STOCK AGGLOMERATIONS ASSESSMENT OF SPRAT AND MEASURES FOR SUSTAINABLE UTILIZATION IN FRONT OF THE BULGARIAN BLACK SEA COAST

Violin St.Raykov*

[a]*Institute of Fishing Resources,4 Primorski Blvd.,P.O.Box 72;E-mail:vio_raykov@yahoo.com*

ABSTRACT

Together with the Anchovy, sprat is one of the most abundant, planktivorous, pelagic species. The level of its stocks depends on the conditions of the environment and on the fishing effort.

Trawl survey in front the Bulgarian Black Sea coast was carried out using pelagic otter trawl in 32 areas. Minimum catch was registered in area G14 from 75-100m strata, as the CPUE was 1kg/h, CPUA = 13.499 кg km2. Maximum catch (in weight) was in area N2 (strata: 50-75м - 1000 kg), as CPUE was 1333.33 кg/h and CPUA: 16 056.5 kg km2. The average rate from all areas was 220.22kg .The average level of CPUE from all areas was 336.54kg/h and average CPUA = 4262.05 kg km2.

Total biomass estimated by “swept area method” in the corresponding area in front the Bulgarian coast is 29 189.864 tones.

The resulted levels for Total Allowable Catch (TAC) according to the applied methodology show that F0.1≠ Fopt i.e., at the present levels of the exploited biomass these criterion results very high values.

Till clarification of the stock-recruitment relationship, it is recommended to be used levels two times less than accepted for assessment natural mortality coefficient M = 0.95.Even in this case the resulted value for Fopt = 0.475 gives very high TAC =16 272.772 tones. More restrictive strategy F0.5 = 0.256139 gives TAC = 8774.93 tones. Annual yield should not exceed 8500-9000 tones.

Stock assessment of sprat is in straight correlation with it rational exploitation, species and biodiversity conservation.

Keywords: Sprat biomass, CPUE, CPUA, rational exploitation, Black Sea

INTRODUCTION

The Black Sea Sprat (*Sprattus sprattus phalericus*) is a key species for the Black sea ecosystem. Together with the Anchovy, sprat is one of the most abundant, planktivorous, pelagic species. The level of its stocks depends on the conditions of the environment mainly and on the fishing effort.

The changes in the environment due to anthropogenic influence, affect the dry land as well as the world ocean. The level of the sea pollution and its “self-purifying” ability are completely different. There is a clear indication of changes in the nature equilibrium in the corresponding ecological niches.

The greatest impact has the commercial fishery, which directly devastating a significant part of the given species populations. As a result of this some of the species stocks are declined or depleted.

This process intensify in the last 10-20 years particularly as a result of the excessive exploitation of numerous of the commercial species are critically endangered or vulnerable.
The abundance of the given fish species generations is dependant on different abiotic and biotic factors. With great importance are: the level of fishing mortality, changes in trophic levels due to mass occurrence of the ctenophore *Mnemiopsis leidyi* ,algal blooms which lead to hypoxia in the shallower waters with mass mortality of the bottom dwelling organisms and etc.

The reasons for the decline of the sprat stocks in the western part of the Black Sea after 1987-1988 have complex character. Intensification of the fishery in the last 20 years has impacted the sprat stocks with great importance for Bulgarian Black sea fishery. The influence of the commercial fishery is a factor with great importance, because of directly devastating significant part of the given species populations. The fast intensification of the fishery and the Black Sea pollution lead to ecological equilibrium disturbance. As a result of this, together with irrational fishery some significant changes in the fish part of the ecosystem occurred.
Overexploitation of the fish species stress the necessity of elaboration the specific measures for sustainable utilization. A number of international organizations has been created with the aim regulation and scientific advising as regards sustainable exploitation of the marine living resources in the World Ocean.
In the Black Sea “Convention for fishery in the Black Sea” between six countries with the purpose fishery regulation in the region has been elaborated.

In relation of the above listed facts, it could be concluded that for the intensively exploited fish stocks recovery, some urgent measures for environmental conditions improvement and sustainable reproduction must be implemented.

Table1.Investigations on sprat by Bulgarian researchers over different periods

AUTHOR	METHODS	OBJECTIVES
Prodanov and Daskalov (1992)	VPA (Pope, 1972)	1976 – 1979 years Sprat biomass variation is from 167. 5 to 204. 6 average 179.8 thousand tons 1980 – 1982 years Sprat biomass decreased from 140. 6 (1980) to 64. 3 (1982) thousand tons
		after 1982 year Sprat biomass varies slightly from 56. 8 (1987) to 73.7 (1984) thousand tons
Daskalov and Prodanov (1995)	Product. models Fox (1970) Bulgarian coast	1976 – 1985 years Ymsy = 17. 71 thousand tons Fmsy = 0. 437 thousand tons 1986 –1990 years Ymsy = 11.95 thousand tons Fmsy = 0.770 thousand tons
Prodanov and Stoyanova (2000)	VPA (Pope, 1972)	1967 – 1992 years average Sprat biomass is 734. 73 thousand tons
	Swept area	1967 –1992 years average Sprat biomass is 668.925 thousand tons
Prodanov et al (1997)	Separable VPA(VPSep)	1951 –1993 years avarage Sprat biomass is 282.67

		thousand tons
	VPA with ad hoc tuning (VP tune)	1951 –1993 years average Sprat biomass is 242.89 thousand tons
	XSA	1951 –1993 years average Sprat biomass is 199.84 thousand tons
Daskalov et al. (1996)	SVPA, VPA and XSA SVPA, VPA and XSA	1970-88 375 500 (SVPA) 356 600 (VPA) 1989-93 132 400 (SVPA), 154 400 (VPA); 185 100 (XSA)
In press.	Hydroacustic survey Bulgarian coast	1984-1991 16 000(1987) to 77 000 (1986) tons.
Ivanov(1983)	Age-structured VPA	1976 и 1977 being 573 600 and 595 900 ton F opt = 1.01
Prodanov (1989)	Modification Ricker's equation	Fopt = 0.68
Prodanov (2003)	Age structured VPA	33 235 (1997) and 55 947 (2000) Mean for 1994-2002 was 43 284.1 tons.
Panayotova and Mikhailov (2006)	LCA and Age based VPA	1998, 1999 and 2000 21 892.2, 28 733.4 и 10 948.1 tons; TAC: 10 968 (1997), 18 463 (2000) tons.
Raykov et al., 2007	LCA and Age structured VPA	1996-2004 41.9-89.7*103 After 2000 41.9-55.9*103 After 2001 Recruitment: 33-35*109 2004 : 37 427 т - biomass

Raykov, 2007	ASPIC 5 Production modeling	MSY: 11.380 t. TRPs: Fmsy/Fnow = 1.579 Bmsy/Bnow = 0.685 B □= 0.928 and F □= 1.166 (ASPIC)

MATERIAL AND METHODS:

The present investigations have been carried out with research vessel"Prof.Aleksander Valkanov". The trawl has the following characteristics (Fig.1):

- vertical opening - 4 m;
- mesh size of the cod end: 65mm;
- "effective" part of the trawl mouth – 16m;

Research vessel was equipped with "Waveon" type GPS with GSM modem GPRS (Vessel monitoring system).The trawling (Fig. 2) were carried out in the northern and southern part of the Bulgarian Black Sea coast, during the day with average vessel velocity 4.82 km/h. Information, send by the equipment on board consist the following parameters: Date, hour of signal, velocity, present coordinates. The positions were generated by the equipment in 1 minute interval. In further removed stations from the coast (above 15 miles) some parts remained unrecorded. Nevertheless, the information collected is good enough (reliable) and could serve for analysis of the data from the trawl survey and stock assessment of sprat in front the Bulgarian Black Sea coast.

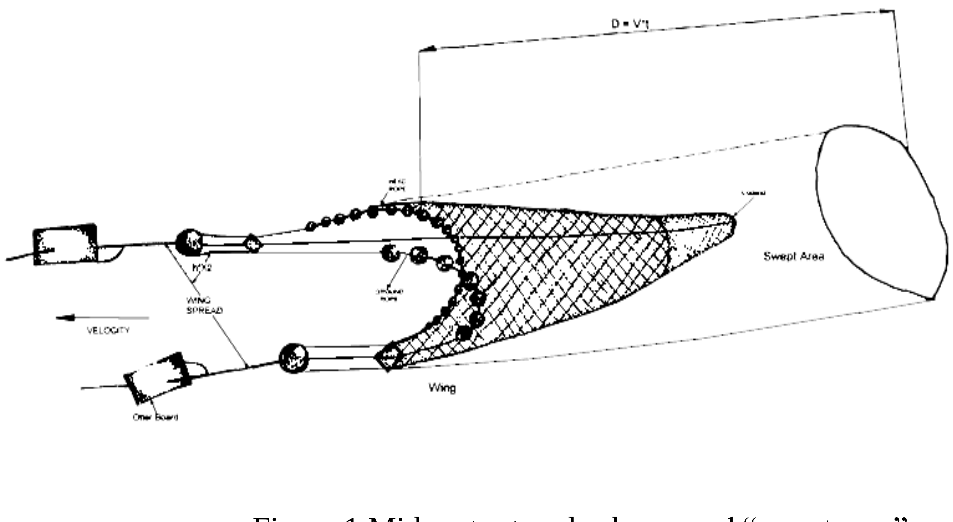


Figure 1.Mid-water trawl scheme and "swept area".

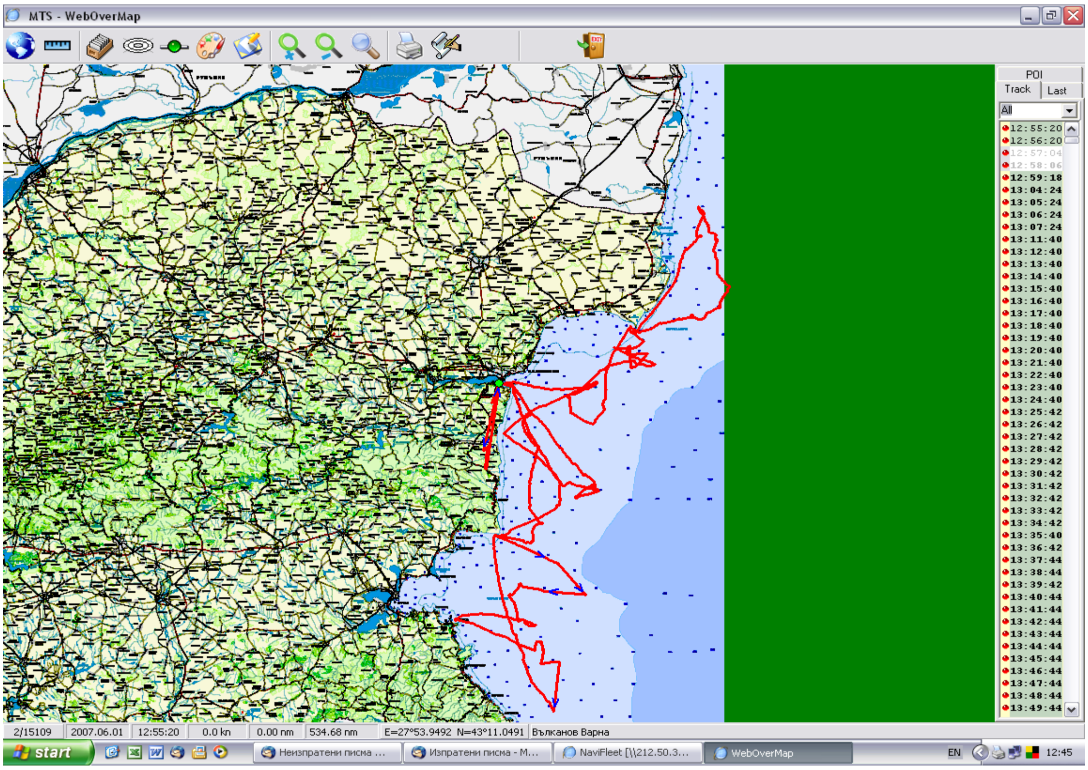


Figure 2. “Trace” from the trawling with R/V “Prof.Al.Valkanov” in the Bulgarian Black Sea coast.

For the purposes of analysis, the standardization of the sampling gears is necessary and in northern and southern part the research was done with one and the same equipment and gears.

Stratification sampling methodology (Sparre et al, 1989; Gulland, 1966, Foote, 1996) in the corresponding marine area was applied (Fig.3). Taking into account exact depths (isobaths), the whole area was divided to sub areas, i.e. “stratums”, depending on the depth: first stratum – 35- 50 m., second 50-75m, and third 75-100m. The examined area was divided to equal sized fields - with total number 113; each sector was assessed as 63 км2 (5' Lat. × 5' Long.). The trawling activities were carried out in meridian direction. The duration of each trawling was between 30 and 60 min, average velocity 2.3 and 2.9 knots (3.889 to 5.37 km/h).

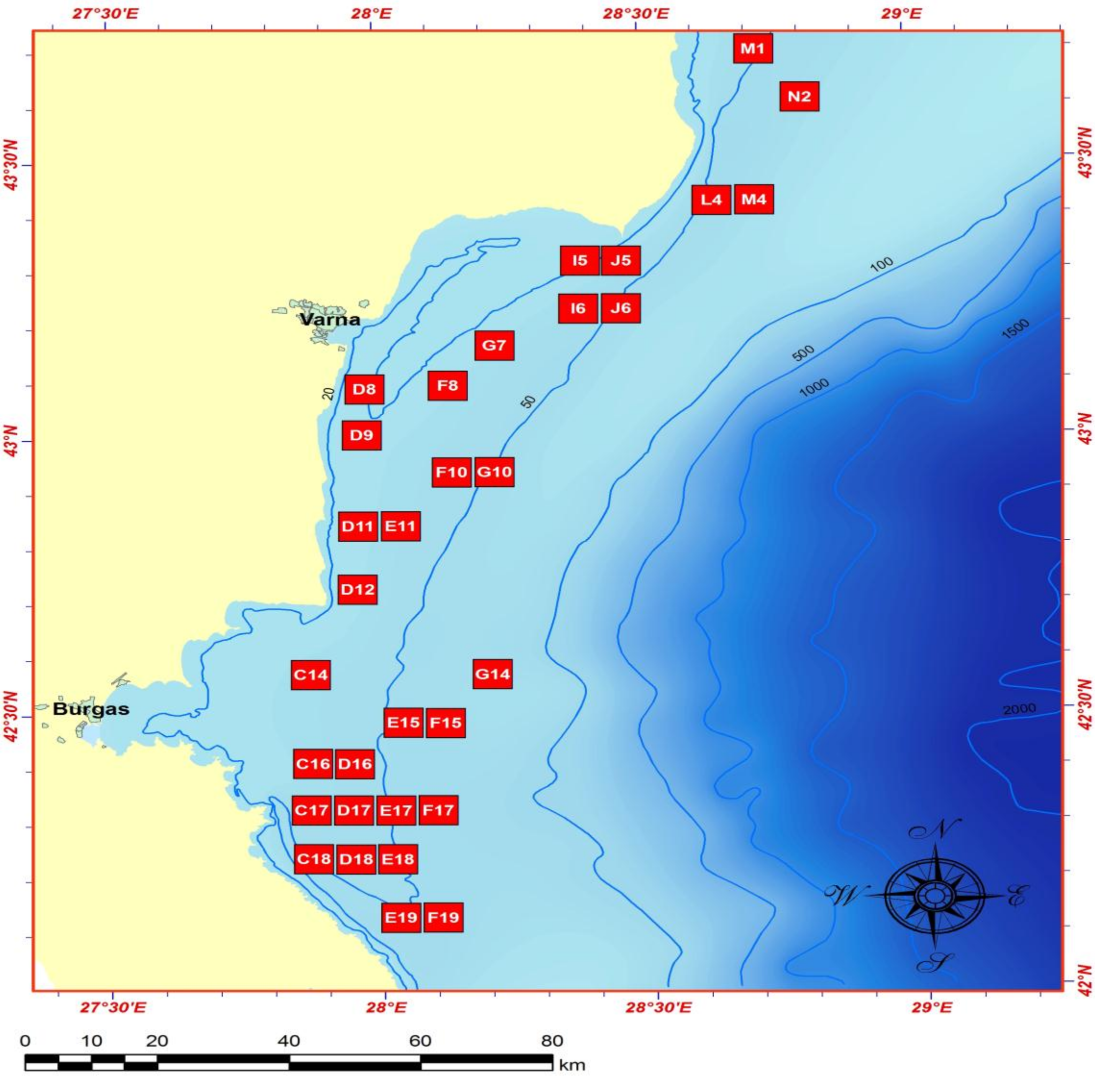


Figure 3.Sampling points off the Bulgarian coast.

Method Pros:

1. Sampling procedure is under control;
2. The reliability of the data obtained; the data are independent from commercial fishery data;

Cons:

Representative character of the sampling (Foote, 1996); the trawl is selective and does not fully present exploited stock; sampling is possible on the soft bottom only (Lleonart, 2002).

Maximum sustainable yield (MSY):

The Gulland’s formulation for unexploited stocks (Gulland, 1970):

(1) *MSY = 0.5*M*Bv*

Where: M – natural mortality coefficient; Bv – unexploited biomass;

Optimum level of the fishing mortality (Fopt):

$$YPR = \int_{tc}^{\infty} F * e^{-(F+M)t} W(t)dt$$
(2)

Where:

(3) $W_t = \alpha L_\infty^{\beta}(1 - e^{-k(t-t0)})^{\beta}$

t_0, k - Von Bertalanffy equation parameters

α, β - Length-weight equation parameters

(4) *Y/R = Y′W∞.exp M (tr – t0) =* $Y' \frac{W_\infty}{(1-\frac{L_t}{L_\infty})^{\frac{M}{K}}}$

$F_{0.1.}$ where, the slope of the curve is 10% from the slope in F = 0

(5) $F_{0.1} < F_{0.x} < F_{max} YPR$ and $F_{0.3} < F_{0.2} < F_{0.3}$

Calculation of TAC is:

(6) TAC= Y (%) when $F_{0.1}$/ B Prodanov and Kolarov (1983)

Production models of Schaefer (1954) and Fox (1970)

(7) *Y/f = Y (i) /f(i), I = 1, 2…..n f(i) ≤ -a/b.* Schaefer (1954)

(8) *ln [Y(i)/f (i)] = c+ d*f(i)* Fox (1970)

Von Bertalanffy (1938) equations have been wide used for determination of the length and weight growth (Spare et al., 1989; Hilborn&Waters, 1992):

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

(10) $W_t = W_\infty \{1 - \exp[-k(t - t_0)]\}^n$

Where: Lt, Wt is the length and weight of the fish at age t years; L∞, W∞ - asymptotic length, weight respectively, k – growth rate parameter, to – pre-natal parameter.

The dependence between length and weight by age is calculated as follows:

(11) $W_t = qL_t^n$

Where: q – parameter: “condition factor”; n – parameter.

Condition factor (c.f.) of Fulton (Ricker, 1975):

Depth	Area	t	V	D	a [km2]	W (kg)	CPUE kg/h	CPUAkg/km^2	Biomass

(12) $K = \frac{W}{L^3} * 100000$

Where: W – weight in kg; L – length in cm.

Natural mortality coefficient:

Pauly’s method (1980):

(13) $\log M = -0.2107 - 0.0824 * \log L_\infty + 0.6757 * \log k + 0.4687 * \log T^\circ C$

Where: L∞, W∞ and к – parameters in von Bertalanffy equation; T◦C – mean annual temperature of the habitat (feeding and spawning area).

RESULTS:

The total catch during the survey was 7047 kg sprats for analysis of the population parameters 7825 individuals were processed. Minimum catch was registered in area G14 from 75-100m strata, as the CPUE was 1kg/h, CPUA = 13.499 кg km2. At the same area the lowest level of the biomass was registered: 844.76 kg. Maximum catch (in weight) was in area N2 (strata: 50-75м - 1000 kg), as CPUE was 1333.33 кg/h and CPUA: 16 056.5 kg km2. Similar rates of w(kg) was established in area E19, 30-50m strata (880 кg; CPUE: 1313.4 кg/h и CPUA: 16 417.9 кg км2) and D17 strata 50-75m (660 кg CPUE: 985.07 и кg/h CPUA: 12 313.4 кg км2).The average arte from all areas was 220.22kg (Tabl.).The average levels of CPUE from all areas was 336.54kg/h (abundance) and average CPUA = 4262.05 kg km2.The average levels of the biomass was 2669.19 tons. The average rates of CPUA in strata 30-50m is3547.903 кg км2, in 50-75: 6243.6 кg км2 and 2253.8 кg км2 for strata 75-100m (Fig.4-6, Tabl.2).

From the results of the summer distribution of sprat could be concluded that the highest abundance was detected between 45 and 60m depths (50-75m and 30-50 m strata) (Tabl.2 and 3).

Table.2.Results from” Swept area method”” in the corresponding area.

30-50	I5	0.5	3.889	1.95	0.0312	176	352	5641.025641	353015.4
30-50	G7	0.67	4.63	3.1021	0.0496	132	197.01493	2659.488733	166430.8
30-50	F8	0.67	5	3.35	0.0664	44	65.671642	662.6506024	41468.67
30-50	M1	1.167	4.82	5.6249	0.09	264	226.22108	2933.385482	183571.3
30-50	L4	0.5	4.63	2.315	0.037	22	44	593.9524838	37169.55
30-50	J5	0.5	5.19	2.595	0.0415	77	154	1854.527938	116056.4
30-50	J6	1	4.82	4.82	0.0771	110	110	1426.348548	89260.89
30-50	C14	0.67	4.63	3.1021	0.0496	44	65.671642	886.4962445	55476.93
30-50	D18	0.67	5	3.35	0.0536	176	262.68657	3283.58209	205486.6
30-50	C17	0.75	5	3.75	0.06	110	146.66667	1833.333333	114730
30-50	C18	0.75	4.82	3.615	0.0578	154	205.33333	2662.517289	166620.3
30-50	E19	0.67	5	3.35	0.0536	880	1313.4328	16417.91045	1027433
30-50	D12	0.5833	4.82	2.8115	0.045	264	452.59729	5868.74081	367265.8
30-50	D11	0.5	5	2.5	0.04	88	176	2200	137676
30-50	D9	0.5	5	2.5	0.04	240	480	6000	375480
30-50	D8	0.67	5	3.35	0.04	110	164.1791	1842.5	115303.7
50-75	I6	0.5	5	2.5	0.04	110	220	2750	172095
50-75	F10	0.5	5.19	2.595	0.0415	286	572	6888.246628	431066.5
50-75	E11	0.75	4.26	3.195	0.0578	264	352	4564.315353	285634.9
50-75	E15	0.75	5.37	4.0275	0.0644	15	20	232.7746741	14567.04
50-75	D16	0.67	5	3.35	0.0536	264	394.02985	4925.373	308229.8
50-75	D17	0.67	5	3.35	0.0536	660	985.07463	12313.43284	770574.6
50-75	E17	0.67	5	3.35	0.0536	330	492.53731	6156.716418	385287.3
50-75	E18	0.67	4.82	3.2294	0.0517	308	459.70149	5960.859602	373030.6
50-75	F19	0.75	4.82	3.615	0.0578	110	146.66667	1901.798064	119014.5
50-75	N2	0.75	5.19	3.8925	0.0623	1000	1333.3333	16056.51895	1004817
50-75	C16	0.5	5	2.5	0.04	264	528	6600	413028
75-100	M4	0.5	4.26	2.13	0.0341	44	88	1291.079812	80795.77
75-100	G10	0.5	4.63	2.315	0.037	176	352	4751.61987	297356.4
75-100	G14	1	4.63	4.63	0.0741	1	1	13.49892009	844.7624
75-100	F15	0.833	4.82	4.0151	0.0642	170	204.08163	2646.28673	165604.6
75-100	F17	0.75	5	3.75	0.06	154	205.33333	2566.666667	160622

Table 3.Average values of the catch per unit area, biomass per strata, extrapolated on the total area in front the Bulgarian coast.

CPUA average	Strata (m)	Biomass	Area km^2	Number of areas
3547.903	**30-50**	6438805	1814.82	29
6213.6	**50-75**	17109272	2753.52	44
2253.83	**75-100**	5641787	2503.20	40
		29189.864	**7071.54**	

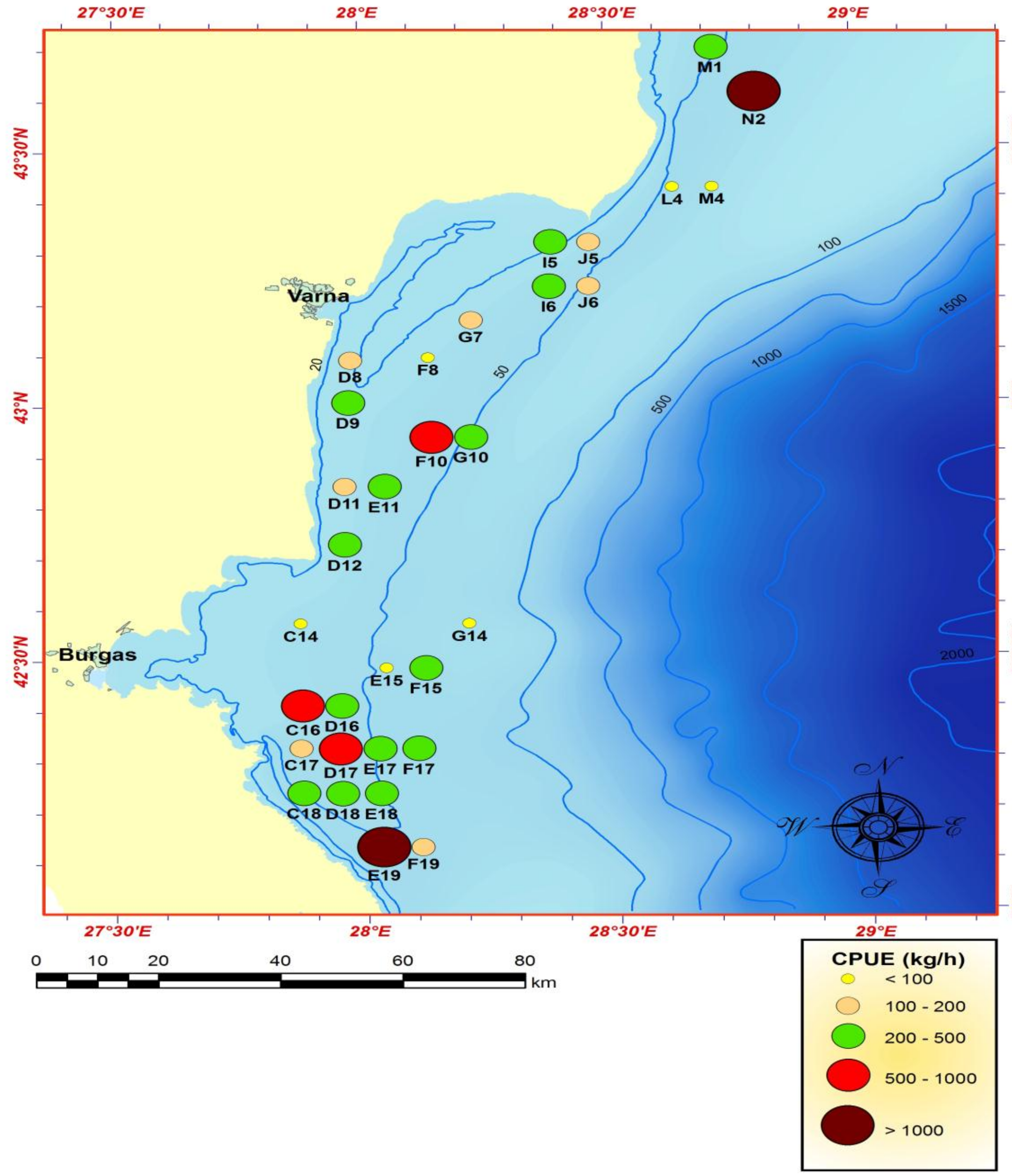


Figure 4 Catch per Unit Effort in the corresponding area

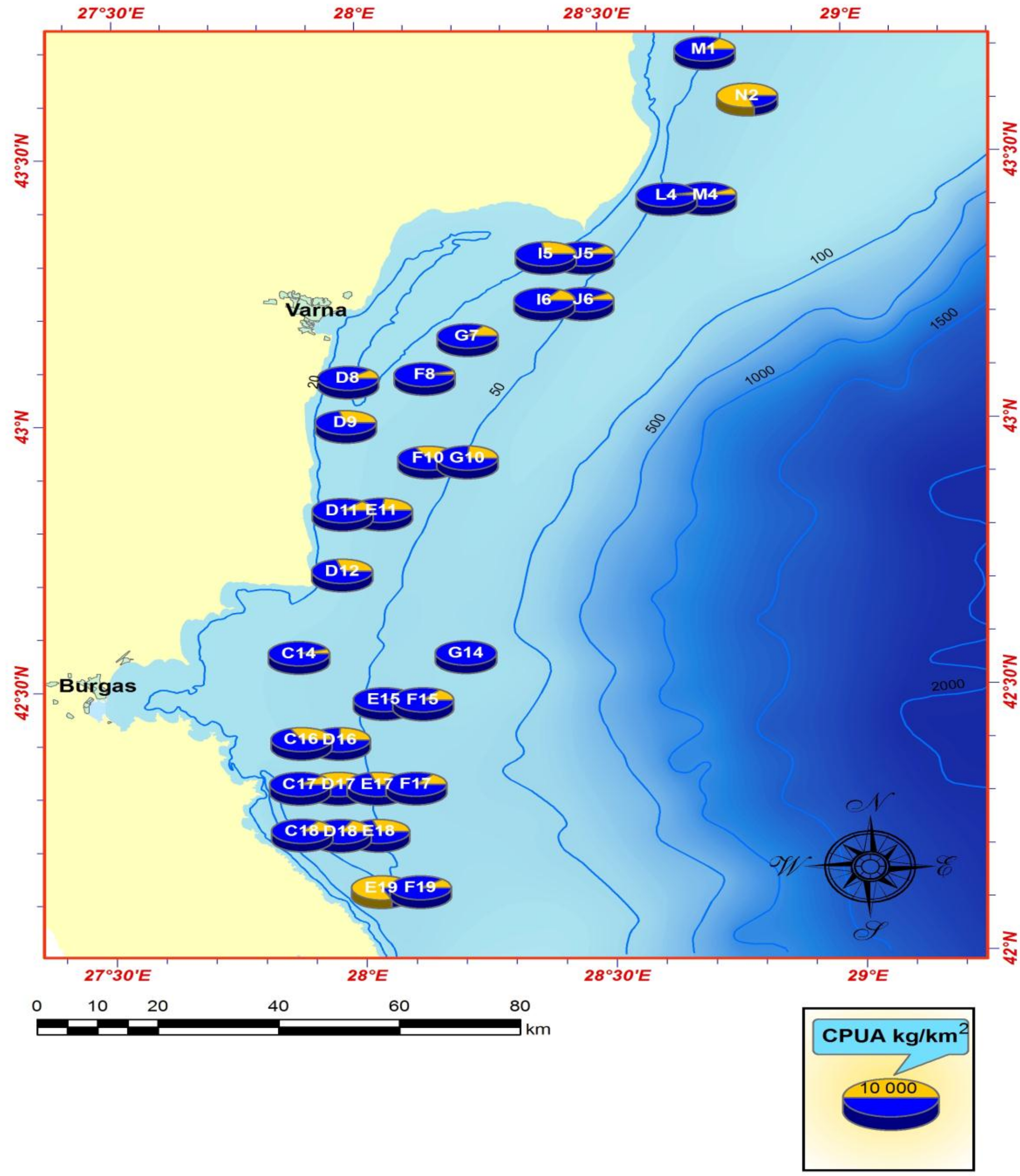


Figure 5 Catch per Unit Area in the corresponding area.

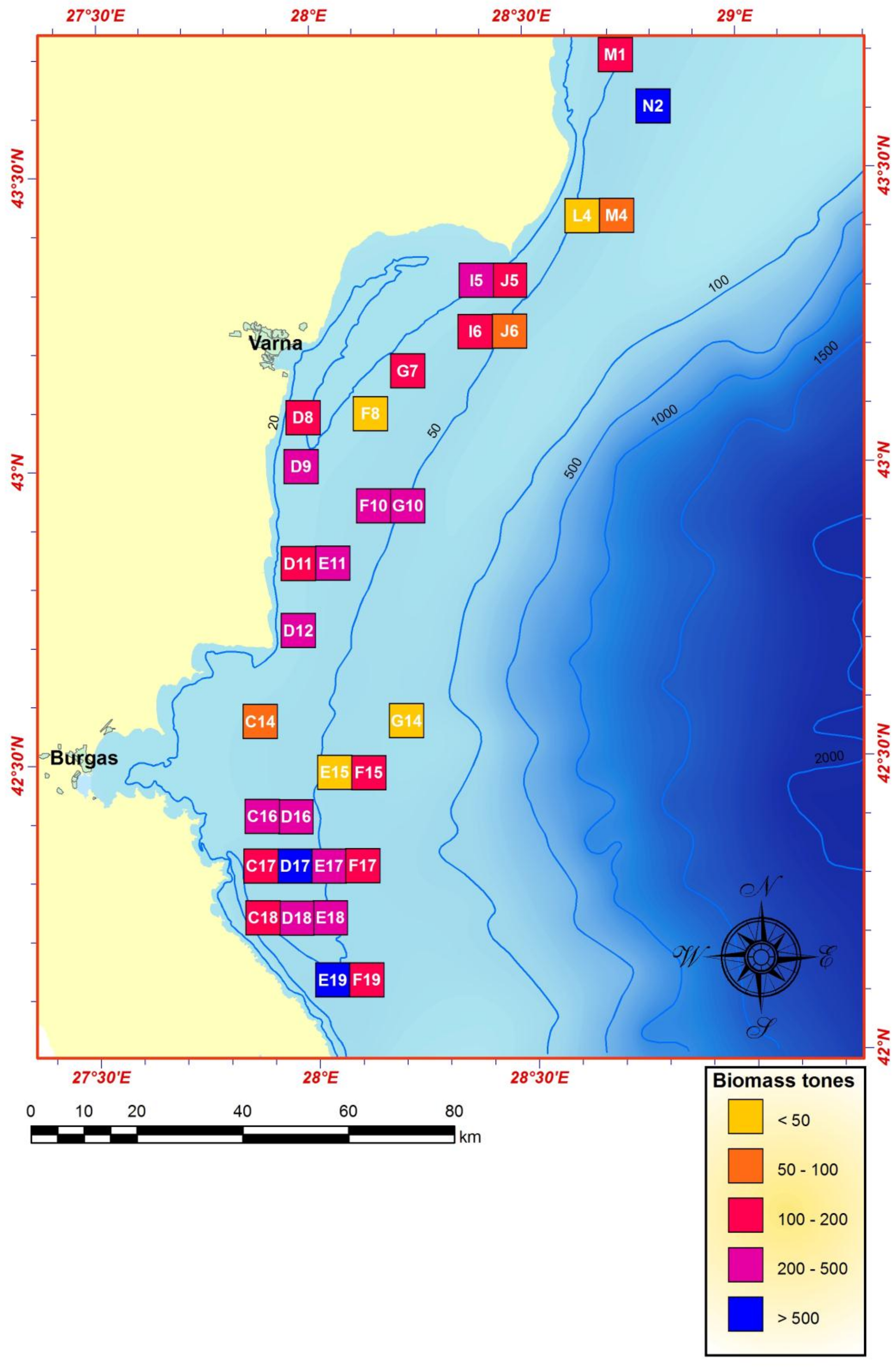


Figure 6. Momentary state of the biomass in the corresponding area

The bulk of the catch per unit area is under 400 kg/`h. The exception was registered just in 3 areas with close higher values of CPUE and CPUA.

Table 4 Confidence intervals and variability of parameters of the stock according Fox (1970).

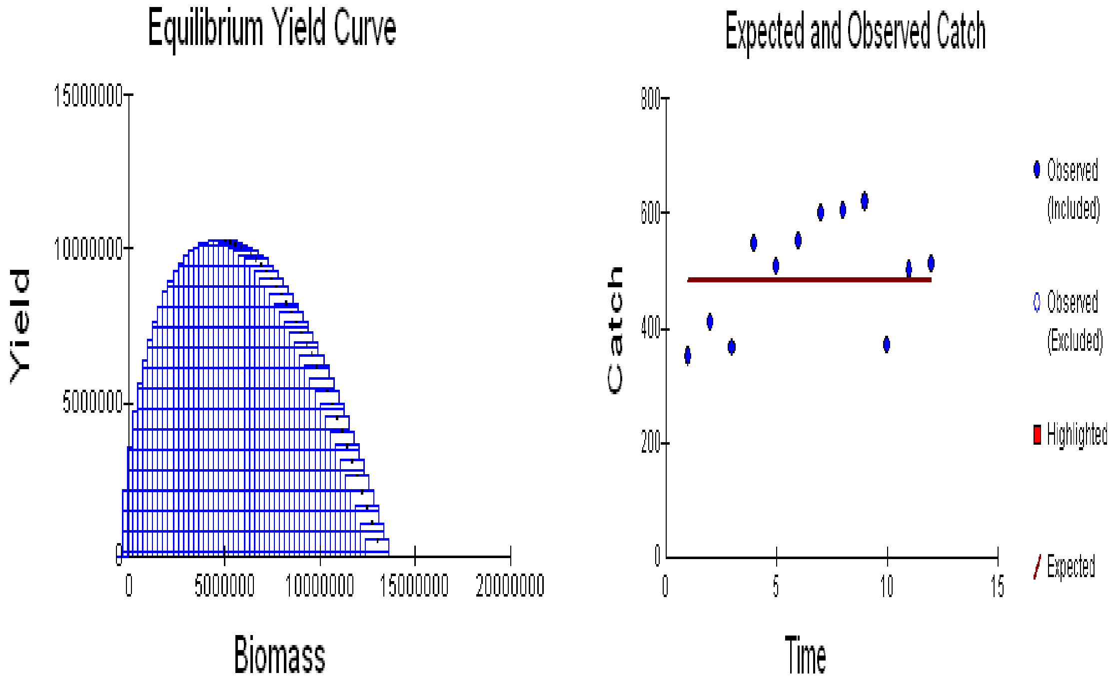
CI 0.025		CI 0.0975
K	56508.14	2.8511+07
q	1.6996E-03	9.13405-03
R.Yield	-1.165914+07	1.077503E+07
r	8.119608E-02	1.694918+07
MSY	2006.7	16 949.18

MSY (average) = 10.262 tones

MSY (Gulland, 1970) is:

MSY = 0.5*0.95*29.189 864 = 13.865 185 tones.

The individuals caught in the cod end of the trawl with minimum allowable length defined by FAA are 1.79% from the total number. This is because the selectivity of the trawl which “spare” immature and undersized specimens.



A. B.

Figure 7. A. Equilibrium Yield curve (Fox, 1970) *log-transformed; B. Expected and observed catch fro 1995-2006.

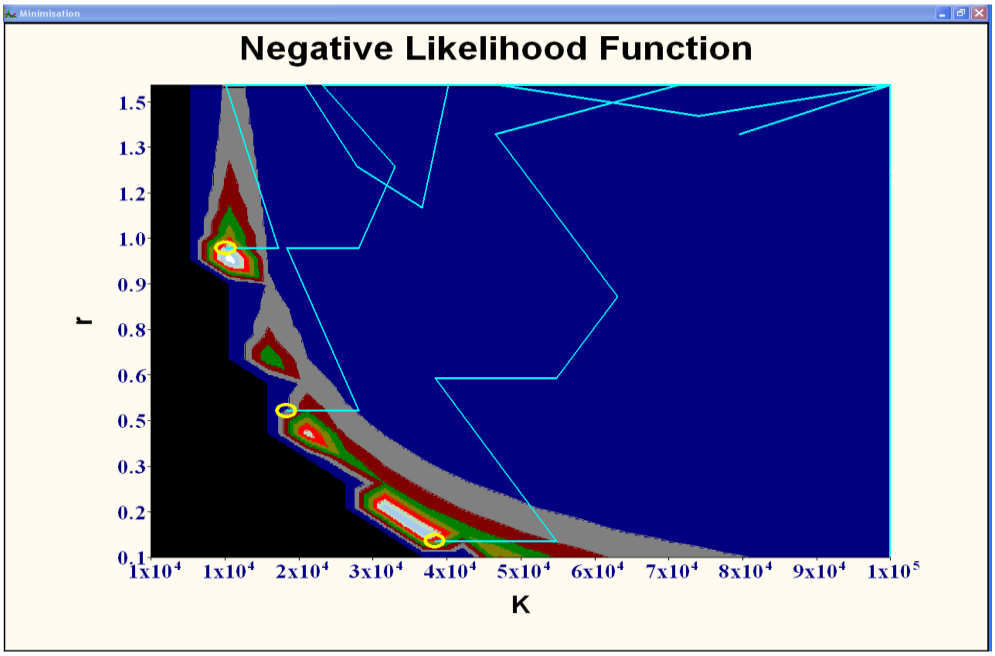


Figure 8 Graphic representation of intrinsic growth of the population(r) vs. carrying capacity (k);* Fox, 1970 model *log-transformed.

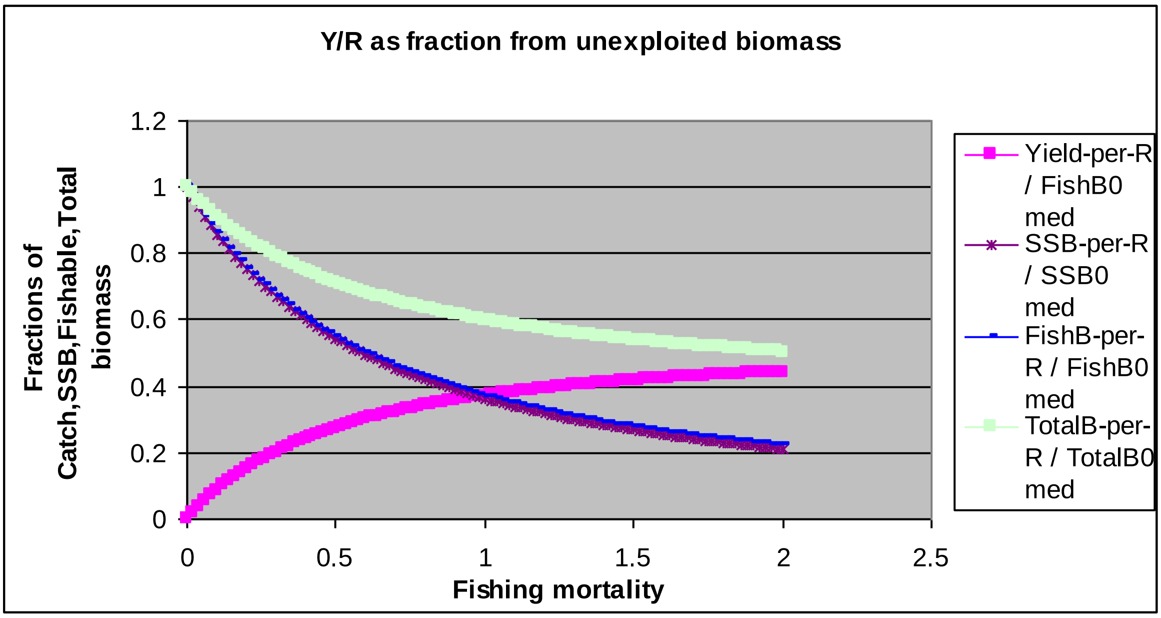


Figure 9 Graphic determination of the coefficient of the $F_{0.1}$

According to the applied methodology, the reference point of the fishing mortality $F_{0.1}$ is equal to 1.14 (Fig.9). In this case, this value is very high and is not applicable to the calculated biomass in TAC determination. In the previous investigations Ivanov (1983) found relative, high levels of $F_{0.1}$= 1.01 and 1.02.

Table 5 Reference points of different strategies for estimation the optimal level of F.

F0.1	***F0.2***	***F0.5***
1.139371	**0.685821**	**0.256139**

The resulted value of $F_{0.1}$ strategy applied to the sprat stock is very high and gives high reference point. $F_{0.2}$ is more restrictive strategy and gives lower values in comparison $F_{0.1}$ The lowest levels are those calculated by $F_{0.5} = 0.2561$. $F_{0.1}$ and $F_{0.2}$ don't give appropriate, optimal levels of exploitation, according to the established stock using "swept area method" (Table.5).

$F_{0.1}$ strategy for optimum levels of exploitation estimation is not appropriate one, concerning sprat stock. If it is used, must following the advice of (Prodanov et al., 1997) to use those values which represents the half of the accepted for the analysis level of natural mortality coefficient (M). In the case with the Black Sea sprat we propose to be used more restrictive management strategies for referent levels F_{opt}, namely: $F_{0.5}$ = 0. 8774.93 tones Total Allowable Catch. The yearly catch must not exceed 8 500 to 9 000 tones.

Total number of investigated individuals from all 32 researched areas is 7825.All parameters were examined with exception the sex differentiation, because this time of the year is not active spawning period and sex differentiation is quite difficult in most of the cases.

In catches were registered individuals from 6.5cm length class (14, all belongs to the 0+ year class) up to 11.5 cm (4+ old) – one individual. Length classes 7.0, 7.5 and 8.0 cm presented in the samples with the highest percent (5817 individuals, 74.34% all belongs to 1-1+ years old). 2-2+ years old belong to 8.5 to 10.0 cm classes. With the lowest number are represented 3-3+ and 4-4+ years old. 5 years old individuals have not been observed in the present investigation (Tabl.6).

As regards individual weight, the average values varied in terms of 1.64 to 8 gr. The lack of the oldest age groups (and low percent in the catches), combined with decreasing length-weight size is a mark of intensively exploitation (fishing press), which leads to "shorten" of the linear sizes and from the other hand more intense growth rate in response of the fishing press.

Table 6.Lenght and weight-at-age key for the sprat from present research.

L, cm	Age groups (number)					%	W (average)	n
	0+	1-1+	2-2+	3-3+	4-4+			
Size class								
6.5	140					1.79%	1.4	140
7		1955				24.98%	2.010	1955
7.5		2386				30.50%	2.440	2386
8		1476				18.86%	2.920	1476
8.5		438	458			11.45%	3.450	896
9		12	256			3.43%	4.050	268
9.5			301			3.85%	4.710	301
10			115	237		4.50%	5.430	352
10.5			10	29		0.50%	6.210	39
11				4	7	0.14%	7.050	11
11.5					1	0.01%	8.000	1
n	140	6267	1140	270	8			7825
%	1.79%	80.10%	14.57%	3.45%	0.10%	100%		
M_L	6.44	8.57	9.88	10.33	11.5			
M_W	1.4	3.55	4.5	5.67	7.05			

The relation between the length and weight of the sprat is described by the equation:

*W = 0.08*L2.7818*

The growth of the sprat is allometric (n ≠ 3), i.e. it is not equal in length and weight.

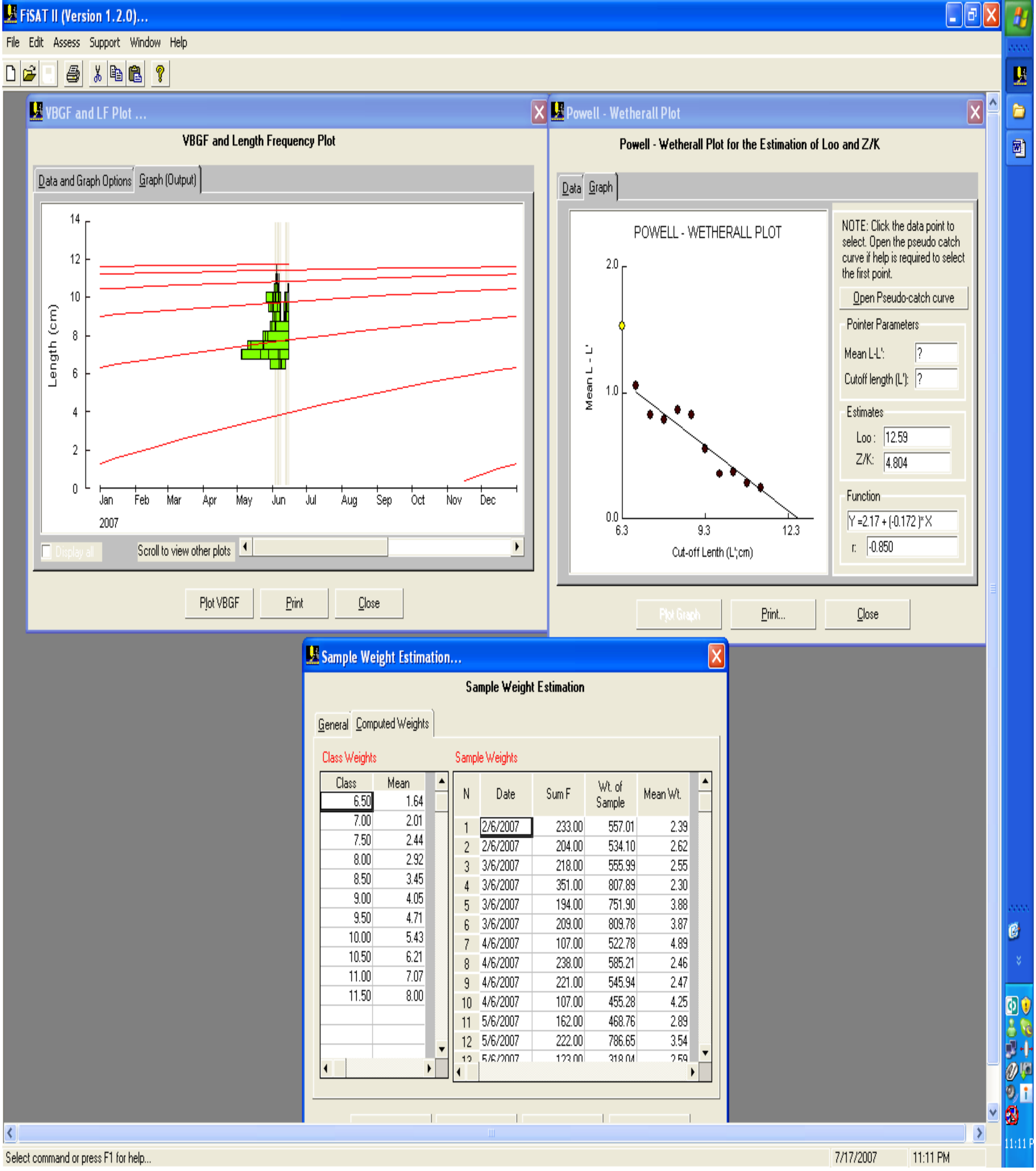


Figure 10. Asymptotic length definition, growth rate and age of the fish, at zero individual length (pre-natal coefficient t_0).Powell-Watherhall method for estimation $L\infty$ and Z/K by equation:

$Y = 2.17 + (-0.172)*x$

$r = -0.885$

$L\infty = 12.59$

$Z/K = 4.804$

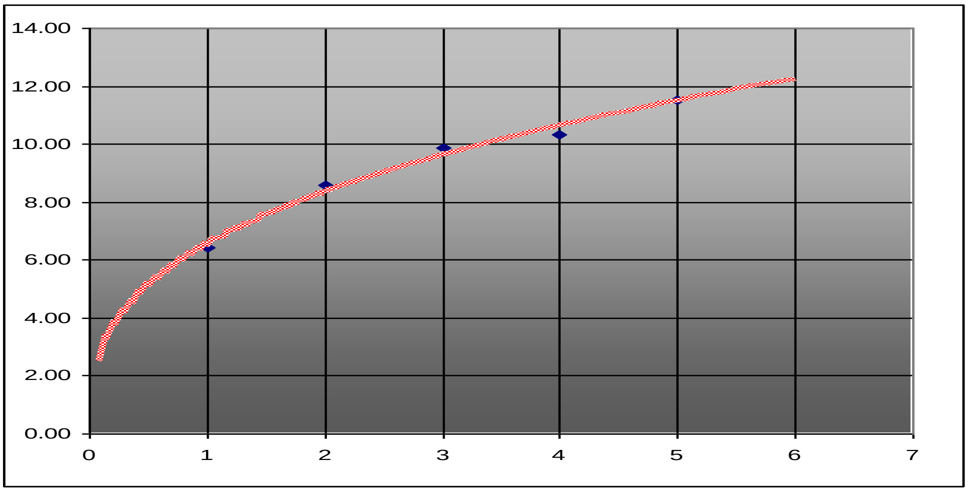


Figure 11. Graphic representation of the turbot length growth.

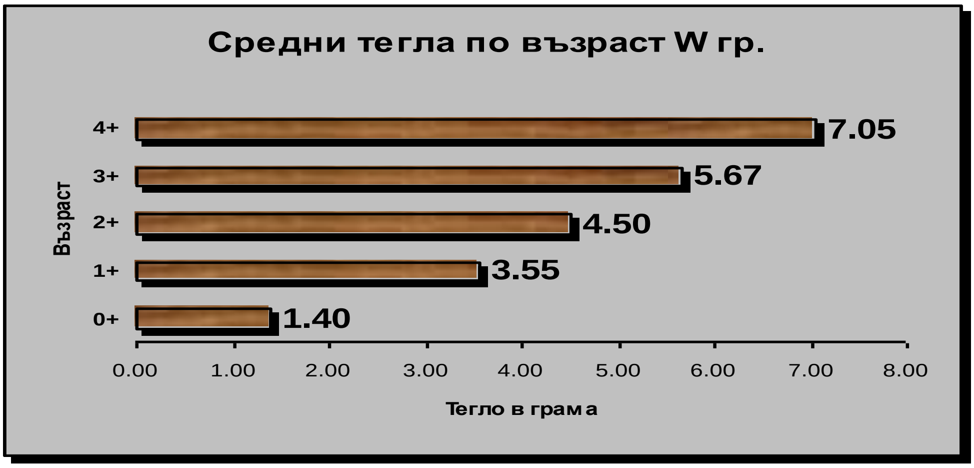


Figure 12. Graphic representation of the turbot weight growth.

Von Bertalanffy parameters of growth:

$L\infty = 12.557$	$W\infty = 11.129$
$r^2 = 0.912$	$r^2 = 0.92$
a = 2.235	a=2.479
b= -0.409	b= -0.207
k =0.409	k = 0.27
$t_0 = -1.95$	$t_0 = -9.178$

$r^2 = 0.965$

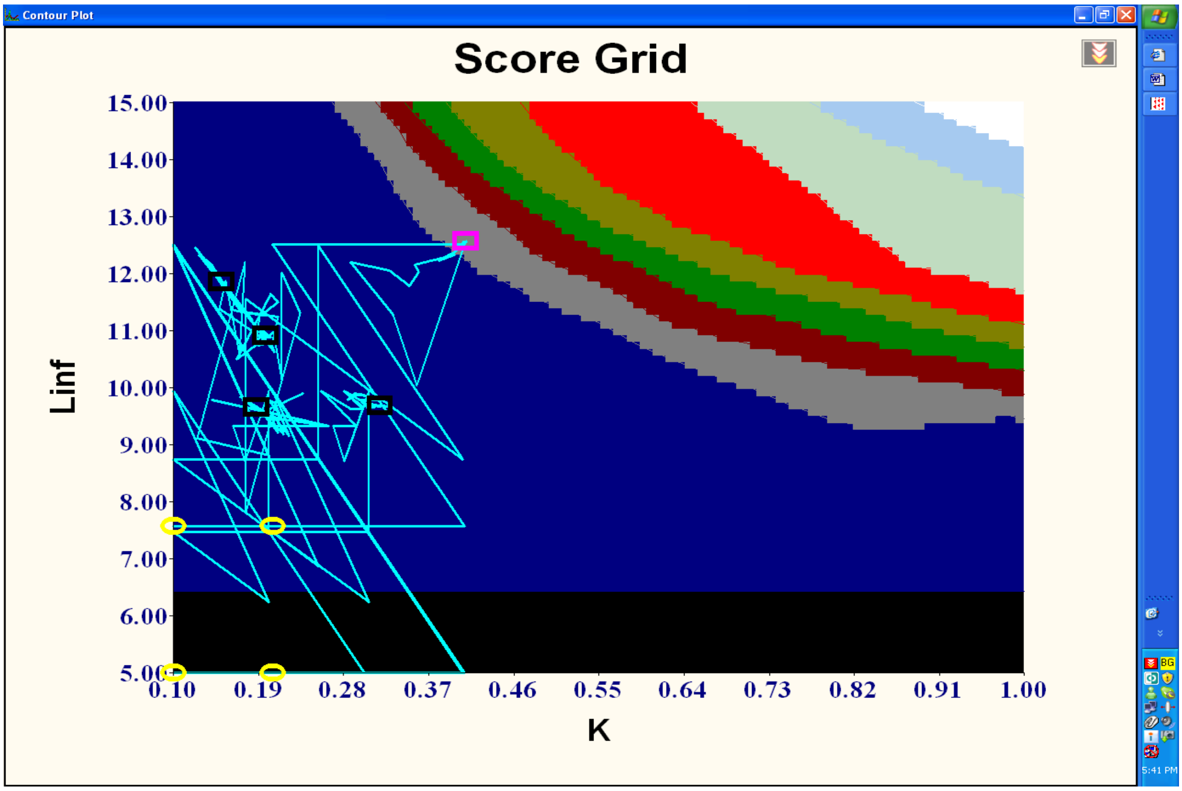


Figure 13. Graphic estimation of asymptotic length and growth rate

Growth rate of the length growth (κ=0.409) exceeds growth rate in weight (κ=0.207).

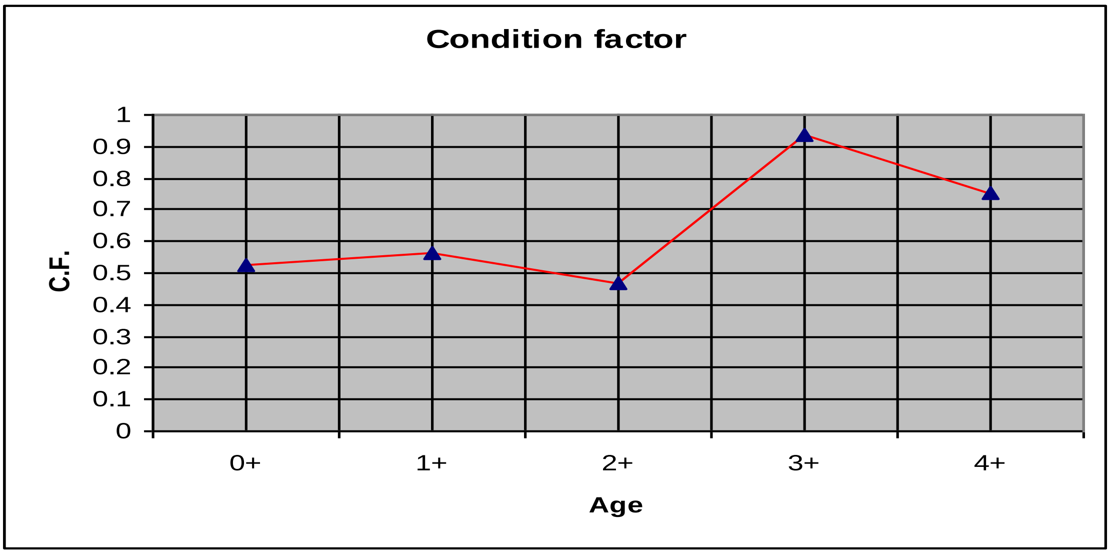


Figure 14. Condition factor of sprat (Ricker, 1975)

Age 0+ (0.524) and 1-1+ (0.564) condition factor show similar values, as for 2-2+ years old significant decrease was observed. 3-3+ old years condition improved and reach high values: average 0.937, which is possible related to the better food availability and with the fact, that the youngest age groups, during the summer period penetrates the termocline where temperature conditions are not appropriate for the cold-water zooplankton – the trophic base of sprat. With increasing the length sizes with age, in 4-4+ years old specimen significant decrease of individual weight was detected. The condition of 4-4+ years is poor and dropped to 0.756 (Fig.14).

It is very likely, that condition of 5 years old fish will continue to decrease, because it is assumed that activity of the oldest specimen is less and they became more vulnerable to the predators and fishing press. Natural mortality coefficient M was accepted to be constant M = 0.95 - independent from age.

CONCLUSIONS:

1. Sprat is a key species for the Black Sea ecosystem with clearly expressed indicative role as regards the changes of the trophic base (zooplankton) and condition of the predators: spiny dogfish, whiting, turbot, thornback ray etc., as well as the changes concerning climate (trough variation of climatic factor from one hand and hydro-chemical –physical parameters of the environment, from another;

2. The sprat catch represents over 80% from the total catch of Bulgaria in the Black Sea. This species is with high importance for Bulgarian fishery. The level of exploitation varies in the years, as the fishing effort and fishing mortality have been changed during different periods with regards the changes in ecosystem and economic reasons, mainly.

3. The research for momentary level of stock (stock assessment by “swept area” method) was carried out with pelagic-otter trawl in the corresponding area in 3 different strata. The momentary rate of the estimated biomass is 29 189.864 tons.

4. The resulted values for optimum fishing mortality using: $F_{0.1}$ strategy is very high. In our research F_{opt} =1.14; According to the more restrictive strategy such $F_{0.x}$ (0.5) It is advisable the annual catch of sprat should not exceed $F_{0.5}$ = 8774.93 tones.

5. Calculated MSY by different methods varies from 10.262 t to 13.866 tones; these levels are so called limit reference points and it is not advisable to be reached, taking into consideration the present levels of the stock biomass;

6. Predominant age class is 1-1+, as during June small percent (1.79%) from length class 6.5 cm are registered. The oldest age groups 3-3+ and 4-4+ are presented with small percent, 5 years old specimen are absent in the catch;

7. Relationship between length and weight is described by the following equation: W = *0.08*L2.7818*.Growth of sprat is allometric. Parameters of growth are:

$L\infty$= 12.557	$W\infty$ = 11.129
r^2 =0.912	r^2 =0.92
a = 2.235	a = 2.479

b= -0.409	b= -0.207
k = 0.409	k = 0.27
t_0 = -1.95	t_0 = -9.178
r2= 0.965	r^2 = 0.955

8. The condition factor (Fulton's index) varied from 0.524 (0+old.) to 0.937(3-3+old).

9. Natural mortality coefficient M was accepted to be constant M = 0.95 - independent from age.

The resulted levels for Total allowable catch (TAC) according to the applied methodology show that F0.1≠ Fopt i.e., at the present levels of the exploited (momentary) biomass these criterion results very high values.
For F_{opt} points, till clarification of the stock-recruitment relationship, it is recommended to be used levels two times less than accepted for assessment natural mortality coefficient M = 0.95.Even in this case the resulted value for Fopt = 0.475 gives very high TAC =16 272.772 thousand tones. Applied more restrictive strategy F0.5 = 0.256139 gives TAC = 8774.93 tones. Annual yield should not exceed 8500-9000 thousand tones.
We propose investigations on population parameters and exploitation stock biomass of this commercially and ecologically valuable species in continuous base in order to create database. Stock assessment of turbot is in straight correlation with it rational exploitation, species and biodiversity conservation.

ACKNOWLEDGEMENTS:

The author want to thank to the team of NIMRD"Grigore Antipa"-Constanta, Romania and especially to Dr. Gh.Radu, Dr. V.Maximov, and Dr.Panayotova - IO-BAS, for the help and valuable advices.
I would like to express my gratitude to all the stuff from IFR-Varna who participated in the field and laboratory work.
This work was conducted according contract between IFR-Varna and NAFA-Bulgaria.

References:

BERTALANFFY L. VON 1938. A quantitative theory of organic growth (Inquiries on growth laws. II). Human Biol. 10: 181-213.

BEVERTON, R.J. and S.J. HOLT. (1957). On the dynamics of exploited fish populations. Fish. Invest. Ser. 2, Vol 19.

DASKALOV, G. 1993 :Rapport de DEA, Univ. Aix-Marseille II, OSU(COM

DASKALOV G & PRODANOV K., 1994 Variability in growth of sprat Sprattus sprattus L. off Bulgarian Black Sea coast with respect to the environmental changes in the black sea.Black Sea '94 Coll.reprints,81-84.

DASKALOV G.K., K.B.PRODANOV, V.SHLYAKHOV, K.MAXIM : Stock assessment of sprat (Sprattus sprattus L.) in the Black Sea during 1945-1993 using international Fishery and research data.Proc.of the IFA, Varna, 24, 67-93 (1996).

GULLAND J.A., 1966. Manual of sampling and statistical methods for fisheries biology. Part I: Sampling methods. FAO Manuals in Fisheries Science No. 3, Rome.

GULLAND J.A., 1970. The fish resources of the ocean. FAO Fish. Techn. Pap. No. 97, 1-425, Rome.

FAO: Precautionary approach to fisheries. FAO Fish. Tech. Paper N. 350 (1), 1995.

FAO: Fisheries statistics, v.86.1. FAO 2000. Rome, Italy

FOOTE, K.G.- 1996. Quantitative fisheries research surveys, with special reference to computers. In: B.A. Megrey & E. Moksness. Computers in fisheries research. Chapman & Hall. 254 pp. 80-112.

IVANOV L., 1979 Dynamics and rational exploitation of natural and artificial reproduced fish populations.Dr.Sci.Dissertation ,IRR-Varna. .(in Bulgarian).

L.S.IVANOV: Population parameters and methods for limiting of the sprat catches (Sprattus sprattus L.) in the western part of the Black Sea. Proceedings of IFR-Varna. (20), 7-47. (1983).

IVANOV L 1990-1992 Technical Reports of IFA-Varna

IVANOV L. 1994. A combined method for estimating of the stocks of sprat (Sprattus sprattus L.) in the Bulgarian aquatory of the Black Sea. Proceedings of the Institute of Fisheries, v. XXII, 105-113.

IVANOV L., 1979 Dynamics and rational exploitation of natural and artificial reproduced fish populations.Dr.Sci.Dissertation ,IRR-Varna. .(in Bulgarian).

L.S.IVANOV: Population parameters and methods for limiting of the sprat catches (Sprattus sprattus L.) in the western part of the Black Sea. Proceedings of IFR-Varna. (20), 7-47. (1983).

IVANOV L 1990-1992 Technical Reports of IFA-Varna

IVANOV L. 1994. A combined method for estimating of the stocks of sprat (Sprattus sprattus L.) in the Bulgarian aquatory of the Black Sea. Proceedings of the Institute of Fisheries, v. XXII, 105-113.

L.S.IVANOV: The sprat stocks (Sprattus sprattus L).BAS, Hydrobiology, (34), 68-78. (1995).

IVANOV L & R.J.H. BEVERTON, 1985. the fisheries resources of the MMediterranean. Part II: Black Sea. FAO Studies and Reviews, No.60, 135 pp.

LLEONART, J., 2002. Overview of stock assessment methods and their suitability to Mediterranian fisheries.5th session of the SAC – GFCM,Rome,1-4 July 2002:4-17.

PAULY D., 1980. Bull.fish.Res.Board.Can.,(191):382p

PRODANOV K.B.K, KOLAROV K, 1983 ON THE QUESTION FOR THE RATIONAL EXPLOTATION OF THE FISH POPULATIONS.IFR PROCEEDINGS, VARNA VOL.20, 47-70.

PRODANOV K.B.., 1989 On the problem of determining the optimum value of fishing mortality coefficient (Fopt) and the value of total allowable catch(TAC).Hydrobiology, BAS, 34:79

PRODANOVK.B.,K.R.MIKHAILOV,G.DASKALOV,C.MAXIM,A.CHASHIN,A.A. ARCHIPOV, V.SCHLYAKHOV,E.OZDAMAR: Environmental management of fish resources in the Black Sea and their rational exploitation. GFCM N. (68), 53-73, 1997.

PRODANOV, K.B., M.P.STOYANOVA: Biological resources of the world ocean. Steno, Varna .1, 150-157, 2000.

RAYKOV V Primary management objectives for sustainable Sprat (Sprattus sprattus L.) stock exploitation at the Bulgarian Black Sea coast - preliminary results J.Environmental Protection and Ecology, 8 (2) (2007),302-318.

RAYKOV V.S, V.V.MIHNEVA, DASKALOV,G: Investigations on sprat (Sprattus sprattus L.) population dynamics related to its trophic base and climate change over the period 1996-2004 in Bulgarian waters of the Black Sea. J.Environmental Protection and Ecology, 8 (2) (2007),319-332.

SPARRE, P., E. URSIN and S.C. VENEMA, 1989. Introduction to tropical fish stock assessment, Part 1: Manual. FAO Fish. Tech. Pap. 306/1, 337 pp.

M.B.SCHAEFER: Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission 1, 27-56 (1954).

.