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Growth and total mortality of argentine in the Northwest Atlantic

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Abstract

The paper gives the growth parameters for argentine, *Argentina silus* Ascanius, by Bertalanffy's equation. A good conformity is obtained between the observed and theoretical data on growth.

Total instantaneous mortality factor for argentine from ICNAF Div. 4X was estimated to be on the average 0.23 in 1968-1970, the total annual mortality being 20.9%.

Introduction

Argentine is one of the commercial species in the Northwest Atlantic. However, the information on biology and abundance dynamics, in particular, is rather poor. Therefore, we have determined linear and weight growth of argentine from Div. 4X and 4W and total mortality rate for argentine from Div. 4X.

Methods and Material

Numerical values of parameters in Bertalanffy's growth equation were estimated by the data on size-age composition of argentine males and females in the catches from Div. 4X and 4W taken in the autumn 1968-1970. Sampling positions are given in Fig. 1, while Table 1 includes all the material analysed. Samples were taken from the Soviet commercial catches.

Linear and weight growth by Bertalanffy is written by the following equation:

$$L_t = L_\infty \left(1 - e^{-k(t-t_0)}\right),$$

$$W_t = W_\infty \left(1 - e^{-k(t-t_0)}\right)^3,$$

where L_t = length of fish in a year (cm)

W_t = weight of fish in a year (g)

L_∞ = theoretical possible maximum length (cm)

W_∞ = theoretical possible maximum weight (g)

e = natural longarithm base

k = growth delay factor

t_0 = theoretical age when length is equal to 0 assuming growth to take place in accordance with Bertalanffy's equation.

The above parameters of Bertalanffy's equation have been estimated by Hohendorf's method (1966). Comparative estimate of the error (S_D) between the observed and calculated values was found by the formula:

$$S_D = \pm \sqrt{\frac{\sum_{t=1}^{n} (D_t\%)^2}{n - 2}}$$

where D_t = the difference between the observed and calculated values in percent

n = the number of degrees of freedom.

Total mortality (Z) of argentine from Div. 4X was determined by the Beverton and Holt method (1956). According to the first method, mortality could be estimated by mean length

$$Z = \frac{K\ (L_\infty - \bar{L})}{\bar{L} - L'},$$

where L' = minimum length of fish fully represented in the samples from the catches

$\bar{L}$ = mean length calculated for sizes from L' and above.

The second method consists in drawing the semi-logarithmic plot where the abundance of every age group is expressed by natural logarithms. In this case, total mortality rate was determined for 7-12 year-old fish, as from 7 years onwards argentine was fully represented in the catches.

Annual mortality rate (ψ) was calculated by the formula:

$$\psi = 1 - e^{-Z}$$

Table 1. Argentine samples analysed for growth and mortality.

		Number of specimens			
		Length (cm)		Weight (g)	
Div.	Year	males	females	males	females
4X	1968	308	372	-	-
4W	1969	479	202	-	-
4X	1970	-	-	273	440
4W	1968	-	-	116	154

Linear Growth

Argentine growth rate estimated by growth equation and by the data of observations is given in Tables 2 and 3. As it is obvious from the Tables, the calculated values of argentine growth well agree with the observed ones for Div. 4X and 4W. Mean percentage error for the calculated values is insignificant and lies within the range from 0.6 to 3.6%. K factors obtained for argentine from the two divisions are extremely negligible (Table 4) and can be explained by slow growth rate.

Furthermore, it is found from the observed data that growth rate for argentine from Div. 4X is higher than that from Div. 4W. Consequently, parameters for argentine in the growth equation will be different in these divisions. Knowing the parameters in Bertalanffy's equation, we can give the equations of linear growth of argentine from Div. 4X

$$L_t = 65.32 \left[1 - e^{0.0465\ (t + 7.971)}\right]$$

and from Div. 4W

$$L_t = 42.56 \left[1 - e^{-0.1091\ (t + 3.320)}\right].$$

Table 2. Mean length of argentine by the observed and calculated data and the evaluation of accuracy of the latter (Div. 4X).

Sex	Males		Females		Males+Females	
Age (years)	Length (cm) obs.	calc.	Length (cm) obs.	calc.	Length (cm) obs.	calc.
1	17.05	16.54	-	-	-	-
2	20.62	19.12	-	-	-	-
3	21.50	21.49	24.00	-	22.33	22.26
4	23.80	23.65	25.33	-	24.37	24.21
5	26.26	25.62	26.70	26.83	26.44	26.07
6	26.86	27.42	28.75	28.58	28.21	27.85
7	28.78	29.07	29.24	30.22	29.02	29.55
8	29.85	30.57	31.48	31.76	30.83	31.18
9	30.25	31.94	33.18	32.94	32.42	32.73
10	33.27	33.20	34.59	34.31	34.37	34.21
11	34.86	34.35	36.09	35.59	35.92	35.62
12	-	-	37.00	36.78	37.04	36.97
S_D%	±3.60		±1.59		±1.14	

Table 3. Mean length of argentine by the observed and calculated data and the evaluation of accuracy of the latter (Div. 4W).

Sex	Males		Females		Males+Females	
Age (years)	Length (cm) obs.	calc.	Length (cm) obs.	calc.	Length (cm) obs.	calc.
5	25.60	25.31	26.00	25.62	25.75	25.71
6	27.43	26.97	28.06	27.38	27.59	27.45
7	28.83	28.53	29.57	29.08	29.05	29.01
8	29.80	29.99	31.10	30.71	30.20	30.41
9	31.38	31.36	32.40	32.28	31.74	31.66
10	32.70	32.64	33.35	33.80	32.83	32.79
11	34.37	33.84	35.58	35.26	34.89	-
12	35.21	34.96	-	-	-	-
13	36.14	36.02	-	-	-	-
14	37.17	37.01	-	-	-	-
S_D%	±2.77		±1.75		±0.58	

Table 4. The comparison of linear growth parameters for argentine from Div. 4X and 4W (according to Bertalanffy).

Population	Sex	L_∞	K	t_0
Div. 4X	♂	46.47	0.0905	- 3.868
	♀	54.38	0.0660	- 9.225
	♂♀	65.32	0.0465	- 7.971
Div. 4W	♂	51.83	0.0648	- 9.488
	♀	73.34	0.0376	-10.593
	♂♀	42.56	0.1091	- 3.320

Weight Increment

The observed data on weight increment of argentine from Div. 4X and 4W are represented in Tables 5 and 6. It can be seen from the Tables that in Div. 4X argentine of the same age are heavier than those in Div. 4W. Weight valued estimated by Bertalanffy's equation are in a good agreement with the observed data. Mean percentage error for the estimated values is in the range of 1.5–9%.

The comparison of argentine weights from the divisions under survey has revealed higher maximum weight for *A. silus* from Div. 4X (Table 7). When weight increment parameters have been determined in Bertalanffy's equation, the latter can be written in the following form:

$$\sqrt[3]{W_t} = 490.92 \left[1 - e^{-0.202\ (t + 4.925)}\right] \text{ for Div. 4X}$$

and $$\sqrt[3]{W_t} = 287.12 \left[1 - e^{-0.233\ (t + 4.366)}\right] \text{ for Div. 4W.}$$

Table 5. Mean weight of argentine by the observed and calculated data and the evaluation of accuracy of the latter (Div. 4X).

Sex	Males		Females		Males+Females	
Age (years)	Weight (g) obs.	Weight (g) calc.	Weight (g) obs.	Weight (g) calc.	Weight (g) obs.	Weight (g) calc.
5	169.23	166.46	166.00	177.77	168.39	166.15
6	200.54	198.54	219.53	227.67	213.02	209.12
7	240.05	230.76	263.25	277.70	251.68	249.25
8	263.57	262.61	307.45	326.47	285.86	285.36
9	279.34	293.68	340.50	372.99	313.26	317.81
10	327.64	323.70	399.54	416.62	347.90	345.84
11	-	-	460.80	456.98	-	-
12	-	-	510.19	493.94	-	-
13	-	-	542.75	527.44	-	-
14	-	-	548.00	557.62	-	-
S_D%	±8.9		±5.41		±1.46	

Table 6. Mean weight of argentine by the observed and calculated data and the evaluation of accuracy of the latter (Div. 4W).

Sex	Males		Females		Males+Females	
Age (years)	Weight (g) obs.	Weight (g) calc.	Weight (g) obs.	Weight (g) calc.	Weight (g) obs.	Weight (g) calc.
3	109.00	106.09	95.77	99.90	102.38	103.58
4	124.00	126.66	130.93	130.15	127.59	131.93
5	153.02	146.68	163.00	161.02	157.96	157.76
6	168.37	165.81	185.61	191.63	177.49	180.47
7	188.44	183.82	214.59	221.28	206.99	199.93
8	203.00	200.60	217.60	249.50	215.17	216.31
9	-	-	246.00	275.95	-	-
10	-	-	303.50	300.51	-	-
S_D%	±3.18		±7.30		±2.62	

Table 7. The comparison of linear growth parameters (according to Bertalanffy) for argentine from Div. 4X and 4W.

Population	Sex	W_∞	K	t_0
Div. 4X	♂	694.07	0.106	-8.194
	♀	778.24	0.145	-5.501
	♂♀	490.92	0.202	-4.925
Div. 4W	♂	345.45	0.135	-7.340
	♀	506.78	0.137	-5.028
	♂♀	287.12	0.233	-4.366

Total Mortality Rate

When the abundance of each age group is known (Table 8), we can express it by natural logarithms and plot a semi-logarithmic curve (Fig. 2). To obtain a smooth curve, we align natural logarithm values by the moving-average method (Plokhinsky, 1970). The total mortality factor Z = 0.24 is given by the slope of the right part of the curve.

The total mortality factor was also estimated by the mean length; it was equal to 0.21. Thus, the two factors of total mortality obtained by different ways are rather similar. The mean factor is 0.23 and hence the decrease of year-classes is equal to 20.9% per year. Thus the argentine stock from Div. 4X is characterized by low total mortality.

Taking into account low intensity of argentine fishery in 1968-1970, we can consider total mortality to be close to natural mortality.

Table 8. Mean abundance of argentine by age groups in the samples taken from the catches in Div. 4X, 1968-70.

Age groups	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Mean abundance of age groups in numbers	3	8	140	97	104	83	50	67	49	28
Mean abundance of age groups in percent	0.48	1.27	22.26	15.42	16.53	13.19	7.94	10.66	7.79	4.46
Natural logariths of mean abundance	-0.803	0.240	3.103	2.736	2.805	2.580	2.018	2.367	2.053	1.495
Aligned row of natural logarithms of mean abundance	-0.37	0.62	2.04	2.56	2.70	2.51	2.28	2.17	1.94	1.66

Conclusions

1. The results of investigations show that Bertalanffy's equation reflects the regularities of argentine growth rather precisely which is supported by the fact that the theoretical values well agree with the observed ones.

2. Total mortality factor for argentine from Div. 4X was estimated on the average as 0.23, or 20.9%, in 1968-1970.

References

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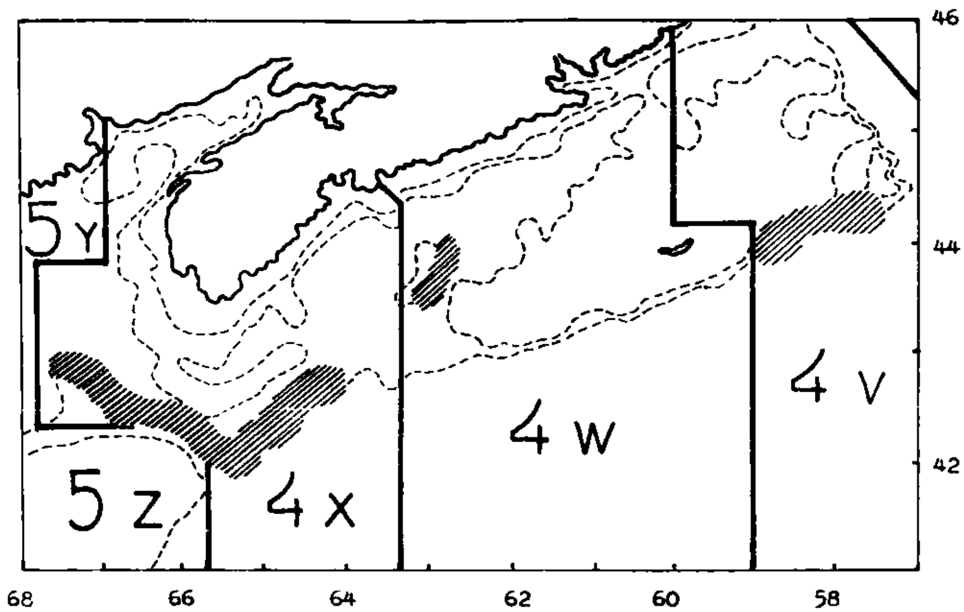

Fig. 1. Distribution of local groups of argentine in the Northwest Atlantic.

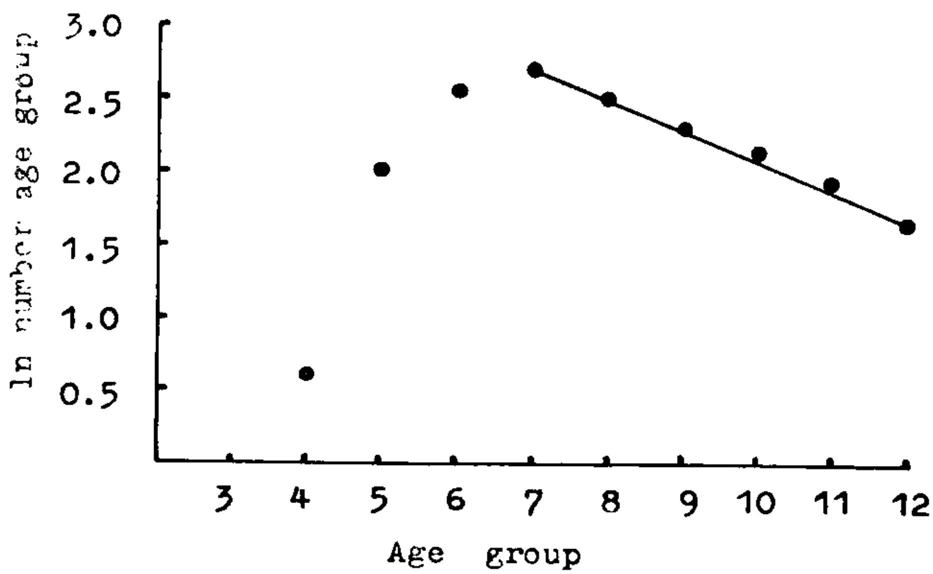

Fig. 2. Age composition of argentine in ICNAF Div. 4X.