

GROWTH PARAMETERS OF THE BLACK SEA SPRAT (*SPRATTUS SPRATTUS* L.) DURING THE PERIOD NOVEMBER 2010 – MARCH 2012 ALONG THE BULGARIAN BLACK SEA COAST

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Abstract

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The goal of the present paper is to define some basic characteristics of the population of Black Sea sprat (*Sprattus sprattus* L.) along the Bulgarian coast such as size and age composition, performance and character growth, relationship between weight and length and index of Fulton. It was found that the growth in the period 2010–2012 is allometric. The values of the parameter n , characterizing the relationship between growth in weight and length, were ranging from 1.475 to 3.074. It was found that in autumn – winter season, the Fulton's index was decreasing and in the spring– summer it was increasing. The parameters in the equation of Von Bertalanffy, estimated by the lengths of the periods from April to October 2011 and November 2011 – March 2012 were as follows: $L_t = 12.68 \{1 - \exp[-0.138(t + 4.283)]\}$ and $L_t = 13.68 \{1 - \exp[-0.267(t + 1.975)]\}$.

Key words: sprat, growth, Fulton, Von Bertalanffy

Introduction

The Black Sea sprat (*Sprattus sprattus* L.) is a key species in the Black Sea ecosystem. Sprat is a marine pelagic schooling species. In the daytime, it keeps to deeper waters and in the night moves near the surface. It forms big schools and undertakes seasonal movements between foraging (inshore) and spawning (open sea) areas (Ivanov and Beverton, 1985). Being cold-water fish species sprat adults tend to remain under the seasonal thermocline, penetrating above it only during the spring and autumn homothermia. Juveniles are distributed in a larger area near the surface. Sexual maturity is attained at the age of 1 year and length of 7 cm.

Sprat is commercially one of the most important fish species, being fished and consumed traditionally in the Black Sea countries. It is the most abundant small pelag-

ic fish species in the region, together with anchovy and horse mackerel and accounts for most of the landings in the northwestern part of the Black Sea. In the sprat fishery, another cold-water fish species the whiting is also taken as by-catch, although there is no targeted fishery (Raykov, 2006) except for the Turkish waters.

The age structure and growth rate of the Black Sea sprat are subject of long-term investigations by a number of authors – Stoyanov (1965, 1966), Ivanov (1983, 1991), Prodanov and Daskalov (1992), Daskalov and Prodanov (1994), Prodanov et al. (1997) with the aim to clarify qualitative and quantitative structure of catches, which represent state of the stocks, as well as the impact of abiotic and biotic factors of the environment on them (Ivanov, 1983).

Sprat fishing takes place on the continental shelf at depth of 15–110 m. The harvesting of the Black Sea

sprat is conducted during the daytime when its aggregations are denser and are successfully fished with trawls. The main fishing gears are mid-water otter trawl, pelagic pair trawls and uncovered pound nets (Daskalov and Rätz, 2011).

During the period 1972–2011, Bulgarian catches of sprat range from 2962 (1972) to 18800 tones (1981), (FAO Yearbook for Fishery Statistics). Since 1981, sharp decline of catches has been recorded – about 2.5 fold and previous few years, catches show slow rising – 4041 tones (2010). Catch and landings of the sprat in the Black Sea are given in Figure 1.

The reasons for the decline of the sprat stocks in the western part of the Black Sea after 1987–1988 are complex. The intensification of the fishery in the last 20 years together with the high level of pollutants and the ctenophore *Mnemiopsis leidyi* expansion in the Black Sea have had a large impact on the sprat stocks and lead to a disturbance of the ecological equilibrium and marked changes in the fish community -

(http://stecf.jrc.ec.europa.eu/documents/43805/55543/0710_Black+Sea+advice+for+sprat+and+turbot.pdf).

The goal of the present paper is to investigate the growth rate of the Black Sea sprat along the Bulgarian Black Sea coast during the period November 2010–March 2012 and to compare the obtained results with foregoing investigations.

Material and Methods

Present analysis was performed on the base of mean length at age data for 2010–2012 from sampling of commercial landings during the following periods:

(1) November 2010 – March 2011

(2) April – October 2011

(3) November 2011– March 2012

The total length (L) and weight (W) were measured and the age was determined by reading the otoliths. The total number of sampled individuals was 9415. The size and age structure was examined by months and subsequently the obtained data were averaged by periods. The selection of periods is relevant to species biology – mass spawning during autumn and winter (October – March) and intensive growth and fattening

during spring and summer (April – September).

Parameters L_{∞} , k and t_0 to be estimated by Von Bertalanffy growth equation (1957):

$$L_t = L_{\infty} \{ 1 - \exp [-k (t - t_0)] \} \quad (1)$$

where: L_t is the length of fishes at age t ; L_{∞} - asymptotic length, k – Brody growth Coefficient, t_0 – age at zero length.

For establishment of weight-length relationship the following equation was used:

$$W = a \cdot L^n \quad (2)$$

where: W – weight (in g); L – length (in cm); a – coefficient; n – coefficient, characterizing the growth rate.

The condition factors (c.f.) were computed by Fulton's index (Ricker, 1975).

$$c.f. = W \cdot 100 / L^3 \quad (3)$$

where: W – average weight by size groups; L – average length by size groups.

Results and Discussion

Source data for average lengths and weights of sprat by periods are given in Table 1.

Pursuant to data from in Table 1 and using Equation (2), the coefficients a and n , characterizing weight-length relationship, were estimated. The results are presented in Table 2.

From the results, given in Table 2, it is seen that the sprat growth is allometric during the investigated periods. Correlation coefficient was highest for the period April – October 2011, $r^2 = 0.996$. For other periods, this coefficient varied from 0.961 to 0.989. The dimensions of the parameter n characterizing growth were in the range between 1.474 and 3.07.

According to the calculated average weights and by using of Equation (3), the Fulton's condition factors by size groups and by period were estimated (Table 3).

The Table shows that during the first period November 2010 – March 2011 the Fulton's indices (c.f.) were decreasing. That is probably due to the fact, that during the winter, sprat is actively spawning and use up the greater part of its energy for forming sex

Table 1
Lengths (cm) and average weight (g) of Black Sea sprat (*Sprattus sprattus*) by periods

L, cm	W, g		
	(1)	(2)	(3)
5.0		0.46	0.50
5.5		0.70	0.83
6.0	1.17	1.14	1.06
6.5	0.92	1.26	1.24
7.0	1.40	1.81	1.89
7.5	2.03	2.35	2.26
8.0	2.87	2.84	2.72
8.5	3.55	3.28	3.47
9.0	4.07	3.93	4.03
9.5	4.68	4.75	4.59
10.0	5.14	5.28	4.83
10.5	5.36	6.18	5.89
11.0	6.38	4.00	2.67
11.5		3.58	
12.0			
12.5			

Note: (1) November 2010 – March 2011; (2) April – October 2011; (3) November 2011 – March 2012

Table 2
Values of coefficients a and n in equation (2) by periods

Coefficients	Periods		
	(1)	(2)	(3)
A	0.1674	0.00391	0.011382
N	1.4749	3.07	2.6649
R	0.9246	0.9938	0.9943
r ²	0.9615	0.9963	0.9896

Note: Periods are the same as in Table 1

Table 3
Condition factors by size groups and by periods

Periods (1)	c.f.	L	Periods (2)	c.f.	L	Periods (3)	c.f.	L
XI 2010	0.6060	8.0–8.5	IV 2011	0.4627	9.0–9.5	XI 2011	0.5948	8.5–9.0
I 2011	0.5717	8.5–9.0	V 2011	0.5707	8.5–9.0	XII 2011	0.5920	9.0–9.5
II 2011	0.5445	8.5–9.0	VI 2011	0.5859	7.5–8.0	I 2012	0.5346	7.0–7.5
III 2011	0.5276	9.5–10.0	VII 2011	0.4763	7.5–8.0	III 2012	0.4760	6.0–6.5
			VIII 2011	0.5332	7.5–8.0			
			IX 2011	0.5647	8.0–8.5			
			X 2011	0.6288	8.0–8.5			

Note: Periods are the same as in Table 1

products and less part – for body growth in length and weight (Panayotova, 2001).

During the second period (April – October 2011), the Fulton's indices were slowly increasing from 0.4627 to 0.6288 and this advance of fish condition was recorded until the start of the spawning season. During the period July – individuals formed October the bottom sprat concentrations are, at age 1 year with smaller lengths. This probably is the reason for decrease of Fulton's index for sprat during July – August 2011. In the third period (November 2011 – March 2012), we observe similar indicators as during the first period (November 2010 – March 2011). What make an impression in March 2012 are the low weight and the weak growth condition. Coefficient of condition factor marked a record lows in this spring. This diminished condition is probably related to the relatively high sprat abundance and thus lower food availability.

On the Figure 2 is shown the relationship between sprat length and Fulton's index by periods.

The parameters in the equation (1) of Von Bertalanffy, estimated by the length of the periods from April to October 2011 and November 2011 – March 2012 are as follows: $L_t = 12.68 \{1 - \exp[-0.138(t + 4.283)]\}$ and $L_t = 13.68 \{1 - \exp[-0.267(t + 1.975)]\}$.

Figure 2 shows that the maximum growth was observed between 0+ and 1 years of age during both periods.

Coefficients values in equation (1) obtained from previous investigations and assessed by us are given in Table 4.

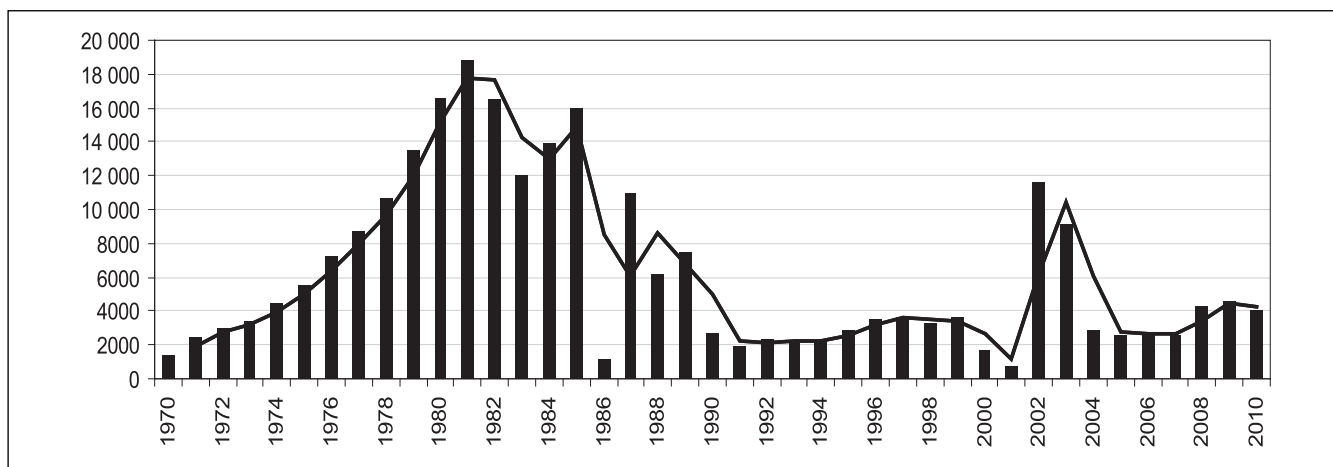
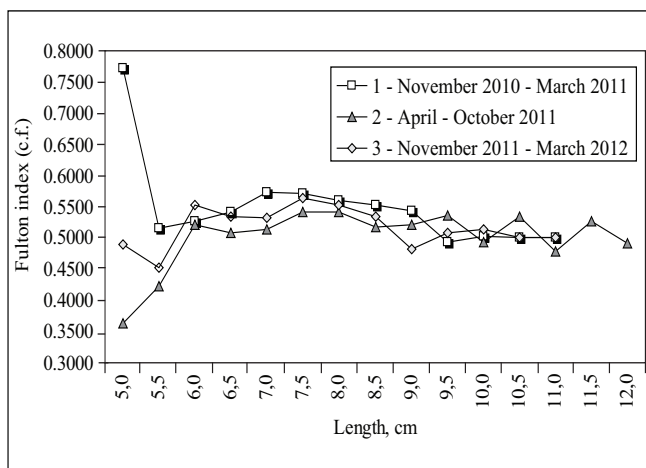
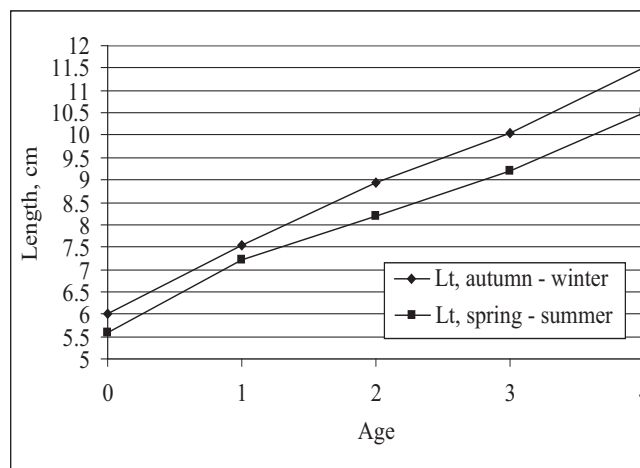
As it is seen from the Table 4, the obtained values of parameters for the second period are close to that

Table 4**Values of the coefficients in Von Bertalanffy by different authors for periods 1965-2011**

Parameter	Stoyanov (1965)	Cautis (1971)	Ivanov (1983)	Prodanov et al. (1994)				
				1981	1982	1983	1984	1985
L_{∞}	14.3	14.6	13.41	12.41	12.80	13.21	12.02	13.50
k	0.215	0.281	0.451	0.594	0.427	0.344	0.544	0.282
t0	-2.97	-1.6	-1.125					

Parameter	Prodanov et al. (1994)					Daskalov et. (2011)	2 nd period	3 rd period
	1986	1987	1988	1989	1990			
L_{∞}	12.65	26.03	19.36	15.34	12.27	12.57	12.68	13.68
k	0.404	0.069	0.129	0.230	0.399	0.82	0.138	0.268
t0						-0.662	-4.283	-1.975

Note: (2) April – October 2011; (3) November 2011– March 2012

**Fig. 1. Catch and landings of the sprat in the Black Sea during 1970–2010 (Daskalov et al. 2011)****Fig. 2. Relationship between sprat length and Fulton's index during the period November 2010–Mach 2012****Fig. 3. Length-at-age relationship of the Black sea sprat during the period November 2010–Mach 2012**

estimated by Prodanov et al. (1986) and Daskalov et al. (2011). The values of parameter L_{∞} for the 3-rd are close to those estimated by Prodanov et al (1985). The results obtained in the Table 4 show that sprat growth parameters undergo considerable variations among years.

Conclusions

Investigations carried out on sprat in the Black Sea and the estimated growth parameters allow making the following conclusions. It was found that the growth in the period 2010–2012 is allometric. During the autumn – winter season, the Fulton's index is decreasing and conversely during the spring – summer season it is increasing. The growth parameters undergo considerable interannual variations.

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