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International Council for the  
Exploration of the Sea

C.M.1986/Assess:12



**REPORT OF THE MACKEREL WORKING GROUP**

Copenhagen, 17-26 February 1986

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\*General Secretary  
ICES  
Palægade 2-4  
DK-1261 Copenhagen K  
Denmark

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## 1 INTRODUCTION

### 1.1 Terms of Reference

At the 73rd Statutory Meeting in London it was decided (C.Res.1985/2:3:2) that the Mackerel Working Group (Chairman: Dr. S.J. Lockwood) should meet at ICES headquarters from 17 February to 26 February 1986 to:

- a) consider the report of the Mackerel Egg Production Workshop;
- b) provide a comprehensive examination of the Norwegian tagging data used as a basis for estimating the rate of mixing between the North Sea and Western stocks of mackerel in Divisions IIa, Vb, and VIa and Sub-area IV;
- c) assess the status of and provide catch options for 1987 for the mackerel stocks in Sub-areas II-VII and Divisions VIIa and b within safe biological limits;
- d) specify safe biological limits for the two mackerel stocks;
- e) provide quarterly catch-at-age and mean weight-at-age data for 1985 for North Sea mackerel as input for the Multispecies VPA, and provide information on the likely level of the Western stock mackerel which are seasonally present in the North Sea;
- f) provide information relative to the following request from the EEC pertaining to the closed area for fishing for mackerel in Divisions VIIe,f,g: "ACFM is requested to evaluate the effect of this closure on the evolution of the Western mackerel stock and in the light of both this evaluation and the current state of this stock, in particular of its distribution, advise the Commission of the European Communities:
  - whether the existing provisions concerning the closed area should be retained in their present form, modified or completely repealed;
  - whether alternative or additional measures should be introduced and, if so, to advise what these measures should be.

If different opinions exist for achieving the objective of protecting the juvenile component of the stock, these should be described and their advantages and disadvantages examined".

In a letter from ACFM (20 January 1986), working groups were asked to provide a description of long-term potential for each stock.

In addition to the data requested in item (e) above, the ICES Statistician passed on a request that this Working Group should provide quarterly North Sea mackerel stock weight-at-age data

(1972 to 1985 inclusive). These data are required for the North Sea multispecies assessment.

### 1.2 Participation

The Working Group met in Copenhagen with the following participants:

E Bakken	Norway
A Eltink	Netherlands
E Kirkegaard	Denmark
S Lockwood (Chairman)	UK (England & Wales)
J Molloy	Ireland
M Walsh	UK (Scotland)
T Westgård	Norway

Dr. E.D. Anderson, ICES Statistician, also attended the meeting.

## 2 REVIEW OF THE MACKEREL EGG PRODUCTION WORKSHOP REPORT

The Mackerel Egg Production Workshop met in June 1985 to review certain aspects of earlier plankton surveys and to plan surveys for 1986 (Anon., 1985b).

A major aspect of work reviewed at the Workshop was the estimation of fecundity. No new data were available, but a new sampling programme was agreed for 1986. The statistical characteristics of earlier surveys were also discussed, but no major revisions resulted. The Workshop adhered to the egg production estimates and corresponding spawning stock sizes previously accepted by this Working Group.

New data were presented for estimating the percentage of the Western stock mature at age (but no changes were proposed for the North Sea stock). An analysis of Dutch data indicated that Western stock mackerel mature younger than was thought hitherto. The effect of the new data, when incorporated into an SVPA, was to reduce the spawning stock biomass by about 5% (Anon., 1985b).

While the change in spawning stock biomass may not be very great, the redistribution of age groups in the mature stock is significant. This facet of the Western stock assessment is discussed further under the Western stock assessment (Section 6.4.3).

## 3 SAFE BIOLOGICAL LIMITS

In recent years, the terms of reference to assessment working groups have included the instruction to formulate catch options "within safe biological limits". Hitherto, this Working Group has observed this requirement without defining limits specifically. In a letter to working group chairmen (20 January 1986), ACFM recommended the adoption of the approach outlined by the Irish Sea and Bristol Channel Working Group (Anon., 1985c).

- 1) "Is there any evidence from stock/recruit data that recruitment is reduced at the lowest levels of spawning stock which have been observed in the historic series?
- 2) Is the spawning stock currently at a level which is lower than any previously observed?
- 3) Does spawning biomass show a declining trend, which, taken with available evidence on recruitment, might indicate that a historically low level will be reached in 1986 or 1987?
- 4) What level of F in 1986 would be needed to reduce the spawning stock biomass to a historically low level in 1987 and what would the corresponding catch be in 1986?"

In addition, there are the guidelines set out by an earlier ad hoc ICES Working Group on the Biological Basis for Fisheries Management (Anon., 1977):

"For each stock there is a need to:

- a) define an optimal range of spawning stock size. This should be assessed either on the basis of a stock/recruitment analysis or chosen more arbitrarily on the basis of historical reviews of periods of "normal" recruitment;
- b) define an agreed minimum fishable biomass level; this may, or may not, differ from the minimum spawning stock level;
- c) assess the characteristics of the fishing pattern in relation to an optimised pattern".

Also, it was recommended (Anon., 1977) that "the TAC corresponding to  $F_{0.1}$  should be calculated in the first place. This TAC should then be modified against the objectives for "optimum fishing", i.e.,

- d) maintain the spawning stock size within the defined range; and
- e) keep the fishable biomass above the agreed minimum level.

Objective (d) must be considered as more important than (e)".

The answers to questions 1 - 4 above are covered specifically following the assessment and prognosis. At this point, however, the questions can be answered in a general way:

- 1) During the past decade, the North Sea mackerel spawning stock has decreased from one million tonnes to one tenth of that level. Throughout this period, the average level of recruitment has been insufficient to maintain the concurrent spawning stock in number (Figure 3.1).
- 2) Both North Sea and Western spawning stocks are at a (recorded) all-time low.

- 3) The general trend is for a continuing decline in the spawning stock biomass of both the North Sea and Western stock.
- 4) Any fishery in the North Sea in 1986/87 will drive the stock even lower. A fishing mortality greater than  $F_{2-10} = 0.3$  might be expected to reduce the Western spawning stock even further.

The points covered in the ad hoc Working Group Report (Anon., 1977) can be covered in a generalised sense also. They are taken in the order listed (a) to (e) above.

### 3.1 Optimum Range of Spawning stock biomass

The optimum level of spawning stock biomass might be defined as that level which, on average, produces sufficient recruits to realise the long-term potential of the stock (see also Section 3.4)

The Working Group does not have stock and recruitment data which may be fitted to a stock and recruitment model with either confidence or universal acceptance. Therefore, the Group prefers to adopt the "arbitrarily" "historic review" of "normal recruitment".

We have estimates of high spawning stock biomasses (ca. 3.0 million tonnes) for both the North Sea stock in the 1960's (Hamre, 1978; 1980) and the Western stock in the 1970's (Lockwood et al., 1981). We do not have estimates of this magnitude for both stocks simultaneously; consequently, we cannot be certain that both stocks can be of this magnitude at the same time. However, we do have concurrent estimates of recruitment for a depleted (North Sea) stock and a large (Western) stock.

For the past decade, the North Sea mackerel stock has been less than 1 million tonnes (Anon., 1985a). Over this period, recruitment has been insufficient to maintain a stable stock in number, even if there had been no fishing (Lockwood, 1983; Lockwood, in press). Over the same period, the Western mackerel stock has been well over one million tonnes and, with the exception of three weak year classes (1977, 1982 and 1983), has produced more than enough recruits to maintain a stable stock in number (Figure 3.1).

On the basis of these two sets of observations, the Working Group suggests that, at some spawning stock level around (but not precisely) one million tonnes, the stock-recruitment relationship may go critical. Above this level, average recruitment may be adequate; below this level, average recruitment may become inadequate. On the assumption that this simplified relationship holds true, fishery managers should take a very firm control of mackerel fisheries on stocks at, or decreasing toward, one million tonnes. Even then, natural phenomena may result in failing recruitment.



### 3.2 Minimum Fishable Biomass

Just as it is not possible to state precisely what the lower end of the range for optimum spawning biomass is, it is not possible to define precisely the minimum fishable biomass. Suffice to say that, as indicated in Section 3.1 above, the fishery managers should take very firm control of all mackerel fisheries on stocks at, or declining toward, one million tonnes.

The results from the 1986 plankton survey of the Western stock will show how close the spawning stock is to one million tonnes, but it is the view of the Working Group that the North Sea stock is well below the biomass at which all exploitation should cease.

### 3.3 Optimum Fishing Pattern

The characteristics of the fishing pattern in the North Sea area are that most, but not all, fishing takes place to the north of the centre of spawning and important nursery areas. Also, most fishing occurs after the spawning season. These are characteristics which are to be encouraged.

The Western area fishing pattern is less than ideal. Throughout the 1970's, there was an increasing trend to concentrate on juvenile fish around the Cornwall peninsula (Divisions VIIe,f). The so-called "Box" around Cornwall (see Section 8.1) was introduced to reduce the adverse affects resulting from this trend. Lockwood and Shepherd (1984) argued that 25-30% greater yield might be taken from a more stable stock if fishing were concentrated on adult fish (more than 30 cm or 3 years of age) along the shelf edge and west of Scotland to the north of the nursery areas.

Recent shifts in the distribution of adult fish have resulted in shifts in the main Western fisheries (Anon., 1985a) toward the pattern advocated by Lockwood and Shepherd (1984). However, recent shifts in the distribution of juvenile fish (see Section 4.2) have diminished the potential benefits which might accrue from the change in fishing pattern. Nevertheless, the same characteristics hold true for optimum fishing pattern, i.e., the main fisheries should be concentrated in those areas where adult fish may be caught in the absence of juvenile fish, thereby maximising yield per recruit.

It must be appreciated also that a higher yield for a given level of  $F$  might be realised if fisheries are concentrated in the third quarter of the year. This benefit results from the seasonal growth characteristics of mackerel, which are in peak condition at this time.

### 3.4 Long-Term Potential

The first step in realising the long-term potential for any stock must be to control the fisheries so that the annual catch is no more than the current stock can sustain, usually assumed to be a catch equivalent to  $F_{0.1}$  (Anon., 1977). In the case of the North Sea stock at present, any exploitation at any level will run counter to achieving long-term potential. For the Western stock, catches not exceeding  $F_{0.1}$  should initiate a period of stock

stability during which time long-term potential might be assessed fully and quantified.

The average stable yield from a stock is the product of average recruitment and the yield per recruit. Thus, the long-term potential for a stock will be realised by that spawning stock biomass which can maintain the average "normal" recruitment at the corresponding "normal" yield per recruit.

Over a spawning stock biomass ranging from 2.0 to 3.5 million tonnes, the Western mackerel spawning stock has maintained "normal" recruitment levels of 3,000 to 4,000 million 1-year-old fish (Figure 3.2) (notable exceptions being the 1977, 1982 and 1983 year classes). The corresponding yield per recruit has been about 160 g (Anon., 1985a). These data indicate a long-term potential yield of 450,000 to 650,000 tonnes.

#### 4 STOCK DISTRIBUTION AND MIXING

##### 4.1 Review of Information on Stocks

At the last meeting of this Working Group, a major effort was made to review all the available data on stock separation (Anon., 1985a). A further four Working Documents on this topic were presented for discussion at this meeting. The conclusions drawn from them were relevant to the assessments made subsequently.

An analysis of Norwegian tagging data (Bakken and Westgård) looked at the mixing ratios of tags recaptured in seven separate fisheries, following release from taggings off Ireland and southern Norway. They considered three hypotheses:

- there is total mixing, with only a single stock;
- there are two separate stocks, with no mixing;
- there is mixing, seasonal or permanent, of more than one stock.

On the basis of tag recapture ratios, the second hypothesis, isolated stocks, is quickly eliminated. Tags from releases in one area are often recovered in the other release area, showing that there is intermixing.

If the ratio of Irish tag recaptures to North Sea tag recaptures were constant in all areas, one could accept the single-stock hypothesis. The data presented show the ratio of Irish to North Sea tags decreasing with increasing distance from the release area. From these data, the conclusion is that there is more than one stock.

A further two Working Documents (Dawson and Hopkins) describe detailed statistical analyses of otolith L<sub>1</sub> characteristics from different sampling areas. Both are at an interim stage and neither author is prepared to draw a firm conclusion from their analyses at this stage. However, they do not present any reason for overturning the two-stock concept.

The fourth Document (Eltink) presented a revised account of evidence linking mackerel found in the southern and central North Sea in summer with those found in the Celtic Sea area in winter and spring. These links raise the possibility that there may be some transfer, an "overspill", of mature mackerel from one spawning area to the other. At present, there are no data for a quantitative examination of this possibility.

On the basis of the data presented in the Working Documents, in addition to evidence discussed at earlier meetings, the Working Group retains the view that there are two principal stocks: the North Sea spawning stock and the Western spawning stock. The Group does not believe that past, present, or future difficulties in identifying stock components for assessment purposes is justification for dismissing the biological evidence for two stocks.

On the basis of the tagging data and the seasonal distribution of the fisheries, it is concluded that a large proportion of the stock which spawns to the southwest of Ireland and in the Celtic Sea during March to June makes a post-spawning migration along the west coasts of Ireland and Scotland. During the summer and early autumn, the shoals appear in Division IIa and the North Sea where they feed heavily. A proportion migrates as far east as the Norwegian and Danish coasts. The shoals appear to leave the North Sea and Division IIa during the autumn and move towards the west of Shetland and northwest of Scotland. During late autumn and winter, they are found along the 200-metre line, to the west of Scotland and Ireland, where they appear to overwinter before moving further south to the spawning grounds. This latter movement was confirmed by large concentrations of mackerel west of Ireland (Jan-Feb 1986) described in a Working Document (Molloy) presented to the meeting. However, it was not possible to quantify these concentrations because of inadequate data about the full extent or density of the shoals.

A small portion of the Western spawning stock migrates eastward, after spawning, through the English Channel.

The stock that spawns in the North Sea and Division IIIa appears to remain in that area, and possibly in Division IIa, during the summer. Some fish may still overwinter in the traditional overwintering quarters in the deep water along the Norwegian coast and some may move, together with Western stock fish, to the overwintering quarters to the west of Scotland and Ireland. A small part of the North Sea spawning stock also migrates westward through the English Channel to overwinter in the Celtic Sea area.

The Working Group's suggested interpretation of recent seasonal migrations of mackerel from western areas to and from the North Sea is shown in Figure 4.1.

## 4.2 Recent Changes in Distribution

### 4.2.1 Juvenile distribution

The 1985 Working Group discussed the apparent recent changes in the distribution of juveniles of the Western stock. These changes were illustrated by comparing the ratios of the catches of juveniles (1- and 2-year-olds) from Division VIa to total catches of juveniles in the Western stock with the ratio of total catches of the Western stock in Division VIa to the total catch of the Western stock. As the proportion of the total Western stock in Division VIa increased, there was a tendency for the catches of juveniles to increase proportionally. From 1982, however, there has been a dramatic change and the proportion of juvenile fish caught in Division VIa has increased at a much higher rate than the increase in total catch taken in Division VIa (Table 4.1 and Figure 4.2).

### 4.2.2 The 1984 year class

The seasonal distribution of abundance indices has been plotted in Figures 4.3a-d. The abundance indices were derived from research vessel trawl surveys by England (first and fourth quarters, 1984 and 1985), Ireland (fourth quarter, 1985), Netherlands (fourth quarter, 1984 and 1985) and Scotland (first, third and fourth quarters, 1985). The distribution of the 1984 year class in commercial catches is also shown. During the winter of 1984/85 (Figure 4.3a), the year class was found to be very abundant on the outer edge of the continental shelf west of Scotland and south of Ireland, but scarce in the North Sea. The abundance of the year class in research vessel catches west of Scotland was an unusual feature, compared to the previous four years, as was the northward extent of the distribution. South of Ireland, the distribution was more westerly than in previous years. The low abundance in the North Sea, compared to previous survey data on strong North Sea year classes, e.g., those of 1969 and 1974 (Walsh, 1974; 1977), suggests that the year class was weak in the North Sea, although the possibility of high abundance in the Norwegian deeps and Skagerrak cannot be precluded.

During the second quarter of 1985 (Figure 4.3b), the year class appeared once more in commercial catches west of Scotland, itself an unusual feature, confirming the unusual northward extent and abundance of the year class. A single research vessel haul made on the boundary between Divisions IVa, Va and VIa in June, consisted almost entirely (98%) of the year class. They were also present in small commercial catches taken by Irish vessels off northwest Ireland. The year class was observed also in May in research vessel catches in the Skagerrak, but was otherwise absent from samples taken in the North Sea and Skagerrak.

During the third quarter of 1985 (Figure 4.3c), the year class was unusually abundant in sampled catches both from the west of Britain and in the North Sea and Skagerrak. Within the North Sea,

it was concentrated on the eastern side. Reports of high abundance were made from Norwegian fjords along the entire North Sea coastline. A Working Document (Kirkegaard), giving provisional results from a Danish acoustic survey off northwest Denmark, indicated an exceptionally high abundance there in July-August.

From October to mid-November (Figure 4.4d), the abundance of the year class, and its relative proportion in the commercial catches, remained high in the Skagerrak and in the southeastern part of the North Sea. Danish sampling of these areas indicated its subsequent disappearance from industrial catches in November and December. In October 1985, a Norwegian survey (Working Document, Iversen and Westgård) covered the Skagerrak and northern part of the North Sea and to the west of the Shetlands. The results from the survey indicated high abundance of the 1984 year class in Division IIIa and low abundance in other parts of the surveyed area. This also fits in with a Norwegian research vessel survey between the western coast of Norway and Shetland in November 1985; no mackerel below 30 cm were found in the area (A. Aglen, pers. comm.).

Limited research vessel sampling of the North Sea in February 1986 also indicated low abundance by then.

West of the British Isles, the year class was absent from October and early November in the main winter fishery, which started north of Scotland near the boundary of Divisions IVa and VIa. Its abundance increased rapidly in the northern part of Division VIa from mid-November onwards as immigration took place from the North Sea. The relative abundance of the year class in the catches remained high as the fishery shifted into the southern part of Division VIa between December and January. Off the southwest of Britain, the year class was also abundant in research vessel catches south of Cornwall and towards the shelf edge in the same latitudes.

#### 4.2.3 The 1985 year class

The distribution of this year class, as indicated by research vessel survey data (see Section 4.2.2) is shown in Figure 4.4. Abundance was again very low in the sampled areas of the North Sea, but relatively high to the west of the British Isles, with centres of abundance off Cornwall, Donegal Bay and along the continental shelf edge south of Ireland. Apart from one good haul in Donegal Bay, the 1985 year class was scarce in Division VIa.

### 4.3 Allocation of Catches to Stocks

#### 4.3.1 Division IIa

In previous years, stock mixing ratios were calculated from Norwegian tagging data and the ratios were applied to all age groups 3 years and older in the catches (Anon., 1985a). All fish of the younger age groups were assumed to be of the North Sea stock.

The same procedure was followed for catches in 1985. The mixing ratio was calculated from returns in 1985 given in Table 4.2, excluding returns from 1985 releases (105 returns from North Sea releases, 108 from releases off Ireland). The North Sea stock, 3 years and older, was set at 238.2 million and the Western stock at 5,188.7 million as computed by the most recent VPA (Anon., 1985a).

The proportion of North Sea stock in Division IIa in 1985 was calculated to be 0.05, and this proportion was applied to the catches in number of fish older than 3 years. (Table 5.4). The resulting catch in number by age by stock is given in Tables 5.5 and 6.4.

#### 4.3.2 Division IVa

The Working Group decided to follow the same procedure as used in 1985 when allocating catches to stocks (Anon., 1985a). Catches taken in the northern part of Division IVa, i.e., north of 59°N, were treated as were catches in Division IIa.

Reports of Norwegian catches by statistical rectangles of Division IVa were available. As catches by Norway accounted for 75% of the total, the distribution of their fishery by area was considered representative and was used as a basis for estimating the catch taken north of 59°N. In doing this, offshore catches only were considered, and 10,063 tonnes were estimated to have been taken in the northern part of Division IVa. This tonnage accounted for 26% of the total catch in Division IVa, and this percentage was applied to the Division IVa catch in number (Section 5.2.1) for all age groups. The resultant catch in numbers is given in Table 5.4.

As outlined above, 10,063 tonnes of mackerel were taken north of 59°N and 28,700 tonnes south of this latitude in Division IVa. Catches from the northern part were allocated to stock by applying the same proportion as that used for Division IIa catches, i.e., 0.05 to the North Sea stock and 0.95 to the Western stock. As for previous years, fish of age 1 and 2 were assumed to be entirely of the North Sea stock.

Data presented to the Group in a Working Document (Bakken and Westgård) indicated that the stock mixing just north (Division IIa) and south of the sub-area border (62°N) was similar. A test fishery was conducted in September-October 1985 in an area 58°-61°N and 2°-4°E. Landings of about 1,600 tonnes from this fishery were screened for tags, and 9 tags from releases in 1978-84 were returned. The returns, although very few, indicated a mixing proportion of 0.06 North Sea fish, which is similar to that calculated for Division IIa.

On the basis of these data, an estimated 10,063 tonnes of North Sea stock were taken in the northern part of Division IVa and 28,700 tonnes in the southern part (Table 5.5).

### 4.3.3 Division VIa

As in previous years, mixing of the two stocks in Division VIa was assumed to occur only in the area north of 58°N in the periods January-March and October-December (Anon., 1985a).

Tag recaptures from three fisheries in this area were available a) by Scotland, first quarter, b) by Scotland, fourth quarter and c) by Norway, fourth quarter (Table 4.2). The following proportions of North Sea mackerel were estimated:

a)	0.06
b)	0.06
c)	0.08
<hr/>	
mean	0.07

The Working Group decided to use the mean value of 0.07 rather than a rounded value of 0.10, as in the previous four years, in view of the larger numbers of tags recaptured from this division in 1985 compared to earlier years.

All age 1 and 2 fish and catches taken in the second and third quarters, together with catches taken south of 58°N in Division VIa, were assumed to be from the Western stock. The catch in number at age for the North Sea stock is given in Table 5.5 and for the Western stock in Table 6.4.

## 5 NORTH SEA AND NORWEGIAN SEA AREAS

### 5.1 The Fishery in 1985

Total landings for 1976-85 by country are shown in Table 5.1 for the North Sea, Skagerrak and Kattegat (Sub-area IV and Division IIIa) and in Table 5.2 for the Norwegian Sea (Division IIa). The catches in 1984 and 1983 were revised according to updated reports, and the recorded catches were increased by the following tonnages:

Year	Area	Tonnes
1983	IV + IIIa	770
1984	IV + IIIa	138
1983	IIa	-
1984	IIa	4,292

The total landings from the North Sea, Skagerrak and Kattegat in 1985 were 49,016 tonnes (an increase of 24% from 1984), of which 63% was taken by Norway, 25% by Denmark and 5% by the Netherlands. The reported landings are substantially higher than the TAC of 37,000 tonnes agreed by Norway and the EEC.

The catch in Division IIa was 71,500 tonnes and in Division Vb 6,400 tonnes, a reduction of about 16,000 tonnes (down 17%) compared to catches in the two divisions in 1984. Most of the catch was taken by Norway during July-September in Division IIa south of 63°30'N and east of 2°E.

The quarterly distribution of the catches by sub-areas and divisions is shown in Table 5.3. The total catch of the North Sea stock in 1985 was estimated at about 63,400 tonnes (Table 5.5).

## 5.2 Assessment of the North Sea Stock

### 5.2.1 Catch in number, 1985

The catch in number at age in Sub-area IV and Divisions IIa, IIIa and Vb is shown in Table 5.4.

#### Division IIa

The Danish and Soviet catches were allocated to numbers using Norwegian data. There was a minor French catch in the Division which was also divided into numbers at age using Norwegian data.

#### Division IIIa

The Swedish catch was allocated into quarters of the year using the combined Norwegian and Danish data.

The Danish and Swedish landings in the second quarter were split into age groups using the Norwegian samples. In the third quarter, the Norwegian data were not representative for a major part of the Danish catch, because they were from two different fisheries. Therefore, 60% of the Danish catch was allocated to age groups using data from an acoustic survey carried out by the R/V "Dana" in July-August 1985. The rest of the Danish catch was split using Norwegian data. The Swedish catch in the third quarter was split using the combined Norwegian and Danish age compositions.

#### Division IVa

Landings of 38,763 tonnes were reported from Division IVa. Norwegian landings accounted for about 75% and most of the remainder by Denmark and the Netherlands. Insignificant catches were reported by other countries.

Catch in number at age by quarter was available from Norway, the Netherlands and Denmark. The remaining catch, amounting to only 1% of the total, was added by applying the overall quarterly age distributions.

#### Division IVb

Catch in number at age by quarter was available only from Norway and the Netherlands. The Dutch data were used for the unallocated catch and the catches taken by the Federal Republic of Germany



and Denmark, except for 200 tonnes of the Danish catch which was assumed to be of the same age composition as the Danish catch in Division IVa.

#### Division IVc

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

#### Division Vb

The catches taken in Division Vb were considered to have the same age distribution as the catches taken in Division IIa.

### 5.2.2 Revision of the 1983 and 1984 data

In Division IIa in 1984, the Soviet catches were increased by 4,287 tonnes, as reported to ICES. This gives an increase of 5% in the total catch. The numbers by age were increased by 5%. The revisions of the catches in Sub-area IV and Division IIIa were minor. Correction of the catches in numbers was made on the computer file, but are not tabulated here.

### 5.2.3 Weight at age and maturity

At the Working Group meeting in 1985, estimated mean weights at age in the catches for each division and quarter of 1984 were provided by the major fishing nations. The new estimates were found to give an improved representation of weights at age in the catches compared to those used previously.

Mean weights at age in catches by quarter in 1985 were provided by Norway (Divisions IIa, IVa and IIIa), Denmark (Divisions IVa,b), Netherlands (Divisions IVa,b,c) and Scotland (Division IVa). Weighted (by number) mean catch weight-at-age estimates were made by division by quarter and by division by year for catches from the North Sea stock (Table 5.6).

A comparison between the calculated sum of products (SOP) for the divisions and the reported catches in 1985 is given below:

	IIa	IIIa	IVa	IVb	IVc
SOP(t)	77,789	3,768	38,309	5,820	913
Catch(t)	79,787	3,728	38,763	5,818	914

The data show a close agreement between SOP's and catches indicating that mean weights at age used for the catch data are satisfactory.

Mean weights at age in the stock on 1 January and at the time of spawning were unchanged from those used in last year's assessment (Anon., 1985a).

No new information on maturity at age were available, and the maturity ogive used previously was retained.

#### 5.2.4 End of separate North Sea assessment

Due to major uncertainties associated with allocating catches to stocks and estimates of recruitment, it was decided not to proceed with a separate North Sea stock assessment.

Some aspects of the problems may be seen by comparing the age structure of samples taken by research vessel on the North Sea spawning ground during the 1984 spawning season with VPA adult age structure for the same year (Figure 5.1). This is also seen by comparing VPA age structures with those from Norwegian gill net fisheries in the 1985 spawning season. The samples from the spawning grounds show a high proportion of fish 8 years and older, while the North Sea stock VPA outputs show few fish this old. The VPA age structures are dominated by younger fish and are little different from Western stock VPA's. Clearly, the mixing of stocks in the commercial catches is resulting in North Sea stock VPA's dominated by Western stock data.

Data from the North Sea area were combined with data from the western area and an assessment was made of the combined stocks (Section 7).

### 6 WESTERN AREA

#### 6.1 The Fishery in 1985

The landings by country for the western area (Sub-areas VI and VII and Divisions VIIa,b) for the 10-year period 1976-85 are shown in Table 6.1. The figures for 1985 are preliminary, while no changes have been made to the 1984 figures estimated by Working Group members. The total catch for 1985 amounted to about 468,000 tonnes, which was slightly lower (2%) than that in 1984 and the lowest recorded since 1977. The total catch which could not be attributed to any country amounted to over 69,000 tonnes, about 15% of the total. This catch was placed in the "Unallocated" category. An estimated 4,500 tonnes of mackerel were also caught but subsequently discarded.

The main catches were taken by Ireland, the Netherlands, Norway and the UK (Scotland). However, these figures cannot be taken as a true indication of catches for all countries because of the amount of fish in the unallocated category. It is clear, however, that a considerable decrease took place in the catches of the UK (England) (-68%) and Norway (-30%), while a considerable increase took place in the UK (Scotland) catch (+15%).

The catches taken by sub-areas are shown in Table 6.2. As has been the pattern in recent years, an increasing proportion of the total catch is now taken in Sub-area VI. The amount taken in this sub-area in 1985 exceeded 80% of the total and shows very clearly the change in the location of the fishery.

The distribution of the catches are given by quarters in Table 5.3. The quarterly catches in Division VIa were again divided into those catches taken north and south of  $58^{\circ}\text{N}$ , in an attempt to give an indication of the importance of the North Rona fishery. As in 1984, catches from north of  $58^{\circ}\text{N}$  exceeded 80% of the total catch taken from Division VIa. It must be stressed, however, that the  $58^{\circ}\text{N}$  line cuts through the important St. Kilda, Flannan Island fishery so that the distribution of all catches to the appropriate area may not be accurate. Again it must be emphasised that the  $4^{\circ}\text{W}$  line, which separates Divisions VIa and IVa, also passes through the important autumn and winter fishery to the west of Shetland. Some catches taken during this fishery from Division IVa have been reported as being taken from Division VIa. Of the total catch from Division VIa, more than 80% was taken from north of  $58^{\circ}\text{N}$ , and of the catch taken north of  $58^{\circ}\text{N}$ , over 80% was taken in the fourth quarter. In contrast, over 85% of the total catch taken in the southern part of Division VIa was taken in the first and second quarters. In Sub-area VII, over 95% of the total catch was taken in these quarters.

## 6.2 Discarded Catches and Unallocated Landings

As discussed in 1984 and 1985, the amounts of fish caught, but subsequently discarded, appears to have decreased in recent years. This appears to be mainly as a result of the shift in the fishery away from the Cornwall peninsula. Data on discards are only provided for the Dutch fleet, but it is felt that a certain amount of discarding must also occur in other fleets. However, the amount of fish killed as a result of discards (including burst nets, etc.) cannot be estimated accurately.

As in recent years, considerable quantities of fish have been landed, but cannot be attributed to any particular country. About 15% of the total reported catch has been placed in the "Unallocated" category compared with 13% in 1984.

## 6.3 Revision of Catches

Mackerel taken in Division VIIIc (by Spain) are no longer considered to be part of the Western stock. (Anon., 1986a) The Spanish catches from this division have been removed from the total catch from the western area (Table 6.1) for the years 1976-85. A reduction has also been made to the Faroese catch in Division VIa for 1982-83. The combined effect of these reductions does not change the total catch from the western area in any year by more than 2%.

#### 6.4 Assessment of the Western Stock

##### 6.4.1 Catch in number, 1985

###### Division VIa

The catches taken in Division VIa during 1985 by Ireland, Netherlands, Norway and Scotland were sampled for age and contributed 93% of the total international catch from this division. Of the remaining catches, those of the Faroe Islands were raised using Norwegian data, while those of France and the Federal Republic of Germany were raised using Dutch data. Landings by England and the Federal Republic of Germany were raised using Dutch data. Landings by England and Northern Ireland were raised using Scottish data in all but the second quarter when Dutch data were used. As in previous years, all age 1-2 fish were allocated to the Western stock, while 7% of all age groups caught north of 58°N during the first and fourth quarters were allocated to the North Sea stock (see Section 4.3.3).

The abundance of 1-year-old mackerel (1984 year class) in the catch was the highest recorded (20%) for this division. The catch in numbers at age in 1985 in Division VIa is shown in Table 6.3 and those allocated to the Western stock are given in Table 6.4. Discards were estimated to account for less than 1% of the total.

###### Divisions VIIa-c

Numbers-at-age data in Division VIIb were supplied by Ireland, the Netherlands and the Federal Republic of Germany. Catches of these countries accounted for 99% of the total catch reported. The number-at-age data are presented in Table 6.3. The age distribution of the Dutch first quarter catch in Division VIIb was applied to English catches in the first and second quarters. The combined Dutch, Irish and Federal Republic of Germany age distribution of the first and second quarters was applied to Northern Ireland catches. The combined English and Dutch age distribution over all quarters of Divisions VIIe,f was applied to the catches of England and Ireland in Division VIIa. It was estimated that about 1% of the total catch was discarded.

###### Divisions VIId-k

Numbers-at-age data were supplied by England, Ireland, the Netherlands and the Federal Republic of Germany. Catches of these countries accounted for 77% of the total catch reported. The numbers-at-age data are presented in Tables 6.3 and 6.4.

The age distribution of the Dutch catch in the second, third and fourth quarters in Division IVC was applied to the French, English and Danish catches in Division VIIId in all quarters.

The age distribution of the English catch in Divisions VIIe,f in all quarters was applied to the French catch in all quarters in both divisions.

The combined age composition of all catches in Divisions VII e,f of all quarters was applied to the English catch in Division VIIg in the second and third quarters. The age distribution of the Dutch catch in Division VIIj in the first and second quarters was applied to the French and English catches in Divisions VIIh,j in the first and second quarters.

The overall age distribution in Divisions VIIId-k was applied to the Soviet catches.

#### Divisions VIIIA-b

No numbers-at-age data were supplied for Divisions VIIIA,b. The age distribution of the total year of Divisions VIIe-j were applied to the French catches in all quarters.

#### 6.4.2 Revision of the 1984 and earlier data

Removal of Division VIIIC from the area to be assessed affected the numbers-at-age data, but no revisions were made because the catch in Division VIIIC did not account for more than 3% of the total Western mackerel catch in number.

#### 6.4.3 Weight at age and maturity

##### Weight at age in the stock

Mean weights at age (kg) in the spawning stock at spawning time were estimated for 1981-85 by using samples from Dutch commercial freezer trawlers in Division VIIj in March, April and May and are shown in the text table below (1-year-olds are rarely taken in samples; therefore, a constant weight is taken):

Age	1981	1982	1983	1984	1985
1	0.070	0.070	0.070	0.070	0.070
2	0.172	0.108	0.156	0.187	0.150
3	0.241	0.202	0.220	0.246	0.292
4	0.300	0.260	0.261	0.283	0.300
5	0.300	0.379	0.322	0.305	0.328
6	0.359	0.329	0.360	0.379	0.366
7	0.401	0.388	0.384	0.429	0.421
8	0.412	0.417	0.420	0.421	0.440
9	0.427	0.425	0.497	0.485	0.448
10	0.413	0.460	0.453	0.515	0.554
11+	0.509	0.513	0.550	0.534	0.600

A simple arithmetic mean weight shows an increasing trend with time.

##### Weight at age in the catch

Those countries which supplied age compositions of the catches in 1985 also supplied mean weights at age for those catches. Weighted (by catch in number) mean weights at age in the catch

were determined from all the catches from the Western stock and are shown below.

Age	1	2	3	4	5	6
Weight (kg)	0.151	0.273	0.349	0.418	0.416	0.434

Age	7	8	9	10	11+
Weight (kg)	0.520	0.544	0.562	0.627	0.696

#### Maturity at age

The Dutch maturity data were accepted as the most representative samples which were well distributed throughout the spawning ground and the juvenile area. Also, these samples were considered to reflect the relative abundance of the exploited population (Anon., 1985b). A condensed table of maturity data for all areas from the original table by area (Anon., 1985b) is shown as Table 6.5.

#### 6.4.4 End of separate assessment

Due to major uncertainties associated with allocating catches to stocks, it was decided not to proceed with a separate Western stock assessment (see Section 5.2.4). Data from the western area combined with data from the North Sea area and an assessment was made of the combined stocks.

### 7 COMBINED STOCKS

#### 7.1 The Case for a Combined Stocks Assessment

For a number of years, concern has been expressed within ICES that separate mackerel stock assessments cannot be viewed with confidence. The reasons for this concern are various: are there two separate stocks, are the tagging data adequate for reliable allocation of catches to stocks, are the basic catch data adequate for reliable assessments?

The last question is one which is certainly not unique to the Mackerel Working Group. However, it is a problem which the Group has endeavoured to cover realistically with estimates of discarded and "unallocated" (non- or mis-reported) catches.

On the subject of stocks, the Working Group maintains the view which it has held since its first meeting in 1974: there are two stocks - a North Sea spawning stock and a Western spawning stock (Section 4.1). However, the Group recognises the possibility that the two stocks may vary in dominance with time. During the time that the Working Group has assessed these stocks, they have differed considerably. The North Sea stock has decreased rapidly from one million tonnes to no more than about 100,000 tonnes. At

the same time, the Western stock has decreased from over three million tonnes to about one million tonnes.

In the 1960's, the North Sea stock was estimated to be in excess of three million tonnes (Hamre, 1978; 1980). There are no concurrent estimates for the Western stock, but speculative estimates have been made suggesting that in the late 1930's, the Western spawning stock was little more than recent North Sea stock estimates (Walsh, 1976; Southward and Bary, 1980). This raises the possibility that the two stocks cannot co-exist with equally high biomasses, rather one is dominant. The recent north-easterly shift in the distribution of fish west of Britain may indicate a change in favour of the North Sea stock.

Environmental changes may be affecting the Western spawning stock adversely, resulting in falling spawning stock biomass (and recruitment). Conversely, the changes may favour the North Sea stock survival and recruitment.

Whatever the true relative status of the two stocks, there is one thing of which we are certain. The recent shifts in seasonal distributions and migrations and the imbalance of stock sizes (Section 5.2.4) are making it increasingly difficult to use the Norwegian tagging data for allocation of catches by age groups to stocks. Just as an agreed procedure for stock allocation is established, new data are produced which suggest that the established procedure is no longer appropriate. This inevitably leads to prolonged debate and further uncertainty. In an effort to reduce some of this uncertainty, the Working Group decided to attempt an assessment combining the North Sea and Western stock data.

Because of uncertainties attached to, and shortages of, data earlier than 1976, it was decided to limit the combined assessment to the period 1976 to 1985. Throughout this period, the Western stock and catches have dominated the total; therefore, the range of age groups is limited to 0 to 11+, as in the earlier Western spawning stock assessment.

#### 7.1.1 Catch in number

The catch in numbers at age for the combined stock assessment was calculated by summing the catch in numbers for the North Sea area (Table 5.4) and western area (Table 6.3). The sums are not shown by division, but the total catch in numbers at age appears in the first part of the VPA tables (Table 7.1). The age range is limited to 0 to 11+, as used previously in the Western stock assessments.

#### 7.1.2 Weights at age and maturity

Weights at age and the maturity ogive for the combined assessment were calculated as the weighted mean of the values incorporated in the separate stock assessments.

The maturity ogives for the North Sea stock and Western stock were weighted by the stock in number at age in 1983, the last year when both stocks were estimated by plankton survey (Section 7.1.3).

Age	0	1	2	3	4	5-11+
Proportion mature	0	0.06	0.60	0.90	0.97	1.00

This maturity ogive was applied to all years covered in this assessment, 1976-85.

Mean weights at age in the 1985 catch were calculated from mean weights at age in the catch by divisions weighted by the catch in numbers by division. Mean weights at age in the catch for earlier years were the weighted means for the separate assessments made earlier. The values are listed in Table 7.2.

Mean weights at age in the spawning stock were calculated from the mean weights at age in each stock each year 1976 to 1985 weighted by the number of mature fish at age in the corresponding stock.

### 7.1.3 Estimates of spawning stock size

As the Western stock is currently an order of magnitude greater than the North Sea stock, it will dominate the combined assessment. It was agreed, therefore, that the combined assessment should follow the procedures previously adopted for the Western stock when running the VPA. The terminal F values were adjusted to estimate a combined spawning stock in number in 1983 corresponding with stock sizes estimated by plankton surveys in that year.

The Western spawning stock in 1983 was estimated to be 6,985 million fish. In the same year, the North Sea spawning stock biomass was estimated to be 240,000 tonnes (Anon., 1984b). This estimate was 43% higher than the "smoothed average" figure estimated in last year's VPA (Anon., 1985a). To give the 1983 North Sea spawning stock estimate equal standing with the Western stock estimate, it was agreed that the VPA spawning stock in number estimate for 1983 (420 million fish) should be increased by 43% to 600 million fish.

A further combined stock in number was estimated for 1980. This was the sum of the 1980 western area spawning stock estimate, 7,340 million fish (Anon., 1984b) and the North Sea stock VPA estimate, 515 million fish (Anon., 1985a), as there was no North Sea plankton survey estimate that year.

Combined spawning stock estimates were:

1983: 7,585 million spawning fish  
1980: 7,825 million spawning fish



### 7.1.4 Exploitation pattern

The exploitation pattern was calculated by running an SVPA on age groups 1-10 for years 1978 to 1985.

The coefficient of variation of the catch-at-age data was 15.7%, 10% less than on the North Sea data and 1% less than the Western area data for 1984 (Anon., 1985a). Only five (8%) of the 63 log catch ratio residuals were in excess of 0.292 [ $2 \ln(1 + CV/100)$ ] (Table 7.4). Four of the excess residuals occurred in data for the period 1979 to 1983 and corresponded with similar excess values observed in the Western stock data last year (Anon., 1985a). The fifth value is in the youngest age data for 1984/85. There does not appear to be any systematic pattern in the excess values. This suggests that there are no serious problems in the age data.

A number of runs were made adjusting the terminal S value to minimise the variation between the maximum value (1.00) at reference age 3 and the values which followed it. A final value for the terminal S of 0.87 was selected (Table 7.4).

The exploitation pattern at ages 2 to 10 in 1985 from the extended analysis of the SVPA (using the terminal populations option) was used to factor the terminal F for 1985 for the standard VPA. [The terminal F on the 1-group in 1985 was adjusted in the light of additional (recruitment) data (Section 7.1.6).]

### 7.1.5 Fishing mortality and stock size

A conventional VPA was run using F values on the oldest true age groups for 1976 to 1985 and ages 2 to 10 in 1985 taken from the extended analysis SVPA. The array of values selected were those which estimated spawning stock in number for 1983 closest to the combined spawning stock size estimates (Section 7.1.3). The best fit came from the SVPA with a terminal F = 0.35 (Table 7.4). Using these data, spawning stock in number was calculated within 1% of the target figure for 1983 and within 1.5% of the 1980 target figure.

The weighted mean F for ages 2 to 10 ( $\bar{F}_{2-10}^w$ ) is 0.34 (unweighted  $\bar{F} = 0.30$ ), the highest value in the 9-year time series calculated, but only 0.02 greater than the value for 1984 (Table 7.5). The F on 1-year-olds in 1985, adjusted to calculate 4,500 million recruits, was 0.06. This is approximately half the value in the preceding two years (which were relatively high on weak year classes), but not exceptionally low compared to some other years.

The overall pattern of fishing mortality rates, and the corresponding stock in number and spawning stock estimates (Table 7.6 and Figure 7.1) appear to be consistent with the patterns and trends observed in the earlier, separate assessments. The Working Group is confident that these data are a realistic combined presentation of recent events in the North Sea and Western mackerel stocks.

#### 7.1.6 Recruitment of 1-year-olds in 1985

Two Working Documents were presented on the size of the 1984 year class of mackerel in the Skagerrak and the North Sea in 1985.

The results of a Danish acoustic survey (Working Document, Kirkegaard) give an estimate of about 4 million 1984 year-class mackerel in the eastern North Sea and Skagerrak in July and August. A Norwegian survey in October in the Skagerrak and northern North Sea (Working Document, Iversen and Westgård) came up with an estimate of 2,000 million 1-year-old mackerel. Using the relative proportion of 1-year-old mackerel tagged by the Norwegians in July-August in 1985 compared with previous years, indicates about 1,000 million. From these data, it was concluded that a very high number of 1-group mackerel were present in the North Sea in 1985 during the summer and autumn. It is assumed that the strength of the 1984 year class in the North Sea is at least as strong as the 1974 year class (which was second only to the 1969 year class), i.e., about 500 million 1-year-old fish.

In recent years, the number of 1-group mackerel in the Western stock on 1 January has been estimated using catch data from the preceding year's fishery and the mean exploitation pattern, as determined by SVPA. For the 1984 year class, this method appears to give an unrealistically low estimate of the size of this year class on 1 January 1986 when compared to abundance indices from trawl surveys. These data are now available over a reasonable time scale and are given in Table 7.7 with, for comparison, estimates of 1-group abundance in the stock from VPA (Anon., 1985a). The data are also given ranked according to abundance in Table 7.8. These indicate a reasonable level of agreement between VPA estimates and Sub-area VII recruit indices for the 1979-84 year classes. According to the recruit indices, the 1984 year class is of comparable size to the strong 1981 and 1979 year classes. A plot of brood strength of 1-year-olds from VPA for the 1975-83 year classes is given in Figure 3.2. These data indicate five good year classes of roughly comparable size with a mean abundance of approximately 4,000 million fish, one year class of medium abundance and three poor year classes. On this basis, the Working Group decided to apply the mean value for the five historically good year classes as a best estimate for the 1984 year class in the Western stock.

Combined recruitment of the 1984 year class was assumed to be the sum of the separate estimates, i.e., 4,500 million fish. The terminal  $F$  on 1-year-olds in the VPA was adjusted ( $F = 0.057$ ) to calculate this number in the stock (Table 7.6).

Preliminary indications from research vessel surveys on the 1985 year class are that this is of medium strength (Section 4.2).

## 7.2 Forecast for Combined Stocks

### 7.2.1 Exploitation pattern

As the Working Group did not anticipate any appreciable change in the fishing pattern in the next three years from that observed during 1978-85, the average exploitation pattern from this period determined by the SVPA was used for the catch and stock forecasts and the yield-per-recruit analysis. This pattern indicated a 100% recruitment at age 3 followed by a decline to a stable level at ages 6 and older (Table 7.4).

### 7.2.2 Future recruitment

Preliminary indications from research vessel surveys on the 1985 year class are that this is of medium strength (Section 7.1.6). The Working Group decided to use a rounded value of 3,000 million for the number of 1-year-old fish in 1986. This value is close to the geometric mean advocated by ACFM (Anon., 1986b). The same value of 3,000 million was also chosen for 1987 and 1988.

### 7.2.3 Catch and stock predictions

The input parameters for the catch forecasts of the combined stocks are given in Table 7.9.

The weights at age in the catch, weights at age in the stock and the maturity ogive were those used in the VPA for 1985. The stock in numbers in 1986 was taken from the VPA (Table 7.6).

A catch of 620,000 tonnes of mackerel in 1986 was used in the forecasts. This comprised the agreed TAC's for the North Sea (55,000 tonnes) and western area (360,000 tonnes), an agreed 'extra allowance' of 30,000 tonnes agreed between EC and Norway, an anticipated catch of 75,000 tonnes in Division IIa and an excess over TAC's of about 100,000 tonnes, mostly from western areas.

A series of stock and catch predictions for 1986-88 were made on the basis of these catch assumptions. The results are summarised in Table 7.10 and Figure 7.1.

The estimated catch of 620,000 tonnes in 1986 results in a spawning stock biomass in 1987 of about 1.4 million tonnes which is close to 10% higher than the 1986 level. The  $\bar{F}_{2-10}$  required to take the assumed catch is 0.30 (unweighted).

Maintaining this catch in 1987 would result in a relatively stable biomass of 1.4 million tonnes in 1988.

Fishing at the  $F_{0.1}$  level in 1987 would give a spawning stock biomass in 1988 of about 1.6 million tonnes, a level intermediate between the levels calculated for 1984 and 1985 (Table 7.6).

## 8 CONSERVATION MEASURES

### 8.1 Closed Area off Southwest England

The original intention of restricting mackerel fishing in the area around Cornwall ( $49^{\circ}30'N$  to  $52^{\circ}N$ ;  $3^{\circ}W$  to  $7^{\circ}W$ ) was to afford some measure of protection to the immature Western stock fish. During the late 1970's and early 1980's, there was an increasing trend for 1- and 2-year-old fish to form a very high percentage of the total catch in number in this area.

The introduction of the restrictions coincided with two very weak year classes (1982 and 1983) which has made comparisons with the period immediately preceding the restrictions very difficult. For this reason, it is necessary to review the situation specifically with reference to 1-year-old fish. An initial comparison was made between the catch of 1-year-old fish as a percentage of total catch in number in Division VIa, Divisions VIIId-k and the western area, 1979 to 1985.

Division	1979	1980	1981	1982	1983	1984	1985
VIa	0.4	0.7	1.3	8.3	0.6	1.2	20.5
VIIId-k	18.3 <sup>1</sup>	24.2	18.9	12.3	3.4	0.9	15.1
Total	4.2	20.1	13.4	10.2	2.1	1.1	17.2

<sup>1</sup> Sub-areas VII + VIII.

As found in earlier Working Group reports (Anon., 1982; 1984), the problem of immature fish in the catches was concentrated in Divisions VIIId-k, but principally in Divisions VIIe,f. It reached a peak in 1980 when almost one quarter of the catch in number was the 1979 class. Low catches of immature fish coincided with the poor 1982 and 1983 year classes, but the 1984 year class provided 15% of the catch in number from Divisions VIIId-k in 1985. This high proportion was taken from a wide area outside the restricted area.

The increased proportion of immature fish in Division VIa in recent years has been described in detail elsewhere (Anon., 1985a and this report, Section 4.2). However, the text table above also shows quite clearly that there has been a significant increase in the proportion of young fish taken in Division VIa (Figure 4.2). There has been a major increase also in the proportion of the total catch taken in Division VIa. In 1985, 85% of the total Western catch in tonnes was taken in Division VIa (Table 6.2) compared with less than 35% in 1979.

The increase in total catch of mackerel taken in Division VIa, plus the increased proportion of young fish in the catches (Figure 4.2) reflect the recent shifts in distribution. However, they must have important implications also for the restricted area around Cornwall.

In 1985, 1-year-old fish contributed 17% of the total catch in number west of Britain, a catch level second only to 1979. This being so, it is difficult to accept that the restricted area around Cornwall has been of anything but marginal benefit to the immature stock of Western mackerel.

While we still cannot describe the total distribution by division of 1-year-old fish in terms of total numbers or tonnage, it is clear that, in 1985, the restricted area covered only a small part of the total (Figures 4.3 and 4.4).

In the light of the most recent information, the restricted area around Cornwall cannot be justified in its present form. Either the same restrictions must be extended to cover a greatly extended area west of the British Isles, or it should be repealed. It is the view of this Working Group that it would be impractical to extend the full restriction, as it applies, 12 months of the year, to the full area occupied by the 1-year-old fish in 1985. The only practical conclusion is to repeal the restrictions as they now stand.

Even though the Working Group recommends the repeal of the specific restrictions around Cornwall, it recognises the continuing need to protect immature fish. After further consideration of the most recent information on the distribution of immature fish, the Group decided that this could be incorporated with wider conservation measures.

## 8.2 Conservation of the North Sea Mackerel Stock

Although the Working Group has presented an assessment and stock forecast for combined stocks, it wishes to emphasize that it has not abandoned the two-stock concept. The combined assessment was made because of the increasing uncertainties in trying to identify small North Sea stock components in catches dominated by the Western stock (Section 5.2.4). This problem is a partial consequence of the depleted state of the North Sea stock.

For several years now, it has been the view of this Working Group, and the advice offered by ACFM, that all fishing on the North Sea stock must cease if the stock is to have a real chance of recovery. Despite this consistent advice, TAC's have been agreed between EC and Norway and the most recent agreement shows a sharp increase in agreed catch levels (Figure 8.1). This agreement is wholly contrary to the conservation advice offered. It is still the view held by the Working Group that all exploitation of the North Sea stock should cease.

While advocating a ban on fishing the North Sea stock, the Working Group is cognizant of the fact that this would mean a cessation of fishing also on Western mackerel in northern areas. The Group recognises that such a proposal is unrealistic and wishes, therefore, to propose measures which it believes will reduce exploitation on the North Sea stock without inhibiting the major Western stock fisheries. This may be achieved by limiting the area in which fishing is restricted.

### 3.3 Conservation of Juvenile Fish

As a general rule, juvenile fish can be expected to be abundant in areas close to main centres of spawning, i.e., the Celtic Sea area to the west and in the central North Sea. Recent information on the distribution of the 1984 year class shows that it was abundant in the southern part of Division IVa and in Divisions IIIa, IVb and IVc (Figures 4.3 and 4.4). It was also widely distributed in the Western area but, historically, we know that the eastern Celtic Sea and English Channel are areas where juvenile mackerel are abundant (Anon., 1982; 1984).

In an effort to reduce exploitation rates on immature fish, it is recommended that fishing for mackerel be limited severely in the following ICES divisions:

Division IIIa;  
Division IVa south of 59°N;  
Divisions IVb,c;  
Divisions VIIa,d-h.

[In Division IVa, juvenile fish are probably more abundant south of 59°N than north of it (Figure 4.3). Also, this latitude marks the boundary between what is thought to be mixed stock fisheries and those thought to be pure North Sea stock fisheries (see Sections 4.3.2 and 5.2.1.).]

The Working Group recognises that a total ban on mackerel fishing in these areas would be impractical (due to by-catches) and probably unacceptable (small-scale traditional fisheries). However, it believes that if catches in these divisions were restricted to a minimal level, the potential benefits to the stocks, by protecting immature fish, would be appreciable. The Working Group recommends that catches within the area defined above should be limited to no more than 5% of the agreed total (Region 2) TAC. (On the basis of regional distribution of catches in small-scale fisheries, this might be split 2.5% North Sea area, 2.5% western area). A figure of 5% of the total TAC should provide a realistic level to accommodate genuine by-catch and regional small-scale fisheries. At the same time, national quotas should be too small to attract intensive effort from large vessels engaged in directed mackerel fishing.

The Working Group prefers to recommend a catch limitation within the defined area without proscribing methods of fishing. The Group believes that this should leave fishery managers the freedom to meet localised requirements. However, it will be prudent to ensure that this small catch is taken in the way intended. The value of the measure will be negated if bulk catches are permitted to take national allocations in a directed fishery of short duration.

The high catches of juvenile fish in Division VIa is a recent phenomenon. It may be transient or it may become established. If it is a transient phenomenon, there will be no lasting cause for concern. If, on the other hand, juvenile fish become an established feature of catches in Division VIa, it will be necessary to consider further conservation measures extending to this area.

## 9 DATA REQUESTED BY THE AD HOC MULTISPECIES WORKING GROUP

In the terms of reference, the Mackerel Working Group was asked to give quarterly catch-at-age and mean weight-at-age data for the North Sea mackerel stock and the likely level of the Western mackerel stock seasonally present in the North Sea. An additional request was to supply quarterly weight-at-age data for the years 1972-85.

The Mackerel Working Group cannot give any better data for the period 1972-85 than those in last year's report. The set of weight-at-age data in the catches is also the best approximation to the weight-of-age in the stock.

### 9.1 Catch-At-Age by Quarter for the North Sea Mackerel Stock

The catch in number of the North Sea mackerel stock in 1985 is given in Table 9.1 by age and quarter. The total catch (in tonnes) in 1985 in each quarter is also included.

### 9.2 Mean Weight-at-Age by Quarter

The observed weighted mean weight-at-age data in the catches by age and quarter are given in Table 9.2. The data have to be used as the best estimates of the mean weight-at-age in the stock as well.

### 9.3 Stock Distribution by Quarter

The best estimate of North Sea stock distribution by quarter, based on the available information from trawl surveys and tagging returns for migration routes of the North Sea mackerel stock, is given in Figure 9.1 for the immature and in Figure 9.2 for the mature part of the stock. The figures given are estimated percentages for the total stock present in different ICES divisions in each quarter of the year.

A highly speculative assessment of the Western mackerel stock distribution by quarter is given in Figures 9.3-9.4 for the immature and mature part of the stock, respectively. It is stressed that these charts should only be used for experimental purposes by the Multispecies Working Group and should not be used as a basis for management.

## 10 DEFICIENCIES IN DATA

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

### 10.1 Catch Statistics

Although most of the Working Group members were satisfied about the accuracy of their recent catch statistics, considerable doubts remain about the quantities reported by some countries.

The Working Group is concerned, therefore, about the continuing high quantities of the total catch that are placed in the unallocated category. Accurate information about the quantities and origin of catches is essential for any realistic assessment. Information is also lacking about the quantities of mackerel which are discarded or lost at sea and, therefore, are not included in the total catch figures. Information about this aspect is only supplied by one country, but it is clear that discarding must affect all fisheries.

## 10.2 Biological Information

Weight at age. There are still inadequate biological data for considerable quantities of the catch. Information is needed for age distributions and weight at age for the spawning stock in the North Sea. General biological data are lacking for the Danish, French and Faroese catches.

Environmental changes. As pointed out in last year's report, the very big changes that have taken place in the distribution of the stocks have created major problems in the assessments. The causes of these changes are not yet known, nor is it known whether the changes are continuing or whether the situation has stabilized. Information about recent trends in environmental or hydrographic conditions may be helpful in this respect.

Recruit surveys. The Working Group has more information about the distribution and abundance of recruiting mackerel than in previous years. This was because trawl surveys were carried out by a number of countries in 1985. It is important that these surveys should be continued and extended. The Working Group is also aware that groundfish surveys are proposed by the Working Group on Fisheries Units in ICES Sub-areas VII and VIII. It is important that liaison be established with those groups carrying out this work so that the maximum benefit is derived from both sets of surveys.

Egg surveys. Egg surveys in 1986 will be reduced compared with those in 1980 and 1983 because of the non-availability of research vessels. The recent change of the Western stock may mean that increased spawning may occur to the northwest of Ireland and west of Scotland. This area will not, however, be covered by the main surveys, so the total egg production may be underestimated. A survey in this area during the main spawning period of May/June would provide valuable information about stock size and distribution and would be welcomed by the Group.

The North Sea stock will be surveyed jointly in 1986 by Denmark and Norway.

It is agreed that regular egg surveys, in both areas, form a vital part of the mackerel assessment programme. Ideally, full-scale surveys should be carried out on both stocks in the same year, particularly if combined assessments are made. In view of recent shifts in stock distribution, the Working Group requests that the Egg Production Workshop investigate the possibility of surveying both the North Sea and western area in 1988 or 1989.



Hydro-acoustic surveys. Apart from the egg surveys, which are not carried out each year, there are no independent methods of assessing the stocks. It is possible, however, that valuable information could be obtained if acoustic surveys were carried out each year on the overwintering concentrations west of Ireland and Scotland.

### 10.3 Analysis of Norwegian Tagging Data

The Working Group believes that the Norwegian tagging data still offer the best possibilities for allocating catches to stocks. In recent years, there have been increasing difficulties in using these data. Some of these difficulties might be resolved if more time were spent analysing them with respect to commercial catch statistics and biological sampling data.

As a first step toward undertaking these detailed analyses, it was agreed that a combined data base of relevant information should be assembled. Initially, this data base can be compiled by an informal exchange of information. It was agreed that T. Westgård (Norway) will draft a proposal for the data base and coordinate the collection and collation of data. In due course, a Workshop (outside the regular Working Group) may meet to work jointly on the analysis.

While the Working Group has made a combined assessment on this occasion, it wishes to see the tagging experiment continued in the expectation that separate stock assessments will be resumed in the future.

### 10.4 Results from the Otolith Exchange

During 1984 and 1985, 484 mackerel otoliths were exchanged between Denmark, England, Federal Republic of Germany, Ireland, Netherlands, Norway and Scotland. The results of the exchange were presented in a Working Document (Dawson). The Working Group agreed that this document should be presented at the Statutory Meeting later in the year.

It was found that there was little disagreement in ages below 5 years of age, and even through the age range 5-10 years, differences do not appear serious. At ages greater than 10 years, the differences show an increasing trend. The standard deviation about the mean age of each otolith aged by the seven otolith readers increases noticeably at ages over 10 years.

In view of these results, the Working Group decided to maintain the age ranges in the assessment which it has used hitherto, i.e., 1 to 15 in the North Sea stock and 0 to 11+ in the Western stock (but the data sheets in the Working Group files contain numbers at age to 15+). However, the Working Group would like to see future assessments extend the age range to 15+ years on both stocks. (This is an essential prerequisite to minimising the bias in calculating F on the aggregated plus group.) Before this can be done with reliability, it will be necessary to increase the level of agreement between otolith readers. The otolith exchange has established the extent of the problem; it will require a meeting of otolith readers to resolve it.

The Working Group recommended that a Mackerel Otolith-Reading Workshop is held early in 1987 so that improved age data may be presented at the Working Group meeting in 1988. (As some of the persons involved also read horse mackerel otoliths, it may be useful/practical to combine this with a horse mackerel ageing workshop.)

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**Table 4.1** Catch in number of juvenile fish (1- and 2-year-olds) and total catch from Division VIa and the Western stock to calculate relative catch rates ratios illustrating the shift of young fish towards Division VIa.

Juvenile catch number from WG report of year	Year of catch	1- and 2-year-old fish			Total catch		
		Div. VIa a (millions)	West. stock W (millions)	a/W x 100	Div. VIa a (millions)	West. stock W (millions)	a/W x 100
1977	1972	0.1	24.5	0.4	29.8	563.2	5.3
1977	1973	0.8	83.2	1.0	57.3	845.0	6.8
1977	1974	1.5	111.3	1.3	72.8	1,103.4	6.6
1978	1975	12.1	156.5	7.7	678.7	2,141.5	31.7
1978	1976	8.0	464.3	1.7	158.9	2,117.3	7.5
1980	1977	13.9	433.0	3.2	166.3	1,268.3	13.1
1980	1978	2.2	595.1	0.4	309.3	2,106.9	14.7
1980	1979	2.4	412.7	0.6	433.6	2,485.7	17.4
1981	1980	25.9	953.2	2.7	436.3	2,413.7	18.1
1984	1981	48.5	772.5	6.3	603.5	1,996.5	30.2
1984	1982	212.6	638.9	33.3	805.0	2,012.3	40.0
1984	1983	209.4	756.3	27.7	860.2	2,184.5	36.9
1985	1984	24.5	96.3	25.4	692.3	1,596.0	43.4
1986	1985	203.3	242.4	83.9	921.7	1,307.2	70.5

**Table 4.2** Results of Norwegian tagging experiments. Tag returns are from Norwegian landings to selected factories 1981-85, and returns by Scotland in the first quarter (1QSc), 1984-85, and the fourth quarter (4QSc), 1984-85.

Releases		Recaptures								
		Norwegian Sea					North Sea			
Year	No.	1981	1982	1983	1984	1985	1982	1984	1985	
O 1970	4,540	-	-	-	1	-	-	-	-	-
F 1971	5,000	-	-	-	-	-	-	-	-	-
F 1972	5,086	-	1	-	1	1	-	-	-	-
1973	8,205	-	1	-	-	-	-	-	-	-
S 1974	10,028	-	4	-	1	2	-	-	-	-
O 1975	10,003	-	-	-	-	4	-	-	-	-
U 1976	9,474	-	3	-	1	1	-	-	-	-
T 1977	14,032	2	4	1	2	3	-	-	-	-
H 1978	18,169	3	5	2	8	5	1	1	-	-
1979	20,183	3	7	1	5	14	-	-	-	3
I 1980	9,992	2	4	-	4	7	-	-	-	-
R 1981	9,872	-	5	3	5	5	-	1	-	-
E 1982	10,065	-	5	5	5	5	1	1	3	3
L 1983	13,400	-	-	16	25	24	-	3	5	5
A 1984	14,512	-	-	-	8	37	-	1	2	2
N 1985	25,069	-	-	-	-	32	-	-	7	7
D Sum	187,735	10	39	38	66	140	2	7	20	
1970	3,505	-	-	-	-	-	-	-	-	-
I 1971	9,305	-	-	-	-	-	-	-	-	-
N 1972	11,818	-	-	-	1	-	-	-	-	-
1973	7,277	-	-	-	2	-	-	-	-	-
T 1974	4,493	-	-	-	1	1	-	-	-	-
H 1975	9,995	-	-	-	1	-	1	-	-	-
E 1976	1,763	-	1	-	-	-	-	-	-	-
1977	7,094	-	-	-	-	1	-	-	-	-
N 1978	12,173	-	2	-	5	3	-	2	1	1
O 1979	11,991	2	2	2	8	5	1	-	-	-
R 1980	5,676	-	1	3	5	5	1	-	1	1
T 1981	4,199	-	-	2	3	8	1	-	-	-
H 1982	13,164	-	-	7	16	25	2	1	2	2
1983	9,216	-	-	-	26	21	-	2	2	2
S 1984	13,587	-	-	-	-	36	-	-	2	2
E 1985	20,273	-	-	-	-	-	-	-	3	3
A Sum	145,529	2	6	14	68	105	6	5	11	

(cont')

Table 4.2 (cont'd)

Recaptures											
Division VIa											
Year	1981	1982		1983		1984			1985		
	4Q	1Q	4Q	1Q	4Q	4Q	1QSc	4QSc	1QSc	4Q	4QSc
O 1970	-	-	-	-	-	-	-	-	-	-	-
F 1971	1	-	-	-	-	-	-	-	-	-	-
F 1972	-	-	-	-	-	-	1	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	1
S 1974	1	1	-	-	-	-	-	1	1	1	-
O 1975	-	-	-	-	-	-	1	-	-	-	-
U 1976	1	-	-	-	-	2	-	-	-	-	-
T 1977	2	-	-	-	-	-	2	-	1	1	1
H 1978	1	-	-	-	-	1	-	-	-	4	1
1979	3	-	-	1	-	-	2	1	1	7	-
I 1980	2	1	-	-	-	3	1	2	2	2	-
R 1981	-	1	-	-	3	7	2	-	-	3	2
E 1982	-	-	-	3	3	4	3	2	-	-	2
L 1983	-	-	-	-	2	12	11	4	-	12	8
A 1984	-	-	-	-	-	13	-	2	3	18	6
N 1985	-	-	-	-	-	-	-	-	-	39	21
D Sum	11	3	-	4	8	42	23	12	8	87	42
1970	-	-	-	-	-	-	-	-	-	-	-
I 1971	-	-	-	-	-	1	1	-	1	-	-
N 1972	-	1	-	-	-	1	-	-	-	-	-
1973	-	-	-	1	-	-	-	1	-	-	1
T 1974	-	-	-	-	-	-	1	-	-	2	-
H 1975	2	-	-	-	-	-	-	-	-	1	-
E 1976	-	-	-	-	-	-	1	-	-	-	-
1977	2	-	-	-	-	-	-	-	1	1	-
N 1978	7	1	1	-	1	-	-	-	-	3	-
O 1979	4	-	-	-	-	2	2	-	1	3	-
R 1980	3	1	-	-	1	2	-	-	-	1	2
T 1981	2	3	-	-	-	2	4	-	1	3	1
H 1982	-	-	-	11	1	19	9	3	1	4	5
1983	-	-	-	-	5	13	8	4	-	16	9
S 1984	-	-	-	-	-	4	-	1	3	20	12
E 1985	-	-	-	-	-	-	-	-	-	1	47
A Sum	20	6	1	12	8	44	26	9	8	55	77

**Table 5.1** Nominal catch (tonnes) of MACKEREL in the North Sea, Skagerrak and Kattegat (Sub-area IV and Division IIIa) 1976-85. (Data were submitted by Working Group members.)

Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985 <sup>1</sup>
Belgium	292	49	10	10	5	55	102	93	68	-
Denmark	27,986	21,833	18,068	19,171	13,234	9,982	2,034	11,285	10,088 <sup>1</sup>	12,424
Faroe Islands	63,476	42,836	33,911	28,118	1,770	-	720	-	-	-
France	2,607	2,529	3,452	3,620	2,238	3,755	3,041	2,248	-	322
German, Dem.Rep.	259	41	233	-	-	-	-	-	-	-
Germany, Fed.Rep.	284	-	284	211	56	59	28	10	112	217
Iceland	302	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	738	733	-	-	-	-
Netherlands	2,163	2,673	1,065	1,009	853	1,706	390	866	340 <sup>1</sup>	2,340
Norway	197,351	180,800	82,959	90,720	44,781	28,341	27,966	24,464	27,311	30,835
Poland	2,020	298	-	-	-	-	-	-	-	-
Sweden	6,448	4,012	4,501	3,935	1,666	2,446	692	1,903	1,263	686
UK (Engl. & Wales)	89	105	142	95	76	6,520	16	16	2	143
UK (Scotland)	1,199	1,590	3,704	5,272	9,514	10,575	44	4	13	7
USSR	1,231	2,765	488	162	-	-	-	-	-	-
Unallocated + discards	-	-	-	500	-	3,216	450	96	202	2,042
<b>Total</b>	<b>305,709</b>	<b>259,531</b>	<b>148,817</b>	<b>152,823</b>	<b>87,931</b>	<b>67,388</b>	<b>35,483</b>	<b>40,985</b>	<b>39,399</b>	<b>49,016</b>

<sup>1</sup>Preliminary.

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

Table 5.2 Nominal catches (tonnes) of MACKEREL in the Norwegian Sea (Division IIa), 1976-85.

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Country	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985 <sup>6</sup>
Denmark <sup>2</sup>	-	-	-	-	-	801	1,008	10,427 <sup>3</sup>	11,787 <sup>4</sup>	7,610 <sup>5</sup>
Faroe Islands <sup>1</sup>	-	-	283	6	270	-	180	-	138	-
France <sup>2</sup>	8	-	2	-	-	6	8	-	-	16
Fed. Rep. of Germany <sup>2</sup>	-	-	-	-	-	51	-	5	-	-
German Dem. Rep. <sup>2</sup>	-	-	53	174	2	-	-	-	-	-
Netherlands <sup>2</sup>	2	-	-	-	-	-	-	-	-	-
Norway <sup>1</sup>	10,516	1,400	3,867	6,887	6,618	12,941	34,540	38,453	82,005	61,065
Poland	-	-	-	-	-	-	231	-	-	-
UK (England & Wales) <sup>1</sup>	+	+	1	-	-	255	-	-	-	-
UK (Scotland) <sup>2</sup>	-	-	-	-	296	968	-	-	-	-
USSR <sup>3</sup>	-	-	-	5	1,450	3,640	1,641	65	5	9,231
Total	10,526	1,400	4,206	7,072	8,340	18,662	37,608	48,950	93,935	77,922

<sup>1</sup>Data provided by Working Group members.

<sup>2</sup>Data reported to ICES.

<sup>3</sup>Includes 1,497 tonnes caught in Division Vb.

<sup>4</sup>Includes 920 tonnes caught in Division Vb.

<sup>5</sup>Includes 4,920 tonnes caught in Division Vb.

<sup>6</sup>Preliminary.



Table 5.3 Quarterly catches of MACKEREL by Division.

Division	I	II	III	IV	Total
IIa	200	+	70,500	800	71,500
IIIa	-	500	3,000	200	3,700
IVa-c	+	1,000	37,200	7,200	45,400
Vb	-	-	6,400	-	6,800
VIa, N of 58 <sup>0</sup>	40,800	-	15,700	263,300	319,800
VIa, S of 58 <sup>0</sup>	50,800	9,900	1,200	9,200	71,100
VII	51,000	18,300	1,700	1,800	72,800
VIIIa,b	100	500	300	2,200	3,100

Table 5.4 MACKEREL catch in numbers ('000) by age group for the North Sea area (Divisions IVa-c), the Norwegian Sea (Divisions IIa and Vb) and the Skagerrak (Division IIIa) in 1985.

Year class	Age	Division						Total
		IIa + Vb	IIIa	IVa N of 59 <sup>0</sup>	IVa S of 59 <sup>0</sup>	IVb	IVc	
1985	0	-	-	-	-	-	-	-
1984	1	1,835	4,531	140	399	397	1,074	8,376
1983	2	353	235	55	155	249	142	1,189
1982	3	3,425	555	1,315	3,752	643	236	9,926
1981	4	53,669	2,830	5,681	16,204	1,831	441	80,656
1980	5	25,252	776	2,961	8,444	1,679	350	39,462
1979	6	15,995	585	1,568	4,472	1,019	231	23,870
1978	7	7,484	120	796	2,271	799	231	11,701
1977	8	2,105	18	333	948	128	8	3,540
1976	9	5,746	250	711	2,028	2,071	315	11,121
1975	10	4,856	136	597	1,703	952	21	8,265
1974	11	2,838	154	660	1,881	841	53	6,427
1973	12	5,050	60	681	1,942	322	33	8,088
1972	13	2,469	118	423	1,205	362	5	4,582
1971	14	3,006	52	247	706	668	44	4,723
1970	15+	4,929	221	854	2,435	1,143	111	9,693
Total		139,012	10,641	17,022	48,545	13,104	3,295	231,619
Tonnes		79,851	3,728	10,063	28,700	5,818	914	129,074

**Table 5.5** MACKEREL catch in numbers ('000) by age group for the North Sea stock in 1985.

Year class	Division								Total
	Age	IIa+Vb	IIIa	IVa		IVb	IVc	Vla	
				S of 59 <sup>0</sup> N	N of 59 <sup>0</sup> N				
1984	1	1,835	4,531	399	140	397	1,074	-	8,376
1983	2	353	235	155	55	249	142	-	1,189
1982	3	171	555	3,752	66	643	236	1,694	7,117
1981	4	2,683	2,830	16,204	284	1,831	441	14,803	39,076
1980	5	1,263	776	8,444	148	1,679	350	9,079	21,739
1979	6	800	585	4,472	78	1,019	231	5,900	13,085
1978	7	374	120	2,271	40	799	231	1,984	5,819
1977	8	105	18	948	17	128	8	642	1,866
1976	9	287	250	2,028	36	2,071	315	1,258	6,245
1975	10	243	136	1,703	30	952	21	1,047	4,132
1974	11	142	154	1,881	33	841	53	661	3,765
1973	12	252	60	1,942	34	322	33	736	3,379
1972	13	123	118	1,205	21	362	5	460	2,294
1971	14	150	52	706	12	668	44	435	2,067
<1970	15+	246	221	2,435	43	1,143	111	1,062	5,261
Total		9,027	10,641	48,545	1,037	13,104	3,295	39,761	125,410
Tonnes		4,373	3,728	28,700	541	5,818	914	19,358	63,432

**Table 5.6** Estimated annual mean weights at age of MACKEREL in 1985 by divisions and for the North Sea stock (grams).

Age	Division					North Sea stock
	IIa	IIIa	IVa	IVb	IVc	
1	164	163	154	148	152	161
2	280	289	312	286	254	286
3	432	389	486	288	269	430
4	502	444	517	377	320	476
5	491	458	525	376	298	469
6	531	487	554	347	310	484
7	609	527	614	401	357	557
8	632	515	651	511	393	610
9	698	732	681	462	366	575
10	723	691	725	524	416	658
11	809	797	778	647	475	734
12	791	647	778	525	418	728
13	804	718	766	539	610	736
14	789	719	774	588	445	698
15+	815	774	851	601	561	767

**Table 6.1** Nominal catch (tonnes) of MACKEREL in the western area (Sub-areas VI and VII and Divisions VIIa,b). (Data for 1976-77, as officially reported to ICES; data for 1978-85 estimated by Working Group.)

Country	1976	1977	1978	1979	1980
Belgium	10	1	1	3	3
Denmark	3	698	8,677	8,535	14,932
Faroe Islands	5,539	3,978	15,076	10,609	15,234
France	33,556	35,702	34,860	31,510	23,907
German Dem. Rep.	4,509	431	-	-	-
Germany, Fed.Rep.	391	446	28,873	21,493	21,088
Iceland	10	-	-	-	-
Ireland	14,395	23,022	27,508	24,217	40,791
Netherlands	15,007	35,766	50,815	62,396	91,081
Norway	4,252	362	1,900	25,414	25,500
Poland	21,375	2,240	-	92	-
Spain	-	2,001	599	543	3,684
Sweden	38	-	-	-	-
UK (England + Wales)	57,311	132,320	213,344	244,293	150,598
UK (N. Ireland)	95	97	46	25	-
UK (Scotland)	28,399	52,662	103,671	103,160	108,372
USSR	262,384	16,396	-	-	-
Unallocated	-	-	-	54,000	98,258
<b>Total, ICES members</b>	<b>447,274</b>	<b>306,122</b>	<b>485,370</b>	<b>586,290</b>	<b>593,448</b>
Bulgaria	28,195	-	-	-	-
Rumania	13,222	-	-	-	-
Discard	-	-	50,700	60,600	21,600
<b>Grand total</b>	<b>488,691</b>	<b>306,122</b>	<b>536,070</b>	<b>646,890</b>	<b>615,048</b>

(cont'd)

Table 6.1 (cont'd)

Country	1981	1982	1983	1984	1985 <sup>3</sup>
Belgium	-	-	+	-	-
Denmark	13,464	15,100	15,000	200	400
Faroe Islands	9,070	11,100 <sup>2</sup>	14,900 <sup>2</sup>	9,200	9,900
France	14,829	12,300	11,000	12,500	7,400
German Dem. Rep.	-	-	-	-	-
Germany, Fed.Rep.	29,221	11,200	23,000	11,200	11,800
Iceland	-	-	-	-	-
Ireland	92,271	109,700	110,000	84,100	91,400
Netherlands	88,117	67,200	73,600	54,100	43,100
Norway	21,610	19,000	19,900	34,700	24,300
Poland	1	-	-	-	-
Spain	1,365	-	-	-	-
Sweden	-	-	-	-	-
UK (England + Wales)	75,722	82,900	62,000	30,000	9,600
UK (N. Ireland)	4,153	9,600	800	1,100	-
UK (Scotland)	109,153	147,400	120,100	167,200	196,300
USSR	-	-	-	-	-
Unallocated	140,322	97,300	105,500	62,900	69,000
Total, ICES members	599,298	582,800	555,800	467,200	463,200
Bulgaria	-	-	-	-	-
Rumania	-	-	-	-	-
Discard	42,300	24,900	11,300	12,100	4,500
Grand total	641,598	607,700	567,100	479,300	467,700

<sup>1</sup> Sub-area VIII does not include Division VIIIc. Spanish catches have been adjusted accordingly since 1976.

<sup>2</sup> Faroese catches have been revised for 1982 and 1983.

<sup>3</sup> Preliminary.

**Table 6.2** Catches of MACKEREL (tonnes) by sub-areas in the western area. Discards not estimated prior to 1978. (Sub-area VIII does not include Spanish catches in Division VIIIc after 1976.)

Year	VI			VII and VIII		
	Landings	Discards	Catch	Landings	Discards	Catch
1969	4,800	-	4,800	66,300	-	66,300
1970	3,900	-	3,900	100,300	-	100,300
1971	10,200	-	10,200	122,600	-	122,600
1972	10,000	-	10,000	157,800	-	157,800
1973	52,200	-	52,200	167,300	-	167,300
1974	64,100	-	64,100	234,100	-	234,100
1975	64,800	-	64,800	416,500	-	416,500
1976	67,800	-	67,800	439,400	-	439,400
1977	74,800	-	74,800	259,100	-	259,100
1978	151,700	15,200	116,900	355,500	35,500	391,000
1979	203,300	20,300	223,600	398,000	39,800	437,800
1980	218,700	6,000	324,700	386,100	15,600	401,700
1981	335,100	2,500	337,600	274,300	39,800	314,100
1982	340,400	4,100	344,500	257,800	20,800	278,600
1983	315,100	22,300	317,400	245,400	9,000	254,400
1984	306,100	1,600	307,700	176,100	10,500	186,600
1985 <sup>1</sup>	388,140	2,735	390,875	75,043	1,800	76,843

<sup>1</sup>Preliminary.

**Table 6.3** MACKEREL catch in numbers ('000) by age group for the western area (Sub-areas VI, VII and VIII) in 1985.

Year class	Age	Via North 58 <sup>0</sup> winter	Via remainder	VIIa-c	VIIId-k	VIIIa,b	Total
1985	0	-	-	-	-	-	-
1984	1	129,801	59,060	602	34,420	2,004	255,887
1983	2	12,689	1,745	26	2,000	96	16,556
1982	3	24,194	8,883	3,814	8,717	469	46,077
1981	4	211,466	77,363	30,619	29,801	1,823	351,072
1980	5	129,704	37,889	19,057	19,770	1,175	207,595
1979	6	84,287	26,618	13,328	13,143	794	138,170
1978	7	28,346	8,447	6,642	5,725	332	49,492
1977	8	9,172	3,507	2,399	292	18	15,388
1976	9	17,971	6,280	5,026	5,558	208	35,043
1975	10	14,961	6,780	3,270	2,930	177	28,118
<1974	11+	47,927	14,422	9,978	14,419	816	87,562
Total		710,518	250,994	94,761	136,775	7,912	1,200,960
Tonnes		304,134	86,741	35,877	38,760	2,206	467,718

**Table 6.4** MACKEREL catch in numbers ('000) by age group for the Western stock in 1985.

Year class	Age	IIa+Vb	IVa	Vla	VIIa-c	VIIId-k	VIIIa,b	Total
1985	0	-	-	-	-	-	-	-
1984	1	-	-	188,861	602	34,420	2,004	225,887
1983	2	-	-	14,434	26	2,000	96	16,556
1982	3	3,254	1,249	31,383	3,814	8,717	469	48,886
1981	4	50,986	5,397	274,026	30,619	29,801	1,823	392,652
1980	5	23,989	2,813	158,514	19,057	19,770	1,175	225,318
1979	6	15,195	1,490	105,005	13,328	13,143	794	148,955
1978	7	7,110	756	34,809	6,642	5,725	332	55,374
1977	8	2,000	316	12,037	2,399	292	18	17,062
1976	9	5,459	675	22,993	5,026	5,026	5,558	39,919
1975	10	4,613	567	20,694	3,270	2,930	177	32,251
<1974	11+	17,379	2,722	58,995	9,978	14,419	816	104,309
Total		129,985	15,985	921,751	94,761	136,775	7,912	1,307,169
Tonnes		75,478	9,522	371,517	35,877	38,760	2,206	533,360

**Table 6.5** The number of immature and mature MACKEREL, the percentage mature, and the mean length of immature, mature and both combined for the Western MACKEREL by age in April, May, June, July and August from 1977-84 according to Dutch samples from mainly commercial freezer trawlers and some from research vessel "Tridens". [For more detailed presentation see Anon., (1985b).]

Item	Age						
	1	2	3	4	5	6	7+
Number immature	214	294	114	27	20	5	4
Number mature	18	432	1,051	835	698	506	2,318
% mature	8	60	90	97	97	99	100
Mean length imm.	24.9	27.4	29.3	30.6	31.6	32.2	32.8
Mean length mat.	27.6	28.7	31.3	33.2	34.3	35.6	38.5
Mean length all	25.1	28.1	31.1	33.1	34.2	35.6	38.5

Table 7.1 VIRTUAL POPULATION ANALYSIS

MACKEREL IN THE NORTH SEA AND WESTERN AREA COMBINED

CATCH IN NUMBERS	UNIT: millions									
-----	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	54.2	2.0	10.5	79.5	19.5	58.5	2.0	.0	.5	.0
1	282.1	154.6	51.3	555.4	487.2	270.0	206.0	45.7	16.7	254.3
2	258.5	508.8	572.0	62.1	474.5	512.4	573.2	729.7	82.6	17.7
3	392.0	212.9	459.7	615.8	77.6	256.6	499.1	472.9	676.5	56.0
4	134.5	220.5	284.5	586.7	595.6	52.8	195.5	408.2	584.4	457.7
5	322.6	60.8	286.2	256.5	505.5	187.3	26.7	157.2	246.0	247.1
6	158.1	166.6	77.9	247.4	171.1	175.9	144.5	21.2	96.8	162.0
7	378.3	96.0	166.1	95.0	175.7	117.5	116.2	96.8	21.2	61.2
8	495.1	215.5	72.5	165.4	64.7	127.1	92.5	77.4	60.5	18.9
9	.0	214.7	127.9	72.5	145.5	40.7	92.5	52.1	46.6	46.2
10	.0	.0	245.1	107.6	47.1	146.2	27.4	55.2	57.0	56.4
11+	.0	.0	.0	207.6	191.5	255.9	255.5	161.5	97.7	121.1
TOTAL	2505.4	1652.0	2552.8	2625.7	2551.4	2118.5	2254.1	2255.7	1766.6	1452.6

Table 7.2 SUM OF PRODUCTS CHECK

MACKEREL IN THE NORTH SEA AND WESTERN AREA COMBINED  
CATEGORY: TOTAL

MEAN WEIGHT AT AGE IN THE CATCH

UNIT: kilogram

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	.066	.066	.066	.066	.066	.066	.066	.066	.069	.066
1	.138	.138	.137	.138	.132	.133	.133	.178	.137	.151
2	.207	.169	.160	.159	.249	.249	.251	.219	.162	.274
3	.263	.275	.250	.243	.285	.287	.285	.276	.302	.359
4	.320	.333	.325	.315	.345	.345	.345	.309	.331	.423
5	.345	.351	.344	.343	.372	.377	.378	.386	.343	.421
6	.406	.407	.402	.401	.455	.455	.455	.426	.435	.438
7	.443	.446	.419	.415	.490	.500	.499	.435	.543	.524
8	.515	.540	.520	.507	.522	.514	.514	.498	.476	.551
9	.000	.536	.537	.513	.543	.545	.542	.546	.569	.564
10	.000	.000	.528	.537	.576	.575	.577	.608	.624	.631
11+	.000	.000	.000	.520	.534	.585	.579	.614	.644	.702



Table 7.3 VIRTUAL POPULATION ANALYSIS

MACKEREL IN THE NORTH SEA AND WESTERN AREA COMBINED

MEAN WEIGHT AT AGE OF THE STOCK UNIT: kilogram

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
0	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
1	.117	.115	.098	.098	.097	.076	.077	.075	.080	.083
2	.151	.140	.154	.155	.155	.175	.178	.165	.192	.158
3	.215	.217	.222	.219	.220	.245	.207	.227	.252	.295
4	.265	.264	.290	.284	.281	.300	.287	.267	.292	.306
5	.277	.281	.329	.354	.329	.307	.385	.328	.310	.354
6	.356	.327	.367	.365	.308	.367	.355	.367	.354	.370
7	.424	.390	.357	.392	.388	.411	.395	.333	.424	.425
8	.496	.454	.411	.407	.414	.419	.420	.420	.425	.443
9	.000	.515	.454	.427	.427	.457	.451	.501	.400	.454
10	.000	.000	.492	.507	.491	.419	.467	.458	.519	.556
11+	.000	.000	.000	.492	.500	.519	.517	.555	.559	.602

Table 7.4 Input parameters and log catch ratio residuals from the separable VPA for the combined North Sea and Western mackerel stocks.

Residuals in    are in excess of the recommended level of  $2 \ln(1 + CV/100)$ .

NATURAL MORTALITY = .150  
 TERMINAL F = .350  
 TERMINAL S = .870

REFERENCE AGE (FOR UNIT SELECTION) IS 5

NO. OF ITERATIONS CHOSEN IS 50  
 MINIMUM DIFFERENCE BETWEEN ITERATIONS IS 10\*\*-5

ITERATION SSQ  
 1 13.8431  
 22 2.3646

APPROX. COEFF. VARIATION OF CATCH DATA = 15.7 %

YEAR	1978	1979	1980	1981	1982	1983	1984	1985
F(I)	.1938	.2423	.2636	.2249	.2364	.2391	.3302	.3500

AGE	1	2	3	4	5	6	7	8	9	10
S(J)	.4016	.3604	1.0000	.9597	.8980	.8019	.8887	.9102	.8663	.8700

#### LOG CATCH RATIO RESIDUALS

78/79 79/80 80/81 81/82 82/83 83/84 84/85

1/ 2	.065	.243	.255	-.171	<span style="border: 1px solid black; padding: 0 2px;">-.703</span>	-.087	<span style="border: 1px solid black; padding: 0 2px;">.403</span>	.004
2/ 3	.007	<span style="border: 1px solid black; padding: 0 2px;">-.372</span>	<span style="border: 1px solid black; padding: 0 2px;">.311</span>	-.065	.089	-.078	.153	.006
3/ 4	.052	.085	.270	-.095	-.136	-.155	-.016	.006
4/ 5	-.008	-.131	.143	-.102	-.003	.137	-.032	.003
5/ 6	.046	.052	-.014	-.010	-.079	.020	-.014	.000
6/ 7	-.205	.093	-.115	.216	.162	-.258	.161	-.001
7/ 8	-.024	.094	-.193	.024	.156	.200	-.256	.001
8/ 9	-.085	-.139	-.092	.060	.277	.186	-.154	.004
9/10	.160	.125	<span style="border: 1px solid black; padding: 0 2px;">-.562</span>	.147	.203	.033	-.163	.006
	.009	.005	.003	.003	.004	.004	.002	.000

Table 7.5 VIRTUAL POPULATION ANALYSIS

MACKEREL IN THE NORTH SEA AND WESTERN AREA COMBINED

FISHING MORTALITY COEFFICIENT											UNIT: Year-1	NATURAL MORTALITY COEFFICIENT = .15										
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985												
0	.007	.003	.003	.010	.005	.008	.004	.000	.000	.000												
1	.072	.040	.059	.145	.124	.076	.053	.114	.167	.057												
2	.097	.100	.191	.151	.277	.175	.217	.254	.307	.253												
3	.138	.103	.200	.303	.270	.205	.244	.262	.372	.333												
4	.191	.102	.184	.244	.308	.165	.244	.304	.333	.406												
5	.143	.034	.176	.231	.292	.221	.186	.256	.267	.349												
6	.167	.097	.140	.215	.251	.257	.251	.209	.276	.293												
7	.264	.153	.126	.233	.218	.232	.255	.251	.315	.266												
8	.183	.210	.164	.166	.253	.232	.274	.254	.252	.432												
9	.000	.107	.178	.231	.203	.219	.249	.230	.226	.264												
10	.000	.000	.160	.196	.218	.310	.212	.210	.240	.262												
11+	.000	.000	.160	.196	.218	.310	.212	.210	.240	.262												
( 2-10)U	.151	.107	.169	.219	.251	.224	.237	.248	.288	.323												
( 2-10)W	.160	.112	.176	.236	.263	.210	.236	.262	.322	.344												

Table 7.6 VIRTUAL POPULATION ANALYSIS

## MACKEREL IN THE NORTH SEA AND WESTERN AREA COMBINED

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: .580  
PROPORTION OF ANNUAL M BEFORE SPAWNING: .400

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
1	5009.4	683.7	5288.2	5317.8	4647.7	5019.2	508.9	155.6	5287.6	.0	*****
2	4368.2	4230.0	580.6	2820.6	4505.4	5982.5	4284.6	456.2	116.7	4550.6	.0
1	5702.9	3498.5	5540.6	475.9	2189.8	3425.5	5177.6	3477.0	535.7	85.0	5699.8
3	3263.1	2345.5	2725.5	2518.5	352.2	1570.0	2474.5	2200.5	2555.6	212.0	56.3
4	1141.9	2445.9	1621.5	1920.7	1600.9	231.4	960.5	1668.4	1457.1	1386.1	150.8
5	2598.1	812.2	1901.5	1504.7	1295.8	1012.6	168.9	647.6	1059.1	899.3	795.0
5	966.5	1957.7	642.8	1571.7	891.5	1535.2	698.5	120.6	450.6	684.4	546.0
7	1844.3	784.2	1515.6	461.2	752.0	689.2	554.6	467.8	84.2	231.2	459.4
8	3135.4	1219.9	517.5	1149.0	528.2	658.8	415.9	570.0	315.2	52.9	165.5
9	.0	2285.9	858.9	577.9	357.8	222.7	449.6	272.5	247.0	215.7	28.1
10	.0	.0	1767.0	615.2	258.2	588.4	154.0	371.7	186.2	169.5	141.5
11+	.0	.0	.0	1218.0	1550.0	241.5	1455.5	214.6	491.8	565.9	465.8
TOTAL NO	25380.4	20211.2	19155.1	19569.2	17618.5	18894.4	15282.6	11052.3	12344.2	9098.8	
SPS NO	15011.9	12453.1	11966.5	9580.2	7714.8	7457.4	7940.9	7531.1	5462.9	3945.4	
TOT. BIO.1	5568.8	5097.4	4651.5	4108.7	3558.7	5234.1	5170.2	2925.9	2223.6	2105.2	
SPS BIO.1	4074.6	3852.0	3601.2	3244.0	2570.3	2541.4	2290.5	2227.6	1732.4	1440.2	

Table 7.7 A comparison of recruitment indices from research vessel surveys and VPA (1985) for the Western stock.

Year class	Research vessel indices (mean no./hr trawl)		VPA index for Western stock
	Sub-area VII O-group	Division VIa 1-group	1-group
1985	41	-	-
1984	525 <sup>1</sup>	1,405	4,634 <sup>2</sup>
1983	0.01	3	194
1982	0.01	13	546
1981	47	2	4,394
1980	-	46	3,856
1979	113	-	4,819
1978	-	-	2,976
1977	-	-	585
1976	-	-	4,405
1975	-	-	4,314

<sup>1</sup>Provisional estimate.

<sup>2</sup>Provisional estimate based on catch as O-group.

Table 7.8 A comparison between ranked abundance indices from research vessel surveys and VPA (1985) for the Western stock.

Year	Research vessel indices			VPA index for Western stock
	Sub-area VII O-group	1-group	Division VIa 1-group	1-group
1985	-	-	-	-
1984	1 <sup>1</sup>	2	1	2
1983	5	8	4	10
1982	4	9	3	9
1981	3	3	5	4
1980	-	5	2	6
1979	2	1	-	1
1978	-	5	-	7
1977	-	-	-	8
1976	-	7	-	3
1975	-	4	-	5

<sup>1</sup>Provisional estimate.

Table 7.9 Input data for catch forecasts, combined MACKEREL stocks  
( $M = 0.15$ ).

Age	Stock in no. in 1986 (millions)	Fishing pattern	Weight at age in catch 1985	Weight at age at spawning 1985	Maturity ogive
1	3,000.0	0.40	0.151	0.083	0.06
2	3,699.8	0.86	0.274	0.158	0.60
3	56.8	1.00	0.359	0.295	0.90
4	130.8	0.96	0.423	0.306	0.97
5	795.0	0.90	0.421	0.334	1.00
6	546.0	0.88	0.438	0.370	1.00
7	439.4	0.88	0.524	0.425	1.00
8	185.5	0.88	0.551	0.443	1.00
9	28.1	0.88	0.564	0.454	1.00
10	141.3	0.88	0.631	0.556	1.00
11+	485.8	0.88	0.702	0.602	1.00

Recruitment at age 1: 1986 3000 million  
 1987 3000 million  
 1988 3000 million

Catch in 1986: 620,000 tonnes

**Table 7.10** Forecasts of stock biomass and catch for the combined North Sea and Western MACKEREL stocks. Basic parameters are given in Table 7.9. Stock biomass and catch are in ('000) tonnes. Spawning biomass is at the time of spawning.

1985		1986				1987				1988		
Total land-ings	$\bar{F}_{(2-10)}$	Stock biomass (1 Jan)	Spawn. stock biom.	$\bar{F}_{(2-10)}$	Total land-ings	Management option	Stock biomass (1 Jan)	Spawn. stock biom.	$\bar{F}_{(2-10)}$	Total land-ings	Stock biomass (1 Jan)	Spawn. stock biom.
597	0.32	2,011	1,300	0.30	620	Maintain catch level	2,126	1,417	0.28	620	2,077	1,385
						$F_{87} = F_{86}$		1,406	0.30	656	2,046	1,351
						$F_{87} = F_{0.1}$		1,475	0.18	409	2,258	1,590
						$F = M$		1,491	0.15	350	2,308	1,648
						$F = 0$		1,580	-	-	2,609	2,011

**Table 9.1** Catch in numbers ('000) and tonnes of the North Sea MACKEREL stock by quarter in 1985.

Age	Quarter			
	1	2	3	4
1	-	-	5,651	982
2	-	9	649	195
3	206	184	4,438	2,290
4	1,666	582	20,435	16,374
5	1,713	367	10,458	9,300
6	1,271	188	5,968	5,658
7	418	130	2,849	2,425
8	96	32	1,005	736
9	427	144	4,075	1,598
10	299	146	2,582	1,105
11	164	117	2,484	1,001
12	131	156	2,046	1,048
13	136	151	1,449	559
14	155	82	1,299	500
15+	306	312	3,347	1,298
Sum	6,988	2,600	68,735	45,069
Tonnes	2,890	1,392	36,373	22,401

**Table 9.2** Quarterly mean weight at age (grams) for the North Sea mackerel stock in 1985.

Age	Quarter			
	1	2	3	4
1	-	-	161	159
2	-	225	312	299
3	335	370	443	410
4	353	393	498	463
5	346	465	498	459
6	371	394	532	472
7	464	474	583	551
8	449	547	645	594
9	470	535	594	564
10	574	640	659	687
11	585	691	762	700
12	571	585	770	685
13	658	668	732	704
14	670	647	706	706
15+	627	688	774	809



Figure 3.1 Anomalies ( $R-R_M$ ) of the number of 1-year-old recruits ( $R$ ) with reference to the number of recruits ( $R_M$ ) required to balance total losses from the stock due to natural mortality.

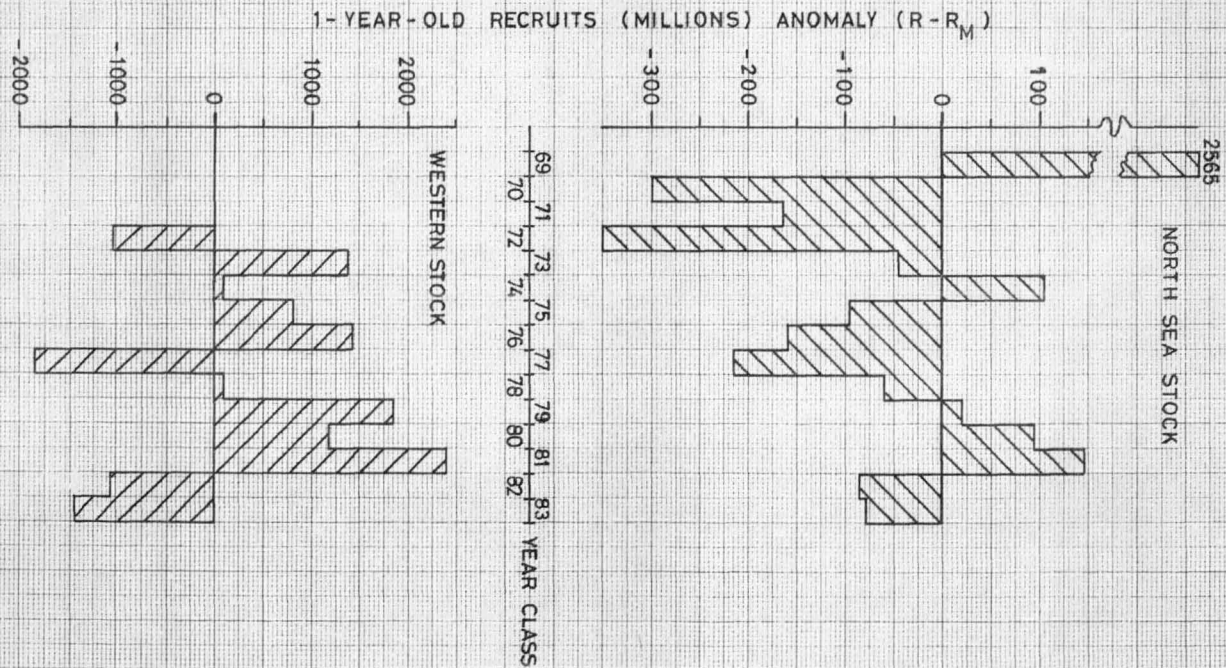
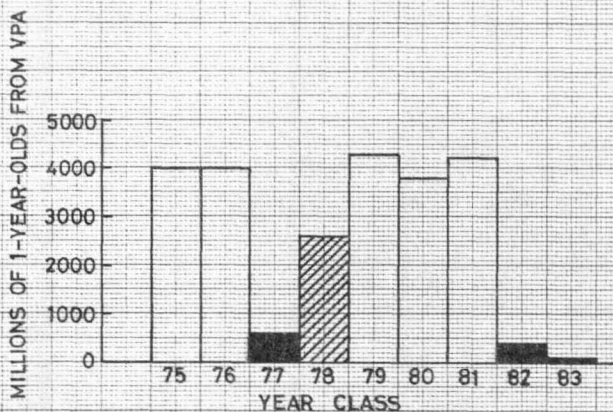


Figure 3.2 VPA estimates of Western mackerel recruitment of 1-year-olds, 1975-83 year classes (Anon., 1985a).



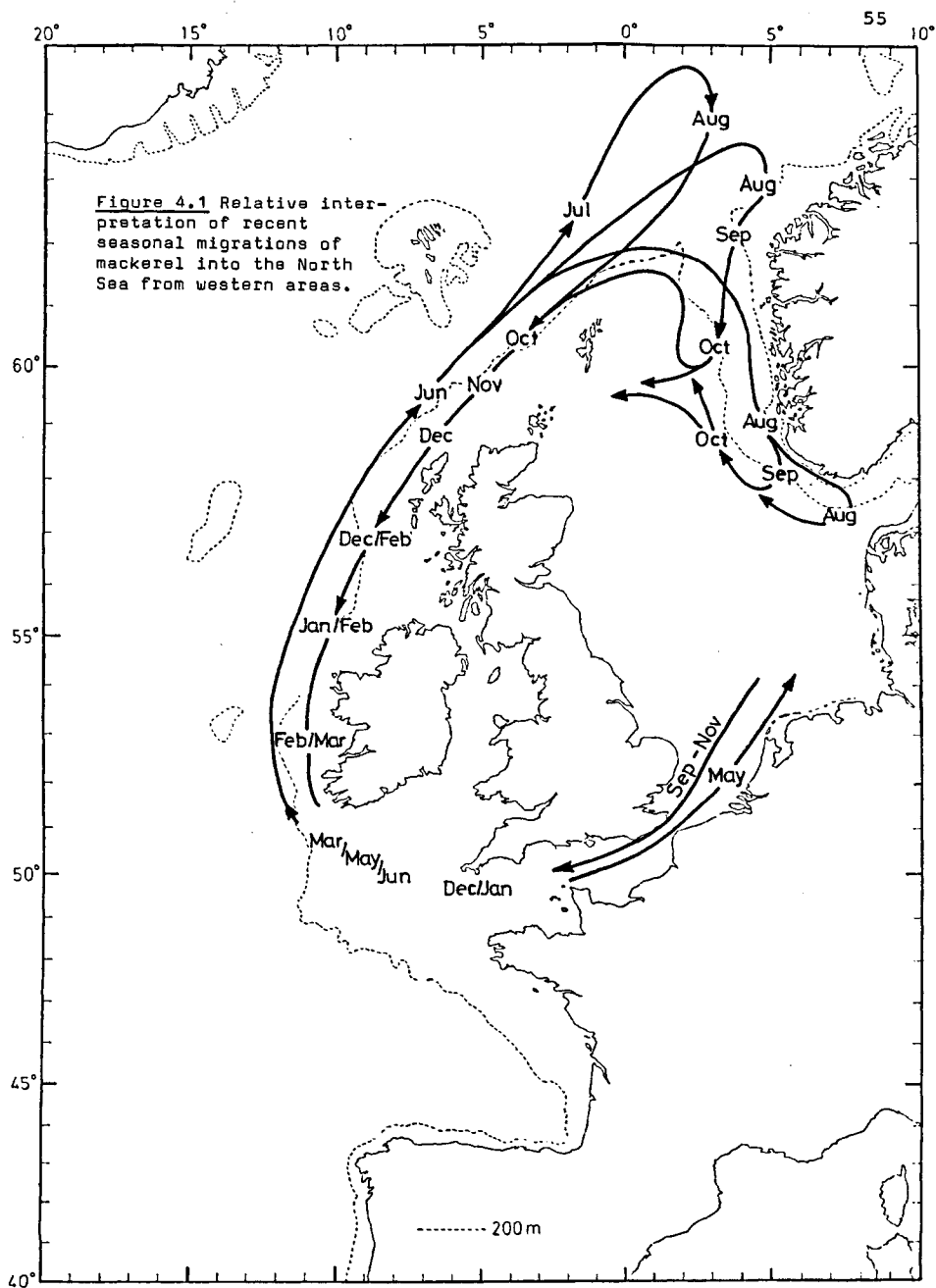
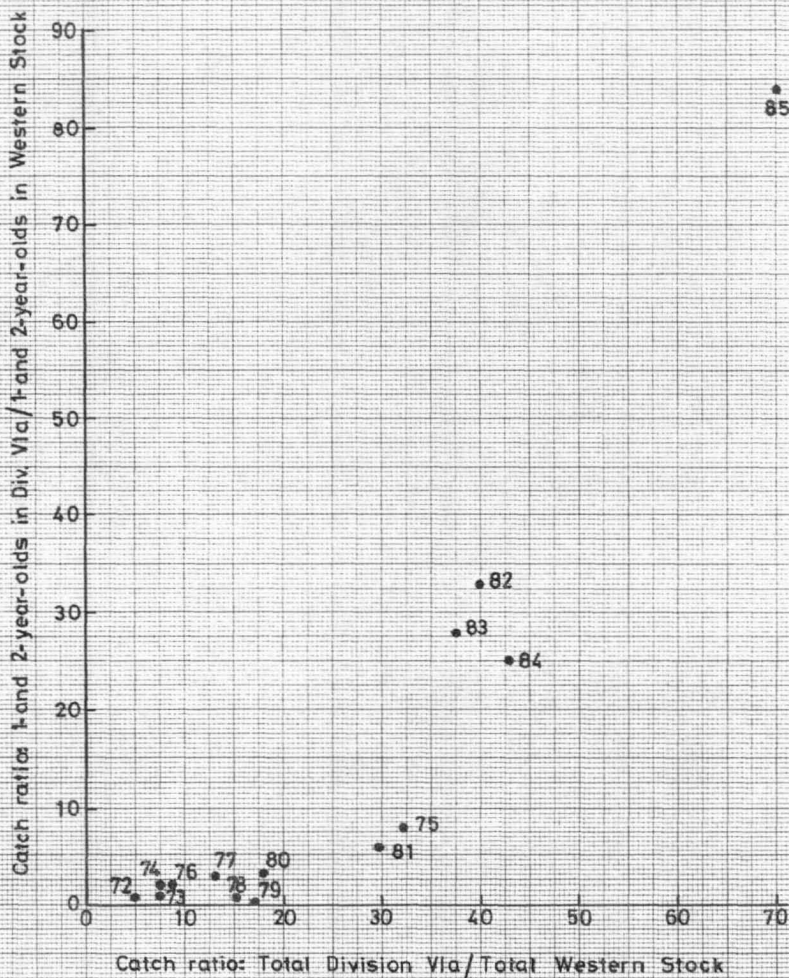
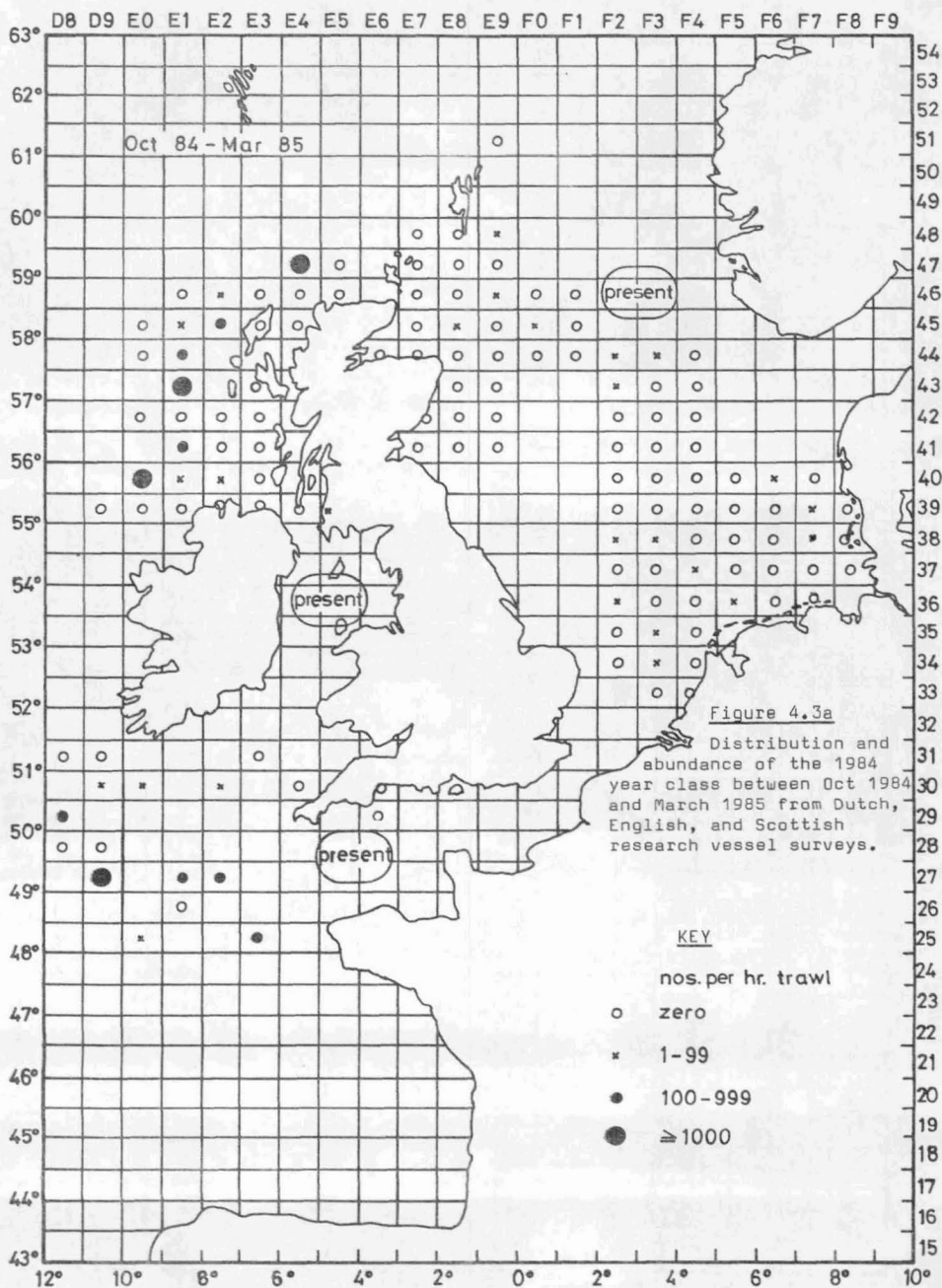


Figure 4.2 The relationship between the juvenile fish (1- and 2-year olds) in Division VIa catches relative to juvenile fish in the Western stock catches and the total Division VIa catch relative to the total Western stock catch.





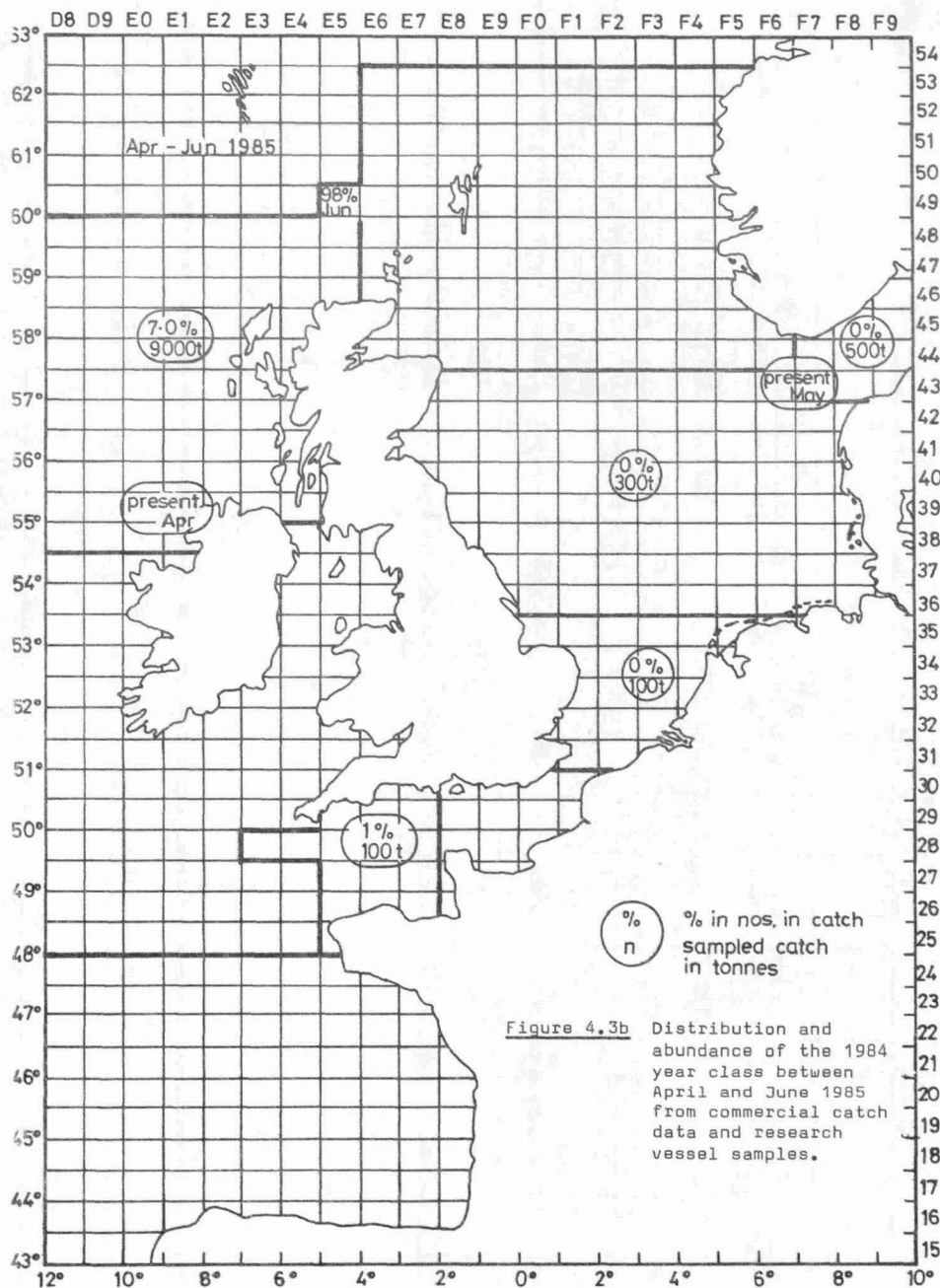
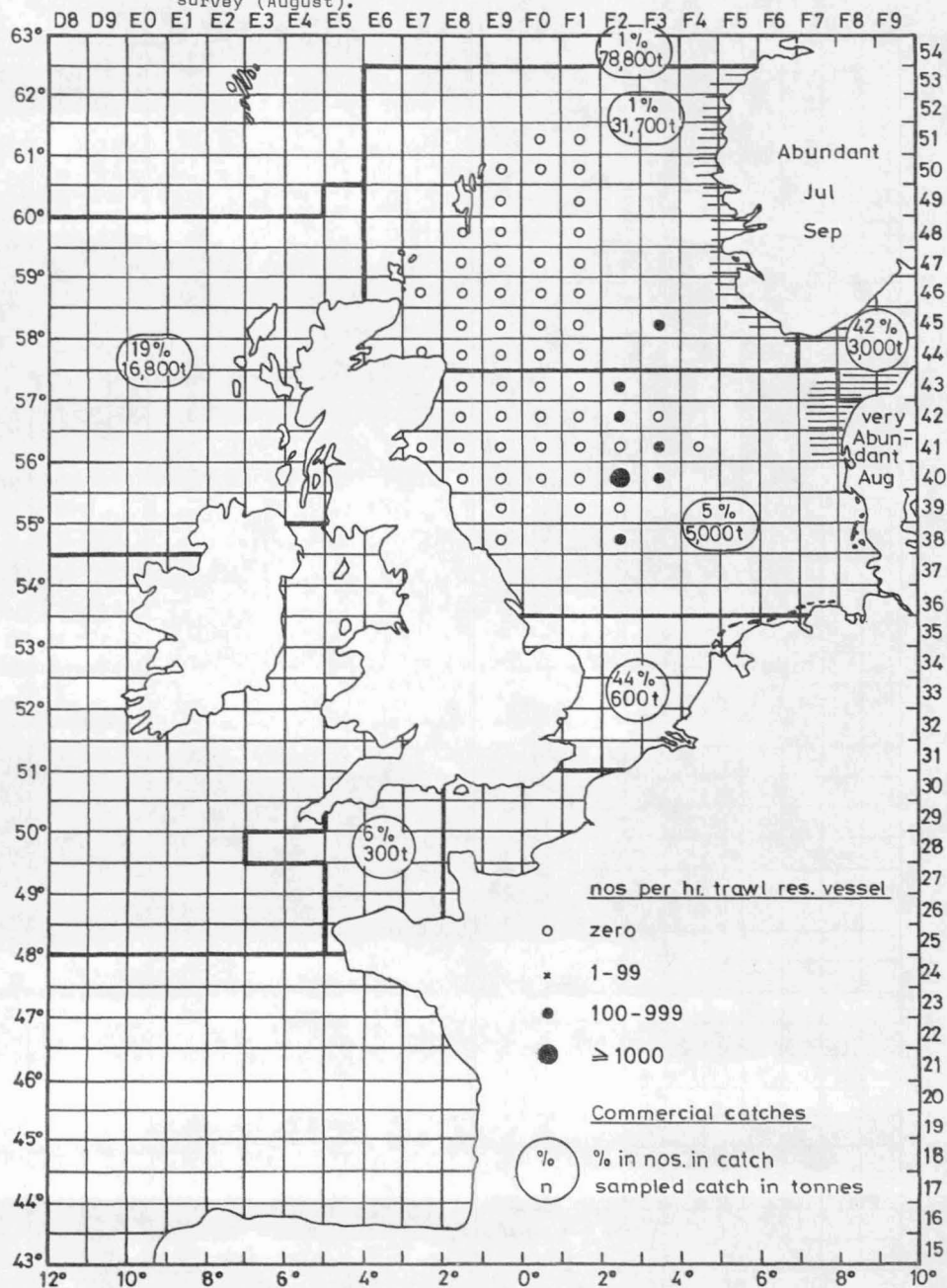


Figure 4.3b Distribution and abundance of the 1984 year class between April and June 1985 from commercial catch data and research vessel samples.



Figure 4.3c Distribution and abundance of the 1984 year class between July and September 1985 from commercial catch data and a research vessel survey (August).



60 Figure 4.3d Distribution and abundance of the 1984 year class between Oct 1985 and Feb 1986 from research vessel data and fourth quarter 1985 catch data.

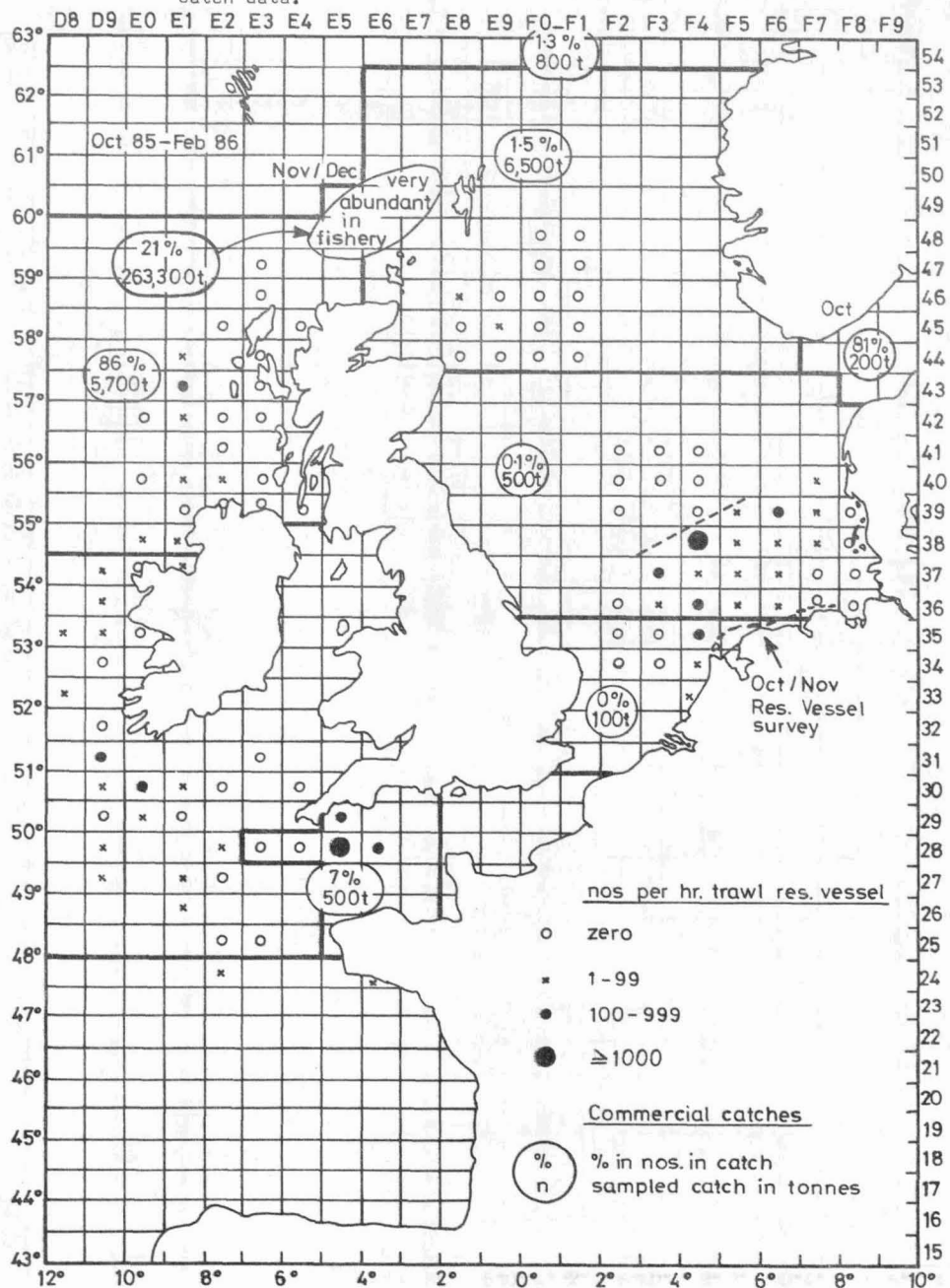




Figure 4.4 Distribution and abundance of the 1985 year class in the winter of 1985-86 from Dutch, English, Irish and Scottish research vessel surveys. 61

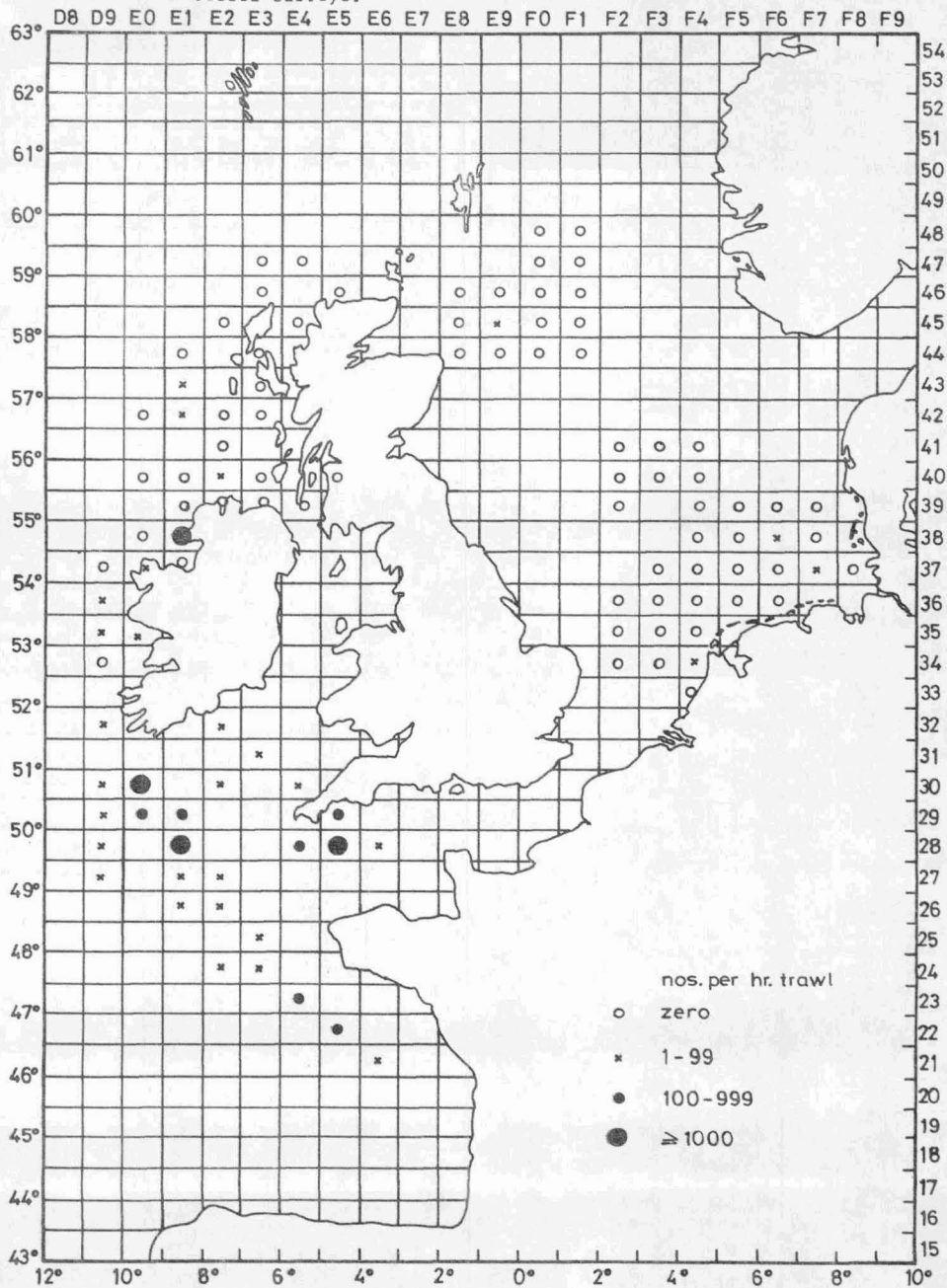
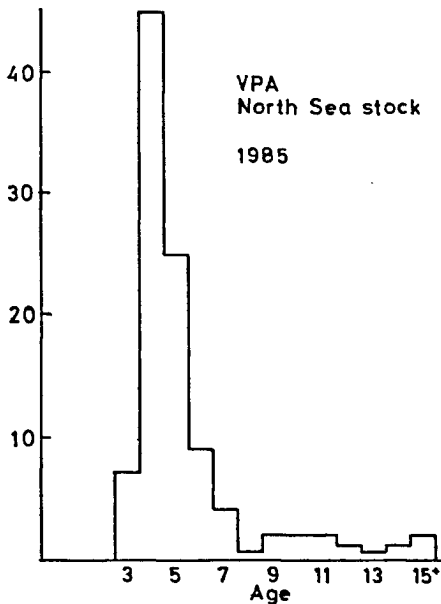
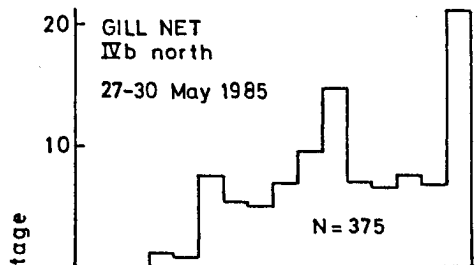
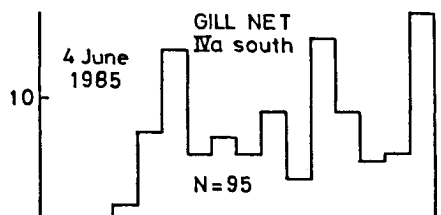
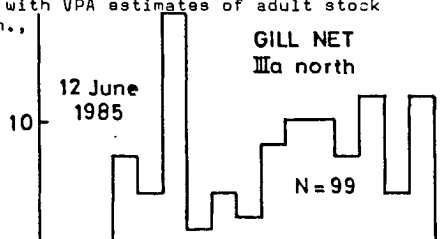
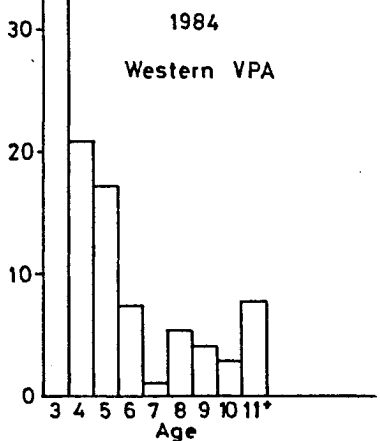
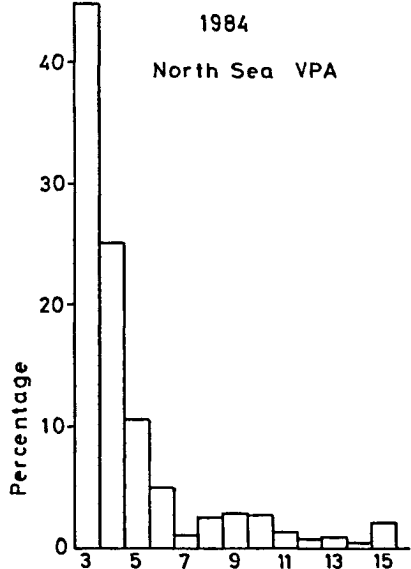
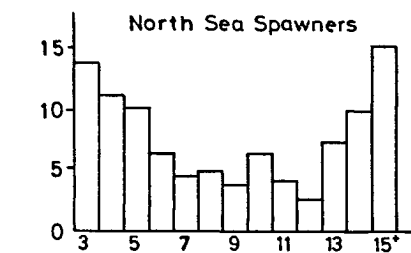


Figure 5.1 A comparison of adult mackerel (3 years and older) age distribution from the North Sea spawning grounds at spawning time in 1984 (Scottish RV samples) and in 1985 (Norwegian gill net fishery) with VPA estimates of adult stock in the North Sea and Western stocks (Anon., 1985a). **1984 RV Samples**



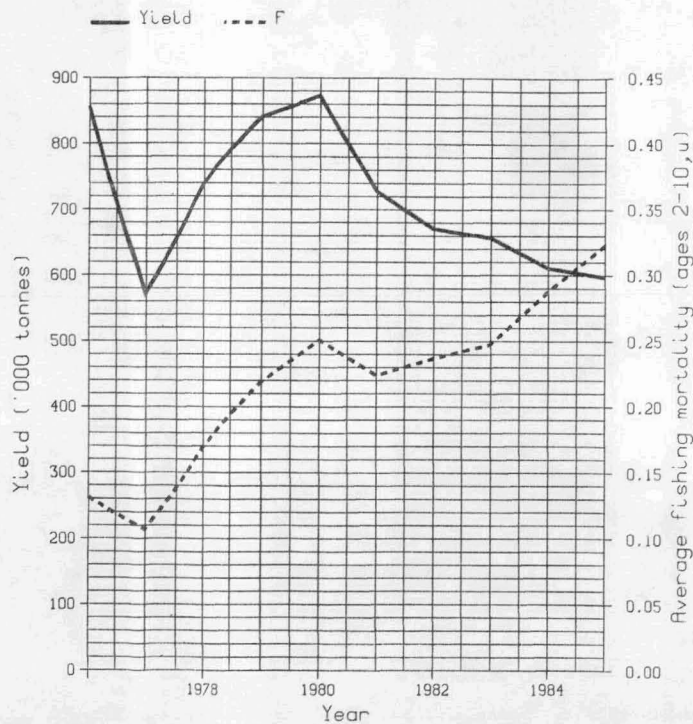
# FISH STOCK SUMMARY

## STOCK: Mackerel - Combined Western and N Sea

25-2-1986

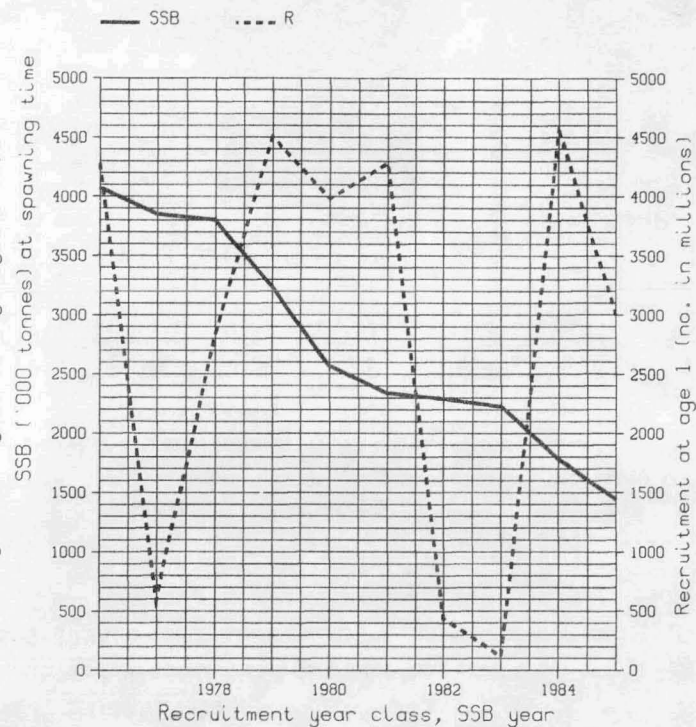
Figure 7.1

Trends in yield and fishing mortality (F)



A

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



B

cont'd.

# FISH STOCK SUMMARY

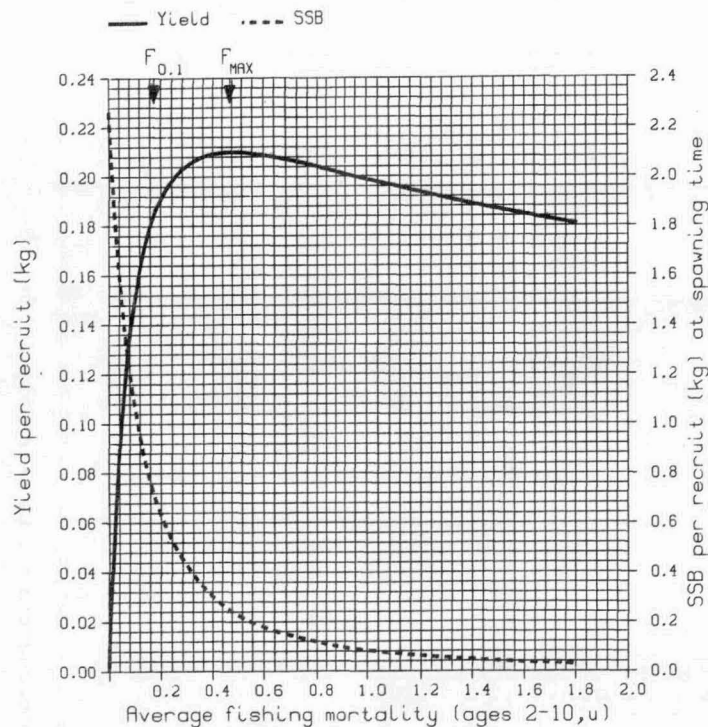
**STOCK: Mackerel - Combined Western and N Sea**

**25-2-1986**

Figure 7.1 cont'd.

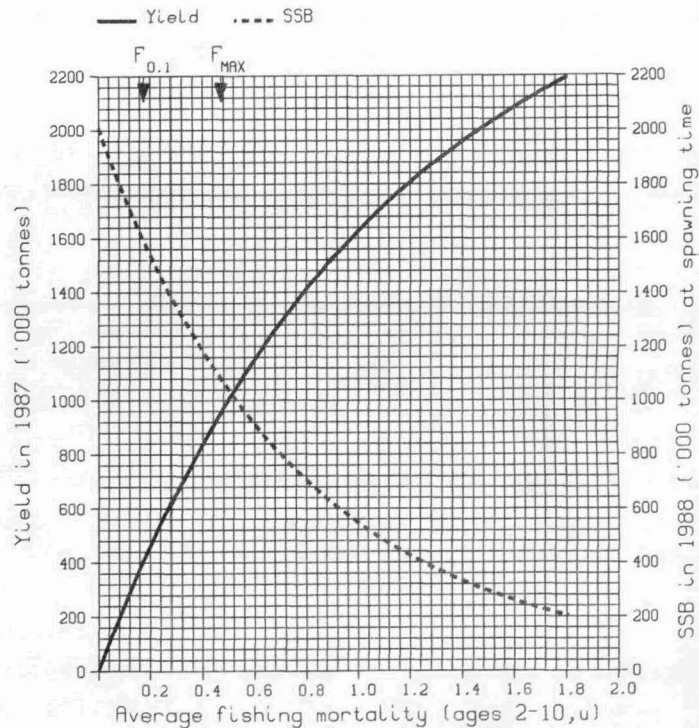
64

Long-term yield and spawning stock biomass



C

Short-term yield and spawning stock biomass



D

## MACKEREL

NORTH SEA AREA (Subarea IV + Division IIIa)

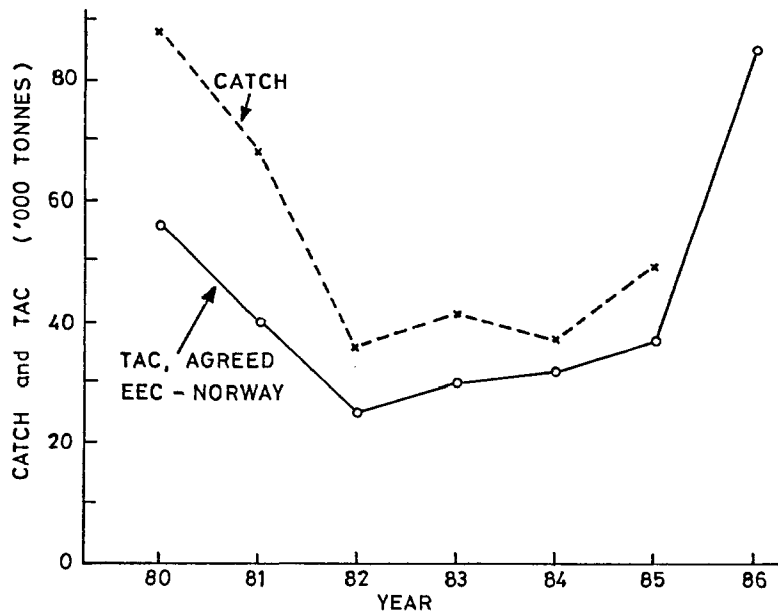
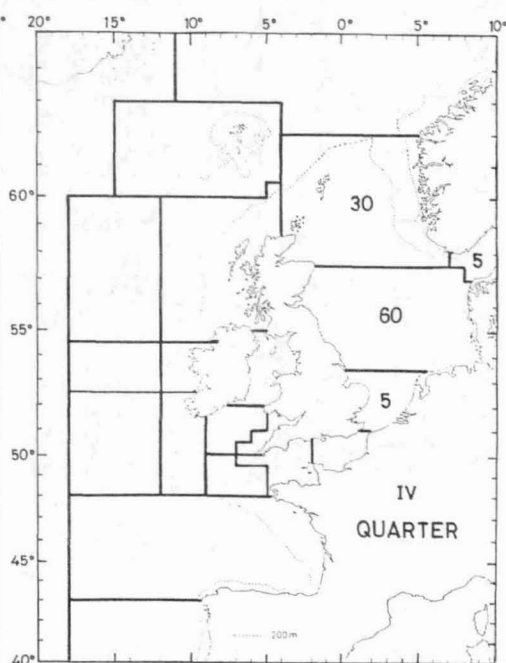
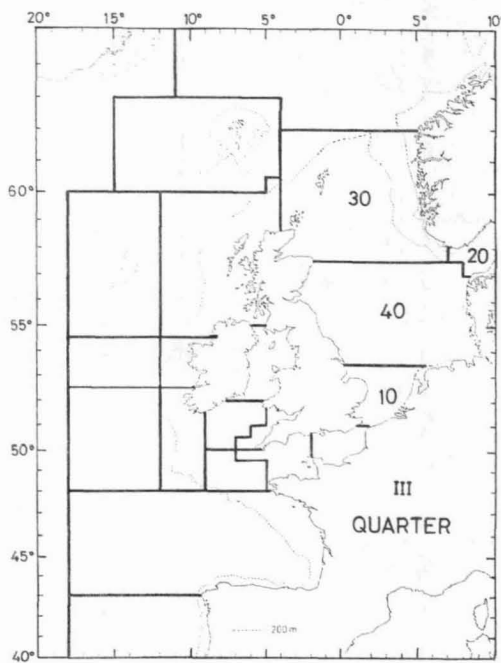
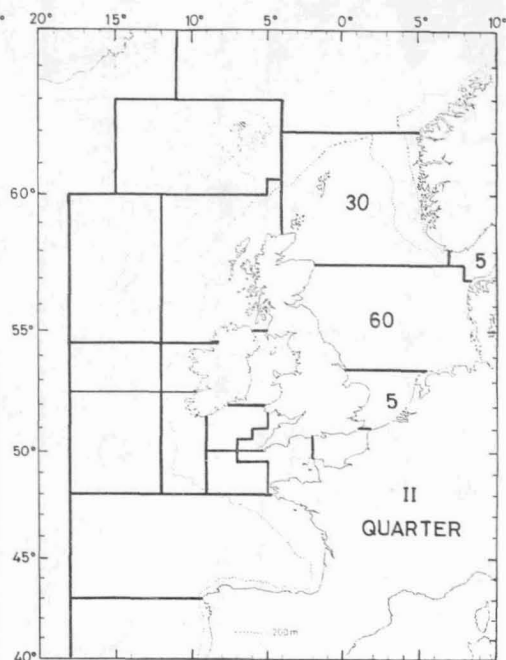
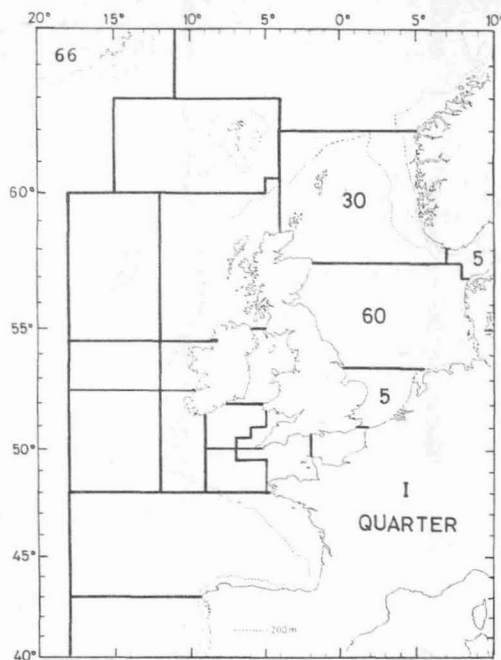
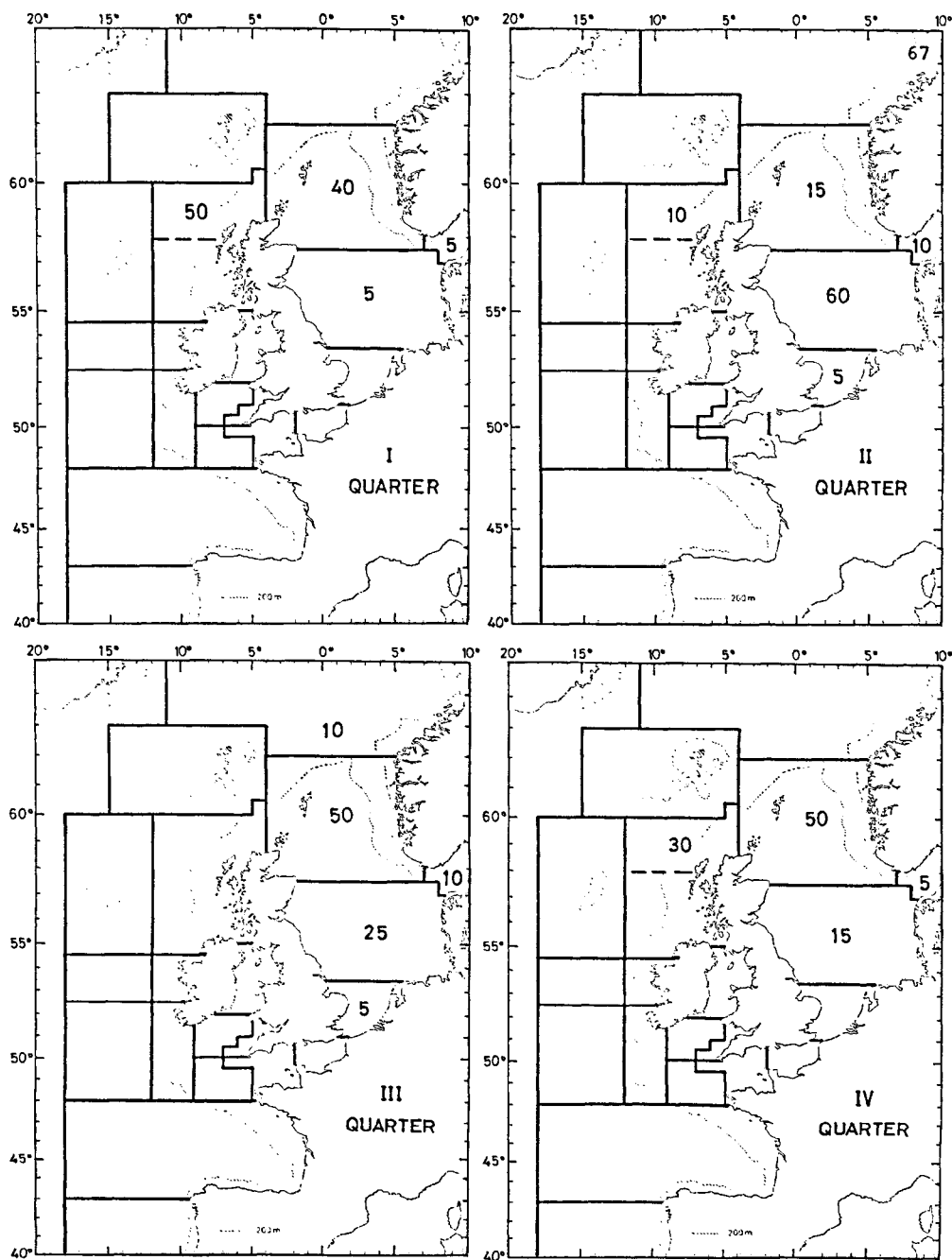


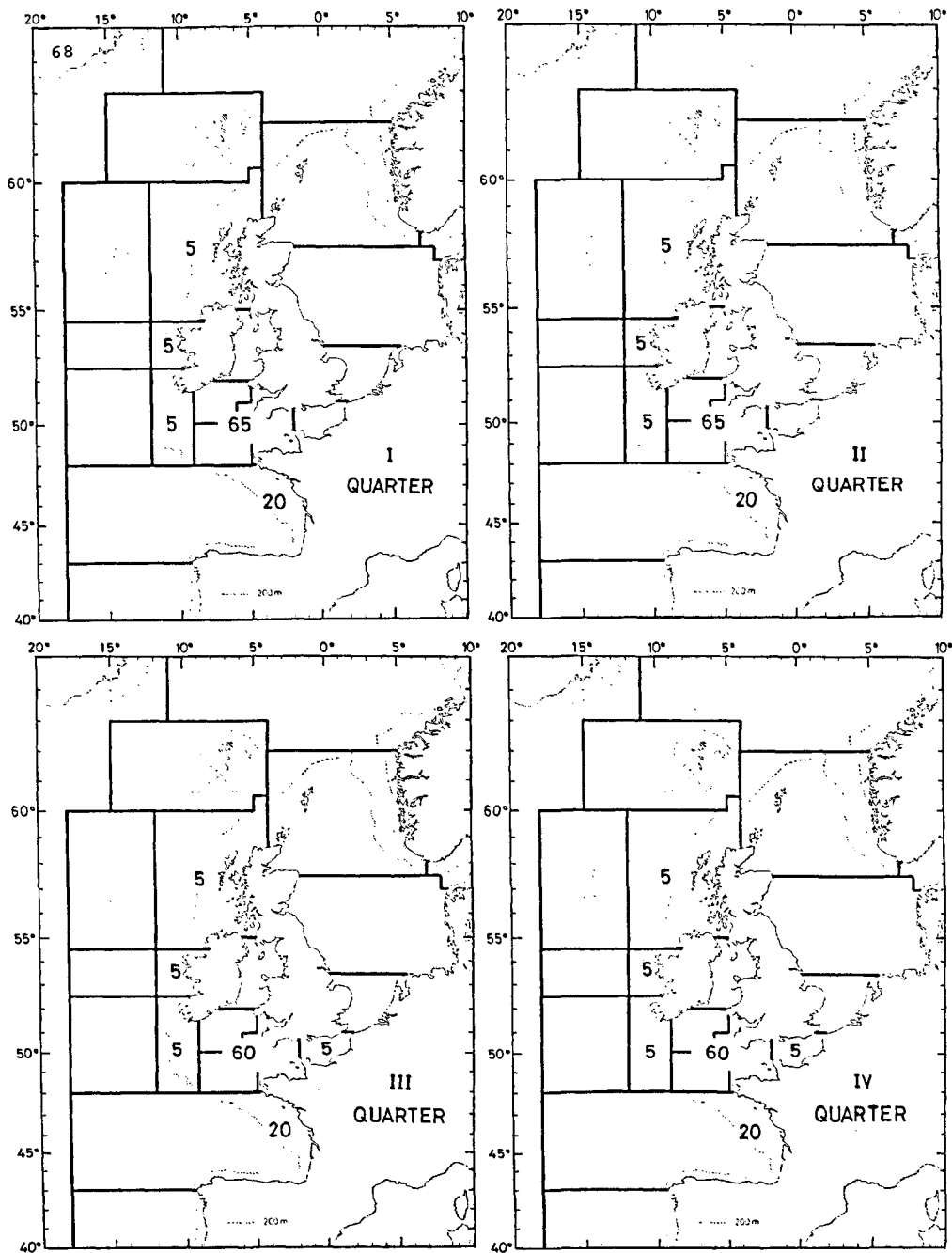
Figure 8.1 Comparison of recent working group estimates of catches in the North Sea area and the TAC (plus allowances "transformed" from Division IIa) agreed between EC and Norway.



**Figure 9.1** A putative assessment of the quarterly distribution (% , numbers) of juvenile mackerel of the North Sea stock.

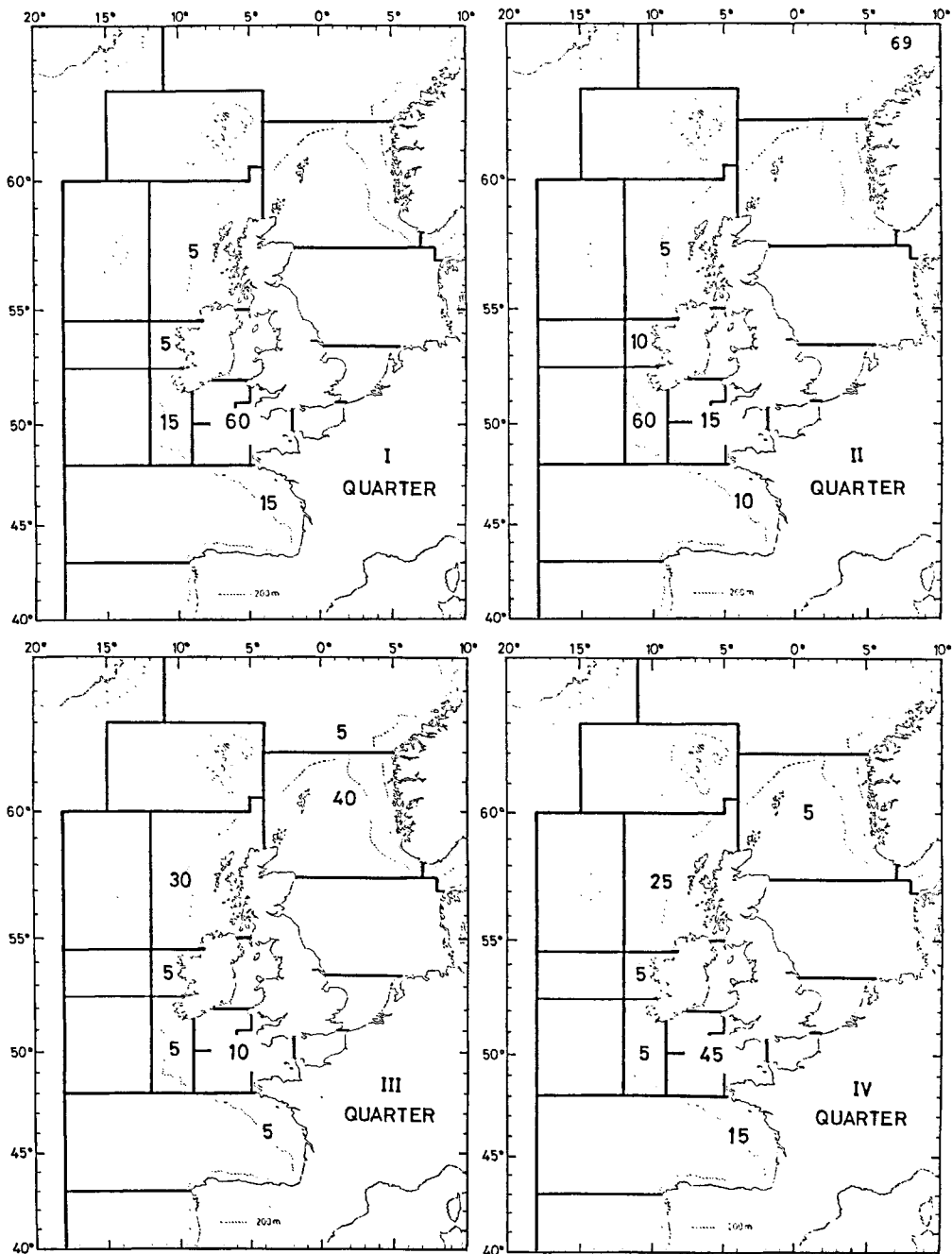


**Figure 9.2** A putative assessment of the quarterly distribution (% , numbers) of adult mackerel of the North Sea stock.



**Figure 9.3** A highly speculative assessment of the quarterly distribution (% , numbers) of juvenile mackerel of the Western stock (not to be used for management purposes).





**Figure 9.4** A highly speculative assessment of the quarterly distribution (% , numbers) of adult mackerel of the Western stock (not to be used for management purposes).