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Growth dynamics of Sprat *Sprattus sprattus L.* off Bulgarian Black Sea Coast

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Sprat shows remarkable variability in size and growth rate between years and this feature creates its specific adaptive response to changes in environment.

In this study we analyse the growth of cohorts 1977 to 1990 in relation with some environmental and population characteristics. Growth was modelled on the base of monthly length-at-age data by fitting the von Bertalanffy growth function (VBGF). Growth performance index:

$$\phi' = log_{10}k + 2log_{10}Loo \qquad 1)$$

(PAULY and MUNRO, 1984) together with direct length-at-age observations were used for growth comparisons.Correlation analysis was performed on growth parameters and environmental indices.(*Table 1.*)

Table 1. Correlation matrix of growth and environmental parameters: ϕ-growth performance; *L1,L2*-length-at-age 1 and 2 years; *L*-mean length; *ΔL1,ΔL2*-annual increment at age 1 and 2; *c.f.*-condition factor; *R*-recruitment; *N1+,B1+*-stock numbers and biomass at age 1 and older; *F*-fishing mortality; *S.I.*-spawning intensity; *Zoo, Ph*-zoo- and phytoplancton biomass; *PO4, To, C.W.*- phosphate concentration, water tempeture and coldness of winter in the N-W Black Sea.

Significance levels: *- $p<0.05$; # - $p<0.01$

	year	ϕ'	L1	L2	L	ΔL1	ΔL2	c.f.	R	N1+	B1+	F	S.I.	Zoo	Ph	PO_4	T°	C.W.
ϕ'	0.09																	
L1	- 0.91#	-0.27																
L2	- 0.87#	0.16	0.77#															
L	-0.88#	0.15	0.78#	1.00#														
ΔL1	0.52	0.79#	-0.73#	-0.28	-0.31													
ΔL2	0.71#	0.04	-0.82#	-0.69#	-0.72#	0.55*												
c.f.	-0.22	0.53	0.27	0.34	0.34	0.30	-0.51											
R	-0.67#	-0.09	0.68#	0.43	0.45	-0.56*	-0.65*	0.03										
N1+	0.83#	-0.48	0.84#	0.66*	0.68#	-0.76#	-0.56*	-0.37	0.52									
B1+	-0.91#	-0.33	0.88#	0.70#	0.73#	-0.70#	-0.67#	-0.19	0.62*	0.97#								
F	-0.02	0.52	-0.15	0.22	0.18	0.55*	0.25	0.66*	-0.10	-0.36	-0.32							
S.I.	0.43	0.70*	-0.44	0.03	-0.02	0.70*	0.23	0.65	-0.43	-0.73*	-0.67*	0.69*						
Zoo	-0.75#	-0.08	0.68#	0.83#	0.82#	-0.40	-0.52	0.19	0.30	0.69#	0.68#	0.13	-0.02					
Ph	-0.58*	-0.23	0.41	0.56*	0.58*	-0.36	-0.38	-0.20	0.26	0.58*	0.58*	-0.32	-0.46	0.50				
PO_4	-0.46	-0.39	0.44	0.61*	0.57	-0.35	0.31	-0.22	-0.06	0.38	0.34	0.00	-0.22	0.73#	0.71#			
T°	0.70	0.78*	-0.81*	-0.56	-0.66	0.88#	0.71*	0.14	-0.25	-0.80*	-0.74*	0.70	0.81*	-0.65	-0.50	-0.51		
C.W.	0..27	-0.45	-0.00	-0.60	-0.56	-0.26	0.15	-0.08	0.08	-0.01	-0.08	-0.00	-0.39	- 0.53	0.06	0.04	-0.61	

An intensification of sprat fishery started in mid70's on the base of rising stock abundance, due to outstanding "eutrophic" productivity of the Black Sea and reduced predatory press. After 1980, sprat biomass being hard exploited, dropped down in Bulgarian waters (PRODANOV and DASKALOV, 1992).

In terms of growth, the period 1977-1993 is characterised by decrease in size and relative increase in growth rate till 1987, when growth dramatically drops on the level of 1978 (*Table 2, fig.*).

Table 2. Growth parameters of sprat

year	*Loo*	*k*	*ϕ'*
1977	12.62	0.329	1.719
1978*	30.73	0.042	1.598
1979	14.30	0.271	1.744
1980	16.85	0.145	1.615
1981	12.41	0.594	1.961
1982	12.80	0.427	1.845
1983	13.21	0.344	1.778
1984	12.02	0.544	1.895
1985	13.50	0.282	1.711
1986	12.65	0.404	1.811
1987	26.03	0.069	1.670
1988*	19.36	0.129	1.684
1989	15.34	0.230	1.733
1990	12.27	0.399	1.770

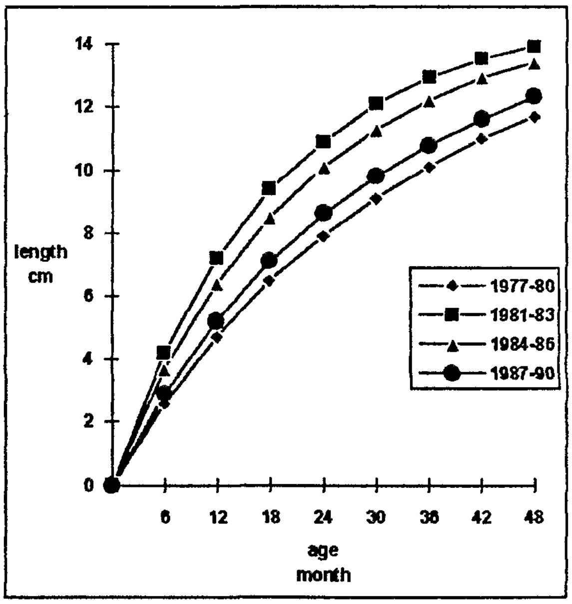

Fig. Growth curves for average cohorts 1977-80, 1981-83, 1984-86, 1987-90.

The relation between length and annual increment is negative: that shows a compensatory effect of growth(*L1 vs. ΔL1 - R = -0.78; L2 vs. ΔL2 - R = -0.69*). Significant correlations between growth parameters and abundance estimates show evidence for density-dependent growth. The rate of exploitation expressed by fishing mortality coefficients(*F*) correlates positively with growth performance(ϕ'): $R= 0.52$; annual increment($\Delta L1$): $R = 0.55$ and *c.f.*: $R = 0.66$. The spawning intensity is negatively related with the abundance and positively related with *c.f.*: $R = 0.65$, and with growth rate.The trophic environment, expressed by zoo- and phytoplancton abundance and by phosphate concentration correlates in some degree with size. The last two indices however give very rough image of the trophic conditions because they are relevant to the Nord-Western part of the sea. The same is the case with the climate indices (T^o and *C.W.*), which nevertheless show significant relation with growth within the period 1977-85. This stresses one more time, the necessity of more severe analysis of the dependence of the fishery productivity on climate.

Although the correlations account for majority of the variation in the analysed time series, they do not indicate direct relationships between them. The changes in growth of sprat can be associated mainly with the graduate reducing of the standing stock under intensive exploitation. After 1986, planctivorous invertebrates (especially the ctenophore *Mnemiopsis sp.*) become dominant in the pelagic community. Competition on food with fish larvae could be one possible explanation of the decrease in growth in the last years.

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