using the abundance indices of first-winter juveniles, the regressions indicate an abundance of the 1989 year class as 1-group to be 6,751 million fish, corresponding to a strong level of recruitment. For the 1989 year class, a recruitment value of 5,400 million as 1-group in 1990 was, therefore, selected from the above text table and used in the prediction.

For the 1988 year class, the regression indicates an abundance of 4,112 million fish as 1-group, an intermediate level of recruitment. The abundance as 1-group in 1989 was assumed to be intermediate (3,300 million), and the mortality estimate from the VPA used to calculate the corresponding numbers of 2-group in 1990 for the prediction.

The stock and catch predictions were based on the following additional assumptions:

a) The fishing pattern in 1990 was assumed to be that estimated by the separable VPA.

b) The catch in 1990 was assumed to be 550,000 t. This was based on the agreed TAC and the likely level of USSR catches. A discard level of about 5,000 t was also assumed (see Section 5.5).

c) Mean weights at age in the stock were assumed to be the same as those in 1989.

The input variables used in the prediction are summarized in Table 5.18.

The predictions for stock and catch in 1991 and 1992 were calculated for F_{med} (Figure 5.6), $F_{0.1}$, $F_{91}=F_{90}$, and $F_{91}=F_{89}$. The results are given in Tables 5.19 and 5.20. Short-term yield and spawning stock biomass in relation to F are also given in Figure 5.7D.

The results indicate that the stock size in 1990 will be about the same as that in 1989, if the 1988 year class is of intermediate strength. Thereafter, with current levels of fishing mortality, the stock will remain at around 2.0 million t in 1991 and 1992.

5.5 Management Considerations - Western and North Sea Stocks

The TAC set for the Western stock for 1989 amounted to 495,000 t, compared with a figure of 573,000 t in 1988. This considerable decrease obviously resulted in consequential decreases in many of the national quotas for the various fleets. The total catch of the Western stock taken during 1989 has been estimated to have been around 567,000 t, which itself was a considerable decrease on the figure for 1988. It was, however, still far in excess of both the agreed level and the recommended level (355,000 t). It is difficult to judge how much of this decrease has been due to the management of the fishery by the various authorities. However, the overall decrease in the total catch, together with the reduction in the amounts of the unallocated catches and in the misreported catches, would suggest an overall improvement in the management regime.

Although the total catch taken from the Western stock decreased in 1989, the level of F in recent years as evident from the VPA has shown a slow but continuous increase. The average level for the last three years (1986-1989) has been around F = 0.26. This level, it should be pointed out, is in excess of F_{med} which is estimated to be 0.15. As F_{med} is the fishing mortality at which the historical data on stock/recruitment suggest that the stock should be sustainable, the present level of F must be considered to be too high.

The management of the fishery in recent years has been considered in detail by both the 1988 and 1989 Working Groups, and by ACFM in May 1989. It has, however, been generally difficult to give clear and precise advice for this stock for a number of reasons. The main difficulties arise because of:

1) The recent major changes in the distribution of the stock and in the fisheries.

2) The mixing of the Western stock with the North Sea stock, particularly in Divisions IIa and IVa in the third and fourth quarters.

3) The misreporting of catches from Divisions IVa and VIa.

4) The various international agreements which have in recent years permitted the TAC to be far in excess of the levels recommended by ACFM.

5) The necessity to provide adequate protection for the juveniles component which itself has changed its distribution in recent years.

Recent Working Groups have, therefore, expressed the view that, despite the above difficulties, any management policy should be aimed at affording maximum protection to the North Sea stock while, at the same time, allowing fishing on the Western stock to be continued at the optimum exploitation rate.

It has been pointed out by previous Working Groups that the management of this fishery should ensure as far as possible that maximum catches are taken during the period July-November. This will improve the exploitation pattern as well as increase the mean weight at age in the catch. During this period mackerel are in their peak condition, having both their highest fat content and the highest mean weight. Catches during this period contain the lowest numbers of fish and, therefore, generate a low level of F in comparison with similar catches during winter and spring.

The present Working Group again considered the management of the fishery against the above background.

Stock distribution and mixing

The situation in regard to the distribution of the Western stock and the mixing of the Western and North Sea stocks is believed to have been very similar in 1989 to recent years. This, therefore, presents the same problem for management authorities. In an effort to allow some flexibility of fishing in 1989, management authorities permitted catches of 47,750 t of the TAC for the Western area to be taken east of 4^0W in a defined "box" (Figure 5.8) during the period October 1989 - December 1989. A similar regulation is in operation for 1990.

Misreporting of Catches

The amount of catches taken in Division IVa and reported as having been taken in Division VIa decreased considerably during 1989. The estimated figure for 1989 was 92,200 t compared with 180,000 t in 1988, 117,000 t in 1987, and 143,000 t in 1986. Although the reduction in these misreported catches is significant and obviously the result of the legal catches permitted in the box, the actual amount of 92,200 t is still extremely high.

Reports that large catches of mackerel in 1989 had been reported as being horse mackerel and other species were also discussed by the Group. Although this practice may have occurred during 1989, the extent of it is not believed to have been significant. However, the Working Group would like to draw the attention of management authorities to the problem with a view to eliminating it, if possible.

International Agreements

In November 1989, ACFM re-affirmed all of its advice for the Western and North Sea mackerel stocks. The recommendation about catch levels stated that the TAC for Western mackerel in 1990 should not exceed 480,000 t, and that this TAC should apply to all areas in which Western mackerel are caught. A summary of the various agreements for 1990 is shown in the text table below.

Agreed TACs for 1990

Vb, VI, VII, VIII (except VIIIc) XII,XIV	EEC	331,630	
	Norway	23,800	
	Faroes	19,200	374,630
IVa north of 59^0N	EEC	15,100	
	Norway	29,200	
	Sweden	~900	45,200
IIa	Norway	96,240	
	EEC	15,430	111,670
Sum			531,500

Obviously the permitted catch is higher than the recommended level, mainly because of fixed agreements between different management authorities which apparently cannot be altered from year to year.

Protection of Juveniles

Recent Working Groups have discussed in detail various management measures designed to ensure adequate protection for juvenile mackerel. These discussions have centered mainly around closed areas, minimum landing size, and minimum mesh size. In 1989, juvenile mackerel were again distributed over a wide area, but the amounts taken in the catches are quite small except for Division IXa (see discussion in Section 3.3). In May 1989, ACFM drew attention to the possibility of increased discarding of young mackerel in the event of the recruitment of strong year classes. However, the Working Group has no evidence of any increased discards during 1989, although this problem will be kept under review. In general, the Working Group has no reason to change any of the conclusions that were made in 1989. It is still considered necessary to retain the "box" around Cornwall, and UK investigations showed that substantial amounts of juvenile mackerel were again present in this area early in 1990. Again, as expressed in 1989, the introduction of a 30 cm minimum size for the Western area does not seem necessary on biological grounds and would lead to a higher discard rate when a strong year class enters the fishery.

Mackerel By-Catch in Division IVc

It was agreed by ACFM that the Working Group should consider the possibility of allowing a small TAC for mackerel in the southern North Sea for the benefit of non-directed (white fish) fisheries in which mackerel are at present discarded. The Working Group discussed this question and concluded that, although there is evidence to suggest that mackerel in the southern North Sea may orginate from the Western stock, they are in fact contributing to the North Sea spawning stock. This spawning stock is still considered to be at a dangerously low level and has shown little signs of recovery. The Working Group cannot recommend any level of fishing because it might further endanger this stock. The matter could, however, be reviewed by ACFM if the 1990 North Sea egg surveys indicate any significant recovery of the stock.

Conclusions

The Working Group would like to reiterate the suggestions made in 1989, which were summarized by ACFM in November 1989. The management regime should attempt to ensure that:

1) The overall TAC should apply to all areas in which mackerel are caught, i.e., including Division IIa, Division Vb, and Divisions VIIIa,b; Sub-areas VI and VII (all for the whole year), and Division IVa from 1 August - 31 December.

2) There should be no fishing for mackerel in Divisions IVb,c at any time of the year.

3) That the entire North Sea area (Sub-area IV and Division IIIa) should be closed during the period 1 January - 31 July.

4) Catches in Divisions IIIa and IVa should be reduced to the lowest practical level to ensure maximum protection for the North Sea stock. In this regard it is noted that the catch permitted for Division IVa during 1989 was from 1 October to 31 December. It is not possible to estimate what quantity of the actual catch taken belonged to the North Sea stock.

5) The 30 cm minimum landing size at present in force in the North Sea (Sub-area IV and Division IIIa) should be maintained, and the present by-catch regulations should be continued.

6) The present closed area in Divisions VIIe,f, should be retained with its present boundaries.

6 MACKEREL IN DIVISIONS VIIIc and IXa

6.1 Review of "The Mackerel in Divisions VIIIc and IXa Workshop" and of Data on Stock Identity

According to a recommendation by the Working Group (Anon., 1989a), later supported by ACFM and the Pelagic Fish Committee, Portuguese and Spanish scientists met at INIP, Lisbon on 12 to 14 March 1990, with the following agenda:

- examination of the available information for defining stock units;
- future needs in that field;
- agreement of a handy format for the data used for assessment for its presentation to the Mackerel Working Group.

6.1.1 Data on stock identity

Spawning seasons and grounds

In central Division IXa, it is evident from the macroscopical examination of maturity stages in commercial catches, that the spawning season extends from January until May, with a very marked peak in February (Gordo and Martins, 1986), and that in southern Division IXa, the peak of spawning occurs in January. At spawning time, the sea surface temperature (SST) is in the range 13-16^{0}C.

In the central and eastern parts of Division VIIIc, the spawning season extends from February to June with peaks in March and April (Cort et al., 1986; Lucio, pers.comm.).

Results of ichthyoplankton monitoring programs in the eastern part of Division VIIIc (S. Sebastian), central Division VIIIc (Santander), and northern Division IXa (Vigo) showed peaks of egg abundance in March and April. The SST at the peak of spawning was about 12-14^{0}C. The disappearance of mackerel eggs coincides with a warming of the sea up to 16^{0}C (Valencia et al., 1989; Sola et al., 1990).

Other Spanish ichtyoplankton surveys conducted to estimate the stock biomass of anchovy and sardine provide little information about the abundance and distribution of the mackerel eggs, because these surveys were carried out in May and June (Anon., 1990a).

Age and length for maturity

Data from commercial catches indicate that all females are mature by age two in central and southern Division IXa (Jorge et al., 1982), whereas in eastern Division VIIIc 100% maturity is at age three (Lucio, pers.com). The length at 50% of maturation is 24 cm in central and southern Division IXa and nearly 30 cm in eastern Division VIIIc.

L_1 studies

Differences in spawning period (mackerel spawn at least one month earlier in Division IXa south than in Division VIIIc), and in the sea temperature can be expected to produce marked differences in growth, particularly in the first year. It was, therefore, expected that studies of the values of L_1 could give some indications of stock identity (Dawson 1983, 1986).

Two kinds of data were presented. First, a set of measurements from samples taken since 1986 over three year classes in southern Division IXa were examined. Although no formal statistical test was performed, there was no indication of differences between year classes.

The observed L_1 differs markedly from those in the western stock (Dawson 1986), suggesting very little mixing between the two areas. In addition, L_1 measurements were made on samples of the 1984 year class taken in the central and southern parts of Division IXa and in Division VIIIc. The results show differences in L_1 between the two areas, with the values from Division VIIIc similar to those observed in the western stock (Dawson, 1986).

It seems likely that the 1-year-old and older mackerel caught in Division VIIIc were spawned later and in a different place from those caught in central and southern Division IXa.

6.1.2 Future work

No conclusive results could be derived from the data on stock identity. The information available indicates that adult mackerel taken from Division IXa and VIIIc spawn in different areas at different times, however, the spawning grounds are not yet well defined. Therefore, the Workshop recommended that future work should include analysis of plankton surveys, biological tags, analysis of available biological information, biochemical analysis and further analysis of the spatio-temporal distribution of catch data. It was also agreed that a more detailed analysis of the available L_1 material should be undertaken.

6.1.3 Data base for assessment

It was agreed to try to collect and present to the Mackerel Working Group, if possible, the basic information available from 1982 onwards. This is necessary in order to attempt any assessment of the mackerel in Divisions VIIIc and IXa.

6.2 Additional Information

Sampling data obtained from the commercial catches in Divisions VIIIa,b during 1987, 1988, and 1989 do not indicate any difference from the data collected from the eastern part of Division VIIIc (Lucio, WD90; Lucio and Martin, WD89, and Martin and Lucio, WD89).

6.3 The Fishery in 1989

Catch estimates by division and country are shown in Table 6.1. For Division IXa, the figures exclude catches which were known to have been taken from the Gulf of Cadiz (southern Division IXa), because no accurate catch data were available. Sampling intensity data in 1989 (Table 6.2) indicate that good sampling coverage was achieved. The catches by different fleets and countries are shown in Table 6.3.

This year an attempt was made to split the catches of Division VIIIc into eastern, central, and western components (Figure 6.1). Table 6.4 summarizes the composition by length and age groups of the catches taken in each of these areas and in Division IXa. Also shown are similar data for Divisions VIIIa,b.

Division IXa

There was an estimated 38% decrease of the catch in Division IXa in 1989 compared to 1988. The catches in numbers at age from the Portuguese fishery for the years 1981 - 1989 are shown in Table 6.5, and those from the Spanish fishery for the years 1988 and 1989 in Table 6.6. These show that landings are mainly of juveniles, the 0- and 1-groups contributing 61% and 29%, respectively of the 1989 catch in number. The catches were dominated by 1-group fish during the first quarter and by 0-group fish during the remainder of the year (Table 6.7 and Figure 3.3). Catches of 0-group were higher in the northern part of Division IXa and were mainly taken as a by-catch of other fisheries.

Division VIIIc

In Division VIIIc there was a 20% decrease in landings compared with 1988 which can be explained by a decrease in fishing effort. The catches in numbers at age are shown for 1988 and 1989 in Table 6.6.

The age distribution of the catches by quarter are shown in Table 6.7. In the eastern and central parts, mackerel catches are almost confined to the first and second quarters, March and April accounting for almost 95% of total annual catches in the eastern part. The concentration of mackerel in the area at this time is predominantly of adult spawning fish. Catches in the third quarter are insignificant and only small catches of mainly adult mackerel occur in the fourth quarter.

As in the eastern and central parts, the largest catches from the western part of Division VIIIc (north Galicia) are obtained in the first and second quarters. These are also predominantly adult fish. However, unlike the eastern and central parts, there are significant catches in the third and fourth quarters, and about 85% of them belong to the 0- and 1- age groups.

A Spanish mackerel (*Scomber japonicus*) fishery also occurs in the eastern and central parts of Division VIIIc, but there is not thought to be any misidentification of species in the fishery (Lucio *et al*., WD90).

6.4 Mortality and Exploitation Pattern

As mentioned in Section 6.1.2, it is at present not possible to define the stock units in Divisions IXa and VIIIc. However, the available information indicates that the mackerel caught in Division IXa have biological characteristics different from the Western stock, and that they may belong to another stock.

Catch in numbers at age are available for Portuguese catches in Division IXa from 1981-1989. To get an idea about the level of mortality and the exploitation pattern, a VPA was run on the Portuguese data. The terminal Fs at age were chosen as the average Fs at age for the entire period. Natural mortality was set to 0.15 for all age groups.

The results show a very high exploitation of juvenile mackerel (ages 0-2) and a decreasing mortality for older age groups. The apparent exploitation pattern may be due to a mixture of migration out of the area and a true decrease in exploitation of the older mackerel.

As the exercise was only carried out using Portuguese data from Division IXa, and the migration and stock identity are unclear, the results can only be taken as a very rough indication of the fishing mortality. Because of these uncertainties it was decided not to use the results in a yield-per-recruit analysis as suggested by ACFM (Minutes of ACFM Meeting 23-31 May 1989).

6.5 Management Considerations

Although improved information was presented by Spanish and Portuguese scientists, the Working Group considered that there was still insufficient information available to define stock units in this area or to determine their relationship with that of the Western stock. It does appear, however, that mackerel from the eastern and central parts of Division VIIIc do not differ from those in the rest of the Bay of Biscay (Divisions VIIIa-b). However, at the moment it is difficult to decide on a boundary which would separate Division VIIIc into 2 sub-units, one in which the catches could be included with those from the Western stock, and one which could be included with a "Southern" stock. It is considered important that a future attempt to do this should be made by compiling the necessary catch and biological information. If this was done, it may then be possible at the next meeting of the Working Group to make a realistic allocation of the catches to the appropriate area and to make a preliminary assessment of the Southern stock. At the moment, catches for Division VIIIc, which might belong to the Western stock, amount to only about 3% of the total catch taken from the Western stock. Their exclusion, therefore, at the moment would have a negligible effect on the assessment.

Therefore, the fishery in this area (Division VIIIc and IXa) was again dealt with separately from that on Western mackerel stock.

Although a reliable assessment was not carried out, some management considerations were discussed. The fishing pattern in Division IXa, and in the second part of the year in the western part of Division VIIIc, is very unsatisfactory, because it is based on juvenile mackerel (Figure 3.9 and Tables 6.4 and 6.7). However, mackerel is only a by-catch in other directed fisheries. The Working Group, therefore, suggested, as it also did in 1989, that management measures should be directed towards trawling in the first half of the year and towards seining in the second half. As a big proportion of the catch of mackerel in the northern part of Division IXa is taken by seiners, mesh sizes are not very relevant, therefore, minimum landing sizes or effort limitations should be considered. However, the losses and gains derived from these measures cannot be assessed at present. Similar measures might be considered for the western part of Division VIIIc in the second half of the year.

In the eastern and central parts of Division VIIIc, the abundance of juveniles is much lower, and the resulting fishing pattern looks satisfactory.

6.5.1 Management considerations: ACFM request

ACFM requested that the Working Group should consider the possibility of protecting the juveniles in Divisions VIIIc and IXa with a view to specifying areas and seasons in which fishing might be prohibited. As indicated in Figure 3.9, large numbers of juvenile mackerel are landed in the western part of Divisions VIIIc and IXa by various fleets. The actual landings, however, in some quarters are quite small. Although the stock identity of these juvenile mackerel is not yet clear, it is certain from the catches in numbers-at-age data (Tables 3.5 and 3.6) that catches of this magnitude must have a considerable adverse effect on the exploitation pattern of whatever stock they recruit to.

Most of the landings of juvenile mackerel from these areas are taken as a by-catch in other directed fisheries [mixed demersal fisheries, horse mackerel (in some quarters), and sardine]. It is clear, therefore, that if landings of juvenile mackerel are to be eliminated completely, then the directed fisheries in which they are taken must be prohibited. This obviously would cause considerable problems for the management authorities.

The 1989 Working Group discussed possible methods on how the exploitation pattern could be improved, and these have again been outlined in the previous Section 6.5. In order to give more precise advice, however, on possible specific area and seasonal closures, a more detailed breakdown of the area catch composition per quarter is required. If such data together with data on an appropriate minimum size were available, it may be possible to identify small areas or time periods during which fishing should be prohibited. It should also be noted that apart from the landings of small mackerel from these areas, it is also believed that considerable quantities may be caught but discarded. Information on the extent of this problem is also urgently required.

7 DATA REQUESTED BY THE MULTISPECIES WORKING GROUP

7.1 Catch at Age by Quarter for the North Sea Mackerel Stock

As for 1987 and 1988, the catches of mackerel in Sub-area IV and Division IIIa in 1989 were included in the assessment of the Western stock.

Adequate samples from the North Sea stock were not available to the Working Group. As mentioned in Section 5.2, the Working Group assumes a catch of 3,000 t North Sea mackerel in 1989 [this is the same as estimated for 1988 (Anon., 1989a]. To construct a catch table for 1989, the numbers caught in 1988 for the year classes of 1986 and older were reduced by Z = 0.21 (Anon.,1989a). Using the same weight at age in catch in 1989 as in 1987 and 1988 (Table 7.2), the estimated catch of North Sea mackerel 3-year-olds and older was about 1,930 t. The catch of the 1-year-olds was set the same as in 1988, i.e., a total of about 70 t. Since the increase observed in spawning stock size between the egg surveys in 1988 and 1989 was probably due to the 1987 year class, the remainder (1,000 t) was assigned to this year class. Over 80% of the catches in number along the southern and southeastern coast of Norway in May were of the 1987 year class. The numbers in catch by age group (Table 7.1) were divided into quarters according to the catch by quarters for Sub-area IV and Division IIIa as given in Table 5.4.

7.2 Weight at Age by Quarter for the North Sea Mackerel Stock

The Working Group had no available data for weight in the stock by quarter for 1989. The Working Group, therefore, recommends the use of the same weights as were used in 1988. Smoothed weights for the different quarters are listed in Table 7.2.

7.3 Stock Distribution by Quarter

Due to the small size of the North Sea stock and the fact that 50% of the total mackerel catches in 1989 were fished in the North Sea and Skagerrak, large proportions of the Western stock must have been distributed in these areas, particularly in quarters three and four. Two-year-old fish were observed in large quantities during both a Norwegian acoustic survey (Aglen, WD90) in the northwestern part of the North Sea and during a Danish acoustic survey in the central North Sea and in the Skagerrak

(Kirkegaard, WD90).

Therefore, the Working Group concluded that the distribution in 1989 was similar to that in 1988 (Table 7.3). Related distributions in percentage by quarter for the Western stock in the North Sea since 1973 is given in Iversen and Skagen (1989).

Available information about distribution of juvenile mackerel is reviewed in Anon. (1990b). Very little is known about the distribution of 0-groups except for the winter period. The main nursery areas for North Sea mackerel are in the east central North Sea and close to the Norwegian trench in the northern North Sea. The nursery area for 0-group mackerel of the Western stock is considered to be in a wide area from North Rona down into the Bay of Biscay with the greatest abundance near to the shelf-edge south of Ireland and in the western Channel and its approaches. The Working Group, therefore, assumes that the amount of Western stock 0-groups in the North Sea is very small.

During the period 1980-1986, about 0-3% of the total catch of 1-group mackerel was caught in Sub-area IV and Division IIIa. During the same period, about 0.5-3.5% of the total catch of 2-group fish was caught in these areas. According to surveys, the 1- and 2-groups were very abundant in the third and fourth quarters in the North Sea and the Skagerrak.

The general picture given in Anon. (1990b) is that up to 1982, 1- and 2-group mackerel were mainly found in Sub-areas VII and VIII where they contributed as much as 50% of the catches in numbers in certain years. From 1982 to 1986, juvenile mackerel formed a higher proportion of the total catch in Division VIa, indicating that the distribution had extended to the north of these areas. Since 1985, large quantities of juvenile mackerel have been present in the third and fourth quarters in the eastern part of the North Sea and Skagerrak.

The Working Group gives its guesstimate for the percentages of Western 1- and 2-group mackerel in the North Sea during 1973-1989 in Table 7.4. The percentages since 1986 are the same as given in the previous Working Group reports.

8 DEFICIENCIES IN DATA

Most Working Group members are satisfied about the accuracy of the national catches which have been estimated. There are, however, still considerable differences between some Working Group catch estimates and the national official figures. The total amount of "unallocated" catches and misreported catches decreased during 1989, although a number of members are still concerned about the accuracy of the reported origin of their catches. It should be pointed out that the log book scheme operated by the EEC permits a 20% tolerance between actual boat landings and the reported catch. It is possible, therefore, that countries relying on the log books for catch data may be consistently underestimating the total catch by a considerable amount. The Working Group would also again draw attention to the lack of information on the quantity of mackerel which are caught but discarded. The problem has been discussed in Section 5.1.1.

9 RECOMMENDATIONS

9.1 Research Recommendations

Mackerel/Horse Mackerel Egg Production Workshop

The Mackerel Working Group recommends that the next Mackerel/Horse Mackerel Egg Production Workshop be held at IJmuiden for three days in early 1991, before research vessel time is firmly scheduled by most countries.

Data processing

It is unlikely that MAFF will be able to take full responsibility for data processing for future egg surveys. Therefore, an alternative arrangement for processing the data has to be found at the next Mackerel/Horse Makcerel Egg Production Workshop meeting.

The batch fecundity method

The Mackerel Working Group recommends that the comparison between the total fecundity method and the batch fecundity method should be repeated in 1992.

Spawning fraction

The observation that mackerel spawn throughout the 24 hour diel cycle means that in order to estimate spawning fraction, good estimates of oocyte maturation and post-ovulatory follicle durations are necessary. Further experiments on captive mackerel are recommended to improve the accuracy of measurement of spawning fraction. Further observations on diel periodicity of spawning are recommended.

Rate of Atresia

The prevalence and intensity of atresia as measured from histological sections can only be used to estimate egg loss through atresia if the duration of atretic stages is known. At present, this information is not available. Research on captive mackerel is recommended to determine the duration of atretic stages.

Acoustic surveys

The acoustic surveys carried out in the summer in the North Sea area should supply data on the distribution of mackerel in the North Sea.

Acoustic surveys should also be carried out on the overwintering population of the Western stock. Such surveys would provide further fishery-independent estimates of stock size.

Recruitment surveys

The Working Group recommends that a planning group should be established by ICES, which would study all existing fish surveys carried out in the Western areas with a view to establishing a proper standardized international survey which would obtain recruitment indices for as many species as possible.

Egg surveys in Divisions VIIIc and IXa

Egg surveys should be carried out in Divisions VIIIc and IXa to supply information on population biomass. This may also provide information on stock identity.

Egg survey design and data analysis

Because most of the variation in the egg survey spawning stock biomass estimate derives from the estimation of egg production, further work on survey design and data analysis is recommended.

The mackerel in Divisions VIIIc and IXa Workshop

The Working Group recommends that a workshop should be held by Spanish and Portuguese scientists in Lisbon at the end of 1990 to consider the problem of stock identity and to try to collect a data base for assessment before the next Mackerel Working Group meeting.

9.2 Management Recommendations

1. The overall TAC should apply to all areas in which mackerel are caught, i.e., including Division IIa, Division Vb, and Divisions VIIIa,b; Sub-areas VI and VII (all for the whole year), and Division IVa from 1 August - 31 December.

2. There should be no fishing for mackerel in Divisions IVb,c at any time of the year.

3. The entire North Sea area (Sub-area IV and Division IIIa) should be closed during the period 1 January - 31 July.

4. Catches in Divisions IIIa and IVa should be reduced to the lowest practical level to ensure maximum protection for the North Sea stock. In this regard it is noted that the catch permitted for Division IVa during 1989 was from 1 October to 31 December. It is not possible to estimate what quantity of the actual catch taken belonged to the North Sea stock.

5. The 30 cm minimum landing size at present in force in the North Sea (Sub-area IV and Division IIIa) should be maintained and the present by-catch regulations should be continued.

6. The present closed area in Divisions VIIe,f, should be retained with its present boundaries.

10 WORKING DOCUMENTS

List of discussion papers presented at the Mackerel Working Group meeting in 1990.

Anon. 1990c. Report of the Workshop on Mackerel in Divisions VIIIc and IXa. Lisbon, 12-14 March 1990.

Aglen, A. Working Document 1990. Records of mackerel during the herring acoustic survey with R/V "Eldjarn", June-July 1989.

Kirkegaard, E. Working Document 1990. Some results from a Danish acoustic survey in the North Sea, July-August 1989.

Lucio, P. Some reproductive aspects of mackerel (Scomber scombrus) in the Bay of Biscay during 1987, 1988, and 1989.

Lucio, P., Villamor, B. and Astudillo, A. Spanish mackerel (Scomber japonicus) fishery in Division VIIIc (eastern and central part). 7 pp.

Lucio, P. and Martin, I. 1989. Biological studies on mackerel of the Bay of Biscay. Some preliminary results for 1987 and 1988. Working document presented at the 1989 Mackerel Working Group.

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Martins, M.M. Mackerel fishery "Scomber scombrus L." off Portugal (1989). 6 pp.

Walsh, M., Working Document 1990. Index to mackerel recruit survey data provided for ICES 1990 Mackerel Working Group.

Watson, J.J. and Priede, I.G., Editor, Working Document 1990. Evaluation of the Batch Fecundity Method for Assessment of Stocks of the Pelagic Spawning Fish. Second Interim Report Submitted to the Directorate General for Fisheries (DGXIV) of the Commission of the European Communities.

11 REFERENCES

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Anon. 1984. Report of the ad hoc Working Group on Mackerel Egg Surveys. ICES, Doc. C.M.1984/H:3, 31 pp (mimeo).

Anon. 1985. Report of the Mackerel Working Group. ICES, Doc. C.M.1985/Assess:7. 98 pp.

Anon. 1986. Report of the Mackerel Working Group. ICES, Doc. C.M.1986/Assess:12, 69 pp., (plus Annex, 14 pp.).

Anon. 1987a. Report of the Mackerel Working Group. ICES, Doc. C.M.1987/Assess:11, 72 pp.

Anon. 1987b. Report of the Mackerel Egg Production Workshop. ICES, Doc. C.M.1987/H:2, 58 pp (mimeo).

Anon. 1988a. Report of the Mackerel Working Group. ICES, Doc. C.M.1988/Assess:12, 82 pp.

Anon. 1988b. Report of the Mackerel Egg and Recruitment Workshop. ICES, Doc. C.M.1988/H:3.

Anon. 1989a. Report of the Mackerel Working Group. ICES, Doc. C.M.1989/Assess:11, 85 pp.

Anon. 1989b. Report of the Norwegian - EEC Joint Scientific Group on Migration and Area Distribution of Mackerel (Western Stock). Bergen, 11-13 November 1987. ICES, Doc. C.M.1988/H:17.

Anon. 1990a. Report of the Mackerel/Horse Mackerel Egg Production Workshop. ICES, Doc. C.M.1990/H:2, 89 pp. (mimeo).

Anon. 1990b. Second report of the EEC - Norwegian Joint Scientific Group on Migration and Area Distribution of Mackerel (Western stock) Brussels, 12-13 December 1989.

Coello, S., Dawson, W.A., and Grimm, W.S. 1989. Incidence of abortive maturation in the Western Stock of the North-east Atlantic mackerel during the 1987 spawning season. ICES, Doc. C.M. 1989/H:49.

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Dawson, W.A. 1983. A preliminary analysis of mackerel (Scomber scombrus, L.) otolith (L1) measurements. ICES, Doc. C.M.1983/H:29.

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Iversen, S.A. and Skagen, D.W. 1989. Migration of Western Mackerel to the North Sea 1973-1988. ICES, Doc. C.M.1989/H:20.

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Valencia, V., Motos, L. and Urrutia, J. 1989. Estudio de la variacion temporal de la hidrologia y el plancton en la zona neritica frente a San Sebastian: resusltados abril 1986 - December 1987. Informes tecnicos del Departmento de Agricultura del Gobierno Vasco, no. 20. Vitoria, 1989.

Table 2.1 Summary of western mackerel stock Stage 1 egg production in 1989. (Revised from Anon., 1990a).

	Daily egg production x 10^{13}				
	Period 1	Period 2	Period 3	Period 4	Period 5
Survey period	1-20 April	23 April-20 May	21 May-6 June	7-24 June	4-19 July
Survey mid point	10 April	3 May	29 May	15 June	11 July
Standard area	Not valid	1.5727	2.1344	1.6532	0.3124
North of 56^0N	-	-	0.0677	-	-
South of $44^0$30'N	-	0.0287	-	0.0032	-

Table 2.2 Summary of the western mackerel stock total egg production in 1989. (Revised from Anon., 1990a).

Area	Total egg production $\times 10^{15}$	%
Standard area 56^0N - $44^0$30'N	1.410	93.8
North of standard area North 56^0N	0.041	2.7
Western Channel East of $7^0$30'W	0.039[1]	2.6
South of standard area South $44^0$30'N	0.014	0.9

[1] 1988 egg production figures.

Table 2.3 Estimated biomass of mackerel in the eastern north Atlantic. Also shown are the components from which biomass is estimated. (Standard errors in parenthesis).

Sector	No. eggs E_d	Fecundity F_{bw}	Spawning Fraction S	Sex ratio r	Biomass B (g)
Northern	1.088×10^{12}	41.33	0.1820	0.5	2.893×10^{11}
	(0.417×10^{12})	(5.52)	(0.0523)		(1.438×10^{11})
Central	1.137×10^{13}	45.72	0.3348	0.5	1.485×10^{12}
	(0.349×10^{13})	(3.41)	(0.0787)		(0.585×10^{12})
Southern	9.945×10^{12}	55.49	0.6205	0.5	5.776×10^{11}
	(2.2099×10^{12})	(2.04)	(0.0545)		(1.338×10^{11})
Total	2.240×10^{13}				2.352×10^{12}
	(0.408×10^{13})				(0.617×10^{12})

Table 2.4 The percentage age composition by number and proportions of mature western mackerel during the trawl survey 23 May - 12 June 1989.

Age	% composition	% males	% females
1	14.9	4	<1
2	29.1	86	93
3	14.0	100	100
4	10.6	100	100
5	13.6	100	100
6	1.3	100	100
7	2.6	100	100
8	5.5	100	100
9	4.4	100	100
10	1.6	100	100
>10	2.3	100	100

Table 2.5 Estimates of total egg production and pre-spawning biomass of mackerel derived from the North Sea egg surveys by the total fecundity method.

Year	Total egg production (10^{12})	Mackerel pre-spawning stock biomass (10^3 tonnes)
1982	126	190[2]
1983	160	240[3]
1984	78	118[4]
1986	30	45[5]
1988	25	37[6]
1989	36[1]	53[7]

[1] Only based on a single coverage at the peak of spawning.

[2] (Iversen & Westgaard, 1984)
[3] (Iversen & Westgaard, 1984)
[4] (Iversen *et al.*, 1985)
[5] (Iversen *et al.*, 1987)
[6] (Iversen *et al.*, 1989)
[7] (Anon., 1990a)

Table 2.6 Estimates of mackerel egg production, of pre-spawning and spawning stock biomass of mackerel derived from the western egg surveys by the total and batch fecundity method.

	TOTAL FECUNDITY METHOD			BATCH FECUNDITY METHOD		
Year	Total egg production (10^{15})	Mackerel pre-spawning stock biomass (10^6 t)	Mackerel spawning stock biomass (10^6 t)[7]	Daily egg production (10^{13})	Mackerel pre-spawning stock biomass (10^6 t)	Mackerel spawning stock biomass (10^6 t)[7]
1977	1.98[1]	2.72[5]	2.94	-	-	-
1980	1.84[2]	2.53[5]	2.73	-	-	-
1983	1.50[2]	2.06[5]	2.22	-	-	-
1986	1.17[3]	1.60[5]	1.73	-	-	-
1989	1.50[4]	1.87[6]	2.01	2.24[8]	2.22[8]	2.40

[1] Lockwood *et al*. 1981.
[2] Anon., 1984.
[3] Standard area and areas to the north (Anon., 1987b).
[4] Standard area and areas to the north, east and south (Anon., 1990a).
[5] Biomass estimated from the fecundity/weight relationship of 1,457 eggs per g of pre-spawning female mackerel. (Anon., 1987b page 3).
[6] Biomass estimated from the fecundity/weight relationship of 1,608 eggs per g of pre-spawning female mackerel (Watson and Priede W.D. 1990).
[7] Spawning stock biomass adjusted using the relative weight of pre-spawning and spawning fish on the spawning grounds (increase of 8%).
[8] Watson and Priede W.D. 1990 (see also Section 2.2).

Table 3.1 (From Walsh, working document 1990).

Mackerel: Abundance index data from research vessel surveys

Survey: IYFS, North Sea, first quarter (south of 59°N only)

Country: All

Fishing gear: GOV

Year	Month	ICES Division	Mean nos/10 hr					Nos valid hauls
			0	1	2	2+	Total	
1970		IVa, b, c		6536	13	1	6550	
1971		IVa, b, c		3250	576	6	3832	
1972		IVa, b, c		13	226	1	240	
1973		IVa, b, c		28	2	1	31	
1974		IVa, b, c		14	12	1	27	
1975		IVa, b, c		26	1	2	29	
1976		IVa, b, c		3	*	1	4	
1977		IVa, b, c		14	*	*	14	
1978		IVa, b, c		8	*	*	8	
1979		IVa, b, c		3	*	0	3	
1980		IVa, b, c		*	*	*	1	
1981		IVa, b, c		1	*	*	1	
1982		IVa, b, c		1	1	1	3	
1983		IVa, b, c		24	64	46	134	
1984		IVa, b, c		1	2	4	7	
1985		IVa, b, c		8	0	1	9	
1986		IVa, b, c		6	1	*	7	
1987		IVa, b, c		2	*	?	?	
1988		IVa, b, c		1	1	?	?	
1989		IVa, b, c		13	21	2	36	
1990[1]		IVa, b, c		409	**	**	**	

Notes:

[1]provisional
* = <0.5
** = not yet available

<u>Table 4.1</u> Recruit indices North and South of 52°30'N.

Years class	First-winter Arithmetic mean North	South	nos/hours Ratio N:S	Second-winter Arithmetic mean North	South	nos/hours Ratio N:S
1980	-	-	-	1	104	0.01
1981	3	258	0.01	8	228	0.04
1982	3	14	0.21	-	55	-
1983	-	5	-	+	14	0.02
1984	137	161	0.85	26	453	0.06
1985	+	85	<0.01	21	57	0.37
1986	14	178	0.08	5	43	0.12
1987	30	187	0.16	108	323	0.33
1988	43	150	0.29	150	131	1.15
1989	250	105	2.48	-	-	-

Table 5.1 Nominal catch (t) of MACKEREL in the North Sea, Skagerrak, and Kattegat (Sub-area IV and Division IIIa), 1980-1989. (Data submitted by Working Group members.)

Country	1980	1981	1982	1983	1984
Belgium	5	55	102	93	68
Denmark	13,234	9,982	2,034	11,285	10,088
Faroe Islands	14,770	-	720	-	-
France	2,238	3,755	3,041	2,248	-
Germany, Fed. Rep.	56	59	28	10	112
Ireland	738	733	-	-	-
Netherlands	853	1,706	390	866	340
Norway	44,781	28,341	27,966	24,464	27,311
Sweden	1,666	2,446	692	1,903	1,440
UK (Engl.& Wales)	76	6,520	16	16	2
UK (Scotland)	9,514	10,575	44	4	13
UK (N. Ireland)	-	-	-	-	-
USSR	-	-	-	-	-
Unallocated + discards	-	3,216	450	96	202
Total	87,931	67,388	35,483	40,985	39,576

Country	1985	1986	1987[1]	1988	1989[2]
Belgium	-	49	14	20	37
Denmark	12,424	23,368	28,217	32,588	26,831
Faroe Islands	1,356	-	-	-	-
France	322	1,200	2,146	1,806	2,200
Germany, Fed. Rep.	217	1,853	474	177	6,312
Ireland	-	-	-	-	8,880
Netherlands	726	1,949	2,761	2,564	7,343
Norway	30,835	50,600	108,250	59,750	81,400
Sweden	760	1,300	3,162	1,003	6,601
UK (Engl.& Wales)	143	18	94	160	5,618
UK (Scotland)	7	541	19,763	616	33,042
UK (N. Ireland)	-	-	-	100	-
USSR	-	-	-	-	-
Unallocated + discards	3,656	7,431	10,789	29,766	4,777[3]
Total	50,446	88,309	174,306	128,550	183,041

[1] May include catches taken in Division IIa.
[2] Preliminary.
[3] Unallocated: 2,587 t, discards 2,190 t.

Table 5.2 Nominal catches (t) of MACKEREL in the Norwegian Sea (Division IIa) and off the Faroes (Division Vb), 1980-1989.

Country	1980	1981	1982	1983	1984	1985	1986	1987[3]	1988[3]	1989[4]
Denmark[1]	-	801	1,008	10,427	11,787	7,610	1,653	3,133	4,265	3,460
Faroe Islands[1]	270	-	180	-	138	-	-	-	22	100
France[2]	-	6	8	-	-	16	-	-	-	11
Germany, Fed. Rep.[2]	-	51	-	5	-	-	99	-	380	-
German Dem. Rep.[2]	2	-	-	-	-	-	16	292	-	2,409
Norway[1]	6,618	12,941	34,540	38,453	82,005	61,065	85,400	25,000	86,400	68,300
Poland[2]	-	-	231	-	-	-	-	-	-	-
UK (Engl. & Wales)[1]	-	255	-	-	-	-	-	-	-	-
UK (Scotland)[2]	296	968	-	-	-	-	2,131	157	1,413	-
USSR[2]	1,450	3,640	1,641	65	4,292	9,405	11,813	18,604	27,924	12,088
Total	8,340	18,662	37,608	48,950	98,222	78,096	101,112	47,186	120,404	87,358

[1] Data provided by Working Group members.
[2] Data reported to ICES.
[3] Includes catches probably taken in the northern part of Division IVa.
[4] Preliminary.

Table 5.3 Nominal catch (tonnes) of MACKEREL in the Western area (Sub-areas VI and VII and Divisions VIIIa,b,d,e). (Data estimated by Working Group.)

Country	1980	1981	1982	1983	1984
Belgium	3	-	-	+	+
Denmark	14,932	13,464	15,000	15,000	200
Faroe Islands	15,234	9,070	11,100	14,900	9,200
France	23,907	14,829	12,300	11,000	12,500
Germany, Fed.Rep.	21,088	29,221	11,200	23,000	11,200
Ireland	40,791	92,271	109,700	110,000	84,100
Netherlands	91,081	88,117	67,200	73,600	99,000
Norway	25,500	21,610	19,000	19,900	34,700
Poland	-	1	-	-	-
Spain	3,684	1,365		-	100
UK (England + Wales)	150,598	75,722	82,900	62,000	30,000
UK (N. Ireland)	-	4,153	9,600	800	10,600
UK (Scotland)	108,372	109,153	147,400	120,100	157,700
USSR	-	-	-	+	200
Unallocated	98,258	140,322	97,300	105,500	18,000
Discard	21,600	42,300	24,900	11,300	12,100
Grand total	615,048	641,598	607,700	567,100	479,600

Country	1985	1986	1987	1988[1]	1989[2]
Belgium	-	+	-	-	-
Denmark	400	300	100	-	1,000
Faroe Islands	9,900	1,400	7,100	2,600	3,600[3]
France	7,400	11,200	11,100	8,900	12,700
Germany, Fed.Rep.	11,800	7,700	13,300	15,900	16,200
Ireland	91,400	74,500	89,500	85,800	61,100
Netherlands	37,000	58,900	31,700	26,100	24,700
Norway	24,300	21,000	21,600	17,300	700
Poland	-	-	-	-	-
Spain	+	-	-	1,500	1,400
UK (Engl. + Wales)	9,600	9,100	25,200	24,100	16,500
UK (N. Ireland)	12,200	9,700	10,700	8,900	11,000
UK (Scotland)	184,100	137,500	164,800	175,400	123,400
USSR	+	-	-	+	-
Unallocated	75,100	51,000	25,800	4,700	16,000
Discard	4,500	-	-	5,800	4,900
Grand total	467,700	380,500	401,700	377,000	293,200

[1] Includes catches taken in Division IVa, but misreported to Division VIa.
[2] Preliminary.
[3] Data reported to ICES.

Table 5.4 Quarterly catches of mackerel by division and sub-area in 1989. (Data submitted by Working Group members.)

Division/ Sub-area	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
IIa + Vb	+	800	86,100	+	86,900
IVa	15,100[1]	200	89,200[2]	156,700[3]	261,200
IVb	200	800	6,800	900	8,700
IVc	100	400	400	2,900	3,800
IIIa	+	300	6,200	1,400	7,900
VI	99,600	2,900	1,500	19,900	123,900
VII	29,900	29,600	3,900	8,500	71,900
VIIIa,b,d,e	1,300	1,500	200	300	3,300
Sub-total	146,200	36,500	194,300	190,600	567,600
VIIIc	6,500	5,800	500	600	13,400
IXa	400[4]	400[4]	800[4]	100[4]	5,700[5]
Grand total					586,700

[1] Includes estimated catches of 9,200 t caught in Division IVa, but misreported to Division VIa

[2] Includes estimated catches of 3,000 t caught in Division IVa, but misreported to Divisions VIa.

[3] Includes estimated catches of 80,000 t caught in Division IVa, but misreported to Division VIa.

[4] Includes only Spanish catches.

[5] Includes both Spanish and Portuguese catches.

<u>Table 5.5</u> Actual catches of mackerel by sub-areas. Discards not estimated prior to 1978. (Data submitted by Working Group members.)

	Sub-area VI			Sub-area VII and Divisions VIIIa,b,d,e			Sub-area IV and Division IIIa		
Year	Landings	Discards	Catch	Landings	Discards	Catch	Landings	Discards[1]	Catch
1969	4,800	-	4,800	66,300	-	66,300	739,182	-	739,182
1970	3,900	-	3,900	100,300	-	100,300	322,451	-	322,451
1971	10,200	-	10,200	122,600	-	122,600	243,673	-	243,673
1972	10,000	-	10,000	157,800	-	157,800	188,599	-	188,599
1973	52,200	-	52,200	167,300	-	167,300	326,519	-	326,519
1974	64,100	-	64,100	234,100	-	234,100	298,391	-	298,391
1975	64,800	-	64,800	416,500	-	416,500	263,062	-	263,062
1976	67,800	-	67,800	439,400	-	439,400	303,842	-	303,842
1977	74,800	-	74,800	259,100	-	259,100	258,131	-	258,131
1978	1,517,000	15,200	166,900	355,500	35,500	391,000	148,817	-	148,817
1979	203,300	20,300	223,600	398,000	39,800	437,800	152,323	500	152,823
1980	218,700	6,000	324,700	386,100	15,600	401,700	87,391	-	87,391
1981	335,100	2,500	237,600	274,300	39,800	314,100	64,172	3,216	67,388
1982	340,400	4,100	344,500	257,800	20,800	278,600	35,033	450	35,483
1983	315,100	22,300	317,400	245,400	9,000	254,400	40,889	96	40,985
1984	306,100	1,600	307,700	176,100	10,500	186,600	39,374	202	39,576
1985	388,140	2,735	390,875	75,043	1,800	76,843	46,168	3,656	50,124
1986	104,100	+	104,100	128,499	+	128,495	236,309	7,431	243,740
1987	183,700	+	183,700	100,300	+	100,300	290,829	10,789	301,612
1988	115,600	3,100	119,700	75,600	2,700	78,300	308,550	29,766	338,316
1989	121,300	2,609	123,900	72,900	2,300	75,200	279,410	2,190	281,600

NB. Catches in Sub-area IV and Division IIIa are taken from 1978 Working Group report and Norwegian catches taken in Division IIa from 1973-1987. [1]Includes unallocated as well as discards.

Table 5.6

CATCH IN NUMBERS ('000) AND MEAN WEIGHT (G) BY QUARTER, DIVISION, AND AGE IN 1989

FIRST QUATER

AGE	IIa,IVa,Vb C	IIa,IVa,Vb W	IIIa C	IIIa W	IVb,c C	IVb,c W	VIa,b C	VIa,b W	VIIa,d-h C	VIIa,d-h W	VIIb,c,j,k C	VIIb,c,j,k W	VIIIa,b,d,e C	VIIIa,b,d,e W	TOTAL C	TOTAL W
0	0		0	0	0		0	0	0	0	0	0	0	0	0	0
1	0		0	194	0		0	0	178	60	0	0	6	74	184	61
2	1146	183	4	305	368	195	13444	174	29236	118	1480	154	348	178	46027	138
3	2214	270	0	359	302	262	19288	262	11093	169	4662	253	1394	248	38959	234
4	2801	337	0	383	76	317	22570	334	4292	200	5590	302	581	321	35910	313
5	10508	339	1	542	216	356	73442	392	3323	258	27918	348	509	373	115917	378
6	1185	416	1	660	0		12299	415	18	313	3699	391	188	464	17391	411
7	2301	546	1	694	76	374	15457	532	276	276	2874	426	517	460	21500	514
8	6061	577	3	671	57	512	32273	575	326	295	5672	480	308	498	44700	560
9	2732	565	2	823	84	550	16902	552	365	220	3419	467	105	549	23508	535
10	1497	589	1	735	0		8929	571	203	276	2525	471	0	0	13064	549
11	384	655	0	0	0		4064	620	255	302	757	477	0	0	5460	588
12	280	613	0	713	0		1436	605	0	0	320	579	29	650	2066	603
13	293	701	0	713	0		2497	712	0	0	269	630	21	766	3081	704
14	217	807	0	0	0		1072	787	0	0	196	663	0	0	1484	774
15	890	825	1	910	0		4237	811	0	0	1159	711	0	0	6285	794
TOTAL	32421	466	14	583	1178	302	227908	437	49571	150	60541	374	4005	338	375638	390
TONNES	15105	15104	8	8	355	355	99574	99510	7160	7437	22713	22665	1285	1355	146200	146435

SECOND QUARTER

AGE	IIa,IVa,Vb C	IIa,IVa,Vb W	IIIa C	IIIa W	IVb,c C	IVb,c W	VIa,b C	VIa,b W	VIIa,d-h C	VIIa,d-h W	VIIb,c,j,k C	VIIb,c,j,k W	VIIIa,b,d,e C	VIIIa,b,d,e W	TOTAL C	TOTAL W
0	0		0	0	0		0	0	0	0	0	0	0	0	0	0
1	0	257	8	194	0		106	110	0	0	1588	53	730	128	2432	78
2	25	294	129	305	1399	193	3074	172	12140	110	7757	142	1205	164	25729	135
3	71	362	15	359	1032	257	2122	246	2620	167	3861	235	1328	255	11048	226
4	146	403	9	383	242	311	1797	284	1374	234	11166	300	977	312	15711	294
5	414	457	31	542	653	352	1984	322	863	285	31812	342	929	360	36686	342
6	115	461	32	660	0		118	362	48	301	3323	375	156	384	3793	379
7	198	529	19	694	242	362	153	407	575	320	3010	404	288	429	4475	399
8	432	557	116	671	166	512	551	439	703	303	5809	449	138	481	7914	446
9	196	599	76	823	245	550	354	433	399	312	4455	425	101	513	5825	435
10	133	609	26	735	0		39	361	463	249	2159	452	10	610	2830	428
11	53	681	0	0	0		16	473	16	394	1654	467	2	588	1742	473
12	5	766	2	713	0		47	463	160	400	167	451	6	647	388	440
13	59	730	9	713	0		50	462	16	389	1367	566	2	755	1503	568
14	1	865	0	0	0		27	510	0	0	214	446	2	695	244	457
15	47	656	22	910	0		127	565	48	330	1256	548	2	715	1502	551
TOTAL	1897	524	495	583	3979	289	10565	271	19423	159	79597	335	5877	270	121924	301
TONNES	998	998	288	289	1147	1149	2862	2865	2987	3082	26637	26659	1532	1587	36441	35618

cont'd.

Table 5.6 cont'd.

THIRD QUARTER

AGE	IIa,IVa,Vb C	IIa,IVa,Vb W	IIIa C	IIIa W	IVb,c C	IVb,c W	VIa,b C	VIa,b W	VIIa,d-h C	VIIa,d-h W	VIIb,c,j,k C	VIIb,c,j,k W	VIIIa,b,d,e C	VIIIa,b,d,e W	TOTAL C	TOTAL W
0	0		0	0	117	120	0	0	10547	59	1022	42	0	0	11686	58
1	81	257	3628	165	1640	165	1163	160	2107	151	2904	135	0	0	11522	156
2	54666	319	16245	261	17402	146	2161	196	7602	192	1067	183	70	190	99214	265
3	54675	377	794	319	3061	224	1081	251	419	295	697	203	70	270	60798	363
4	40070	447	206	335	2553	262	574	279	419	302	733	235	70	322	44625	429
5	105960	517	223	498	1900	251	244	319	0	0	187	271	70	354	108485	511
6	5935	576	72	660	1970	314	184	356	0	0	125	302	70	386	8357	504
7	14583	645	80	683	1067	306	74	371	0	0	62	295	0	0	15866	619
8	29750	689	609	630	1182	354	257	321	0	0	227	337	0	0	32025	670
9	20645	682	326	774	1182	333	248	360	0	0	105	336	0	0	22507	660
10	8173	711	113	732	394	368	187	328	0	0	121	374	0	0	8988	694
11	2739	751	0	0	0		55	397	0	0	21	378	0	0	2915	741
12	2510	766	35	713	394	441	8	395	0	0	11	408	0	0	2958	720
13	3450	805	41	713	0		41	466	0	0	28	417	0	0	3560	797
14	662	868	0	0	0		18	476	0	0	0	0	0	0	691	859
15	4631	839	52	910	788	620	8	411	0	0	19	558	0	0	5497	897
TOTAL	348430	503	22424	276	33651	215	6303	238	21093	124	7331	170	350	306	439582	441
TONNES	175250	175116	6191	6187	7205	7218	1508	1502	2617	2612	1250	1247	210	107	194231	193989

FOURTH QUARTER

AGE	IIa,IVa,Vb C	IIa,IVa,Vb W	IIIa C	IIIa W	IVb,c C	IVb,c W	VIa,b C	VIa,b W	VIIa,d-h C	VIIa,d-h W	VIIb,c,j,k C	VIIb,c,j,k W	VIIIa,b,d,e C	VIIIa,b,d,e W	TOTAL C	TOTAL W
0	23	73	0	0	739	121	168	62	10282	62	1541	54	0	0	12753	64
1	5055	208	813	172	10240	167	496	209	11614	130	473	163	0	0	28692	160
2	96070	286	4631	253	4246	191	11429	293	14616	196	4202	256	692	196	135886	272
3	76519	346	101	302	918	270	11236	343	1993	219	1250	284	508	247	92525	341
4	56882	402	19	355	1053	276	7641	393	880	269	571	332	139	278	67184	336
5	82397	452	22	498	385	280	11366	448	338	282	813	370	46	302	95368	449
6	14166	501	6	660	312	310	1825	492	78	191	0	0	0	0	16388	495
7	10681	573	6	683	438	367	905	539	34	240	109	329	0	0	12172	560
8	18879	621	57	630	171	362	1972	601	0	0	0	0	0	0	21080	617
9	12732	581	32	774	152	333	1550	626	123	218	134	420	0	0	14723	579
10	5294	601	10	732	70	347	741	580	416	264	0	0	0	0	6531	574
11	3263	765	0	0	0		290	652	0	0	0	0	0	0	3553	756
12	753	666	3	713	51	441	122	658	0	0	0	0	0	0	929	653
13	1420	773	3	713	0		105	794	4	453	0	0	0	0	1532	773
14	471	872	0	0	0		13	1002	0	0	0	0	0	0	484	876
15	2311	822	6	910	121	572	162	814	0	0	0	0	0	0	2599	810
TOTAL	386916	406	5709	253	18896	198	50023	397	40378	147	9093	239	1384	226	512399	372
TONNES	156670	157090	1447	1445	3735	3741	19880	19881	6294	5939	2203	2173	323	313	190552	190574

Table 5.7 Countries provided sampling data from the fisheries in 1989 and the percentages of the total catch sampled. 0 = no catch; + = sampling data available; - = catch but no sampling data. The Table only includes countries who have provided sampling data from at least one quarter.

Division	Quarter	Denmark	Ireland	Nether-lands	Norway	Spain	UK(Engl. & Wales)	UK Scotland	USSR	% Sampled	Total Catch t
IIa	1	0	0	0	0	0	0	0	0	0	3
	2	0	0	0	0	0	0	0	+	83	804
	3	-	0	0	+	0	0	0	+	83	86,083
	4	0	0	0	0	0	0	0	0	0	1
IIIa	1	-	0	0	0	0	0	0	0	0	8
	2	-	0	0	+	0	0	0	0	87	288
	3	+	0	0	+	0	0	0	0	52	6,191
	4	+	0	0	+	0	0	0	0	31	1,447
IVa	1	-	+	0	0	0	-	+	0	98	15,102
	2	-	0	0	0	0	0	0	0	0	184
	3	-	0	+	+	0	-	0	0	76	89,167
	4	+	+	+	+	0	-	+	0	90	15,667
IVb	1	-	0	0	0	0	0	0	0	0	258
	2	-	0	+	0	0	-	-	0	3	753
	3	-	0	+	0	0	-	-	0	3	6,755
	4	-	0	0	0	0	-	-	0	0	870
IVc	1	0	0	0	0	0	0	0	0	0	97
	2	0	0	+	0	0	-	0	0	10	394
	3	-	0	+	0	0	-	0	0	7	450
	4	-	0	+	0	0	-	0	0	8	2,865
VI	1	0	+	+	0	0	-	+	0	89	99,574
	2	0	+	+	0	0	-	+	0	61	2,862
	3	0	+	+	-	0	-	+	0	31	1,508
	4	0	+	+	0	0	0	+	0	64	19,880
VIIa,d-h	1	-	0	0	0	0	+	-	0	49	7,160
	2	-	0	0	0	0	+	0	0	6	2,987
	3	-	0	-	0	0	-	0	0	0	2,617
	4	-	0	+	0	0	+	-	0	62	6,294
VIIb,c,j,k	1	0	+	+	0	0	-	-	0	73	22,713
	2	0	+	+	0	0	0	0	0	73	26,637
	3	0	+	+	0	0	0	0	0	100	1,250
	4	0	+	0	0	0	-	0	0	97	2,203
VIIIa,b	1	0	0	0	0	+	-	0	0	50	1,285
	2	0	0	0	0	+	0	0	0	50	1,532
	3	0	0	0	0	+	0	0	0	1	210
	4	0	0	0	0	+	0	0	0	2	323

Table 5.8 Summary of samples from different areas (1989).

Area		Catch	No.of samples from commercial fishery	No. measured[1]	No. aged[1]
IIa	1989	86,800	14	20,756	1,513
IIIa	1989	7,934	2	446	466
IV	1989	273,500	60	11,278	5,820
Vb	1989	7,500?	-	412	100
VI	1989	123,800	78	16,711	5,106
VII	1989	71,900	86	36,578	9,303
VIIIa,b,d,e	1989	3,300	56	8,805	781
VIIIc-IXa	1989	19,000	380	25,967	1,956

[1] Number of fish measured and aged includes research vessel data.

Table 5.9 Annual length distribution ('000) of mackerel catches per fleet per country in 1988.

Length (cm)	Denmark	Ireland	Netherlands		Norway		UK(Eng.)	UK(Scot.)
	P.seine	Pr.tr.	Pel.tr.	Beam+bt.tr.	Coastal	P.seine	All gear	P.seine
6	-	-	-	-	-	-	-	-
7	-	-	248	-	-	-	-	-
8	-	-	746	-	-	-	-	-
9	-	-	395	-	-	-	-	-
20	-	33	1,102	-	-	-	36	-
1	-	-	1,047	-	-	-	85	22
2	-	-	1,138	-	-	-	78	22
3	-	-	231	-	-	-	54	-
4	-	-	306	-	-	-	472	235
5	-	-	68	-	<26=10	6	3,055	892
6	-	33	357	44	235	2	6,792	2,061
7	-	133	470	311	196	-	9,440	3,347
8	-	333	2,339	311	52	106	8,517	3,652
9	-	733	2,732	300	20	2,424	9,812	5,779
30	533	1,936	3,620	328	268	4,504	5,200	10,980
1	389	7,834	6,039	537	710	7,663	5,410	15,810
2	1,683	14,836	8,512	514	795	10,210	5,868	26,400
3	3,613	23,704	10,209	460	1,178	17,587	4,073	31,727
4	6,965	30,139	13,122	416	1,479	29,164	2,930	40,536
5	7,395	30,805	14,412	378	2,126	36,710	2,068	44,547
6	6,319	23,737	12,407	248	1,721	36,715	1,069	37,510
7	4,525	17,768	3,732	174	1,918	32,362	690	28,802
8	3,065	17,503	8,056	190	1,553	28,722	255	20,672
9	2,741	16,769	8,429	117	1,254	28,216	161	16,131
40	2,760	14,869	8,777	132	1,459	26,017	7	14,231
1	1,764	9,134	5,308	47	1,309	13,953	5	11,544
2	917	6,567	2,955	62	457	6,130	2	6,722
3	469	5,134	2,920	-	674	5,754	1	3,809
4	230	3,167	1,655	11	1,197	3,242	-	2,494
5	150	1,333	771	16	-	-	-	695
6	-	600	86	-	-	-	-	463
7	-	233	-	-	-	-	-	384
8	-	33	-	-	-	-	-	-
9	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-
Total	43,524	227,366	128,789	4,596	18,611	289,423	66,080	329,467

(cont'd)

Table 5.9 (cont'd)

Length (cm)	Spain				Portugal			USSR
	Liners	Gillnet	P.Seine	Trawl	Artisan	P.seine	Trawl	Pel.tr.
6	-	-	605	4	-	-	+	-
7	-	-	1,968	+	-	-	+	-
8	-	-	5,599	11	-	66	10	-
9	-	-	11,580	127	-	394	261	-
20	-	-	15,820	2,396	-	1,634	896	-
1	7	-	14,606	7,507	-	2,407	2,035	-
2	9	-	4,520	4,098	+	940	2,286	-
3	12	-	2,351	1,150	24	794	2,109	-
4	15	-	1,466	132	37	214	1,495	62
5	15	-	818	131	84	214	924	123
6	-	-	611	97	145	553	644	494
7	19	-	111	373	152	825	417	1,049
8	22	-	198	227	220	714	522	1,296
9	105	-	419	254	144	447	551	1,605
30	187	-	583	408	174	78	426	2,963
1	534	-	326	878	151	84	505	5,309
2	803	-	1,169	1,071	220	176	382	6,790
3	994	-	2,244	1,123	252	159	299	9,383
4	1,284	-	1,914	1,077	210	360	185	9,259
5	997	-	2,138	1,124	191	378	82	5,679
6	1,043	-	2,767	694	112	197	62	6,049
7	1,659	-	1,769	748	109	230	23	5,926
8	2,362	-	2,553	696	59	220	16	2,346
9	2,626	60	3,394	888	34	87	11	1,358
40	2,618	60	2,081	347	83	6	8	988
1	1,642	30	611	430	52	9	4	617
2	790	60	440	367	55	4	+	185
3	425	60	586	248	17	9	+	185
4	465	149	-	80	7	4	-	-
5	242	119	-	194	1	-	-	62
6	91	30	-	192	-	-	-	-
7	30	-	-	57	+	-	-	-
8	4	30	-	+	-	-	-	-
9	15	-	-	+	-	-	-	-
50	-	-	-	+	-	-	-	-
Total	19,017	596	83,247	27,129	2,533	11,203	14,153	61,727

Beam + Bt.tr. = beam and bottom trawlers.
Pel.tr. = pelagic trawlers.
Pr.tr. = pair trawlers.
Artisan = artisinals.

Table 5.10 Annual length distribution ('000) of mackerel catches per fleet per country in 1989.

Length	Denmark	Ireland	Netherlands		Norway	UK(Eng.)	UK(Scot.)		Spain				USSR
(cm)	P.seine	Pr.tr.	Bt.+ beam tr.	Pel.tr.	P.seine	Pel.tr.	P.seine	2-b.-pel.	Trawl	P.seine	Gillnet	Liners	Pel.tr.
15	-	72	-	-	-	-	-	-	-	3,629	-	-	-
16	-	184	-	-	-	-	-	-	-	10,999	-	-	-
17	-	540	-	-	-	-	-	-	-	7,734	-	-	-
18	-	651	-	1,089	-	-	-	-	9	1,848	-	-	-
19	-	621	-	890	-	45	-	-	66	432	-	-	-
20	-	971	-	1,423	-	195	-	-	498	443	-	-	-
21	-	497	-	1,115	-	661	-	17	3,208	1,668	-	-	-
22	-	239	-	1,089	-	602	-	-	2,562	3,896	-	-	-
23	-	273	26	-	-	253	-	-	1,410	2,638	-	-	-
24	-	320	48	27	-	1,143	-	-	1,003	1,546	-	3	-
25	-	2,017	180	236	415	2,922	-	17	418	895	-	-	-
26	3	6,916	432	498	435	5,851	114	51	476	617	-	5	23
27	6	3,845	432	2,289	602	5,600	1,255	154	563	437	-	3	23
28	15	3,168	289	5,137	1,067	5,231	2,553	139	910	427	-	16	71
29	110	4,624	251	3,869	8,140	4,893	3,978	824	755	365	1	66	354
30	528	8,803	191	5,055	15,779	3,508	10,535	325	557	276	-	61	826
31	276	17,883	122	4,687	20,347	2,753	15,811	1,400	650	148	-	129	1,534
32	1,005	18,940	138	7,189	30,366	2,138	20,406	1,336	682	299	1	264	3,070
33	1,326	12,939	144	8,459	23,843	1,632	29,077	927	777	391	1	332	4,297
34	3,148	15,750	72	11,482	27,021	715	28,882	921	832	570	2	583	4,793
35	2,938	14,940	38	17,303	26,070	536	32,450	1,385	764	754	22	738	3,282
36	4,050	17,654	35	18,937	29,193	91	25,632	1,822	823	699	2	805	1,605
37	3,745	14,265	44	17,579	29,568	76	24,575	948	805	1,036	23	737	1,299
38	3,855	10,898	25	13,882	25,329	202	16,229	4	701	945	29	1,040	1,133
39	2,387	10,614	-	6,296	18,454	-	11,675	19	604	1,226	3	1,268	590
40	2,614	10,352	2	6,410	15,029	-	8,708	1	627	1,493	52	1,810	401
41	1,678	9,675	2	4,897	13,634	-	7,300	1	592	1,306	73	1,632	212
42	1,470	6,468	2	2,763	10,110	-	5,131	-	407	705	111	978	71
43	500	3,275	2	3,201	5,428	-	3,879	-	245	267	75	325	24
44	678	5,391	-	915	4,855	-	1,603	-	58	169	59	160	-
45	339	964	11	977	-	-	636	-	24	61	24	133	-
46	-	338	-	-	-	-	662	-	20	2	24	34	-
47	-	154	-	-	-	-	64	-	-	-	-	32	-
48	-	-	-	-	-	-	-	-	3	2	-	8	-
49	-	-	-	-	-	-	54	-	3	-	-	8	-
50	-	17	-	-	-	-	-	-	-	-	3	2	-
Total	30,670	204,258	2,486	147,686	305,685	39,047	251,011	10,292	21,052	47,923	515	11,170	23,588

Table 5.11

Title : MACKEREL, WESTERN STOCK

from 72 to 89 on ages 0 to 11
with Terminal F of .275 on age 5 and Terminal S of 1.000

Initial sum of squared residuals was 457.700 and
final sum of squared residuals is 98.091 after 122 iterations

Matrix of Residuals

Years	72/73	73/74	74/75	75/76	76/77	77/78	78/79
Ages							
0/ 1	1.610	-3.406	1.023	-1.026	2.351	1.948	1.048
1/ 2	-.021	1.625	1.227	.019	.496	.072	.558
2/ 3	-1.044	-.367	-.710	-.626	-.059	.219	.380
3/ 4	-.964	-.202	-.492	-.331	.176	-.097	.339
4/ 5	.177	-.276	-.258	.206	.607	-.190	.181
5/ 6	.169	.110	.451	.473	-.038	-.247	.005
6/ 7	.113	.028	-.680	-.731	-.209	-.041	-.341
7/ 8	.126	.041	.121	.993	.336	.183	-.152
8/ 9	.087	.003	.085	-.085	.178	.093	-.387
9/10	.212	.127	.208	.038	-.713	-.142	.062
10/11	.124	.039	.119	-.053	-.807	.053	-.031
	.000	.000	.000	.000	.000	.000	.000
WTS	.001	.001	.001	.001	.001	.001	.001

Years	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88	88/89		WTS
Ages												
0/ 1	2.458	1.485	2.597	1.160	-2.140	-1.893	-2.458	4.300	.729	-.687	.000	.088
1/ 2	.632	.717	.437	-.346	.198	.866	.478	-.548	-.639	-.163	.000	.308
2/ 3	-.079	.701	.192	.108	.096	.627	-.387	-.066	.121	-.293	.000	.401
3/ 4	.311	.570	.093	.086	-.055	.357	-.263	-.369	.289	-.014	.000	.489
4/ 5	-.017	.360	.021	.102	.156	.226	.122	-.152	-.337	.139	.000	.754
5/ 6	-.043	-.012	-.145	-.205	-.153	.042	-.047	.246	-.236	-.006	.000	.871
6/ 7	-.117	-.268	-.071	-.060	-.297	.023	-.045	.120	-.029	-.066	.000	.760
7/ 8	.018	-.322	-.269	-.021	.030	-.449	.118	.224	-.006	.112	.000	.593
8/ 9	-.419	-.267	-.173	.103	.012	-.240	.030	-.015	.159	.066	.000	1.000
9/10	.087	-.530	.027	.220	.176	-.144	.161	-.523	.334	.172	.000	.615
10/11	-.047	-.238	-.006	-.205	.281	-.202	.176	.015	.082	-.069	.000	.777
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	11.033	
WTS	.001	.001	.001	.001	.001	1.000	1.000	1.000	1.000	1.000		

Fishing Mortalities (F)

	72	73	74	75	76	77	78	79		
F-values	.0584	.0836	.1130	.1728	.2368	.1519	.2279	.3043		
	80	81	82	83	84	85	86	87	88	89
F-values	.2977	.2456	.2390	.2272	.1916	.1808	.1871	.2387	.2698	.2750

Selection-at-age (S)

	0	1								
S-values	.0015	.1294								
	2	3	4	5	6	7	8	9	10	11
S-values	.4180	.6568	.8428	1.0000	1.0321	1.0078	.9954	.9436	1.0141	1.0000

Table 5.12 VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

CATCH IN NUMBERS UNIT: millions

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	2	0	1	1	34	2	10	80	20	38	2	0
1	12	34	87	53	279	154	31	351	485	266	203	44
2	12	49	24	104	185	290	564	62	469	506	436	713
3	29	64	124	95	322	154	425	603	75	225	484	445
4	508	116	109	306	171	166	244	366	381	32	184	392
5	0	582	192	192	289	51	258	217	282	175	25	130
6	0	0	567	144	119	140	72	233	145	159	137	20
7	0	0	0	1246	280	64	152	87	158	100	109	91
8	0	0	0	0	439	89	57	154	52	117	85	71
9	0	0	0	0	0	159	83	71	140	35	87	47
10	0	0	0	0	0	0	211	75	44	139	24	49
11	0	0	0	0	0	0	0	189	48	29	90	19
12+	0	0	0	0	0	0	0	0	115	176	148	126
TOTAL	563	845	1103	2141	2117	1268	2107	2486	2414	1997	2012	2147
A) SOP	222	319	411	862	682	381	628	767	803	700	700	678
B)NOMIN.	171	219	298	491	507	326	504	606	605	662	624	614
(B/A) %	77	69	72	57	74	85	80	79	75	95	89	91

	1984	1985	1986	1987	1988	1989
0	1	0	18	2	0	24
1	15	234	26	23	99	43
2	80	16	398	148	127	307
3	662	49	30	654	175	203
4	375	420	64	52	505	163
5	238	243	332	79	67	356
6	92	158	194	237	78	46
7	16	59	120	149	179	54
8	51	16	38	84	112	106
9	39	42	11	33	52	67
10	25	33	29	18	19	31
11	21	20	20	25	12	14
12+	44	80	60	61	52	35
TOTAL	1659	1371	1339	1565	1478	1449
A) SOP	565	556	535	630	626	568
B)NOMIN.	551	561	538	615	628	567
(B/A) %	98	101	101	98	100	100

Table 5.13 VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

MEAN WEIGHT AT AGE OF THE STOCK UNIT: kilogram

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
1	.113	.113	.113	.113	.113	.113	.095	.095	.095	.070	.070	.070
2	.131	.131	.131	.131	.131	.131	.150	.150	.150	.172	.108	.156
3	.201	.201	.201	.201	.201	.201	.215	.215	.215	.241	.202	.220
4	.380	.251	.251	.251	.251	.251	.275	.275	.275	.300	.260	.261
5	.000	.410	.264	.264	.264	.264	.320	.320	.320	.300	.379	.322
6	.000	.000	.440	.316	.316	.316	.355	.355	.355	.359	.329	.360
7	.000	.000	.000	.470	.380	.380	.380	.380	.380	.401	.388	.384
8	.000	.000	.000	.000	.490	.412	.400	.400	.400	.412	.417	.420
9	.000	.000	.000	.000	.000	.511	.420	.420	.420	.427	.425	.497
10	.000	.000	.000	.000	.000	.511	.485	.485	.485	.413	.460	.453
11	.000	.000	.000	.000	.000	.000	.000	.485	.485	.509	.513	.550
12+	.000	.000	.000	.000	.000	.000	.000	.000	.485	.509	.513	.550

	1984	1985	1986	1987	1988	1989
0	.000	.000	.000	.000	.000	.000
1	.070	.070	.070	.070	.070	.070
2	.187	.150	.164	.139	.146	.176
3	.246	.292	.261	.233	.233	.238
4	.283	.300	.290	.268	.302	.299
5	.305	.328	.345	.363	.327	.342
6	.379	.366	.337	.371	.434	.363
7	.429	.421	.395	.392	.455	.419
8	.421	.440	.467	.402	.436	.468
9	.465	.448	.441	.459	.460	.441
10	.515	.554	.451	.483	.528	.451
11	.497	.579	.472	.442	.606	.496
12+	.547	.601	.612	.559	.684	.585

Table 5.14 SUM OF PRODUCTS CHECK

MACKEREL, WESTERN STOCK
CATEGORY: TOTAL

MEAN WEIGHT AT AGE IN THE CATCH UNIT: kilogram

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.066	.066	.066	.066	.066	.066	.000	.000	.066	.066	.066	.066
1	.137	.137	.137	.137	.137	.137	.137	.137	.131	.131	.131	.178
2	.158	.158	.158	.158	.158	.158	.158	.158	.248	.248	.248	.216
3	.241	.241	.241	.241	.241	.241	.241	.241	.283	.283	.283	.270
4	.416	.314	.314	.314	.314	.314	.314	.314	.343	.343	.343	.306
5	.000	.437	.334	.334	.334	.334	.334	.334	.373	.373	.373	.383
6	.000	.000	.472	.398	.398	.398	.398	.398	.455	.455	.455	.425
7	.000	.000	.000	.480	.410	.410	.410	.410	.497	.497	.497	.430
8	.000	.000	.000	.000	.508	.503	.503	.503	.508	.508	.508	.491
9	.000	.000	.000	.000	.000	.511	.511	.511	.539	.539	.539	.542
10	.000	.000	.000	.000	.000	.511	.511	.511	.573	.573	.573	.608
11	.000	.000	.000	.000	.000	.000	.000	.511	.573	.573	.573	.608
12	.000	.000	.000	.000	.000	.000	.000	.000	.573	.573	.573	.608
13	.000	.000	.000	.000	.000	.000	.000	.000	.000	.573	.573	.608
14	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.573	.608
15+	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.608

	1984	1985	1986	1987	1988	1989
0	.069	.000	.000	.049	.071	.061
1	.137	.151	.166	.176	.157	.154
2	.176	.273	.245	.222	.260	.238
3	.294	.349	.339	.318	.326	.321
4	.324	.418	.421	.399	.390	.377
5	.341	.416	.473	.478	.462	.434
6	.429	.434	.444	.513	.537	.455
7	.538	.520	.456	.492	.567	.546
8	.468	.544	.541	.496	.563	.596
9	.561	.562	.593	.577	.568	.579
10	.619	.627	.546	.635	.617	.582
11	.636	.666	.692	.634	.627	.649
12	.636	.683	.692	.707	.686	.655
13	.636	.694	.692	.704	.659	.728
14	.636	.693	.692	.662	.666	.784
15+	.636	.727	.692	.751	.754	.778

Table 5.15 VIRTUAL POPULATION ANALYSIS

MACKEREL, WESTERN STOCK

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

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.001	.000	.000	.000	.007	.002	.003	.015	.004	.006	.002	.000
1	.003	.022	.024	.019	.074	.039	.044	.142	.115	.060	.037	.042
2	.007	.013	.019	.035	.081	.098	.187	.109	.270	.160	.126	.166
3	.013	.043	.040	.088	.137	.085	.192	.295	.178	.190	.214	.173
4	.065	.059	.091	.123	.215	.092	.178	.237	.291	.101	.222	.254
5	.000	.094	.125	.219	.155	.087	.191	.225	.274	.198	.101	.229
6	.000	.000	.118	.124	.193	.099	.161	.248	.218	.231	.222	.106
7	.000	.000	.000	.386	.352	.144	.141	.281	.252	.215	.232	.215
8	.000	.000	.000	.000	.214	.171	.173	.197	.258	.281	.270	.220
9	.000	.000	.000	.000	.000	.106	.225	.317	.259	.262	.330	.224
10	.000	.000	.000	.000	.000	.000	.189	.305	.312	.417	.275	.295
11	.000	.000	.000	.000	.000	.000	.000	.244	.309	.338	.497	.339
12+	.000	.000	.000	.000	.000	.000	.000	.244	.309	.338	.497	.339
(4- 8)U	.013	.031	.067	.170	.226	.119	.169	.238	.259	.205	.209	.205
(4- 8)W	.065	.086	.116	.251	.214	.107	.171	.233	.266	.212	.219	.232

	1984	1985	1986	1987	1988	1989
0	.000	.000	.008	.001	.000	.000
1	.026	.043	.017	.013	.029	.044
2	.095	.033	.091	.123	.085	.112
3	.216	.074	.075	.200	.199	.179
4	.204	.196	.123	.171	.222	.272
5	.229	.187	.221	.210	.324	.228
6	.236	.221	.212	.230	.309	.366
7	.106	.221	.245	.236	.258	.345
8	.171	.145	.207	.256	.264	.225
9	.173	.194	.132	.261	.234	.235
10	.169	.204	.186	.309	.226	.207
11	.192	.191	.175	.229	.340	.233
12+	.192	.191	.175	.229	.340	.233
(4- 8)U	.189	.194	.201	.221	.275	.287
(4- 8)W	.208	.198	.208	.225	.245	.249

Table 5.16 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

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	1966	4515	3527	4872	5015	906	3319	5656	5703	7068	1333	741
1	4708	1691	3886	3035	4193	4284	778	2847	4794	4891	6048	1145
2	1898	4041	1424	3264	2563	3350	3545	641	2126	3678	3963	5018
3	2538	1623	3432	1203	2713	2035	2615	2530	494	1397	2697	3007
4	8643	2157	1337	2839	948	2037	1609	1858	1621	356	994	1875
5	0	6969	1750	1051	2160	658	1599	1160	1262	1043	277	685
6	0	0	5459	1328	727	1592	519	1138	797	825	736	216
7	0	0	0	4174	1010	516	1241	380	764	552	564	508
8	0	0	0	0	2443	611	384	928	247	511	383	385
9	0	0	0	0	0	1697	444	278	656	164	332	252
10	0	0	0	0	0	0	1314	305	175	435	109	206
11	0	0	0	0	0	0	0	936	194	110	247	71
12+	0	0	0	0	0	0	0	0	466	659	404	470
TOTAL NO	19753	20995	20815	21767	21772	17687	17369	18657	19299	21690	18087	14578
SPS NO	11256	11804	11504	10926	10101	10135	10118	8340	6957	7327	8056	9033
TOT.BIOM	4575	4445	4515	4384	3974	3835	3756	3431	3082	3101	2906	3185
SPS BIOM	3533	3580	3546	3270	2892	2843	2968	2609	2115	2128	1940	2339

	1984	1985	1986	1987	1988	1989	1990
0	6937	1886	2319	4331	1252	63790	0
1	637	5970	1624	1979	3725	1077	54882
2	945	535	4922	1374	1682	3115	887
3	3660	740	445	3868	1045	1330	2397
4	2177	2538	591	356	2725	737	957
5	1252	1528	1796	450	258	1878	484
6	469	857	1091	1239	314	161	1287
7	167	319	591	759	847	198	96
8	353	129	220	399	516	563	121
9	266	256	96	154	266	341	387
10	173	192	181	73	102	181	232
11	132	126	135	130	46	70	127
12+	273	495	402	319	195	180	170
TOTAL NO	17441	15572	14414	15430	12973	73622	
SPS NO	7881	6841	5744	7214	6429	6423	
TOT.BIOM	2945	3073	2966	2748	2741	2580	
SPS BIOM	2357	2271	1903	2111	2014	1930	

Table 5.17 Research vessel survey abundance indices and VPA estimates.

Year class	First winter mackerel			Second winter mackerel			Number of rectangles sampled
	Arithmetic mean	Estimated (millions)	No. 1-gr. from VPA	Arithmetic mean	Estimated (millions)	No. 2-gr. from VPA	
1980	-	-		50	3,963		-
1981	125	1,048		78	5,018		65
1982	6	1,145		46	945		63
1983	4	637		8	535		36
1984	149	5,970		210	4,922		78
1985	37	1,624		37	1,374		88
1986	89	1,979		25	1,682		96
1987	110	3,725		225	3,115		115
1988	106	-		149	-		122
1989	174	-		-	-		117

Table 5.18

List of input variables for the ICES prediction program.

WESTERN MACKEREL

The reference F is the mean F for the age group range from 4 to 8

The number of recruits per year is as follows:

Year	Recruitment
1990	3900.0
1991	3900.0
1992	3900.0

Proportion of F (fishing mortality) effective before spawning: .4000
Proportion of M (natural mortality) effective before spawning: .4000

Data are printed in the following units:

Number of fish:	millions
Weight by age group in the catch:	kilogram
Weight by age group in the stock:	kilogram
Stock biomass:	thousand tonnes
Catch weight:	thousand tonnes

age	stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
0	3900.0	.00	.15	.00	.061	.000
1	5400.0	.13	.15	.08	.154	.070
2	2718.0	.42	.15	.60	.238	.176
3	2397.0	.66	.15	.90	.321	.238
4	957.0	.84	.15	.97	.377	.299
5	484.0	1.00	.15	.97	.434	.342
6	1287.0	1.03	.15	.99	.455	.363
7	96.0	1.01	.15	1.00	.546	.419
8	121.0	1.00	.15	1.00	.596	.468
9	387.0	.94	.15	1.00	.579	.441
10	232.0	1.01	.15	1.00	.582	.451
11	127.0	1.00	.15	1.00	.649	.496
12+	170.0	1.00	.15	1.00	.655	.585

Table 5.19

Effects of different levels of fishing mortality on catch, stock biomass and spawning stock biomass.

WESTERN MACKEREL

Year 1990					Year 1991					Year 1992	
factor	ref. F	stock biomass	sp.stock biomass	Mgmt catch	Mgmt. Option	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.2	.24	2880	1970	550	F_{med}	.15	3144	2278	382	3427	2596
					$F_{0.1}$	.19		2243	497	3330	2474
					$F_{(90)}$	.24		2211	600	3244	2367
					$F_{(89)}$	.29		2177	709	3152	2255

The data unit of the biomass and the catch is 1000 tonnes.
The spawning stock biomass is given for the time of spawning.
The spawning stock biomass for 1992 has been calculated with the same fishing mortality as for 1991.
The reference F is the mean F for the age group range from 4 to 8

Table 5.20

Results

11.42.50 30 APRIL 1990
WESTERN MACKEREL

```
****************************************************
* Year 1990. F-factor   .244 and reference F   .2384 *
*---------------------------------------------------*
* Run depending on a TAC value                      *
****************************************************
```

						at 1 January		at spawning time	
age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	sp.stock size	sp.stock biomass	sp.stock size	sp.stock biomass
0	.0004	1.33	.081	3900.0	.00	.00	.00	.00	.00
1	.0316	156.11	24.041	5400.0	378.00	432.00	30.24	401.73	28.12
2	.1021	245.35	58.392	2718.0	478.37	1630.80	287.02	1474.36	259.49
3	.1605	330.66	106.141	2397.0	570.49	2157.30	513.44	1905.36	453.48
4	.2059	165.80	62.508	957.0	286.14	928.29	277.56	805.11	240.73
5	.2443	97.72	42.410	484.0	165.53	469.48	160.56	400.98	137.13
6	.2522	267.21	121.579	1287.0	467.18	1274.13	462.51	1084.80	393.78
7	.2462	19.52	10.656	96.0	40.22	96.00	40.22	81.93	34.33
8	.2432	24.33	14.501	121.0	56.63	121.00	56.63	103.39	48.39
9	.2305	74.21	42.965	387.0	170.67	387.00	170.67	332.36	146.57
10	.2478	47.43	27.601	232.0	104.63	232.00	104.63	197.87	89.24
11	.2443	25.64	16.641	127.0	62.99	127.00	62.99	108.47	53.80
12+	.2443	34.32	22.482	170.0	99.45	170.00	99.45	145.19	84.94
Total		1489.62	550.000	18276.0	2880.30	8025.00	2265.92	7041.55	1969.99

cont'd.

Table 5.20 cont'd.

* Year 1991. F-factor .244 and reference F .2381 *

age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	at 1 January sp.stock size	at 1 January sp.stock biomass	at spawning time sp.stock size	at spawning time sp.stock biomass
0	.0004	1.33	.081	3900.0	.00	.00	.00	.00	.00
1	.0316	96.88	14.920	3355.5	234.89	268.44	18.79	249.64	17.47
2	.1020	405.99	96.625	4503.2	792.56	2701.91	475.54	2442.84	429.94
3	.1603	291.03	93.422	2112.3	502.72	1901.06	452.45	1679.18	399.65
4	.2056	304.09	114.643	1757.3	525.42	1704.53	509.66	1478.51	442.07
5	.2440	135.20	58.677	670.4	229.28	650.30	222.40	555.48	189.97
6	.2518	67.67	30.788	326.3	118.44	323.02	117.26	275.06	99.85
7	.2459	174.80	95.443	860.8	360.69	860.84	360.69	734.76	307.87
8	.2429	12.97	7.732	64.6	30.23	64.59	30.23	55.20	25.83
9	.2302	15.64	9.056	81.7	36.01	81.66	36.01	70.14	30.93
10	.2474	54.01	31.433	264.5	119.30	264.51	119.30	225.63	101.76
11	.2440	31.43	20.400	155.9	77.31	155.86	77.31	133.14	66.04
12+	.2440	40.38	26.448	200.2	117.13	200.22	117.13	171.03	100.05
Total		1631.43	599.669	18252.6	3143.98	9176.96	2536.76	8070.61	2211.43

cont'd.

Table 5.20 cont'd.

```
***********************************************************
* Year 1992. F-factor    .244 and reference F    .2381 *
***********************************************************
```

						at 1 January		at spawning time	
age	absolute F	catch in numbers	catch in weight	stock size	stock biomass	sp.stock size	sp.stock biomass	sp.stock size	sp.stock biomass
0	.0004	1.33	.081	3900.0	.00	.00	.00	.00	.00
1	.0316	96.88	14.920	3355.5	234.89	268.44	18.79	249.64	17.47
2	.1020	252.29	60.045	2798.4	492.51	1679.02	295.51	1518.03	267.17
3	.1603	482.25	154.802	3500.1	833.02	3150.09	749.72	2782.44	662.22
4	.2056	268.03	101.047	1548.9	463.11	1502.38	449.21	1303.17	389.65
5	.2440	248.32	107.773	1231.3	421.12	1194.41	408.49	1020.25	348.93
6	.2518	93.76	42.659	452.1	164.11	447.57	162.47	381.12	138.35
7	.2459	44.33	24.205	218.3	91.47	218.31	91.47	186.34	78.08
8	.2429	116.37	69.358	579.4	271.16	579.41	271.16	495.15	231.73
9	.2302	8.35	4.836	43.6	19.23	43.61	19.23	37.46	16.52
10	.2474	11.40	6.635	55.8	25.18	55.83	25.18	47.63	21.48
11	.2440	35.85	23.266	177.8	88.17	177.76	88.17	151.84	75.31
12+	.2440	48.43	31.719	240.1	140.47	240.13	140.47	205.11	119.99
Total		1707.59	641.346	18101.3	3244.45	9556.97	2719.88	8378.17	2366.90

Table 6.1 Landings (tonnes) of Mackerel in Divisions VIIIc, and IXa, 1977-1989.

Division VIIIc

Country	1977	1978	1979	1980	1981	1982	1983
Spain	19,852	18,543	15,013	11,316	12,834	15,621	10,390
Total	19,852	18,543	15,013	11,316	12,834	15,621	10,390

Country	1984	1985	1986	1987	1988	1989[1]
Spain	13,852	11,810	16,533	15,982	16,844[2]	13,446[2]
Total	13,852	11,810	16,533	15,982	16,844	13,446

Division IXa

Country	1977	1978	1979	1980	1981	1982	1983
Portugal	1,743[2]	1,555[2]	1,071[2]	1,929[2]	3,108[2]	3,018[2]	2,239[2]
Spain	2,935	6,221	6,280	2,719	2,111	2,437	2,224
Poland	8	-	-	-	-	-	-
USSR	2,879	189	111	-	-	-	-
Total	7,565	7,965	7,462	4,648	5,219	5,455	4,463

Country	1984	1985	1986	1987	1988	1989[1]
Portugal	2,250	4,178[2]	5,565[3]	5,525[3]	3,882[2]	2,825[2]
Spain	4,206	2,000[2]	1,837[2]	491[1]	3,540[2]	1,763[2]
Poland	-	-	-	-	-	-
USSR	-	-	-	-	-	-
Total	6,456	6,178	7,402	6,016[1]	7,422[2]	4,588[2]

[1] Preliminary.
[2] Working Group estimate.
[3] Official numbers.

TABLE 6.2 Sampling data from the mackerel fishery in 1989 in Divisions VIIIc and IXa and the percentages of the total catch sampled. 0 = no catch; + = sampling data available; ? = catch but not sufficient sampling data; * = at less this % has been sampled.

Division	Quarter	Portugal	Spain	% Sampled	Total Catch t
VIIIc	1	0	+	100	6462
	2	0	+	100	5846
	3	0	+	100	558
	4	0	+	100	581
IXa	1	?	+	50*	414 + ?
	2	?	+	50*	386 + ?
	3	?	+	50*	825 + ?
	4	?	+	50*	138 + ?

Table 6.3 Spanish and Portuguese landings of Mackerel by gear (tonnes) in Divisions VIIIc, and IXa 1985-1989.

Division VIIIc

Gear	1985	1986	1987	1988	1989
Purse seine	4,208	2,105	4,277	7,413	5,659
Trawl	1,135	2,850	1,900	2,321	2,273
Hook	6,371	11,323	9,739	6,799	5,208
Gillnet	96	255	66	312	306
Total	11,810	16,533	15,982	16,845	13,446[1]

Division IXa

Gear	1985	1986	1987	1988	1989
Spain	2,000	1,837	491[2]	3,540	1,763[1]
Purse seine	1,150	1,436	254[2]	2,644	1,151
Trawl	850	401	237[2]	896	612
Artisanal	-	-	-	-	-
Portugal	4,179	5,565	5,525	3,882	2,825[1]
Purse seine	14	829	1,564	1,528	1,277
Trawl	3,658	3,565	2,824	1,764	1,302
Artisanal	507	1,171	1,137	590	246

[1] Working Group estimate.
[2] Estimated catch does not include Riveira landing port.

Table 6.4 Percentages of some lengths and age ranges in the annual catches (in nos.) of mackerel, all gears combined, from the different areas of Divisions VIIIc and IXa, in 1989. Values from Divisions VIIIa,b - estimate from trawler and hook and lines by-catches are presented for comparison.

Length (cm)	Divisions VIIIa,b total	Division VIIIc East.	Centr.	West.	Total	Division IXa North.	Cent+S	Total
<25	1.4	0.4	7.3	53.5	22.4	96.0		
<30	21.2	5.6	12.7	67.8	31.2	99.8		
Age								
0	0.0	0.0	2.3	52.3	19.4	77.8	29.3	61.4
1	7.2	1.6	8.0	4.3	4.4	10.1	47.0	29.2
2	15.8	4.3	3.0	13.6	7.3	1.2	15.0	5.9
3+	77.0	94.2	86.7	29.7	68.9	0.9	8.7	3.5
C(n)	5,502	13,345	10,876	13,509	37,726	32,655	20,358	
Tonnes	1,408	6,005	4,723	2,717	13,446	1,763	2,825	4,588

Table 6.5 MACKEREL IN Division IXa (Portugal). Catch in numbers ('000) by age group in 1981-19898.

Age	1981	1982	1983	1984	1985	1986	1987	1988	1989
0	7,675	12,436	4,500	19,516	25,692	12,024	1,927	14,787	5,962
1	6,571	6,433	3,353	2,679	26,367	15,112	12,644	9,023	9,566
2	1,920	6,618	2,892	2,422	2,779	6,858	4,479	1,545	3,063
3	587	1,264	892	1,085	272	1,227	214	1,562	982
4	101	298	159	241	206	175	742	622	598
5	41	71	44	70	42	156	548	227	137
6	33	46	12	19	36	55	61	70	23
7	15	68	11	10	3	35	61	8	6
8	8	41	8	13	2	20	45	27	11
9	5	24	6	8	1	11	47	8	6
10+	31	102	15	10	3	8	45	2	4
Tonnes	3,108	3,018	2,239	2,250	4,178	5,565	5,525	3,882	2,825

Table 6.6 Mackerel in Divisions VIIIc and IXa (Spain). Catch in numbers ('000) by age group and division in 1988 and 1989.

Age	Division VIIIc	
	1988	1989
0	19	7,320
1	6,391	1,667
2	1,908	2,742
3	4,648	2,367
4	9,003	3,025
5	2,923	5,922
6	5,433	2,501
7	12,785	3,998
8	5,508	4,885
9	1,785	1,833
10	530	578
11	284	150
12	752	112
13	713	240
14	124	58
15+	931	330
Tonnes	16,884	13,446

Age	Division IXa	
	1988	1989
0	59,736	30,946
1	11,123	7,993
2	97	486
3	101	76
4	172	34
5	89	46
6	88	24
7	12	39
8	11	78
9	-	22
10	-	11
11	-	4
12	-	-
13	-	6
14	-	1
15+	-	4
Tonnes	3,540	1,763

Table 6.7 Catch in numbers ('000) and mean weight (g) by quarter, Division (VIIIc and IXa) and age, in 1989.

FIRST QUARTER

	VIII c								IX a	
	Eastern p. (Basque C.		Central p. (Cant+Astur		Western part (N.Galicia)		ALL VIII c		North. part (S.Galicia)	
AGE	C(n	W(g)	C(n	W(g)	C(n)	W(g)	C(n)	W(g)	C(n)	W(g)
0	0	0	0	0	0	0	0	0	0	0
1	19	75	572	74	261	90	852	81	6215	68
2	314	152	272	154	1187	155	1773	153	66	156
3	526	261	118	256	353	233	998	245	11	210
4	736	327	183	362	264	329	1182	325	5	253
5	1816	421	365	403	413	359	2595	402	5	263
6	776	464	317	488	161	440	1253	459	1	313
7	1486	496	541	514	239	465	2266	489	1	341
8	895	495	1095	523	400	485	2390	494	1	323
9	655	534	333	552	107	522	1094	531		
10	39	612	137	539	57	502	234	523		
11			50	570	12	576	62	551		
12	56	670					56	670		
13	1	806	82	580	24	574	107	558		
14			25	531	4	532	29	519		
15+			112	730	30	708	142	696		
TOT	7319		4202		3512		15033	357	6305	70
TONN	3525		1852		1085		6462		414	

SECOND QUARTER

	VIII c								IX a	
	Eastern p. (Basque C.		Central p. (Cant+Astur		Western part (N.Galicia)		ALL VIII c		North. part (S.Galicia)	
AGE	C(n	W(g)	C(n	W(g)	C(n)	W(g)	C(n)	W(g)	C(n)	W(g)
0	0	0	0	0	0	0	0	0	3006	16
1	189	133	0	0	67	110	256	127	1523	99
2	237	166	52	192	511	147	800	155	333	132
3	589	255	417	270	125	257	1130	258	39	214
4	842	324	632	341	174	351	1648	329	26	290
5	1766	385	1013	370	319	374	3098	374	38	321
6	532	444	524	455	131	449	1187	443	24	406
7	679	475	765	477	213	479	1657	467	39	424
8	607	486	1403	494	373	502	2383	481	77	431
9	220	539	387	523	97	528	704	517	22	441
10	86	529	192	508	50	521	329	503	10	442
11	3	598	69	595	13	567	85	576	4	491
12	56	604					56	604		
13	8	714	92	582	27	577	126	568	6	482
14	2	657	19	531	7	532	28	519	1	445
15+			177	739	8	614	186	729	4	546
TOT	5816		5742		2115		13673	357	5152	68
TONN	2406		2653		787		5846		386	

cont'd.

Table 6.7 cont'd.

THIRD QUARTER

AGE	VIII c Eastern p. (Basque C.) C(n	W(g)	Central p. (Cant+Astur C(n	W(g)	Western part (N.Galicia) C(n)	W(g)	ALL VIII c C(n)	W(g)	IX a North. part (S.Galicia) C(n)	W(g)
0	0		189	39	3572	64	3762	69	26530	34
1	0		0	157	63	158	63	154	137	131
2	10	183	1	219	144	174	155	170	36	161
3	2	262	17	254	124	244	143	230	9	203
4	1	312	15	298	94	305	109	278	1	223
5	1	301	17	308	117	320	135	289	2	230
6	0		2	359	21	387	23	340		
7	0		2	415	19	424	21	369		
8	0		3	430	29	438	31	380		
9	0		1	473	6	464	7	403		
10	0			517	3	467	3	407		
11	0			536		504	1	435		
12	0									
13	0			598	1	509	1	453		
14	0			531		531				
15+	0			343	1	433	1	330		
TOT	14		247	99	4194	94	4455		26715	74
TONN	3		27		528		558		825	

FOURTH QUARTER

AGE	VIII c Eastern p. (Basque C. C(n	W(g)	Central p. (Cant+Astur C(n	W(g)	Western part (N.Galicia) C(n)	W(g)	ALL VIII c C(n)	W(g)	IX a North. part (S.Galicia) C(n)	W(g)
0	0	0	57	87	3501	75	3558	81	1421	72
1	0	0	301	115	195	103	496	111	117	139
2	7	241	7	172			14	207	51	162
3	52	315	44	259			96	289	16	190
4	42	368	44	328			86	348	2	196
5	23	400	71	354			94	365	1	196
6	13	466	25	450			38	452		
7	13	496	41	493			54	494		
8	5	544	76	513			81	513		
9	5	452	23	543			28	526		
10	1	569	11	541			12	544		
11			2	525			2	525		
12										
13			6	586			6	586		
14			1	531			1	531		
15+			1	461			1	461		
TOT	161		710	94	3696	76	4567		1608	82
TONN	71		192		318		581		138	

Table 7.1 Assumed catch in numbers ('000) of North Sea mackerel stock by quarter in 1989.

Age	Quarter 1	2	3	4	Total
1	23	2	149	236	410
2	250	27	1,654	2,614	4,545
3	18	2	121	191	332
4	18	2	121	191	332
5	18	2	121	191	332
6	9	1	59	93	162
7	14	2	91	144	251
8	23	2	150	238	413
9	14	2	91	144	251
10	25	3	165	261	454
11	32	3	209	331	575
12	5	1	32	51	89
13	9	1	59	93	162
14	5	1	32	51	89
15+	41	4	268	424	737

Table 7.2 Mean weight at age (g) by quarter in the North Sea mackerel stock.

Age	Quarter 1[1]	2[2]	3[3]	4[3]	Weighted mean
1	180	140	180	180	180
2	210	255	240	210	220
3	240	330	280	240	255
4	260	395	330	260	285
5	300	450	375	300	330
6	325	500	420	325	360
7	355	540	465	355	400
8	380	570	510	380	430
9	410	605	550	410	465
10	435	635	585	435	495
11	465	670	620	465	525
12	500	700	650	500	560
13	530	730	680	530	590
14	560	765	705	560	615
15	590	790	720	590	640

[1] The same data as for 4th quarter.
[2] Data from Anon.(1989a).
[3] Smoothed data from Anon. (1988a).

Table 7.3 Estimated percentages of each mackerel stock present in the North Sea during each quarter.

	North Sea stock				Western stock			
Age	1	2	3	4	1	2	3	4
1	100	100	100	100	-	20	30	30
2	80	100	100	80	10	10	50	70
≥3	80	100	50	70	10	+	50	70

Table 7.4 Estimated percentages of Western juvenile[1] mackerel present in the North Sea during each quarter 1973-1989.

	Quarter							
Years	1-group				2-group			
	1	2	3	4	1	2	3	4
1973-1981	-	-	-	-	-	-	-	-
1982	-	5	10	10	5	5	10	10
1983	-	10	10	10	5	5	20	20
1984	-	15	25	25	5	5	30	30
1985	-	20	30	30	5	5	30	30
1986	-	20	30	30	10	10	50	70
1987	-	20	30	30	10	10	50	70
1988	-	20	30	30	10	10	50	70
1989	-	20	30	30	10	10	50	70

[1] The Working Group assumes there were no western 0-group mackerel in the North Sea during the period.

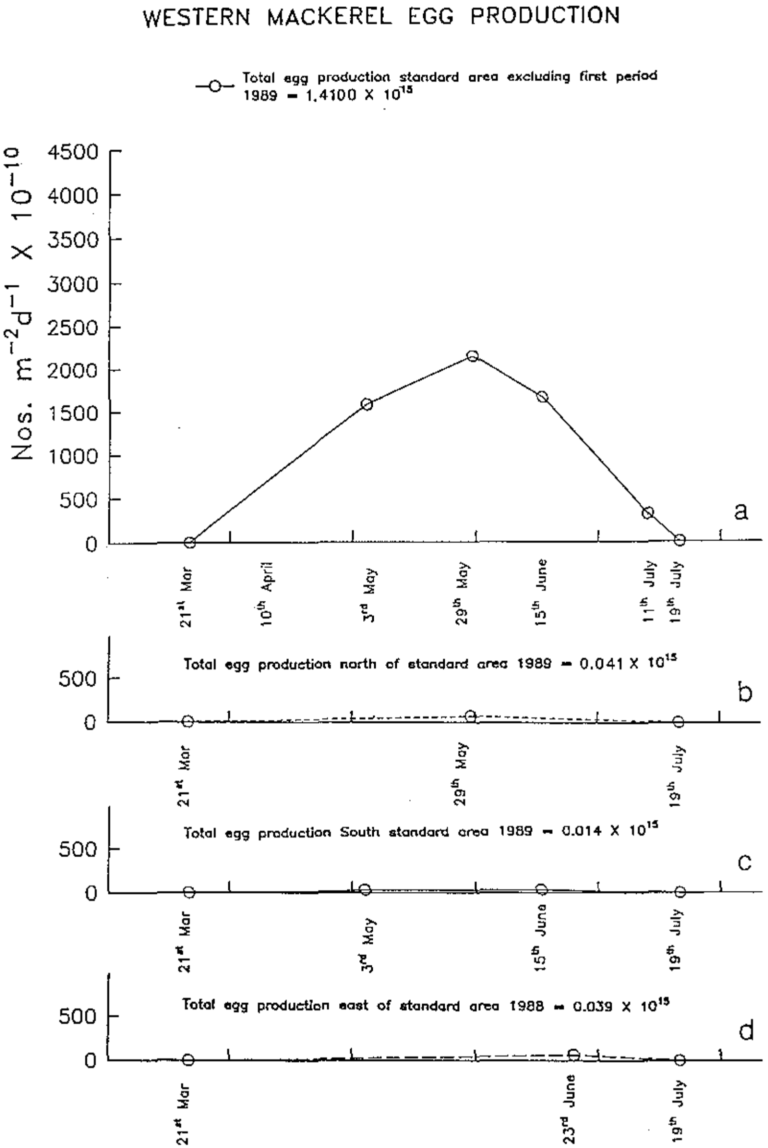
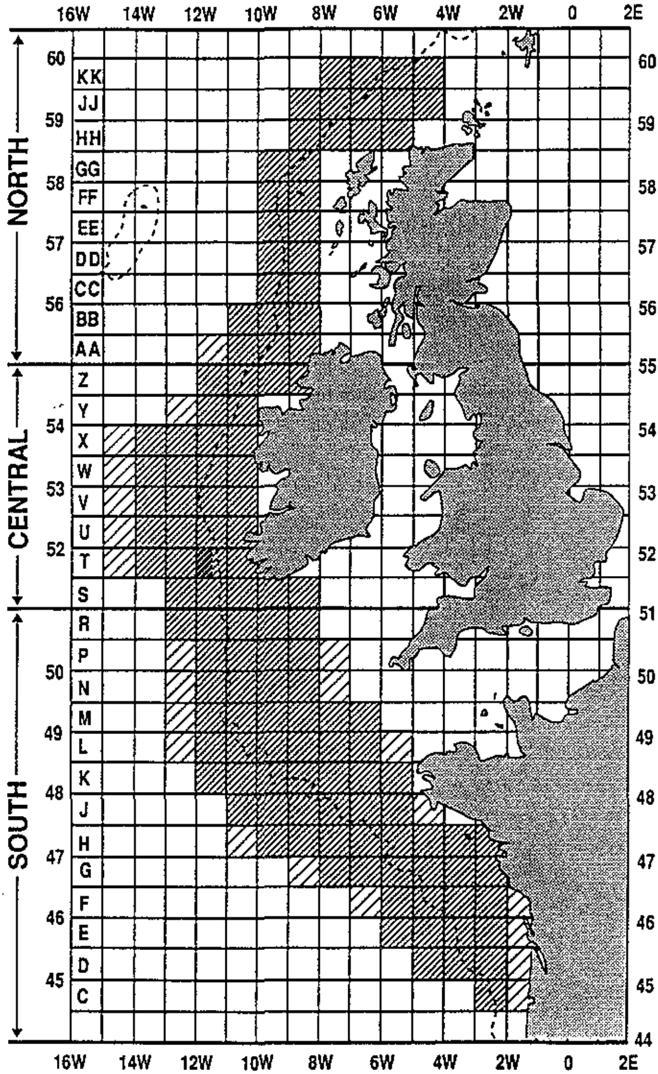


Figure 2.1 Production curves for stage 1 mackerel eggs for a) the standard survey area in 1989 excluding the anomalous first survey point: b) the area north of the standard area (N of 56°N) in 1989: c) the area south of the standard area (S of 44°30'N) in 1989: d) the area east of the 1989 sampled area in 1988. (Revised from Anon., 1990a.)

Figure 2.2 Area covered by plankton survey during the "Kings Cross" fish survey, 23 May-12June 1989.



Squares with light shading were only sampled over half the area and therefore data for egg production (m-2) was given a half weighting. The darkly shaded rectangle shows the location of samples taken to elucidate the 24th egg production cycle (See Section 2.1).

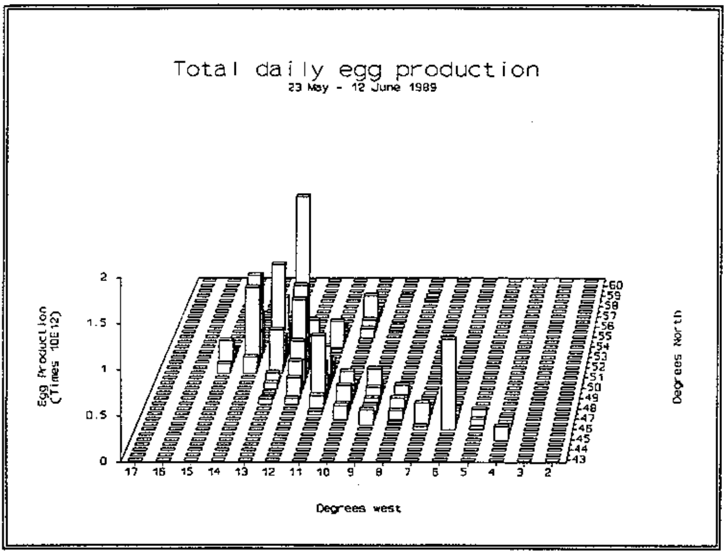


Figure 2.3 Total daily egg production by rectangle (0.5° latitude x 1° longitude) for the survey area covered as part of the batch fecundity programme (23 May-12June, 1989).

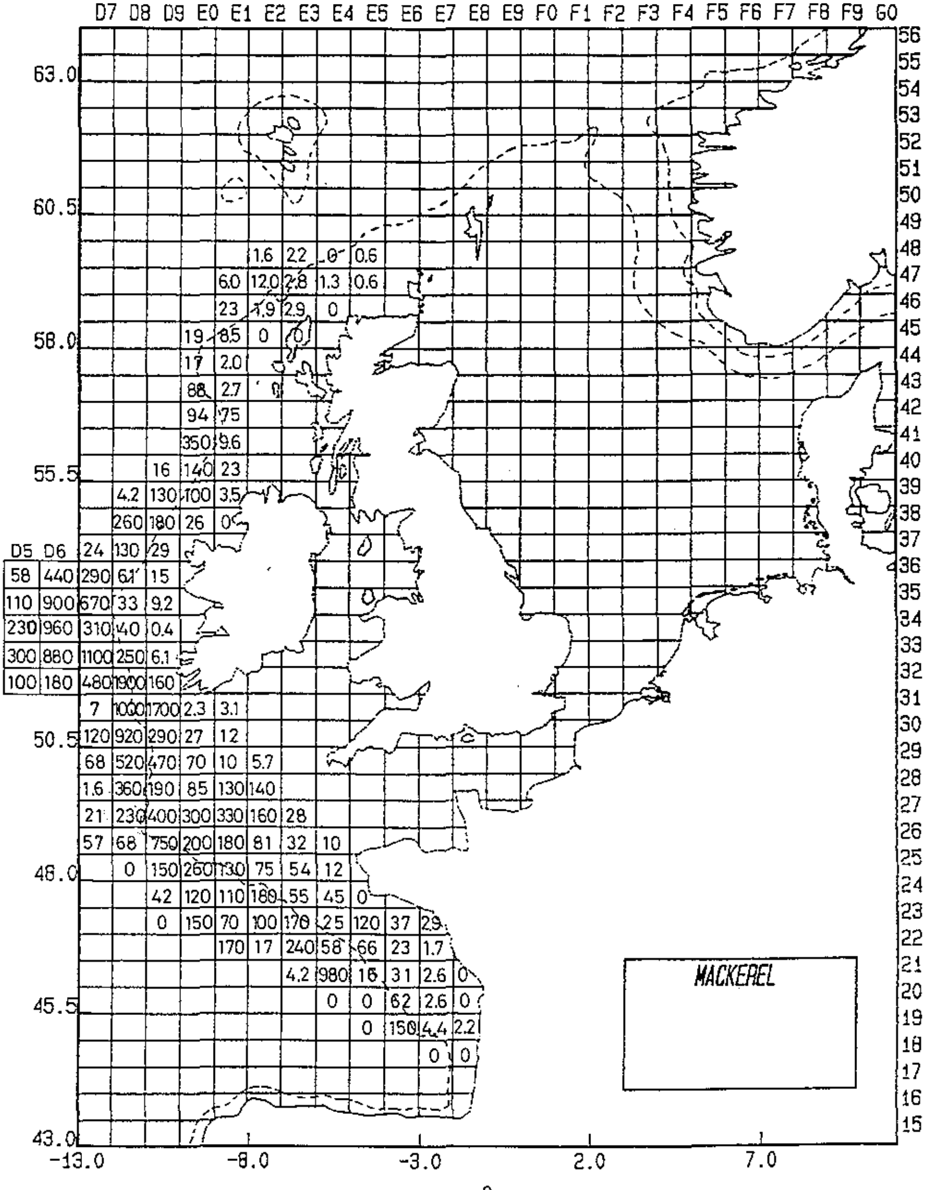


Figure 2.4 Total daily egg production (x 10^{-9}) by rectangle for the period 23 May-12 June, 1989.

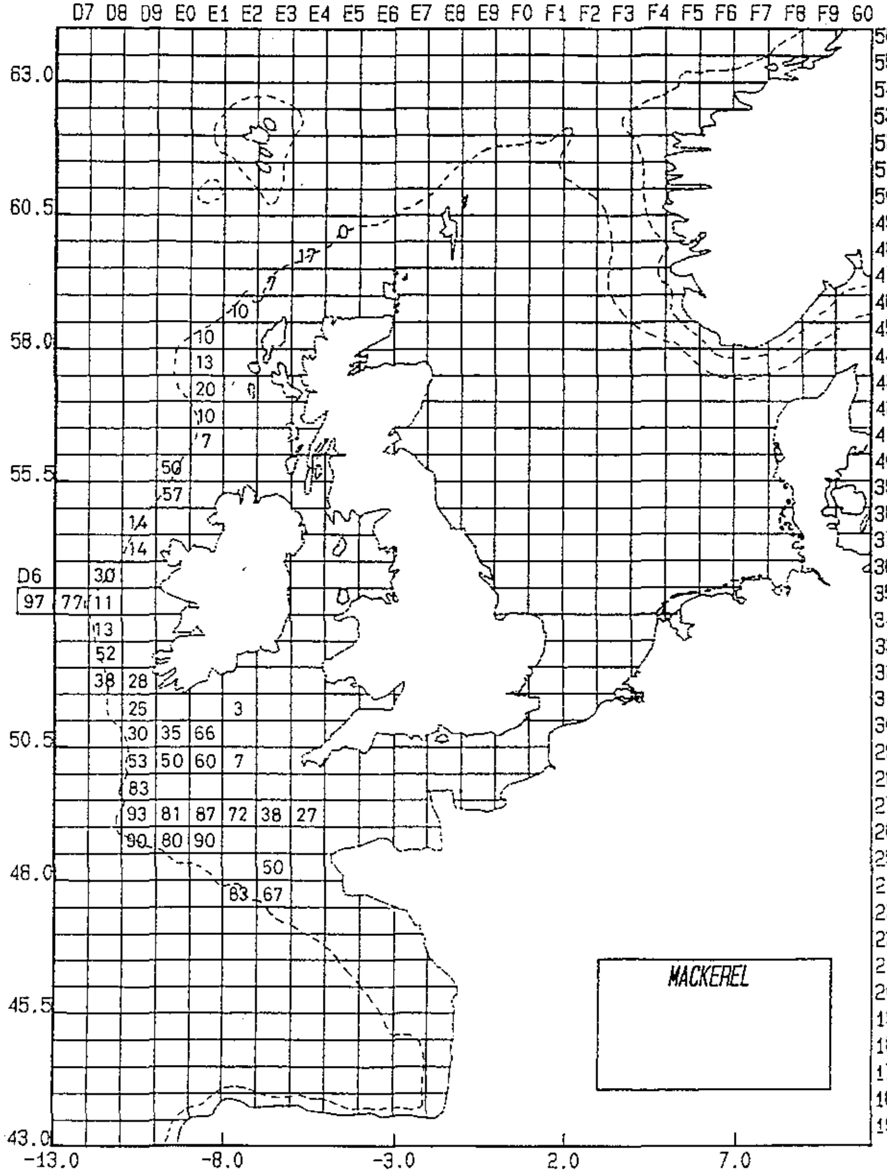


Figure 2.5 Fraction of female mackerel (percentage) spawning by rectangle at the peak of spawning season (23 May-12 June 1989).

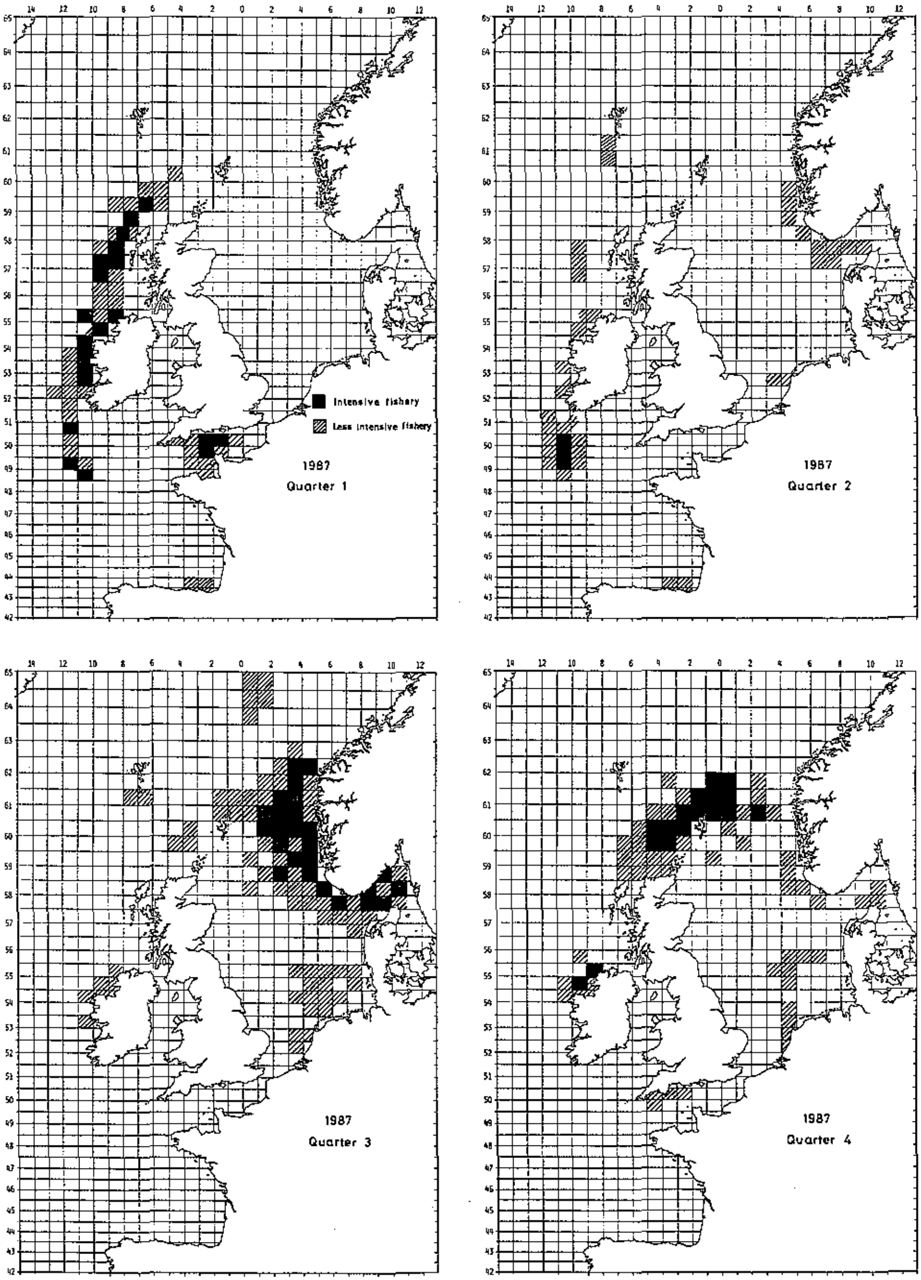


Figure 3.1 Revised distribution of mackerel fisheries, first-fourth quarter 1987.

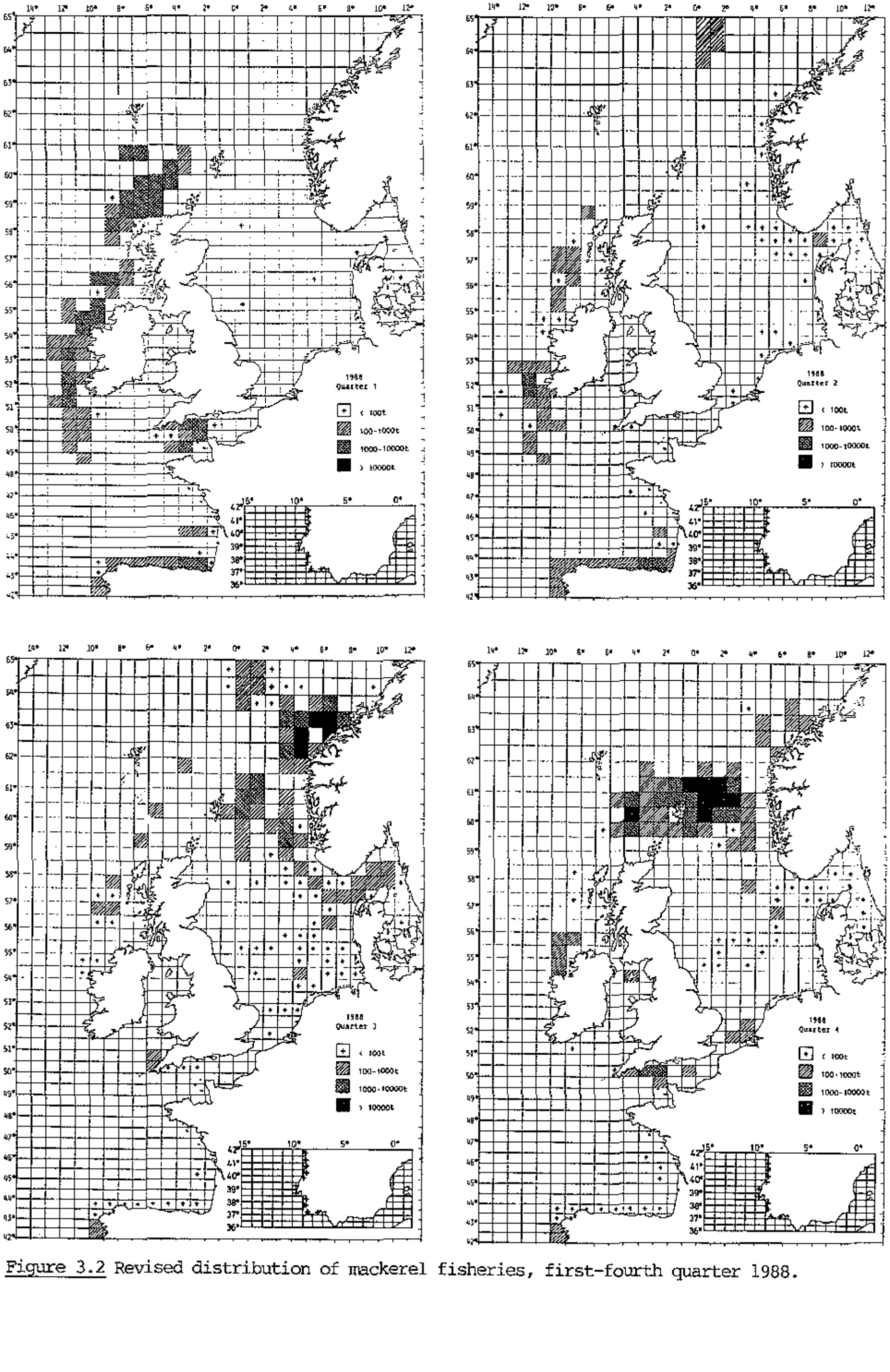


Figure 3.2 Revised distribution of mackerel fisheries, first-fourth quarter 1988.

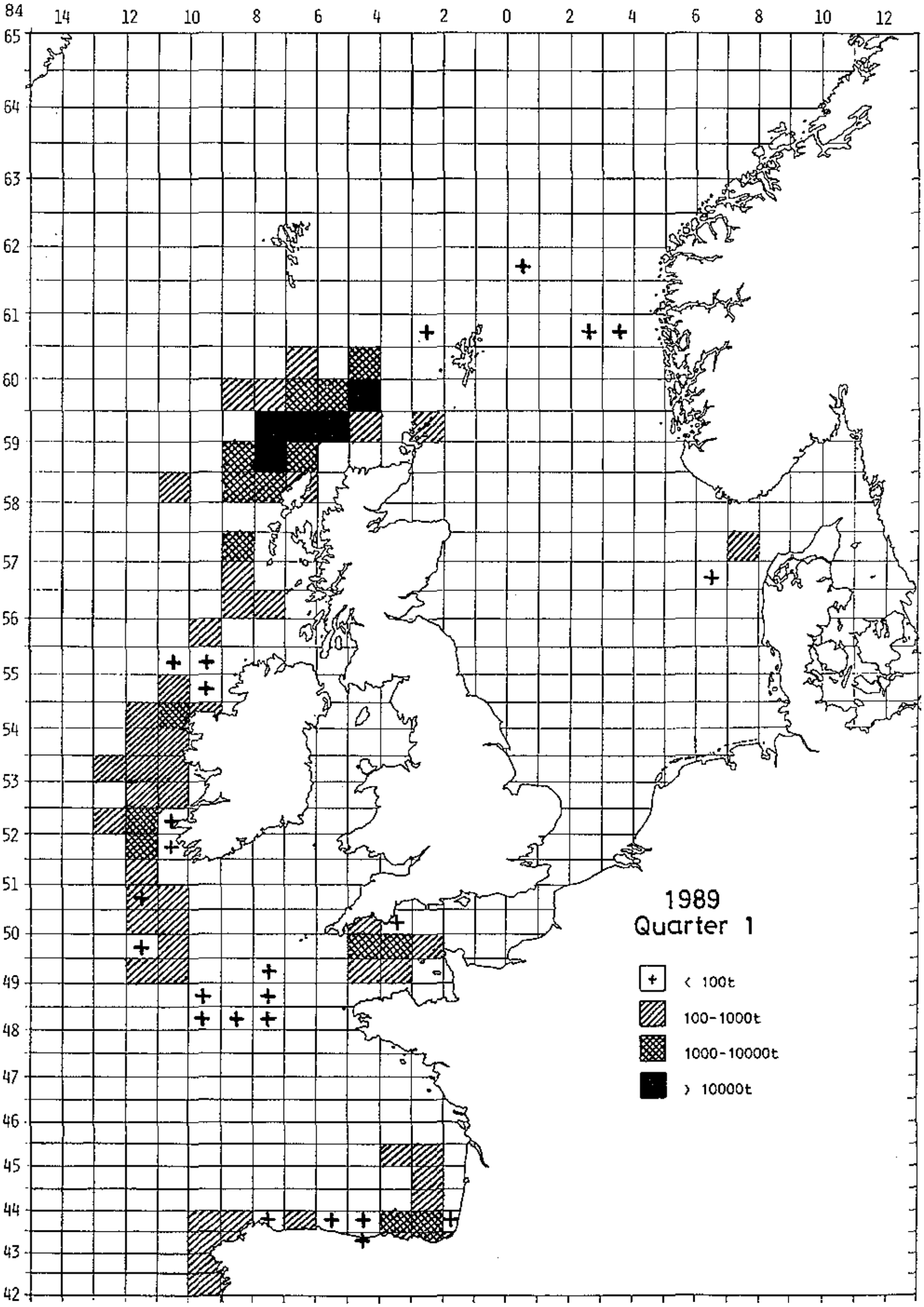


Figure 3.3a Distribution of mackerel fisheries, first quarter 1989.

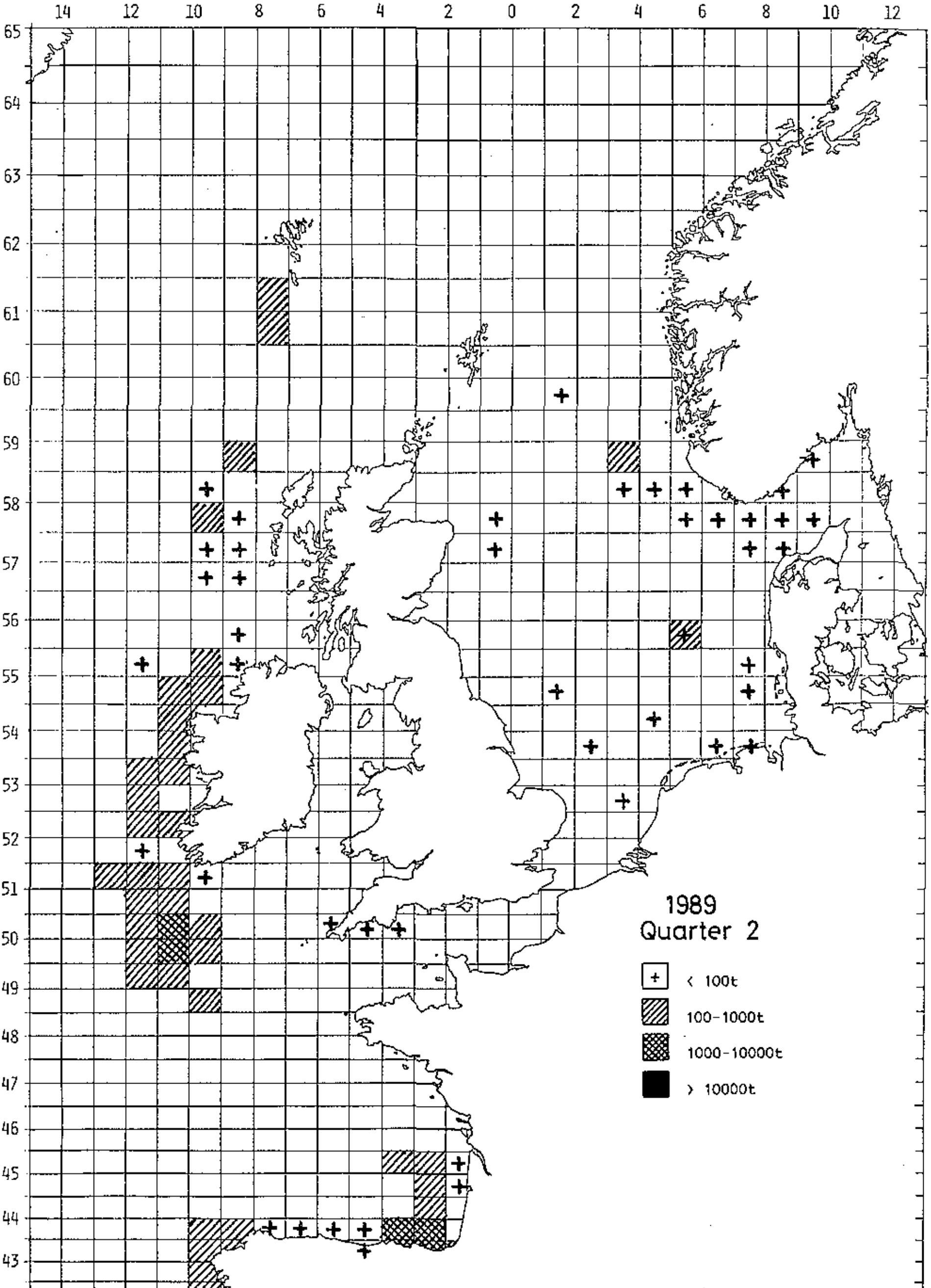


Figure 3.3b Distribution of mackerel fisheries, second quarter 1989.

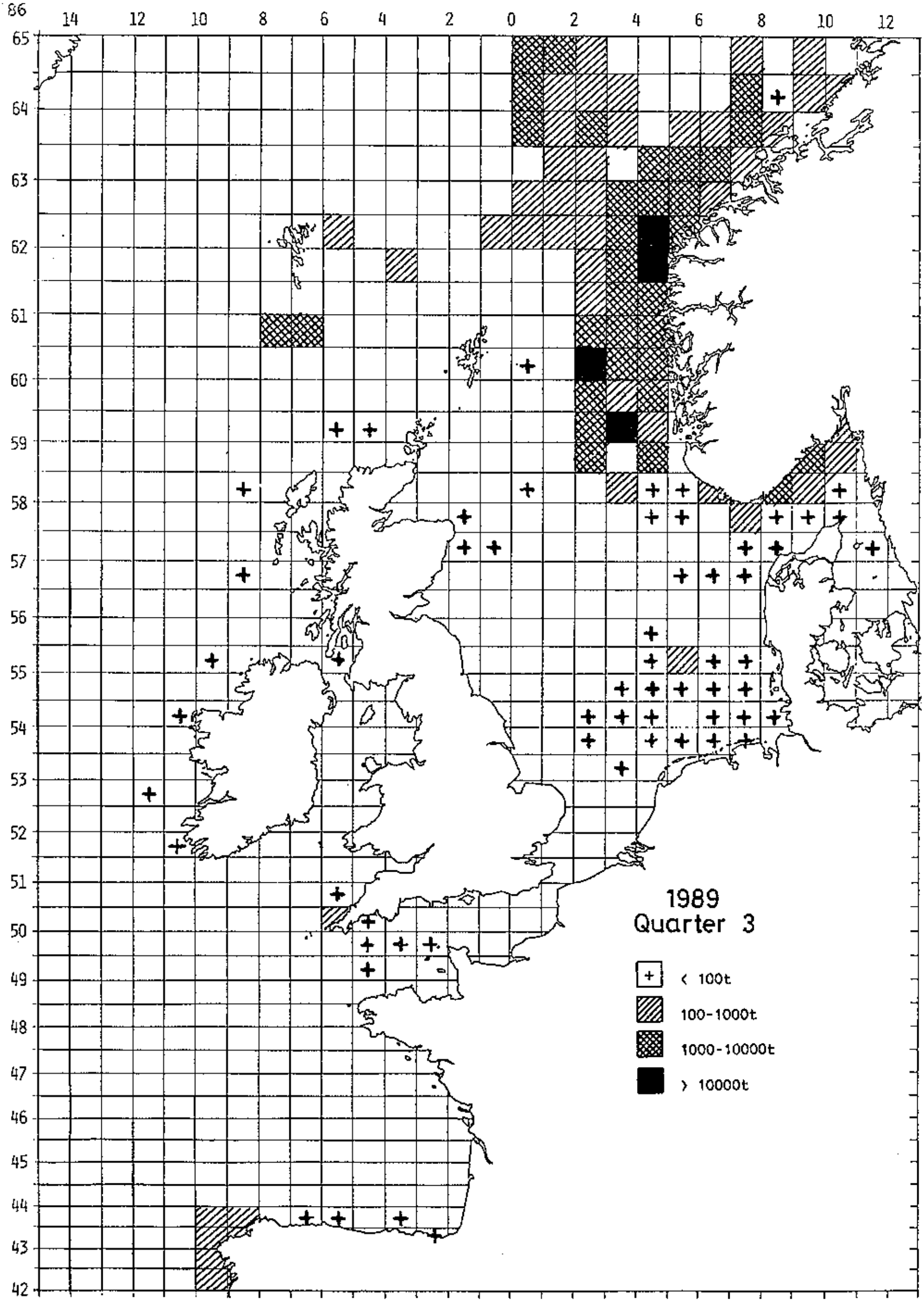


Figure 3.3c Distribution of mackerel fisheries, third quarter 1989.

87

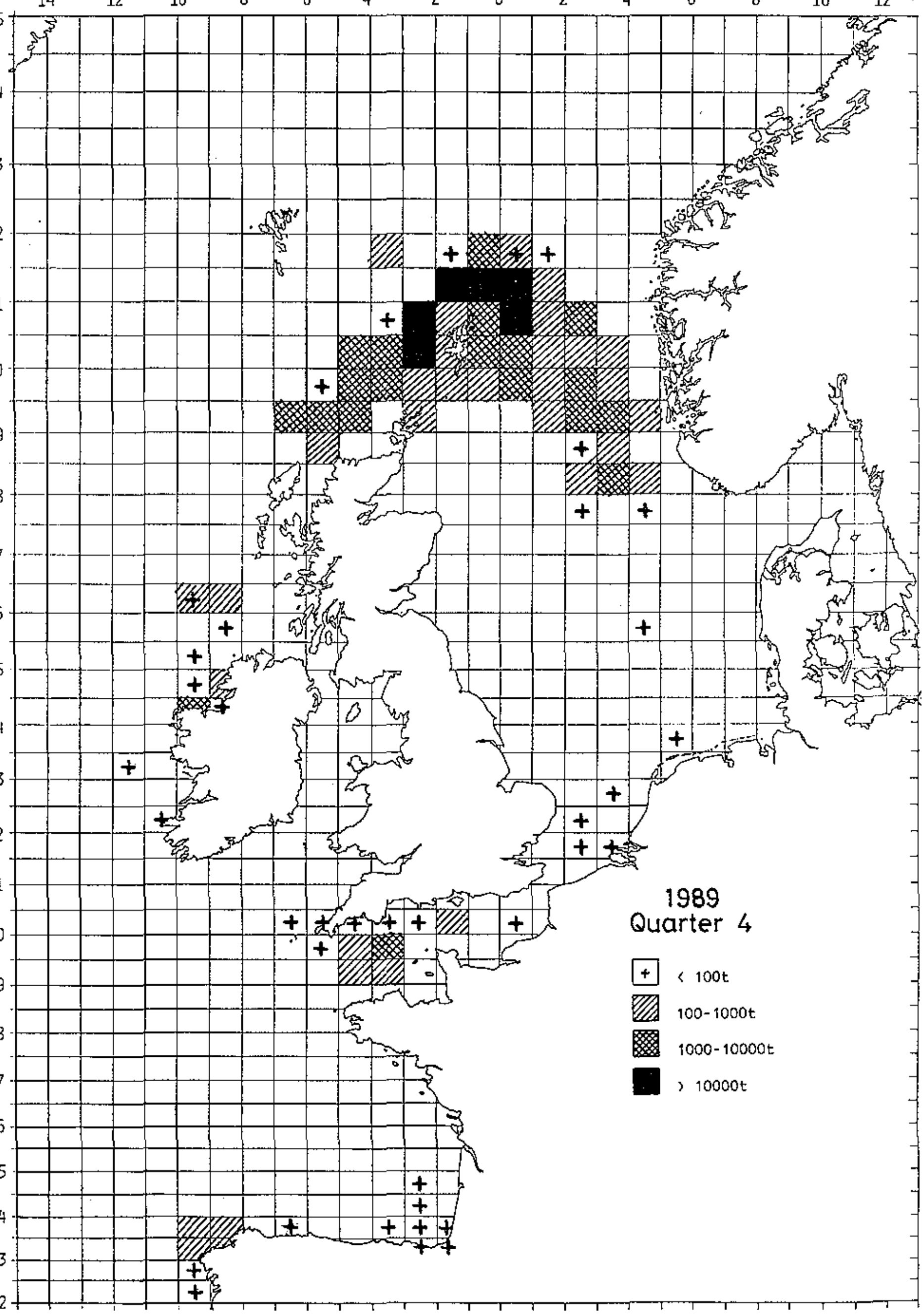


Figure 3.3d Distribution of mackerel fisheries, fourth quarter 1989.

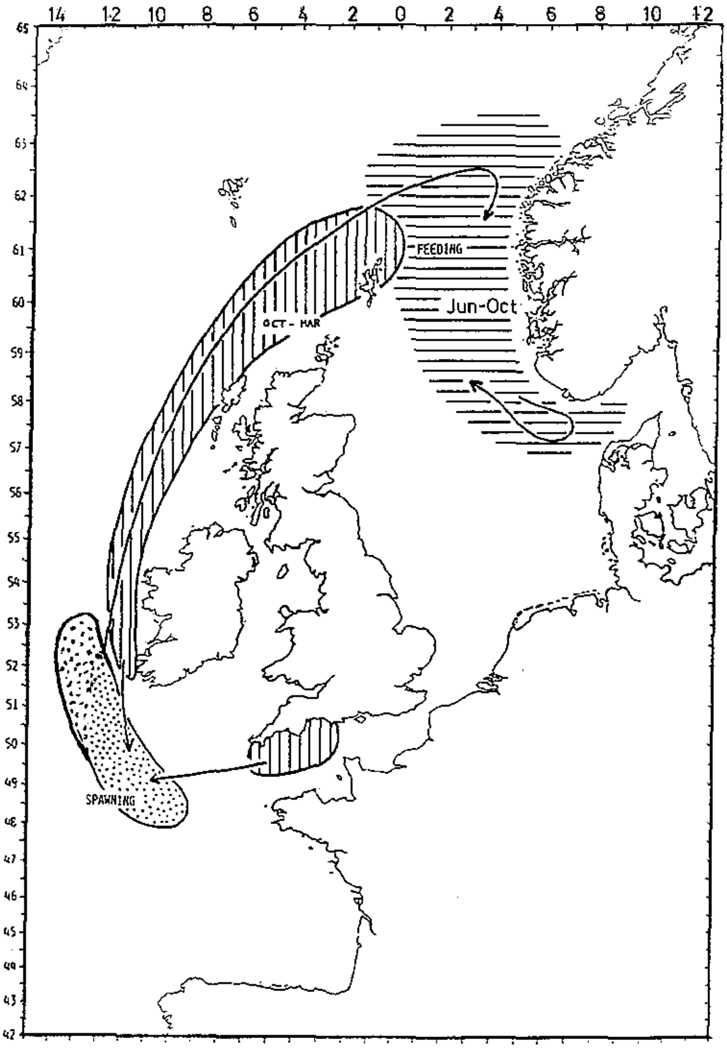


Figure 3.4 Schematic outline of the migration pattern of the Western mackerel stock (adults) in the later half of the 1980s.

Figure 3.5 Distribution and abundance of the 1989 year class between October 1989 and March 1990 from Dutch, English, Scottish, and French research vessel data, and also IYFS data.

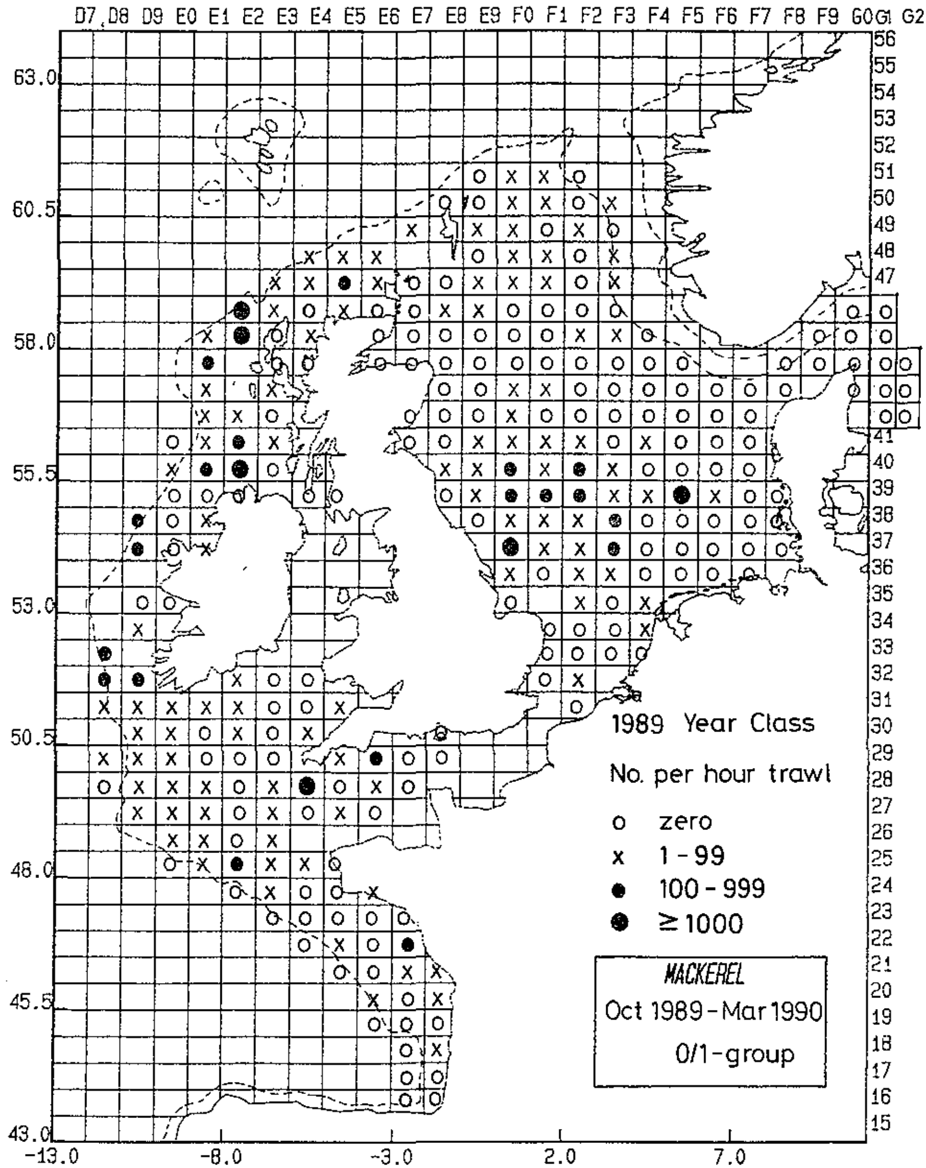


Figure 3.6 Revised distribution and abundance of the 1988 year class between October 1988 and March 1989 from Dutch, English, Scottish, Irish and French research vessel data.

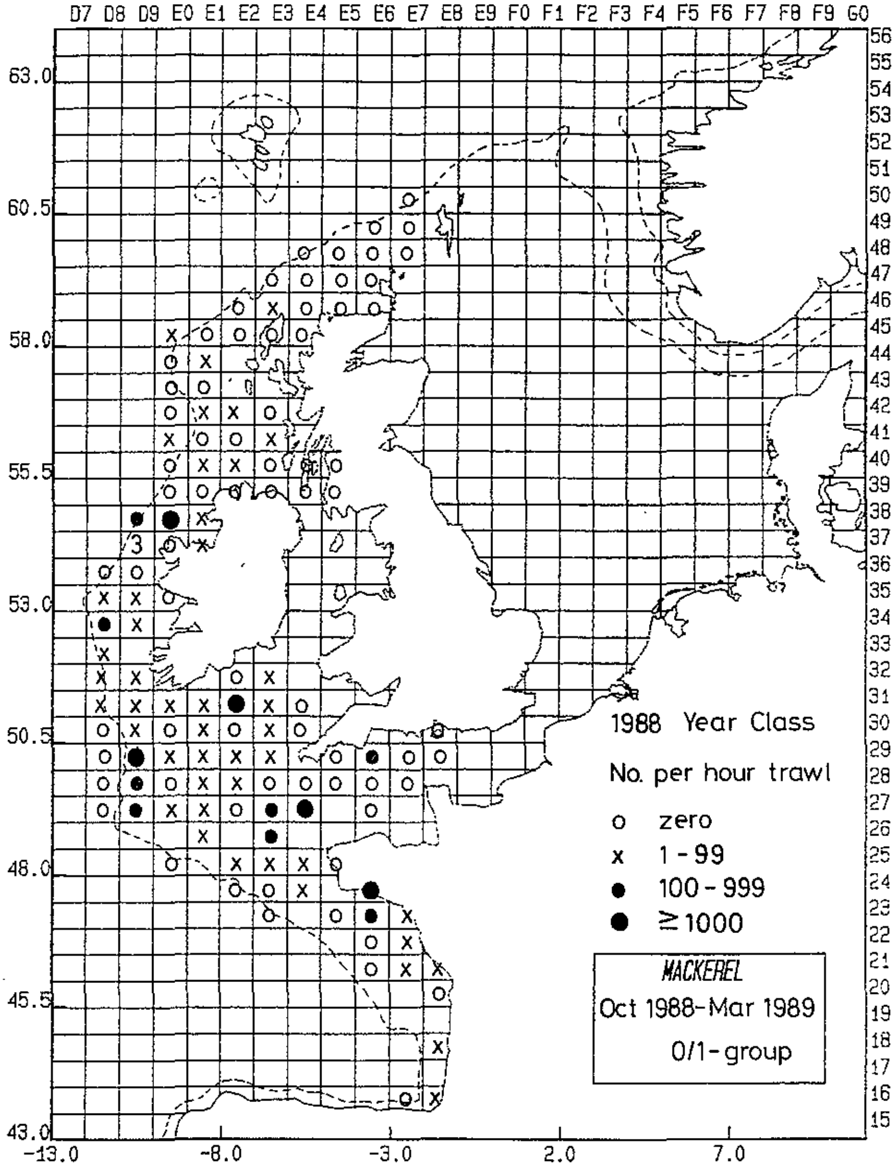


Figure 3.7 Distribution and abundance of the 1988 year class between October 1989 and March 1990 from Dutch, English, Scottish, Norwegian and French research vessel data.

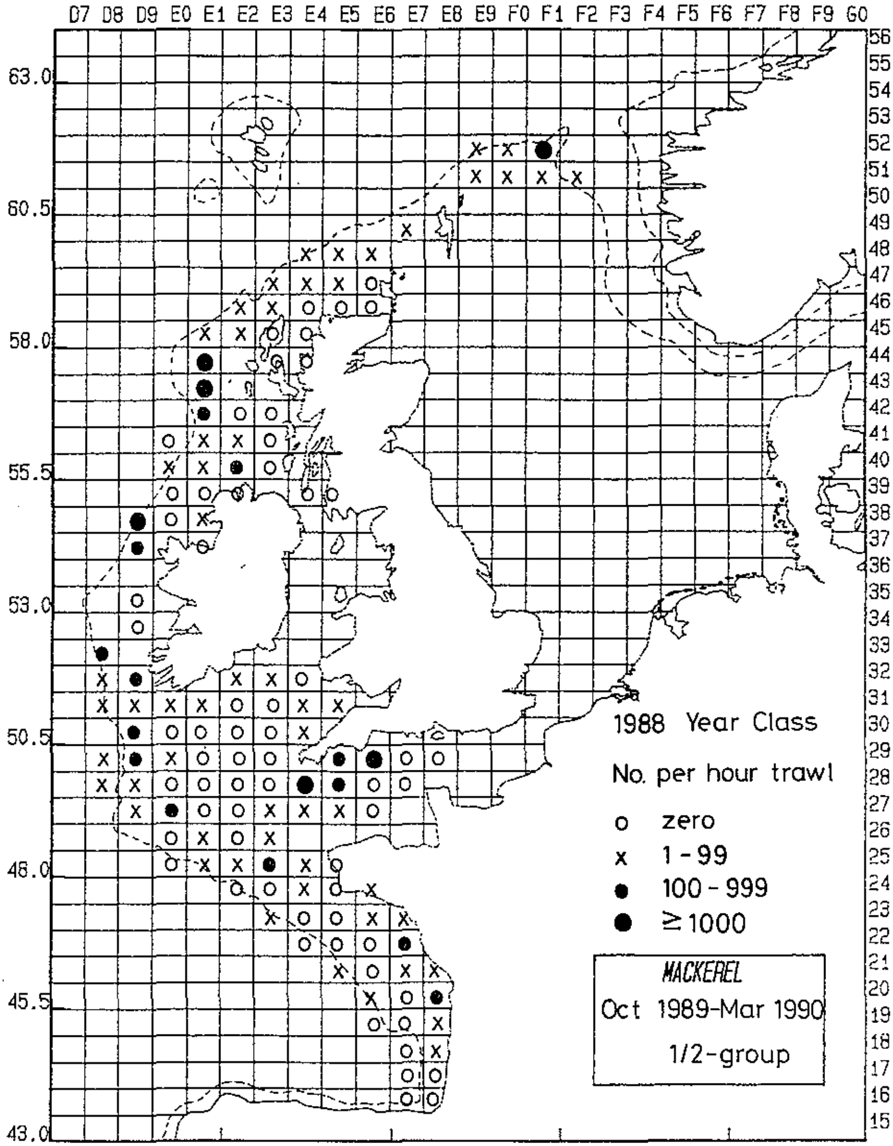
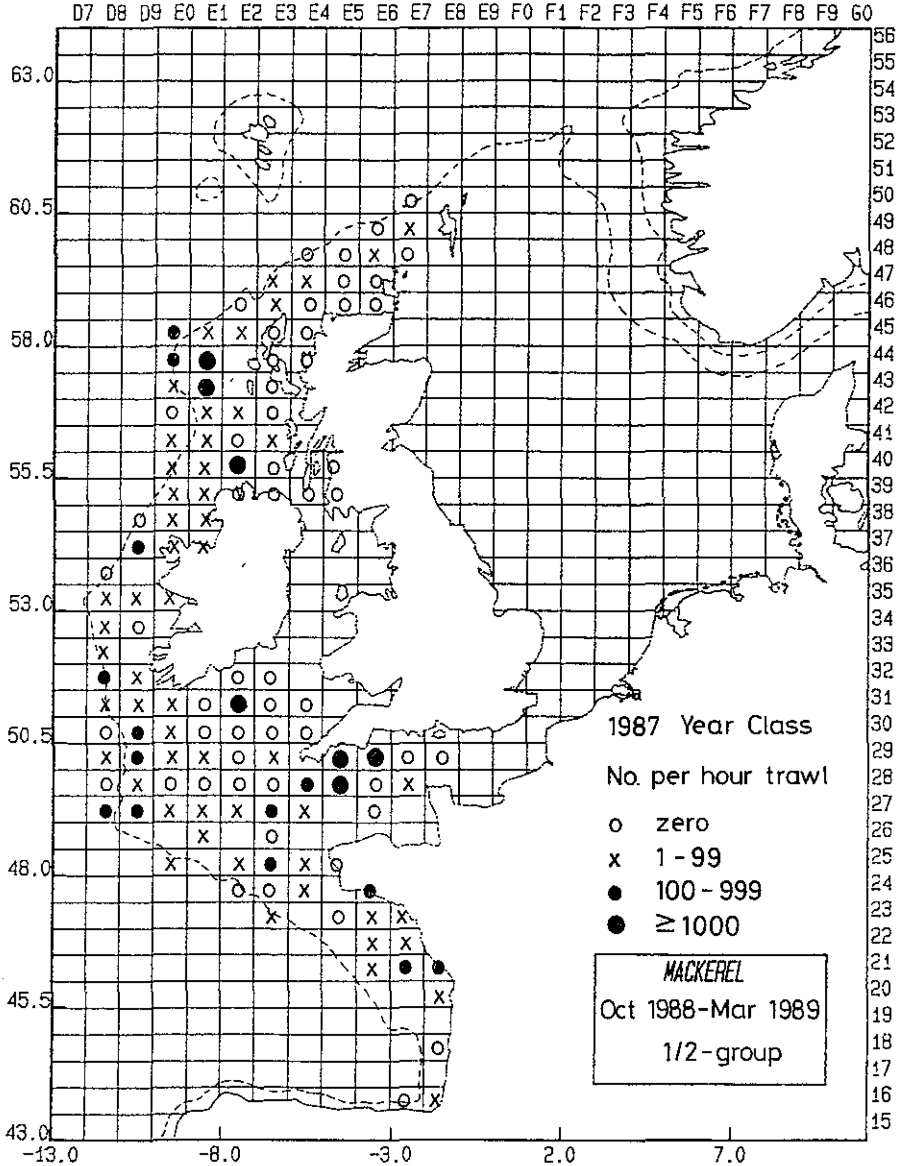


Figure 3.8 Revised distribution and abundance of the 1987 year class between October 1988 and March 1989 from Dutch, English, Scottish, Irish and French research vessel data.



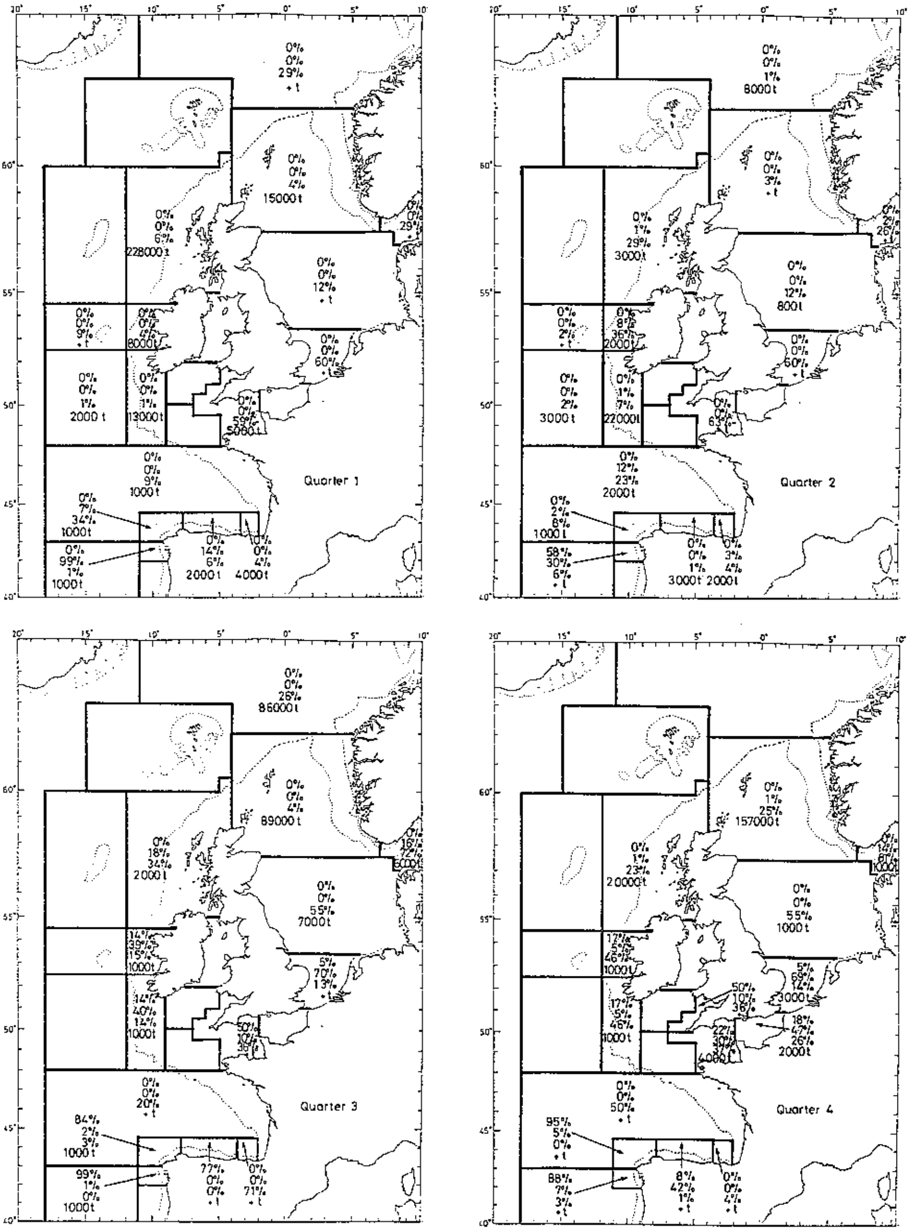


Figure 3.9 The occurrence of juvenile mackerel expressed as a percentage by numbers in the commercial catches that could be allocated to ICES divisions or sub-divisions in 1989. Values in each area are expressed from top to bottom as: 0-group; 1-group; 2-group; tonnage that could be allocated (+ = less than 500 t).

Figure 3.10 The percentage of 0-,1-and 2-group mackerel in the Dutch and English commerical catches by rectangle in the first quarter

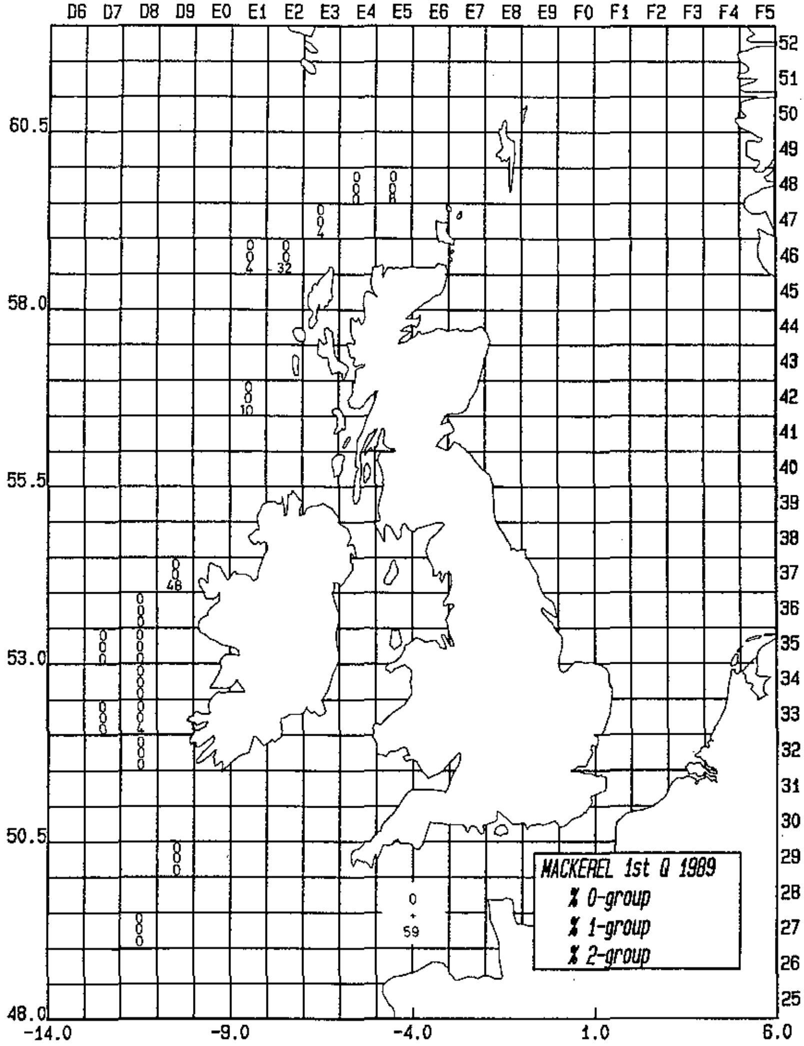


Figure 3.11 The percentage of 0-, 1-and 2-group mackerel in the Dutch and English commercial catches by rectangle in the second quarter.

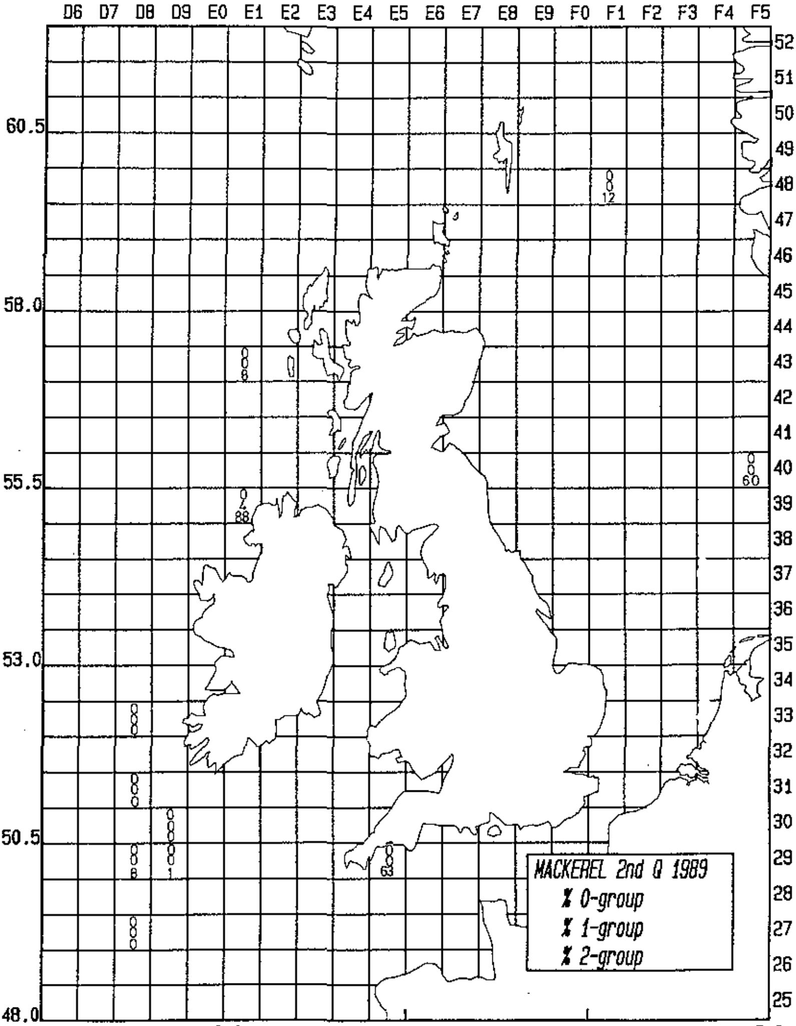


Figure 3.12 The percentage of 0-, 1- and 2-group mackerel in the Dutch and English catches by rectangle in the third quarter.

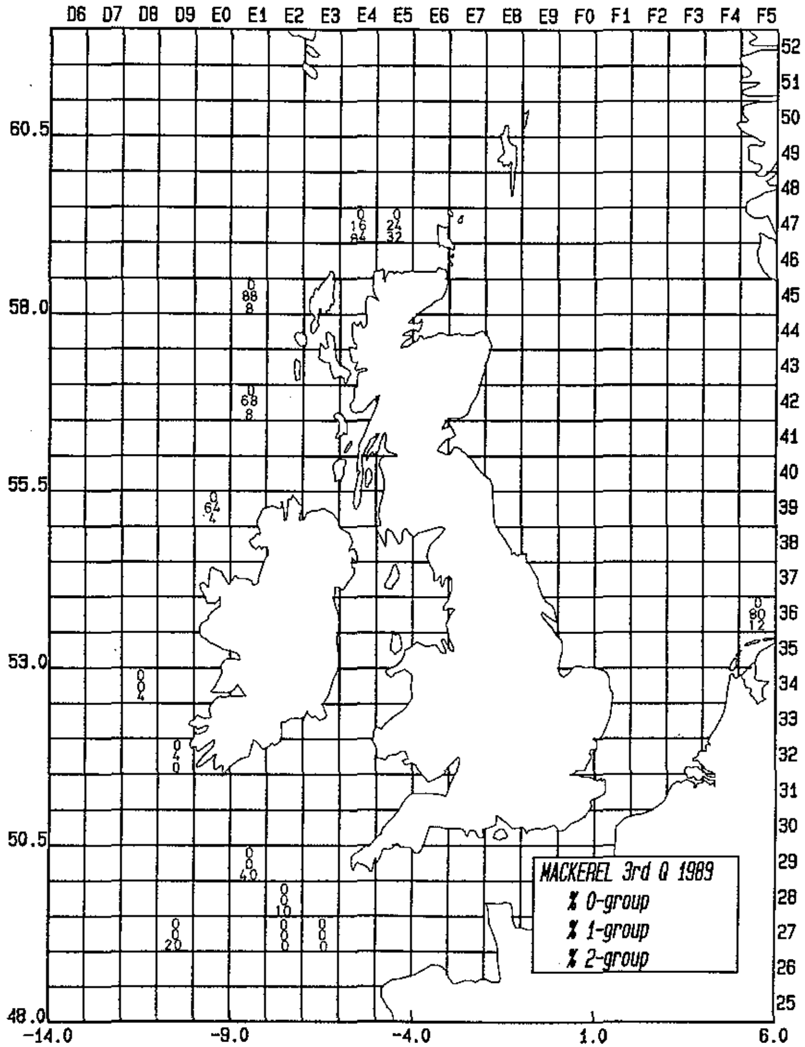
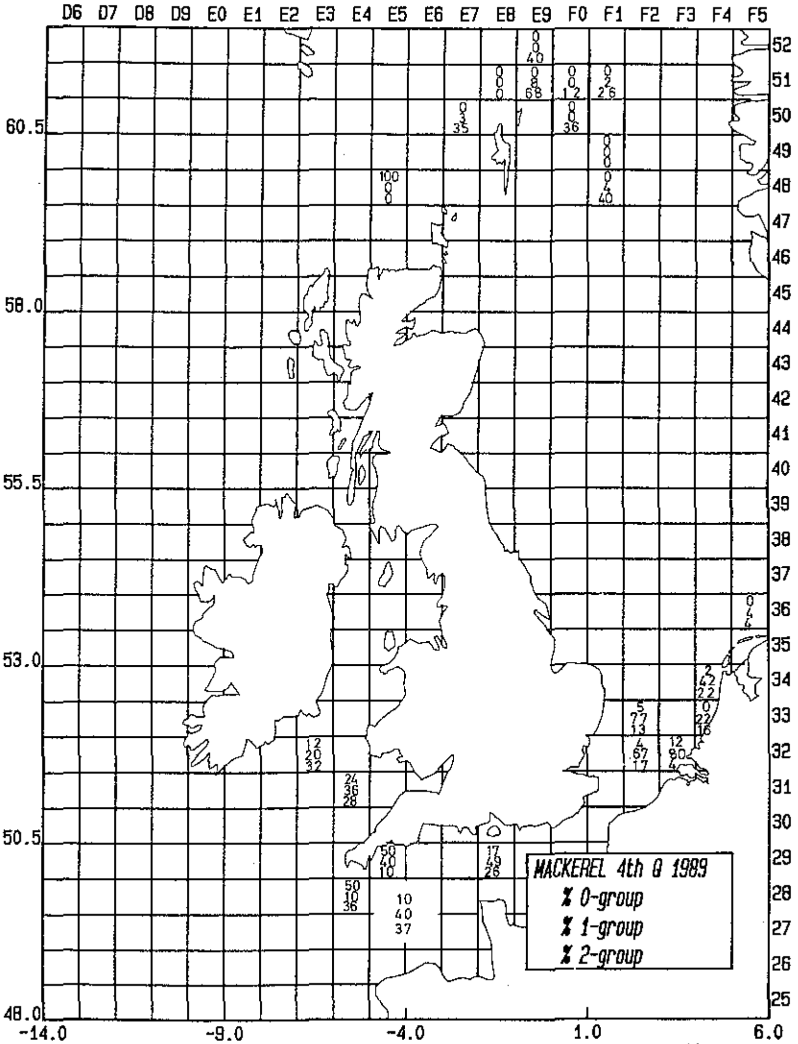


Figure 3.13 The percentage of 0-, 1- and 2-group mackerel in the Dutch and English commercial catches by rectangle in the fourth quarter.



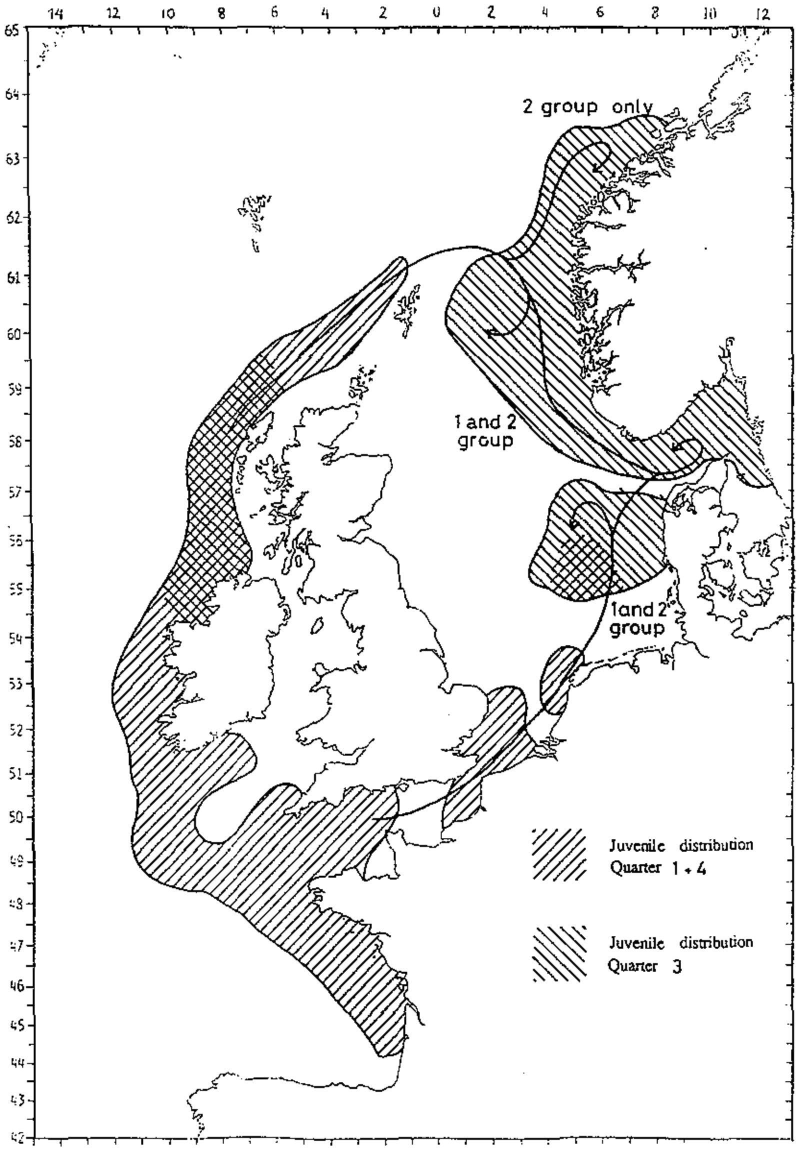


Figure 3.14 Juvenile migration and distribution from both research and catch data covering the period 4th Quarter 1986 - 3rd Quarter 1989.

Figure 4.1 Areas of high abundance in the Western area recruitment surveys, 1981-1990.

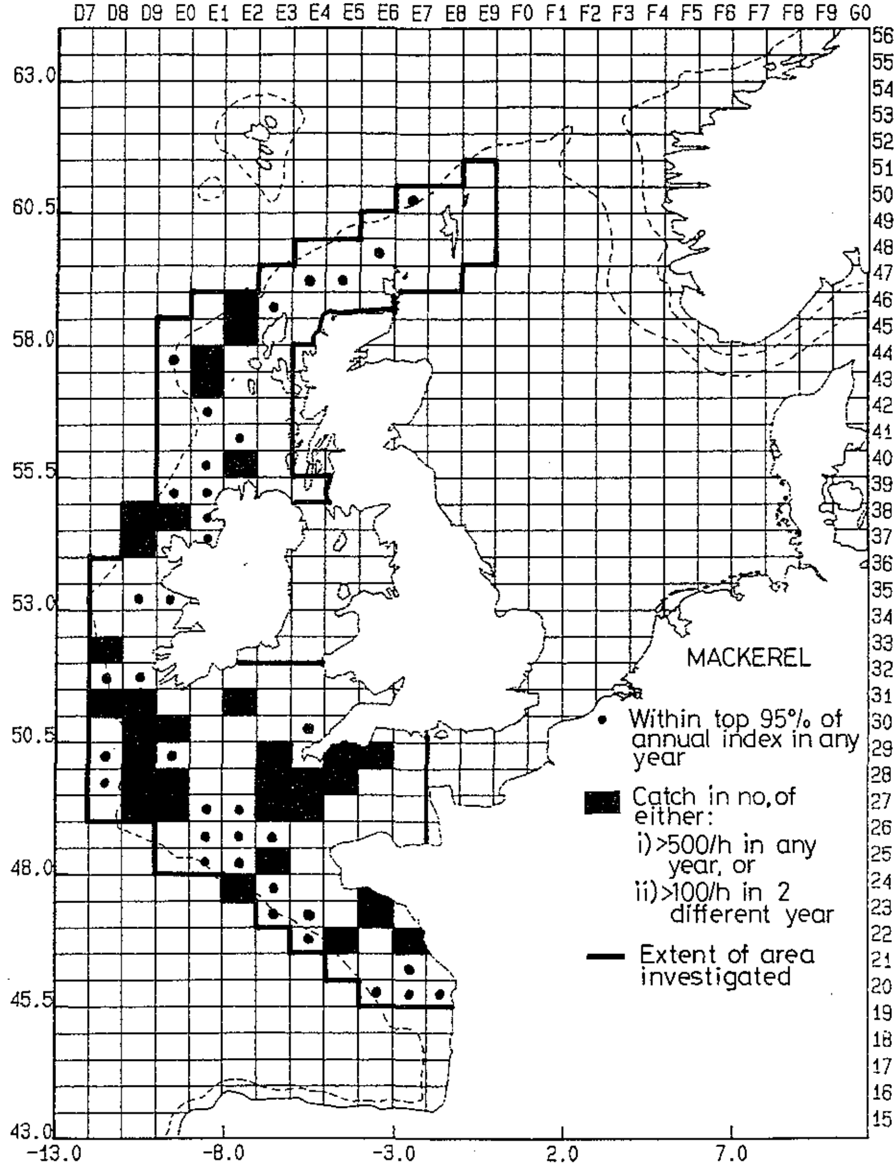


Figure 5.1 Sum of squared residuals against F at age 4-12+.

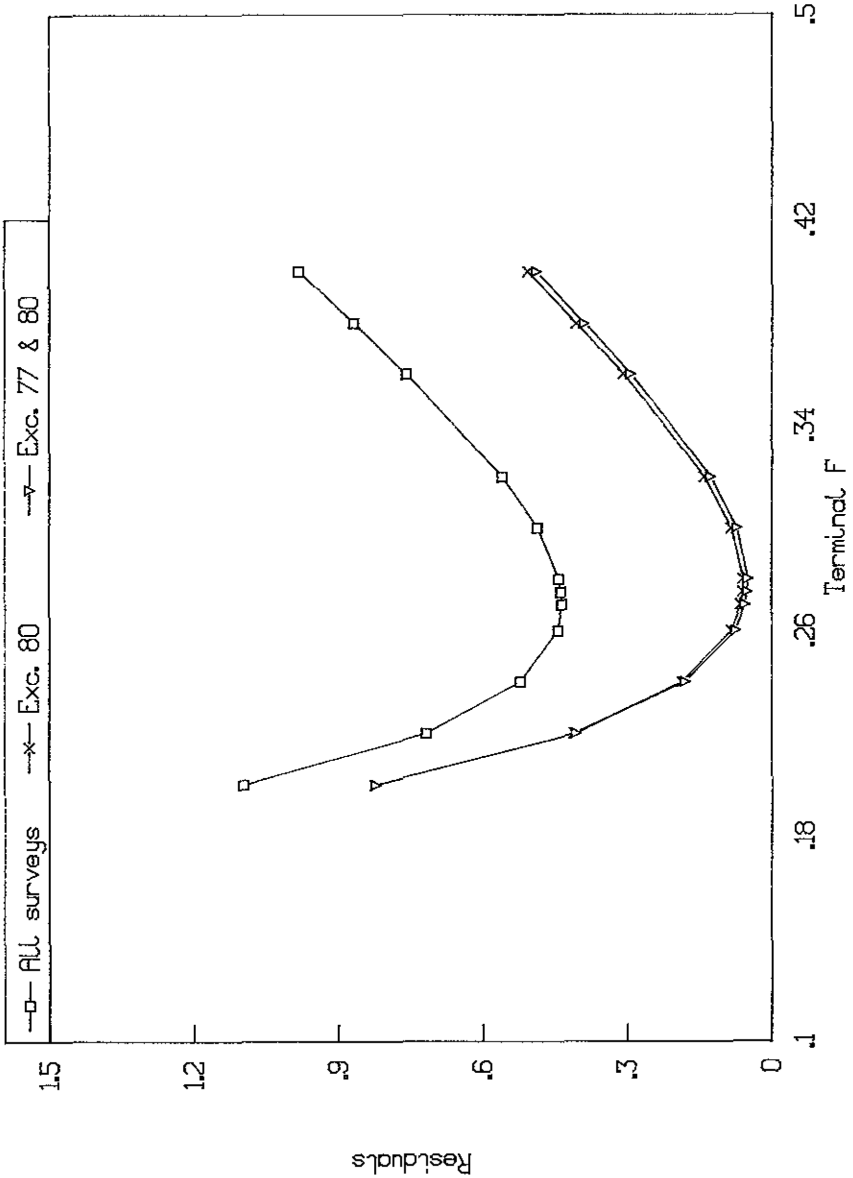


Figure 5.2 Spawning stock biomass at spawning time estimated from the VPA and from the egg surveys.

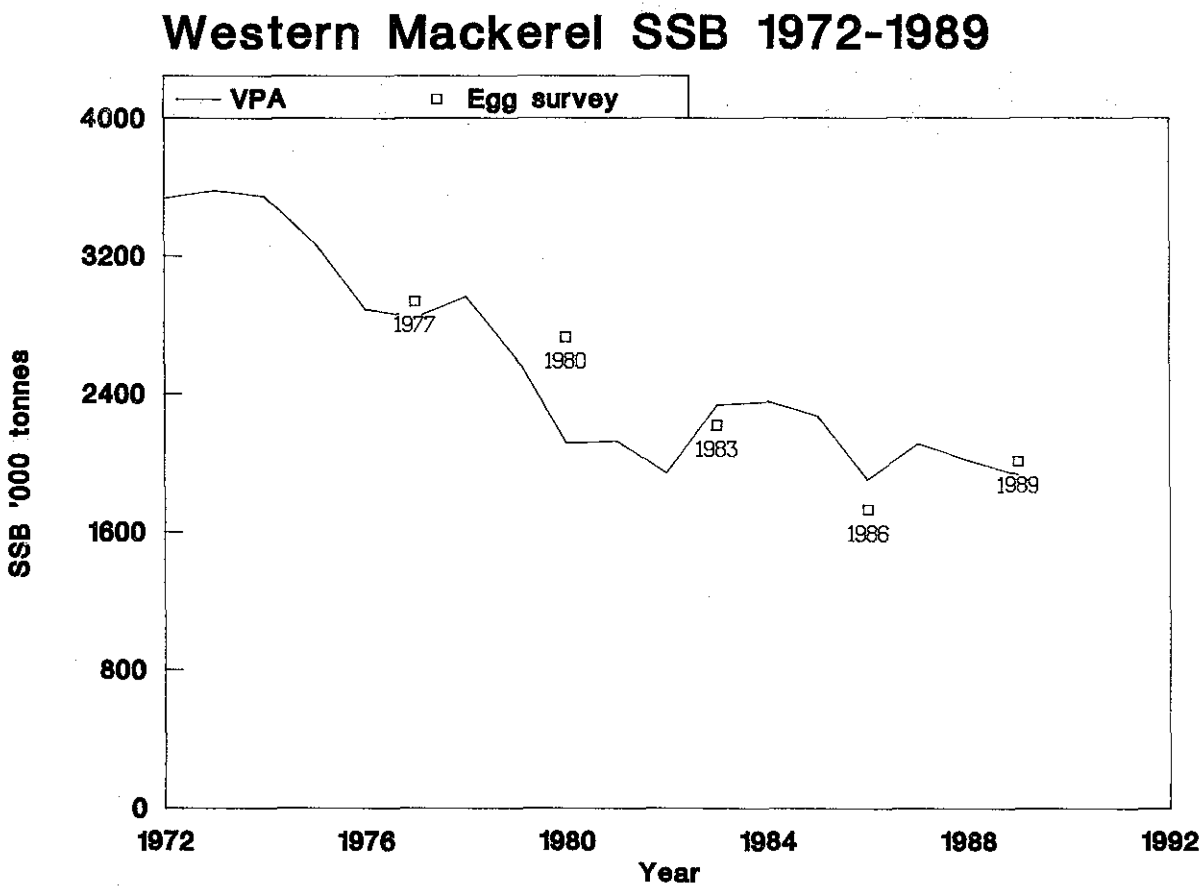


Figure 5.3 Comparison of the age distributions estimated by VPA and by the trawl survey of the western stock (See Section 2.3).

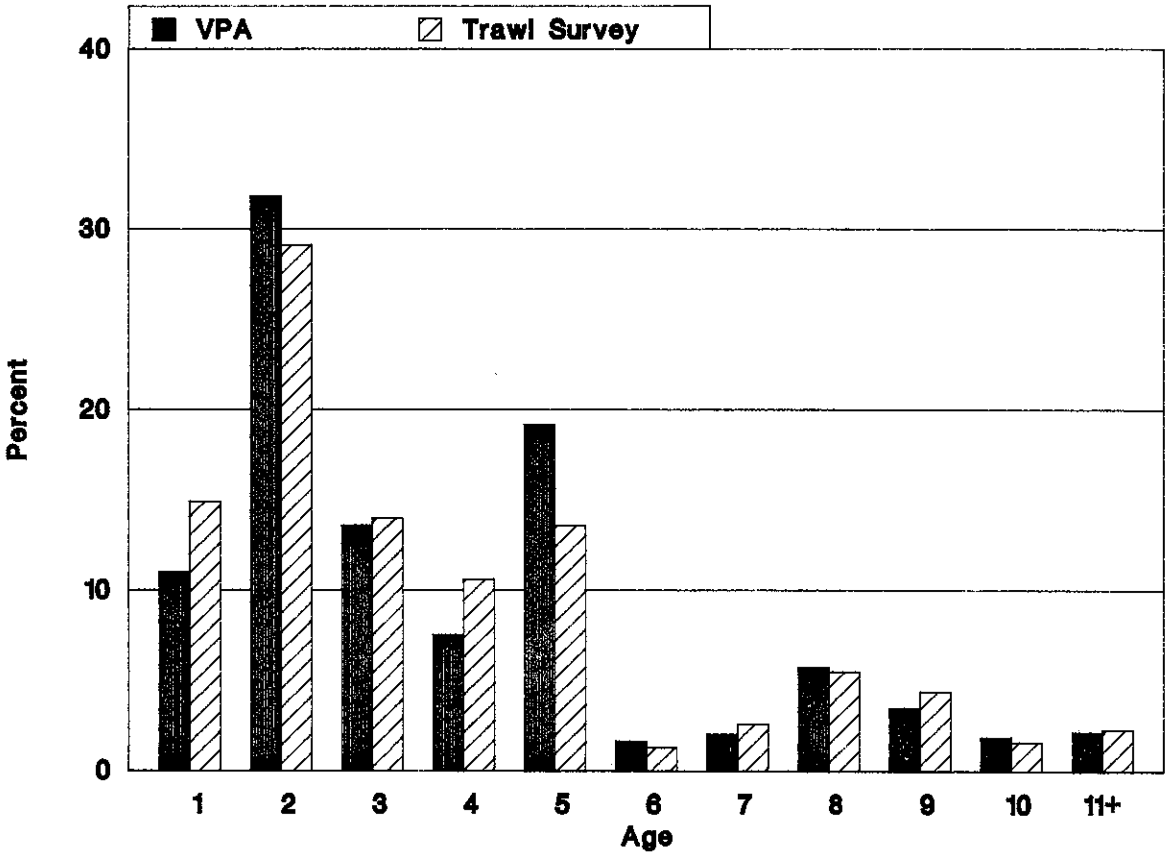


Figure 5.4

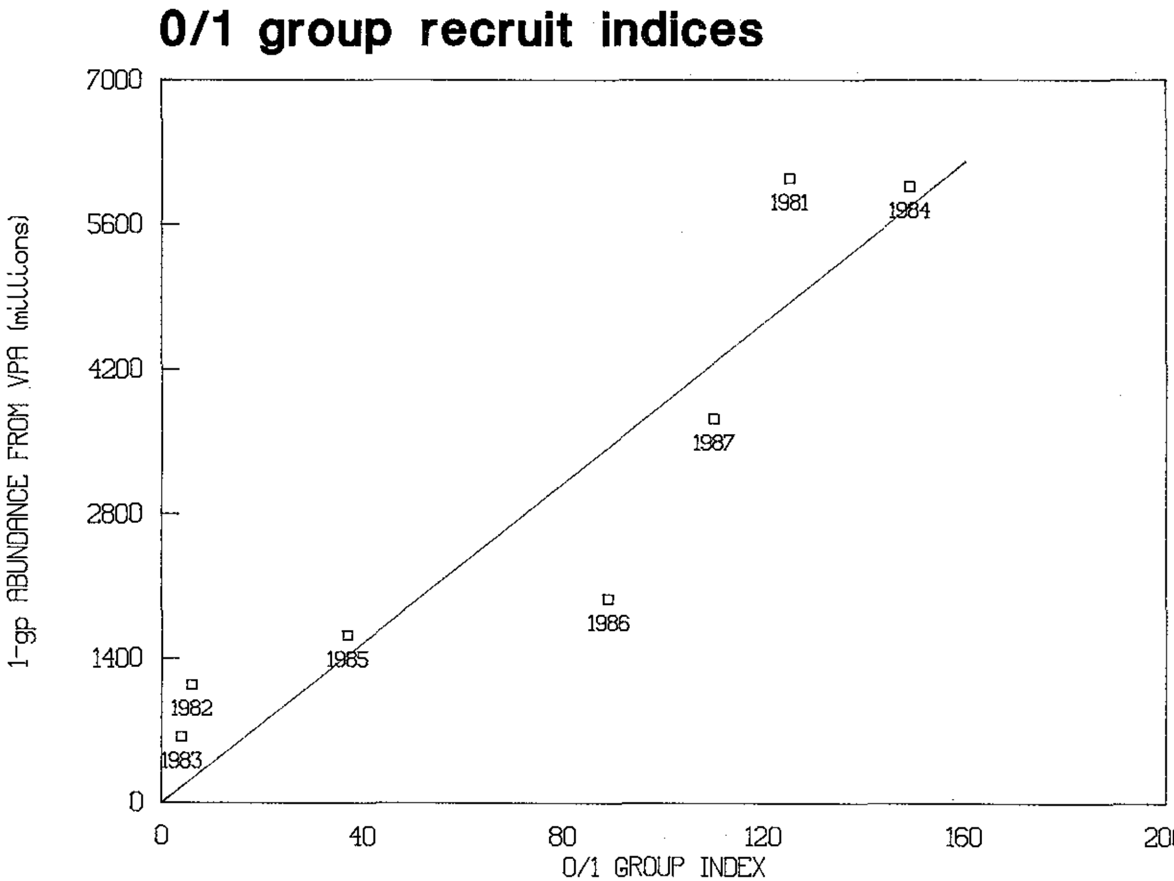

0/1 group recruit indices
1-gp ABUNDANCE FROM VPA (millions)
7000
5600
4200
2800
1400
0
0
40
80
120
160
200
0/1 GROUP INDEX
1981
1984
1987
1986
1985
1982
1983

Figure 5.5

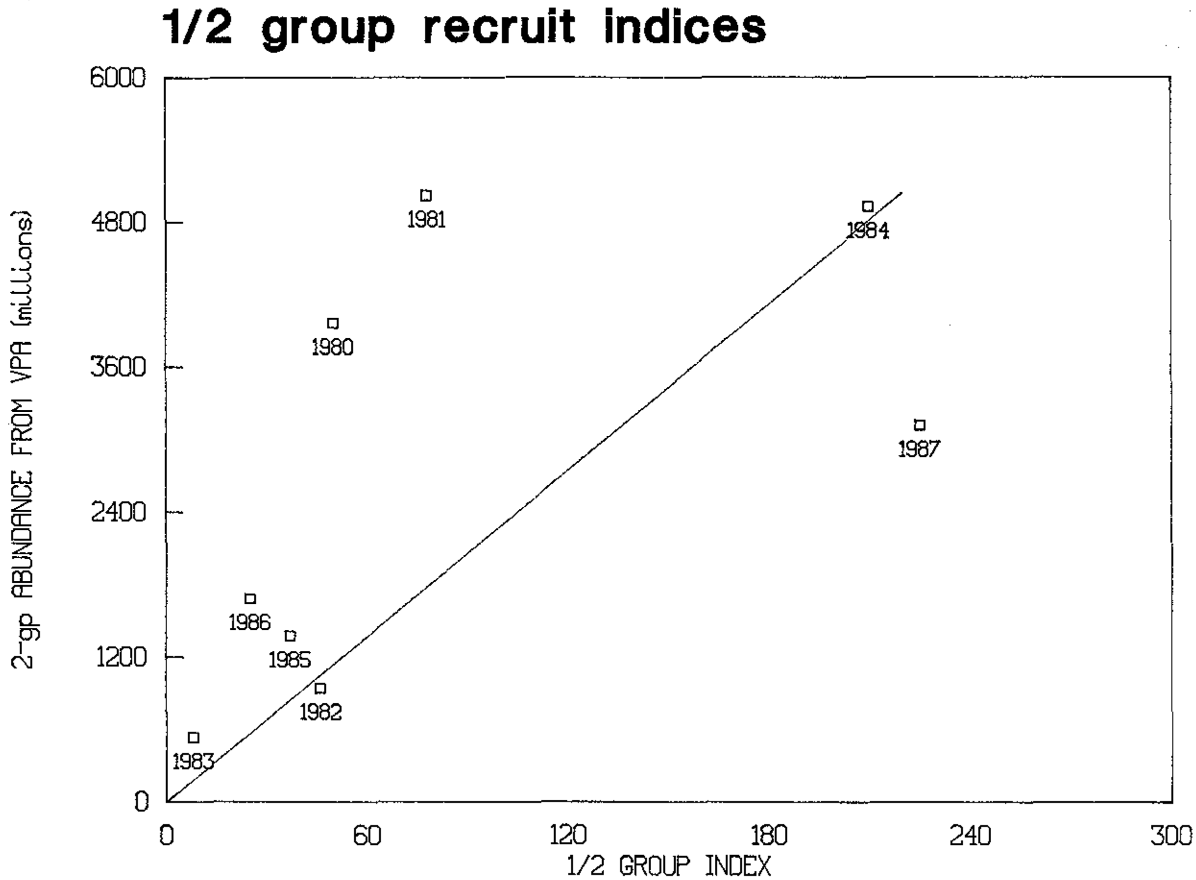

1/2 group recruit indices
2-gp ABUNDANCE FROM VPA (millions)
6000
4800
3600
2400
1200
0
0
60
120
180
240
300
1/2 GROUP INDEX
1981
1980
1984
1987
1986
1985
1982
1983

Figure 5.6

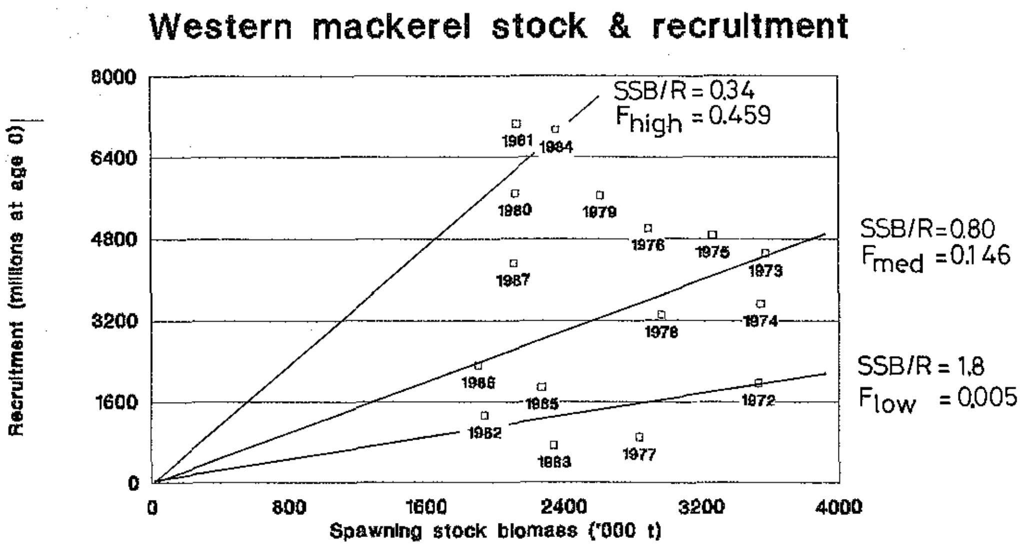
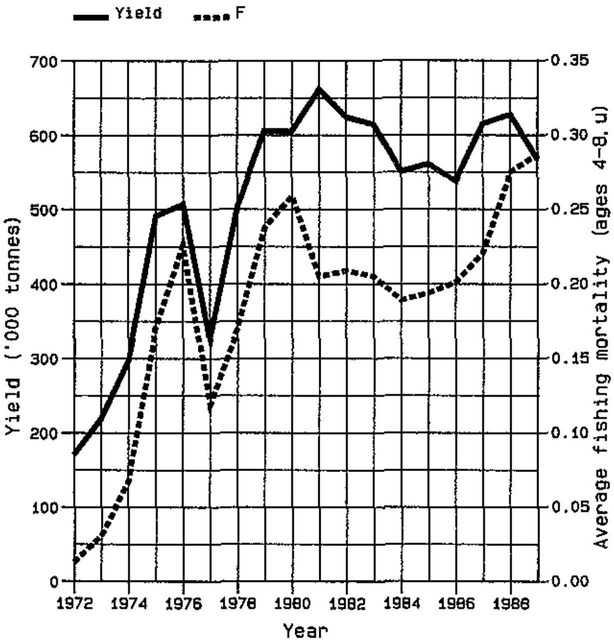

Western mackerel stock & recruitment
Recruitment (millions at age 0)
8000
6400
4800
3200
1600
0
0
800
1600
2400
3200
4000
Spawning stock biomass ('000 t)
SSB/R = 0.34
F high = 0.459
SSB/R = 0.80
F med = 0.146
SSB/R = 1.8
F low = 0.005
1961
1964
1980
1979
1976
1975
1973
1987
1974
1978
1986
1985
1972
1982
1983
1977

Figure 5.7

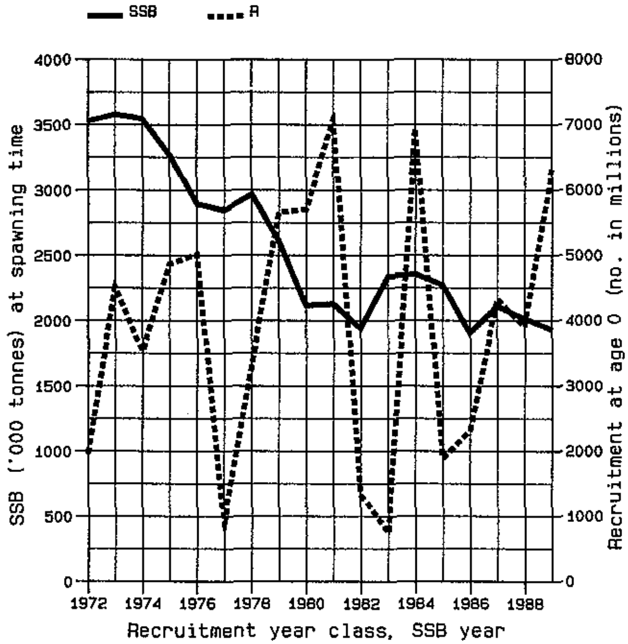
FISH STOCK SUMMARY
STOCK: Mackerel, Western Stock
09-05-1990

Trends in yield and fishing mortality (F)



A

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



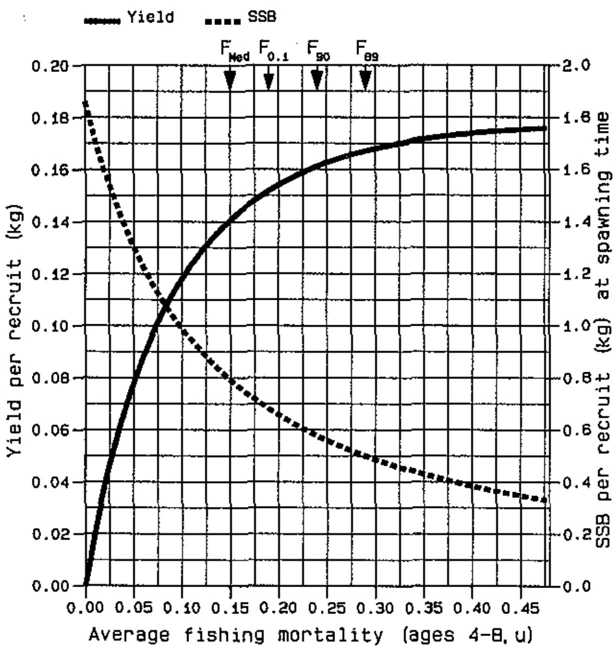
B

cont'd.

Figure 5.7 cont'd.

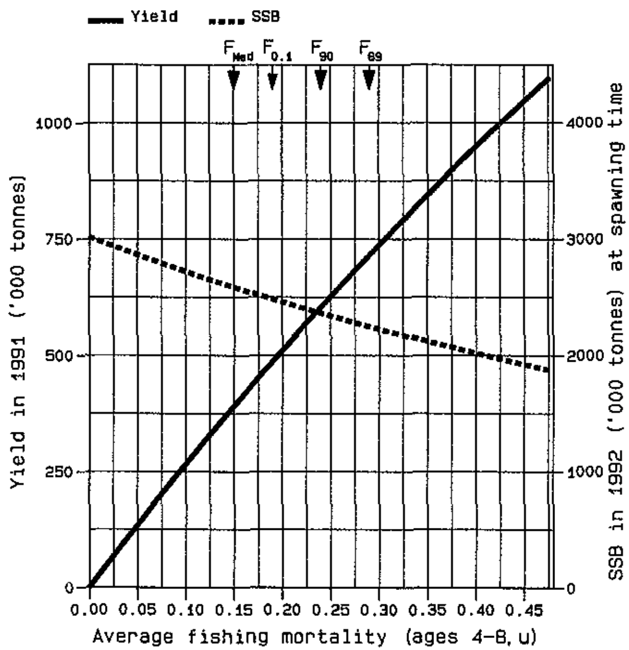
FISH STOCK SUMMARY
STOCK: Mackerel, Western Stock
09-05-1990

Long-term yield and spawning stock biomass



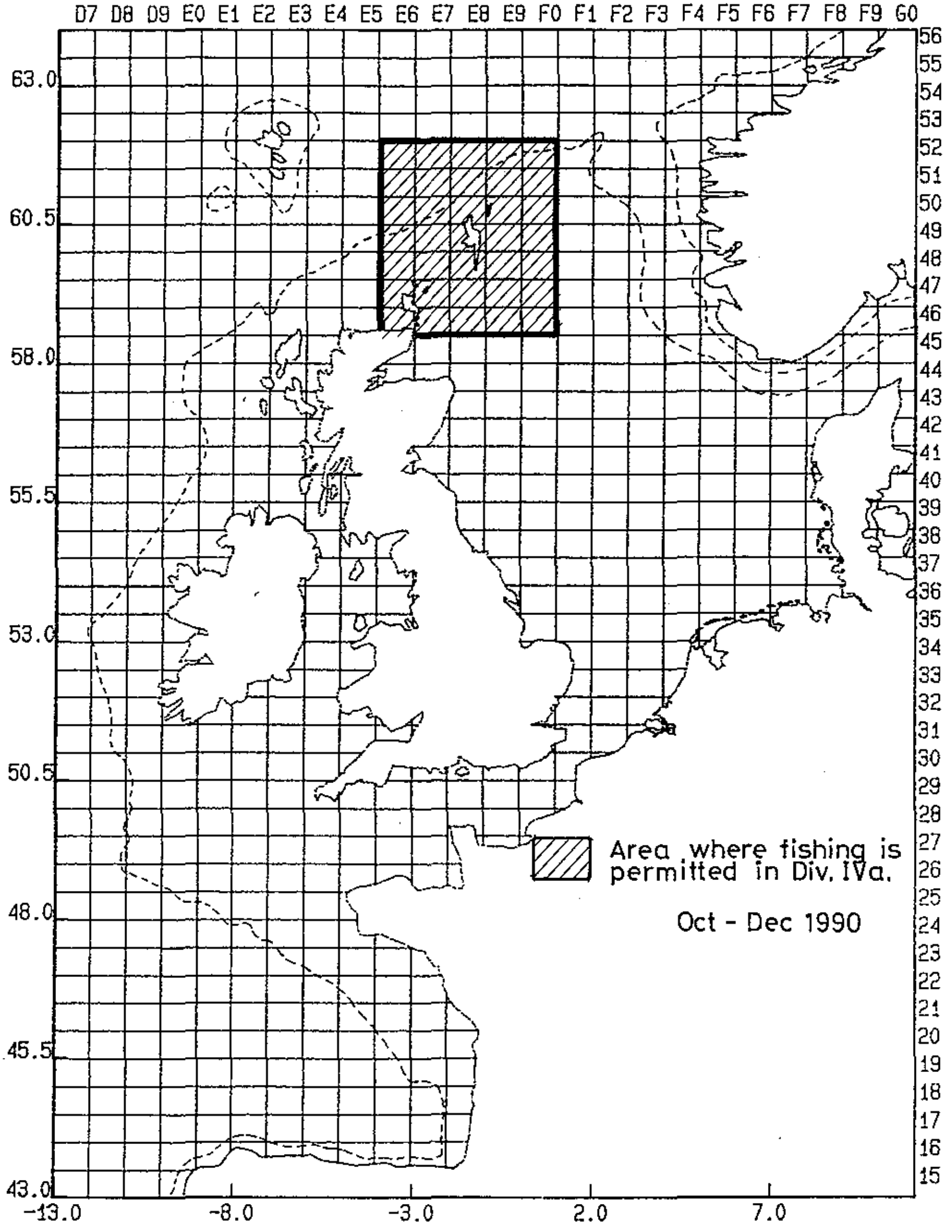
C

Short-term yield and spawning stock biomass



D

Figure 5.8 The area where parts of the TAC for the western are were allowed to be taken in the North Sea in 1989.



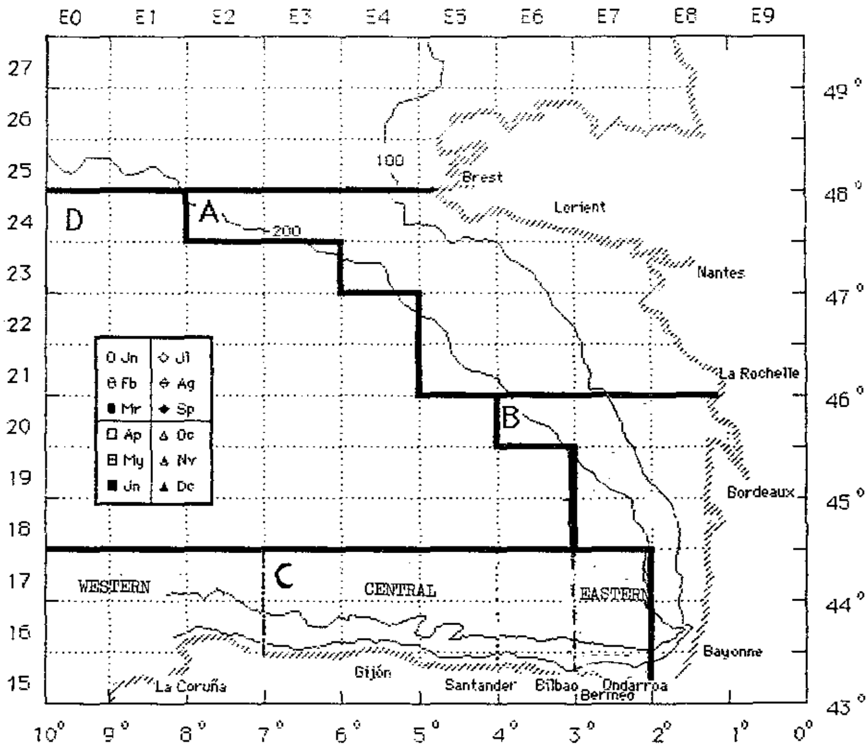


Figure 6.1 Eastern, central and western components of Division VIIIc, as they have used in Section 6.