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## REPORT OF THE MACKEREL WORKING GROUP

10 - 11 March, 1975 Bergen, Norway

### 1. Introduction

Following a request made by NEAFC at its mid-term meeting in Hamburg on 4-8 November 1974, to advise on a TAC for Mackerel in the ICES statistical areas IIIa and IV for 1976, the Mackerel Working Group met in Bergen 10 - 11 March, 1975.

The following members participated:

Mr. E. Bakken	Norway
Dr. J. Guéguen	France
Mr. J. Hamre (Chairman)	Norway
Dr. S. Lockwood	U.K. (England)
Mr. S. Munch-Petersen	Denmark
Mr. K. Postuma	Netherlands
Mr. E.S. Prosvirov	U.S.S.R.
Mr. A. Revheim	Norway
Mr. A. Saville	U.K. (Scotland)
Mr. M. Volodarsky	U.S.S.R.

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As pointed out in the previous report of this Working Group (CM 1974/H:2) in the NEAFC area there are two major stocks of mackerel, one spawning in the North Sea and another spawning in the Celtic Sea. In the part of sub-area IV north of 60°N there is a major fishery which exploits a population to which both stocks contribute. Therefore in considering the TAC for sub-area IV and division IIIa it was necessary for the working group to take into consideration both stocks and the extent of their mixing in the Shetland area.

## 2. The fisheries

### 2.1. The North Sea, Skagerak and Kattegat

The development of the mackerel fishery in these waters (ICES statistical sub-area IV and IIIa) during the last decade has been outlined in the previous report by the Mackerel Working Group.

The total landings of mackerel increased greatly from 1972 to 1973 when the landings were about 376 000 tons (Table 1). This is nearly 20 000 tons less than the estimates given in the previous report. Only preliminary catch data are available for 1974, and for some countries no information could be obtained. Based on the data reported to the working group and assuming national catches equal to those of 1973 when data are lacking, the total catch of mackerel was about 326 000 tons in 1974.

The 1974 catch is about 14% less than in 1973. This reduction is mainly due to the restrictions in the Norwegian mackerel fishery, as the national quota was lowered by 40 000 tons compared to 1973.

As shown in Table 3c, the bulk of the catch was taken in July - September in the Shetland area (ICES division IVa).

The only significant increase in national catch in 1974 was shown by the Faroe Islands.

## 2.2. The Western area

In this area (ICES sub-areas VI and VII) the total catch increased both in 1972 and 1973 (Table 2) and the catch in 1973 was about 170 000 tons. This is twice the quantity of 1971.

The catch by Ireland in 1974 was assumed to be at least as large as that of 1973. The total catch in 1974, therefore, is likely to be slightly higher than that of 1973 at around 178 000 tons.

## 3. Stock Distribution in the NEAFC area

As pointed out in the previous report of the Mackerel Working Group the two major spawning stocks mix in the Shetland area. Recent data from tagging experiments have provided additional information on the extent of this mixing (HAMRE, in press). These tag returns suggest that, after spawning, a major component of both stocks migrate to the area around Shetland where they mix, during July and August, in proportions relative to the size of the two stocks. After August the western component withdraws from this area, and throughout the rest of the year the mackerel population in sub-area IV can be regarded as belonging solely to the North Sea stock.

## 4. Stock Sizes

### 4.1. North Sea Stock

Estimates of the size of the North Sea stock are almost entirely based on Norwegian tagging experiments, carried out annually in August in each year, over the period 1969 - 1974. During these experiments 40 630 fish were tagged and released of which 5 215 had been returned up to 31 December 1974. The methods used to calculate the survival rate, and fishing mortality rate, using these tag return data are described by HAMRE (in press). In the previous report of the working group a provisional estimate of the size of the stock in 1973 derived from such tagging data was given of  $1090 \times 10^3$  tons.

Subsequent returns from these experiments have led to a revision of this estimate to  $1360 \times 10^3$  tons. This is considered a reliable estimate of the stock size at 31 August 1973, and is the last data for which a reliable stock size estimate can be given (Table 4).

#### 4.2. The Western Stock

The estimate of stock size in the Western area is somewhat less reliable than for the North Sea. This is based on a total of 32 864 tags distributed over annual releases in May, in the period 1970 - 1974. Of these only 607 tags had been returned up to the end of 1974. These results, however, suggest that the stock size in this area was of the order of 3 000 000 tons in 1973.

#### 5. Fishing Mortality Rates

From all experiments in the two areas mean estimates of the fishing mortality rates in 1973 - 1974 of the two stocks are: North Sea stock 0.175 Western stock 0.05 (Table 5). The fishing mortality rate estimated directly from the tagging data for the western stock refers only to that generated in division IVa: for the stock as a whole the total fishing mortality is estimated as about 0.10 . These results suggest that the fishing mortality rate in the Western stock is about half that of the North Sea stock.

#### 6. The Estimation of Total Allowable Catch (TAC)

The estimate of the total allowable catch is dependent on two factors:

- a) the fishing mortality rate which should be applied to the stock to obtain the required management objective.
- b) an estimate of the stock size in the year in question .

These two factors are discussed below.

##### a) Fishing mortality

The yield per recruit, at the current age of first capture of 2 years, is given as Figure 1. This shows that, on the assumption that recruitment is independent of stock size, the yield from a

stock will not decrease at high levels of fishing mortality. However, high values of fishing mortality will seriously reduce the size of the spawning stock, which may reduce recruitment.

Recruitment to the North Sea mackerel stock has been at a rather low level since the 1969-yearclass recruited in 1971-72. The maintenance of an adequate spawning stock in that area, therefore should be a prime consideration. The estimated sustainable yield at various levels of fishing mortality, in the situation where recruitment is dependent on stock size, is shown in Figure 2 for what is considered the likely value of the coefficient  $b$  in the Beverton & Holt stock-recruitment relationship (HAMRE and ULLTANG, 1972). In this situation the greatest yield is taken at a value of fishing mortality of 0.2. Referring to Figure 1 it can be seen that the yield per recruit at this value of  $F$  is only about 20% less than the maximum. In the current stock situation the working group considers that it would be advisable to apply a TAC calculated at this value of  $F$  rather than risk a breakdown of the stock and the fishery, due to the establishment of a relationship between recruitment and stock size. The estimate of  $F$  for the North Sea stock, given in paragraph 5, is already very close to the value given above as providing the optimum yield where recruitment is a function of stock size. In the Western stock the estimated  $F$  in 1973 was well below that value. Priority therefore should be placed on restricting further increase of fishing effort in the North Sea stock.

b) Size of North Sea stock in 1976

The last reliable estimate of the North Sea stock is that given for 1973 in paragraph 4.1, of 1 360 000 tons. From the catch statistics for 1973 and 1974 it is estimated that 825 000 tons of this stock will remain at 1 January 1975. Assuming maintenance of the 1974 fishing mortality rate in 1975, and a natural mortality rate of 0.2, this stock will be reduced to 544 000 tons by 1 January 1976. To this must be added an estimate of recruitment in the years 1974 - 1976. This recruitment will chiefly be derived from the 1972 and 1973 yearclasses both of which, on current indications, are of about the same order of size as the 1970 and

1971 yearclasses. It is estimated that these two yearclasses will add about 256 000 tons to the residual of the 1973 stock by 1976. On this basis the total stock size for the North Sea stock in 1976 is estimated at 800 000 tons.

## 7. Total Allowable Catches

### 7.1. The TAC for the North Sea and Skagerrak in 1976

From the size of the North Sea stock and the optimum fishing mortality rate, given in paragraph 6, the estimate of the TAC from this stock is 132 000 tons. This is an estimate only of the TAC which should be taken from that stock in these areas. In addition in sub-area IV there is a fishery in July and August around Shetland which exploits a population consisting of a mixture of North Sea and Western stocks. The contribution from the Western stock to the Shetland catches in July-August in 1973 and 1974 was approximately 70% of the total catch in these months. The overall TAC which can be taken from region IV and IIIa is therefore largely dependent on the proportion of the TAC for the North Sea stock which is taken in July-August in the Shetland area. The Working Group considers, however, that 50 000 tons of the North Sea stock TAC should be allocated to the Shetland area, and 82 000 tons to sub-area IV and division IIIa south of 60°N. On this basis the overall TAC of sub-area IV and division IIIa would be 249 000 tons of which 167 000 tons must be taken north of 60°N, for the whole of 1976. It must be stressed, however, that the overall TAC for this sub-area and division must be taken, in the proportions given, from the areas north and south of 60°N. If it was all to be taken from the area south of 60°N, and thus only from the North Sea stock that stock would be very heavily over-exploited.

### 7.2. The TAC for Sub-Areas VI and VII

In earlier paragraphs it was stated that the best available estimate of the fishing mortality rate of the Western stock in 1973 was considerably below the rate given above as ~~that~~ for the maximum sustainable yield. However, the exploitation rate of this stock

has been increasing in recent years and it must be expected that with maintenance of these catch levels the size of this stock will slowly decline. Moreover with all other pelagic fish stocks in the NEAFC area being under either actual or projected quota regulation it would seem most unlikely that the fishing effort on this western stock will not increase if it is left unregulated. The Working Group therefore considered that a precautionary upper level of catch should be introduced for this western stock in 1976.

Because the data available for the Western stock is less satisfactory than that for the North Sea stock the appropriate level of such a precautionary TAC can be estimated with rather less precision. Taking the estimate of the western stock in 1973 of 3 million tons, given in paragraph 4.2, with current recruitment levels and exploitation rates it is estimated that by 1976 this stock will have declined to a level of about 2.5 million tons. Applying the same optimum fishing mortality rate of 0.2, used in deriving the TAC for the North Sea stock, one would get a TAC of 412 000 tons from the Western stock. Of this quantity, however, under the fishing strategy advocated above for sub-area IV and division IIIa, 117 000 tons would be taken in sub-area IV north of 60°N. This would leave 295 000 tons to be taken in sub-area VI and VII in 1976.

## 8. Summary

8.1. The revised catch statistics for 1973 and preliminary ones for 1974 show that in the North Sea the total catch was about the same level in both years; with over 60% of the catch in both years being taken, in summer, in the Shetland area. In the western area the preliminary catch statistics for 1974 also suggest a total catch close to the 1973 level.

8.2. The yield per recruit curve for mackerel, at the present age at first capture, does not have a maximum which can be used in estimating the total allowable catch. At the present low level of spawning stock size for North Sea mackerel, and the low levels of recruitment in recent years, the Working Group concluded that the

optimum fishing mortality for mackerel should be estimated making some provision for a relationship between stock size and recruitment level. This gave a desirable fishing mortality level of 0.2 . The present fishing mortality levels in the North Sea and Western stocks are 0.175 and 0.10 respectively.

8.3. The size of the North Sea stock in 1976 is estimated to be 800 000 tons on the assumption that the fishing mortality rate in 1975 is maintained at the 1974 level. This will entail a TAC of 132 000 tons in 1976 from this stock. The size of the Western stock in 1976 can be estimated with much less precision. It is likely, however, to be of the order of 2.5 million tons giving a TAC of about 412 000 tons.

8.4. In sub-area IV the catch taken north of 60°N is composed of a mixture of the North Sea and Western stocks. To specify TAC's for ICES statistical sub-areas it is necessary therefore to specify how much of the total TAC for the North Sea stock should be taken north of 60°N. This has been rather arbitrarily taken as 50 000 tons. On this basis the TAC for mackerel in sub-area IV and division IIIa in 1976 is estimated as 249 000 tons and that for sub-areas VI and VII as 295 000 tons.

## 9. References

ANON. 1974. Report of the Mackerel Working Group. Coun.Meet.int. Coun.Explor.Sea, 1974(H:2): 1-14, 5 figs. [Mimeo.]

HAMRE, J. (In press). The effect of recent changes in the North Sea mackerel fishery on stock and yield. Symposium on The Changes in the North Sea Fish Stocks and their Causes, Aarhus 1975. No. 22

HAMRE, J. and ULLTANG, Ø. 1972. The effects of regulations of the mackerel fishery in the North Sea. Coun.Meet.int.Coun.Explor. Sea, 1972 (H:26): 1-14. [Mimeo.]



Table 1. Total mackerel catch by countries, 1964 - 1974, in the North Sea (IVa, IVb, IVc), Skagerak and Kattegat (IIIa). (Metric tons).

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Belgium	125	138	67	201	77	139	19	85	129	78	128
Denmark	6 311	6 509	7 552	20 282	9 887	10 851	26 753	17 590	2 023	7 460	3 875
Faroe Islands	-	-	-	-	-	3 080	2 134	3 603	7 551	10 014	18 625
France	9 901	7 635	5 390	7 486	4 684	11 353	4 677	8 953	6 830	622	4 317
Germany (DDR)	-	-	-	-	-	-	-	-	-	-	233
Germany (FR)	3 495	2 221	1 501	2 132	1 353	1 161	225	408	374	563	409
Iceland	-	-	-	105	352	612	1 492	649	676	3 079	?
Netherlands	17 085	16 977	12 247	10 801	5 986	4 928	2 956	4 945	4 436	2 316	2 665
Norway	51 383	156 605	484 428	866 548	779 084	683 045	278 631	200 635	160 141	337 600	279 400
Poland	7 617	3 695	2 294	2 261	1 629	12	205	130	244	561	4 520
Sweden	15 006	13 364	13 754	15 246	11 783	10 820	4 407	3 157	4 748	2 960	2 824
U.K. (England + Wales)	67	76	99	46	55	35	35	23	32	30	35
U.K. (Scotland)	854	1 019	618	742	583	231	148	616	395	2 942	1 500
U.S.S.R.	3 153	227	1 778	4 098	6 094	12 516	718	2 600	611	11 030	7 600
Total	114 997	208 466	529 728	929 948	821 567	738 783	322 400	243 394	188 190	379 255	326 131

Note: 1974 catches are provisional estimates.

Table 2. Total Mackerel Catch by Countries, 1964 - 1974, in the Western Area  
(ICES Sub-areas VI and VII). (Metric tons).

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Belgium	3	3	5	7	2	11	8	2	-	3	9
Faroe Islands	-	-	-	-	-	-	-	-	-	2 063	8 659
France	21 591	14 651	38 309	28 655	29 751	27 290	35 593	24 538	29 904	36 501	30 384
Germany (DDR)	-	-	-	-	-	-	-	-	-	-	2 883
Germany (FR)	187	1 959	302	333	613	428	783	258	98	559	1 700
Iceland	-	-	-	-	-	-	90	86	74	52	?
Ireland	1 334	1 860	1 507	2 245	2 164	1 615	1 055	3 107	4 592	8 314	?
Netherlands	1 218	1 411	2 831	3 859	2 597	4 441	3 828	3 837	6 166	7 807	4 409
Norway	-	-	-	-	-	-	-	1 611	-	-	-
Poland	330	212	3	520	1 518	2 149	6 054	10 832	13 129	10 536	22 405
U.K. (England and Wales)	1 794	1 583	1 884	2 634	2 585	2 692	3 374	4 791	6 923	13 124	20 000
U.K. (N.Ireland)	103	111	97	158	151	279	243	315	57	93	?
U.K. (Scotland)	567	426	670	490	537	402	803	805	1 412	5 168	8 130
U.S.S.R.	61	54	-	-	-	6 147	13 555	36 390	71 247	86 000	71 120
Total	27 188	22 270	45 608	38 901	39 918	45 454	65 386	86 572	133 602	170 220	169 699

Note: 1974 catches are provisional estimates.

Table 3a. Mackerel Catch in 1972 by ICES Statistical Divisions and Periods (metric tons).

Area	Jan - Mar	Apr - Jun	Jul - Sept	Oct. - Dec	Not specified	Total
IVa	203	6 332	103 572	30 184	17 012	157 303
IVb	42	695	8 007	5 206	3 613	17 563
IVc	65	491	506	989	259	2 310
IIIa	1	1 044	5 403	22	63	6 533
North Sea, Baltic etc.	311	8 562	117 488	36 401	20 947	183 709
VIa	13	341	2 123	655	9 138	12 270
VIIb	-	-	2	-	49	51
VIIa+f	1	992	239	20 902	203	22 337
VIIb+c	-	-	-	-	1 063	1 063
VIIId,e	-	-	-	108	41 581	41 689
VIIg-k	-	-	-	-	48 022	48 022
Western area	14	1 333	2 364	21 665	100 056	125 432
Total	325	9 895	119 852	58 066	121 003	309 141

Table 3b. Mackerel Catch in 1973 by ICES Statistical Divisions and Periods (metric tons).

Area	Jan - Mar	Apr - Jun	Jul - Sept	Oct - Dec	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, Baltic etc.	3 614	9 081	276 625	71 012	18 921	379 252
Via	11	1 061	5 865	1 801	9 085	17 850
Vib	-	-	-	-	150	150
VIIa+f	217	4 656	143	1 198	33 188	39 402
VIIb+c	-	-	-	-	1 823	1 823
VII d,e	-	-	-	59	61 006	61 065
VIIg-k	-	27	-	-	49 891	49 891
Western area	228	5 744	6 008	3 058	155 143	170 181
Total	3 842	14 825	282 633	74 070	174 064	549 433

Table 3c. Mackerel Catch in 1974 by ICES Statistical Divisions and Periods (metric tons).  
Preliminary Data.

Area	Jan - Mar	Apr - Jun	Jul - Sept	Oct - Dec	Not specified	Total
IVa	1 566	6 717	200 873	74 059	8 910	292 125
IVb	139	1 778	7 919	8 077	8 583	26 496
IVc	1	1 171	231	-	2 929	4 332
IIIA	13	1 494	2 253	61	-	3 821
North Sea, Baltic etc.	1 719	11 160	211 276	82 197	20 422	326 774
VIa	261	2 638	2 735	8 266	12 627	26 527
VIIb	-	3	2	-	-	5
VIIa+f	385	1 882	6	430	33 513	36 216
VIIb+c	13	409	135	8	23	588
VII d,e	1 060	1 200	8 320	6 950	16 858	34 388
VIIg-k	22 150	20 640	2 800	-	26 375	71 965
Western area	23 869	26 772	13 998	15 654	89 396	169 689
Total	25 588	37 932	225 274	97 851	109 818	496 463

Table 4. Total mortality rates (Z) and stock size (P in 1000 tons) of North Sea mackerel for 1969 - 1973. The estimates of P refer to September of each year, the Z estimates to the following one year period.

Year	Z	P
1969	1.05	920
1970	0.76	720
1971	0.36	920
1972	0.36	1290
1973	0.38	1360

Table 5. Estimates of fishing mortality (F) by area for the North Sea stock and the Western stocks of mackerel in September 1973 to 1974.

Area	NORTH SEA STOCK			WESTERN STOCKS		
	IIIa + IV S of 60°N	IVa N of 60°N	Total	IVa N of 60°N	VI + VII	Total
F	0.125	0.05	0.175	0.05	0.05	0.10

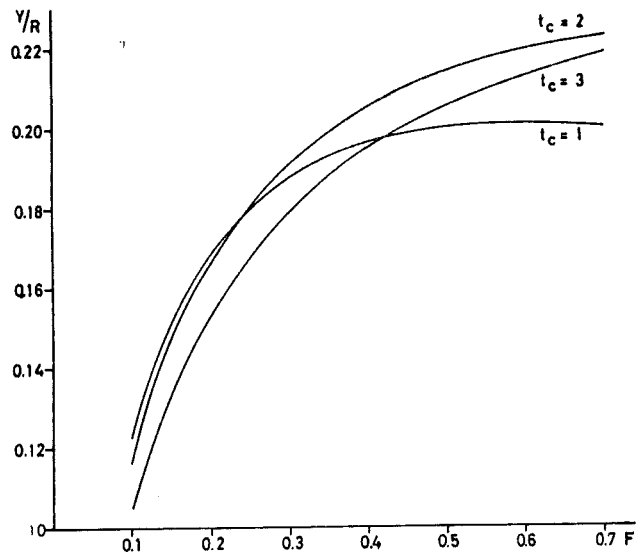


Figure 1. Yield per recruit ( $Y/R$  in kg) by fishing mortality ( $F$ ) and age at first capture ( $t_c$ ).

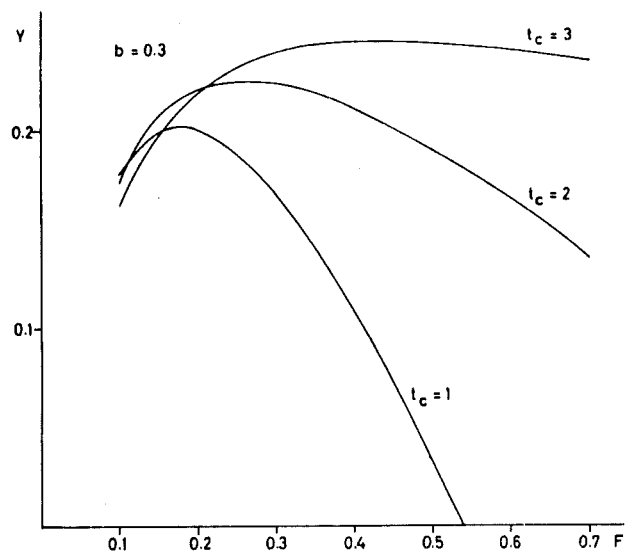


Figure 2. Estimated sustained yield ( $Y$  in million tons) by fishing mortality ( $F$ ) and age at first capture ( $t_c$ ) for density-dependent recruitment.