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REPORT OF THE MACKEREL WORKING GROUP

8 - 12 March 1976, Charlottenlund, Denmark

1. Introduction

At the Statutory Meeting of ICES in Montreal in October 1975 it was decided to convene the Mackerel Working Group "... to reassess the mackerel stocks in Sub-areas III, IV and VII, and to plan for egg and larval surveys and hydroacoustic survey in the area south of Ireland, including the French continental shelf" (Res.1975 + II(9)).

The Group met at Charlottenlund, 8-12 March 1976, with the following participating members:

Mr E. Bakken (Chairman)	Norway
Dr S.S. Fedorov	USSR
Dr J. Guéguen	France
Mr M. Liwoch	Poland
Dr S.J. Lockwood	U.K. (England)
Mr A.S. Malkov	USSR
Mr S. Munch-Petersen	Denmark
Mr K. Postuma	Netherlands
Mr A. Saville	U.K. (Scotland)

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The assessments outlined in the previous report of the Group (Anon. 1975) were mainly based on catch reports and estimates relating to the North Sea stock based on Norwegian mackerel taggings. At the meeting reported here, the Working Group considered all relevant data now available with the aim of improving reliability by the use of different, independent methods.

Two mackerel stocks were considered: the one overwintering in the North Sea (here termed the North Sea stock), and the one overwintering in the Celtic Sea area (here termed the Western stock). The stocks are mainly found in Sub-areas III, IV and in VI, VII respectively, but taggings have shown that they are not confined to these areas as, e.g. mackerel from Sub-area VII migrate to Sub-area IV in summer.

Stock size estimates refer to these two separate stocks, whereas catch summary tables relate to ICES areas, not the separate stocks.

2. The fisheries

2.1. The North Sea

Although the data are provisional estimates, total landings in 1975 were about 314 000 tons (Table 2.1.1), which is nearly the same figure as in 1974. The 3% increment can be attributed to the increase in Danish, Faroes and Soviet catches (147%, 25% and 227% respectively).

The catches of the third and fourth quarters (Table 2.1.3, 2.1.4 and 2.1.5) are now of the same order and represent 84% of the annual total. Between 1974 and 1975 summer landings from Division IVa have been reduced by more than one half whilst autumn landings doubled.

The numbers of mackerel at each age in the catches in Division IVa, IVb, IVc and Sub-area II are shown in Table 2.1.2. Norwegian, Dutch and Scottish catch data in numbers at each age, covering about 70% of the total catch by weight from these areas

were available. From these data it is clear that no 0-group mackerel were landed in the years 1972-75, and that the year-class 1969 is still predominant in the catches of 1975.

2.2 The Western area

The trend pointed out in 1974 is still the same. In 1975 the total landings of 295 380 tons (Table 2.2.1) represented an increase of 19% on those of the previous year and 241% of those of 1971. In this amount the catches of Spain are not included, as they have not yet been reported, neither have those of some non-member countries, which, are thought to be significant, but cannot be estimated.

The increased catches were taken in the Irish Sea, the Celtic Sea and Bristol Channel (Division VIIa and VIIe-k). These Divisions accounted for 81% of the landings attributed to the western fishery. One can note an important drop in Faroese, French and Norwegian catch, as well as an increase in that of nearly all other countries.

Because of the importance of "not specified" in landing statistics (Tables 2.1.3, 2.1.4 and 2.1.5) it is difficult to specify a precise season for the major catches. From what is known of the behaviour of mackerel it can be assumed that the fishery is mainly based on late autumn and winter concentrations. It is important that in future the Working Group receive statistics of landings split on a quarterly basis.

The numbers of mackerel at each age in the catches in Division VIa, VIb and VIIa-k are shown in Table 2.2.2. Data on numbers at each age of the Dutch, English, French and percentage distributions of the Sovjet and Scottish catches were available, covering about 80% of the total catch made in the Divisions mentioned. These data were applied to the total catch in the Western area.

3. Stock separation and distribution

In the previous Mackerel Working Group Reports (Anon. 1974 and 1975), the existence of two mackerel stocks was recognized, the North Sea stock and the Western stock. For assessment purposes the two stocks are considered as being separate management units but there is increasing evidence that the Western stock has at least two components.

3.1. Tagging returns

Western stock mackerel were tagged throughout the Celtic Sea area during the 1960s by Bolster (1974) and each May since 1970 south of Ireland by Hamre (1975). Returns from these releases show that part of the Western stock migrates north, from the Celtic Sea in spring to the region of Shetland in summer. Here it mixes with the North Sea stock. Bolster's work also shows that part of the Western stock migrates eastward into the English Channel and the central-southern North Sea. Fish tagged in this area during summer by Zijlstra and Postuma (1965) have been recovered from the Celtic Sea area. This indicates that Western stock mackerel which over-winter in the Celtic Sea area may contribute both to the Celtic Sea spawning and the North Sea spawning.

3.2. Mean weight-at-age

Mean weight-at-age data were presented for six countries, England, France, Netherland, Norway, Poland and Scotland, although they did not all have data for all areas in all quarters. The weighted mean weight-at-age by areas and quarters are given in Table 3.2.1.

These data show a reasonably consistent age/weight relationship by quarter within Division with the exception of the fourth quarter in Sub-area VII. Postuma (in prep.), analysing the Dutch data, found that the age/weight curve for the fourth

quarter in Sub-area VII was significantly higher than in the earlier quarters. The relationship is closer to that found in Divisions IVa and VIa, while the relationships during the first and third quarters are closer to those in Divisions IVb and IVc. Postuma suggests that this may be related to the migration pattern shown by tagging; there is a faster growing component in the Western stock, closer in weight-at-age to the North Sea population at Shetland. The residual component is slower growing and is closer in weight-at-age to those found in Divisions IVb and IVc.

4. Stock sizes and mortalities

4.1. Number per year-class caught from the North Sea stock

In Table 4.1.1 the number per year-class caught from the North Sea stock in the period 1972-75 are shown. There are no adequate age composition data available to permit this to be estimated for earlier years. The numbers per year-class were estimated by subracting from the numbers caught in Sub-area IV and II, (Table 2.1.2) the part of the Western stock present in Norwegian purse seine catches, in the Shetland area, using the annual ratios per age groups of the Western stock to the North Sea stock in the Shetland area as estimated by Hamre (1975). These numbers were used in a VPA.

4.2. Number per year-class caught from the Western stock

In Table 4.2.1 the number per year-class of mackerel caught from the Western stock in the period 1972-75 are shown. These numbers were arrived at by adding to the numbers caught in the Sub-areas VI and VII (Table 2.2.2), the part of the Western stock caught in the Norwegian purse seine fishery in the Shetland area. These numbers were used in a VPA.

4.3. Natural mortality

In the absence of further evidence the assumed natural mortality of 0.2 for both the North Sea stock and the Western stock used in previous reports of the Mackerel Working Group was retained.

4.4. Fishing mortalities

4.4.1. Fishing mortality of the North Sea stock

Survival rates from the tagging data were calculated from the number of tagged mackerel released and the recaptures over several fishing seasons (Table 4.4.1). It was assumed that mortality due to tagging is constant from year to year. The survival rate (S) was calculated from the equation given by Hamre (1975).

The calculated annual survival rates (S) and the corresponding instantaneous total mortality rate (Z) are given in the two last columns of Table 4.4.1. With the assumed natural mortality rate of 0.2 as given in paragraph 4.3, the following fishing mortalities (F) are estimated:

	Year-class	
	1969	older
1969-70		1.00
1970-71	0.31	0.40
1971-72	neg.	0.17
1972-73	0.14	0.33
1973-74	0.15	0.28
1974-75	0.15	0.49

In these mortality estimates no allowance is made for a possible emigration of the North Sea stock to the Western area or visa versa.

Using the catch in numbers at each age (Table 4.1.1) and an input M = 0.2 a VPA was carried out.

It was realised that using the conventional VPA technique with only four years catch data, no accurate measure of fishing mortality rates would be obtained unless there was a reliable estimate of the fishing mortality rate for the last year for which there was catch data. However, if one has a reliable estimate of F in any of the years for which there are catch data, one can try different input F's for the last year until one obtains an F from the VPA for the year for which one has an independent estimate which coincides with that estimate. This

VPA will then give as good estimates of F and stock size for all the years for which there are good catch in numbers data as the reference F used in the calculation.

From the results of the tagging data reported by Hamre (1975) it was decided that the best estimate of F for the North Sea stock in the period 1973-75 was that of 0.15 for 1974. By an interative procedure an input F for 1975 was estimated which gave the closest approximation to this as an output value from VPA for 1974.

Table 4.4.2 shows fishing mortalities in the period 1972-75 for the different ages, with weighted F for mackerel $\geq$ 3 years. Since 1972 fishing mortality of the adult part of the stock in the North Sea appears to have increased from 0.06 in 1972 to 0.21 in 1975.

4.4.2. Fishing mortality of the Western stock

For the Western stock the procedure described in paragraph 4.4.1 could not be followed because it was considered that no sufficiently reliable estimates of F were available from any source for the period 1972-75. However, Hamre (1975) gives what were considered as reliable estimates of the proportions of the 1969 year-class originating from the Western and North Sea stocks in the fishery in the Shetland area in 1974 and 1975. There are also strong indications that the mixing of the two stocks in this area are in proportion to the stock sizes, at least for the older ages. If one has reliable estimates of the abundance of a year-class in one of these stocks in a year one can then estimate from these proportions what the abundance of that year-class in the other stock would be. From the North Sea VPA using the estimated abundance of the 1969 year-class in 1974 and 1975, and Hamre's (1975) estimates of the proportions of this year-class in the Shetland fishery in these years, it was estimated that this year-class in the Western stock would be 1.032×10^9 in 1974 and 0.546×10^9 in 1975.

The VPA for the Western stock was then run with various input

F's for 1975 until values close to those for the abundance of the 1969 year-class were obtained. It is appreciated that this procedure is very dependent on the evidence that the proportions of the 1969 year-class in the Shetland area reflects the proportion of its abundance in the two stocks. However, the VPA procedure suggests this may well be true as it gave very close approximations to the estimated values in both years. In the absence of any other method of estimating the 1975 input F it was decided that this procedure would give the most reliable value obtainable with the data currently available.

In Table 4.4.3 fishing mortalities are shown for the period 1972-75 for the different ages with a weighted F for mackerel $\geq$ 3 years. Since 1972, also in the Western stock, the fishing mortality has increased considerably, e.g. from 0.013 in 1972 to 0.108 in 1974 and 0.18 in 1975.

4.5. Stock sizes

4.5.1. The North Sea stock size

Mackerel have been tagged in the North Sea in late summer every year since 1969. The number of released mackerel has varied from about 3 500 to 11 000 each year.

The number of recovered tags from the Norwegian fishery is given in Table 4.4.1 together with the calculated survival rates. The tagging technique, the system of recovering tags in reduction plants, and the methods of calculation are given by Hamre (1975).

As pointed out previously, the catches in later years have been dominated by the 1969 year-class. The annual survival rates of this year-class has been about 0.7 in the last three fishing seasons (1 September - 31 August the following year) as calculated from tag returns. For the year-classes older than the 1969, the survival rates were reduced from 0.6 in the 1972-73 and 1973-74 seasons to 0.5 in the 1974-75 season.

On the basis of the calculated survival rates, the number of tagged mackerel in the sea within seasons were calculated (Table 4.5.1 and 4.5.2). The relationship between these numbers and the number of recaptures in the catch which has been effectively screened for tags, provides an estimate of the stock in number taking into account the initial tagging mortality.

The estimates of the stock derived in this way are as follows:

Stock size (x 10^6) at 1 September

	1970	1971	1972	1973	1974	1975
1969 year-class	1 207	1 676	2 272	1 759	1 198	999
Older	1 173	555	1 469	956	315	315
Total	2 380	2 231	3 741	2 715	1 513	1 314

To estimate the size of the stock at the beginning of the year the catches taken by the Norwegian fishery after 1 September and an assumed natural mortality over the last four months of the year, set to 5%, have been subtracted from the values given above. The following stock sizes are estimated:

Stock size (x 10^6) at 1 January

	1971	1972	1973	1974	1975	1976
1969 year-class and older	1 835	2 014	3 416	2 273	1 282	993

The tagging data give estimates of the number of mackerel from the 1969 year-class and older, but do not provide a sufficient basis for estimates of the younger age groups. These age groups constitute a small portion of the exploited stock, and consequently very few have been available in the catches taken for tagging.

The low number of tagged, younger mackerel in the sea are therefore at present not giving reliable estimates of survival and stock size of these groups.

In Table 4.5.3 the stock sizes in numbers of fish up to seven year old derived from the VPA for the period 1972-75 are shown.

Since 1972 these adult stock sizes have decreased in number from 4 088 x 10^6 in 1972 to 2 018 x 10^6 in 1975, and in weight from 914 x 10^3 tons in 1972 to 729 x 10^3 tons in 1975.

The weight of the stock was estimated by applying the mean weight-at-age in the first quarter given by Castello and Hamre (1969) to the number per age group of the stock in the different years. This data on mean weight-at-age was used in preference to those given in Table 3.2.1 because the greater number of observations available made it appear more reliable. A comparison of the estimated North Sea stock in number (x 10^6) from tagging (1969 year-class and older) and from VPA (age $\geq$ 3 years is shown below:

Estimated stock size (x 10^6) at 1 January

	1972	1973	1974	1975
Taggings	2 014	3 416	2 373	1 282
VPA	4 088	3 518	2 922	2 018

These estimates are in close agreement, and show that recruitment to this stock in recent years has been poor.

4.5.2. The Western stock size

In Table 4.5.4 the stock sizes in number at ages up to six years as derived from the VPA for the period 1972-75 are shown. As in the North Sea stock the Western one has decreased from 10 572 x 10^6 in 1972 to 3 028 x 10^6 in 1975. As available data from the Western stock for weight-at-age in the first quarter of the year

do not seem to be representative for the stock as a whole, it was thought better not to estimate the weights of the stock at 1 Janauary as this might be biased. No strong year-class has been recruited to the Western stock in recent years.

4.5.3. Catch per unit effort

The Working Group considered the available catch per unit effort data which only cover the most recent years. Data are available from the Dutch, English and Scottish fisheries.

The Dutch data refer to a herring-directed fishery and the Scottish data to a white fish fishery in which mackerel is taken as by-catch. This may imply that these catch per unit effort figures for mackerel reflect the density of the stock better than if it had been a specialized mackerel fishery. When comparing the calculated stock size for the North Sea (1 September) on the basis of tagging with the Scottish and Dutch catch per unit effort figures for July-September, there seems to be a reasonable corespondence (Fig. 4.5).

The English catch per unit effort data are derived from the mackerel hand-line fishery off south-west England (Division VIIe,f). Such data are available from November 1972.
The catch per unit effort of the total catch and the large-category (fish over 450 grams) show a seasonal change in abundance with a peak during December and January. Seasonal maximum values, and a simple integrated seasonal mean (September-March) are listed below:

	1972/73	1973/74	1974/75	1975/76
Maximum	0.50	0.52	0.37	0.40
Integrated mean	0.27	0.23	0.16	0.10

(tons per 100 hook hours)

All catch per unit effort data show a marked decline in abundance of both the North Sea and the Western stock.

5. Total allowable catch (TAC)

5.1. North Sea TAC for 1977

In calculating the TAC for the North Sea stock in 1977 the basic input data was the estimate of stock in number per age group at 1 January 1975 given in Table 4.5.3 and the estimated F value for this stock in 1975 given in Table 4.4.2. From these the stock surviving to 1 January 1976 was calculated and is shown in the text table below. In the North Sea stock the mean fishing mortality rate on 1-year-old fish in 1972-74 was about 10% of that on the older age groups and this value was used in estimating the stock of 2-year-olds in 1976 from the catch in number of 1-year-olds in 1975. For calculation of the stock at 1 January 1977 recruitment of 1-year-old fish in 1976 and 1977 was assumed to be as the mean recruitment level of 1-year-old fish in the years 1971-1974 from VPA.

In calculating stock size it is also necessary to make some assumption about the exploitation rate on the stock in 1976. In the light of NEAFC and Norwegian national restrictions on the fishing for this stock it was assumed that the F in 1976 would be maintained at the 1975 level. This will produce a catch in 1976 from this stock of 158 000 tons. The resulting stock size at 1 January 1977 is shown in the text table below. For estimating the weight-at-age in the catch the data of Castello and Hamre (1969) for the last quarter of the year were used.

Age	1	2	3	4	5	6	7	>7
Stock in number ($x10^6$) at 1/1-76	360	370	59	64	229	121	780	470
Stock in number ($x10^6$) at 1/1-77	360	289	272	39	43	152	81	830
Mean weight-at-age (grams) in catch	139	262	354	430	428	464	527	527

In calculating the TAC for 1977 the fishing mortality rate of 0.2 advocated in the previous report of the Working Group (Anon. 1975) has been maintained. The Fs on 1-year-olds and 2-year-olds were taken as 10 and 50% of those of the fully exploited age groups. There would seem to be a need to adopt a conservative management strategy for this stock in 1977 in the light of the evidence presented above of the decline in the size of the stock up to that date. This fishing mortality rate in 1977 applied to the estimated stock at 1 January 1977 will give a yield of 120 000 tons.

5.2. Western stock TAC for 1977

As described above for the North Sea stock the basic data used in calculating the TAC for the Western stock in 1977 were the 1975 estimate of stock abundance given in Table 4.5.4, and the estimated F given in Table 4.4.3 derived from VPA.

From these the stock in number at 1 January 1976 was estimated and is shown in the text table below. For this stock the fishing mortalities (Table 4.4.3) would suggest that the fishing mortality rate of 1-year-old fish is about 17% of that for adult fish. The stock of 1-year-olds at 1 January 1975 has accordingly been calculated from the catch in numbers of this age group using this percentage of the estimated F for older fish in that year. In setting the recruitment to this stock of 1-year-olds in 1976 and 1977, the average level of recruitment ($1\ 244 \times 10^6$) obtained from VPA was used. As this stock is under no regulation, the assumption had to be made that the catch in Sub-areas VI and VII in 1976 would be at a level of about 300 000 tons as in 1975. In addition, there will be a catch from this stock in the Shetland area in July-September 1976. In 1974 and 1975 this has been equivalent to an F of 0.04 on the fish 5-years-old and older which would entail a catch from this stock in the Shetland area of 60 000 tons in 1976. The total F on the Western stock in 1976 would therefore be 0.21. The resulting stock size in 1977 is also shown in the text table below. In this stock there are major differences in mean weight-at-age between the catches taken during the same season in Sub-area VI and in the Shetland area, and those taken in Sub-area VII. Accordingly, the mean weight-

at-age for this stock in the catch were calculated by weighting the mean weights for these Sub-areas by the catches taken in them, in 1975. The values used are also shown in the text table below.

Age	1	2	3	4	5	6	>6
Stock in number ($x10^6$) at 1/1-76	1 200	152	1 207	267	773	578	2 584
Stock in number ($x10^6$) at 1/1-77	1 200	948	120	801	177	513	2 099
Mean weight-at-age (grams) in catch	153	185	217	299	346	408	478

As in the North Sea stock the TAC for 1977 has been calculated on the assumption of an F of 0.2. The TAC recommended is on this basis 265 000 tons for 1977 for the Western stock.

5.3. TAC and stock mixing

In the previous report of the Working Group it was stressed that, because of mixing of the two stocks in the Shetland area (Division IVa) in summer it was necessary to allocated part of the TAC for the Western stock to the TAC for the North Sea (Sub-area IV).

The catches taken in the Shetland area from the Western stock in 1974 and 1975 are estimated as 117 000 tons and 77 000 tons respectively. These are fish 5-years-old and older. From the numbers of fish of these age groups in the Western stock, given in Table 4.5.4, it has been estimated that the fishery in the Shetland area generated a fishing mortality on the Western stock of 0.04 in both years.

As the fishing mortality rate on the North Sea stock in these years was fairly stable and close to the value used in calculating the TAC for the North Sea stock in 1977, it would appear justifiable to calculate the catch taken from the Western stock in 1977 from this fishing mortality rate. This would entail a catch from the Western stock in 1977 of 45 000 tons. On this basis the TAC for Sub-area IV and Division IIIa in 1977 would be 165 000 tons and for Sub-areas VI and VII 220 000 tons.

6. Egg and larval surveys

6.1. Current knowledge

The only egg and larval surveys carried out in recent years with the primary objective to assess mackerel spawning were those carried out by Norway, as described by Iversen (1973). A summary distribution chart of this work was presented by Hamre (1975). The surveys were restricted to the northern North Sea, N 56^{o}-61^{o}, E 10^{o}- W 2^{0}.

During the same period as Iversen's work (June-July) a plankton survey of the southern and central North Sea, N 52^{o}-57^{o}, was carried out by England in 1972 (Johnson and Dawson, 1975). This survey was carried out to assess the abundance and distribution of all pelagic fish eggs within the area, but particularly those of sprat and mackerel. In the area where the two surveys overlap there is a close level of agreement, the major mackerel egg concentration was found in the central North Sea from N 54^{o}-58^{o}, E 0^{o}-7^{o}. These observations are also supported by long-term records obtained from the Continuous Plankton Recorder (Bainbridge et al. 1973).

Plankton surveys made in the English Channel during 1967 and 1968 show that there is a mackerel spawning there too (Wallace and Pleasants, 1972) but it is not of the same order of magnitude.

A preliminary estimate of the North Sea spawning stock size based on these Norwegian and English surveys indicate the stock to be about 1.2×10^{6} tons in 1972 (Johnson, pers.comm.). This is in close agreement with Hamre's (1975) estimates from tagging data for that year.

Surveys carried out in the Western area, Bay of Biscay, Celtic Sea, are not so recent nor were they carried out with quantitative plankton samplers. Arbault and Lacroix (1975) found mackerel commence spawning in southern Biscay in March and the spawning spreads northwards. Corbin (1947) found mackerel eggs throughout the Celtic Sea from March to July by which time it is occuring in the English Channel and the North Sea. A summary of times for commencement, peak production and cessation of spawning are given in Table 6.1.1 and the spawning areas in Fig. 6.1.

6.2 Stock assessment by plankton survey

From what is known of the geographical and temporal distribution of mackerel it is not considered practical to plan a plankton survey which covers the total spawning. As the North Sea stock is adequately estimated by Norwegian tagging experiments greater priority should be given to plankton survey on the Celtic Sea spawning grounds. This does not mean that mackerel egg and larval data from other plankton surveys in the North Sea should not be utilized.

In the Celtic Sea area a plankton survey is probably the most reliable method of obtaining a stock size estimate independent of catch data.

Even in the Celtic Sea area there is a problem due to the long spawning period and extensive spawning area (Table 6.1.1 and Fig. 6.1). To be of practical value a plankton programme would need to cover Biscay and Celtic Sea in April and May, better still mid-March to mid-June. This would require an absolute minimum of two ships for 1 month each or better four ships for 1 month each.

Unless a definite commitment to a joint programme on an adequate scale is forthcoming it is not considered worthwhile commencing an ICES mackerel egg and larval survey.

6.3. Prerecruitment surveys

In the light of the need for early measurements of year-class strength for TAC purposes, concideration should be given to international surveys of 0- and 1-group mackerel in both areas.

7. Acoustic surveys for stock assessment

Hydroacoustical methods have been used with good results in assessment work of several species in the ICES area. Special problems arise, however, when this method is applied to mackerel due to the low target strength of this species. This is particularly true when mackerel occur dispersed as in summer or

together with other species as e.g. blue whiting, Maurolicus sp. and euphausiids in winter in the Norwegian Trench (Hamre and Nakken, 1971).

Acoustic surveys are most appropriate when the stock being surveyed is isolated from other species. This is the case with mackerel off Cornwall during the winter months and surveys have been made each winter since 1972 by England. The surveys have been carried out both for stock assessment and acoustic gear development purposes. "Cornish stock" estimates for 1974-75 are about 0.5 - 1.0 x 10^6 tons with the higher values during December (unpubl. data Lowestoft). Any acoustic stock estimate is only as good as the target strength estimate for the fish and further work needs to be done here.

The surveys off Cornwall will continue, and may be expanded to include work in the Celtic and Biscay Sea.

Those equipped for such work should be encouraged to continue and valuable support may be given by other research vessels operating within the same area by recording distribution and sampling.

If the F value of 0.18 derived by the VPA for the Western stock is applied to the estimate of the stock of 1.0 x 10^6 given above, this gives an estimate of the stock at 1 January 1976 of 0.68 x 10^6 tons plus recruitment. The VPA estimate at this date is 2.0 x 10^6 tons calculated from the text table in paragraph 5.2. This suggests that the acoustic estimate was based on å survey of only part of the overwintering distribution of this Western stock.

8. Summary

8.1. The catch statistics for the fisheries in 1975 show a maintenance of the 1974 level in the North Sea and an increase of about 50 000 tons in the Western area. In view of the evidence from the age composition in both areas, showing rather poor recruitment in recent years, and as catches were dominated by older fish with little gain in weight this in itself suggests increased fishing mortality rates on both stocks.

8.2. In previous reports estimates of stock sizes and fishing mortality rates have been entirely derived from Norwegian tagging experiments and as a result the Working Group has expressed considerable reservations about the reliability of the estimates for the Western stock. In this report estimates have also been made from VPA, acoustic surveys (for the Western stock) and from catch per unit effort data. Although there are still some reservations about the accuracy of the estimates some degree of agreement in the estimates from these sources has resulted in greater confidence in the final conclusions.

8.3. In both areas the data from all sourced show sharp declines in stock size and an increase in exploitation over the last four years.

8.4. The estimates of stock size in 1976 obtained from a modified VPA, incorporating parameters from tagging experiments are not considered completely reliable, but are the best available. In the light of all the evidence that the stocks are declining sharply it is considered that the lack of precision in the estimates cannot be used as grounds for not taking firm regulatory action if the stocks are not to be placed in serious jeopardy.

8.5. On this basis the TAC recommended for the North Sea stock for 1977 is 120 000 tons.

8.6. For the Western stock the TAC recommended for 1977 is 265 000 tons. The reduction in the TAC for this stock in 1977 compared with that previously recommended for 1976 is partly due to the deficiencies of the data previously used particularly the weight-at-age data; partly to the continuing low level of recruitment and partly to the fact that no regulatory action has been taken although recommended in the previous report.

8.7. Because the Western stock is also fished in summer in Sub-area IV it is necessary to allocate a proportion of the TAC for that stock to that area. In 1974 and 1975 when the exploitation rates for the North Sea stock were not very different from that at which the TAC has been calculated, the fishing mortality rate on the Western stock in this area was 0.04. On this basis it is estimated that 45 000 tons of the Western stock TAC will be taken in Sub-area IV in 1977. As a result the mackerel TACs for 1977 are 165 000 tons for Sub-area IV and 220 000 tons for Sub-areas VI and VII.

8.8. It is recommended that in the light of the extensive area and time period which it would be necessary to cover, priority should be given to mackerel egg and larval surveys for assessment purposes in the Celtic Sea, and even in this area these should only be considered if sufficient countries are prepared to give a firm commitment of involvment.

8.9. It is recommended that serious consideration should be given to organising 0- and 1-group surveys in both areas.

8.10. Further work on acoustic methods and acoustic surveys is required. It would appear that the latter would be most effective in the Western area.

8.11. In Sub-area VII the data on catch composition suggests that the exploitation pattern of the Western stock may not be the most appropriate one. It is recommended that at the next meeting of the Mackerel Working Group selectivity data for mackerel be requested and the whole question of exploitation pattern be dealt with more thoroughly.

9. References

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Table 2.1.1. Total catch of mackerel by countries, 1965-1975, in the North Sea, Skagerak and Kattegat (IVa,b,c, IIIa). Metric tons.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[1]
Belgium	138	67	201	77	139	19	85	129	78	-	38[2]
Denmark	6 509	7 552	20 282	9 887	10 851	26 753	17 590	2 023	7 460	3 910	9 681
Faroe Islands	-	-	-	-	3 080	2 134	3 603	7 551	10 014	18 625	23 314
France	7 635	5 390	7 486	4 684	11 353	4 677	8 953	6 830	622	2 218	2 536
Germany,Dem.Rep.	-	-	-	-	-	-	-	-	-	233	142
Germany,Fed.Rep.	2 221	1 501	2 132	1 353	1 161	225	408	374	563	273	434
Iceland	-	-	105	352	612	1 492	649	676	3 079	4 689	0
Netherlands	16 977	12 247	10 801	5 986	4 928	2 956	4 945	4 436	2 316	3 253	2 399
Norway	156 605	484 428	866 548	779 084	683 045	278 631	200 635	160 141	337 600	255 102	241 476[3]
Poland	3 695	2 294	2 261	1 629	12	205	130	244	561	4 520	2 300
Sweden	13 364	13 754	15 246	11 783	10 820	4 407	3 157	4 748	2 960	3 579	4 636[2]
U.K. (England + Wales)	76	99	46	55	35	35	23	32	30	61	39
U.K. (Scotland)	1 019	618	742	583	231	148	616	395	2 942	390	500
U.S.S.R.	227	1 778	4 098	6 094	12 516	718	2 600	611	11 030	8 160	26 741
Total	208 466	529 728	929 948	821 567	738 783	322 400	243 394	188 190	379 255	305 013	314 236

1) Provisional

2) Preliminary data as reported to ICES

3) Includes 34 653 tons from Norwegian Sea (IIa)

Table 2.1.2 Catch of mackerel in number (x 10^6) by age.
North Sea area (IVa, IVb, IVc and IIIa).

Year \ Age	0	1	2	3	4	5	6	> 6	Total
1975	-	12.4	10.4	17.4	6.3	48.9	232.5	21.3	349.2
1974	-	3.1	18.8	37.4	57.0	215.8	332.6	175.7	840.4
1973	-	4.5	12.1	38.2	206.1	124.6	52.9	235.6	674.0
1972	-	2.6	37.0	235.8	50.9	27.8	32.2	46.3	432.6

Table 2.2.2 Catch of mackerel in number (x 10^6) by age.
Western area (VIa, VIb and VII a-k.)

Year \ Age	0	1	2	3	4	5	6	> 6	Total
1975	-	5.3	42.1	58.4	169.3	106.0	71.7	345.0	797.8
1974	-	51.0	8.1	98.7	72.9	80.8	93.1	319.1	723.7
1973	-	22.4	22.1	54.2	106.0	103.2	43.1	189.7	540.7
1972	-	1.0	0.1	6.7	18.5	16.5	39.8	204.2	286.8

Table 2.1.3. Catch of mackerel in 1973 by ICES statistical divisions and periods. Metric tons.

Area	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Nov	Not specified	Total
IVa	3 477	4 263	256 542	68 440	9 591	342 313
IVb	110	3 066	14 219	1 305	8 468	27 168
IVc	1	394	361	193	839	1 788
IIIa	26	1 358	5 503	1 074	23	7 983
North Sea, etc.	3 614	9 081	276 625	71 012	18 921	379 252
VIa	11	1 061	5 865	1 801	9 085	17 823
VIb	-	-	-	-	150	150
VIIa+f	217	4 656	143	1 198	33 188	39 402
VIIb+c	-	-	-	-	1 823	1 823
VIId,e	-	-	-	59	61 006	61 065
VIIg-k	-	27	-	-	49 891	49 918
Wester area	228	5 744	6 008	3 053	155 143	170 181
Total	3 842	14 825	282 633	74 070	174 064	549 433

Table 2.1.4. Catch of mackerel in 1974 by ICES statistical divisions and periods. Metric tons.

Area	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Nov	Not specified	Total
IVa	1 815	5 718	202 454	57 356	14 930	282 273
IVb	-	623	151	2 018	9 360	12 152
IVc	-	-	-	-	4 373	4 373
IIIa	15	1 596	3 223	1 362	-	6 196
IIIb,c	-	-	-	-	19	19
North Sea, etc.	1 830	7 937	205 828	60 736	28 682	305 013
VIa	261	2 508	10 475	42 508	8 178	63 930
VIb	-	-	-	-	210	210
VIIa+f	-	-	-	-	41 401	41 401
VIIb+c	-	23	-	-	2 386	2 409
VIId,e	-	96	-	28	65 368	65 492
VIIg-k	2 954	2 117	5 286	8 241	56 796	75 394
Vb	-	75	-	-	1	76
Western area	3 215	4 819	15 761	50 777	174 340	248 912
Total	5 045	12 756	221 589	111 513	203 022	553 925

Table 2.1.5. Catch of mackerel in 1975 by ICES statistical divisions and periods. Metric tons.

Area	Jan-Mar	Apr-Jun	Jul-Sept	Oct-Nov	Not specified	Total
IVa	1 167	9 882	96 040	119 767	24 472	251 328
IVb	169	1 355	5 846	1 089	2 645	11 104
IVc	49	948	1 273	309	736	3 315
IIIa	41	3 538	4 573	1 039	4 636	13 827
IIIb,c	-	-	-	-	-	0
IIa	-	-	34 660	-	-	34 660
North Sea, etc.	1 426	15 723	142 392	122 204	32 489	314 234
VIa	2 045	1 663	17 043	2 868	19 474	43 093
VIb	-	2	-	-	12	14
VIIa+f	117	216	787	791	64 086	65 997
VIIb+c	1	-	607	50	7 184	7 842
VIId,e	7 435	803	832	21 764	25 265	56 099
VIIg-k	9 991	8 228	3 296	7 691	89 225	118 431
Vb	-	-	-	-	40	40
VIII	-	-	-	-	3 864	3 864
Western area	19 589	10 912	22 565	33 164	209 150	295 380
Total	21 015	26 635	164 957	155 368	241 639	609 614

Table 2.2.1. Total catch of mackerel by countries, 1965-1975, in the Western area (V, VI, VII, VIII). Metric tons.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[1]
Belgium	3	5	7	2	11	8	2	-	3	-	17
Faroe Islands	-	-	-	-	-	-	-	-	2 063	8 659	1 748
France	14 651	38 309	28 655	29 751	27 290	35 593	24 538	29 904	36 501	34 186	22 774
Germany, Dem.Rep.	-	-	-	-	-	-	-	-	-	2 885	9 459[2]
Germany, Fed.Rep.	1 959	302	333	613	428	783	258	98	559	993	1 355
Iceland	-	-	-	-	-	90	86	74	52	-	-
Ireland	1 860	1 507	2 245	2 164	1 615	1 055	3 107	4 592	8 314	8 526	8 500[3]
Netherlands	1 411	2 831	3 859	2 597	4 441	3 828	3 837	6 166	7 807	7 262	13 299
Norway	-	-	-	-	-	-	1 611	-	-	32 598	1 907
Poland	212	3	520	1 518	2 149	6 054	10 832	13 129	10 536	22 406	21 500
U.K. (England and Wales)	1 583	1 884	2 634	2 585	2 692	3 374	4 791	6 923	13 124	21 126	32 594
U.K. (N.Ireland)	111	97	158	151	279	243	315	57	93	75	30
U.K. (Scotland)	426	670	490	537	402	803	805	1 412	5 168	8 466	14 500
U.S.S.R.	54	-	-	-	6 147	13 555	36 390	71 247	86 000	101 730	167 697
Total	22 270	45 608	38 901	39 918	45 454	65 386	86 572	133 602	170 220	248 912	295 380

1) Provisional
2) Preliminary data as reported to ICES
3) Estimated by Working Group

Table 3.2.1 Mackerel mean weight (grams) at age. The values given are the weighted mean values from data supplied by: France, Netherlands, Norway, Poland, UK (England), UK (Scotland). Age + includes grouped data, older than: 7 years (Norway), 10 years France, Netherlands, Poland, UK.

Subareas and divisions	Age group / Quarter	1	2	3	4	5	6	7	8	9	10	+
IV a	Jan - Mar	No data available										
	Apr - Jun	-	340	404	385	423	470	477	520	489	640	-
	July -	217	315	371	372	414	478	474	481	508	576	-
	Oct/Dec	252	377	450	401	449	497	477	523	561	561	-
IV b	Jan-Mar	No data available										
	Apr - Jun	-	207	406	399	453	440	506	541	506	552	-
	Jul - Sept	212	319	356	341	392	422	390	395	357	-	-
	Oct-Dec *	-	-	-	-	-	313	405	396	403	625	550
IV c	Jan-Mar	No data available										
	Apr - Jun *	-	113	170	213	273	299	267	369	315	413	524
	Jul - Sept *	-	179	226	213	273	273	282	333	324	333	475
	Oct -Dec *	-	175	264	226	279	316	330	429	311	529	593
VI	Jan - Mar	No data available										
	Apr - Jun	-	245	281	306	327	350	386	392	460	489	-
	Jul - Sept	-	254	300	289	350	479	401	506	505	597	-
	Oct-Dec	-	222	354	309	372	450	407	494	496	541	-
VII	Jan - Mar	-	154	195	259	269	350	353	431	363	511	-
	Apr - Jun	150	178	211	206	280	300	304	342	309	358	470
	Jul - Sept	108	179	230	263	298	294	306	335	353	415	474
	Oct - Dec	135	156	199	270	382	382	395	474	520	578	-

* Netherlands data only.

Method of capture:
- Demersal trawl: France
- Herring trawl: Netherlands, Poland
- Pelagic trawl: Scotland
- Purse seine: Norway, Scotland
- Handline: England

Table 4.1.1. North Sea stock. Catch of mackerel in number (x 10^6) by yearclass.

Year \ Yearclass	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
1975				83.8	39.4	204.6	31.8	60.0	16.8	7.2	8.7	452.3
1974			70.7	15.8	41.2	244.3	64.5	35.7	18.9	2.0		493.1
1973		72.4	32.0	34.5	77.8	316.7	38.6	9.4	1.9			583.3
1972	21.7	25.3	26.2	22.6	54.8	183.5	11.9	0.1				346.1

Table 4.2.1. Western stock. Catch of mackerel in number (x 10^6) by yearclass.

Year \ Yearclass	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total
1975					466.8	99.1	126.6	178.0	59.3	42.1	5.3	974.2
1974				448.1	135.1	193.1	72.9	98.7	8.1	51.0		1007.0
1973			346.7	67.3	164.5	106.0	54.2	22.1	22.4			783.2
1972		266.6	61.6	36.4	18.5	6.7	0.1	1.0				390.9

Table 4.4.1. Tagged mackerel of the 1969 year-class (A) and older (B) recaptured in the North Sea (NS) and Shetland area (Sh) by seasons.

	Year of release	No. released	Year of recapture																		Sum recaptur.	Sum recaptur. year of release excl.	Survival rate (S)	Inst. total mortality rate (Z)
			1969-70		1970-71		1971-72		1972-73		1973-74		1974-75		1975									
			NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS	Sh	NS 1)									
A	1970	1 085			32	4	9	3	11	9	21	4	22	2	15						117	81	.60	.51
	1971	6 900					113	36	113	109	232	64	170	16	137						853	704	(.84)	.17
	1972	9 447							131	108	401	92	382	29	282						1143	904	.71	.34
	1973	4 642									299	33	270	22	214						624	292	.70	.35
	1974	2 740											264	7	131						271		.70	.35
	1975	4 716													446									
B	1969	4 187	547	15	195	47	6	4	5	22	2	8	9	2	5						862	300	.30	1.20
	1970	2 420			431	30	10	6	19	23	26	13	15	3	15						576	115	.45	.60
	1971	2 450					41	21	36	35	52	23	48	6	36						262	200	.69	.37
	1972	2 126							44	33	80	20	68	5	44						250	173	.59	.53
	1973	1 518									106	17	79	8	62						210	87	.62	.48
	1974	1 344											121	4	47						125		.50	.69
	1975	1 048													99									

1) Not included in calculations

Table 4.4.2. Fishing mortalities from VPA and weighted mean values of F of the North Sea stock.

Age \ Season	1972	1973	1974	1975
0	-	-	-	-
1	0.0002	0.012	0.023	0.021
2	0.011	0.018	0.162	0.105
3	0.066	0.111	0.089	0.210
4	0.098	0.154	0.276	0.210
5	0.109	0.196	0.171	0.210
6		0.243	0.151	0.210
$\bar{F}$ age $\geq$ 3 yr	0.058	0.134	0.166	0.210

Table 4.4.3. Fishing mortalities from VPA and weighted mean values of the Western stock.

Age \ Season	1972	1973	1974	1975
0	-	-	-	-
1	0.0005	0.041	0.030	0.031
2	0.0001	0.013	0.019	0.031
3	0.004	0.043	0.076	0.180
4	0.009	0.090	0.075	0.180
5	0.033	0.098	0.234	0.180
6	0.013	0.079	0.108	0.180
$\bar{F}$ age $\geq$ 3 yr	0.013	0.079	0.108	0.180

Table 4.5.1. Calculated number of surviving tagged mackerel of the 1969-yearclass of the North Sea stock with recaptures by season. P indicates catch in number (x 10^6) effectively screened for tags, N is the estimated stock at 1 September and N_2 is the stock corrected for tagging mortality (15%). Survival rates from Table 4.4.1.

	No. released	1970-71	1971-72	1972-73	1973-74	1974-75	1975
	S	0.60	(0.84)	0.71	0.70	0.70	0.70
1970	1 085	1 085	640	538	382	267	187
1971	6 900		6 900	5 796	4 115	2 881	2 017
1972	9 447			(9 447)	6 707	4 695	3 287
1973	4 642				4 642	3 249	2 274
1974	2 740					2 740	1 918
1975	4 716						4 716
Sums		1 085	7 540	6 334	15 846	13 832	14 399
Recaptures		36	161	242	1 146	1 184	1 225
P		47.1	42.1	102.1	149.7	120.6	100.0
N_1		1 420	1 972	(2 672)	2 070	1 409	1 175
N_2		1 207	1 676	2 272	1 759	1 198	999

Table 4.5.2. Calculated number of surviving tagged mackerel of the North Sea stock older than the 1969-yearclass. For explanations see Table 4.5.1.

	No. released		1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975
		s	0.30	0.45	0.69	0.59	0.62	0.50	0.50
1969	4 187		4 187	1 256	565	390	230	143	72
1970	2 420			2 420	1 089	751	443	275	138
1971	2 450				2 450	1 691	998	619	310
1972	2 126					2 126	1 254	777	389
1973	1 518						1 518	941	471
1974	1 344							1 344	672
1975	1 048								1 048
Sum			4 187	3 676	4 104	4 958	4 443	4 099	3 100
Recaptures			562	703	88	216	347	368	308
P			315.5	263.9	14.0	75.3	88.1	33.3	36.8
N_1			2 351	1 380	653	1 728	1 125	371	370
N_2			1 998	1 173	555	1 469	956	315	315

Table 4.5.3. North Sea stock. Calculated stock sizes in number ($\times 10^6$) by age and year at 1 January. (M = 0.2).

Year / Age	1972	1973	1974	1975
0				
1	706	173	99	462
2	501	578	140	80
3	3197	406	465	90
4	650	2452	297	348
5	241	483	1721	185
6	(1432)	177	325	1188
7		(916)	114	229
>7			(509)	(486)
Total adult (3-7 yr) stock	4088 +(1432)	3518 +(916)	2922 +(509)	2018 +(486)
Adult (3-7 yr) stock biomass, $\times 10^3$ tons	913.8	973.2	923.6	729.0

Table 4.5.4. Western stock. Calculated stock size in number ($\times 10^6$) by age and year at 1 January. (M = 0.2).

Year / Age	1972	1973	1974	1975
0				
1	2254	618	1914	192
2	1734	1844	485	1521
3	1675	1420	1490	390
4	2411	1365	1113	1131
5	1233	1957	1023	845
6	5253	976	1453	662
>6	(22769)	(5023)	(4821)	(3117)
Total adult (3-6 yr) stock	10572 +(22769)	5718 +(5023)	5079 +(4821)	3028 +(3117)

Table 6.1.1 Timing estimates for mackerel egg and larval production

Area	Egg Production			Larval Production		
	Commence	Peak Period	End	Commence	Peak Period	End
Biscay	End Feb.	May	July	March	May-June	August
Celtic Sea/ Bristol Channel/ W. End English Channel (post war period)	Mid March	April-May	Early August	March	May-June	August
Celtic Sea	-	-	-	March	April-May	August
North Sea (S of 55°N)	Late May	June	July	June	July	August
North Sea (55°-58°N)	June	June-July	Late July	June	July	August

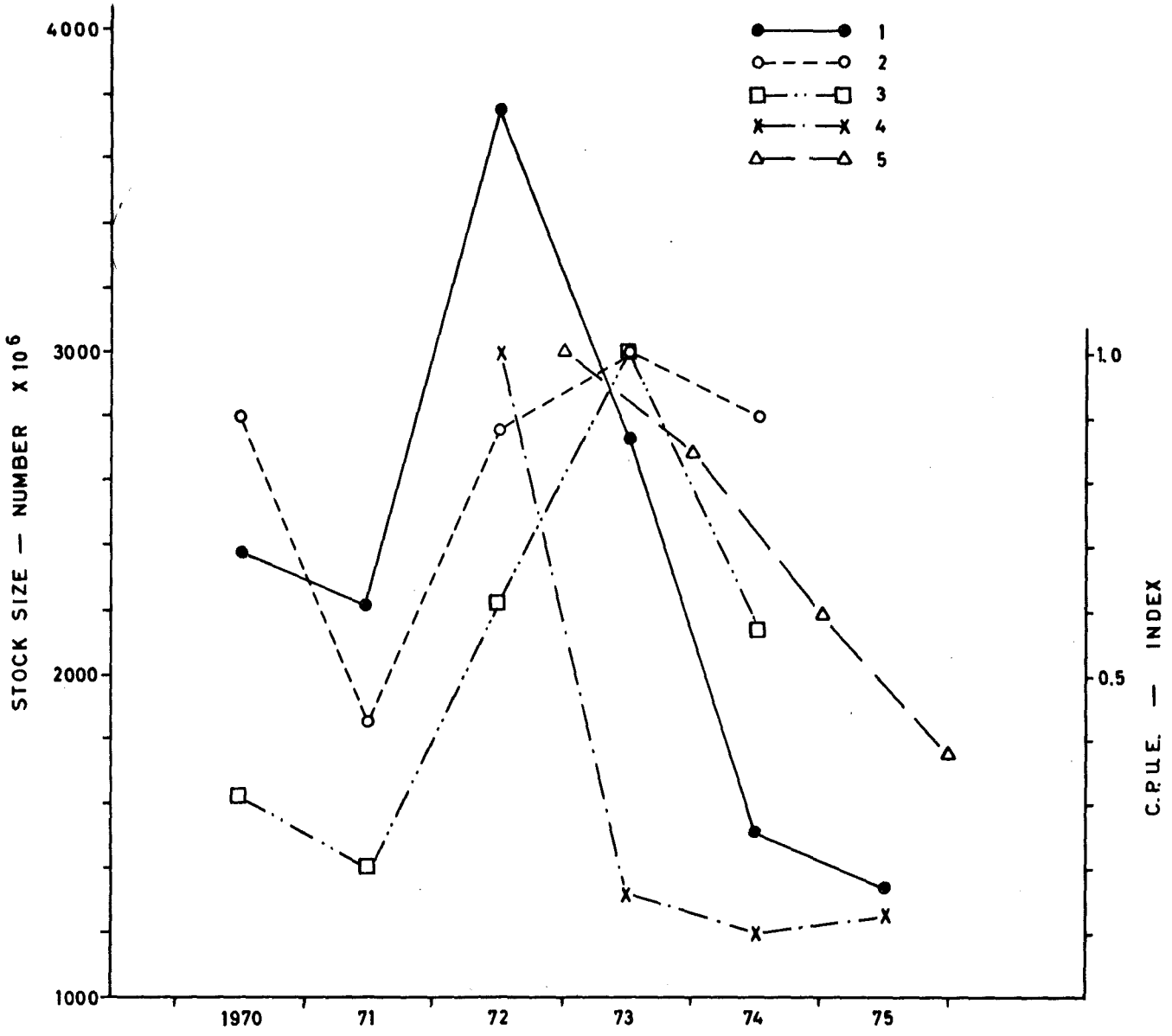

Fig. 4.5 Mackerel stock size in the North Sea as derived from tagging compared to measures of catch per unit of effort (C.P.U.E.) from various mackerel fisheries.

1. Stock size (1969-yearclass + older yearclass) at 1 Sept
2. C.p.u.e. Scottish trawl fishery (Orkney-Shetland)
3. " " " " (Cape Butt) } July-Sept
4. " Dutch trawl fishery (North Sea)
5. " English hand-line fishery (Div. VII e, f) Sept-March

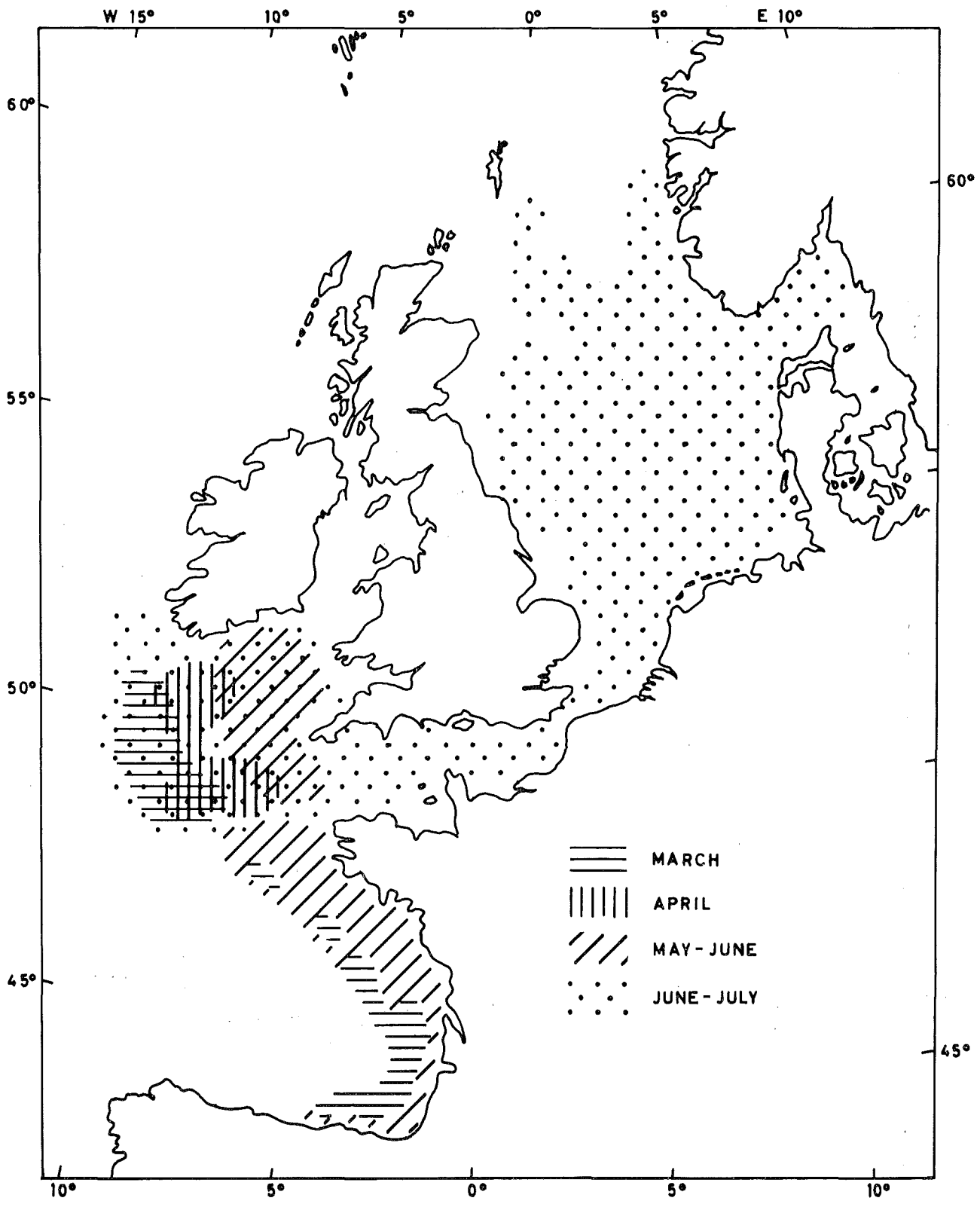

Fig. 6.1. Mackerel spawning areas
(from egg distribution)