BLACK SEA ANCHOVY, *ENGRAULIS ENCRASICOLUS PONTICUS* ALEKSANDROV

Recently the Black Sea anchovy has been considered one of the populations of the European anchovy, *Engraulis encrasicolus* Linneaneus, by some authors (Lindberg, 1980; Tshashchin, 1985; Dobrovolov, 1988; Dobrovolov and Mikhailov, 1990), while others consider it a distinct subspecies (Fage, 1911; Aleksandrov, 1927; Pusanov, 1936; Svetovidov, 1948; Rass, 1987; Prodanov *et al.*, 1993).

Commercially and ecologically, the Black Sea anchovy is the fish species of primary importance in the basin. Being most abundant, it has traditionally supported the largest commercial fishery in the Black Sea. The anchovies low trophic position gives it a significant role as a component of the energy flow to higher levels, thus considerably affecting the ecosystem as a whole. On this account, there has been extensive interest in this fish and appreciable effort was devoted to studying its biology, ecology and exploitation parameters.

Recent research advances work concern the discovery of hybridisation between the Black Sea and Azov anchovy populations (Tchashchin, 1985; Mikhailov and Dobrovolov, 1990). Moreover, migrations of Azov and/or hybrid types were established through electrophoretic and morphometric studies along the Bulgarian coast, primarily during autumn and winter (Mikhailov and Dobrovolov, 1991).

The anchovy is known to mature at 1 year of age but since 1987 young-of-the-year anchovies (some months after hatching) were detected maturing and spawning in the north-western part of the basin (Mikhailov, 1991; Lisovenko *et al.*, 1993).

The co-existence of two populations (Black Sea and Azov stocks) in the Black Sea and the high fluctuations in anchovy stock biomass, enforced the applying of new and more reliable methods of surveying and assessment of anchovy resources. Since 1978 regular echo-acoustic and (since 1980), echo-integrator surveys have commenced off the Caucasian and Crimean coasts during the wintering period (November-April) carried by YugNIRO (Ukraine). They aimed at investigating the distribution, and obtaining separate estimates of the two stocks, thus providing the possibility of rationalising their fisheries (Artyomov and Tchashchin, 1982; Tchashchin, 1990). Since 1984 joint (the former USSR and Bulgaria) echo-integrator surveys have been carried out off the Bulgarian coast, which showed relatively good anchovy concentrations even at the beginning of the autumn migration. For instance, the biomass early in September 1984 was estimated at 32 thousand tonnes.

Since 1987 regular ichthyoplankton surveys have been conducted by YugNIRO. Both Bulgaria and Romania have joined consecutively in 1989 and 1990. Their final goal was to assess the spawning biomass by Parker's "egg production method" (Parker, 1980) (Arkhipov *et al.*, 1992; Mikhailov *et al.*, in press) successfully used for other anchovy stocks (northern anchovy, Peruvian anchovy, etc.). The results obtained show a drastic decline of spawning biomass after 1988: 1988 - 235 000; 1989 - 32 000, 1990 - 48 000, and 1991 - 92 000 tonnes in the Black Sea.

The research performed revealed the negative natural and anthropogenic impacts due to the Mnemiopsis outburst and anchovy over-fishing, in particular); simultaneously acting on the anchovy stock size and population structure.

Table 33 shows the anchovy catches by countries during fishing seasons 1967/1968 - 1993/1994

TABLE 33. Black Sea anchovy catches (tonnes) during fishing seasons 1967/1968 - 1993/1994

Fishing seasons	Bulgaria	Romania	former USSR	Turkey	Total
1967/1968	210	2072	42450	43065	87797
1968/1969	104	901	50050	36422	87477
1969/1970	68	713	58100	53801	112682
1970/1971	137	1921	56050	66738	124846
1971/1972	83	1508	52300	76058	129949
1972/1973	313	3466	65100	85061	159087
1973/1974	86	642	80800	77509	159037
1974/1975	8	207	87200	64509	151924
1975/1976	59	2266	148000	70326	220651
1976/1977	134	3183	125000	56742	185059
1977/1978	38	1113	118000	84686	203837
1978/1979	272	3951	71000	76391	151614
1979/1980	187	3146	170000	264325	457658
1980/1981	121	4932	120000	274710	399763
1981/1982	107	2941	126000	267389	396437
1982/1983	890	8329	130000	267888	407107
1983/1984	150	1743	145000	309729	456622
1984/1985	229	6066	70000	181019	257314
1985/1986	98	2553	100000	302770	405421
1986/1987	23	827	100000	350087	450937
1987/1988	11	394	130000	338402	468807
1988/1989	106	2953	70000	115237	188296
1989/1990	0	38	65000	130975	196008
1990/1991	1	1	2000	37049	39051
1991/1992	82	122	25000	72295	97499
1992/1993	7	279	4000	69450	73736
1993/1994	0	346	0	77468	77814

It is clear that both Romanian and Bulgarian catches (in the western part of the Black Sea, only) represent insignificant proportions of the total catches; on average 1.03%. The Romanian catches are taken in April-December but mainly in May-August. They were distributed by months, as follows (in %):

Months	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
%	0.87	17.85	25.70	33.52	14.87	6.69	0.47	0.02	0.01	100

The Bulgarian monthly catches were, respectively:

Months	IV	V	VI	VII	VIII	IX	X	XI	XII	Total
%	4.64	36.43	12.26	15.61	6.53	2.78	10.71	4.82	6.22	100

The Turkish and former USSR yields (in the eastern part of the Black Sea) have always been dominant. The fishery is carried out in October - April, but mostly from December - March (96.03%). The former USSR catches distributed by months are the following (in %):

Months	X	XI	XII	I	II	III	IV	Total
%	0.25	2.80	26.71	32.46	24.48	12.98	0.32	100.00

The monthly catch distribution for Turkey is similar. However, during the last two fishing seasons a significant shift in the catch distribution by quarters has been observed (catches in %):

Quarters	X-XII	I-III	IV-VI	VII-IX	Total
1992/1993	66.50	33.50	0.00	+	100.00
1993/1994	85.88	14.12	0.00	0.00	100.00

From the figures given it is apparent that during the two fishing seasons mentioned the catches were obtained, as early as October-December, averaged 76.19%, while those in January-March sharply decreased, averaging 23.81%. Such variations in catches are normal for all regions under consideration. Various causes may be responsible for this, beginning with the environmental conditions and ending with the stock size in different years. For instance, during the last few years (1990-1992) when the anchovy total and spawning biomasses dropped dramatically, its catches in the western part of the Black Sea were negligible. For the occurrence of dense concentrations, amount of fat deposited in the fish and the sea water temperature, are of great importance . The data from research surveys showed that 1+ and 2+ year old fishes begin to form schools at water temperatures 14-16°C when the fat content reaches 12-17%. For 0+ year old fishes, the indices are 10.5-13°C and not less than 13% fat, respectively. All this inevitably affects the period of migration of the particular age groups, as well as the migration of the different cohorts of 0+ year old fishes.

Figure 8 shows anchovy stock size during the 1967/1968 - 1993/1994 fishing seasons (three estimates were carried out). Two of them were performed with software package ANACO (Mesnil, 1989) and the third by the modified equation of Baranov (Shlyakhov *et al.*, 1990). The former two differ between them primarily by the approach to defining the initial F_{st} values: (The initial F value for oldest age groups). In the first estimate the values of F_{st} have been determined by regressions on the basis of the age composition of the catches. After that, iteration procedures were used to eliminate possible errors when computing F_{st}. The background to this method is the assumption that fishing mortality rates have to be approximately equal for all fully available age groups in the exploited stock. In the second approach the F_{st} values were calculated on the basis of the regression between the estimated initial F_{st} values and Turkish fishing effort data. Hence, a correction of the F_{st} values was made (**Table 34**).

The results obtained from VPA show that the final estimates after 9-10 iterations (performed until the difference between the mean F values for ages 2+ and 3+, become less than 0.01 for all fishing seasons) were almost equal during the period 1978/1979 - 1990/1991. For this reason, two estimates only are presented in **Figure 8,** one from the VPA estimates, the other according to Baranov's equation as modified by Shlyakhov, Chashchin and Korkosh (1990).

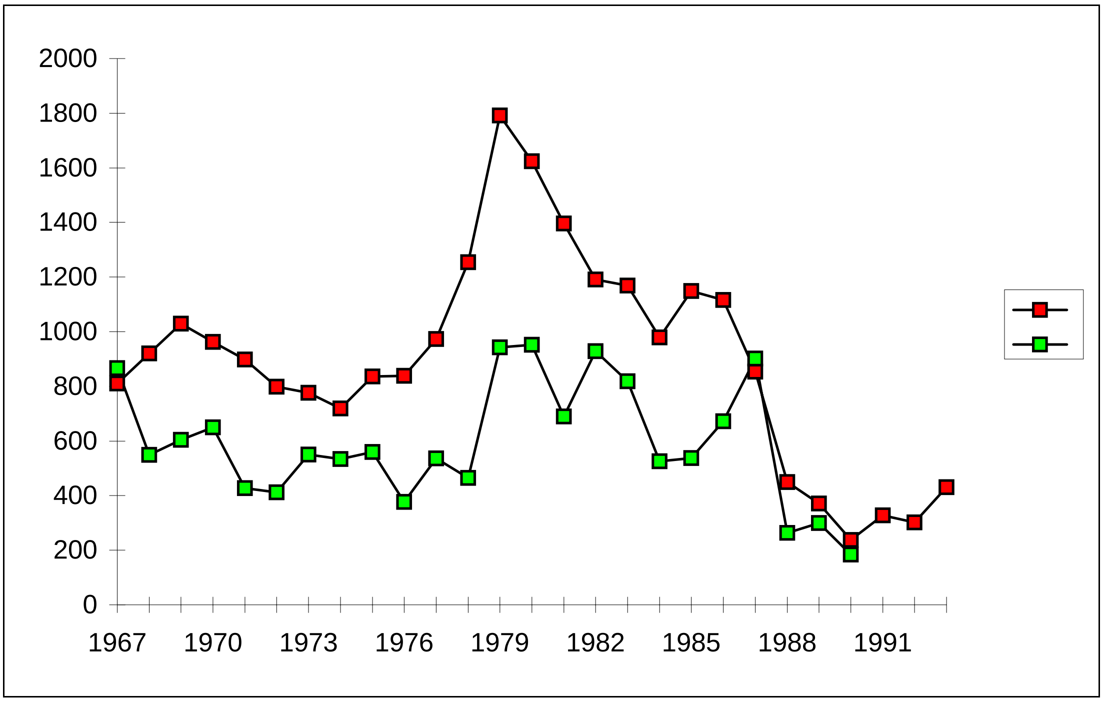

FIGURE 8. Anchovy exploited biomass (in thousand tonnes) during the period 1967 - 1993.
Upper line: results from VPA
Lower line: results from Baranov's modified method

TABLE 34. Values for anchovy fishing mortality rate during the period 1967/1968 - 1993/1994; F_{st} - initial value for the oldest age group. The given values are estimated by the regression curves of catch age composition; $F_{st}*$ - F_{st} is specified by the regression curve of Turkish fishing effort data; F_{1-4} and $F_{1-4}*$ were obtained by corresponding values of F_{st} and $F_{st}*$, respectively

Fishing seasons	F_{st}	F_{1-4}	$F_{st}*$	$F_{1-4}*$	$F_{0-4}**$	U
1967/68	0.3516	0.2795			0.16	0.105
1968/69	0.3300	0.2308			0.26	0.159
1969/70	0.3790	0.2217			0.31	0.186
1970/71	0.4374	0.2987			0.32	0.192
1971/72	0.2346	0.3433			0.56	0.304
1972/73	0.3778	0.4286			0.73	0.374
1973/74	0.4607	0.4845			0.52	0.289
1974/75	0.2940	0.4992			0.51	0.285
1975/76	0.5265	0.4976			0.79	0.394
1976/77	0.6190	0.6133			1.10	0.491
1977/78	0.5506	0.3386			0.75	0.380
1978/79	0.5541	0.2677	0.3518	0.2682	0.61	0.326
1979/80	0.5887	0.5565	0.5282	0.5569	1.08	0.486
1980/81	0.6186	0.4863	0.5055	0.4866	0.86	0.420
1981/82	0.4879	0.5589	0.5618	0.5591	1.44	0.575
1982/83	0.4388	0.5292	0.5453	0.5295	0.92	0.438
1983/84	0.5136	0.6705	0.6039	0.6709	1.40	0.556
1984/85	0.5152	0.5428	0.5034	0.5429	1.09	0.489
1985/86	0.5949	0.7767	0.7031	0.7769	2.78	0.754
1986/87	0.7888	0.9492	0.7733	0.9496	2.00	0.671
1987/88	0.8865	1.6147	0.9465	1.6149	1.20	0.520
1988/89	0.7452	0.8827	0.8546	0.8829	2.34	0.713
1989/90	0.4325	0.9310	0.8573	0.9912	1.89	0.655
1990/91	0.3145	0.3920	0.4424	0.4832	0.86	0.212
1991/92	0.4520	0.4730				
1992/93	0.3559	0.4576				
1993/94	0.3013	0.3795				

U=Y/B; Y - catch per fishing season; B - exploited biomass at the beginning of the corresponding fishing season

The mean values for $F_{0-4}**$ (calculated from Shlyakhov *et al.*, 1990) for ages 0+ to 4+ are believed to be fairly accurate because the equation $Y = B. F/Z (1 - e^{-Z})$ is not equal to the equation $C = N. F/Z (1-e^{-Z})$ - Prodanov and Kolarov (1983).

The values of F_{1-4} are means for ages 1+ to 4+ from age composition calculated by Taylor's method.

Table 34 shows that using this VPA approach, the initial values of F_{st} have no serious effect on the final assessment, with the exception of the last fishing season, data for comparison of the two approaches are available (1990/1991). The differences obtained during the mentioned later years (a major problem of VPA) were due to the fact that the year classes had not completed their life span, especially 0+ and 1+ year old fishes. All this reduces the accuracy of the forecasts for the stock size in the next fishing season. In this respect, estimations suggesting that the total anchovy biomass increased during the 1993/1994 season, contain the highest possibility for error. That is why the catches predicted to be taken in the fishing season 1994/1995 will be of extreme importance for the accuracy of the appraisals made for the last two fishing seasons. This problem complicated still more if one considers that the catches do not always reflect exactly the stock size due to conditions determining the occurrence of dense concentrations susceptible to fishing. Therefore, there does not always exist a coincidence between Turkish and the former USSR data for catches per fishing vessel during 1981/1982 - 1988/1989. Similar comparison of the catches is at present impossible in view of the special situation in Georgia, as a result of which nowadays no foreign fishing can be carried out along its coast. This would incidentally favour recovery of the anchovy biomass. On the other hand, the Mnemiopsis biomass increased again (**Table 13**) during the summer of 1994 (preliminary Ukrainian data).

This is the main reason why we suppose that the expected trend towards increasing anchovy biomass may change once more, since the fish has a short lifetime and the entry of even one weak year class would lead to a decline of the exploited stock. The positive effect diminished fishing effort, especially in unfavourable environmental conditions, is of great importance (Prodanov, 1990) and this may be decisive for the anchovy biomass recovery.

This has already been observed in the Sea of Azov where after cessation of the anchovy fishery for a few years, its stock increased considerably in spite of the high Mnemiopsis biomass.

The third estimate was accomplished with the modified Baranov's equation. This method is based on anchovy spawning biomass data obtained early in May by trawl surveys, the catches, and the values of Z. Out of these three parameters, the highest errors come from the biased assessment of the spawning biomass. Estimates by their common trend with this method, are akin to those obtained by two previous approaches using VPA. However, they differ significantly in the absolute figures obtained. For example, according to VPA, the total biomass (B_{0+}) in November 1979 reached 1 791,5 thousand tonnes and then dropped to 237.3 thousand tonnes at the beginning of November 1990. During the same years, the assessments by Baranov's equation were 942.4 and 184.3 thousand tonnes, respectively.

Figure 9 shows the results from VPA conducted by the usual approach, i.e. the computed values for F_{st} were not subject to additional iterations, except for those inherent to the method. These estimates do not differ essentially from those by the same method, but accompanied by additional iterations for reconciling the F values for fully recruited age groups. Thus, during the two years considered (1979 and 1990) the exploited anchovy biomass had been 1 765.0 and 262.4 thousand tonnes, respectively. The assessment showing an increase of exploited biomass (389.1 thousand tonnes) at the beginning of November 1993 then is akin to values obtained by the above-mentioned approaches to VPA, respectively. The same concerns the predicted spawning biomass (B1+) at the beginning of the fishing season 1994/1995; notably 215.8 thousand tonnes. The lowest estimate comes from the approach that corrects the initial values of F_{st} by means of the regression between them and the Turkish fishing effort data. During the two years considered, the total biomass was as follows: 1979 - 1 676.6 thousand tonnes and 1990 -194.0 thousand tonnes.

Each estimate was made using the following weights (g) in November:

Age	0+	1+	2+	3+	4+
Weight	4.7	11.9	16.3	19.0	21.3

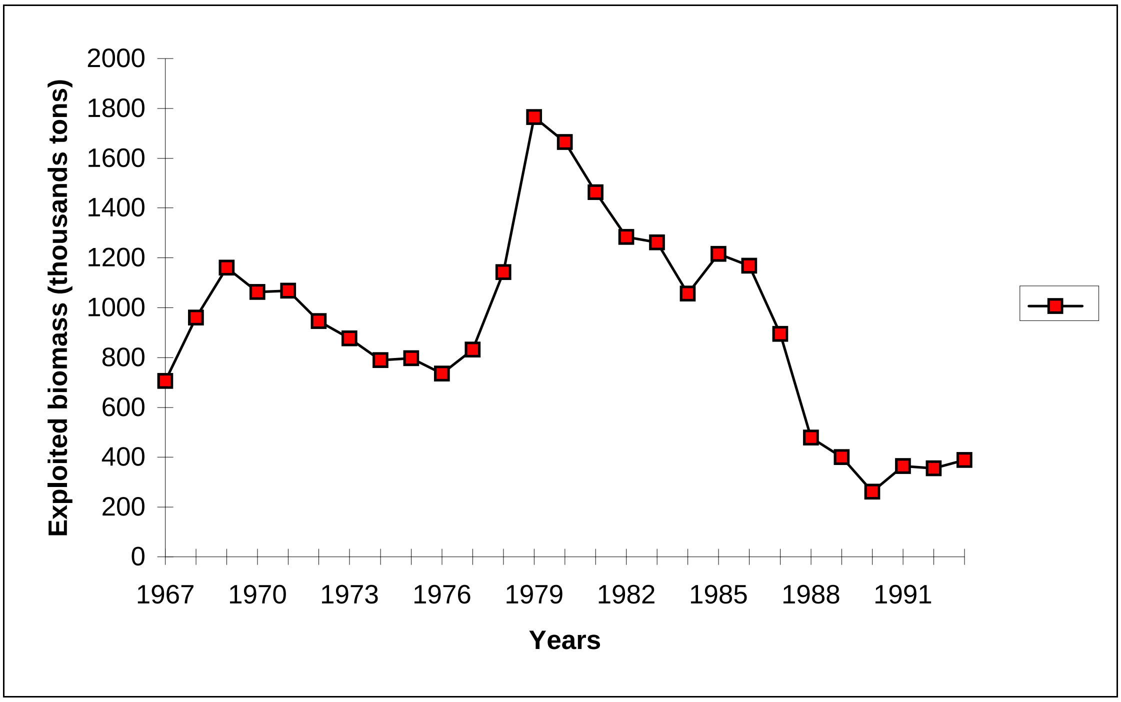

FIGURE 9. Exploited anchovy biomass during 1967 - 1993 (the values for F_{st} are not corrected by additional iterations)

The data differ from those reported by Ivanov and Beverton (1985) primarily in the first two age groups. Later on, Ivanov and Mikhailov (1990) specified the growth rate of the youngest age class. The authors assumed that the larvae hatched (probably early in June), attained a weight of 5.5 g at 150 days of age (i.e. early in November). Following the same approach the hatched larvae early in July and August would reach the same weight of 5.5 g in early December and January, respectively. However, the environmental conditions in the last two months are much less favourable for anchovy growth since it is a warm-water species. Therefore the late cohorts of 0+ year old fishes probably remain in Anatolian waters, while the early cohorts of the same year class mainly hibernate off the Georgian coast. This assumption is consistent with Turkish data for the distribution of age 0+ weights by months:

Recent data largely stemming from recent data on Turkish catches, suggest that the recovery of anchovy populations has been more pronounced. The spawning and exploited biomasses at the beginning of May 1993, and in the 1993 fishing seas on (November) is calculated to have reached 297 and 637 thousand tonnes respectively, as opposed to earlier calculations which suggested 170 and 340 thousand tonnes for these same quantities.

Months	Age 0+ - weights (g)
November	5.37
December	4.69
January	3.32
February	4.04
March	4.47
Average	4.40

It is seen from **Tables 37 and 38** that trends in anchovy stock size are akin to those determined by the above and differ only in absolute values. According to VPA conducted by season, the spawning and exploited anchovy stocks have ranged from 137.5 (1990) to 768.1 (1979) thousand tonnes and from 271 (1990) to 1 427.4 (1979) thousand tonnes (**Figures 10 and 11**). The steady decline in exploited biomass is associated with the poor environmental conditions in the Black Sea, and the outburst of the ctenophore *Mnemiopsis leidyi*, and the over-exploitation of the anchovy stock during 1987-1989. During the period in question the coefficient of exploitation ($U = Y/B_{0+}$) ranged between 0.422 and 0.567 with the corresponding F values 0.81 and 1.44, respectively.

TABLE 35. Number (x 10^{-9} specimens) of anchovy spawning (early May) and exploited stocks (early November) in the Black Sea

Year	V 0	XI 0+	V 1	XI 1+	V 2	XI 2+	V 3	XI 3+	V 4	XI 4+
1967	113.00	75.10	23.20	15.30	7.02	4.63	2.53	1.68	0.77	0.51
1968	90.50	60.00	45.30	30.00	6.96	4.53	2.08	1.37	0.80	0.52
1969	96.50	64.00	35.50	23.50	16.80	11.10	2.06	1.36	0.60	0.40
1970	103.00	68.60	35.40	23.50	12.10	8.02	6.22	4.12	0.58	0.38
1971	81.40	54.00	41.50	27.50	11.50	7.54	3.28	2.13	2.13	1.41
1972	73.50	48.70	31.20	20.70	14.50	9.55	3.00	1.96	0.82	0.54
1973	95.30	63.20	26.60	17.60	8.87	5.83	4.47	2.95	0.63	0.41
1974	85.10	56.50	28.30	18.80	6.99	4.62	2.42	1.59	1.58	1.04
1975	122.00	81.20	28.70	19.00	8.03	5.32	1.66	1.10	0.46	0.31
1976	95.50	63.40	33.30	22.00	8.23	5.37	1.76	1.13	0.38	0.24
1977	132.00	87.30	32.30	21.40	8.60	5.63	1.72	1.12	0.38	0.25
1978	169.00	112.00	43.20	28.60	9.78	6.35	2.55	1.68	0.45	0.29
1979	217.00	144.00	68.70	45.50	14.40	9.48	3.33	2.19	0.93	0.61
1980	176.00	116.00	63.60	41.80	16.00	10.50	4.36	2.87	0.80	0.53
1981	141.00	93.40	56.60	37.40	15.80	10.40	4.50	2.94	1.31	0.86
1982	137.00	90.70	45.50	30.10	13.40	8.82	3.82	2.51	1.14	0.75
1983	152.00	101.00	44.90	29.70	12.00	7.77	3.31	2.14	0.84	0.52
1984	128.00	84.70	40.20	26.60	10.10	6.52	2.89	1.85	0.68	0.45
1985	161.00	107.00	48.30	32.00	11.10	7.31	2.42	1.60	0.73	0.51
1986	157.00	104.00	53.70	35.60	10.80	7.11	2.10	1.37	0.42	0.27
1987	93.50	62.00	49.70	32.90	11.00	7.29	1.63	1.08	0.37	0.24
1988	60.10	39.90	21.30	13.80	6.49	4.29	1.71	1.13	0.19	0.13
1989	63.10	41.80	15.00	9.95	4.52	3.00	1.54	1.02	0.45	0.30
1990	40.20	26.70	12.80	8.51	3.00	1.99	0.94	0.62	0.00	0.00
1991	50.70	33.60	15.20	10.10	4.57	3.03	0.99	0.66	0.00	0.00
1992	39.50	26.20	14.90	9.86	4.66	3.09	1.46	0.97	0.00	0.00
1993	54.60	36.20	12.90	8.57	4.55	3.02	1.41	0.94	0.45	0.30
1994			18.30		4.22		1.49		0.46	

TABLE 36. Values of anchovy fishing mortality coefficient (by age) in the spawning and exploited stock during the period 1963-1993 ; V - May ; XI - November

Year	V 0	XI 0+	V 1	XI 1+	V 2	XI 2+	V 3	XI 3+	V 4	XI 4+
1967	0.0006	0.0961	0.0054	0.3771	0.0069	0.3901	0.0004	0.3363	0.0006	0.3362
1968	0.0005	0.1156	0.0011	0.1694	0.0211	0.3794	0.0098	0.4157	0.0064	0.3253
1969	0.0005	0.1828	0.0004	0.2529	0.0034	0.1710	0.0022	0.4405	0.0011	0.4656
1970	0.0001	0.0935	0.0012	0.3038	0.0044	0.4837	0.0034	0.2476	0.0069	0.4413
1971	0.0001	0.1384	0.0007	0.2318	0.0110	0.5123	0.0200	0.5405	0.0061	0.1876
1972	0.0016	0.1954	0.0017	0.4361	0.0002	0.3501	0.0168	0.7260	0.0179	0.3946
1973	0.0007	0.3938	0.0009	0.5139	0.0110	0.4703	0.0053	0.2146	0.0077	0.4573
1974	0.0001	0.2687	0.0010	0.4387	0.0042	0.6132	0.0104	0.8188	0.0051	0.2254
1975	0.0006	0.4825	0.0002	0.4276	0.0017	0.6958	0.0047	0.6509	0.0063	0.5245
1976	0.0001	0.2643	0.0027	0.5292	0.0166	0.7275	0.0331	0.6854	0.0280	0.6396
1977	0.0000	0.2942	0.0003	0.3741	0.0133	0.3823	0.0231	0.4941	0.0086	0.5584
1978	0.0000	0.0797	0.0019	0.2765	0.0216	0.2369	0.0104	0.1818	0.0244	0.4975
1979	0.0001	0.4088	0.0020	0.6376	0.0070	0.3667	0.0062	0.5923	0.0129	0.5959
1980	0.0013	0.3115	0.0087	0.5605	0.0137	0.4316	0.0070	0.3753	0.0072	0.6029
1981	0.0008	0.3083	0.0040	0.6155	0.0141	0.5880	0.0155	0.5429	0.0094	0.4895
1982	0.0002	0.2931	0.0054	0.5056	0.0089	0.5719	0.0125	0.6834	0.0018	0.4341
1983	0.0004	0.5127	0.0028	0.6694	0.0269	0.5804	0.0254	0.7304	0.0512	0.5083
1984	0.0005	0.1516	0.0037	0.4612	0.0276	0.5789	0.0340	0.4635	0.0104	0.5037
1985	0.0002	0.2782	0.0028	0.6735	0.0087	0.8391	0.0063	0.9328	0.0026	0.5914
1986	0.0001	0.3314	0.0014	0.7642	0.0093	1.0632	0.0177	0.9066	0.0320	0.7860
1987	0.0003	0.6610	0.0026	1.2244	0.0016	1.0388	0.0059	1.3239	0.0038	0.8837
1988	0.0001	0.5677	0.0235	0.7036	0.0023	0.6131	0.0010	0.5134	0.0038	0.7313
1989	0.0001	0.7721	0.0002	0.7894	0.0002	0.7532	0.0001	0.4823	0.0016	0.4823
1990	0.0000	0.1549	0.0000	0.2124	0.0000	0.2905	0.0000	0.3144	0.0000	0.0000
1991	0.0001	0.4063	0.0002	0.3600	0.0002	0.3210	0.0001	0.4517	0.0000	0.0000
1992	0.0003	0.2971	0.0003	0.3637	0.0002	0.3741	0.0001	0.3507	0.0000	0.0000
1993	0.0008	0.2711	0.0015	0.2996	0.0014	0.2996	0.0001	0.2996	0.0000	0.2996

TABLE 37. Anchovy spawning biomass (B_{1+} in thousand tonnes) in early May during the period 1967-1993

Year	1	2	3	4	Total
1967	158.5	83.1	39.2	14.0	294.8
1968	309.4	82.4	32.2	14.6	438.6
1969	242.5	198.9	31.9	10.9	484.2
1970	241.8	143.3	96.3	10.6	492.0
1971	383.4	136.2	50.8	38.8	509.2
1972	213.1	171.7	46.4	14.9	446.1
1973	181.7	105.0	69.2	11.5	367.4
1974	193.3	82.8	37.5	28.8	342.4
1975	196.0	95.1	25.7	8.4	325.2
1976	227.4	97.4	27.2	6.9	358.9
1977	220.6	101.8	26.6	6.9	355.9
1978	295.1	115.8	39.5	8.3	458.7
1979	469.2	170.5	51.5	16.9	708.1
1980	434.4	189.4	67.5	14.6	705.9
1981	386.6	187.1	69.7	23.8	667.2
1982	310.8	158.7	59.1	20.7	549.3
1983	306.7	142.1	51.2	15.3	515.3
1984	274.6	119.6	44.7	12.4	451.3
1985	329.9	131.4	37.5	13.3	512.1
1986	366.8	127.9	32.5	7.7	534.9
1987	339.5	130.2	25.2	6.7	501.6
1988	145.5	76.8	26.5	3.5	252.3
1989	102.5	53.5	23.8	8.3	188.1
1990	87.4	35.5	14.6	0.0	137.5
1991	103.8	54.1	15.3	0.0	173.2
1992	101.8	55.2	22.6	0.0	197.6
1993	88.1	53.9	21.8	8.3	172.1
1994	125.0	50.0	23.1	8.4	206.5

TABLE 38. Anchovy exploited biomass (B_{0+} in thousand tonnes) in early November during the period 1967-1993

Year	0+	1+	2+	3+	4+	B0+	U
1967	353.0	182.1	75.5	31.9	10.3	653.4	0.1344
1968	282.0	357.0	73.8	26.0	11.1	749.9	0.1167
1969	300.8	279.7	180.9	25.8	8.5	795.7	0.1416
1970	322.4	279.7	130.7	78.3	8.1	819.2	0.1523
1971	253.8	327.3	122.9	40.5	30.0	774.5	0.1677
1972	228.9	246.3	155.7	37.2	11.5	679.6	0.2341
1973	297.0	209.4	95.0	56.1	8.7	666.2	0.2387
1974	265.6	223.7	75.3	30.2	22.2	617.0	0.2462
1975	381.6	226.1	86.7	20.9	6.6	721.9	0.3058
1976	298.0	261.8	87.5	21.5	5.1	673.9	0.2747
1977	410.3	254.7	91.8	21.3	5.3	783.4	0.2601
1978	526.4	339.2	103.5	31.9	6.2	1007.2	0.1505
1979	676.8	541.5	154.5	41.6	13.0	1427.4	0.3207
1980	545.2	497.4	171.1	54.9	11.3	1279.5	0.3125
1981	439.0	445.1	169.5	55.9	18.3	1127.8	0.3515
1982	426.3	358.2	143.8	47.7	16.0	992.0	0.4104
1983	474.7	353.4	126.7	40.7	11.1	1006.6	0.4536
1984	398.1	316.5	106.3	35.2	9.6	865.7	0.2972
1985	502.9	380.8	119.2	30.4	10.9	1044.2	0.3882
1986	488.8	423.6	115.9	26.0	5.8	1060.1	0.4253
1987	291.4	391.5	118.8	20.5	5.1	827.3	0.5667
1988	187.5	164.2	69.9	21.5	2.8	445.9	0.4223
1989	196.5	118.4	48.9	19.4	6.4	389.6	0.5031
1990	125.5	101.3	32.4	11.8	0.0	271.0	0.1443
1991	157.9	120.2	49.4	12.5	0.0	340.0	0.2868
1992	123.1	117.3	50.4	18.4	0.0	309.2	0.2384
1993	170.1	102.0	49.2	17.9	6.4	339.2	0.2294

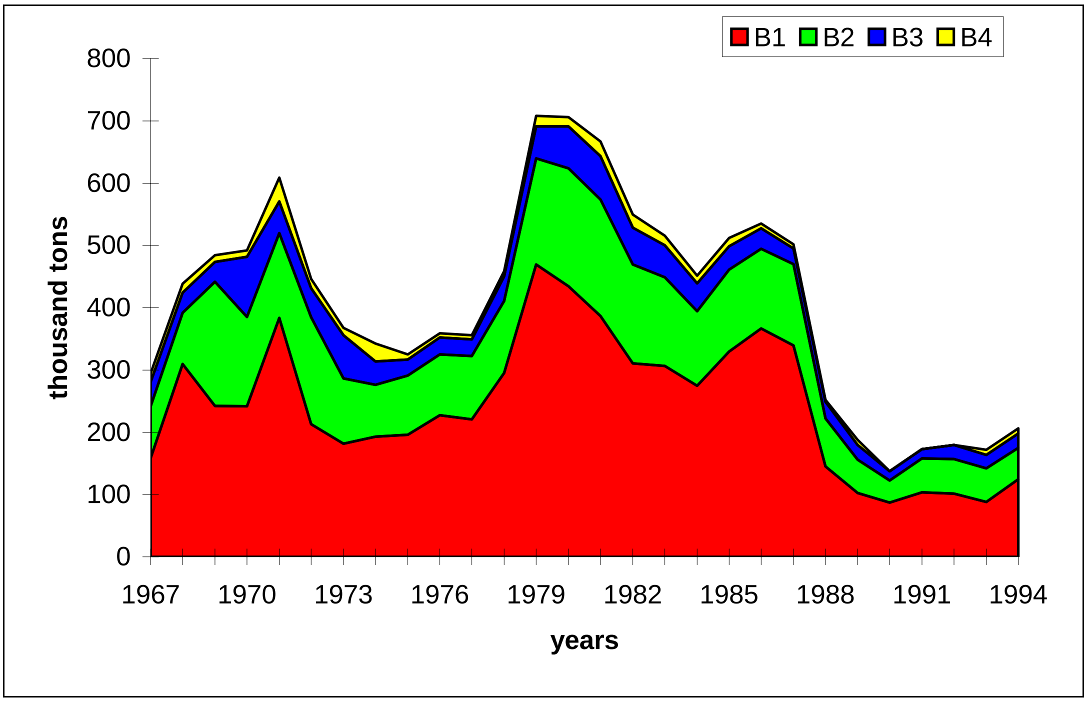

FIGURE 10. Spawning biomass of the Black Sea anchovy in early May 1967-1993

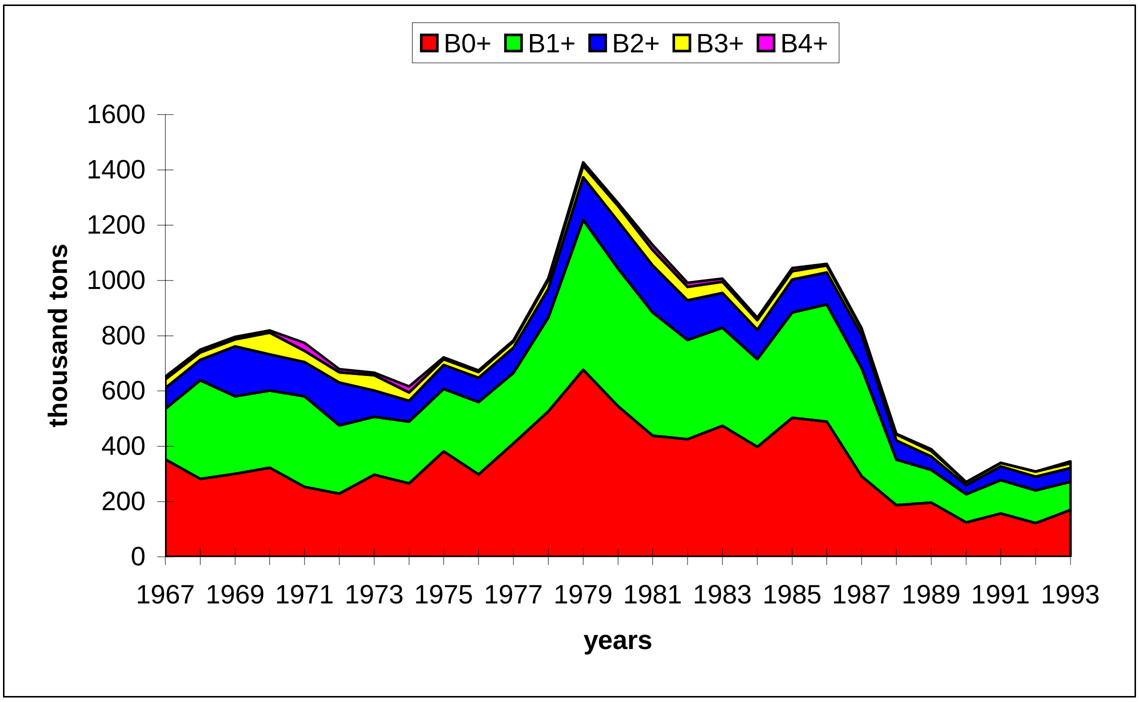

FIGURE 11. Exploited biomass of the Black Sea anchovy at the beginning of the fishing season (November) in the period 1967-1993.

Anchovy stock size assessments agree with those performed by Johanesson and Loose (1973); Ivanov and Beverton (1985); Ivanov and Mikhailov (1990). The first estimate was obtained from trawl (hydroacustic survey) in March 26-31, 1976, off the Turkish coast. From this the anchovy biomass during this year was 990.0 thousand tonnes. On the basis of these data and the fact that the assessment was related only to the wintering stock off the Anatolian coast, Ivanov and Beverton (1985) estimated the stock in the whole Black Sea at around 1 500 thousand tonnes. Ivanov and Mikhailov (1990) gave an average estimate of the exploited anchovy biomass of 1 000 thousand tonnes assuming that in some years it has peaked at 1 300 thousand tonnes.