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International Council for the Exploration of the Sea

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REPORT OF THE MACKEREL WORKING GROUP

Copenhagen, 27 February - 7 March 1989

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ERRATA TO C.M. 1989/ASSESS:11 - MACKEREL WORKING GROUP REPORT

Page 13 In the text table under 1984: replace SSS 133 by 118.

Page 29 2nd para., replace the sentence in the 2nd line by the following:

However, the fishery should be concentrated in the northern areas (Divisions VIa north, IVa and IIa) and kept at a low level in those areas where juvenile fish are consistently found.

Page 40 Table 3.5: Under Sub-area VI, year 1978, column: Landings: replace 1,517,000 by

151,000

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1 INTRODUCTION

1.1 Terms of Reference

At the 76th Statutory Meeting in Bergen, it was decided (C.Res. 1988/2:4:3) that the Mackerel Working Group (Chairman: S.A. Iversen) should meet at ICES Headquarters from 27 February - 7 March 1989 to:

a) assess the status of and provide catch options for 1990 within safe biological limits for the mackerel stocks and management units in Sub-areas II-IX (including the mackerel in Divisions VIIIc and IXa);

b) provide an analysis of all available quantitative information [numbers caught (commercial and research) and percentage contribution] pertaining to the distribution and relative abundance of juvenile mackerel by season and by as fine an area breakdown as possible to provide a basis for evaluating the need to modify the boundaries of the mackerel box;

c) consider, in detail, the practicality of a 30-cm minimum landing size for mackerel;

d) 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 1988 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.

In a telex (16 February 1989) from the Chairman of ACFM, the Working Group was asked to consider new information on the distribution of mackerel in the North Sea. This should be looked at with special reference to the recommendations given for recent years that "any catches taken in Division IVa should in so far as possible be taken in the northern and western part of this Division".

1.2 Participation

The Working Group met in Copenhagen with the following participants:

A. Astudillo	Spain
W.A. Dawson	UK (England and Wales)
A. Eltink	Netherlands
P. Hopkins	UK (Scotland)
S.A. Iversen (Chairman)	Norway
E. Kirkegaard	Denmark
P. Lucio	Spain (Basque Country)
M.M. Martins	Portugal
J. Molloy	Ireland
D.W. Skagen	Norway

The ICES Statistician, Dr E.D. Anderson, attended parts of the meeting.

2 STOCK DISTRIBUTION AND MIXING

2.1 Distribution of Mackerel Fisheries in 1988

As for 1987 (Anon., 1988a), 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. An attempt was made by the Working Group to map the catches using information from unofficial sources, but it was not possible to express the catch distribution in precise quantitative terms. For some smaller fisheries, no information was available on catch location and season. The quarterly distribution of the fisheries in 1988, as estimated by the Group, is shown in Figures 2.1A-D.

First quarter

In the first quarter (Figure 2.1A), 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. 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.

Second quarter

In the second quarter (Figure 2.1B), 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. A small quantity was taken, mainly by drift nets and as by-catch in trawl fisheries.

In Divisions VIIIc and IXa, the fishery in the second quarter was similar to that in the first quarter.

Third quarter

In the third quarter (Figure 2.1C), the major fishery took place in the southeastern part of Division IIa and in the eastern part of Division IVa. The fishing area was more northerly distributed than in 1987. Most of the catches were taken by purse seiners. In Division IIIa, the catch was smaller than in 1987. Small by-catches were recorded in the southern and central North Sea.

There is consistantly a marked decrease in catches in Division VIIIc from the second to the third quarter. In Division IXa, the catches consisted mainly of 0-group mackerel instead of 1-group as in the first and second quarters.

Fourth quarter

In the fourth quarter of 1988 (Figure 2.1D), the main fishery shifted southwestwards 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 east of the Shetlands. In addition to the Shetland area fishery, smaller quantities were taken off northwest Ireland, Cornwall, and Divisions IIIa and IVb,c.

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

2.2 Review of Information on the Adult Stocks

A meeting of a Norwegian-EEC Joint Scientific Group on Migration and Area Distribution of Mackerel (Western Stock) took place in Bergen in November 1987 (Anon., 1988c). The Group was asked to collect and update the most relevant information on stock and catch distribution, particularly for the most recent years, specified on seasons and year classes.

This report was reviewed at last year's Working Group meeting together with the available information at that time (Anon., 1988a). Additional information on the distribution of Western mackerel was obtained from the distribution of the fisheries as shown in Figures 2.1A-D, as dealt with in Section 2.1. The migrations to and from the feeding grounds and the actual distribution of the shoals during the main feeding and over-wintering season can vary substantially from year to year. The distribution was more northerly during feeding in 1988 than in 1987. The period during which the Western mackerel remained in the North Sea area in 1988 seemed to be even more extended than in 1987, because the distribution of the catches during the fourth quarter in 1988 (Figure 2.1D) seemed to be predominantly east of Shetland in contrast to the fourth quarter in 1987 when half of the catch distribution seemed to be west of Shetland (Anon., 1988a).

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

2.3 Juvenile Distribution

The apparent changes in the distribution of juvenile Western mackerel since about 1981 have been discussed in earlier Working Group reports (Anon., 1985a, 1986a, 1987a, 1988a). These changes were illustrated by comparing the annual ratios of the catches of Western stock juveniles (1- and 2-year-olds) from Division VIa to the total catches of Western stock juveniles in all areas with the ratios of total catches of all ages of the Western stock in all areas. After 1981, there was a tendency for the catches of both juveniles and adults to increase proportionally in Division VIa. This ratio could not be calculated on the same area basis in 1987 and 1988 because of misreporting of catches. However, if the ratio is calculated from officially reported catches in the northern area, the proportion of juveniles in the north remains high.

The distribution of the juvenile year classes is given in more detail in Figures 2.2-2.5 which show the catch rates for research vessel surveys. Abundance indices were derived from research vessel trawl surveys by England (first and fourth quarters, 1984-1988), Ireland (fourth quarter, 1985-1988), and the Netherlands (fourth quarter, 1985-1988) (see Section 2.8).

The occurrence of the 1986, 1987, and 1988 year classes expressed as a percentage (number) of the catches taken in the commercial fishery in each ICES division in 1988 is shown in Figure 2.6. The abundance of the 2-year-olds in the 1988 catches (1986 year class) is slightly higher compared with the 2-year-olds present in 1987 (1985 year class). 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 1986, 1987, and 1988 year classes is also expressed in the same way by rectangle in Figures 2.7 - 2.10.

Since 1985, an acoustic survey has been carried out in July-August in the eastern part of the Skagerrak and Kattegat. The abundance estimates of 1-, 2-, and 3-year-old mackerel from these surveys are summarized in Table 2.1. Since 1985, the concentration of juvenile mackerel in these areas has been very high. There is no indication of major difference in year-class strength. This may partly be due to the northeastern changes in the distribution of juvenile mackerel during the period.

2.3.1 The 1988 year class

Fourth quarter 1988

Research vessel surveys during this quarter were undertaken by Ireland, Scotland, the Netherlands, and England and covered most of the Western area. The highest concentrations were once again found mainly in Divisions VIIb,j,h and the southern part of Division VIa (Figure 2.2).

The 1988 year class was present in the catches in the fourth quarter in Division VIIe only (Figures 2.6 and 2.10).

First quarter 1989

The IYFS in February 1989 provided additional information on the distribution of the 1988 year class in the North Sea. No high concentrations were observed.

2.3.2 The 1987 year class

Fourth quarter 1987 and first quarter 1988

The revised distribution of the 1987 year class during this period is presented in Figure 2.3 and includes additional information that was not available to the Working Group in 1988.

Large concentrations were found mainly in the Celtic Sea, close to the Shelf edge. No high concentrations were observed in the North Sea.

The 1987 year class was only present in the catches northwest of Ireland in the first quarter of 1988 (Figures 2.6 and 2.7).

Second quarter 1988

The 1987 year class was not present in the samples taken during the egg survey in the North Sea. The 1987 year class was present in the Western area during a research vessel survey carried out in June (Hopkins, working document).

Again, this year class was only present in the catches northwest of Ireland. None were taken in the North Sea (Figures 2.6 and 2.8).

Third quarter 1988

No research vessel data were available for the third quarter in the Western area. Large quantities were found in the North Sea during the acoustic survey in July-August in the eastern part of the North Sea, Skagerrak, and Kattegat (Table 2.1).

Large numbers were also present in the fishery in Division IIIa (85%), Sub-area IV, and Divisions IIa, VIa, and VIIb,e (Figures 2.6 and 2.9).

Fourth quarter 1988

The 1987 year class was again found to be abundant in the fourth quarter of 1988 in the Western area from research vessel surveys. The largest concentrations were found off the Cornish peninsula and in the Celtic Sea south of Ireland. In addition, a large concentration was found in the southern North Sea during a Dutch bottom trawl survey (Figure 2.4).

The 1987 year class was well represented in the main fishery in Division IVa. In addition, it was also taken in smaller quantities from the fishery in all other areas, except Division IIa (Figures 2.6 and 2.10).

2.3.3 The 1986 year class

Fourth quarter 1987 and first quarter 1988

Additional information on the distribution of the 1986 year class was made available to the Working Group for the period October 1987 - March 1988 and is illustrated in Figure 2.5. No large concentrations were found, however, but it was abundant once again in Divisions VIIj,e. No high concentrations were observed in the North Sea.

The distribution of the 1986 year class was also reflected in the same way in the catches taken during the first quarter of 1988 when large numbers were taken in the Western area close to the shelf edge and off southwest England (Figures 2.6 and 2.7).

Second quarter 1988

The 1986 year class was not present in the catches taken during the egg survey in the North Sea. It was also present in large numbers in the Western area during a research vessel survey carried out in June (Hopkins, working document).

This year class was only present in the catches taken in Division VIa and the Celtic Sea (Figure 2.6).

Third quarter 1988

No research vessel data were available for the third quarter in the Western area. Large quantities were found in the North Sea during the acoustic survey in July-August in the eastern part of the North Sea, Skagerrak, and Kattegat (Table 2.1). This year class was well represented in the catches in Divisions IVa and IIa (Figure 2.6).

Fourth quarter 1988

The 1986 year class was also well represented in all areas in the fourth quarter fishery, with 10% being taken from the main fishery in Division IVa (Figures 2.6 and 2.10).

2.3.4 The 1985 year class

No additional data were available on the distribution of the 1985 year class from research vessel surveys. However, the proportion that appeared in the catch during 1988 confirms that this year class is below average abundance.

2.4 Recruit Indices from Research Vessel Surveys

A method of predicting year-class strength from combined research vessel surveys during the first and fourth quarters was described by Dawson *et al*. (1988). A previous attempt to use the data collected from these surveys with estimates of recruitment from VPA made by Dawson (1988), using the RCRTINX2 method of Shepherd, was unsuccessful. Shepherd's method combines each survey series by weighting them according to the reciprocal of the variance of their agreement with VPA recruitment estimates. However, high annual variation within the overall distribution meant that individual surveys did not reflect overall abundance.

The method of Dawson *et al*. (1988) avoids the use of weighting factors and is less affected by fluctuations within the distribution. A potential disadvantage is that the annual indices are based upon individual surveys in different months using different types of bottom trawl. The method was applied to the VPA presented here (Section 3.4.3) and provisional recruit indices calculated from the fourth quarter of 1988 research vessel surveys. The results are plotted for first- and second-winter mackerel in Figures 2.11 and 2.12, respectively. The regression lines were forced through the origin and the equations and correlation coefficients are given below:

Age group	Regression equation	Correlation coefficient
First-winter juveniles	y = 37.5x	r = 0.90
Second-winter juveniles	y = 29.1x	r = 0.70

The data presented in Figures 2.11 and 2.12 indicate better agreement between the VPA and survey abundance indices for first-winter mackerel than for second-winter mackerel; however, the correlation coefficients show general agreement.

Recruitment predicted by the method of Dawson et al. (1988) using the data from the recruit surveys has been shown to give a better estimate of recruitment than the index presently used for the catch prognosis input. However, the time series of data used is relatively short and so, for the time being, the recruit indices calculated in this way should be used with caution. The recruitment indices from the research vessel surveys together with the estimated numbers of 1-group and 2-group are presented in Table 2.2. Only the indices up to and including 1986 were used in the regression because the 1987 and 1988 data are too dependent on input F values. The 1987 year class was predicted to be 4,665 million fish from the first-winter abundance estimate. However, because only the fourth quarter data were available for this winter's estimates, the most recent estimates for the 1987 year class as second-winter fish, and the 1988 year class as first-winter fish were considered unreliable. They have not been converted to abundance estimates because they are outside the range of the regression.

The Western mackerel stock has become more and more dependent upon recruitment in recent years as the spawning stock biomass is declining. It is, therefore, becoming more important to have a reliable indication of recruitment as early as possible. The most recent information on recruitment does not become available until after the end of March when the research vessel surveys have been completed. For these reasons, the Working Group strongly recommends that the recruit surveys should be continued, and that future Mackerel Working Group meetings should be convened after mid-April so that all available information may be utilized in the assessment.

2.5 Catches in Tonnes of the Western and North Sea Mackerel

The catches of mackerel have in the past been divided into North Sea and Western mackerel based on total catch in numbers. The sum of products (SOP) of the numbers and average weights for the different year classes will be an estimate of the catch in tonnes of the two stocks.

A comparison of the SOPs for the two stocks for the different years with the catch in tonnes, as given in Table 3.1 in last year's Working Group report (Anon., 1988a), indicates some discrepancies, particularly for the period 1976-1980 (Table 2.3). The tonnages given last year were taken from the CATON files at ICES. However, the basis for the values given for 1976-1980 is not described anywhere. This was investigated further in a working document (Iversen).

The total catch of mackerel in the North Sea, Norwegian Sea, and the Western areas for the period 1972-1987 are given in Table 2.3. The catches are within ±10% of the total SOP for all years except for 1975 (32%), 1980 (23%), and 1983 (11%). These differences might be due to the applied catch in numbers for the two stocks, the average weight by age, or a combination of both. For the Western stock, the same weights at age in the catch were used for the period 1972-1979, and similarly for the North Sea stock, the same weights at age were used for the period 1969-1983. The North Sea weights in this period were on average 28% higher than those used for the Western stock in 1972-1979. Therefore, the Working Group thinks that the main cause for the difference between the SOP and actual catch is the applied weight in catch. The catch in numbers for the North Sea stock has been calculated for 1986 and 1987; therefore, the catch in tonnes has also been altered (see Section 5.1).

Since the actual catch and SOPs usually agree well (Table 2.3), the actual total catch in tonnages of the two stocks might be divided into catches of Western and North Sea mackerel in accordance with the SOP for each stock (Table 2.3).

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

3.1 The Fishery in 1988

The changes that have taken place in recent years in the distribution of the stocks and the location of the fisheries has meant that the system used by previous Working Groups, in which the fisheries for the North Sea and Western stocks were described in different sections, is no longer appropriate. The situation is further complicated by the amount of misreporting that takes place between the different areas. This section, therefore, deals with the fisheries in the above-mentioned areas, and it must be emphasized that the 1988 catch figures are in all cases preliminary.

Nominal catches in the North Sea, Skagerrak, and Kattegat (Sub-area IV and Division IIIa) are given in Table 3.1, and catches in the Norwegian Sea and off the Faroes (Divisions IIa and Vb) in Table 3.2. An estimated by-catch of mackerel in the horse mackerel fishery of 500 t in Division IIa and 13,000 t in Division IVa was included in these numbers. The nominal catch in Divisions IIa and Vb was the largest ever recorded in this area, exceeding the 1986 catch by 19%. The total nominal catch in the two reporting areas increased by 27,917 t (12.6%) compared to 1987, thus continuing the trend of recent years. Misreporting is known to have occurred, and the catches by area as given in Tables 3.1 and 3.2 are inaccurate.

The quantity of catches which could not be allocated to any country increased dramatically and, together with the discards, totalled 29,000 t or 23% of the total. This figure is the highest ever recorded for the fishery in this area and is a major cause for concern.

Table 3.3 gives the estimated catch by quarter for the various sub-areas and divisions, based on information provided by Working Group members. As in previous years, the major part of the fishery took place in the northern part of Division IVa and in the southeastern part of Division IIa in July-November.

The landings made by each country from the Western area (Sub-areas VI and VII and Divisions VIIIa,b) for the 10-year period 1979-1988 are shown in Table 3.4. This table also shows the estimated discards (see also Section 3.1.1 on discarded catches). The landing figures for 1988 are preliminary and are based on data supplied by Working Group members. Some slight revisions were made to the 1987 catch data, but the overall total catch was not altered significantly. Some changes were also made in the UK (N. Ireland) catches from 1984-1987. During this period, most of these catches had been included with UK (Scotland), but are now shown separately.

The total catch reportedly taken from Sub-areas VI and VII and Divisions VIIIa,b was about 377,000 t compared to 401,700 t in 1987. However, it must immediately be pointed out that this figure, as in 1986 and 1987, includes considerable quantities of mackerel which were reportedly taken in the northern part of Division VIa, but were in fact taken east of 4°W in Division IVa. It was estimated that the amount misreported in this way totalled about 180,000 t compared to 117,000 t in 1987 and 148,000 t in 1986. (The 1987 figure of misreported catches has been revised slightly.) The total landings also include some catches which were misreported as horse mackerel.

The total amount of "unallocated" catches amounted to 4,700 t compared to 25,800 t in 1987.

As in 1987, the main catches taken from Sub-areas VI and VII and Divisions VIIIa,b were those taken by UK (Scotland), Ireland, and the Netherlands. It must again be emphasized that these catches must be treated with caution because of the amounts of misreported and unallocated catches. However, it does appear that there has been little change in recent years in the reported catches of the main countries. Spain took about 1,500 t in Divisions VIIIa,b.

The actual catch taken from Sub-areas VI and VII in 1988 amounted to about 197,000 t (Table 3.3). This is a decrease from the figure of 290,000 t for 1987 and is a further result of the factors pointed out by the 1988 Working Group. These were: 1) the shift in the distribution of the stock which was again evident in 1988, 2) the more effective management of the fishery in these areas, e.g., the restrictions imposed by the "box" off Cornwall and the closure of the Irish fishery from April-October, and 3) the continuing decrease in effort by the Dutch fleet which now concentrates mainly on horse mackerel.

The catches taken by sub-area are shown in Table 3.5. This table has been altered from that shown in previous reports. It is now based on the actual catches taken from each area and has been extended to include catches taken in Sub-area IV and Division IIIa. The catches show very clearly the change in the distribution of the stock and the location of the fisheries. The catches in Sub-area VII and Divisions VIIIa,b are mainly from the northern divisions (Divisions VIIb-k) and amounted to 78,300 t in 1988 compared to nearly 440,000 t in 1979. Catches taken from

Sub-area VI have, on the other hand, decreased from 340,000 t in 1981 and 1982 to 119,700 t in 1988, while there has been a dramatic increase in the catches from Sub-area IV and Division IIIa from 50,000 t in 1985 to 338,000 t in 1988.

3.1.1 Discarded catches

The total amount of mackerel shown in Table 3.4 as having been discarded is 5,800 t. The Working Group considers this to be a minimum estimate as it includes the discards of only one country. The amount of mackerel discarded by other countries may be considerable, but has not been estimated. As pointed out by the 1988 Working Group, discarding of small fish may again become a serious problem when a big year class enters the fishery.

Some data were presented to the Working Group about Spanish discards. Igelino et al. (1988) studied the discarding rates for different fleets operating in Sub-area VII and Divisions VIIIa,b in 1987 and found that an average of about 50% of the total catch was discarded by trawlers. The proportion of mackerel in the discarded catch was less than 10% except in April-May, when values of nearly 30% were found. The discards of the longliners were negligible except in April, when discarding of mackerel was about 10% of the total catch. However, it has not been possible to calculate the discards and they are, therefore, not included.

3.1.2 Catch in numbers in 1988

The catch in number at age for Divisions IIa, IVa, and Vb; IIIa; IVb,c; VIa,b; VIIa,d-h; VIIb,c,j,k; and VIIIa,b is shown in Table 3.6.

Divisions IIa and Vb

All the catches in this area were allocated to quarters and age groups by quarters using Norwegian data.

Division IVa

For the two first quarters, the catches were allocated in numbers by age group according to Norwegian data. In the third and fourth quarters, a combination of Norwegian, Danish, and Dutch data were applied to the catches taken by Northern Ireland, Scotland, England, and Wales.

Estimated catches of about 180,000 t and 4,300 t misreported to Division VIa and Vb, respectively, were included in Division IVa. Unallocated catches were converted to numbers at age using appropriate quarterly sampling data.

Divisions IVb,c

In Division IVb, the catches were allocated to age groups according to Norwegian, Danish, and Dutch data. In Division IVc, Dutch data were used for calculating catch in numbers per age group.

Division IIIa

Sampling data were supplied by Norway and Denmark. These data were applied to the Swedish catch for allocating in numbers per age group.

Divisions VIa,b

Sampling data were provided by Scotland, the Netherlands, Ireland, and Norway. Landings by the Federal Republic of Germany and the UK (England and Wales) were converted to numbers at age using the combined sampling data by quarter. Unallocated catches were converted to numbers at age using appropriate quarterly sampling data.

As in 1987, a large part of the reported catch for Division VIa was taken in Division IVa.

Divisions VIIb,c,j,k

For 1988, the divisions of Sub-area VII were combined in a way that better reflects the distribution of juveniles and adults than the area combination previously used. In earlier years, the numbers at age of Sub-area VII were provided for both Divisions VIIa-c and Divisions VIId-k. This was changed so that the numbers at age of Sub-area VII were given for Divisions VIIb,c,j,k where mainly the adult mackerel occur and for Divisions VIIa,d-h where mainly the juvenile mackerel occur.

Sampling data for Divisions VIIb,c,j,k were provided by the Netherlands and Ireland. Landings by the Federal Republic of Germany and the UK (England, Scotland, and Wales) were converted to numbers at age using the combined sampling data by quarter. French catches were allocated to area and quarter using appropriate annual sampling data.

Divisions VIIa,d-h

Sampling data were provided by Ireland, the Netherlands, and England. Landings by Scotland, the Federal Republic of Germany, and part of the landings by UK (England and Wales) were converted to numbers at age using the combined sampling data by quarter.

The French catches were allocated to area, quarter, and age using appropriate sampling data.

Divisions VIIIa,b,d,e

Numbers at age were not supplied for Divisions VIIIa,b. The annual age distribution for Sub-area VII was applied to convert catches from France, Spain, and UK (England and Wales) to numbers at age.

3.1.3 Revision of the 1987 catch in numbers at age

Revisions to the catch data for 1987 were a reduction of approximately 5,600 t due to an accounting error and an increase of approximately 2,000 t due to previously unreported by-catches of mackerel in the horse mackerel fishery in Division IVa. The net reduction of 3,600 t is approximately 0.5% of the total catch, and was considered negligible.

However, the decision made by the 1988 Working Group that the 13,000 t caught in the central North Sea should be allocated to the North Sea stock was questioned (see Section 3.2). These catches contained a high proportion of juveniles which did not subsequently recruit to the North Sea stock, and a working document (Kirkegaard) suggests that catch rates for the North Sea stock must be much lower than this. It was, therefore, decided to revise the 1987 catch-in-numbers data for the Western stock to include the 13,000 t previously allocated to the North Sea stock.

3.2 Allocation of Catches to Stocks

In 1988, the Working Group allocated the 1987 catches to stocks assuming that all mackerel caught in Divisions IVb, IVc, and IIIa were North Sea fish, and that the proportion of North Sea mackerel in all other areas was insignificant. The catches were estimated to be 13,000 t for the North Sea Stock and 615,000 t for the Western stock. The catch in numbers at age for the North Sea stock indicated that more than 50% of the mackerel caught in 1987 were juvenile (1- and 2-year-old fish).

Based on egg surveys, the size of the North Sea spawning stock was estimated to be 37,000 t in 1988 (Iversen et al., working document) and 45,000 t in 1986 (Iversen et al., 1987). Using the two stock estimates, the average total mortality rate (Z) for the spawning stock was estimated to be 0.21 (Kirkegaard, working document). This low mortality rate corresponds to a catch in the order of 2,000-5,000 t per year.

The Working Group reviewed the procedure used to split the 1987 catches and found that the resulting catch-at-age figure for the North Sea stock was inconsistent with the results from the egg surveys. Regarding both the total biomass and the age composition, the Working Group found the method unsuitable for allocating catches to stocks.

The Working Group did not find any reliable method to split the 1987 and 1988 data and decided to allocate all mackerel caught in Sub-areas II-VII in 1988 to the Western stock. Including a small catch of North Sea fish in the Western stock will have very little influence on the assessment of the Western stock.

In 1987, the Working Group allocated the 1986 catches to stocks using three sources of information: 1) the estimate of the relative proportion of the two stocks present in the North Sea by quarter and age group, 2) an estimate of the number of 1-year-old fish in 1984 and 1985 in each of the two stocks, and 3) the age distribution of the North Sea spawning stock in 1986. The method gave a catch of 32,000 t of North Sea fish.

The information from the egg surveys in 1986 and 1988 in the North Sea indicated that the catches from the North Sea stock in 1986 were overestimated and that the real catch was somewhat smaller. However, lacking a reliable method to split catches, the Working Group was not able to change the catch figures for 1986.

Based on the assumed catch in numbers of the North Sea stock, as given in Section 5.1, the catch from this stock was about 3,000 t in 1988. This implies a catch of about 623,000 t from the Western stock in 1988.

3.3 Assessment of the North Sea Stock

3.3.1 Spawning stock biomass estimate from the egg survey in 1988

During the period 5 April - 28 July, the spawning areas of North Sea mackerel and horse mackerel were investigated by the Netherlands, Denmark, and Norway. The total egg production of North Sea mackerel was estimated to be 25 x 10^{12} eggs and the spawning stock at 37,000 t (Iversen et al., working document). This is about 20% less than the 1986 estimate and is an all-time low.

3.3.2 The state of the North Sea stock

As in the three previous years, the Working Group decided that it could not carry out an analytical assessment of the North Sea stock.

The only new information about the state of the North Sea stock which was available to the Working Group was the results from the 1988 egg survey in the North Sea (Iversen et al., working document). Data were not available to quantify the recruitment of the last three year classes to the North Sea stock. As mentioned in Section 3.2, the Working Group was not in a position to allocate catches to stocks.

The egg survey in 1988 (see Section 3.3.1) gave an estimate of the spawning stock biomass of 37,000 t. The development in spawning stock biomass for the period 1975-1988 is given in the text table below (in '000 t).

Year	1975	1976	1977	1978	1979	1980	1981	1982	1983
SSB	826	700	583	436	336	258	189	162	168

Year	1984	1985	1986	1987	1988
SSB	133	-	45	-	37

The figures for the period 1975-1983 are taken from the VPA given in the Working Group report (Anon., 1985a). For the years 1984, 1986, and 1988, the estimates from the egg surveys were used (Iversen et al., 1985; Iversen et al., 1987; and Iversen et al., working document).

There has been a steady decline in the spawning biomass, and the 1988 figure is the lowest on record.

Based on the estimates of spawning stock size and the age composition from the egg surveys in 1986 and 1988, Kirkegaard (working document) estimated the total mortality rate of the spawning stock to be 0.21 per year. The Working Group uses a value of natural mortality of 0.15. Even though the figures may be very uncertain, they indicate a very low fishing mortality and correspond to a catch in the order of 2,000-5,000 t.

The age composition of the spawning population observed during the spawning period (Iversen et al., working document) shows that the recruitment of the 1984 and 1985 year classes to the stock has been very low. The 1984 year class only accounts for about 9% in number of the spawning fish in the North Sea, while it accounts for about 50% in the Western area. The relatively large quantities of juvenile mackerel (1- and 2-year-olds) observed since 1985 in the third and fourth quarters in Divisions IIIa and IVb, both in the catches and in the surveys (see Section 2.3), are likely to be Western fish. This means that mackerel found in all areas in the third and fourth quarters are predominantly Western stock, and that the North Sea stock makes up only a small proportion, even in Divisions IVb,c and IIIa.

3.3.3 Egg survey in 1989

During the last two weeks of June, which usually is the peak of the spawning in the North Sea, Norway will survey the spawning area at least once. The results will be available for the ACFM meeting in November 1989.

3.4 Assessment of the Western Stock

3.4.1 Mean weight at age

Mean weights at age in the catches by quarter in 1988 were provided by Scotland (Divisions VIa and IVa,b), England (Divisions VIIe,f), Ireland (Divisions VIa and VIIb,j), the Federal Republic of Germany (Divisions IVa,b and VIa), Norway (Divisions IIa and IVa), Denmark (Divisions IVa,b and IIIa), and the Netherlands (Divisions IVa,b,c, VIa, and VIIb,d,e,f,j).

Weighted (by number) mean catch weight-at-age estimates were made by division by quarter and by division by year for catches from the Western and North Sea area (Table 3.6).

Mean weights at age (g) in the spawning stock at spawning time were estimated for 1988 by using samples from Dutch commercial freezer trawlers in Sub-area VII in March and April, but not in May as previously. These weights (in g) are shown in the text table below (1-year-olds are rarely taken in samples; therefore, a constant weight of 70 g was taken):

Age	1	2	3	4	5	6	7	8	9	10	11	12+
1988	70	146	233	302	327	434	455	436	460	528	606	634
1987	70	139	233	268	363	371	392	402	459	483	442	538

These mean weights in 1988 are higher than those in 1987 probably due to the absence of mean weights at age from the spawning area in May, which previously were combined with the mean weights at age in March and April, since the mean weights at age decrease as the spawning season progresses (Eltink, 1987).

3.4.2 Maturity at age

In 1988, the Working Group recognized the need for a more accurate estimation of the maturity at age because strong incoming year classes have a greater influence on the size of the spawning stock biomass now that the stock is declining (Anon., 1988b). With the exception of the 1986 data (1984 year class), maturity/age ogives have been estimated from the number of immature and mature fish from both the juvenile and spawning areas (Lockwood et al., 1981; Anon., 1985b). There are two disadvantages of estimating maturity in this way:

1) The samples were not weighted by the relative abundance of the immature fish of a particular age group in the juvenile area and the mature fish of that group in the spawning area. Using unweighted samples could cause severe bias.

2) Massive degeneration of vitellogenic oocytes has been observed in first-time spawning females, mainly 2-year-olds (Coello et al., working document; Greer-Walker et al., 1987). Maturity ogives calculated previously have been based on macroscopic examination of the gonad. Therefore, these abortive females may have been classified as mature, when in fact they would not have contributed to spawning during that season. This suggests that previous maturity ogives may have overestimated the proportion mature of first-time spawners.

A method of estimating the percentage of spawning fish by age group based on L_1 measurements (Eltink, 1988), independent of weighting has also been considered (Anon., 1988a; Anon., 1988b). Preliminary results suggest this method to be promising. Although the Working Group in 1988 recommended further work on this technique to check the validity of the method, additional information is not yet available. Provisional results indicated that about 35% of the 1981 year class was actually spawning at age 2.

Biological information from samples taken during the 1986 Western mackerel egg survey also indicated the number of spawning fish at age 2 (1984 year class) to be less than 60%, and 20% mature fish of the 1984 year class at age 2 was accepted. This was based on a much lower number of 2-year-olds in the spawning areas than expected and on a slower growth compared to the preceding 1985 year class at age 2 (Anon., 1987b; Anon., 1988b).

An attempt to quantify the percentage of females showing abortive maturation during the 1987 spawning season (1985 year class) using histological procedures was presented to the Working Group (Coello et al., 1989 working document). The true proportion mature was estimated by weighting the proportion of 2- and 3-year-olds on the spawning ground to the proportion of mature fish on the spawning ground using the mature fish curve calculated from the 1986 Western mackerel egg surveys (Anon., 1987b). Abortive maturation was not found to occur in fish older than age 3. The true proportion of mature females for the 2- and 3-year-olds was found to be 51% and 90%, respectively. This indicated that 42% of the 2-year-old females show abortive maturation, but it is only evident in 10% of the 3-year-olds. While the true proportion of age 2 females is slightly lower than that used in the maturity ogive for the assessment (60%), it should be pointed out that the maturity ogive used in the assessment includes males and females. Also, the proportions calculated by Coello et al. (working document) assume that all 2- and 3-year-old fish migrate to the spawning area. For these reasons, the Working Group decided to continue using 60% for age 2 fish in this year's assessment. The true proportion mature of 3-year-olds was found to be exactly the same as the proportion presently used by the Working Group (90%).

Because the 1987 year class appears to be strong, the Working Group recommends that all available biological information on the proportion mature first-time spawners should be collected, as available data suggest that this proportion is likely to be more critical for good year classes.

3.4.3 Fishing mortality and tuning of the VPA

The VPA was tuned to the estimates of spawning stock biomass from the egg surveys in 1977, 1980, 1983, and 1986 using the same method as described by the 1988 Working Group (Anon., 1988a). The method converts the egg survey estimates of spawning stock biomass at spawning time to estimates at 1 January for comparison with the VPA estimates. The fishing mortalities in the VPA are then adjusted to minimize the sum of squared residuals between the VPA and egg survey estimates of spawning stock biomass.

The 1988 Working Group decided that future assessments should use catch-at-age data extended to include a 15+ group. This was done for the 1989 assessment, and the exploitation pattern was examined using separable VPA (SVPA). With an arbitrarily chosen terminal fishing mortality of 0.3 and a reference age of 4, the selection patterns for different values of terminal S are shown in Figure 3.1.

In previous assessments, a flat exploitation pattern was assumed for fully-recruited age groups, and it is difficult to account for the apparent trend in the selection pattern using the newly disaggregated age groups 11-14. Moreover, it was found that the fishing mortality derived by tuning the VPA to the egg surveys was critically dependent on the terminal S chosen, since the choice of F on the oldest age groups strongly influenced the VPA values in the years corresponding to those of the egg surveys.

The oldest age groups are not well represented in the catches, and it is possible that the corresponding catch-in-number data are unreliable, because they are sensitive to the numbers of otoliths read (Armstrong and Ilardia, 1986). Also, at the Age Determination Workshop held in Lowestoft in June 1987, it was found that the older ages were underrepresented in the age determinations by some participants. Agreement in the age determination of these older ages improved to acceptable levels only subsequent to this workshop, so that extending the catch-in-number data for years prior to this might not be justified. The Working Group considered that it was preferable to extend the numbers-at-age data by just one age group each year, and for this year's assessment, the oldest true age group was, therefore, taken to be 11, with the catches of older fish combined into a 12+ group. The SVPA was rerun and, using a reference age of 4 with a terminal S of 1.2, a reasonably flat exploitation pattern was obtained on ages 5-11 (Table 3.7).

The output of the VPA

The fishing mortalities derived from the SVPA based on the terminal populations were used to generate VPA estimates of spawning stock biomass at a range of terminal F values. The residuals of the VPA and egg survey estimates are shown in Figure 3.2. Due to equipment problems during the 1980 egg survey, the reliability of this estimate of spawning stock biomass is questionable (Anon., 1984). If this survey is excluded from the tuning procedure, a much more well defined minimum is obtained (Figure 3.2). Excluding the 1977 egg survey and tuning to the latest two egg surveys does not significantly affect the behaviour of the residuals.

Figure 3.2 indicates a minimum at a terminal F of 0.275. A separable VPA with this value of terminal F was used to derive input fishing mortalities for the final VPA. The results are shown in Tables 3.8 - 3.10. Basing the fishing mortalities on the terminal populations has increased the unweighted mean F from 0.250 in 1987 to 0.337 in 1988. Mean F over the same range of ages weighted by population size also shows an increase but this is much less marked due to the relatively low fishing mortalities on the strong 1981 and 1984 year classes.

The spawning stock biomass estimate of 1,713,000 t in 1988 is based on the weights at age in the stock data given in Section 3.4.1, where their reliability is discussed.

3.4.4 Forecast for the Western stock

In recent years, recruitment has been extremely variable, with a tendency for values to be either very high or very low. Recruitment of intermediate strength was last observed in 1978. Since the spawning size in 1978 was around 3 million t and the present stock size is nearer to 1.5 million t, only data from 1979 onwards were used for the prediction of recruitment. Three levels of year-class strength were defined. Predicted recruitment of strong and weak year classes was taken to be the geometric mean of recent strong year classes (1979, 1980, 1981, and 1984) and recent weak year classes (1982, 1983, 1985, and 1986), respectively. An intermediate value was also defined, even though no recent recruitment of intermediate strength has been observed. Recruitment values corresponding to these definitions are shown below (in millions).

Level	0-group	1-group
Strong	6,100	5,245
Intermediate	3,600	3,100
Weak	1,200	1,000

The recruit survey indices were used to indicate the strength of the recruiting year class and hence the appropriate level of recruitment for the forecast (Section 2.4).

The stock and catch predictions were based on the following assumptions and parameters summarized in Table 3.11:

a) The stock size in number at age on 1 January 1989 was taken from the VPA (Table 3.10), with the exception of the 1987 and 1988 year classes. On the basis of recruit survey data, the size of the 1987 year class was assumed to be 5,245 million as 1-group in 1988. After applying the fishing mortality from the VPA, this corresponds to 4,350 million fish in 1989.

b) The available recruit index data indicate that the 1988 year class is strong. The number of 1-group in 1989 was, therefore, assumed to be 5,245 million. However, the recruit survey index must be considered unreliable until the supplementary data are available from the first quarter of 1989. The prediction was, therefore, also made assuming the 1988 year class to be of intermediate strength, that is, 3,100 million fish as 1-group in 1989.

c) The strengths of the 1989, 1990, and 1991 year classes were assumed to be intermediate, or 3,600 million fish at age 0.

d) The fishing pattern in 1989 was assumed to be that estimated by the separable VPA (Table 3.7), but scaled to the 1988 mean level.

e) The maturity ogive was assumed to be the same used for all years except 1986, when 20% maturity was assumed for the 1984 year class.

f) Based on the agreed TACs for 1989 of about 495,000 t and a USSR fishery in the same order as in 1988, the catch in 1989 was assumed to be 600,000 t.

Agreed TACs for 1989

Vb, VI, VII, VIII (except VIIIc), XII, XIV	EEC	324,750	
	Norway	19,200	
	Faroes	19,200	363,150
IVa north of 59^{0}N	EEC	10,500	
	Norway	28,500	
	Sweden	700	39,700
IIa	Norway	78,600	
	EEC	13,100	91,700
Sum			494,550

g) Mean weights at age in the stock were taken to be the average for the years 1986-1988.

The predictions for stock and catch in 1990 and 1991 were calculated for F_{med} (Figure 3.3), $F_{0.1}$, $F_{90} = F_{88}$, and F_{high}. The results are given in Tables 3.12 - 3.15. Short-term yield and spawning stock biomass in relation to F are also given in Figure 3.4.

The results indicate that, given strong 1987 and 1988 year classes, the spawning stock will increase in 1990 and 1991 even at F_{high}. If an intermediate 1988 year-class strength is assumed, spawning stock biomass stabilizes in 1990 and 1991 at an average of around 1.750 million t if present levels of fishing mortality are maintained (Table 3.13). It is important to note, however, that the fishery is becoming increasingly dependent on the younger age groups and that the prediction is, therefore, highly dependent on the accurate estimation of the strength of recruiting year classes. Attention is also drawn to the highly variable recruitment in recent years and the absence of year classes of intermediate strength.

3.4.5 Egg surveys in 1989

A Western mackerel egg survey will be carried out in 1989. The participating countries in this survey will be the Federal Republic of Germany, Scotland, Ireland, England, France, and the Netherlands. The total egg production over the spawning period will be estimated by five coverages of the spawning area in succession in order to convert this total egg production into spawning stock biomass by using the "total" fecundity (traditional method). At the peak of spawning, stock biomass will also be estimated by the "batch" fecundity method. This method will use the daily egg production from the third survey period. Preliminary results of the "total" fecundity method will be available at the ACFM meeting in November 1989. ACFM will be informed about the progress of the "batch" fecundity method.

In addition, an egg survey in the eastern Bay of Biscay will be carried out in 1989 as in 1987 (Santiago et al., 1988) and 1988 by the Basque Country (Spain) with at least two coverages, one in May and one in June. Although the anchovy will be the target species, egg distributions of other commercially important species (mackerel, horse mackerel, and sardine) will be obtained.

3.5 Management Considerations

At its November 1988 meeting, ACFM, to protect the North Sea stock, recommended that catches from the North Sea stock should be kept at the lowest practicable level and that the fishery in Division IVa should take place as far north and west as possible. A TAC of 430,000 t was recommended for the Western stock. With the exception of closing the fishery in the Cornwall box, no additional management advice was given for the Western stock.

The TAC of 430,000 t set by ACFM should apply to all areas in which Western mackerel are caught, i.e., including Divisions IIa, Vb, and VIIIa,b, Sub-areas VI and VII all year, and Division IVa from 1 August - 31 December. On this basis, the recommended total catch from both stocks taken in all areas was about 430,000 t, while the actual catch in 1988 amounted to 626,000 t.

The TACs for 1988 agreed by the EEC, the EEC and Norway, the EEC and Faroes, and Norway and the Faroes totalled about 573,000 t, which is 33% above the recommended level.

As in previous years, it is expected that the actual catches in 1989 will exceed the recommended TAC. The agreed TAC for 1989 for all areas is about 500,000 t, and the Working Group estimated the total catch in 1989 to be in the order of 600,000 t.

As there are no signs of improved recruitment to the North Sea stock, the Working Group assumed that the spawning stock is likely to remain low in 1989 and 1990. The Working Group agreed that a management system is needed which at the same time gives maximum protection to the North Sea stock and ensures an optimum exploitation of the Western stock.

The North Sea stock mixes with the Western stock at all times except during the spawning season. The ratios of mixing by time and area cannot be determined with certainty; however, it is still believed that the North Sea fish are found mainly in Divisions IIa, IVa,b,c, and IIIa. Closing the fishery in these areas at all times of the year will give maximum protection to the North Sea stock, but will, at the same time, have a very large impact on the fishery on the Western stock, as more than 50% of the catches are taken in the northern divisions.

The Western stock is mainly distributed in the Western area during the first half of the year and closing the fishery in the North Sea areas will have little effect on the exploitation of the Western stock. In the third and fourth quarters, the two stocks mix in the North Sea. The adult fish are dominating in the northern areas, with a tendency to increase in mean size when going from west to east. The juvenile mackerel are found in high concentrations in the Skagerrak and the central and southern North Sea. As mentioned in Section 3.3.2, the mortality of the North Sea stock is likely to be very low, indicating that only a small proportion of the catches taken in the North Sea are fish of North Sea origin.

In addition to the high concentrations of juvenile mackerel in Divisions IVb,c and IIIa in the second half of the year, juveniles are in general found in large quantities in the southern areas (Division VIa south and Sub-area VII), and a shift in the fishery from these areas to the northeastern areas will give a more optimal exploitation of the Western stock.

The Working Group recommends that fishing for mackerel should be prohibited in Divisions IIIa, IVb, and IVc at any time of the year and in Division IVa from 1 January - 31 July.

The Working Group does not find it possible to set separate area TACs within the total TAC. It is, however, recommended that the fishery should be concentrated in the northern areas (Divisions VIa north, IVa, and IIa) and kept at a low level in the southern areas (Division VIa south and Sub-area VII). The advice to keep the fishery in the Western area, as given previously, might be in conflict with the protection of juveniles, as observed in 1988. The TAC recommended for the Western mackerel stock should cover all parts of the total distribution, and catches taken by all nations should be counted against the TAC.

3.5.1 Minimum size regulation

The Working Group has again been asked by ACFM to study in detail the practicality of a 30-cm minimum landing size for mackerel. A 30-cm minimum size limit is at present in operation in the North Sea and Division IIa, and ACFM, at its May 1988 meeting, reiterated its recommendation that this minimum size limit should be extended to all areas.

In order to study the landings of fish less than 30 cm, the length distributions per quarter per fleet for as many areas as possible were examined. These length distributions, together with details of the catches, are available in the Working Group file. The percentage numbers of fish less than 30 cm were calculated for as many areas and fleets as possible, and the weighted averages of these percentages are shown in Figures 3.5 - 3.8. The Working Group also had available the length distributions of the Scottish fleets in relation to a proposed 30-cm minimum landing size (Hopkins, working document).

The practicality of adopting a 30-cm minimum landing size throughout all areas was discussed in detail. It was felt that:

1) An examination of the F values of 0- and 1-year-old fish from the most recent VPA (Table 3.9) indicates that, in the most recent years, the exploitation of juvenile fish has been extremely low, even when strong year classes entered the fishery, and would not suggest any need for a minimum landing size.

2) Apart from the "box" off Cornwall, young fish were also found during 1988 in other areas throughout Divisions VIa south, VIIb, VIIj, and IVb. While this was the pattern in 1988, the Working Group felt it would be unwise to draw conclusions about the distribution of young mackerel below 30 cm based on the length distributions of only one year. This is particularly true because of the continual changes in the distributions of these fish.

3) In general, the percentages of small mackerel are highest in the southern areas. However, even within these areas, there are extreme variations between the amounts of small mackerel landed by different fleets. Very high levels of small mackerel are taken by some fleets, but the landings, when viewed in the context of the total landings of the Western stock, are insignificant.

4) In the northern areas (Sub-areas II and VI), the percentage of small mackerel landed in 1988 was very small. However, the Working Group was aware that, when the strong 1984 year class recruited in 1985, it did not appear in quantity in the landings in the first two quarters in 1985. In the last two quarters, however, considerable quantities were taken particularly by the fleets fishing in the southern part of these areas.

The Working Group drew attention to the inconsistency of enforcing a 30-cm minimum landing size in the North Sea and not in the Western area when the bulk of the catches was taken in Division IVa. The Working Group, therefore, discussed the implications of either enforcing or removing the 30-cm minimum landing size regulation in both areas.

As discussed above, a 30-cm minimum landing size in the Western area does not seem necessary on biological grounds. Part of this argument is based on the low fishing mortality on juveniles. However, it was the view of the Working Group that the fleets were able to avoid areas of juvenile abundance in the North Sea area, and removal of the minimum landing size regulation could lead to higher juvenile fishing mortalities. In the Norwegian fishery, discarding is illegal, so that catches of small fish are slipped and the fleet moves elsewhere.

The introduction of a 30-cm minimum landing size in the Western area could lead to higher discard rates when a large year class enters the fishery. For example, catches of juveniles of the 1984 year class in the winter of 1985-1986 were high. Moreover, evidence was presented which showed that the percentage of juveniles in the catches during this fishery varied from 0% to over 90% even within a very small area (Hopkins, working document). This suggests that juvenile areas cannot be avoided and that the effect of a minimum landing size regulation would be to increase the incidence of slippage or discards. Available information from this area indicates a rather high mortality in slipped fish (Lockwood et al., 1983). The 1987 year class also appears to be strong, and the percentage of juveniles in the catches may increase in the first quarter of 1989.

Conclusions

The 30-cm minimum size limit was originally introduced in the North Sea by Norway in 1971 and was intended to protect the very strong 1969 year class from exploitation in the industrial fishery. It does not seem necessary to extend this measure to the Western area. The introduction of a 30-cm minimum size in the area in order to make it consistent with similar measures in the North Sea may result in an increase in the quantities of juvenile mackerel which will be slipped or discarded. This would lead to an increase in the exploitation rate on juveniles and a deterioration in the age composition of the stock which is already becoming heavily dependent on incoming year classes. However, it is extremely important that the situation be kept constantly under review because of the changing state of the fisheries and of the delicate nature of the age composition of the stock.

3.5.2 The mackerel box

ACFM has requested that data should be given in as fine a breakdown as possible to provide a basis for evaluating the need to modify the boundaries of the mackerel box. The percentage of juveniles by age group (Figures 2.6-2.11), the percentage less than 30 cm (Figures 3.5-3.9), the main fishing areas (Figures 2.1A-D), and the distribution of first-winter and second-winter mackerel from research vessel data are presented (see Section 2).

A small fishery took place around the box in the first and fourth quarters of 1988 in which there was a high proportion of juveniles in the catches. The Working Group, therefore, recommends that it should continue to be enforced within its present boundaries which were extended to 2^0W after 1 January 1989.

4 MACKEREL IN DIVISIONS VIIIc AND IXA

4.1 Review of Data on Stock Identity

There was little information on stock identity in this area. However, information was compiled for discussion in order to arrive at a general conclusion. One set of data showed monthly landings of trawlers from different harbours along the coast from south Portugal to east of the Cantabrian Sea (Table 4.1 and Figure 4.1). Using the length composition by quarter in different areas, the proportion of juveniles (less than 26 cm long) was calculated and is referred to in Figure 4.1 as the shaded portion of the bars. It clearly shows a very different pattern of distribution of the two components of the stock, with juveniles being predominant in Division IXa and adults in Division VIIIc. Further examination shows that the proportion of adults in Division IXa seems to shift to the north from Portimao to Ribeira. In Division VIIIc, the fishery seems to move eastward from Gijon to Ondarróa in the spring, as one might expect if these fish belonged to the Western stock and are migrating along the continental shelf to spawn later in June southwest of Ireland.

Data on spawning grounds were examined, but the information was scarce and the egg surveys did not cover the entire spawning season or the whole area. Franco and Sola (1988) found two discrete areas of egg abundance, one at the eastern Cantabrian Sea and the other at the western part, north of La Coruña. The Working Group felt that a more precise study should be made, covering all the area and the production curve. On the other hand, Santiago et al. (1988) showed a shift to the north of the spawning grounds located in late May - early June in 1987 at the inner Bay of Biscay. This could confirm the migration suggested in the paragraph above, but data are still insufficient.

Some other biological issues were also examined. The mackerel become mature earlier in southern waters. In Portugal, the peak of spawning takes place in February-March, whereas in the Cantabrian Sea, peak spawning occurs in April-May (Cort et al., 1986; Lucio and Martin, working document), and southwest of Ireland in May-June. The length at 50% maturity was estimated to be 24 cm in both Portuguese and Cantabrian waters (Gordo and Martins, 1984; Cort et al., 1986). In Division IXa, 100% of the 24-cm fish are age 1; in Division VIIIc, 76% and 24% of the 24-cm fish are age 1 and 2, respectively. This suggests a different growth pattern in the two divisions. However, the differences in estimated growth parameters between Divisions IXa and VIIIc and the Western stock are very small.

Historical series of year-class strength could give an indication of a separate stock. Alvarez et al. (1986) indicate that the number of landing days for the seiners might give an effort index. Because the landings in Vigo (Division IXa) by this fleet were composed of 90% juveniles in the second half of the year, the catch per unit effort of this fleet was adopted as a recruit index. Similarly, the catch per unit effort of trawlers from Portugal, which account for 45% of the total catch, could also be used as an index of year-class strength (Figure 4.2). There is some correspondence between these series of data ($r = 0.55$ for $n = 9$), which could support the links which are suggested between the mackerel caught in the Spanish part of Division IXa and those in Portuguese waters.

The only information available on year-class strength in Division VIIIc was a catch curve in log numbers for 1988 which was compared to the catch curve from Portugal (Figure 4.3). There seems to be no correspondence at all between these series, but some similarity was found when comparing the catch curve for Division VIIIc and the CPUE in Vigo shown in Figure 4.3 ($r = 0.59$ for $n = 9$).

In addition, there is a coincidence between peaks in the catch curve of Division VIIIc and those of the series of recruitment estimates for the Western mackerel stock (good year classes in 1975, 1976, 1981, 1984, and 1987, and poor ones in 1974, 1977, 1983, and 1986).

The Working Group felt that there was still insuffficient information for defining unit stocks in this area, although it is likely that the mackerel in Division VIIIc, 85% of which are caught in the eastern part, belong to the Western mackerel stock. If this is the case, the catch data from this division will not greatly affect the assessment of this stock, because it accounts for less than 4% of the total catch (Table 3.3). In Division IXa, it was speculated whether or not the adults are actually present; they might be in other areas, or be very scarce.

Until sufficient information is available, the fishery in this area will be dealt with separately, and the Working Group recommends that the main research to be carried out in the near future should be L_1 studies, egg surveys covering the entire area and the spawning season, tagging (including biological tags), and development of a method to calculate year-class strength.

4.2 The Fishery in 1988

Landings by division and country are shown in Tables 4.2 and 4.3. In Division IXa, there was a 23% increase from 1987. Catches were estimated by the Working Group, but do not include those from the Gulf of Cadiz (southern IXa) which were not available. A fishery for mackerel occurs in this area, but the catches are taken from other adjacent areas (Mediterranean Sea, African waters) and are not allocated. They are, therefore, not included in the whole series, which are referred to in Table 4.3.

Landings in Division IXa were based on juveniles in 1988, as in previous years. Age 1 was predominant in the catches in the first two quarters, whereas age 0 was more abundant in the second and third quarters. These age groups contributed 94% in weight and 99% in numbers to the total catch. The landing figures from this area have remained stable (5,000-7,000 t) since 1975 and do not reflect the likely fluctuations which might occur in a fishery which depends completely on incoming year classes. The catches by different fleets are shown in Table 4.4.

In Division VIIIc, there was a 5% increase in landings compared to 1987. A working paper was presented (Martin and Lucio) which accurately described the activity of the Basque fleet in the mackerel fishery. This represented 75% of the total catch in Division VIIIc. Landings by this fleet were composed almost entirely of adults.

Purse seiners and handliners account for the majority of the catch (Table 4.5), and the main effort in relation to mackerel is restricted to March-June. Occasional catches are, however, made throughout the year. In autumn and winter, a Spanish mackerel fishery (Scomber japonicus) also occurs, in which the landings are about 1,000 t (927 t in 1988) (Martin and Lucio, working document).

Catches of juveniles (ages 0 and 1) constitute 12% in number and 2.8% in weight. This fishery took place mainly in the first quarter in the western part of Division VIIIc.

4.3 Length and Age Composition

Length distributions, age-length keys, and catch-at-age data are available from Portugal since 1981. Data from Spain are available since 1983, but they need some important revision since they have not been split by division before 1988. Age-length keys are available for Division VIIIc for 1982-1985, that from 1987 is preliminary (Martin and Lucio, working document), and there is none for 1986. The Portuguese keys were considered more reliable for Spanish landings in Division IXa, when reviewing the set of data.

Catch-at-age data from Portugal are shown in Table 4.6 for the period 1981-1988 (Anon., 1987c, updated). Table 4.7 shows the catch at age by Spain in 1988. Length distributions are referred to in Table 6.1.

4.4 Management Considerations

An assessment of the mackerel in this area could not be carried out because of deficiencies in the data. An effort should be made to construct a well disaggregated set of data on catch by length and age for each division separately. There are, however, no age-length keys for Division VIIIc in 1986, so some other approaches should be made, e.g., the inverse age-length key (Hoenig and Heisey, 1987; Kimura and Chikumi, 1987). A series of catches at age could then be obtained back to 1981 for Division IXa and since 1982 for Division VIIIc. The Working Group encourages the Spanish and Portuguese scientists to perform this task before its next meeting in 1990.

In spite of the lack of a reliable assessment, some management considerations were discussed. The fishing pattern in Division IXa is very unsatisfactory, and if management measurements are going to be taken, they 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 is taken by seiners, mesh sizes are not very relevant, so mininum landing sizes and effort limitations may be a better approach. However, the losses and gains derived from these measures could not be assessed at present.

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

Before an assessment can be carried out in this area, the question about stock identity must be solved. The Working Group, therefore, recommends that the Spanish and Portuguese scientists meet to consider this problem before the next meeting of this Working Group.

5 DATA REQUESTED BY THE MULTISPECIES WORKING GROUP

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

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

The catch from the North Sea stock was estimated based on the results from spawning stock estimates from egg surveys in 1986 and 1988. The average yearly total mortality for the 1983 year class and older was calculated to be 0.21 (M = 0.15 and F = 0.06) in a working document (Kirkegaard, 1989). Based on this, the catch in numbers was estimated.

Since the egg survey in 1988 indicated hardly any recruitment to the North Sea spawning stock in recent years, the catch in numbers from the 1984-1987 year classes was set at 0.5 and 0.4 million, respectively for 1987 and 1988. The catch from the 1984 year class of North Sea mackerel in 1986 was estimated at 28.5 million (Anon., 1987a), which is is about 7% of the estimated total catch in all areas from this year class. Since the 1984 year class did not recruit to the North Sea stock, the catch in numbers of this year class was reduced to 1 million individuals in 1986. This change is minor compared to the catch of the 1984 year class of Western mackerel this year. Therefore, the catch of Western fish was not adjusted.

The calculated catch in numbers was distributed by quarters according to the catches in Divisions IVb, IVc, and IIIa (Table 5.1).

It must be emphasized that these estimates are subjective and are, therefore, not a basis for an analytical assessment.

5.2 Mean 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 except for those obtained during the egg surveys (Iversen *et al.*, working document). A smoothed version of these data is given in Table 5.2. Since there are no data for the first, third, and fourth quarters, the Working Group's advice is to use the same weights at age as given for 1987 in last year's report (Anon., 1988a).

5.3 Stock Distribution by Quarter

Due to the small stock size of the North Sea stock and the fact that about 50% of the mackerel catches in 1988 were fished in the North Sea and Skagerrak, large proportions of the Western stock were distributed in this area, particularly in the third and fourth quarters. Age 1-2 fish were also observed in relatively large quantities in the Norwegian tagging experiment in August and in an acoustic survey in July (Kirkegaard, working document). Therefore, the Working Group concluded that the indication of the percentage of each stock that was in the North Sea during each quarter in 1986 and 1987 (Anon., 1987a) seemed also to reflect the distribution in 1988 (Table 5.3).

The Multispecies Assessment Working Group (Anon., 1988d) points out that a similar table for all years back to 1974 would be extremely useful. Based on data from the Norwegian tagging experiments, a working document on this matter will be prepared for the forthcoming Multispecies Assessment Working Group meeting.

6 DATA REQUESTED BY ACFM

Acting on request from ACFM, the length distributions per year for each fleet (numbers of fish per cm length group) are shown in Table 6.1. These data were available for all the major fishing fleets and coverage of about 80% of the total landings was obtained. However, no data were available for the fleets of France and the Federal Republic of Germany, who together took nearly 20,000 t. The length distributions were also extracted per quarter per division, and these data are available in the Working Group file. The data for Spain are shown for different fleets working different areas.

7 DEFICIENCIES IN DATA

As has been the case in recent years, the Working Group discussed the information which was inadequate or lacking and which was necessary to improve the assessments. This is summarized below.

7.1 Catch Data

The 1988 Working Group considered that the quality of the catch data had improved in recent years. However, there is still some concern about the accuracy of the total catch recorded. It was noted that the amounts of mackerel misreported in 1988 from Division IVa to Division VIa had increased dramatically, considerable quantities of mackerel have again been reported as horse mackerel, and national catches may have been underreported so that quotas would not appear to have been exceeded. It must again be pointed out that the accuracy of the spawning stock estimate very much depends on the basic catch data. It is particularly important, therefore, because of the increasing dependence of the stock on good year classes, to ensure that the basic catch data are as accurate as possible.

7.2 Discards

As has been pointed out throughout the report, discarding of young mackerel may again become a problem because of the strong 1987 year class and the increasing proportion of young fish in the stock. It is important, therefore, that estimates of quantities discarded should be available.

7.3 Data on Maturity and Fecundity

Methods of determining accurate maturity ogives and better estimates on atresia are required. These are especially important for the estimation of spawning stock biomass from egg surveys.

7.4 Acoustic Surveys

There are still no estimates of stock size apart from the egg surveys which are only carried out every two and three years. As mentioned in the 1988 Working Group report, acoustic surveys should be encouraged in the overwintering area as an additional fishery-independent stock size estimate.

7.5 Stock Separation

No additional information was available about stock separation, and information is needed in this respect. At the moment, it is not clear whether there is in fact any distinction between the North Sea and Western stocks or whether the stocks have merged.

Additional information is required to investigate the relationship between the Western stock, the North Sea stock, and mackerel in Divisions VIIIc and IXa.

7.6 Divisions VIIIc and IXa

As discussed in Section 4, no assessment was possible for the stock in these divisions. The data required to enable an assessment to be carried out are discussed in Sections 4.1 and 4.3.

8 RECOMMENDATIONS

* The fishery is becoming increasingly dependent on younger age groups and the prediction is, therefore, highly dependent on the accurate estimation of the strength of recruiting year classes. It is strongly recommended that the Western area recruit surveys in the fourth quarter be continued. Participants should use a GOV trawl if possible, otherwise gear parameters should be measured so that catch rates can be standardized.

* Reliable estimates of recruitment are required for the assessment of the Western stock. These data do not become available until after mid-April. It is, therefore, recommended that future Working Groups be convened after mid-April.

* Investigations on maturity at age should be continued in order to obtain a reliable maturity ogive for good, average, and poor year classes. These should include further analysis of L_1 data and the proportions of abortive maturation in first-time spawners.

* The Working Group was not able to advise area TACs within the total TAC. However, the fishery should be concentrated in the northern areas (Divisions VIa north, IVc, and IIc) and kept at a low level in those areas where juvenile fish are consistantly found.

* Fishing for mackerel should be prohibited in Divisions IIIa, IVb, and IVc throughout the year and in Division IVa from 1 January - 31 July.

* The TAC recommended for the Western mackerel stock should apply to the whole of the area of distribution and not just the Western area. Catches taken by all countries should be counted against the TAC.

* The mackerel box should be continued with its present boundaries.

* Research should be done on stock identity from fish in Divisions VIIIc and IXa. This should include L_1 studies, egg surveys covering the entire area throughout the spawning season, tagging (including biological tags), and indices of year-class strength.

  Spanish and Portuguese scientists should meet to consider this problem before the next Mackerel Working Group meeting.

* Acoustic surveys should be carried out on the overwintering population of the Western stock. Such surveys will provide a method in addition to the egg production method of assessment which is independent of catch data.

9 WORKING DOCUMENTS

Coello, S., Dawson, W.A., and Grimm, W.S. Incidence of abortive maturation in the western stock of the North-East Atlantic mackerel during the 1987 spawning season. 10 pp.

Dawson, W.A. Mackerel recruit indices from 1988 research vessel data. 8 pp.

Hopkins, P. The length compositions of Scottish mackerel catches in relation to a proposed 30 cm minimum landing size. 8 pp.

Hopkins, P. Report of a survey to sample the Western mackerel spawning stock in 1988. 12 pp.

Iversen, S.A. Catches of Western and North Sea mackerel stocks during 1972-1987. 2 pp.

Iversen, S.A., Eltink, G., Kirkegaard, E., and Skagen, D.W. The egg production and spawning stock size of the North Sea mackerel and horse mackerel stocks in 1988. 23 pp.

Kirkegaard, E. The mortality of the North Sea mackerel. 2 pp.

Kirkegaard, E. Some results from a Danish acoustic survey in the North Sea, July-August 1988. 9 pp.

Lucio, P. and Martin, I. Biological studies on mackerel of the Bay of Biscay. Some preliminary results for 1987 and 1988. 17 pp.

Martin, I. and Lucio, P. Landings of mackerel and Spanish mackerel by the fleets of the Basque Country in 1987 and 1988. Length frequency and spatial distribution of the landings. 17 pp.

Skagen, D.W. Diversity in growth patterns in the North Sea and Western mackerel in Norwegian catches, 1960-1985. 20 pp.

Thompson, T. On the estimation of daily production of eggs by mackerel. 2 pp.

Walsh, M. The future of Western mackerel recruit surveys. 8 pp.

Walsh, M. Atresia in Western mackerel stock. 8 pp.

10 REFERENCES

Alvarez, F., Porteiro, C. and Cruces, X. 1986. Analysis de la pesquen'a de cerco Galicia. Inf. Tec. Inst. Esp. Oceanogr. (15) 1986.

Anon. 1984. Report of the Mackerel Working Group. ICES, Doc. C.M.1984/Assess:1.

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

Anon. 1985b. Report of the Mackerel Egg Production Workshop. ICES, Doc. C.M.1985/H:7.

Anon. 1986a. Report of the Mackerel Working Group. ICES, Doc. C.M.1986/Assess:12.

Anon. 1986b. Report of the Working Group on the Appraisal of Sardine Stocks in Divisions VIIIc and IXa. ICES, Doc. C.M. 1986/Assess:2.

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

Anon. 1987b. Report of the Egg Production Workshop, Lowestoft, 3-7 November 1986. ICES, Doc. C.M.1987/H:2.

Anon. 1987c. Report of the Working Group for the Assessment of Pelagic Stocks in Divisions VIIIc and IXa and Horse Mackerel. ICES, Doc. C.M.1987/Assess:23.

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

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

Anon. 1988c. 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. 1988d. Report of the Multispecies Assessment Working Group. ICES, Doc. C.M.1988/Assess:23.

Armstrong, D.W. and Ilardia, S. 1986. On bias in estimates of population parameters obtained by means of length-stratified sampling for age/length keys. ICES, Doc. C.M.1986/G:10.

Cort, J.L., Gonzalez, Ilardia, S. 1986. La pesqueria de caballa (o verdel), (Scomber scombrus, Linnaeus 1758) en el Mar Cantabrico, 1982-1983. Inf. Tec. Inst. Esp. Oceanogr. No.38.

Dawson, W.A. 1988. Mackerel recruitment estimates estimated from research vessel indices. (Working document for Mackerel Egg and Recruitment Workshop, Aberdeen, 1988).

Dawson, W.A., Walsh, M., Hopkins, P., Eltink, A. and Molloy, J. 1988. The distribution and abundance of juvenile mackerel (Scomber scombrus L.) west and south of the British Isles. ICES, Doc.C.M.1988/H:16.

Degnbol, P., Iversen, S.A., Kirkegaard E. and Lewy, P. 1988. Report on an Acoustic Survey in the North Sea, Skagerrak and Kattegat in July-August 1987. ICES, Doc. C.M.1988/H:40.

Eltink, A. 1987. Changes in age-size distribution and sex ratio during spawning and migration of Western mackerel (Scomber scombrus L.). J. Cons. int. Explor. Mer, 44:10-22.

Eltink, A. 1988. Estimation of percentage mackerel spawning by age group based on the L_1-measurements of otoliths from both the spawning and the juvenile area. (Working document for the Mackerel Egg and Recruitment Workshop, Aberdeen, 1988.)

Franco, C. and Sola, A. 1988. Contribution to the study of the ichthyoplankton of commercial species on the continental shelf off Spain. ICES, Doc. C.M.1988/H:74.

Gordo, L. and Martins, M.B. 1984. On some biological characteristics of mackerel (Scomber scombrus L.) from the west continental coast of Portugal. ICES, Doc. C.M.1984/H:49.

Greer-Walker, M., Whitthames, P., Enerson, L. and Walsh, M. 1987. Estimation of fecundity in the Western mackerel stock, 1986. ICES, Doc. C.M.1987/H:41.

Hoenig, J.M. and Heisey, D.M. 1987. Use of a log-linear model with the EM algorithm to correct estimates of stock composition and to convert length to age. Trans. Amer. Fish. Soc., 116:232-243.

Igelino, A., Legarra, J. and Lerga, S. 1988. Estudio de la problematica del by-catch y pescado descartado en las pesquerias vascas. Ondarroa, 1988 (mimeo).

Iversen, S.A., Westgård, T., Kirkegaard, E., Eltink, A., Hopkins, P. and Walsh, M. 1985. The egg production and spawning stock size of the North Sea mackerel stock in 1984. ICES, Doc. C.M.1985/H:38.

Iversen, S. A., Kirkegaard, E. and Westgård, T. 1987. Mackerel egg production and spawning stock size in the North Sea 1986. ICES, Doc. C.M.1987/H:8.

Kimura, D.K. and Chikumi, S. 1987. Mixtures of empirical distributions. An interactive application of the age length key. Biometrics (43):23-35.

Kirkegaard, E. 1986. Report on the acoustic survey for herring off the west coast of Denmark in July 1985. ICES, Doc. C.M. 1986/H:69.

Kirkegaard, E., Lewy, P., and Stæhr, K-J. 1987. The Danish acoustical survey in Division IIIa and eastern North Sea, August 1986. ICES, Doc. C.M.1987/H:42.

Lockwood, S.J., Nichols, J.H. and Dawson, W.A. 1981. The estimate for mackerel (Scomber scombrus L.) spawning stock size by plankton survey. Journ. Plankton Res., 3:217-233.

Lockwood, S.J., Pawson, M.G. and Eaton, D.R. 1983. The effects of crowding of mackerel (Scomber scombrus) - physical condition and mortality. Fish. Res., 2(1983)129-147.

Santiago, J., Artexte, I. and Zamakona, A. 1988. Distribution and abundance of mackerel, horse mackerel and pilchard eggs in the southern Bay of Biscay in 1987. ICES, Doc. C.M.1988/ H:10.

ODE TO THE MACKEREL WORKING GROUP

Now the Working Group is over,
For yet another year,
Assessment matches the prediction -
It must be all that beer.

It really is amazing
How we manage to get done
So many things to discuss
And lots of problems to overcome.

Cries Paulino "in area VIIIc
The catches aren't quite precise"
"Never mind" replies Pope John,
"We'll just have to count them twice".

From where have all the catches come?
Have the Faroes been included?
Have they been counted as Scad?
The true figures still elude us.

Working Group members too go missing
At ICES they don't remain -
I wonder who was responsible
For losing Wendy on the train.

But we always know, where is John?
Cause every time we hear a bark
We know another dog is trying
Upon John to leave a mark.

Catch in numbers table complete
Peter runs the VPA,
"Now what did we do last year -
Cause it was the wrong way!"

How to use exploitation pattern
Isn't really understood,
But now it matches the F value
"So far so good".

"What about these extra numbers
from 87?" remarks Eskild
"Shall we include them in this assessment?
Cause another form we'll have to fill?"

Complicated figures are given
To Dankert to calculate
He writes a computer program
So not so long we had to wait.

And just how many times
To the egg survey do we tune?
Laughs Guus "It'll be more fun next year

Temperature gets too low
And Manet develops a nasty cough,
We don't know what to do
Except recommend Carlsberg Hof!

Recruitment too can be a problem
Cause it doesn't stay the same
What index shall we put in?
for ACFM to change again.

On ACFM Armando sits
So in the Working Group uses his head
He's trying to remember
What this crazy group have said.

Finally, we should thank the Chairman
for a job so well he's done
And bid him a fond farewell
Will next year be as much fun?

Anon. 1989

Table 2.1 The estimated abundance ('000 t) of juvenile mackerel observed during accoustic surveys carried out in July-August in the eastern part of Division IVb and the Skagerrak.

	Eastern IVb				Skagerrak			Total		
Age	1985[1]	1986[2]	1987[3]	1988[4]	1986[2]	1987[3]	1988[5]	1986	1987	1988
1	273	550	450	589	75.2	13.0	96.8	625	463	685
2	-	350	392	593	23.2	20.4	14.8	373	412	608
3	-	14	52	92	2.9	6.8	0.1	17	58	92

[1] Kirkegaard (1986).
[2] Kirkegaard et al.(1987).
[3] Degnbol et al.(1988).
[4] Kirkegaard (Working document).
[5] Hagström (pers.com.).

Table 2.2 Research vessel survey abundance indices and VPA estimates.

	First-winter mackerel		Second-winter mackerel	
Years class	Arithmetic mean	Estimated no. 1-gr. (millions) from VPA	Arithmetic mean	Estimated no. 2-gr. (millions) from VPA
1980	-	-	50.1	3,817
1981	124.6	5,967	78.1	4,948
1982	6.1	1,013	45.5	832
1983	4.3	517	7.6	431
1984	149.2	5,594	210.0	4,598
1985	37.0	1,244	37.3	1,047
1986	89.1	1,521	28.4	1,288
1987	124.2	-	547.4[1]	-
1988	184.8[1]	-	-	-

[1] Provisional.

Table 2.3 Catches of mackerel ('000 t) by area and stock.

Year	SOP			Catch by stock given in Table 3.1, Anon.(1988a)			Total catch in all areas	Estimated catch by stock	
	Western	North Sea	Total	Western	North Sea	Total		Western	North Sea
1972	222	118	340	-	-	-	360	235	125
1973	319	211	530	-	-	-	360	342	226
1974	411	189	600	-	-	-	603	413	190
1975	862	182	1,044	-	-	-	789	651	138
1976	682	175	857	507	298	805	806	641	165
1977	381	189	570	326	241	567	567	379	188
1978	628	110	738	503	185	688	689	586	103
1979	767	68	835	606	210	816	807	741	66
1980	803	75	878	605	107	712	711	650	61
1981	700	63	763	662	66	728	728	668	60
1982	700	44	744	624	57	681	681	641	40
1983	678	50	728	614	43	657	657	614	43
1984	565	60	625	551	67	618	618	551	67
1985	556	36	592	561	35	596	561	561	35
1986	530	25	555	537	32	569	569	544	25
1987	615	3	618	615	13	628	628	625	3

Table 3.1 Nominal catch (t) of MACKEREL in the North Sea, Skagerrak, and Kattegat (Sub-area IV and Division IIIa), 1979-1988. (Data submitted by Working Group members.)

Country	1979	1980	1981	1982	1983
Belgium	10	5	55	102	93
Denmark	19,171	13,234	9,982	2,034	11,285
Faroe Islands	28,118	14,770	-	720	-
France	3,620	2,238	3,755	3,041	2,248
Germany, Fed. Rep.	211	56	59	28	10
Ireland	-	738	733	-	-
Netherlands	1,009	853	1,706	390	866
Norway	90,720	44,781	28,341	27,966	24,464
Sweden	3,935	1,666	2,446	692	1,903
UK (Engl.& Wales)	95	76	6,520	16	16
UK (Scotland)	5,272	9,514	10,575	44	4
UK (N. Ireland)	-	-	-	-	-
USSR	162	-	-	-	-
Unallocated + discards	500	-	3,216	450	96
Total	152,823	87,931	67,388	35,483	40,985

Country	1984	1985	1986	1987[1,2]	1988[1]
Belgium	68	-	49	14	20
Denmark	10,088	12,424	23,368	28,217	32,588
Faroe Islands	-	1,356	-	-	-
France	-	322	1,200	2,146	1,806
Germany, Fed. Rep.	112	217	1,853	474	177
Ireland	-	-	-	-	-
Netherlands	340	726	1,949	2,761	2,564
Norway	27,311	30,835	50,600	108,250	59,750
Sweden	1,440	760	1,300	3,162	1,003
UK (Engl.& Wales)	2	143	18	94	160
UK (Scotland)	13	7	541	19,286	616
UK (N. Ireland)	-	-	-	-	100
USSR	-	-	-	-	-
Unallocated + discards	202	3,656	7,431	10,789	29,766
Total	39,576	50,124	88,309	173,829	128,550

[1] Preliminary.
[2] May include catches taken in Division IIa.

Table 3.2 Nominal catches (t) of MACKEREL in the Norwegian Sea (Division IIa) and off the Faroes (Division Vb), 1979-1988.

Country	1979	1980	1981	1982	1983	1984	1985	1986	1987[3,4]	1988[3]
Denmark[1]	-	-	801	1,008	10,427	11,787	7,610	1,653	3,133	4,265
Faroe Islands[1]	6	270	-	180	-	138	-	-	-	22
France[2]	-	-	6	8	-	-	16	-	-	-
Germany, Fed. Rep.[2]	-	-	51	-	5	-	-	99	-	380
German Dem. Rep.[2]	174	2	-	-	-	-	-	16	292	-
Norway[1]	6,887	6,618	12,941	34,540	38,453	82,005	61,065	85,400	25,000	86,400
Poland[2]	-	-	-	231	-	-	-	-	-	-
UK (Engl. & Wales)[1]	-	-	255	-	-	-	-	-	-	-
UK (Scotland)[2]	-	296	968	-	-	-	-	2,131	157	1,413
USSR[2]	5	1,450	3,640	1,641	65	4,292	9,405	11,813	18,604	27,924
Total	7,072	8,340	18,662	37,608	48,950	98,222	78,096	101,112	47,186	120,404

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

Table 3.3 Quarterly catches of mackerel by division or sub-area in 1988.

Division/ Sub-area	Quarter 1	2	3	4	Total
IIa + Vb	600	400	112,700	2,500	116,200
IVa	8,700[1]	200	66,800[2]	219,400[3]	295,100
IVb	-	100	5,400	900	6,400
IVc	-	600	1,400	1,400	3,400
IIIa	-	300	5,900	600	6,800
VI	98,800	6,100	2,500	12,500	119,900
VII	48,100	15,000	3,500	10,100	76,700
VIIIa,b	1,200	300	+	+	1,500
Sub-total	157,400	23,000	198,200	247,400	626,000
VIIIc	7,700	8,700	200	200	16,800
IXa	1,600	1,400	3,100	1,200	7,300
Sub-total	9,300	10,100	3,300	1,400	24,100
Grand total	166,700	33,100	201,500	248,800	650,100

[1]Estimated catch misreported to Division VIa.
[2]Includes estimated catches of 3,200 t and 1,000 t caught in Division IVa, but misreported to Divisions VIa and Vb, respectively.
[3]Includes estimated catches of 167,200 t and 3,300 t caught in Division IVa, but reported to Divisions VIa and Vb, respectively.

Table 3.4 Nominal catch (tonnes) of MACKEREL in the Western area (Sub-areas VI and VII and Divisions VIIIa,b). (Data estimated by Working Group.)

Country	1979	1980	1981	1982	1983
Belgium	3	3	-	-	+
Denmark	8,535	14,932	13,464	15,000	15,000
Faroe Islands	10,609	15,234	9,070	11,100	14,900
France	31,510	23,907	14,829	12,300	11,000
Germany, Fed.Rep.	21,493	21,088	29,221	11,200	23,000
Ireland	24,217	40,791	92,271	109,700	110,000
Netherlands	62,396	91,081	88,117	67,200	73,600
Norway	25,414	25,500	21,610	19,000	19,900
Poland	92	-	1	-	-
Spain	543	3,684	1,365	-	-
UK (England + Wales)	244,293	150,598	75,722	82,900	62,000
UK (N. Ireland)	25	-	4,153	9,600	800
UK (Scotland)	103,160	108,372	109,153	147,400	120,100
USSR	-	-	-	-	+
Unallocated	54,000	98,258	140,322	97,300	105,500
Discard	60,600	21,600	42,300	24,900	11,300
Grand total	646,890	615,048	641,598	607,700	567,100

Country	1984	1985	1986	1987	1988[1,2]
Belgium	+	-	+	-	-
Denmark	200	400	300	100	-
Faroe Islands	9,200	9,900	1,400	7,100	2,600
France	12,500	7,400	11,200	11,100	8,900
Germany, Fed.Rep.	11,200	11,800	7,700	13,300	15,900
Ireland	84,100	91,400	74,500	89,500	85,800
Netherlands	99,000	37,000	58,900	31,700	26,100
Norway	34,700	24,300	21,000	21,600	17,300
Poland	-	-	-	-	-
Spain	100	+	-	-	1,500
UK (Engl. + Wales)	30,000	9,600	9,100	25,200	24,100
UK (N. Ireland)	10,600	12,200	9,700	10,700	8,900
UK (Scotland)	157,700	184,100	137,500	164,800	175,400
USSR	200	+	-	-	+
Unallocated	18,000	75,100	51,000	25,800	4,700
Discard	12,100	4,500	-	-	5,800
Grand total	479,600	467,700	380,500	401,700	377,000

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

Table 3.5 Actual catches of mackerel by sub-areas. Discards not estimated prior to 1978.

	Sub-area VI			Sub-area VII and Divisions VIIIa,b			Sub-area IV and Division IIIa		
Year	Land-ings	Discards	Catch	Land-ings	Discards	Catch	Land-ings	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

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 3.6 Catch in numbers ('000) and mean weight (g) by quarter, division, and age in 1988.

First quarter

Age	IIa,IVa,Vb c	IIa,IVa,Vb $\bar{W}$	IIIa c	IIIa $\bar{W}$	IVb,c c	IVb,c $\bar{W}$	VIa,b c	VIa,b $\bar{W}$	VIIa,d-h c	VIIa,d-h $\bar{W}$	VIIb,c,j,k c	VIIb,c,j,k $\bar{W}$	VIII c	VIII $\bar{W}$	Total c	Total $\bar{W}$
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	6	95	-	-	-	-	5,080	46	31	71	880	46	18	47	6,015	46
2	541	231	-	-	-	-	3,745	204	17,845	134	1,233	170	386	136	23,761	149
3	3,706	285	-	-	-	-	28,814	269	16,722	198	8,048	245	501	213	57,791	246
4	9,677	353	-	-	-	-	96,939	327	16,156	257	48,127	304	1,301	292	184,200	315
5	1,116	426	-	-	-	-	9,473	398	786	357	4,023	363	97	362	15,493	389
6	1,628	479	-	-	-	-	13,509	461	1,516	318	4,367	416	119	391	21,139	443
7	2,412	503	-	-	-	-	43,416	504	1,300	359	15,423	457	338	449	62,889	489
8	1,835	516	-	-	-	-	19,269	510	1,692	300	9,141	456	219	432	32,516	484
9	832	520	-	-	-	-	9,061	486	712	245	4,303	465	101	434	15,009	470
10	212	647	-	-	-	-	3,054	575	245	291	1,874	539	43	510	5,428	552
11	256	607	-	-	-	-	3,095	668	310	283	1,560	667	37	523	5,177	644
12	175	648	-	-	-	-	3,095	668	310	283	1,560	667	38	603	5,178	644
13	237	696	-	-	-	-	2,315	702	132	300	1,155	599	26	568	3,865	657
14	191	676	-	-	-	-	1,942	681	-	-	971	616	20	616	3,124	660
15+	256	725	-	-	-	-	4,730	744	-	-	2,795	710	57	710	8,291	731
Total	23,081	405	-	-	-	-	247,790	399	57,823	200	105,356	365	3,302	307	437,352	364
Tonnes	9,337		-		-		98,799		11,575		38,473		1,013		159,197	

Second quarter

Age	IIa,IVa,Vb c	IIa,IVa,Vb $\bar{W}$	IIIa c	IIIa $\bar{W}$	IVb,c c	IVb,c $\bar{W}$	VIa,b c	VIa,b $\bar{W}$	VIIa,d-h c	VIIa,d-h $\bar{W}$	VIIb,c,j,k c	VIIb,c,j,k $\bar{W}$	VIII c	VIII $\bar{W}$	Total c	Total $\bar{W}$
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	1,873	77	26	124	41	126	1	125	1,941	79
2	-	-	-	-	13	202	1,087	198	58	183	541	169	12	170	1,711	187
3	3	365	4	365	259	229	1,272	246	8	220	1,743	231	35	231	3,324	234
4	16	428	14	426	568	292	5,975	305	5	249	17,941	292	363	292	24,882	291
5	3	530	21	524	466	314	793	317	2	344	2,019	307	41	307	3,372	310
6	56	556	38	527	54	446	821	424	-	316	1,390	367	28	367	2,387	391
7	96	535	70	526	370	426	1,715	466	-	306	3,983	426	81	426	6,315	434
8	149	543	117	549	254	472	2,375	476	2	301	4,397	404	89	404	7,383	430
9	49	576	32	538	-	-	693	442	2	262	2,708	442	55	442	3,539	438
10	49	584	27	573	131	526	257	467	-	258	923	502	19	502	1,406	495
11	37	677	27	683	15	593	19	436	-	-	197	552	4	552	299	567
12	92	645	46	656	-	-	440	616	-	-	537	572	11	572	1,126	593
13	40	730	13	708	-	-	60	542	-	-	309	527	6	529	428	546
14	19	702	8	699	-	-	356	682	2	413	564	577	11	576	960	612
15+	251	733	105	730	28	669	235	639	-	-	1,432	615	29	615	2,080	630
Total	886	628	522	602	2,159	355	17,971	337	105	181	38,726	352	786	351	61,153	354
Tonnes	556		314		767		6,057		19		13,641		276		21,630	

(cont'd)

Table 3.6 (cont'd)

Third quarter

Age	IIa,IVa,Vb c	IIa,IVa,Vb $\bar{W}$	IIIa c	IIIa $\bar{W}$	IVb,c c	IVb,c $\bar{W}$	VIa,b c	VIa,b $\bar{W}$	VIIa,d-h c	VIIa,d-h $\bar{W}$	VIIb,c,j,k c	VIIb,c,j,k $\bar{W}$	VIII c	VIII $\bar{W}$	Total c	Total $\bar{W}$
0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	7	185	24,215	153	14,962	149	1,347	87	1,159	124	373	181	31	138	42,094	149
2	17,166	305	758	234	8,879	249	634	206	2,514	183	390	238	59	190	30,400	274
3	22,508	402	268	327	1,670	297	804	251	359	220	276	270	13	242	25,898	386
4	80,639	473	468	428	1,240	325	1,642	334	222	249	168	324	8	281	84,387	467
5	10,744	563	252	534	712	374	518	313	95	344	24	326	2	340	12,347	539
6	15,068	641	331	547	604	404	296	402	15	316	26	296	1	303	16,341	625
7	32,312	660	760	580	1,010	404	504	514	16	306	11	326	1	314	34,614	648
8	20,993	653	350	586	439	427	572	480	104	301	17	378	2	312	22,477	641
9	8,093	670	137	568	172	479	580	410	93	262	-	-	2	262	9,077	644
10	1,621	679	97	627	154	555	187	501	2	358	-	-	-	-	2,061	651
11	1,136	856	97	651	17	532	30	755	-	-	-	-	-	-	1,280	834
12	390	862	195	710	152	492	169	496	-	-	-	-	-	-	906	699
13	163	955	137	674	120	520	151	526	-	-	-	-	-	-	571	683
14	163	955	97	705	27	778	65	633	86	413	-	-	2	413	440	735
15+	1,334	873	368	747	98	675	180	670	1	458	-	-	-	-	1,981	825
Total	212,337	531	28,530	207	30,257	226	7,679	330	4,666	181	1,284	245	120	192	284,873	453
Tonnes	112,668		5,907		6,833		2,532		846		314		23		129,123	

Fourth quarter

Age	IIa,IVa,Vb c	IIa,IVa,Vb $\bar{W}$	IIIa c	IIIa $\bar{W}$	IVb,c c	IVb,c $\bar{W}$	VIa,b c	VIa,b $\bar{W}$	VIIa,d-h c	VIIa,d-h $\bar{W}$	VIIb,c,j,k c	VIIb,c,j,k $\bar{W}$	VIII c	VIII $\bar{W}$	Total c	Total $\bar{W}$
0	-	-	-	-	-	-	-	-	287	71	-	-	6	71	293	71
1	21,274	200	2,000	153	3,284	166	1,569	198	15,753	140	5,982	171	440	149	50,302	173
2	18,222	301	66	239	4,209	231	3,084	230	7,266	225	5,178	234	252	229	68,277	280
3	62,987	361	28	341	1,440	244	3,734	358	3,907	283	3,673	266	153	275	75,922	350
4	172,882	412	59	428	1,133	314	9,902	407	3,940	314	2,360	313	127	314	190,403	408
5	28,982	455	32	534	108	403	1,681	453	220	428	227	324	9	375	31,259	454
6	30,259	549	41	547	106	324	1,476	522	404	445	169	294	12	401	32,467	544
7	51,732	581	95	580	11	367	2,943	571	481	375	197	357	14	370	55,473	578
8	37,458	559	43	586	7	423	2,056	548	313	428	161	363	10	406	40,048	557
9	16,940	593	17	568	6	440	932	580	222	515	3	500	5	515	18,125	591
10	6,638	656	11	627	2	396	356	651	49	479	-	-	1	479	7,057	654
11	3,763	681	11	651		-	217	676	20	569	-	-	-	-	4,011	680
12	5,535	72	24	710	4	672	243	717	17	570	-	-	-	-	5,823	720
13	3,222	755	17	674	2	698	195	740	2	657	-	-	-	-	3,438	754
14	1,528	767	11	705	-	-	103	767	18	398	-	-	-	-	1,660	763
15+	5,801	791	46	747	-	-	327	783	14	568	-	-	-	-	6,188	790
Total	497,223	446	2,501	229	10,311	224	28,818	434	32,913	211	17,951	212	1,029	212	590,746	422
Tonnes	221,881		572		2,313		12,500		6,575		4,220		218		248,279	

Table 3.7

Title : MACKEREL, WESTERN STOCK
At 15.51.24 04 MARCH 1989
from 72 to 88 on ages 0 to 11
with Terminal F of .275 on age 4 and Terminal S of 1.200

Initial sum of squared residuals was 424.347 and
final sum of squared residuals is 103.415 after 127 iterations

Matrix of Residuals

Years	72/73	73/74	74/75	75/76	76/77	77/78
Ages						
0/ 1	1.875	-3.142	1.286	-.761	2.617	2.214
1/ 2	-.108	1.536	1.137	-.070	.407	-.017
2/ 3	-1.132	-.456	-.799	-.713	-.148	.132
3/ 4	-.965	-.203	-.492	-.327	.178	-.094
4/ 5	.167	-.286	-.266	.203	.602	-.195
5/ 6	.194	.135	.477	.505	-.006	-.217
6/ 7	.160	.073	-.634	-.682	-.159	.007
7/ 8	.147	.060	.140	1.014	.357	.203
8/ 9	.105	.018	.099	-.070	.192	.107
9/10	.220	.133	.212	.042	-.709	-.138
10/11	.060	-.027	.053	-.118	-.675	-.012
	.000	.000	.000	.000	.000	.000
WTS	.001	.001	.001	.001	.001	.001

Years	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88		WTS
Ages												
0/ 1	1.314	2.727	1.757	2.869	1.436	-1.861	-1.612	-2.174	4.593	1.039	.000	.088
1/ 2	.469	.543	.631	.353	-.427	.119	.788	.402	-.616	-.697	.000	.315
2/ 3	.293	-.166	.615	.107	.025	.014	.545	-.467	-.141	.052	.000	.400
3/ 4	.344	.317	.576	.098	.092	-.048	.362	-.256	-.359	.303	.000	.483
4/ 5	.179	-.018	.358	.018	.099	.153	.221	.117	-.154	-.338	.000	.749
5/ 6	.039	-.009	.022	-.114	-.173	-.122	.071	-.019	.275	-.206	.000	.868
6/ 7	-.293	-.068	-.218	-.023	-.012	-.249	.070	.000	.165	.016	.000	.760
7/ 8	-.134	.036	-.304	-.252	-.003	.048	-.432	.135	.240	.008	.000	.587
8/ 9	-.376	-.409	-.256	-.163	.115	.025	-.228	.042	-.004	.166	.000	1.000
9/10	.062	.085	-.531	.027	.220	.177	-.143	.162	-.524	.329	.000	.618
10/11	-.098	-.116	-.308	-.075	-.274	.212	-.271	.107	-.054	.009	.000	.771
	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	14.238	
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
F-values	.0467	.0672	.0910	.1394	.1920	.1237	.1867

	79	80	81	82	83	84	85	86	87	88
F-values	.2511	.2479	.2070	.2042	.1975	.1700	.1633	.1739	.2303	.2750

Selection-at-age (S)

	0	1
S-values	.0017	.1852

	2	3	4	5	6	7	8	9	10	11
S-values	.5474	.7846	1.0000	1.1663	1.2248	1.2457	1.2524	1.2049	1.3035	1.2000

Table 3.8 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

	1984	1985	1986	1987	1988
0	1	0	18	2	0
1	15	234	26	23	99
2	80	16	398	148	127
3	662	49	30	654	175
4	375	420	64	52	505
5	238	243	332	79	67
6	92	158	194	237	78
7	16	59	120	149	179
8	51	16	38	84	112
9	39	42	11	33	52
10	25	33	29	18	19
11	21	20	20	25	12
12+	44	80	60	61	52
TOTAL	1659	1371	1339	1565	1478

Table 3.9 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	.008	.003	.003	.015	.004	.006	.002	.000
1	.003	.020	.024	.019	.076	.040	.047	.145	.117	.063	.037	.047
2	.007	.013	.017	.035	.083	.100	.192	.117	.277	.162	.131	.168
3	.013	.044	.040	.082	.137	.087	.197	.305	.194	.196	.218	.181
4	.065	.060	.092	.124	.198	.092	.183	.245	.304	.111	.231	.260
5	.000	.094	.126	.220	.157	.079	.191	.233	.286	.210	.112	.240
6	.000	.000	.119	.124	.194	.100	.145	.249	.227	.244	.239	.120
7	.000	.000	.000	.386	.354	.145	.143	.246	.252	.227	.248	.235
8	.000	.000	.000	.000	.215	.172	.175	.200	.218	.281	.290	.241
9	.000	.000	.000	.000	.000	.106	.226	.321	.264	.212	.330	.246
10	.000	.000	.000	.000	.000	.000	.190	.307	.318	.428	.210	.295
11	.000	.000	.000	.000	.000	.000	.000	.245	.312	.347	.517	.239
12+	.000	.000	.000	.000	.000	.000	.000	.245	.312	.347	.517	.239
(4- 8)U	.013	.031	.067	.171	.223	.118	.167	.234	.258	.215	.224	.219
(4- 8)W	.065	.086	.116	.252	.212	.107	.171	.236	.273	.223	.233	.243

	1984	1985	1986	1987	1988
0	.000	.000	.011	.001	.000
1	.032	.046	.022	.016	.037
2	.108	.041	.098	.165	.112
3	.220	.086	.095	.218	.283
4	.216	.200	.145	.223	.246
5	.235	.200	.228	.255	.463
6	.252	.229	.231	.239	.403
7	.121	.239	.256	.263	.270
8	.191	.169	.229	.272	.304
9	.193	.222	.159	.297	.252
10	.190	.232	.219	.390	.267
11	.192	.219	.206	.281	.476
12+	.192	.219	.206	.281	.476
(4- 8)U	.203	.208	.217	.250	.337
(4- 8)W	.220	.207	.222	.249	.276

Table 3.10 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	2099	4512	3452	4776	4902	848	3256	5590	5506	6974	1179	601
1	4674	1805	3884	2970	4110	4187	728	2793	4737	4721	5967	1013
2	1889	4011	1522	3262	2507	3279	3462	598	2079	3629	3817	4948
3	2531	1615	3407	1288	2712	1987	2554	2458	458	1357	2655	2882
4	8637	2151	1330	2818	1021	2036	1568	1805	1560	324	960	1838
5	0	6964	1745	1045	2142	721	1598	1124	1216	990	250	656
6	0	0	5455	1324	721	1576	573	1137	767	786	691	192
7	0	0	0	4170	1007	511	1227	427	763	526	530	468
8	0	0	0	0	2440	608	380	916	287	510	360	356
9	0	0	0	0	0	1694	441	275	646	199	332	232
10	0	0	0	0	0	0	1311	303	172	427	138	205
11	0	0	0	0	0	0	0	934	192	107	239	97
12+	0	0	0	0	0	0	0	0	462	644	391	638
TOTAL NO	19829	21058	20794	21652	21561	17448	17100	18359	18843	21194	17510	14126
SPS NO	11237	11779	11523	10959	10100	10078	10004	8193	6786	7119	7786	8894
TOT.BIOM	4566	4449	4518	4383	3965	3812	3723	3387	3027	3023	2822	3179
SPS BIOM	3529	3574	3544	3274	2895	2834	2948	2576	2071	2069	1873	2349

	1984	1985	1986	1987	1988	1989
0	6500	1445	1787	3376	687	0
1	517	5594	1244	1521	2903	591
2	832	431	4598	1047	1268	2407
3	3599	642	356	3589	764	991
4	2069	2486	507	279	2485	495
5	1220	1435	1751	378	192	1672
6	411	830	1011	1201	252	104
7	147	297	568	691	814	145
8	319	112	201	379	457	535
9	241	227	81	138	248	290
10	156	171	156	60	88	166
11	131	111	117	108	35	58
12+	272	438	347	266	148	98
TOTAL NO	16447	14220	12725	13031	10362	
SPS NO	7513	6361	5239	6402	5390	
TOT.BIOM	2803	2859	2686	2452	2337	
SPS BIOM	2241	2102	1707	1883	1713	

Table 3.11

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
1989	3600.0
1990	3600.0
1991	3600.0

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	3600.0	.00	.15	.00	.071	.000
1	3100.0	.05	.15	.08	.157	.070
2	4350.0	.16	.15	.60	.260	.150
3	991.0	.22	.15	.90	.326	.242
4	495.0	.29	.15	.97	.390	.287
5	1672.0	.33	.15	.97	.462	.345
6	104.0	.35	.15	.99	.537	.381
7	145.0	.36	.15	1.00	.567	.414
8	535.0	.36	.15	1.00	.563	.435
9	290.0	.35	.15	1.00	.568	.453
10	166.0	.37	.15	1.00	.617	.487
11	58.0	.34	.15	1.00	.627	.507
12+	98.0	.34	.15	1.00	.705	.564

Table 3.12

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

WESTERN MACKEREL

(Assuming 1988 year class is strong)

Year 1989					Year 1990					Year 1991	
factor	ref. F	stock biomass	sp.stock biomass	catch	mgmt. option	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.8	.27	2608	1687	600	F_{med}	.12	2833	2067	307	3194	2465
					$F_{0.1}$	.19		2020	480	3057	2291
					F(88)	.34		1930	795	2807	1986
					F_{high}	.43		1876	974	2666	1821

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 1991 has been calculated with the same fishing mortality as for 1990.
The reference F is the mean F for the age group range from 4 to 8

Table 3.13

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

WESTERN MACKEREL

(Assuming 1988 year class is intermediate)

Year 1989					Year 1990					Year 1991	
factor	ref. F	stock biomass	sp.stock biomass	catch	mgmt. option	ref. F	stock biomass	sp.stock biomass	catch	stock biomass	sp.stock biomass
.8	.28	2457	1672	600	F_{med}	.12	2558	1912	283	2836	2170
					$F_{0.1}$	.19		1867	441	2712	2012
					F(88)	.34		1781	730	2484	1736
					F_{high}	.43		1730	892	2357	1587

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 1991 has been calculated with the same fishing mortality as for 1990.
The reference F is the mean F for the age group range from 4 to 8

Table 3.14
Results

11.53.22 10 MARCH 1989
WESTERN MACKEREL

(Assuming 1988 year class is strong)

* Year 1989. F-factor .803 and reference F .2706 *

* 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	1.34	.095	3600.0	.00	.00	.00	.00	.00
1	.0426	203.15	31.895	5245.0	367.15	419.60	29.37	388.49	27.19
2	.1261	479.46	124.660	4350.0	652.50	2610.00	391.50	2337.06	350.56
3	.1800	151.91	49.523	991.0	239.82	891.90	215.84	781.62	189.15
4	.2298	94.64	36.908	495.0	142.07	480.15	137.80	412.48	118.38
5	.2683	366.65	169.392	1672.0	576.84	1621.84	559.53	1371.94	473.32
6	.2812	23.76	12.757	104.0	39.62	102.96	39.23	86.65	33.01
7	.2860	33.61	19.059	145.0	60.03	145.00	60.03	121.79	50.42
8	.2876	124.63	70.165	535.0	232.73	535.00	232.73	449.09	195.35
9	.2772	65.42	37.158	290.0	131.37	290.00	131.37	244.45	110.74
10	.2997	40.07	24.720	166.0	80.84	166.00	80.84	138.67	67.53
11	.2756	13.02	8.162	58.0	29.41	58.00	29.41	48.92	24.80
12+	.2756	22.00	15.507	98.0	55.27	98.00	55.27	82.66	46.62
Total		1619.64	600.000	17749.0	2607.65	7418.45	1962.92	6463.82	1687.09

* Year 1990. F-factor 1.000 and reference F .3368 *

						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	.0005	1.67	.119	3600.0	.00	.00	.00	.00	.00
1	.0530	148.57	23.325	3097.3	216.81	247.78	17.34	228.46	15.99
2	.1570	584.85	152.062	4326.2	648.93	2595.73	389.36	2295.77	344.37
3	.2240	616.78	201.069	3300.4	798.69	2970.34	718.82	2557.62	618.94
4	.2860	165.16	64.411	712.5	204.48	691.10	198.35	580.50	166.60
5	.3340	89.65	41.418	338.6	116.81	328.43	113.31	270.62	93.36
6	.3500	303.08	162.755	1100.4	419.25	1089.40	415.06	891.92	339.82
7	.3560	18.88	10.704	67.6	27.97	67.57	27.97	55.19	22.85
8	.3580	26.32	14.817	93.8	40.78	93.76	40.78	76.52	33.28
9	.3450	93.98	53.383	345.4	156.46	345.38	156.46	283.34	128.35
10	.3730	54.95	33.903	189.2	92.13	189.18	92.13	153.47	74.74
11	.3430	28.67	17.977	105.9	53.68	105.88	53.68	86.93	44.07
12+	.3430	27.60	19.459	101.9	57.49	101.93	57.49	83.69	47.20
Total		2160.16	795.401	17379.1	2833.50	8826.48	2280.76	7564.02	1929.59

* Year 1991. F-factor 1.000 and reference F .3368 *

						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	.0005	1.67	.119	3600.0	.00	.00	.00	.00	.00
1	.0530	148.55	23.323	3097.0	216.79	247.76	17.34	228.44	15.99
2	.1570	341.79	88.866	2528.3	379.24	1516.96	227.54	1341.66	201.25
3	.2240	594.76	193.892	3182.6	770.19	2864.33	693.17	2466.33	596.85
4	.2860	526.33	205.271	2270.6	651.66	2202.47	632.11	1849.99	530.95
5	.3340	121.98	56.356	460.7	158.94	446.88	154.17	368.22	127.04
6	.3500	57.48	30.864	208.7	79.51	206.59	78.71	169.14	64.44
7	.3560	186.47	105.727	667.4	276.31	667.43	276.31	545.13	225.69
8	.3580	11.44	6.438	40.7	17.72	40.74	17.72	33.25	14.46
9	.3450	15.35	8.719	56.4	25.56	56.41	25.56	46.28	20.96
10	.3730	61.15	37.730	210.5	102.53	210.53	102.53	170.79	83.18
11	.3430	30.36	19.039	112.1	56.85	112.13	56.85	92.07	46.68
12+	.3430	34.37	24.231	126.9	71.59	126.93	71.59	104.21	58.78
Total		2131.71	800.574	16562.0	2806.88	8699.15	2353.61	7415.51	1986.26

Table 3.15
Results

11.59.43 10 MARCH 1989
WESTERN MACKEREL

(Assuming 1988 year class is intermediate)

* Year 1989. F-factor .823 and reference F .2773 *

* Run depending on a TAC value *

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	1.38	.098	3600.0	.00	.00	.00	.00	.00
1	.0436	123.00	19.311	3100.0	217.00	248.00	17.36	229.52	16.07
2	.1293	490.67	127.574	4350.0	652.50	2610.00	391.50	2334.13	350.12
3	.1845	155.37	50.649	991.0	239.82	891.90	215.84	780.22	188.81
4	.2355	96.73	37.726	495.0	142.07	480.15	137.80	411.54	118.11
5	.2750	374.62	173.073	1672.0	576.84	1621.84	559.53	1368.27	472.05
6	.2882	24.27	13.032	104.0	39.62	102.96	39.23	86.41	32.92
7	.2931	34.34	19.470	145.0	60.03	145.00	60.03	121.45	50.28
8	.2948	127.31	71.675	535.0	232.73	535.00	232.73	447.80	194.79
9	.2841	66.83	37.962	290.0	131.37	290.00	131.37	243.77	110.43
10	.3071	40.92	25.249	166.0	80.84	166.00	80.84	138.26	67.33
11	.2824	13.30	8.339	58.0	29.41	58.00	29.41	48.79	24.74
12+	.2824	22.47	15.842	98.0	55.27	98.00	55.27	82.43	46.49
Total		1571.20	600.000	15604.0	2457.50	7246.85	1950.91	6292.58	1672.15

* Year 1990. F-factor 1.000 and reference F .3368 *

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	.0005	1.67	.119	3600.0	.00	.00	.00	.00	.00
1	.0530	148.57	23.325	3097.3	216.81	247.78	17.34	228.46	15.99
2	.1570	345.31	89.779	2554.3	383.14	1532.55	229.88	1355.45	203.32
3	.2240	614.84	200.438	3290.0	796.19	2961.02	716.57	2549.59	617.00
4	.2860	164.42	64.123	709.3	203.57	688.01	197.46	577.90	165.86
5	.3340	89.14	41.182	336.7	116.15	326.55	112.66	269.08	92.83
6	.3500	301.06	161.671	1093.1	416.46	1082.14	412.29	885.98	337.56
7	.3560	18.75	10.629	67.1	27.78	67.10	27.78	54.81	22.69
8	.3580	26.13	14.711	93.1	40.49	93.09	40.49	75.97	33.05
9	.3450	93.31	53.001	342.9	155.34	342.91	155.34	281.31	127.44
10	.3730	54.57	33.670	187.9	91.50	187.88	91.50	152.41	74.22
11	.3430	28.46	17.843	105.1	53.28	105.09	53.28	86.28	43.75
12+	.3430	27.41	19.326	101.2	57.09	101.23	57.09	83.11	46.88
Total		1913.63	729.816	15577.9	2557.79	7735.36	2111.70	6600.37	1780.58

* Year 1991. F-factor 1.000 and reference F .3368 *

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	.0005	1.67	.119	3600.0	.00	.00	.00	.00	.00
1	.0530	148.55	23.323	3097.0	216.79	247.76	17.34	228.44	15.99
2	.1570	341.79	88.865	2528.2	379.24	1516.94	227.54	1341.65	201.25
3	.2240	351.15	114.476	1879.0	454.73	1691.13	409.25	1456.15	352.39
4	.2860	524.68	204.626	2263.5	649.61	2195.56	630.12	1844.18	529.28
5	.3340	121.44	56.104	458.6	158.23	444.88	153.48	366.58	126.47
6	.3500	57.15	30.688	207.5	79.05	205.41	78.26	168.17	64.07
7	.3560	185.22	105.022	663.0	274.47	662.98	274.47	541.50	224.18
8	.3580	11.36	6.393	40.5	17.60	40.45	17.60	33.02	14.36
9	.3450	15.24	8.658	56.0	25.37	56.01	25.37	45.95	20.82
10	.3730	60.71	37.460	209.0	101.80	209.03	101.80	169.57	82.58
11	.3430	30.16	18.908	111.4	56.46	111.36	56.46	91.43	46.36
12+	.3430	34.13	24.058	126.0	71.08	126.02	71.08	103.47	58.36
Total		1883.25	718.700	15239.7	2484.43	7507.54	2062.79	6390.11	1736.10

Table 4.1 Monthly catches of mackerel by selected trawl fleets along the Portuguese and Spanish coasts.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Portimão (Div. IXa)	66	20	6	7	5	10	21	11	6	7	1	21	181
%	36.5	11.0	3.3	3.9	2.8	5.5	11.6	6.1	3.3	3.9	0.6	11.6	
Matosinhos (Div. IXa)	65	143	140	156	100	13	12	10	4	12	21	24	700
%	9.3	20.4	20.0	22.3	14.3	1.9	1.7	1.4	0.6	1.7	3.0	3.4	
Ribeira (Div. IXa)	158	222	150	107	34	5	2	3	3	12	5	8	709
%	22.3	31.3	21.2	15.1	4.8	0.7	0.3	0.4	0.4	1.7	0.7	1.1	
La Coruña (Div. VIIIc)	49	121	398	607	92	16	19	3	9	2	1	13	1,330
%	3.7	9.1	29.9	45.6	6.9	1.2	1.4	0.2	0.7	0.2	0.1	1.0	
Gijòn (Div. VIIIc)	1	1.6	96	26	1	-	-	-	-	-	-	-	142
%	0.7	12.7	67.6	18.3	0.7	-	-	-	-	-	-	-	
Ondarroa (Div. VIIIc)	-	42	219	60	78	8	3	1	-	-	-	-	411
%	-	10.2	53.3	14.6	19.0	1.9	0.7	0.2	-	-	-	-	

Table 4.2 Landings (tonnes) of Mackerel in Division VIIIc, 1977-1988.

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

Country	1983	1984	1985	1986	1987	1988[1]
Spain	10,390	13,852	11,810	16,533	15,982	16,844[2]
Total	10,390	13,852	11,810	16,533	15,982	16,844

[1] Preliminary.
[2] Working Group estimate.

Table 4.3 Landings (tonnes) of Mackerel in Sub-area IX, 1977-1988.

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

Country	1983	1984	1985	1986	1987	1988
Portugal	2,239[2]	2,250	4,178[2]	5,565[3]	5,525[3]	3,882[2]
Spain	2,224	4,206	2,000[2]	1,837[2]	491[1]	3,540[2]
Poland	-	-	-	-	-	-
USSR	-	-	-	-	-	-
Total	4,463	6,456	6,178	7,402	6,016[1]	7,422[2]

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

Table 4.4 Spanish and Portuguese landings of Mackerel by gear (tonnes) and by year in Division IXa.

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

[1] Estimated catch does not include Riveira landing port.

Table 4.5 Spanish landings of Mackerel by gear (tonnes) in Division VIIIc, 1985-1988.

Gear	1985	1986	1987	1988
Purse seine	4,208	2,105	4,277	7,413
Trawl	1,135	2,850	1,900	2,321
Hook	6,371	11,323	9,739	6,799
Gillnet	96	255	66	312
Total	11,810	16,533	15,892	16,845

Table 4.6 MACKEREL IN Division IXa (Portugal). Catch in numbers ('000) by age group in 1981-1988.

Age	1981	1092	1983	1984	1985	1986	1987	1988
0	7,675	12,436	4,500	19,516	25,692	12,024	1,927	11,729
1	6,571	6,433	3,353	2,679	26,367	15,112	12,644	13,637
2	1,920	6,618	2,892	2,422	2,779	6,858	4,479	1,411
3	587	1,264	892	1,085	272	1,227	214	1,055
4	101	298	159	241	206	175	742	404
5	41	71	44	70	42	156	548	146
6	33	46	12	19	36	55	61	68
7	15	68	11	10	3	35	61	5
8	8	41	8	13	2	20	45	-
9	5	24	6	8	1	11	47	-
10+	31	102	15	10	3	8	45	-
Tonnes	3,108	3,018	2,239	2,250	4,178	5,565	5,525	4,106

Table 4.7 Mackerel in Divisions VIIIc and IXa (Spain). Catch in numbers ('000) by age group and division in 1988.

Age	1988	
	Division IXa	Division VIIIc
0	59,736	19
1	11,123	6,391
2	97	1,908
3	101	4,648
4	172	9,003
5	89	2,923
6	88	5,433
7	12	12,785
8	11	5,508
9	-	1,785
10	-	530
11	-	284
12	-	752
13	-	713
14	-	124
15+	-	931
Tonnes	3,540	16,884

Table 5.1 Estimated catch in numbers ('000) of the North Sea mackerel stock by quarter in 1987 and 1988.

Age	1987				1988			
	Quarter				Quarter			
	1	2	3	4	1	2	3	4
1	-	80	300	130	-	30	300	80
2	-	80	300	130	-	30	300	80
3	-	80	300	130	-	30	300	80
4	-	30	120	50	-	30	300	80
5	-	60	240	100	-	10	150	40
6	-	30	360	150	-	20	230	60
7	-	60	240	100	-	30	380	100
8	-	50	180	80	-	20	230	60
9	-	120	420	200	-	10	150	400
10	-	10	60	30	-	40	530	140
11	-	30	120	50	-	10	80	20
12	-	10	60	30	-	10	150	40
13	-	30	120	50	-	10	80	20
14	-	10	60	30	-	10	150	40
15+	-	120	480	200	-	40	530	140

Table 5.2 Quarterly mean weights at age (g) in the North Sea mackerel stock, second quarter, 1988.

Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Weight	140	255	330	395	450	500	540	570	605	635	670	700	730	765	790

Table 5.3 Indicative percentages of each mackerel stock present in the North Sea during each quarter.

Age	North Sea stock				Western stock			
	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 6.1 Annual length distribution of catches per fleet per country.

Length (cm)	Denmark	Ireland	Netherlands		Norway		UK(Eng.)	UK(Scot.)		Spain			
	P.seine	Pr.tr.	Pel.tr.	Beam+bt.tr.	Coastal	P.seine	All gear	P.seine	Dist.tr.[1]	Dist.tr.[2]	Gillnet	VIIIc trawl	Liners
6	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	248	-	-	-	-	-	-	-	-	-	-
8	-	-	746	-	-	-	-	-	-	-	-	-	-
9	-	-	395	-	-	-	-	-	-	-	-	-	-
20	-	33	1,102	-	-	-	36	-	-	-	-	457	-
1	-	-	1,047	-	-	-	85	22	-	-	-	2,648	7
2	-	-	1,138	-	-	-	78	22	-	-	-	1,189	9
3	-	-	231	-	-	-	54	-	-	-	-	366	12
4	-	-	306	-	-	-	472	235	-	-	-	-	15
5	-	-	68	-	<26=10	6	3,055	892	-	-	-	96	15
6	-	33	357	44	235	2	6,792	2,061	-	14	-	40	-
7	-	133	470	311	196	-	9,440	3,347	-	38	-	282	19
8	-	333	2,339	311	52	106	8,517	3,652	1	63	-	110	22
9	-	733	2,732	300	20	2,424	9,812	5,779	2	71	-	130	105
30	533	1,936	3,620	328	268	4,504	5,200	10,980	5	240	-	151	187
1	389	7,834	6,039	537	710	7,663	5,410	15,810	17	443	-	352	534
2	1,683	14,836	8,512	514	795	10,210	5,868	26,400	46	583	-	412	803
3	3,613	23,704	10,209	460	1,178	17,587	4,073	31,727	48	859	-	196	994
4	6,965	30,139	13,122	416	1,479	29,164	2,930	40,536	49	814	-	194	1,284
5	7,395	30,805	14,412	378	2,126	36,710	2,068	44,547	46	601	-	460	997
6	6,319	23,737	12,407	248	1,721	36,715	1,069	37,510	30	370	-	279	1,043
7	4,525	17,768	3,732	174	1,918	32,362	690	28,802	15	284	-	434	1,659
8	3,065	17,503	8,056	190	1,553	28,722	255	20,672	9	225	-	439	2,362
9	2,741	16,769	8,429	117	1,254	28,216	161	16,131	5	95	60	728	2,626
40	2,760	14,869	8,777	132	1,459	26,017	7	14,231	10	51	60	194	2,618
1	1,764	9,134	5,308	47	1,309	13,953	5	11,544	8	24	30	286	1,642
2	917	6,567	2,955	62	457	6,130	2	6,722	5	38	60	283	790
3	469	5,134	2,920	-	674	5,754	1	3,809	2	21	60	197	425
4	230	3,167	1,655	11	1,197	3,242	-	2,494	1	4	149	69	465
5	150	1,333	771	16	-	-	-	695	-	2	119	192	242
6	-	600	86	-	-	-	-	463	-	-	30	192	91
7	-	233	-	-	-	-	-	384	-	-	-	57	30
8	-	33	-	-	-	-	-	-	-	-	30	-	4
9	-	-	-	-	-	-	-	-	-	-	-	-	15
50	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	43,524	227,366	128,789	4,596	18,611	289,423	66,080	329,467	291	4,841	596	10,436	19,017

cont'd.

Table 6.1 (cont'd)

Length (cm)	Spain ctd.			Portugal		
	VIIIc Purse seine	IXa Trawl	P.seine	Artisan	P.seine	Trawl
5	-	+	+	-	-	-
6	-	4	605	-	-	+
7	-	+	1,968	-	-	+
8	-	11	5,599	-	66	10
9	3	127	11,580	-	394	261
20	-	1,939	15,820	-	1,634	896
1	47	4,859	14,559	-	2,407	2,035
2	480	2,909	4,040	+	940	2,286
3	595	784	1,756	24	794	2,109
4	141	132	1,325	37	214	1,495
5	17	35	801	84	214	924
6	201	43	410	145	553	644
7	46	53	65	152	825	417
8	69	53	129	220	714	522
9	143	51	276	144	447	551
30	107	12	476	174	78	426
1	238	66	88	151	84	505
2	1,156	30	13	220	176	382
3	2,236	20	8	252	159	299
4	1,905	20	9	210	360	185
5	2,130	17	8	191	378	82
6	2,753	15	12	112	197	62
7	1,758	15	11	109	230	23
8	2,550	23	3	59	220	16
9	3,392	60	2	34	87	11
40	2,081	92	+	83	6	8
1	611	1,117	+	52	9	4
2	440	41	+	55	4	+
3	586	28	-	17	9	+
4	-	6	-	7	4	-
5	-	+	-	1	-	-
6	-	+	-	-	-	-
7	-	+	-	+	-	-
8	-	+	-	-	-	-
9	-	+	-	-	-	-
50	-	+	-	-	-	-
Total	23,687	11,560	59,874	2,533	11,203	14,153

[1]Catches from ports in Basque Country.
[2]Aproximately 50% of total catch in Divisions VIIIa,b.

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

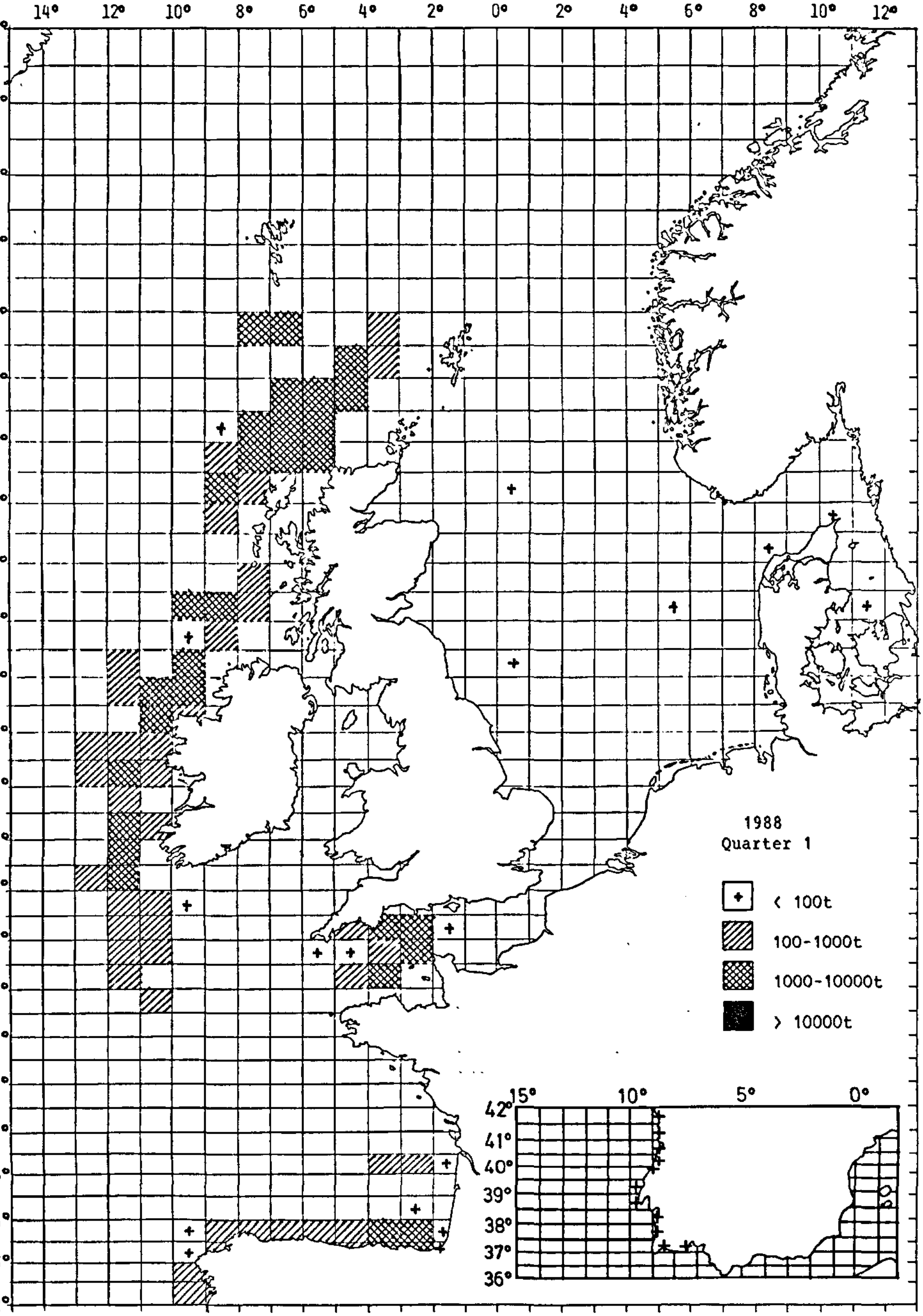


Figure 2.1A Distribution of mackerel fisheries, first quarter 1988.

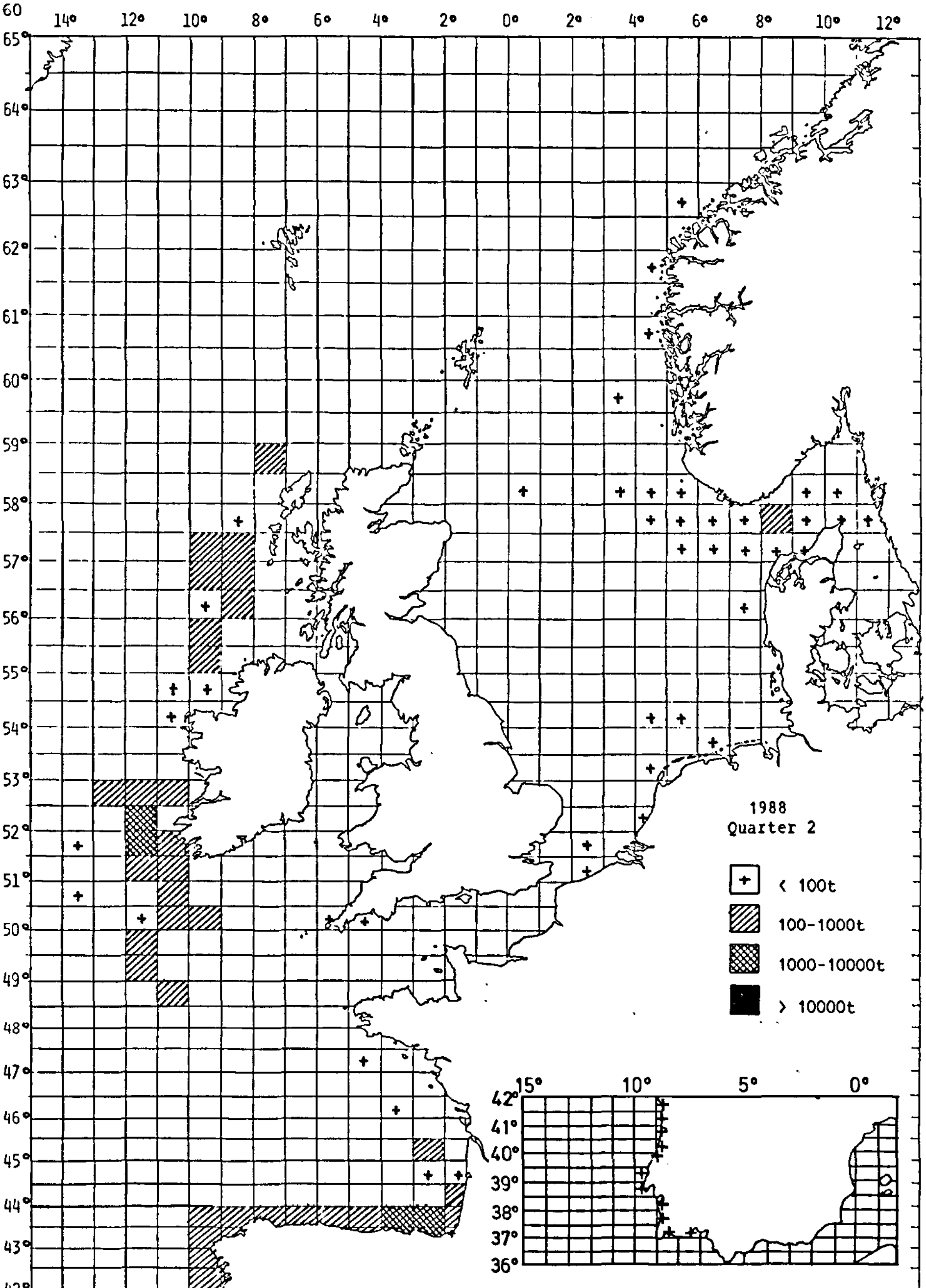


Figure 2.1B Distribution of mackerel fisheries, second quarter 1988.

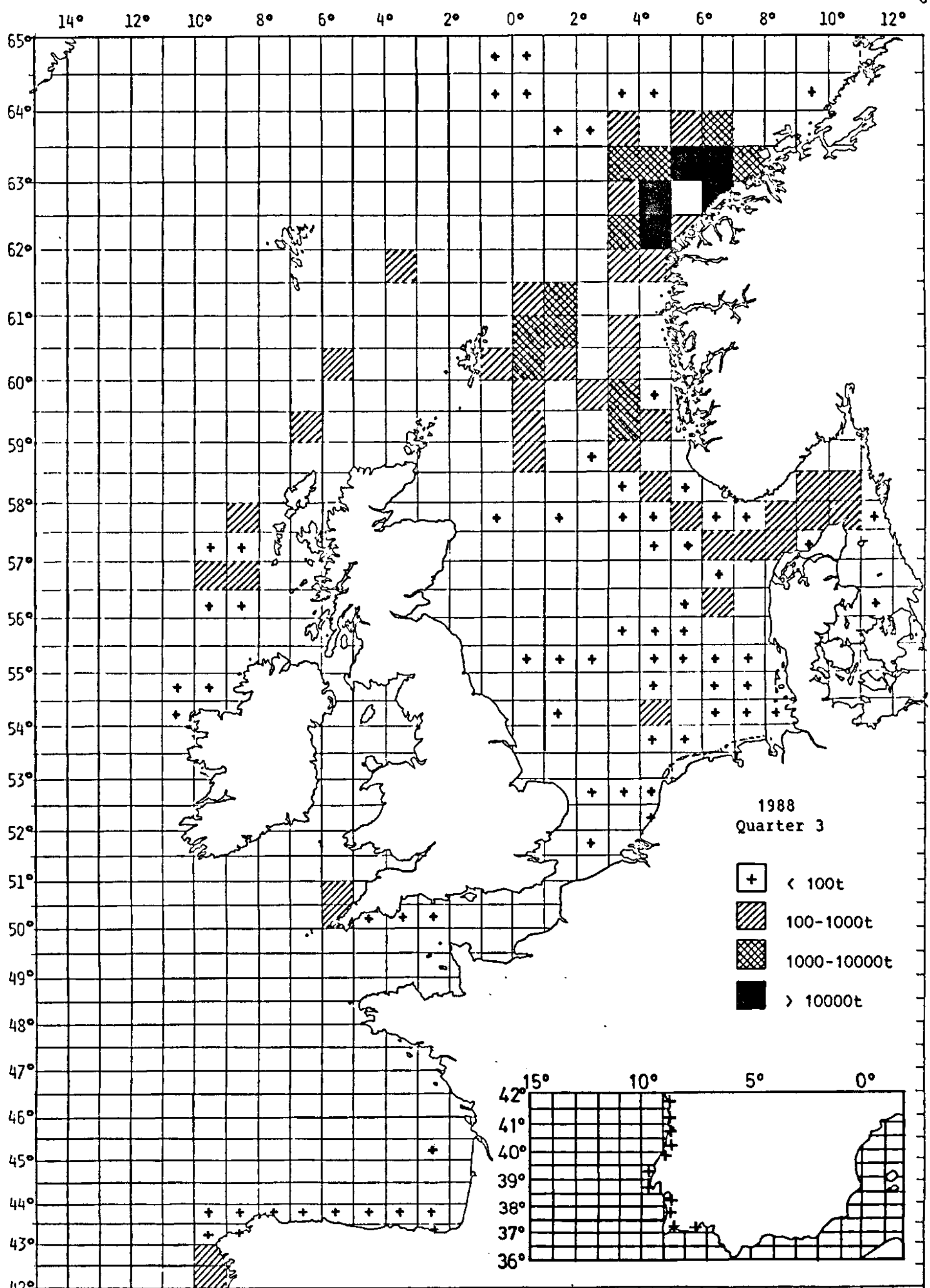


Figure 2.1C Distribution of mackerel fisheries, third quarter 1988.

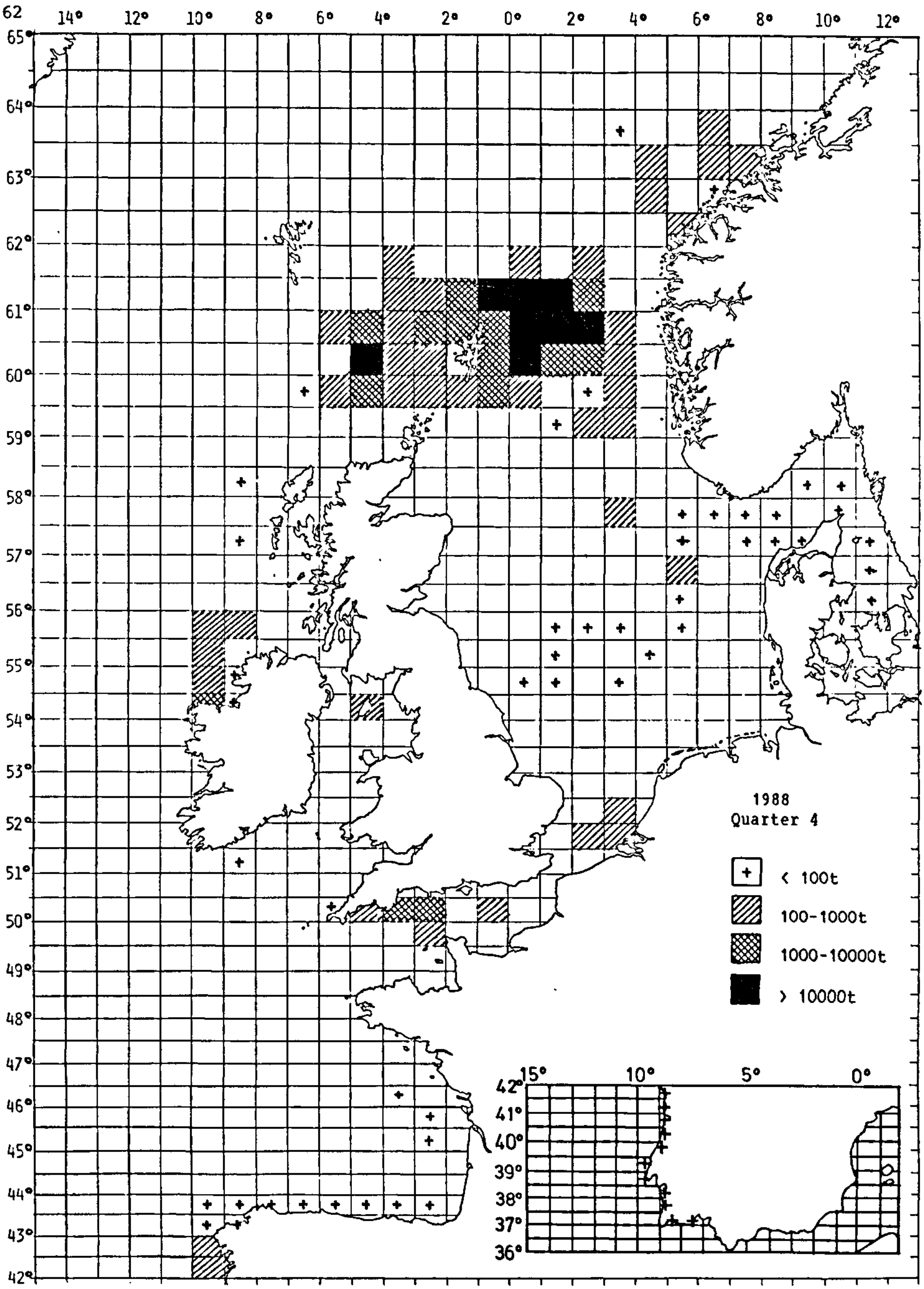


Figure 2.1D Distribution of mackerel fisheries, fourth quarter 1988.

Figure 2.2 Distribution and abundance of the 1988 year class between October 1988 and December 1988 from Dutch, English, Irish, and Scottish research vessel data.

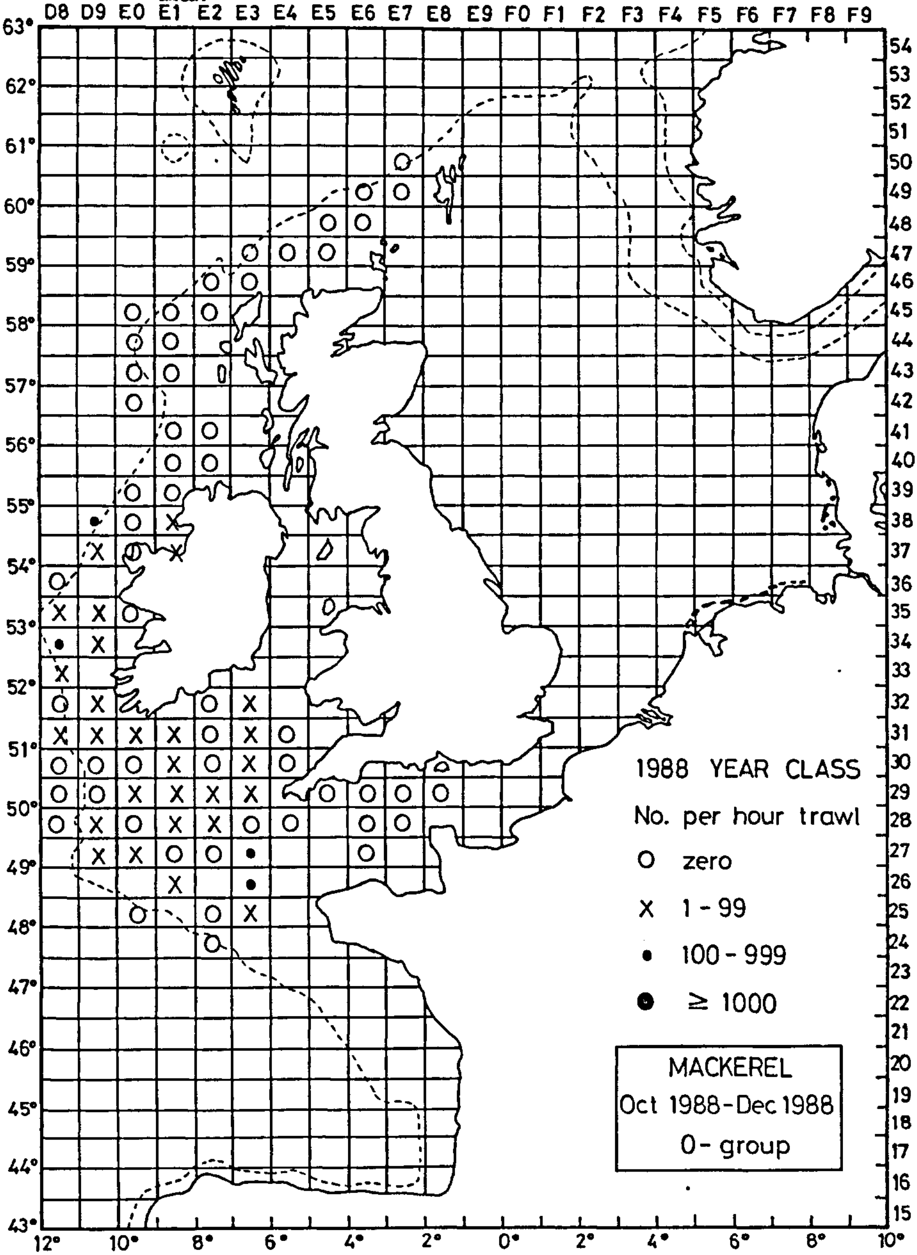


Figure 2.3 Distribution of mackerel "0/1-groups" from October 1987 to March 1988 from Dutch, English, Irish, and Scottish research vessel data.

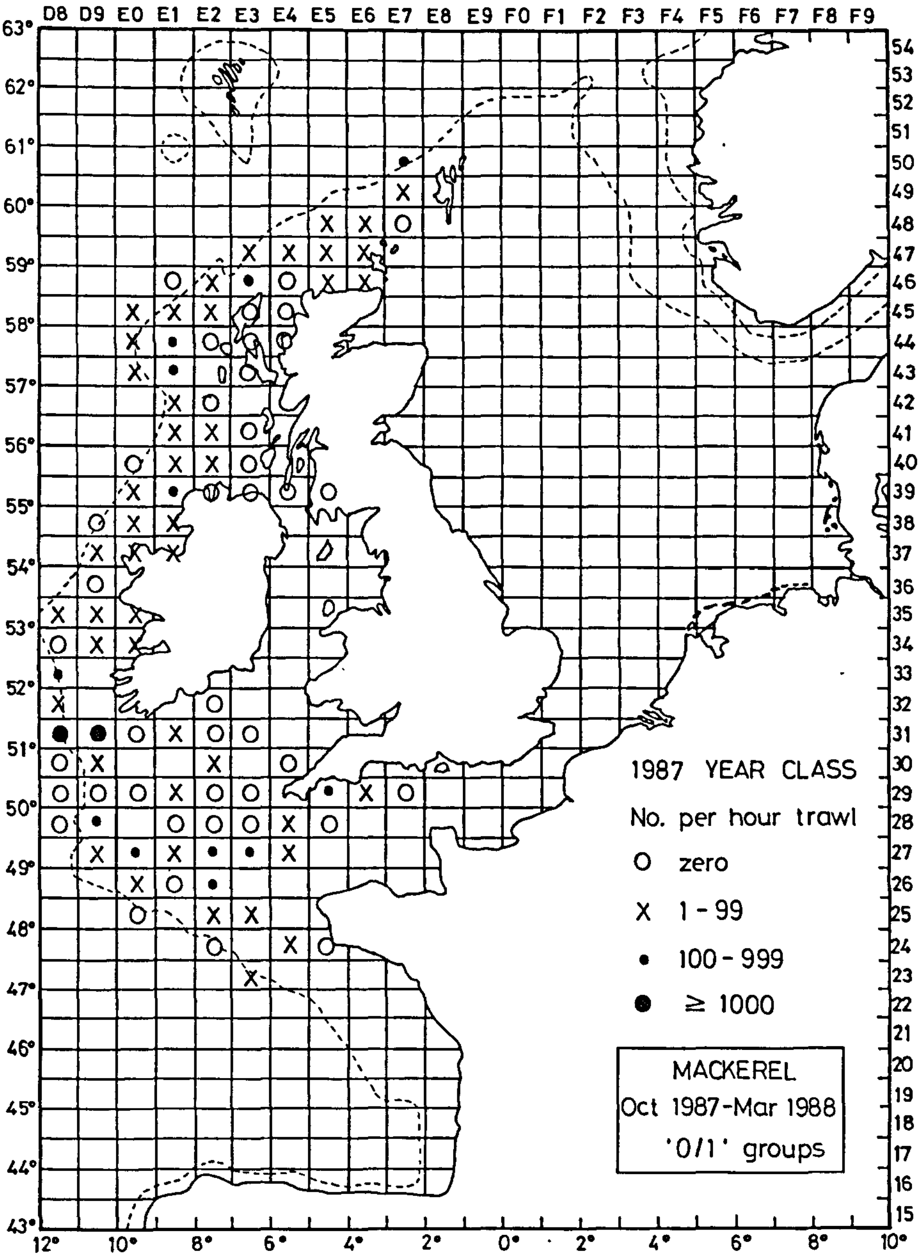


Figure 2.4 Distribution and abundance of the 1987 year class between October 1988 and December 1988 from Dutch, English, Irish, and Scottish research vessel data.

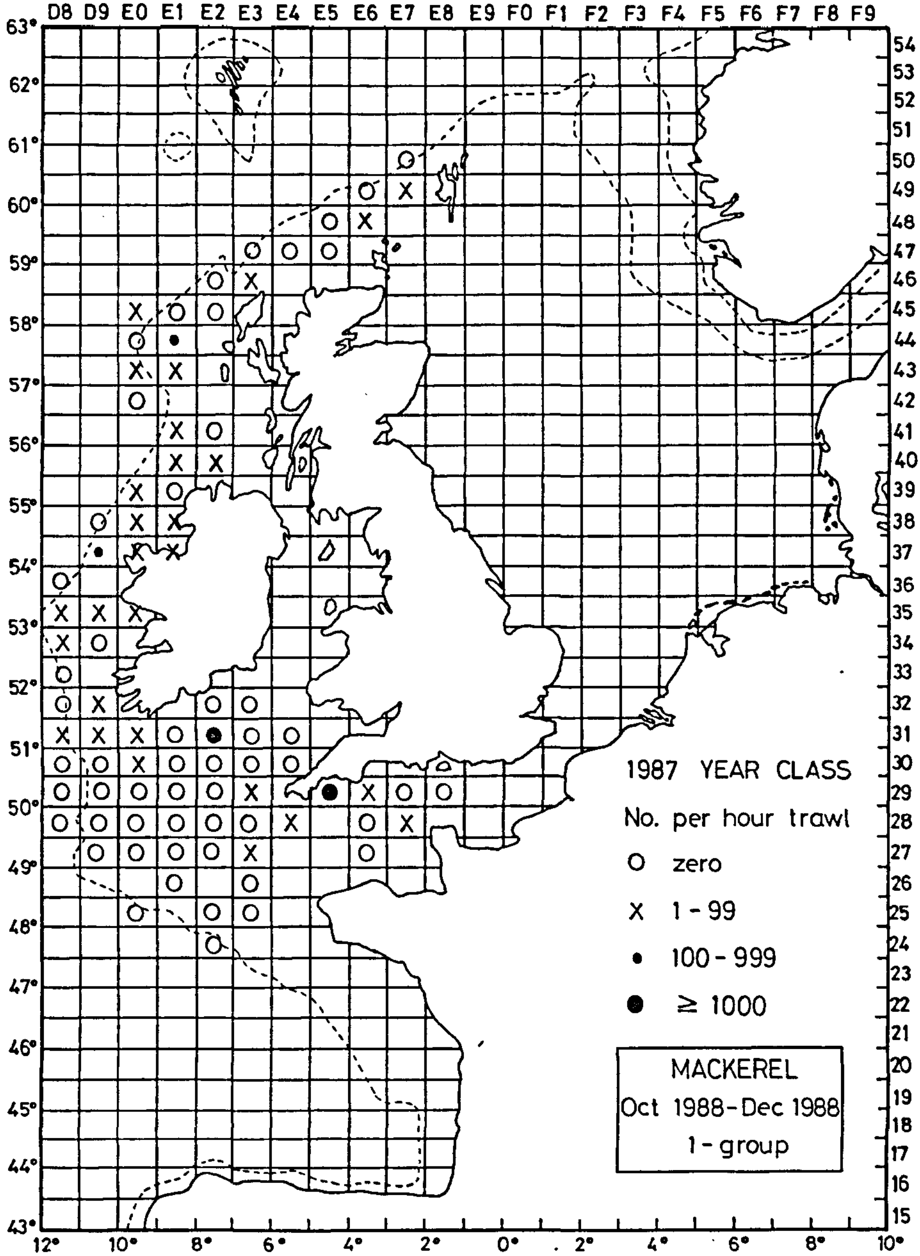


Figure 2.5 Distribution of mackerel "1/2-groups" from October 1987 to March 1988 from Dutch, English, Irish, and Scottish research vessel data.

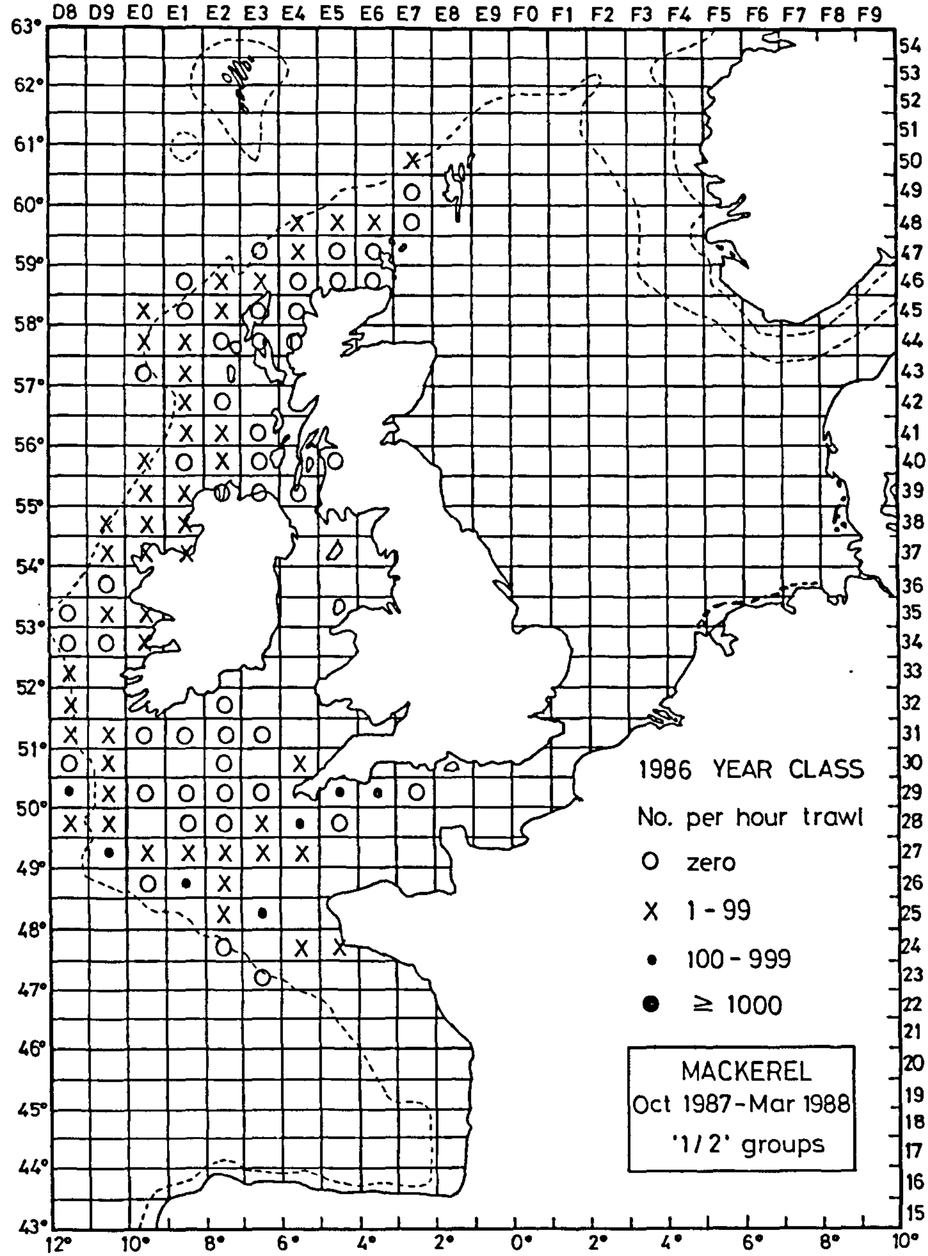


Figure 2.6 The occurrence of juvenile mackerel expressed as a percentage by numbers in the commercial catches that could be allocated to ICES divisions or sub-divisions in 1988. Values in each area are expressed from top to bottom as: 0-group; 1-group; 2-group; tonnage that would be allocated (+ = less than 500 t). Catches in Division IVa were mainly located north of 59°N as indicated by the shaded area.

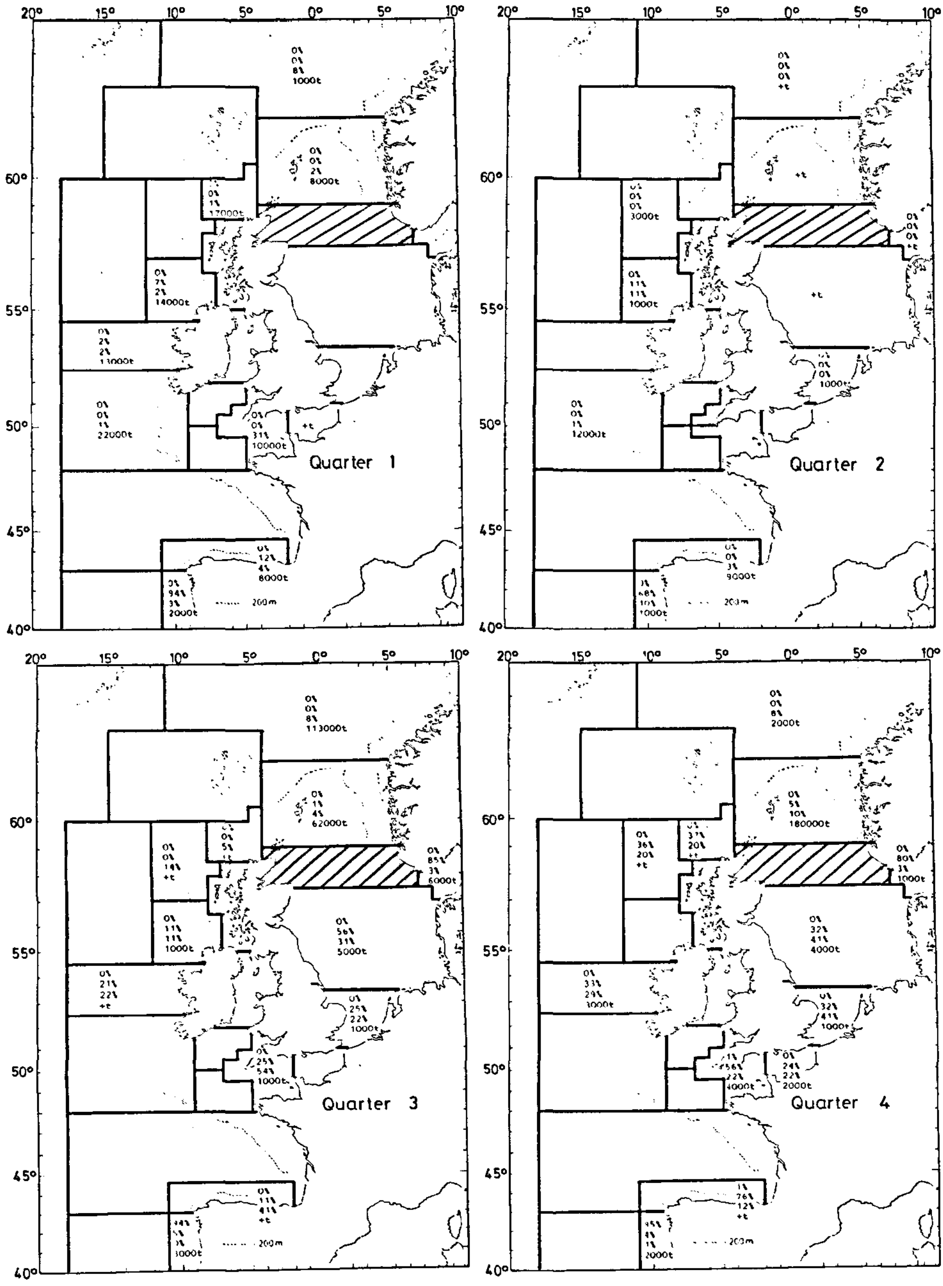


Figure 2.7 The percentage of 0-,1-and 2-group mackerel in the Dutch and English commerical catches by rectangle in the first quarter in 1988.

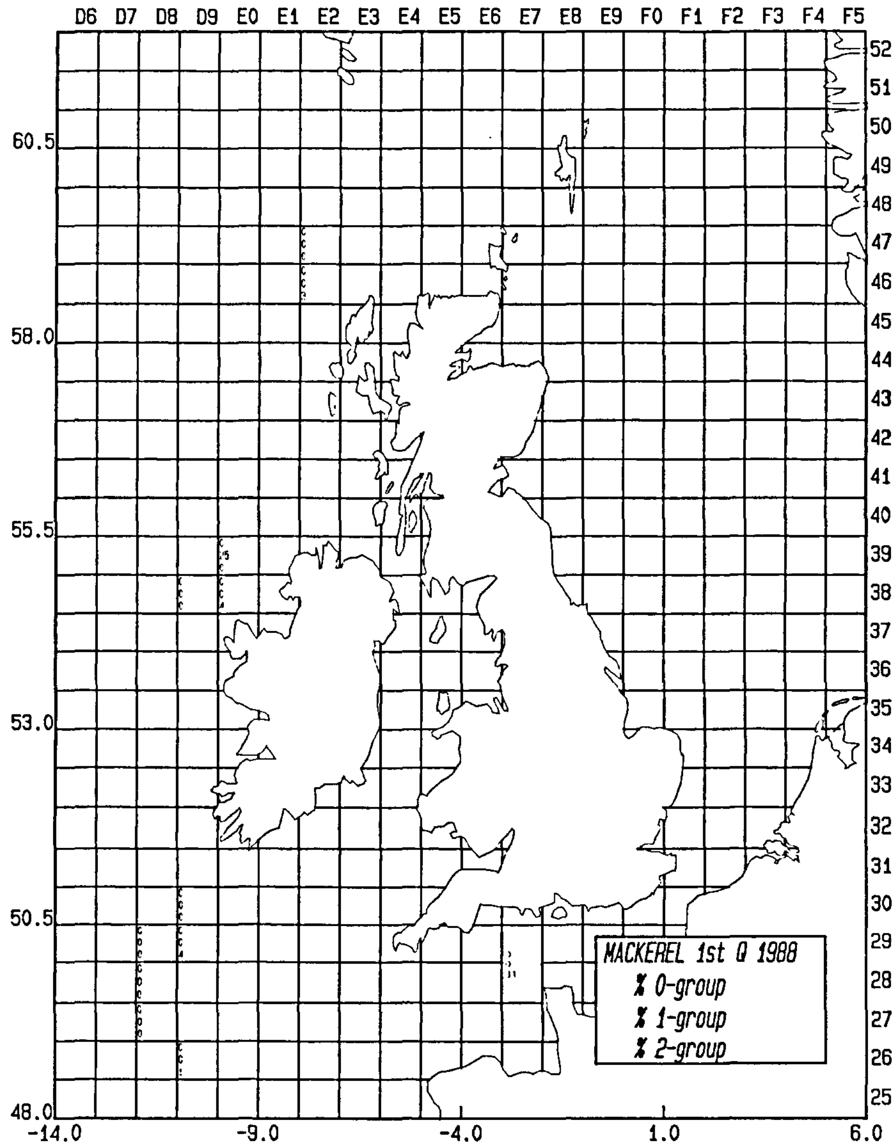


Figure 2.8 The percentage of 0-,1-and 2-group mackerel in the Dutch commercial catches by rectangle in the second quarter.

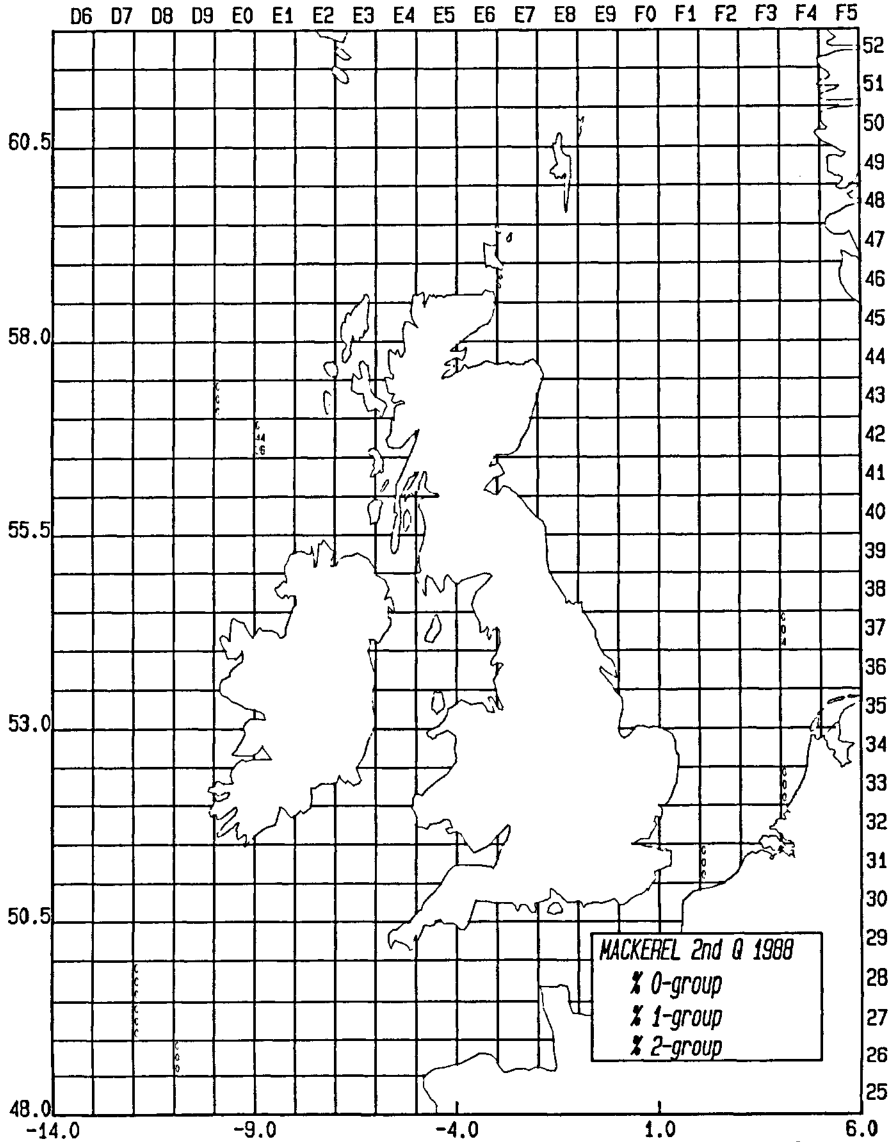


Figure 2.9 The percentage of 0-,1-and 2-group mackerel in the Dutch and English commercial catches by rectangle in the third quarter.

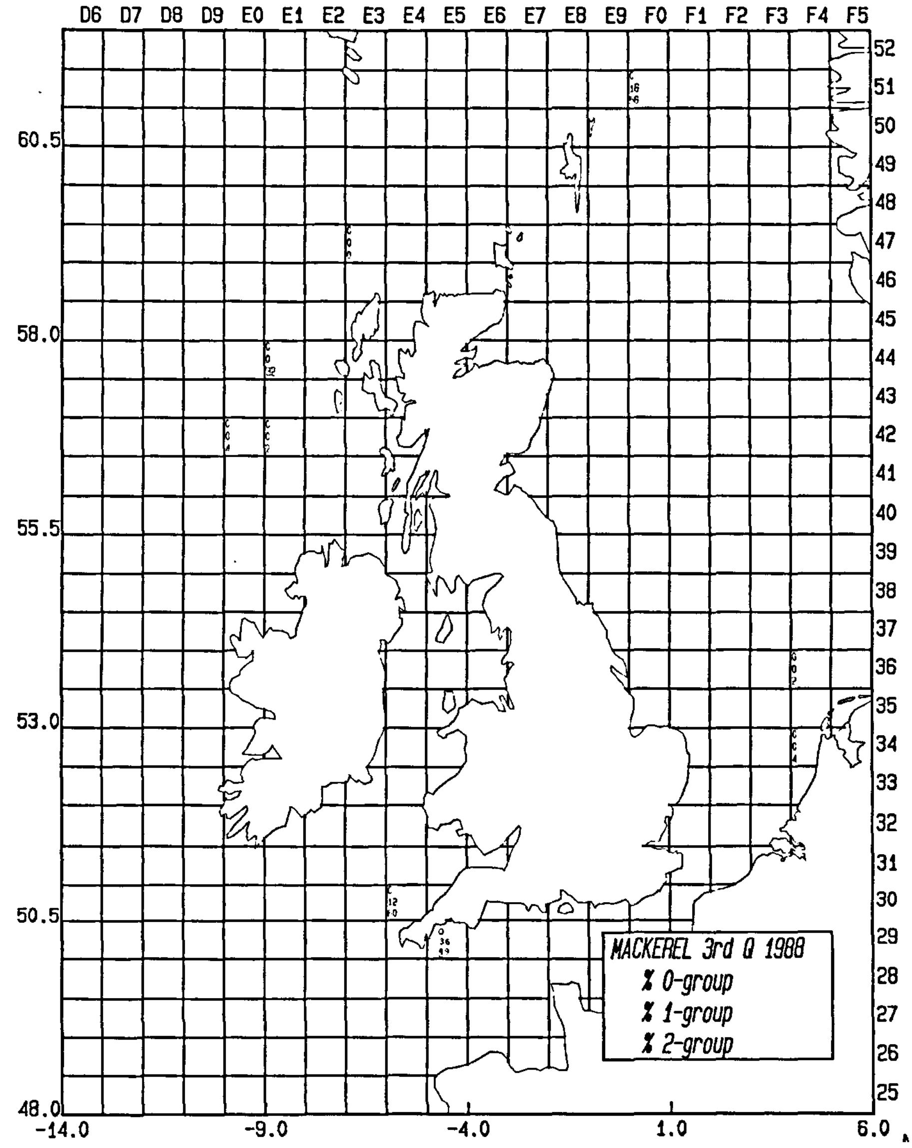


Figure 2.10 The percentage of 0-,1-and 2-group mackerel in the Dutch and English commercial catches by rectangle in the fourth quarter.

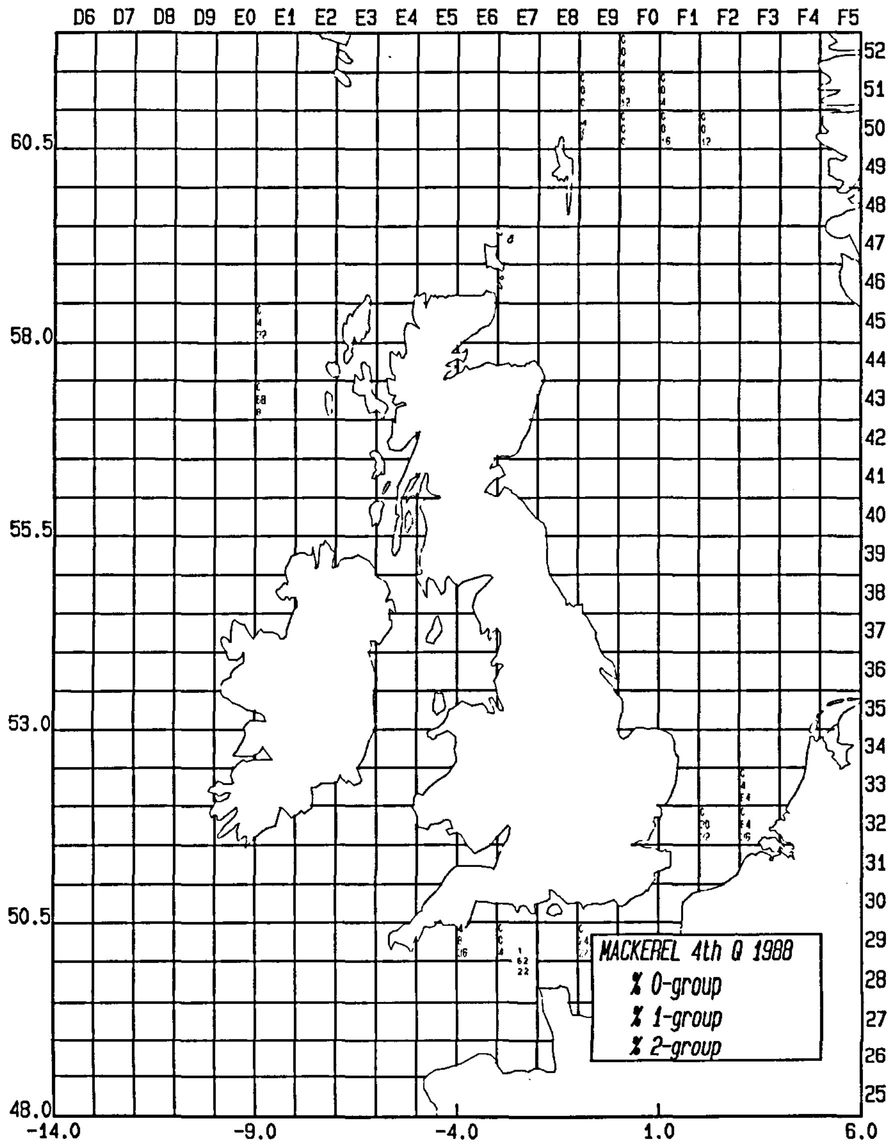


Figure 2.11 Mackerel 0/1-group survey indices vs. 1-group in numbers from VPA.

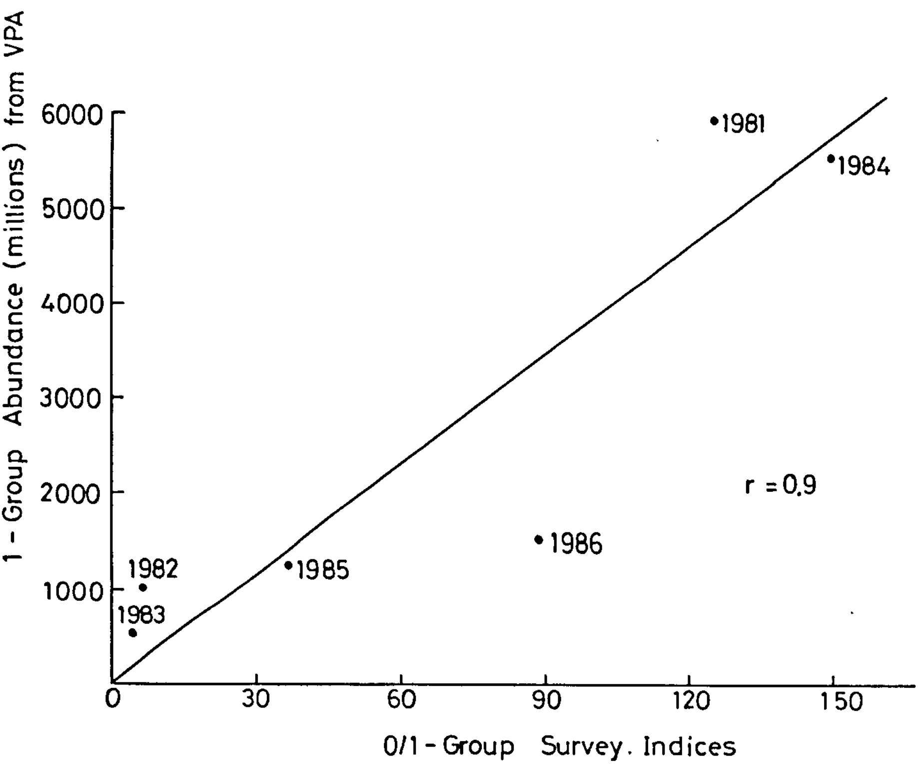


Figure 2.12 Mackerel 1/2-group survey indices vs 2-group in numbers from VPA.

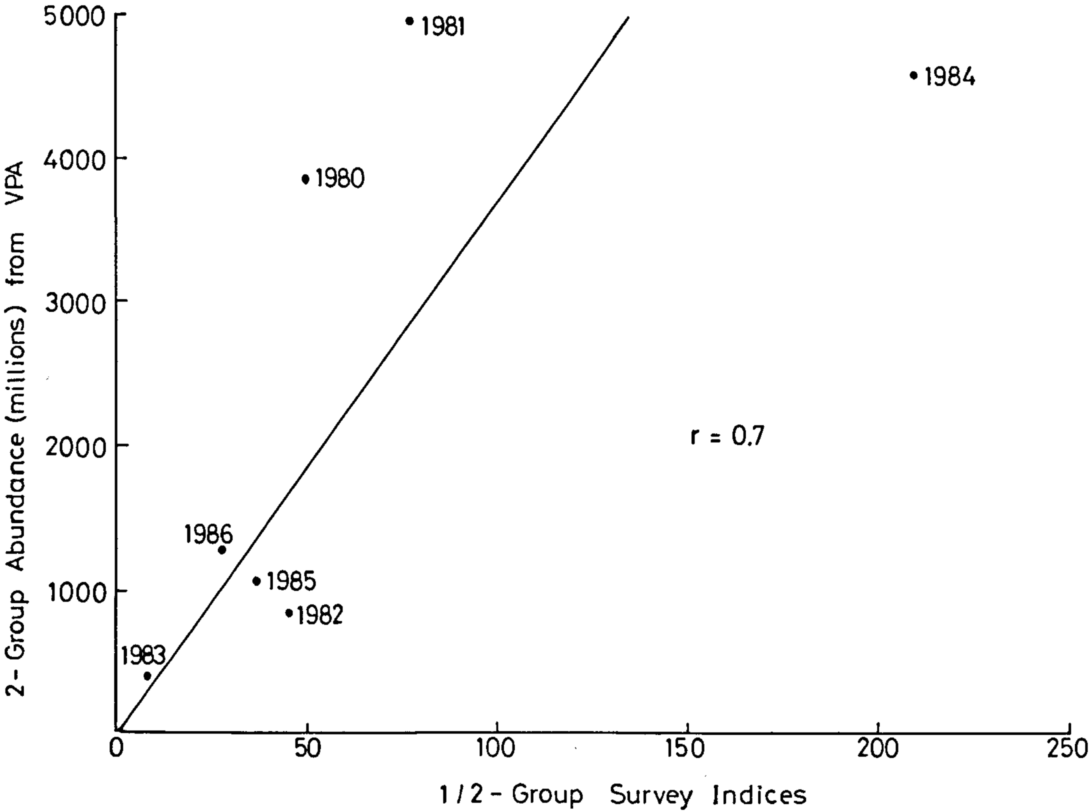


Figure 3.1 Selection patterns for different values of terminal S.

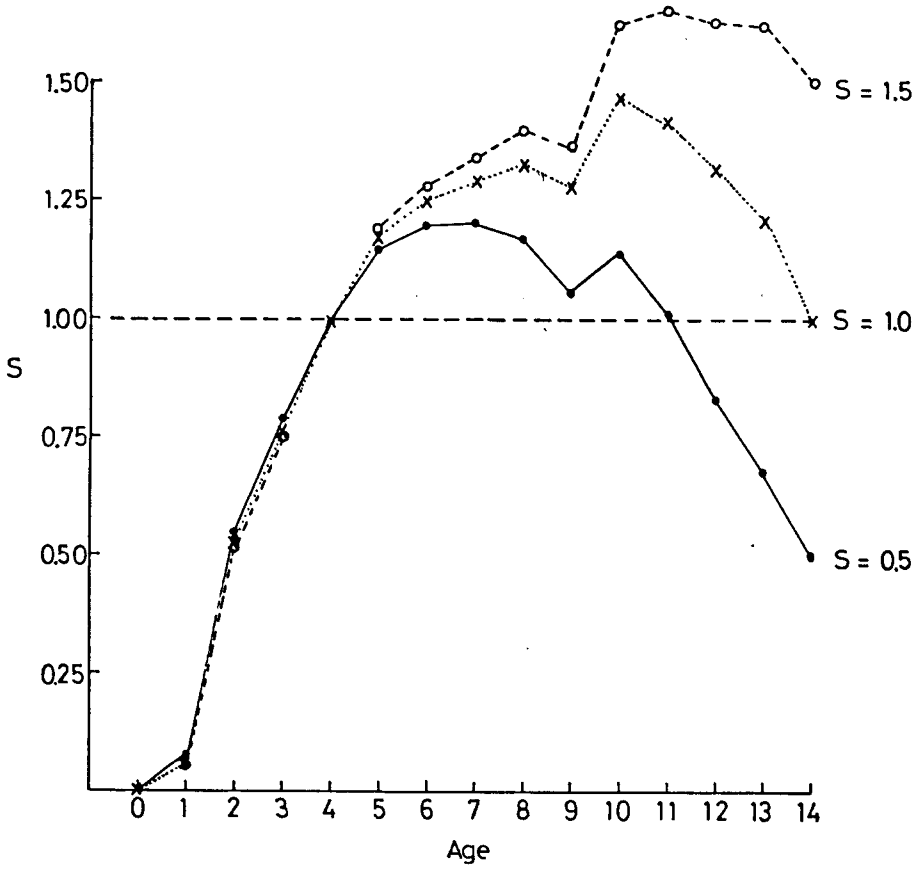
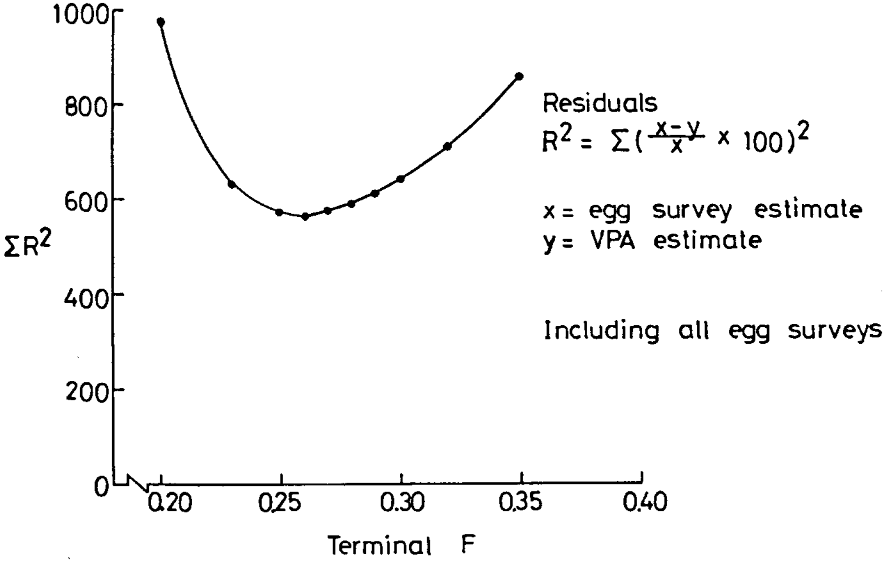
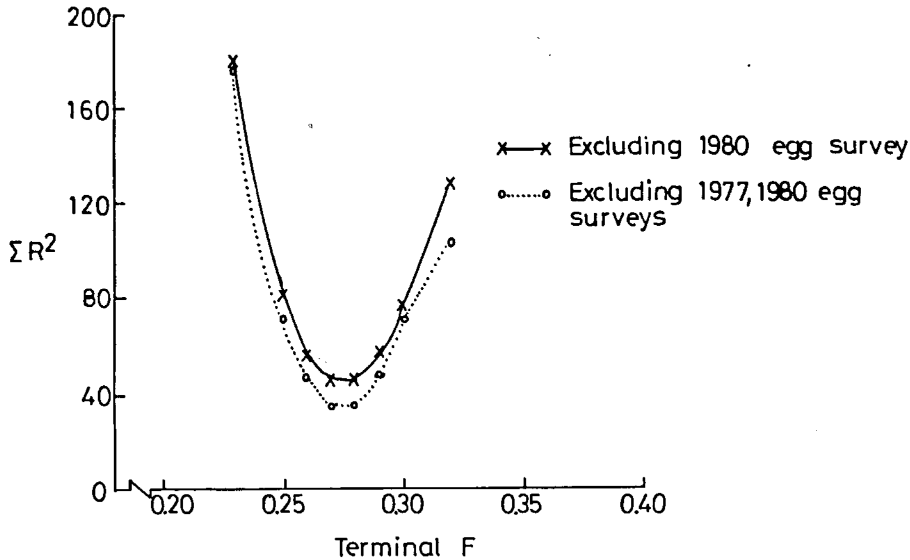


Figure 3.2 Sum of squared residuals against F at age 4-12+.





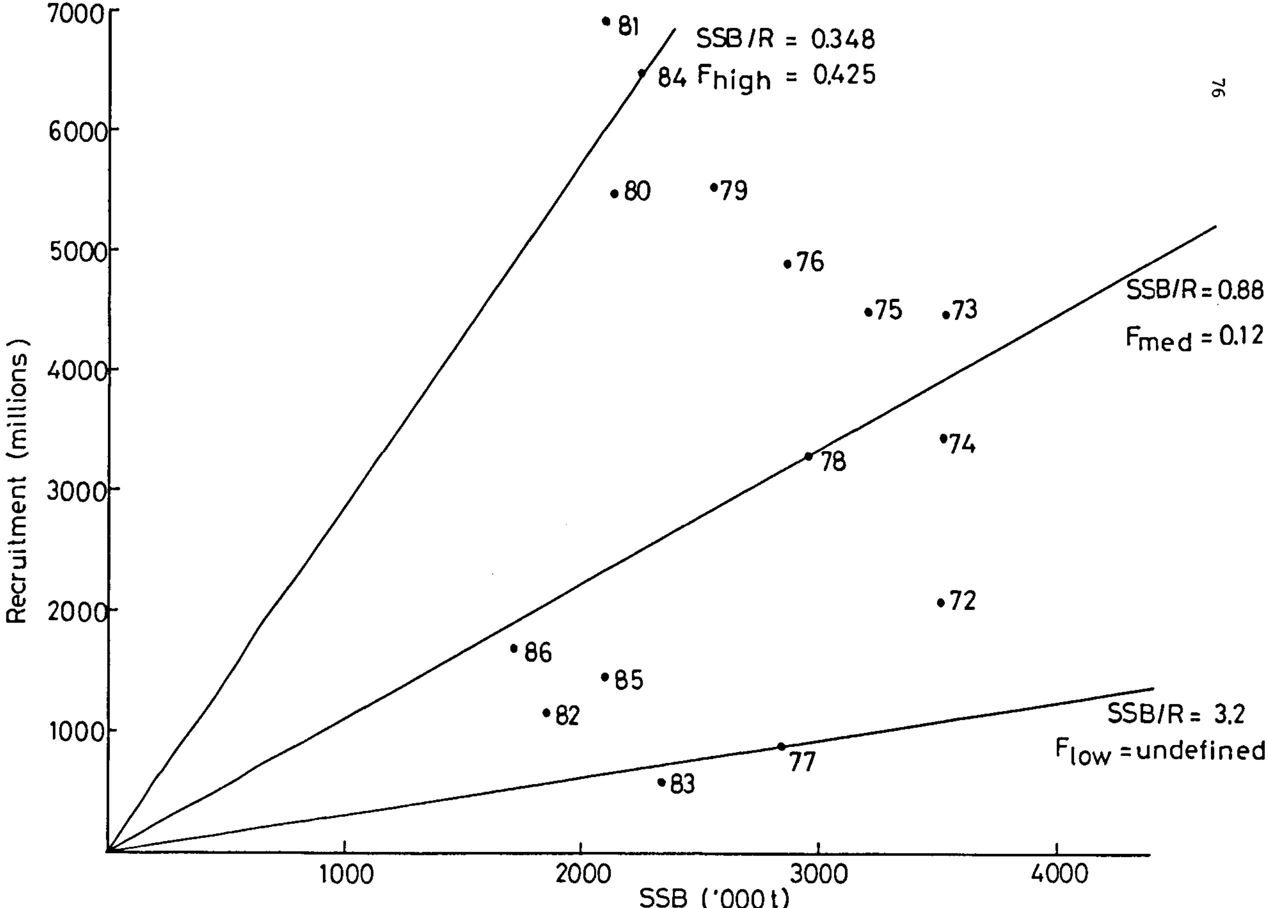
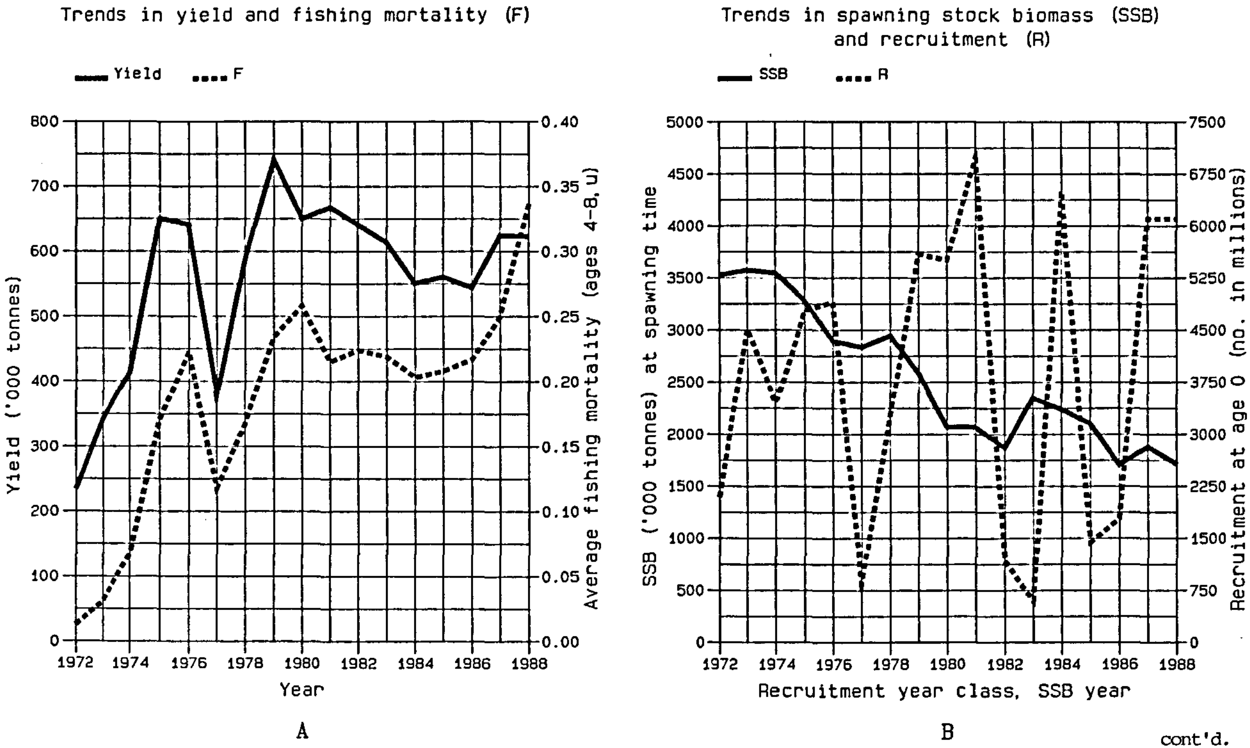


Figure 3.3 Western mackerel spawning stock-recruitment relationship.

Figure 3.4

FISH STOCK SUMMARY
STOCK: Mackerel, Western Stock
13-03-1989



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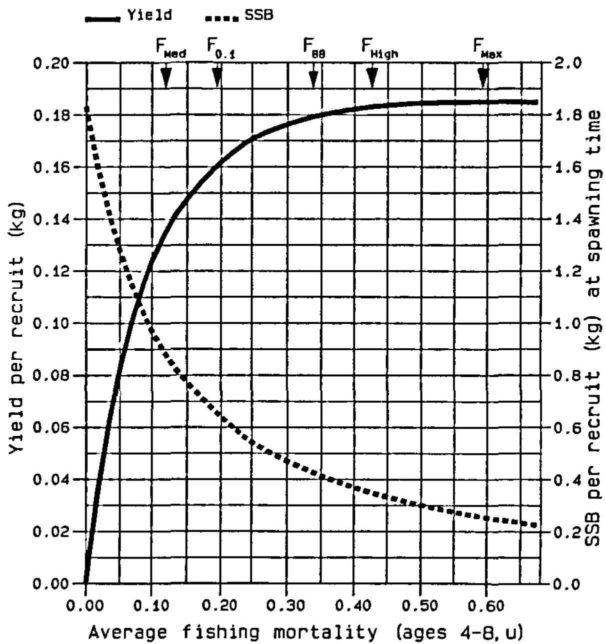
FISH STOCK SUMMARY
STOCK: Mackerel, Western Stock
13-03-1989

Figure 3.4 cont'd.

Long-term yield and spawning stock biomass



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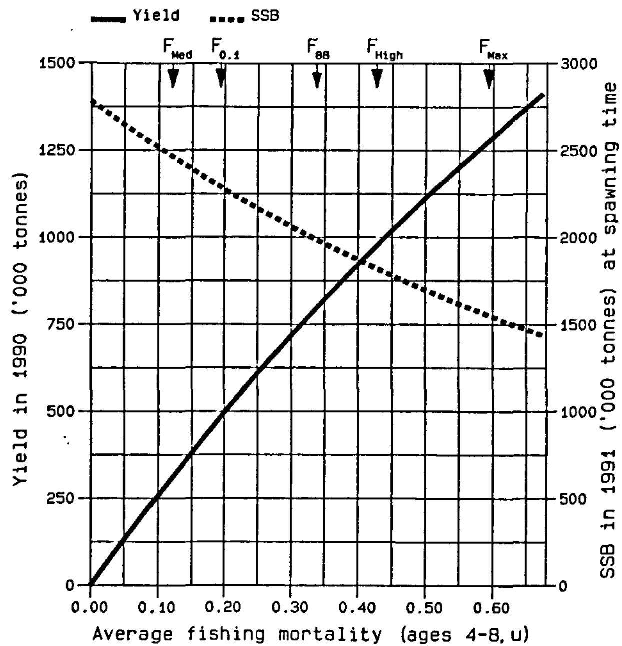
Short-term yield and spawning stock biomass



D

$F_{med} = 0.12$, $F_{0.1} = 0.19$, $F_{high} = 0.43$, $F_{max} = 0.59$

Figure 3.5 The occurrence of mackerel 30 cm expressed as a percentage by number for catches that could be allocated. NB. Data were not available for all catches, which are approximate. Catches for all gears and fleets are combined.

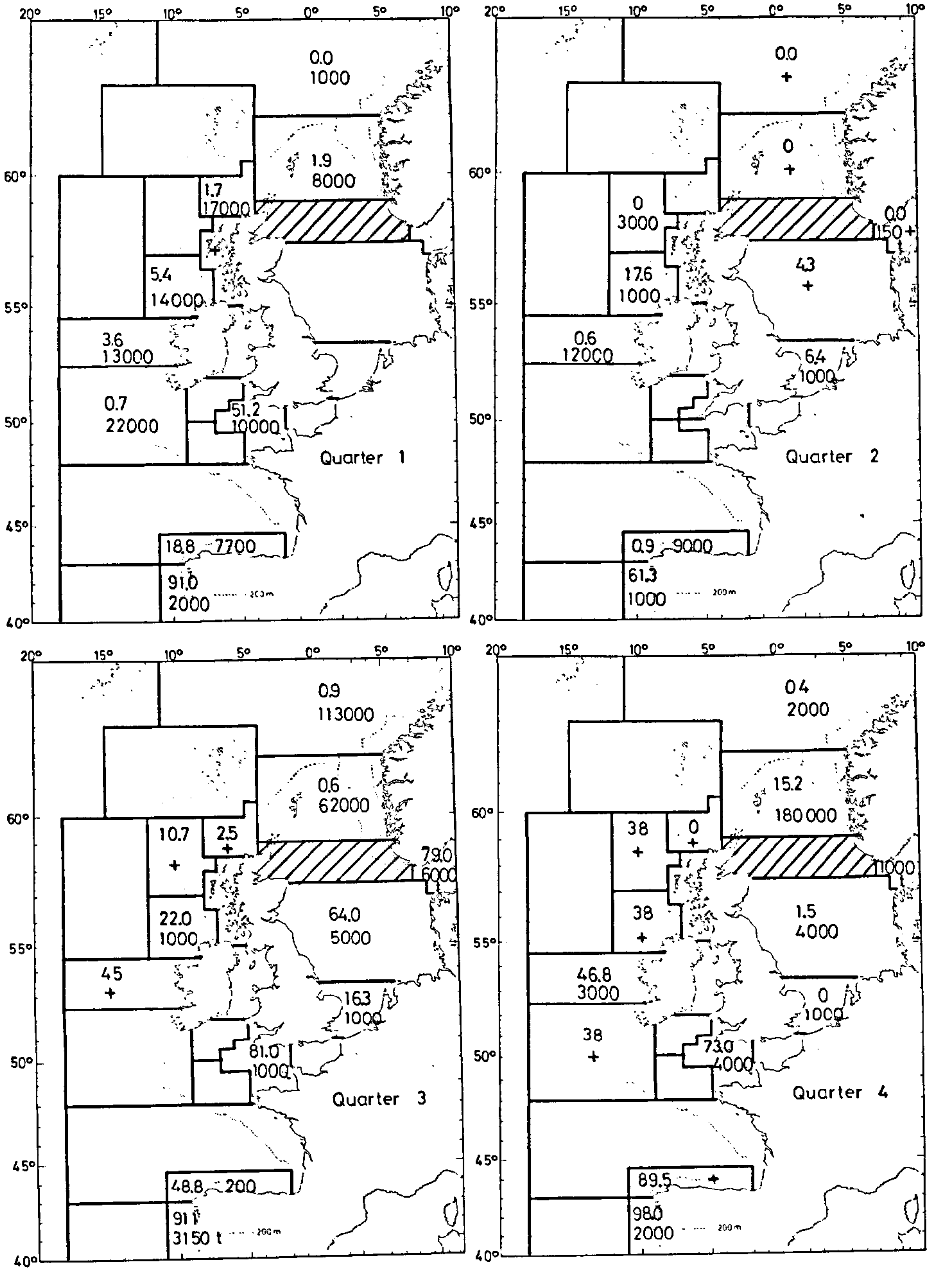


Figure 3.6 The percentage of mackerel smaller than 30 cm in the Dutch, Scottish and English commercial catches by rectangle in the first quarter in 1988.

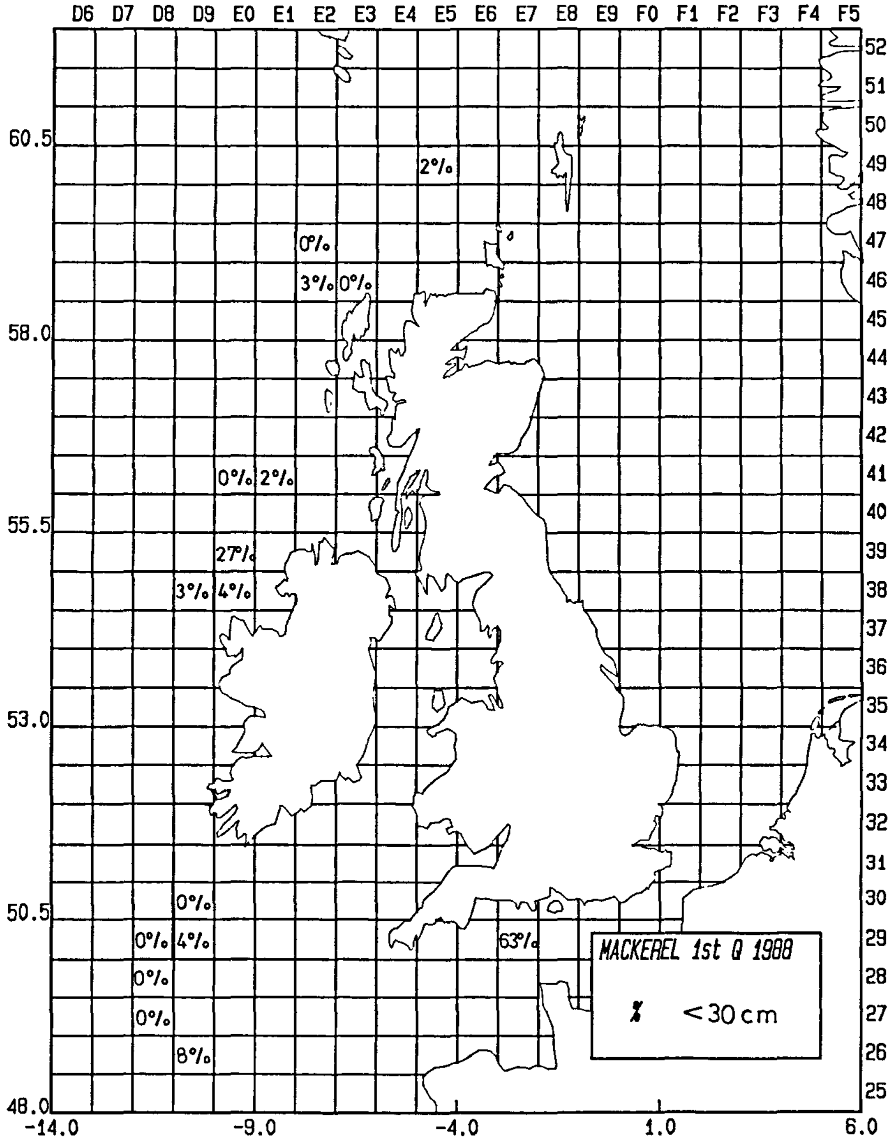


Figure 3.7 The percentage of mackerel smaller than 30 cm in the Dutch commercial catches by rectangle in the second quarter in 1988.

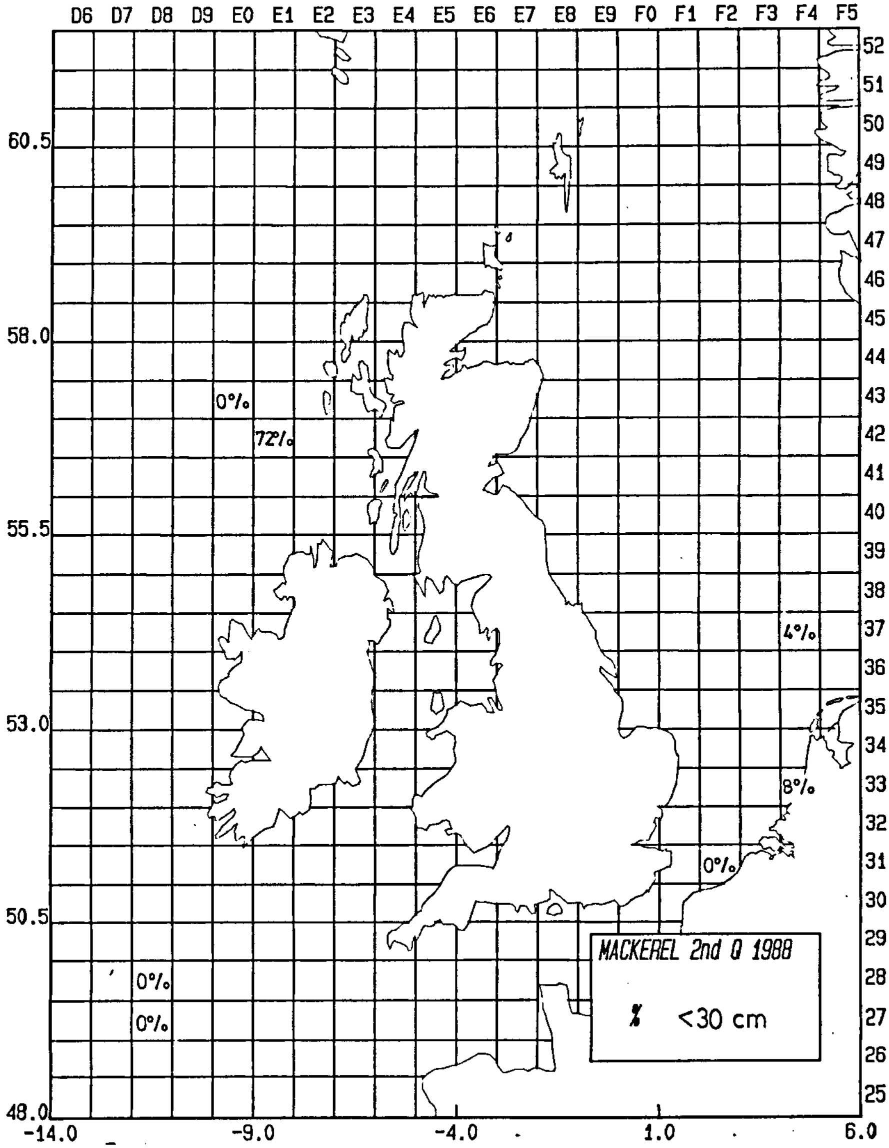


Figure 3.8 The percentage of mackerel smaller than 30 cm in the Dutch and Scottish commercial catches by rectangle in the third quarter in 1988.

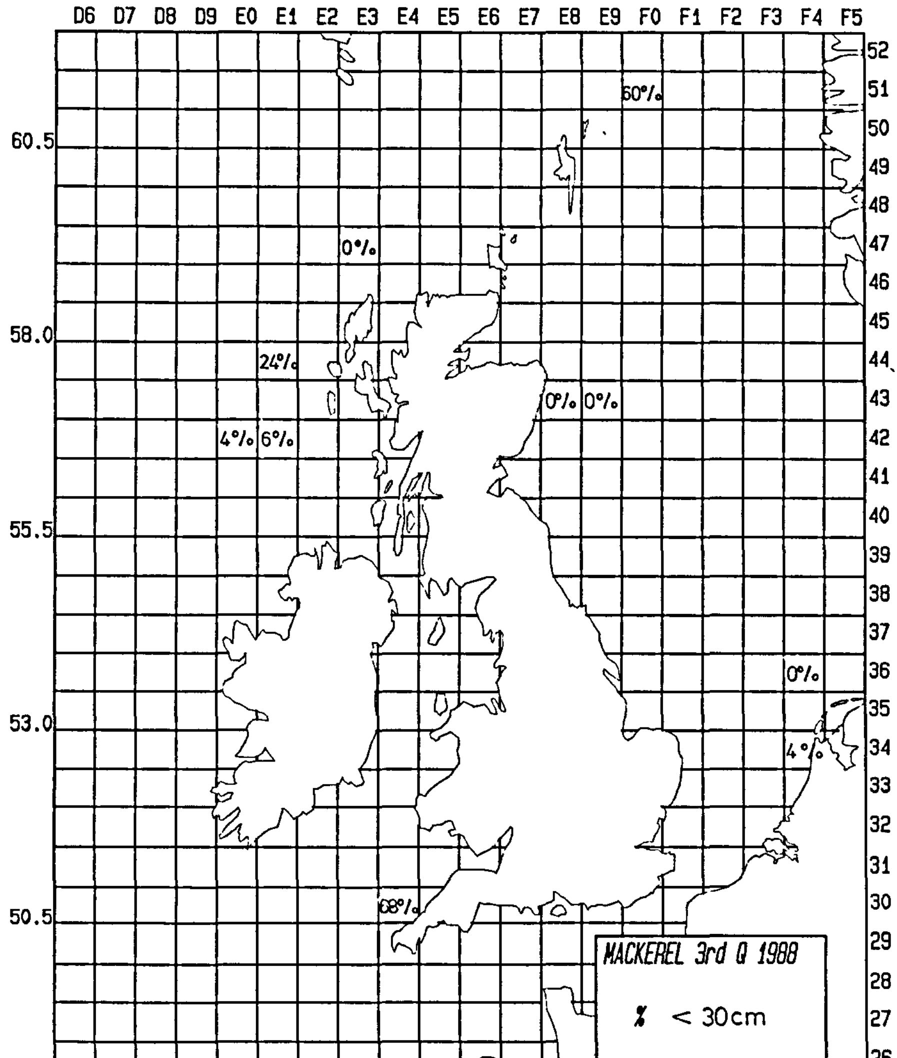
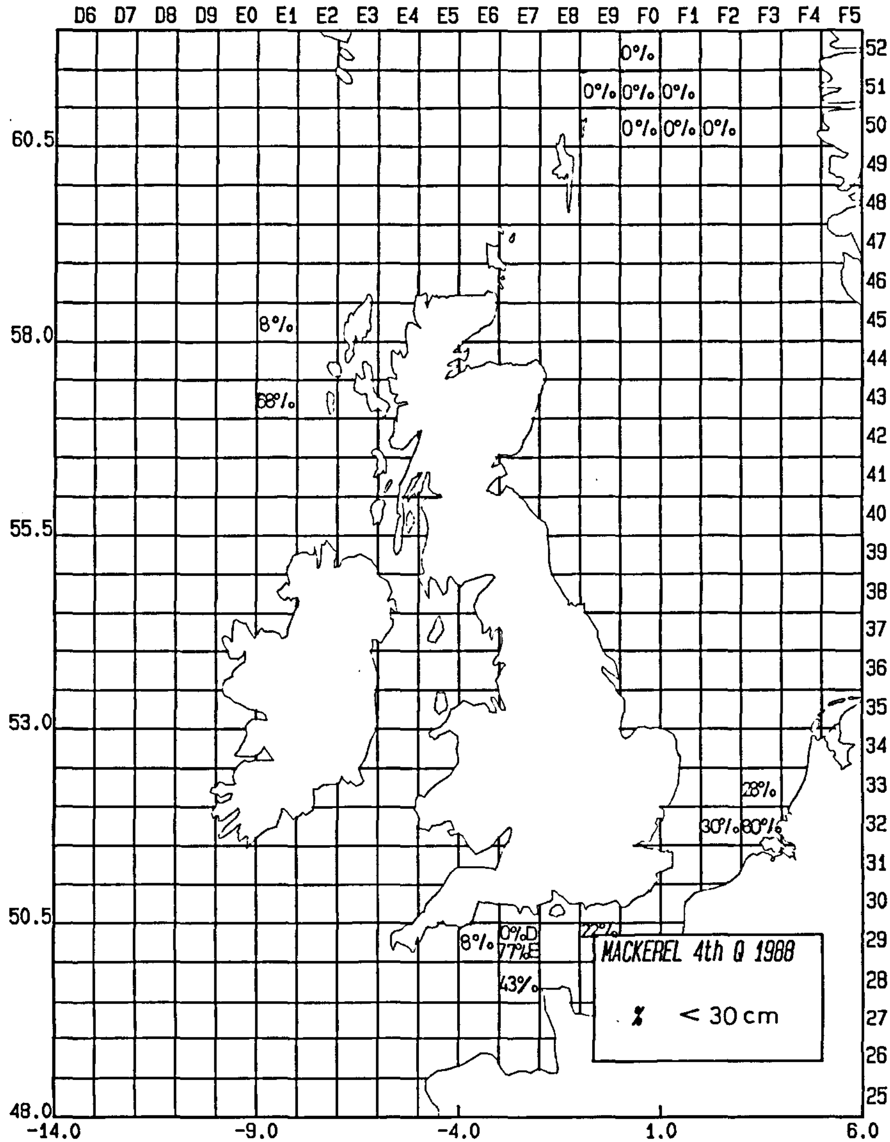


Figure 3.9 The percentage of mackerel smaller than 30 cm in the Dutch (D) and English (E) commercial catches by rectangle in the fourth quarter in 1988.



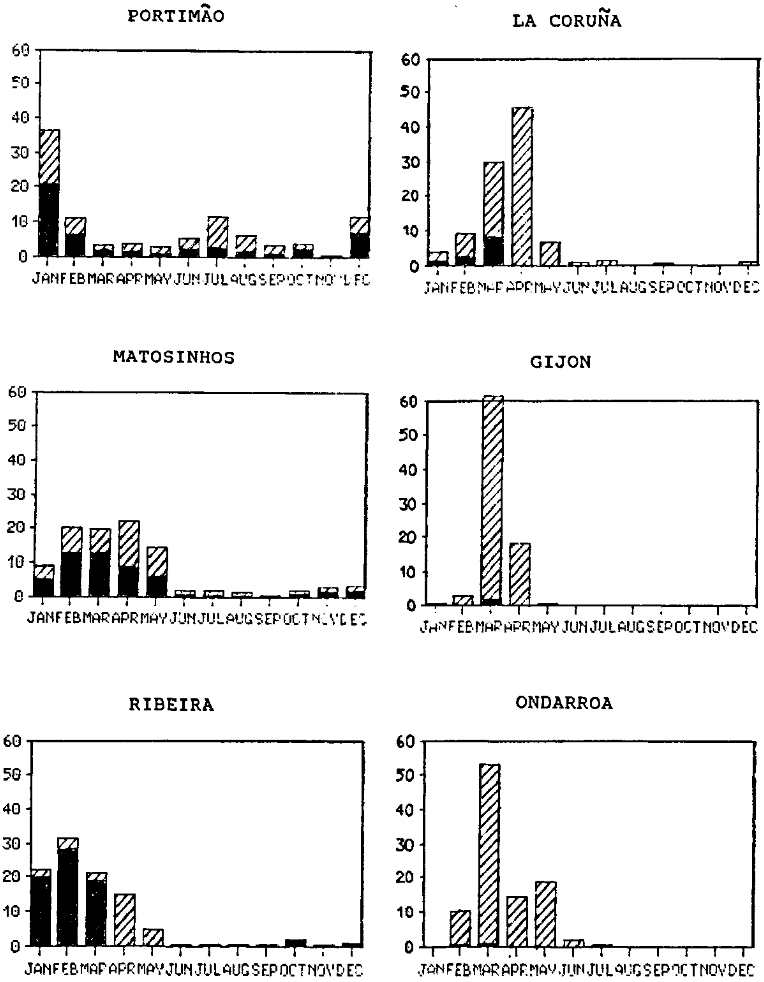


Figure 4.1 Monthly catches of selected trawl fleets, as in Table 4.1. Shaded areas correspond to catches of individuals ≤ 25 cm.

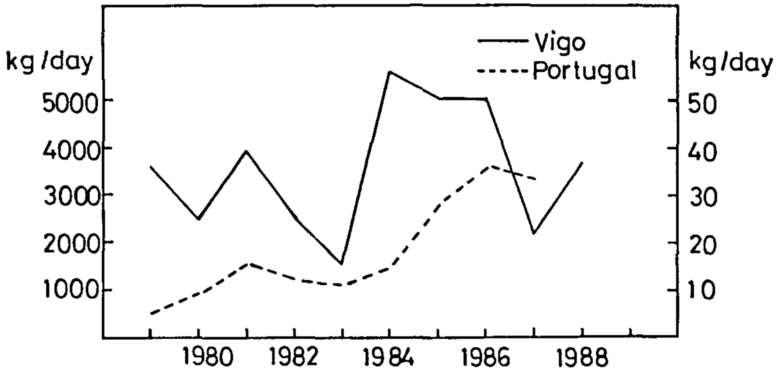


Figure 4.2 Indices of CPUE at Vigo (Division IXa, Spain) expressed in kg/landing days and at Portugal (Division IXa), in kg/h trawling.

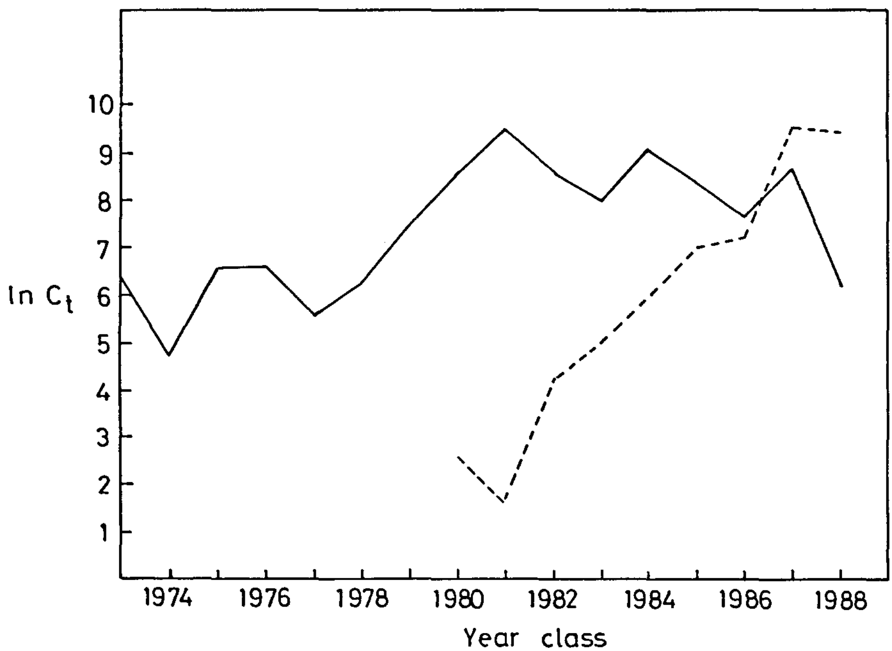


Figure 4.3 Catch curves for 1988 in Division VIIIc (full line) and in Portugal (Division IXa, broken line).