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 to 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 : $\phi' = \log 10k + 2\log_{10}Loo$ 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[1]; Zoo, Ph-zoo- and phytoplancton biomass; PO4, To, C.W.- phosphate concentration, water tempeture and winter cold[2] 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°
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	0.05	-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	0.59#	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.	-0.69	-0.77	0.48	0.10	0.13	-0.63	-0.06	-0.45	0.37	0.62	0.54	-0.42	-0.90#	0.24	0.52	0.42	-0.61

1 As a relative index of interannual variability of the spawning intensity was used the average percentage of fishes with ovaries in maturity stages IV and V during the peak spawning season: November - January.
2 Winter conditions are importants because of the positive effect of the winter convection (which is particularly intensive in cold and windy winters) on bioproductivity.

An intensification of sprat fishery started in the mid 70'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 characterized by decrease in size and relative increase in growth rate till 1987, when growth dramatically drops on the level of 1978 (Table 2, fig.). 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 perfor-mance (ϕ'): R= 0.52; annual increment (ΔL1): R = 0.55 and c.f.: R = 0.66. The spawning intensity is negatively related with the abundance and positi-vely 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 Northwestern part of the sea. The same is the case with the climate indices (T ° 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.

year	Loo	k	ϕ'	ΔL1	L	c.f.
1977	12.62	0.329	1.719	0.89	10.59	-
1978	30.73	0.042	1.598	0.89	10.13	0.58
1979	14.30	0.271	1.744	1.31	10.17	0.553
1980	16.85	0.145	1.615	1.04	10.67	0.587
1981	12.41	0.594	1.961	1.79	10.40	0.614
1982	12.80	0.427	1.845	1.48	10.23	0.616
1983	13.21	0.344	1.778	1.37	10.10	0.585
1984	12.02	0.544	1.895	1.44	10.27	0.588
1985	13.50	0.282	1.711	1.27	9.80	0.596
1986	12.65	0.404	1.811	1.49	9.80	0.576
1987	26.03	0.069	1.670	1.19	9.27	0.581
1988	19.36	0.129	1.684	1.39	9.57	0.554
1989	15.34	0.230	1.733	1.57	9.06	0.568
1990	12.27	0.399	1.770	1.45	9.10	0.593

Table 2. Growth parameters of sprat

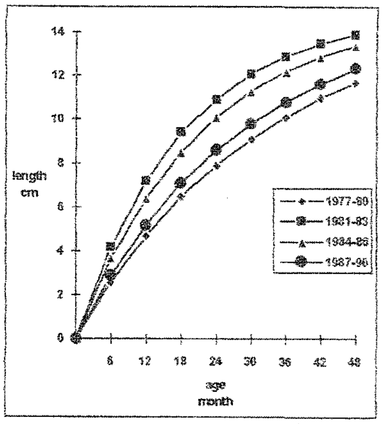

Fig. Growth curves for average cohorts 1977-80, 1981-83, 1984-86, 1987-90.

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STOCK ASSESSMENT OF SPRAT *SPRATTUS SPRATTUS* L. OFF BULGARIAN BLACK SEA COAST, USING LENGTH COHORT ANALYSIS

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First attempt is made to evaluate the dynamics of abundance and mortality of sprat stock by means of the Length Cohort Analysis (LCA) (JONES, 1981).

Length composition data for Bulgarian sprat catches was averaged generally by 3 years over the period 1945-92 and the resulting pseudo-cohorts were assumed to be under steady state conditions.

LCA was performed using ANALEN software package (CHEVAILLIER et LAUREC, 1990), where an iterative procedure for running the analysis was employed. It was also possible to estimate the fishing mortality rates per fishing gear for 1970-92, when separated statistics for coastal (trapnets, beach seines) and trawl fisheries were available. Sensitivity analysis was taken into account, for the optimal choice of parameters.

It was not possible to estimate directly the von Bertalanffy's parameters, because of lack of satisfactory data covering all the period studied. Even though such estimates were available for 1977-93 (DASKALOV, this vol.), we did not obtain reasonable results using these values. The procedure suggested by JONES (1990) gives closest results with previous studies (DASKALOV, 1993).

Table. **A** : Parameters used in anlysis. **B** : Basic results.
R= recruitment in 106 numbers, B = mean biomass in tons, F = average fishing mortality rate

	A			B		
years	k(Loo=16)	M	F+	R	B	F
45-49	0.156	1.2	0.014	4449.8	7575.1	0.108
56-59	0.155	1.2	0.026	9877.7	17634.0	0.089
60-62	0.164	1.2	0.013	55244.1	133686.2	0.007
63-65	0.188	1.2	0.011	12224.2	26035.4	0.029
66-68	0.239	1.2	0.006	12998.0	32174.3	0.014
69-71	0.239	1.2	0.014	9354.6	21751.7	0.046
72-74	0.265	1.2	0.024	311150.0	79686.2	0.024
75-77	0.241	0.95	0.041	29197.2	113437.9	0.028
78-80	0.185	0.95	0.088	46438.5	176661.6	0.039
81-83	0.314	0.95	0.06	16373.7	58990.0	0.146
84-86	0.267	0.95	0.04	13682.3	39556.5	0.237
87-89	0.237	0.95	0.028	13553.4	37006.7	0.135
90-92	0.217	0.95	0.009	7766.65	23495.6	0.070

The average value Loo = 16cm (1977-92) was assumed for all the period and then k was found :

$$k = \ln((Loo-l1)/(Loo-l2))$$

where l1 and l2 were respective lengths-at-age 1 and 2 years (Table, A). Terminal length group (+) was chosen to be 12 or 11.5 cm (> 75%Loo). Natural mortality rate was assumed - 0.95 for 1975-92 and 1.2 for 1945-74 – the last one for the purpose of reflecting the higher predation in that period (STOYANOV, 1966, IVANOV and BEVERTON, 1985). Terminal fishing mortality rates were obtained according to DASKALOV's VPA estimates (1993). A functional regression built between catches (C) and fishing mortality rates (F) with coastal gears for 1975-92 was used to determine F+ values before 1975.

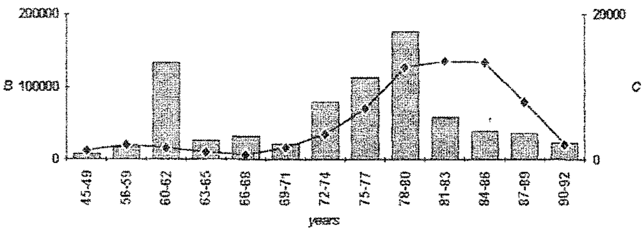

Fig. Sprat mean biomass (B : columns) and catches (C : line) in tons : 1945-92

The evolution of the sprat stock state could be devised into three main stages (Table, B. Fig.). In the years up to mid 70's, stock biomass remains relatively low in relation with a strong predatory press. As an exception, we observe the period 1960-62 where higher abundance is probably resulting from the combination of stable recruitment and favourable environment at the end of 50's. The second stage is characterised by a very strong increase of stock biomass and fishing from mid 70's to mid 80's. Such an "explosion" could be related with the extinction of top predators in late 60's and early 70's, and the rise of the sea trophic level due to progressive eutrophication. The combined action of two factors explains the decrease in sprat biomass after the late 70's. In the beginning, the high nutrient abundance resulted in amelioration of the trophic base, but soon the outstanding eutrophication created different negative effects, like hypoxia and increasing domination of gelatinous megaloplancton, which is feeding on fish eggs and larvae and competes planctivorous fish on food. The second factor is obviously the fishing effort remaining too high at the same time when the standing stock is decreasing.

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