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Re-assessment of the mackerel stock in the ICNAF Area

by

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Introduction

Experts from Bulgaria, GDR, Poland, and USSR met in Varna, Bulgaria on 20-26 September 1976 to analyze the state of the mackerel stock in the northwestern Atlantic on the basis of new data available from commercial and survey catches in 1976.

Comparison of stock size estimates from the June assessment and estimated age composition of 1976 catches showed that stock sizes in both options for fully recruited ages (3+) were on the same level or even lower than 1976 catches. This implies that assumed fishing mortalities in 1975 were overestimated. In this connection, the reassessment of the state of the mackerel stock with the use of new, although incomplete, data from the 1976 fishery as well as the spring groundfish survey data appeared to be needed.

Catches

The mackerel catches of Bulgaria, GDR, Poland, and USSR from January to July 1976 totalled 167,931 tons (Table 1). Total mackerel catch in 1976 has been estimated at 252,244 tons, assuming that the TAC in 1976 would not be reached due to the influence of the second-tier quota system or taking into account, in the case of Canada, the catch statistics for the last few years. The catches of other countries were assumed to be at the level of their quotas.

Age Composition

The observed catches in numbers by age-groups of Bulgaria, GDR, Poland, and USSR in the first half of the year were calculated using age composition and mean weights of commercial samples of these countries, applying the monthly weighting procedure.

The estimated catches of the above-mentioned countries in the second part of the year were partitioned by age-groups, using their age composition from the first part of 1976 and assuming a 40% share of age 1 on the basis of the fact that the mean length of this age-group will be higher than the size limit and, therefore, the fish be available for the fishery.

The estimated catches of other countries (mostly in Subarea 5 and Statistical Area 6) were partitioned into age-groups in numbers according to the total age composition of Bulgaria, GDR, Poland, and USSR in Subarea 5 and Statistical Area 6 (Table 2).

The USSR estimated catch (17,000 tons) and the Canadian quota (15,300 tons) in Subareas 3 + 4 were partitioned into age-groups, using USSR age composition

data for the second quarter and assuming a 10% share of age 1 on the basis of age composition in Subareas 3 + 4 reported in former years. The other age-groups were pro-rated on the same basis.

Three-year-old fish from the 1973 year-class composed the largest part of estimated overall catches totalling at 34.6% in numbers. Two-year-old mackerel of the 1974 year-class was also very abundant in catches constituting 32.9% of the total. Age-groups 4 and older comprised 25.2% in the catches. The value did not indicate any sharp decrease of abundance of these ages in the stock. The small share (1.4%) of age-group 1 in the total age composition during the first half of the year (the mean length of this age-group at this time is lower than the size limit) and its estimated share for the whole year (7.3%) is directly related to the newly-introduced size limit.

According to the information available from Bulgarian, GDR, Polish, and USSR fisheries, every effort was made to avoid active fishing for fish below 25 cm (total length) i.e., age 1 mackerel mainly, and this goal has been achieved successfully. Moreover, all countries concerned introduced more restrictive regulations prohibiting processing on board and landings of mackerel below the size limit. The important role, in this respect, has been played too by the Joint Enforcement Scheme in the ICNAF Convention Area.

Estimate of Fishing Mortality

Catch per unit of effort (CPUE) from the directed mackerel fishery of Distant Water Fleets was taken as a first measure of fishing mortality.

The CPUE of Bulgaria, GDR, Poland, and USSR did not show the same clear trend. The CPUE of Bulgarian freezer-trawlers in 1976 was 50% higher than in 1975. GDR factory trawler catch rate increased by 4%, Polish B-18 trawlers decreased by 12%, and USSR RTM-A trawlers declined by 4% (Table 3).

The CPUE of all above-mentioned countries did not indicate any substantial decrease of stock biomass in 1976. Using regression analysis for GDR data on CPUE (4% increase) and data on CPUE of DWF (presented by G.H. Winters at the April Assessments Meeting) against fishing mortalities from VPA (Option 2 from the June 1976 Annual Meeting), the fishing mortality was estimated at the level of $F = 0.47$. $F = 0.55$ was estimated using the 12% decrease of B-18 CPUE.

The next estimate of F was obtained using Albatross IV spring survey data (presented by E.D. Anderson at the June 1976 Annual Meeting) and the 1976 abundance index of 0.137 calculated from the US computer printout sent to GDR.

The abundance indices were smoothed in a different way from that by E.D. Anderson at the June 1976 Annual Meeting, assuming a steady decline in stock abundance throughout 1968-1976 (Table 4).

Computations of regression of these two sets of data resulted in the following equation:

$$y = 0.042 + 0.000\ 000\ 208 x$$

The instantaneous fishing mortality coefficient in 1976, calculated with the use of this regression equation, was found to be 0.425.

Taking into account the fishing mortality estimates computed from a decrease of CPUE in the commercial fishery and the need to be on the conservative side for the purpose of actual VPA, the value of F of 0.6 was chosen.

The close agreement of fishing mortalities estimated from this regression line in 1974 and 1975 with corresponding values obtained from the VPA presented here should be noted (see Tables 4 and 6).

Recruitment

Stock sizes of two recruiting year-classes, 1974 and 1975 at age 1, were determined as follows:

- (1) Assuming a certain level of partial recruitment (P.R.) of these year-classes in 1976;
- (2) By the method proposed by E.D. Anderson (Res.Doc. 76/VI/29) on the basis of R/V Albatross IV spring survey data.

With reference to (1) above:

1974 year-class

It was found from the actual VPA (based on the newest catch at age data from the commercial fishery) that the 1976 fishing mortality of age-group 2 is not likely to be greater than 75% of F of fully recruited ages. The P.R. of age 2 mackerel at the level of about 50% had been observed in 1968 and 1969 (Table 6), i.e., in the period when the age composition of the stock was similar to the present one. The lowest 12% P.R. value of this age-group took place in 1970. In spite of the fact that fishing mortality in 1972 was about four times greater than that of the 1968-1969 period and that the 1970 year-class was the second poorest observed from 1968 to 1975, the P.R. of this age-group did not exceed 22%. The P.R. increased rapidly in 1973 and 1974, in the former case perhaps mainly due to an increase of fishing effort and in the latter case, due to the occurrence of the poor 1972 year-class (the poorest observed since 1968). In 1975 the P.R. of age 2 mackerel, computed from the VPA assuming 100% P.R. at age 3 in 1976, decreased by about 10% to the level of 85% (i.e., 15% less than it was assumed in Option 1 at the June 1976 Annual Meeting).

Taking into account other data indicating a high abundance of the 1974 year-class (commercial and survey data) and the substantial decrease of nominal as well as effective fishing effort in 1976, one can easily predict a further decline of P.R. of age 2 in 1976 to 75% at least, or even a much lower value. For the purpose of catch prediction, a P.R. of 60% was used. The resulting stock size of this year-class at age 1 was found to be 2,053.2 millions. However, high catches at age 1 and 2 in relation to catches of other year-classes indicate an even greater abundance of this year-class.

1975 year-class

As 1976 catches of age 1 mackerel were affected by the new regulation on size limit, a conclusion on the 1975 year-class abundance from actual catches or a percentage thereof cannot be drawn here, although this was possible at the April Assessments Meeting when an estimation of the 1974 year-class at age 1 was presented by A. Paciorewski. Bearing in mind, however, every effort made by DWF towards searching for shoals of large-sized mackerel, one can assume a substantial decrease of P.R. at age 1 in 1976. The assumed decrease of P.R. to 5% in relation to P.R. values from preceding years (Table 6) seemed to be a reasonable estimate of actual relative fishing mortality. The resulting abundance of 1975 year-class at age 1 - 2,765.4 millions - is only 5% higher than the long-term average for the 1969-1974 period.

With reference to (2) above:

In spite of the reservations expressed earlier in connection with the usage of groundfish survey data for recruitment prediction of pelagic schooling species encountered in clusters, the method proposed by E.D. Anderson (1976) was applied as an indicative one and for comparison purposes.

The least square linear regression of $\log_e (\text{number/tow} + 1)$ for age-group 1 against corresponding year-class sizes at age 1 from the actual VPA (Table 6) from 1968 to 1974 was calculated (Table 5). The resulting regression equation is:

$$y = 1,278 + 1,351 x$$

1974 year-class

The estimated size of the 1974 year-class at age 1 of 2,587.2 millions (Table 5) is only 6% and 19% greater than in Options 2 and 1 from the June 1976 Annual Meeting, respectively. This abundance is also within the range of estimates by method B from the April Assessments Meeting.

The 45% P.R., calculated from the estimated stock size of this year-class (assuming $F_{3+} = 0.6$) is not improbable, taking into account a substantial decrease of effort in a directed mackerel fishery in 1976 and the probable great abundance of this year-class. Moreover, from the length composition of age 2 in the first quarter of 1976, it can be found that about 8-10% of this age-group is below the size limit. The decrease of the actual estimate of the P.R. compared with values from the June 1976 Annual Meeting assessment can be at least partially attributed to the size limit regulation.

1975 year-class

The size of the 1975 year-class estimated (Table 5) at 1,492.8 millions agrees well with the previous estimate from Option 2 from the June 1976 Annual Meeting. Much lower partial recruitment (10%) of this age-group is an obvious result of the newly-introduced size limit as was discussed earlier.

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For the purpose of catch prediction, two options of recruitment level of age-group 1 in 1977 and 1978 were used. The first, which was applied together with estimates based on P.R. assumptions, was the average abundance of age 1 of the actual VPA for the period 1969-1974. The second option, applied in conjunction with groundfish survey estimates, was assumed to be the same as that for the 1975 year-class at age 1, i.e., at the level of the second lowest observed year-class in this fishery from 1968 (21% of the size of the 1967 year-class).

The estimated and assumed values of recruiting year-classes at age 1 are as follows:

Option	Year-class at age 1			
	1974	1975	1976	1977
1	2,053.2	2,765.4	2,624.0	2,624.0
2	2,587.2	1,492.8	1,492.8	1,492.8

Catch Prediction

Two options of total allowable catches in 1977 were determined (Table 7), both based on estimated F_{3+} in 1976 at 0.6.

Option 1

Sizes of two recruiting age-groups 1 and 2 in 1976 were estimated, assuming a 5% P.R. for age 1 and a 60% P.R. for age 2, as discussed earlier. The resulting sizes of the 1974 and 1975 year-classes at age 1 were, in the former case, 22% below the long-term average and, in the latter case, 5% greater than the average

(for absolute numbers, see page 5). The size of the 1976 year-class, which is not playing an important role in the 1977 catches, was assumed to be at the average level.

The TAC in 1977, estimated with the use of these stock sizes and $F_{0.1} = 0.35$, would be at the level of 180,000 tons, i.e., 70,000 tons below the estimated 1976 catch. Attention should be drawn to the small foreseen share of 1-year-old fish in 1977, lower than 2.3% by weight.

The spawning stock size in 1977 would be reduced to about 600,000 tons, i.e., by about 5% in relation to the 1976 stock, but in 1978 the stock would increase to about 740,000 tons. This size of spawning stock would be greater by approximately 100,000 tons than in 1976.

Option 2

Stock sizes of the 1974 and 1975 year-classes at age 1 were determined with the method proposed by E.D. Anderson (1976) on the basis of spring survey data from R/V Albatross IV (Table 5 and page 5). The resulting relative size of the 1974 year-class is 2% below the long-term average.

The predicted allowable catch in 1977 at $F_{0.1} = 0.35$ would be about 160,000 tons, i.e., 90,000 tons lower than the estimated catch in 1976. The foreseen catch in 1978 would be at the same level. It should be noted that the share of 1-year-old mackerel in both years will be smaller than 3% by weight.

The predicted biomass of the spawning stock would decrease from about 670,000 tons in 1976 to about 595,000 in 1977. However, in the next year the spawning stock will be maintained at the 1977 level. The decline in 1977 is directly related to the assumptions on low abundance of incoming year-classes (1975 and 1976) which constitute only about 57% of the average recruitment from 1969 to 1974, i.e., excluded from the average of the most abundant 1967 year-class.

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Bearing in mind that there is a substantial probability that the size of the 1974 year-class is greater than was estimated in Option 1 or even in Option 2 (which can be derived from the magnitude of age 1 and 2 catches in 1975 and 1976, respectively, in relation to catches of other year-classes at the same ages) as well as the very likely situation that the P.R. value of the 1975 year-class in 1976 catches is close to 5% (which is implied by the successful exploitation pattern of DWF in response to the new regulation on size limit), it should be emphasized that the estimated TAC from Option 1 should be regarded as a better approximation of the present productivity of the stock.

References

- Anderson, E.D. 1976. Recruitment estimates for the mackerel stock in ICNAF Subareas 3, 4, and 5 and Statistical Area 6 based on US research vessel spring trawl surveys, 1968-1975, with implications assessment. Intl. Comm. for the Northwest Atlantic Fisheries Research Document 76/VI/29. (mimeographed)
- Paciorkowski, A., and B. Vaska. 1976. Alternative assessment of mackerel stock in ICNAF Area. Intl. Comm. for the Northwest Atlantic Fisheries Research Document 76/VI/107.
- _____. 1976. Report of the ad hoc Working Group on Mackerel. Intl. Comm. for the Northwest Atlantic Fisheries Redbook 1976, Part C, Appendix VII.

Table 1. Mackerel catches 1976 estimated for assessment purposes.

Country	Subarea	C a t c h		Estim. Catch Period	Total Catch Tons	National Quota	Total Catch minus Quota
		Period	Tons				
Bulgaria	5 + 6	I - III	12616	XI - XII	1784	16300	1900
G D R	5 + 6	I - VI	32122	XI - XII	4710	48900	12068
Poland	5 + 6	I - VII	36141	XI - XII	20000	78300	22140
USSR	5 + 6	I - III	87052	XI - XII	-	88000	948
Other countries ^m /Canada/	3 + 4	I - IV	-	V - XII	17000	17000	700
	3 - 6	-	-	I - XII	40800	60800	20000
	5 + 6	-	-	I - XII	/4400/	/4400/	/-/
	3 + 4	-	-	I - XII	/15300 ^m /	/35300/	/20000/
Total	3 - 6	I - VII	167931	I - XII	75303	310000	57756

^mCanada included

ⁿcatch on the level of last 2 years

^o19 tons from SA3 included

Table 2. Age composition of commercial mackerel catches in SA 3-b, 1976 (estimated).

Country	Year-class												Mean individual weight /kg/	
	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964		Numbers /10 ³ /
	1	2	3	4	5	6	7	8	9	10	11	12		
Bulgaria	160	476	243	57	38	18	19	10	6	2	1			
	10209	30336	13585	3619	2428	1165	1192	623	382	150	82		63771	14400
GDR	67	238	267	89	93	98	68	55	15	10				
	7536	26773	30058	9976	10478	10981	7652	6191	1723	1116			112484	36832
Poland	169	296	252	77	65	42	35	37	22	5				
	36497	63754	54193	16601	13924	9124	7500	7989	4781	1171			215531	56160
USSR	6	363	454	59	46	18	28	22	4	+				
	2245	148221	185424	24179	18683	7489	11280	9103	1773	181			408578	87052
Others	7451	35259	27148	7136	5981	3178	3568	3148	1154	315	+		104938	25500
1976	53938	304343	320408	61511	54491	32537	31192	27054	9813	2933	82		905302	219944
Total	7939	19661	20075	7706	12217	2364	639	6353	1842	76	564		79436	32300
Grand total	73	329	346	70	65	35	32	34	12	3	1			
	71877	324004	340483	69217	63708	34901	31831	33407	11655	3009	646		984738	252244
														.256

Table 3. Catch per unit of effort DMF, January-May (tons/day fished).

Year	Bulgaria /freezing-trawlers/	GDR /factory trawlers/	Poland		USSR
			B-29	B-18	
1975	30.6	44.2	36.1	33.0	4.27 t/hour fished
1976	45.9	46.1	33.3	29.2	4.10 t/hour fished
Ratio of 1976/1975	1.50	1.04	0.92	0.88	0.96

Table 4. Estimation of F from survey abundance index.

Year	Spring survey abundance index strata 1-25, 61-76	International catch St 3-6 ^{3/}	Fishing effort index	F from Option 2 of June 1976 assessment
1968	.406	80 810	199 039	.093
1969	.351 ^{1/}	131 810	375 584	.077
1970	.296	230 603	779 064	.239
1971	.276	373 033	1 351 569	.355
1972	.227	409 724	1 804 952	.376
1973	.191 ^{1/}	449 306	2 195 319	.508
1974	.154	339 580	2 205 065	.501 ^{4/}
1975	.145 ^{1/}	290 800	2 005 517	.459 ^{4/}
1976	.137 ^{2/}	252 244 ^{4/}	1 841 197	.425 ^{4/}

^{1/} Mean values

^{2/} Index calculated from US computer out-prints

^{3/} Catch data from summ. Doc. 76/VI/41.

^{4/} estimated

Table 5. Estimation of recruitment from survey abundance index.

Year	Survey abundance index of age 1 log _e /no/tow + 1/	Stock-sizes of age 1 from VPA
1968	4.126	7 194.0
1969	0.088 ^{1/}	3 447.4
1970	1.068	3 195.2
1971	0.647	1 620.3
1972	1.552	1 961.7
1973	0.470	1 171.8
1974	0.500	3 824.1
1975	0.969	2 587.2 ^{3/}
1976	0.159 ^{2/}	1 492.8 ^{3/}

^{1/} not used

^{2/} from WP 76/VI/117

^{3/} estimated

Table 6. Fishing mortalities and stock sizes from VPA.

	Year-class	1968	1969	1970	1971	1972	1973	1974	1975	1976 ^x	
Fishing mortality	1959	.01	/.08/								
	1960	.11	.30	.82	.54	1.46	/.45/				
	1961	.02	.08	1.21	1.78	0.32	0.29	.60			
	1962	.08	.08	.48	.42	1.29	0.77	.60			
	1963	.10	.07	.22	.30	.86	1.11	.60			
	1964	.08	.06	.18	.29	.33	.59	.35	.60		
	1965	.11	.07	.18	.35	.57	.55	.77	1.07	.60	
	1966	.05	.07	.21	.50	.56	.46	.68	.79	.60	
	1967	.02	.04	.14	.32	.48	.55	.75	.80	.60	
	1968		.05	.02	.08	.24	.35	.46	.41	.60	
	1969			.05	.16	.27	.47	.45	.48	.60	
	1970				.07	.08	.44	.39	.43	.60	
	1971					.03	.35	.54	.38	.60	
	1972						.10	.47	.43	.60	
	1973							.05	.39	.60	
	1974								.17	.27	
	1975									.06	
	Wtd, F	.096	.077	.173	.265	.359	.454	.498	.456	.600	
	P.R. age 2	52	52	12	60	22	77	94	85	45	
	P.R. age 1	21	65	29	26	8	22	10	37	10	
Stock size /10 ⁶ /	1959	18.2	13.4								
	1960	87.2	57.9	31.8	12.7	5.5	0.9				
	1961	41.9	44.9	30.7	6.8	0.8	0.4	0.2			
	1962	139.4	95.3	65.2	29.9	14.5	3.0	1.0			
	1963	175.3	117.5	81.2	48.3	26.5	8.3	2.0			
	1964	216.4	148.0	103.3	63.9	35.4	18.9	7.8	4.0		
	1965	657.2	436.4	301.6	186.7	97.4	40.8	17.4	6.0	1.5	
	1966	2320.0	1635.	1130.2	678.1	304.5	128.8	60.3	22.6	7.6	
	1967	7194.0	5223.0	3718.6	2394.8	1288.4	590.1	252.0	88.2	29.4	
	1968		3447.4	2430.4	1764.5	1206.9	703.6	367.3	171.9	84.6	
	1969			3195.2	2252.6	1421.4	804.5	372.5	175.8	80.5	
	1970				1620.	1119.6	765.8	365.3	183.4	88.4	
	1971					1961.7	1410.5	736.3	318.1	161.3	
	1972						1171.8	785.1	363.5	175.2	
	1973							3824.1	1717.0	862.0	
	1974								2587.2 ^{xx}	1617.9	
	1975									1492.8 ^{xx}	
	<u>Age 1+</u>										
	Total /10 ⁶ /										
		10849.6	11161.5	11088.2	9581.0	7757.9	5647.4	6791.3	4635.7	3816.2	
Wt /10 ³ t/											
	1991.4	2633.1	2111.6	1976.7	1769.8	1435.0	1275.0	1073.8	952.9		
<u>Spawning stock</u>											
Total /10 ⁶ /											
	2495.6	5102.6	6677.8	6312.0	5098.8	3770.4	2574.6	2192.0	1934.4		
Wt /10 ³ tons/											
	869.8	1640.7	1662.0	1680.4	1518.5	1219.8	872.8	685.5	669.7		

Table 7. Catch predictions.

Mackerel SA 3-4	1976			1977			1978		
	Spawning stock (^{'000} tons)	F ₃₊	Catch (^{'000} tons)	Spawning stock (^{'000} tons)	F ₃₊	Catch (^{'000} tons)	Spawning stock (^{'000} tons)	F ₃₊	Catch (^{'000} tons)
<u>OPTION 1</u>									
$F_1 = F_{3+} \times 0.05$									
	635.9	0.6	252.2	604.1	0.35	183.7	743.0	0.35	218.5
$F_2 = F_{3+} \times 0.60$									
<u>Recruitment</u>									
1975 y.c. = 2,765.4									
1976 y.c. = 2,624.0									
<u>OPTION 2</u>									
$F_1 = F_{3+} \times 0.10$									
	669.7	0.6	252.2	595.5	0.35	157.6	592.3	0.35	157.0
$F_2 = F_{3+} \times 0.45$									
<u>Recruitment</u>									
1975 and 1976 y.c. = 1,492.8									