RESTRICTED

International Commission for the Northwest Atlantic Fisheries

Serial No. 3838
(D.c.9)

ICNAF Res.Doc. 76/VI/52

ANNUAL MEETING - JUNE 1976

On some results of biological studies on mackerel from the Northwest Atlantic

by

V.I. Isakov
AtlantNIRO
Kaliningrad, USSR

ABSTRACT

The present paper as well as the study of size-weight indices, maturation rate and the infection of mackerel is aimed at the establishing of resemblance or distinction in variation of these characteristics in various mackerel populations from the Northwest Atlantic.

The analysis of the data gas not revealed any reliable differences in all the indices of interest between the studied populations.

New evidence have been obtained on the spwning and maturation age of mackerel. It should be noted that the commencement of spawning depends upon the hydrological conditions in the spawning ground.

INTRODUCTION

For organization of rational mackerel fishery the identification of stocks should be made.

Our investigations are based on the analysis of various qualitative indices of mackerel (size-weight characteristics, infection by Anisakis sp. larvae, maturation dynamics). At that we proceeded from an assumption on existence of two mackerel stocks - the northern and southern ones. This subdivision was suggested by O.Sette (1950).

By now, the available material allows to make a comparative analysis of biological indices of individual mackerel populations

ffom the Northwest Atlantic, which, in its turn, may give an answer to the question.

Material and Methods

This paper is based on the material presented below in Table 1.

Table 1

The total amount of material processed, 1968-1975.

Kind of material	AREA	
	New England	Nova Scotia
Age determinations, sp.	9394	1756
Weighted, sp.	7871	1756
Biological analysis		
sample number	125	18
specimen number	11250	1570

Statistical processing of material was made according to Plokhinsky N.A.(1970). To establish a resemblance or distinction of mackerel populations under study the values of

$$\text{Diff.} = \frac{M_1 - M_2}{\pm\sqrt{m_1^2 + m_2^2}}$$

have been calculated, where $M_1 - M_2$ is a difference between mean values of taken rows, and $\pm\sqrt{m_1^2 + m_2^2}$ is a mean error of this difference. A difference between variarional rows (Diff.) is admitted to exist in case when a formula on solution gives a quotient exceeding the value of 3 (Pravdin,1966).

The data on mackerel maturation age and spawning terms have been obtained by means of analysis of material collected during the cruises, and bioanalysis made in the laboratory. The sex and maturity stage of sexual products were determined visually, simultaneously the age was read. It should be noted that the material collected during the spawning period (March - July) was subjected to analysis. This period was more convenient for classification by maturation stage: immature, pre-spawners, spawners, and post-spawners.

In all the fish analysed the body length was measured - from the tip of the lower jaw to the end of the middle rays of the caudal fin (fork length).

For age determinations the otoliths were collected. One of the methods of the study of local character of fish schools, their distribution and migrations is a parasitological analysis.

In this respect the studies on mackerel are cinfined to the investigations by Liubinitsky(1972) and Umnova(unpublished, 1973,1974). The author carried out the studies on mackerel infection together with Umnova in 1973-1974 and individually in 1974-1975.

In these studies the larval Anisakis sp. were used as "natural tags".

The number of fish subjected to analysis is given in Table 2.

Table 2

Number of fish (sp.) analysed for infection by larval nematodes in the ICNAF area.

Areas / Years	6	5	4
1973	-	500 (Feb. 5Ze)	300 (June, 4W)
1974	-	442 (Mar.-Apr.,6a+5Zw)	148 (Apr.,4W)
1975	100 (Apr., 6b)	93 (May, 5Ze)	-

Parasitological analysis presented a visual calculation of the larval nematodes number within the body cavity, followed by further calculation of infected fishes and comparison of extensiveness (percentage of infected fish) and intensity (mean number of nematodes per infected fish) of infection in various regions.

RESULTS

Growth rate. The data on mackerel linear growth by age are presented in Tables 3 and 4. Both, our data and the data of Anderson(1973) (Table 5) indicate that the intensive linear growth continues for three years till massive maturation in mackerel population is reached. By this time they reach 2/3 of hteir maximum length (L_{∞} = 45 cm) and 1/4 of maximum weight(W_{∞}=1019g). In his studies on growth regularity in the West Atlantic mackerel Mackay (1967) noted that mackerel growth rate, like in many other fish species, depended on population density.

A comparison of linear and weight growth rates for the 1967, 1969-1973 year classes demonstrated their resemblance (Table 6). Since the growth rate of these year classes has not changed considerably, it can be suggested that the stock size in the period under study maintained approximately at the same level.

The analysis of body length increments by seasons averaged for 1968-1975 (Tables 7-9) showed an increase of the body weight in one year old fish taking place all the year round. In older age groups the weight growth was intensive in 1-3 quarters, being of little importance in the 4th quarter, and sometimes the mean weight appeared to be lower compared with the 3rd quarter. The loss of mackerel weight in the 4th quarter was likely to occur due to large expense of energy during the autumn migrations. Considerable weight losses occured in the wintering period at the end of the 4th and in the 1st quarters.

The first person to suggest a possibility of existence of two mackerel stocks in the Northwest Atlantic was Sette (1950), who proceeded from a difference between the modal and mean lenghts of mackerel from the catch samples taken in the New England and Nova Scotian areas. However, that difference might be attributed to varying age composition in mackerel catches taken from these areas. Therefore, a comparison between the individuals belonging to the same year classes and age groups was required. To establish a degree of resemblance and distinction between the two supposed mackerel populations, we followed the variations in mean length

and weight in the principal age groups of 2-6 year old fish. As soon as those age groups were representative of the bulk of the catches, there was every reason to consider the resultant data valid for the population as a whole.

As it is accepted in the studies concerned with the analysis of biostatistics, a reliability of distinctions between the characteristics subjected to comparison was examined using the mean difference error (Diff.). For comparison those samples were selected which were simultaniously obtained from various areas in October 1973 (Table 10).

As a result of comparison, no reliable distinctions have been discovered between the northern and southern populations in terms of the characteristics studied; in all cases Diff. was below the value of three.

The studies on mackerel infection. The parasitological analysis has not revealed any great differences in extensiveness and intensity of mackerel infection by areas.

The extensiveness of mackerel infection on Georges Bank in 1973 was 33%, the intensity being 1-4 specimens, and in the Nova Scotia area - 40% and 1-5 specimens, respectively; the extensiveness of infection on Georges Bank in 1974 was 31%, the mean intensity being 1.5 specimens, and in the Nova Scotia area - 40% and 2.2 specimens, respectively.

No annual fluctuations in infection degree have been discovered in comparison of mackerel sampled from the Nova Scotian area in June 1973 and April 1974.

Insignificant variations in the extensiveness and intensity of mackerel infection by larval nematodes were also marked in zones 6a and 6b, in the samples analysed by Liubinitsky (1972) in 1971, and between the zones 5W and 6c in the samples of 1975.

Age at sexual maturity and spawning terms. A question on age at sexual maturity and spawning terms is not profoundly studied.

However, the consideration of this question is urgent for organization of rational fishery and in the studies of mackerel abundance dynamics.

According to special literature spawning of mackerel begins at mid April in the Chesapeake Bay, in May the spawning continues along the coast of New Jersey, in June - in the Gulf of Main; on the Nova Scotia shelf, in the Gulf of St. Lawrence and in some years around the Newfoundland Island mackerel spawning takes place in June-July (Bigelow H.B. and Schroeder, 1953; Mackay K.T. 1967; Moores C.A. et al., 1974). The data obtained during our studies make it possible to amplify and specify the terms of mackerel spawning (Table 11). Our studies confirm that the spawning of mackerel begins in the Chesapeake Bay region moving gradually northwards to the Gulf of St. Lawrence. The spawning of mackerel is prolonged in the New England area as well, and lasts for three months on the average, from April to June. According to our data the commencement of the spawning along the coast of New Jersey (Sub-area 6a) may fall on the end of March, as it occurred in 1974; which is in contrast with the evidence of Bigelow and Schroeder (1953) who indicated the month of May. In that same year an unusually early commencement of spawning - at the beginning of April - was recorded in the Nova Scotia area as well.

In spite of the delay in spawning in 1972 and early spawning in 1974, the end of the spawning has not shifted according to our observations, and fell on the end of June - start of July in the New England area and on the end of July in the Nova Scotia area. Unusual spawning period in 1972, 1974 can be attributed to hydrological regime in the spawning ground. Moores et al.(1974) noted that it was unusually cold in 1972, while 1974 was the warmest year in the long-term observational period from 1962 to 1974 (ICNAF Summ. Doc. 75/30).

Sette (1950), Mackay (1967), Moores et al.(1974) also noted that sexual maturity in mackerel is reached at age 2-3. Our results presented in Table 12 indicate that massive maturation of mackerel occurs at age 3 (81.5%). These data are in good agreement with the results submitted by Moores et al.(1974)

with the exception of two year old fish. It appeared that the number of immature individuals of 2 year old was greater in the Newfoundland waters, them in the New England area.

It is evident from our data (Table 13) that 45.2% of individuals of 27cm in length were participating in spawning for the first time. The length of the largest immature fish reached 31 cm, however, at the length of 32 cm - which corresponded to age 3-4 - all the individuals became mature.

SUMMARY

The results of studies showed that mackerel in New England and Nova Scotia areas is represented by a single stock.

Growth rates of body length and weight are most intensive in the first three years of life.

Maximum weight of mackerel is reached in 3-4th quarters.

The spawning terms of mackerel depend on hydrological conditions on the spawning grounds.

R E F E R E N C E S

1. Plokhinsky, N.A., 1970. Biometry. Ed. by the Moscow University.

2. Pravdin, I.F., 1966. A guide for study of fishes.M., "Pishchevaja promyshlennost".

3. Anderson E.D.,1973. Assessment of Atlantic Mackerel in ICNAF Subarea 5 and Statistical Area 6. ICNAF Res.Doc.73/14

4. Konstantinov K.G. and Noskov A.S., 1975 USSR Research Report, 1974. ICNAF Summ. Doc. 75/30 pp. 1-34

5. Jubieniecky B., 1972 Some Notes on the Occurence of Larval Nematodes in Adult Herring and Mackerel Caught in Divisions 6a and 6b of ICNAF Subarea 6. ICNAF Res. Doc. 72/58

6. Bigelow H.B.and Schroeder, 1953. Fishes of the Gulf of Main. Washington.

7. Mackay K.T., 1967. An acological study of mackerel Scomber scombrus in the coastal waters of Canada. Fish. Res. BD Canada, Tech.Rep.No 31, p. 127.

8. Moores J.A. Some biological characteristics of mackerel Scomber scombrus from Newfoundland waters.ICNAF Res. Doc. 74/8.

9. Sette O.E., 1950. Biology of the Atlantic mackerel Scomber scombrus of North America. Part 11. Migrations and habits.Bull. Fish.Wild.Serv./49/.

Table 3. Linear growth rate of mackerel from the New England area

Age groups	YEAR-CLASSES																			
	1968		1969		1970		1971		1972		1973		1974		1975		1968 - 1975		Growth rate	
	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	cm	%
1	25.2	406	-	-	24.3	317	24.0	96	22.6	71	20.3	80	20.2	110	20.1	81	23.5	1161	23.5	52.2
2	30.4	246	27.3	639	28.5	147	26.0	481	27.0	137	26.5	16	26.5	211	26.0	129	27.2	2157	3.7	8.2
3	31.8	148	-	-	30.0	1216	28.0	187	30.3	230	28.3	194	29.6	232	30.0	152	29.8	2359	2.6	5.8
4	-	-	34.0	35	32.6	447	31.7	726	32.5	144	32.1	161	33.0	75	32.4	113	32.2	1701	2.4	5.3
5	-	-	-	-	35.2	124	33.6	338	33.7	250	34.5	132	34.0	94	34.3	32	34.1	970	1.9	4.2
6	-	-	-	-	37.3	46	35.4	71	36.2	99	35.2	167	35.5	88	35.9	22	35.7	493	1.6	3.6
7	-	-	-	-	38.4	45	37.3	24	-	-	37.3	42	36.8	58	36.6	32	37.3	201	1.6	3.6
8	-	-	-	-	38.5	75	38.0	7	-	-	38.4	17	39.0	22	37.6	62	38.2	183	0.9	2.0
9	-	-	-	-	38.7	75	38.5	10	-	-	38.8	5	40.5	14	38.5	13	38.9	117	0.7	1.5
10	-	-	-	-	39.1	35	39.2	14	-	-	-	-	-	-	-	-	39.1	49	0.2	0.4

NOTE: 1968 data given for 3-4 quarters; 1969 data - for 2-4 quarters; 1970 data - for 1,2,4 quarters.

Table 4. Linear growth rate of mackerel from Nova Scotia area

A G E groups	1970		1972		1973		1970, 1972-1973		Growth rate	
	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	Mean L, cm	Sp. No	cm	%
1	25.2	133	-	-	23.6	16	24.1	149	24.1	53.5
2	29.5	263	27.7	45	26.7	166	27.5	474	3.4	7.6
3	30.8	230	31.0	94	29.4	82	30.6	406	3.1	6.9
4	32.8	53	33.6	62	31.8	53	32.9	168	2.3	5.1
5	-	-	34.1	105	34.5	23	34.2	128	1.3	2.9

NOTE: 1970 data given for 2-3 quarters; 1972 data-for 3-4 quarters; 1973 data - for 2-4 quarters.

Table 5. Linear growth rate of mackerel from Northwest Atlantic.

A G E	New England, 1968 - 1974		New England* (Autumn)		Nova Scotia, 1970, 1972-1973	
	Mean L, cm	Growth rate, %	Mean L, cm	Growth rate, %	Mean L, cm	Growth rate, %
1	23.9	53.1	20.2	44.9	24.1	53.6
2	27.3	7.5	26.5	14.0	27.5	7.5
3	29.8	5.6	30.1	8.0	30.6	6.9
4	32.2	5.3	32.3	4.9	32.9	5.1
5	33.9	3.8	33.5	2.7	34.2	2.9
6	35.7	4.0	34.6	2.4	-	-
7	37.5	4.0				
8	38.7	2.7				
9	39.4	1.5				
10	39.8	0.9				

NOTE: Data presented by Anderson (1973).

Table 6. Linear-weight growth of various mackerel year classes from New England

AGE	YEAR - CLASSES											
	1967		1969		1970		1971*		1972*		1973*	
	Length, cm	W, g	Length, cm	W, g	Length, cm	W, g	Length, cm	W, g	Length, cm	W, g	Length, cm	W, g
1	25.2	128	24.3	142	24.0	91	-	-	19.3	64	20.3	64
2	27.3	189	26.0	155	27.0	195	25.0	171	26.4	139	25.7	150
3	30.0	268	30.3	264	28.3	217	29.9	187	29.8	240	-	-
4	31.7	309	32.1	333	-	-	32.3	323	-	-	-	-
5	33.7	388	34.0	417	-	-	-	-	-	-	-	-
Increment, %	66.6	36.3	67.3	25.9	62.9	21.3	66.4	18.4	66.2	23.6		

NOTE: Length and weight increments were calculated for three year old fish (%) of maximum length L_∞ = 45 cm and weight W_∞ = 1019 g .

* Data for the 1st quarter.

Table 7. Mean weight of mackerel (g) from the New England area, 1968 - 1975.

Fishing period	1st quarter		2nd quarter		3rd quarter		4th quarter		1 - 4 quarters	
AGE	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No
0	-	-	-	-	-	-	82	69	82	69
1	69	234	102	95	123	127	147	250	111	706
2	139	273	157	680	235	344	227	386	186	1683
3	223	452	239	797	326	349	303	531	266	2129
4	299	377	318	669	379	168	374	231	329	1445
5	367	231	381	336	452	187	467	109	404	863
6	420	117	447	159	518	127	532	46	469	449
7	512	70	512	82	582	44	574	13	531	209
8	552	68	599	57	625	17	605	6	581	148
9	597	30	591	43	670	1	601	9	595	83
10	623	18	594	29	-	-	649	5	609	52
10+	700	14	682	21	-	-	-	-	689	35

Table 8. Mean weight of mackerel (g) from the Nova Scotia area, 1970 - 1973.

Fishing period	2nd quarter		3rd quarter		4th quarter		2-4 quarters	
A G E	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No
0	-	-	-	-	75	1	75	1
1	86	92	116	45	157	134	126	271
2	175	164	202	129	233	130	201	423
3	224	109	288	104	306	293	285	506
4	362	60	374	82	394	89	379	231
5	428	26	434	48	418	64	424	138
6	439	38	479	25	501	42	493	105
7	559	18	618	11	535	35	556	64
8	630	1	715	1	687	4	682	6
9	625	2	-	-	768	4	721	6
10	800	4	713	1	-	-	783	5

Table 9. Mean weight of mackerel (g) from the Northwest Atlantic, 1968 - 1975.

Fishing period	1st quarter		2nd quarter		3rd quarter		4th quarter		1-4 quarters	
A G E	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No	Mean W	Sp. No
0	-	-	-	-	-	-	81	70	81	70
1	69	234	94	187	121	172	150	384	115	977
2	139	273	160	844	226	473	228	516	189	2106
3	223	452	238	906	316	453	304	837	270	2635
4	299	377	322	729	377	250	380	320	336	1676
5	367	231	384	362	448	235	449	173	406	1001
6	420	117	456	197	512	152	517	88	473	554
7	512	70	520	100	589	55	546	48	537	273
8	552	68	599	58	630	18	638	10	585	154
9	597	30	593	45	670	1	652	13	604	89
10	623	18	619	33	713	1	649	5	625	57
10+	700	14	682	21	-	-	-	-	683	35

Table 10. Length - weight indices of mackerel from the Northwest Atlantic

AGE	NOVA SCOTIA				NEW ENGLAND				
	M ± m	$\hat{\sigma}$	c	n	M ± m	$\hat{\sigma}$	c	n	M diff.
					1970, 4th quarter, length (cm)				
1	25.2 ± 0.01	1.00	4.0	133	25.7 ± 0.09	1.41	5.5	242	2.2
2	29.5 ± 0.21	1.73	5.9	63	29.0 ± 0.17	1.97	6.8	131	1.9
3	30.8 ± 0.11	1.70	5.5	230	30.9 ± 0.07	1.52	4.9	457	0.8
4	32.8 ± 0.29	1.58	4.8	53	33.4 ± 0.17	1.80	5.4	105	2.1
					1973, October, length (cm)				
2	27.3 ± 0.26	2.24	8.2	75	27.7 ± 0.26	1.98	7.2	56	1.1
3	29.9 ± 0.26	1.64	5.5	40	29.4 ± 0.34	1.41	4.8	18	1.2
4	32.8 ± 0.18	0.90	2.7	26	33.1 ± 0.20	1.95	2.9	23	1.1
5	34.4 ± 0.56	1.58	4.6	8	35.0 ± 0.39	1.82	5.2	22	0.9
6	36.4 ± 0.37	2.21	6.1	36	35.5 ± 0.37	1.52	4.3	17	2.1
					1973, October, weight (g)				
2	208 ± 7.7	61.2	29.4	64	220 ± 7.0	52.1	23.7	56.	1.2
3	280 ± 9.4	57.0	20.4	37	256 ± 9.9	42.1	16.4	18	1.7
4	384 ± 7.5	35.9	9.3	23	399 ± 7.0	35.9	9.0	26	1.3
5	474 ± 27.7	62.0	13.1	5	474 ±15.7	73.6	15.5	22	0
6	528 ± 19.1	99.5	18.8	27	499 ±13.7	58.3	11.7	18	1.2

Table 11. The pattern of mackerel spawning in the Northwest Atlantic, 1970 - 1974.

AREAS	Years	Beginning of spawning	Massive spawning	End of spawning
New England	1970	1st decade of April (6 + 5Zw)	-	3rd decade of June, 1st decade of July (4W)
Nova Scotia	1970	-	-	3rd decade of July (4W)
New England	1971	2nd decade of April (6a + 6b)	1st-2nd decades of May (5Ze)	3rd decade of June (5Ze)
Nova Scotia	1971	-	-	-
New England	1972	1st decade of May (5Ze)	-	1st decade of July (5Ze)
Nova Scotia	1972	-	-	1st decade of July (4W)
New England	1973	1st decade of May (5Ze)	1st decade of June (5Ze)	-
Nova Scotia	1973	-	-	3rd decade of July (4W)
New England	1974	3rd decade of March (6a + 6b)	1st decade of April (6a + 5Zw)	1st decade of July (5Ze)
Nova Scotia	1974	-	3rd decade of April - 1st decade of July(4W)	3rd decade of July (4W)

Table 12. Age at sexual maturity in mackerel from the Northwest Atlantic

AGE	New England, 1969-1975		Nowa Scotia, 1970, 1972-1973		Newfoundland, 1970-1973	
	Number of sp. studied	Mature %	Number of sp. studied	Mature %	Number of sp. studied	Mature %
2	1215	49.1	83	46.3	92	22.8
3	891	81.5	134	77.1	184	85.9
4	753	98.8	26	96.0	562	94.1
5	345	99.1	24	91.0	661	100

* Data presented by Moores (1974).

Table 13. The number of mature mackerel from the New England area, 1974 - 1975.

LENGTH, cm	24	25	26	27	28	29	30	31	32	33
Number of specimens studied	8	9	7	29	47	45	33	40	41	50
Number of mature specimens, %	0	0	0	45.2	63.8	68.9	94.0	97.5	100.0	100.