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Growth and total mortality of mackerel from the New England area

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Abstract

This paper presents growth parameters for mackerel (*Scomber scombrus*) determined by Bertalanffy's equation. Weight and linear values estimated for mackerel according to Bertalanffy's equation well agree with the observed data. In 1968-1971, total mortality rate of mackerel from the New England area was on the average 0.60, while total annual mortality was equal to 45.1%.

Introduction

Mackerel is one of the abundant species in the Northwest Atlantic. In spite of the fact that the fishery has been conducted in the area for more than a hundred years, the information on biology and, particularly, on the population dynamics of the Northwest Atlantic mackerel is evidently scanty. Some data on mackerel biology and distribution can be found in publications by Sette (1950) and Mackay (1957). Sette, who has investigated migrations, spawning and size composition of mackerel, suggests that there are two groups of mackerel, namely southern and northern stocks. However, tagging experiments and biochemical investigations, as well as the study of meristic features do not confirm this supposition. Mackerel from the New England area and on the American Shelf are considered here as a single population, and the growth and mortality data given in this paper concern equally the mackerel both from ICNAF Subareas 5 and 6 (Fig. 1).

Material and Methods

The paper is based upon samples collected and processed in the period from 1968 to 1971. Age was determined by otoliths according to the common methods. The results of age determination were used for constructing the length-age keys, from which length compositions were converted into age compositions. Mean length of each age-group was calculated and the parameters of the Bertalanffy growth equation were estimated by the method suggested by Hohendorf (1966). Catch per unit effort was determined for the vessels of BMRT and RTM type from January to March inclusively.

Mortality rate (instantaneous mortality factor) was estimated both by integral method and by the difference between natural logarithms (Beverton and Holt, 1956).

Linear and Weight Growth

The following Bertalanffy equation can be used to calculate length and weight in the form presented by Beverton and Holt (1956):

$$L_t = L_\infty \left[1 - e^{-k(t-t_o)}\right]$$

where L_∞ is the mean maximum length; K is relative growth rate (parameter of growth rate) and t_o is theoretical age at L_o. The parameters in the weight growth equation are of the same denotations.

Further use of these parameters requires good agreement between the calculated and observed values. The results of the comparisons are given in Table 1. As can be seen, weight and linear values calculated for mackerel by the Bertalanffy equation agree well with the observed data. The difference between empirical and calculated values is below 5%, SD = ±4.82% (see Table 1). Therefore, we can conclude that the observation material is rather reliable. Mean annual values of parameters are as follows:

L_∞ = 44.89 cm; K = 0.2206; t_o = -1.7625

Table 1. Mean length and weight of mackerel based on the observed and calculated data.

Sampling period	Age (years)	Length (cm) observed	Length (cm) calculated	Weight (g) observed	Weight (g) calculated
Jan-Feb 1970	1	19.7	18.13	79.1	78.4
	2	24.7	23.91	149.1	153.1
	3	29.5	28.29	227.3	237.2
	4	32.4	31.61	336.2	321.4
	5	34.6	34.13	393.6	398.7
	6	36.8	36.04	-	-
	7	37.7	37.49	-	-
Calculated parameters	L_∞ = 43.02	K = 0.2786		W_∞ = 781.23	K = 0.2455
	t_o = -0.9623	SD = ±4.82%		t_o = 1.543	SD = ±1.29%

Sampling period	Age (years)	Length (cm) observed	Length (cm) calculated	Weight (g) observed	Weight (g) calculated
Jan-Mar 1971	1	20.6	20.55	73.4	73.8
	2	24.9	24.48	129.6	130.2
	3	27.3	27.83	190.2	198.1
	4	30.7	30.67	278.9	273.4
	5	33.0	33.08	360.3	352.1
	6	35.2	35.13	429.9	431.2
Calculated parameters	L_∞ = 46.75	K = 0.1626		W_∞ = 1257.26	K = 0.1424
	t_o = -2.5627	SD = ±1.29%		t_o = 2.4564	SD = ±2.54%

Total Mortality

Total mortality rate was obtained on the basis of the mean abundance indices by age-groups given in Table 2. The moving-average method was used to align the obtained series. Based upon this, a semi-logarithmic curve was constructed where abundance of each age-group (axis of ordinate) was expressed by natural logarithms (Fig. 2). As can be seen, the points of natural logarithms for fish of every age fall on almost a straight line, except for the first one and the last but one. The slope of the line determines the mean instantaneous mortality which is equal to 0.60 for 5-11 year old fish. It should be noted that mortality becomes relatively stable only in age-group 5 and older. The value of the total mortality rate estimated by the difference between the natural logarithms of abundance of adjacent age-groups and relative mortality rate in percent is given in Table 3. Relative mortality rate was determined by the formula: $a = 1-e^{-Z}$; where Z = total instantaneous mortality.

Instantaneous mortality rate was estimated by mean length using the formula: $Z = \frac{K(L_\infty - L')}{\bar{L} - L'}$; where L_∞ is maximum length; $\bar{L}$ is mean length of mackerel in catches; L' is minimum length of fish fully represented in samples from catches;

$$Z = \frac{0.2206\ (44.89 - 30.3)}{30.3 - 25.0} = 0.60$$

Having analysed the data obtained, we can see that the values of total mortality rate determined by different ways appeared to be very similar and varied from 0.55 to 0.60. Since the two of the three cases considered the value of the total mortality rate is equal to 0.60, we can accept this figure to be instantaneous mortality rate; hence total annual mortality rate is 45.1%.

Table 2. Mean catch of mackerel per 1-hour haul taken by large-sized trawlers in Statistical Area 6 (ICNAF) by year-classes (in numbers) during January - March 1968-1971.

Years	Age Group										
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
1968	72	29	40	20	14	12	18	15	10	6	3
1969	121	1923	1600	826	389	55	50	40	25	8	2
1970	3040	898	8780	3988	655	275	170	160	154	59	39
1971	424	2404	1109	6078	1844	274	124	75	62	37	25
Relative abundance of age groups	914.2	1313.5	2882.2	2728.0	725.5	154.0	90.5	72.5	62.8	27.5	15.5
Natural logarithm of relative abundance	6.82	7.18	7.97	7.91	6.59	5.04	4.51	4.28	4.14	3.31	2.74
Aligned series of natural logarithms of relative abundance	6.84	7.27	7.55	7.20	6.47	5.45	4.74	4.23	3.90	3.37	2.84

Table 3. Total mortality rate and annual mortality rate of mackerel in the New England area, 1968-1971.

Year	Z	Mortality (%)
1968	0.26	22.9
1969	0.88	58.5
1970	0.51	41.1
1971	0.72	50.8
Mean	0.59	43.4

Summary

1. Bertalanffy's equation gives a reliable reflection of mackerel growth regularities. The values obtained by theoretical methods are in a good agreement with the observed ones.

2. In 1968-1971, the instantaneous mortality rate for mackerel from the New England area was on the average 0.60 (5-11-year-old fish) and total annual mortality was equal to 45.1%.

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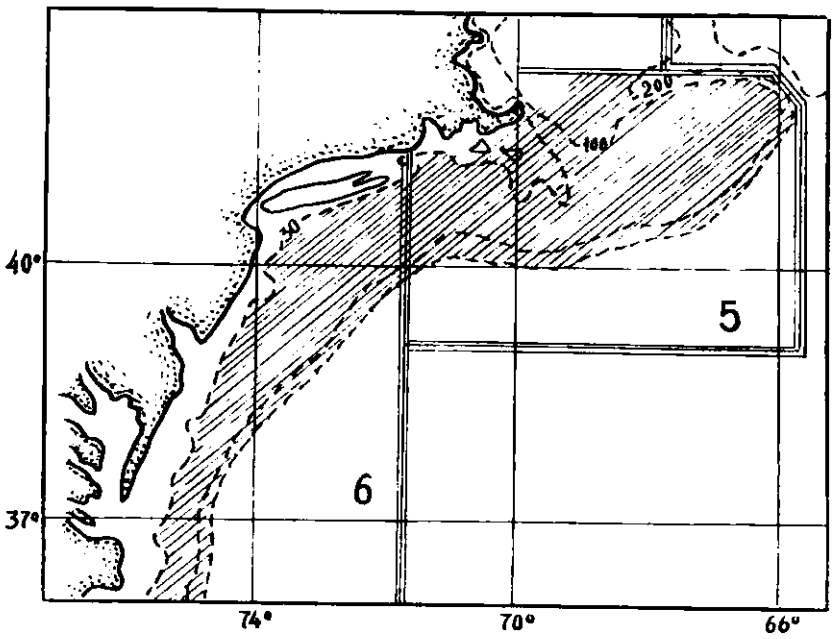

Fig. 1. Mackerel distribution in the New England area.

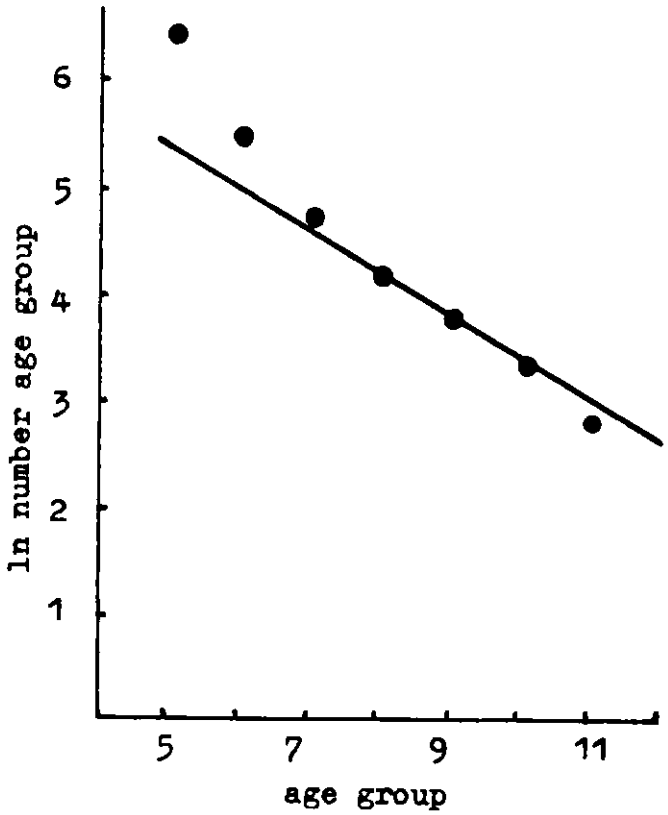

Fig. 2. Determination of the total mortality rate by natural logarithms of abundance of each age group.