

BLACK SEA WHITING, *MERLANGIUS MERLANGUS EUXINUS* NORDMANN

The taxonomic position of the Black Sea whiting like that of a great number of Black Sea fish species is rather complicated, and is still a controversial question. According to Svetovidov (1935) the Black Sea whiting (*Odontodadus merlangus euxinus*) is related to genus *Odontogadus*, subfamily Gadinae, family Gadidae, order Gadiformes and represent subspecies of *Odontogadus merlangus merlangus*. The latter is distributed along the European coast (from Murmansk to Gibraltar) and in the Mediterranean. The genus name *Odontogadus* is given by Gill (1863). *Odontogadus merlangus merlangus* was described by Linnaeus (1758) as *Gadus merlangus*. Subsequently Cuvier (1817) detached this species from the genus *Gadus*, giving it the name *Merlangius merlangus*. The Black Sea whiting was described for the first time by Nordmann (1830) as *Gadus euxinus*. Some researchers consider the Black Sea and Atlantic whiting as the same fish species (Steindachner and D'Ancona - after Svetovidov, 1935), others as two species (Svetovidov). On the basis of morphometric, biological (Prodanov, 1983) and electrophoretic investigations (Dobrovolo, Dobrovolova and Prodanov, 1984) concluded that both types of whiting are separate species and gave them the following names: *Merlangius merlangus* (Atlantic whiting) and *Merlangius euxinus* (Black Sea whiting). In the FAO Yearbook of Fishery Statistics, the Black Sea whiting was presented under the name *Odontogadus merlangus euxinus* up to 1973, later on as *Merlangius merlangus*; i.e. initially it was considered a subspecies, but subsequently as identical to the Atlantic whiting. However, it is difficult to explain why whiting from the eastern Black Sea have a growth rate quite different from that in the western half of the basin. In terms of growth and life span, the fish inhabiting the eastern part of the Black Sea have an intermediate position between the two mentioned types. Therefore, assessments of the stock dynamics of the Black Sea whiting were carried out separately for the two parts of the Black Sea.

In the eastern part of the basin the whiting is subject to a specialised fishery, while in its western part it is fished primarily as a by-catch in trawl sprat catches and by trap nets. This last consideration reduces the precision of fishery statistics for whiting catches in the western Black Sea (Prodanov, 1984). For this reason it has always been considered that in the west the species is lightly exploited. Domashenko and Serobaba (1990) reported that in 1980-1981 the coefficient of exploitation had values around 0.20, i.e. considerably lower than the optimum value of 0.45 (Domashenko *et al.*, 1985). In contrast, Prodanov (1990) claimed that the coefficient of exploitation had to be around 0.35.

According to Shlyakhov (1982) the sharp fluctuations in the whiting biomass were caused by the different year class strengths and also changes in its natural mortality.

Kirsonova and Lushnikova (1990) established that the Black Sea spiny dogfish consume annually an average of 70 000 tonnes of whiting. Whiting is also a basic food component in the diet of the turbot, the thornback ray and the stingray. From the above it is evident that the rate of natural mortality of the whiting is highly correlated with the abundance of predators. The most important of these is at present the spiny dogfish, because it has no enemies. Its reproduction being oviparous it is not directly affected by environmental conditions and is not heavily exploited (at least from official fishery statistics). **Table 54** shows the whiting catches in the western and eastern parts of the basin.

Table 55 shows the age composition of whiting catches in the western part of the basin.

According to the data presented, mean values of total mortality for fully represented age groups are as follows: 2 - 0.6592; 3 - 0.8063; 4 - 1.0241; 5 - 0.9767. Given that the mean value of *M* is in the range of 0.65-0.70 (Prodanov, 1984) we may deduct that it has the following values by age groups: 1 - 0.70; 2 - 0.55; 3 - 0.70; 4 - 0.90; 5 - 0.90. The value mentioned for the oldest age group may be slightly high. Such an approach is not well accepted by most researchers since using the traditional VPA this would always lead to overestimates of the biomasses for exploited fish species. The overestimation is especially high for species with a short life span and high natural mortality such as most pelagic fish in the Black Sea.

TABLE 54.Whiting landings in the Black Sea by areas and countries (in tonnes) during the period 1967-1994

Years	West. part of the Black Sea						East. part Total	West. part Total	Grand Total
	Bulgaria		Romania	Former USSR		Turkey			
	FAI	*	FAI	FAI	*	**			
1967								2966.7	
1968								4526.8	
1969								4728.9	
1970						124.7	8987.3	9112.0	
1971	0.0	0.0	381.0	0.0	0.0	65.4	5889.3	381.0	6335.8
1972	0.0	0.0	416.0	0.0	0.0	41.4	5023.2	416.0	5480.6
1973	0.0	0.0	329.0	0.0	0.0	522.6	1734.9	329.0	2586.5
1974	0.0	0.0	1305.0	0.0	0.0	138.4	2510.0	1305.0	3953.3
1975	454.0	754.0	346.0	0.0	0.0	381.3	3436.7	1100.0	4918.0
1976	377.0	1715.1	541.0	22.0	107.4	159.3	4054.0	2363.5	6576.8
1977	218.0	2134.6	1495.0	0.0	800.0	875.0	4851.3	4429.6	10155.9
1978	407.0	2912.6	1345.0	583.0	3283.0	1264.9	20000.3	7540.6	28805.8
1979	71.0	2563.5	1205.0	11377.0	17877.0	778.0	20000.0	21645.5	42423.5
1980	30.0	3889.8	618.0	2720.0	5500.0	1043.0	5795.0	9791.8	16630.2
1981	1.0	2563.5	894.0	2530.0	6500.0	1918.0	2751.0	9957.5	14626.5
1982	0.0	2750.3	800.0	1514.0	8200.0	1751.0	2513.0	11750.3	16014.3
1983	0.0	1506.5	1080.0	2381.0	7800.0	4045.0	7651.0	10386.5	22082.5
1984	0.0	1710.7	1192.0	4759.0	10500.0	5856.0	5739.0	13402.7	24997.7
1985	0.0	1500.8	3138.0	2684.0	5000.0	4948.0	11088.0	9638.8	25674.8
1986	0.0	1118.2	1949.0	2660.0	4800.0	3140.0	14598.0	7967.2	25605.2
1987	0.0	1057.6	615.0	2764.0	4500.0	4798.0	22305.0	6172.6	33275.6
1988	0.0	885.9	1009.0	2223.0	4500.0	3008.0	25255.0	6394.5	34657.9
1989	0.0	744.5	2738.0	591.0	6000.0	4075.0	15208.0	9482.5	28765.5
1990	0.0	359.4	2653.0	322.0	8800.0	2634.0	13625.0	11812.4	28071.4
1991	0.0	246.2	59.0	24.0	2600.0	7642.0	11314.013	2905.2	21861.2
1992	0.0	482.6	1357.0	0.0	900.0	5176.8	143.4	1739.6	21059.8
1993	0.0	619.8			500.0	2856.3	7143.7		
1994	0.0					4350.1	10649.9		

* - the expert assessments of the level of real whiting catches of Bulgaria and former USSR are according to Prodanov's and Shlyakhov's data, respectively;

** - the Turkish catches in the eastern part of the Black Sea are taken eastern of Sinop, while these in the western part - from around the Bosphorus. According to Ozdamar's data, the length compositions of these catches in the pointed areas are similar. That is why they were summerized and related to the eastern part only.

According to the above-mentioned distribution of natural mortality coefficients, the mean value of M is 0.69; i.e. very close to 0.70. On account of this, VPA was carried out in several variants - the first two at $M = \text{const.} = 0.70$ and with $F_{st} = 1/2 F_{st}$ of sprat; this latter since the whiting from the western part of the Black Sea is caught mainly as a by-catch in the trawl sprat fishery. The first variant was carried out in the traditional manner and the second, by tuning the values of F_{st} through additional iteration procedures. The third and fourth variants were also performed with $M = \text{const.} = 0.70$, but here the values of F_{st} were set equal to $1/5$ of those for sprat, since there is no specialized fishery for whiting. Besides, the older age groups inhabit more open areas of the sea (at depths 40-50 to 90-110m) and the most intensive trawl sprat fishery is conducted during spring and summer at depths 25-30 - 50-60m. This last variant was carried out in accordance with the above-mentioned values of M by age groups, and also by tuning the values of F_{st} , initially adopted as equal to those of sprat.

TABLE 55. Age composition ($\times 10^{-6}$ specimens) of whiting catches (in tons) in the western part of the Black Sea

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	C_N	C_W	W
1971	7.17	11.2	6.57	2.89	1.49	0.70	0.29	30.31	381.0	12.57
1972	5.85	14.57	6.31	2.74	1.40	0.69	0.30	31.86	416.0	13.06
1973	4.03	9.59	6.46	3.51	1.67	0.80	0.23	26.29	329.0	12.51
1974	6.91	32.69	19.33	15.10	6.90	3.30	1.20	85.43	1305.0	15.28
1975	18.68	21.84	16.41	8.09	5.51	2.88	1.20	74.61	1100.0	14.74
1976	30.10	58.62	34.60	19.66	7.40	6.01	2.27	158.66	2363.5	14.90
1977	7.30	116.10	108.83	48.19	16.12	2.59	3.78	302.91	4429.6	14.62
1978	26.73	134.70	192.50	85.02	26.61	3.89	0.91	470.36	75.46	16.03
1979	32.11	134.33	358.59	246.57	94.59	6.21	1.30	873.70	21645.5	24.77
1980	310.50	220.50	103.71	88.59	75.20	35.66	1.92	836.08	9791.8	11.71
1981	30.29	353.08	184.91	85.79	34.76	18.89	8.92	716.64	9957.5	13.89
1982	626.30	253.31	175.37	98.64	38.98	18.56	7.63	1218.79	11750.3	9.64
1983	113.35	360.48	132.33	86.27	45.68	14.77	6.09	758.97	10386.5	13.68
1984	172.24	303.03	259.97	112.21	48.83	19.12	2.78	918.18	13402.7	14.60
1985	160.08	232.72	133.52	104.75	39.84	15.78	6.86	693.55	9638.8	13.90
1986	105.08	225.82	110.03	54.24	36.94	10.34	9.70	552.15	7967.2	14.43
1987	59.38	205.71	101.04	39.92	19.47	18.58	3.25	447.35	6172.6	13.80
1988	82.96	204.58	83.12	46.28	14.45	5.12	10.25	446.76	6394.5	14.31
1989	215.86	260.63	105.55	46.33	24.91	6.12	2.34	661.74	9482.5	14.33
1990	755.43	157.25	129.97	30.56	14.01	10.36	2.86	1100.44	11812.4	10.73
1991	71.18	90.00	42.90	12.78	4.93	1.79	1.96	225.54	2905.2	12.88
1992	61.85	69.49	40.96	19.05	3.69	0.96	0.55	196.55	2739.6	13.94
1993	41.89	44.91	18.13	15.16	4.65	0.86	0.13	125.73	1718.8	13.67

CN - catch in numbers ($\times 10^{-6}$ specimens) ; CW - catch in tonnes; W - mean weight (g)

Table 56 and **Figure 20** present the results from the first variant of VPA.

From Table 56 it is seen that the whiting biomass (B_{1+}) in the western part of the basin during the period 1971-1993 has varied from 65.8 (1989), to 204.5 (1981) and to 209.0 (1983) thousand tonnes. This variation is due to the different abundance of individual year classes. The most abundant appeared to be the 1982 and 1980 year classes - 15.708×10^9 and 14.160×10^9 numbers of age groups 0+, respectively. The 1975, 1979 and 1976 year classes (13.262 , 12.627 and 12.236×10^9 , respectively) were close to the above values, followed by the 1977, 1971 and 1990 year classes (10.428 , 9.804 and 9.086×10^9 numbers, respectively). The other year classes were mediocre, and ranged within sizes 4.907×10^9 (1983) and 8.332×10^9 (1985). This factor dominated fluctuations in whiting biomass during the period 1971-1993.

TABLE 56.Whiting numbers (x 10-9 sp.) and biomass (x 10-3 tonnes) in the western part of the Black Sea during the period 1971-1994 (M = const. = 0.70; FSst = 1/2Fst of sprat - I variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	\hat{A}_{1+}
1971	9.804	3.430	1.173	3.512	0.133	0.074	0.038	197.3
1972	2.094	4.864	1.696	0.578	1.742	0.065	0.036	203.1
1973	2.228	1.036	2.405	0.838	0.285	0.864	0.032	162.7
1974	3.538	1.104	0.508	1.190	0.414	0.140	0.429	126.5
1975	13.262	1.752	0.526	0.239	0.580	0.201	0.067	85.6
1976	12.627	6.573	0.855	0.250	0.113	0.284	0.098	134.1
1977	10.482	6.250	3.223	0.401	0.111	0.051	0.137	174.4
1978	6.191	5.200	3.023	1.526	0.166	0.044	0.024	189.1
1979	12.236	3.056	2.489	1.369	0.699	0.064	0.019	174.2
1980	14.160	6.054	1.425	0.992	0.512	0.283	0.027	178.9
1981	7.272	6.818	2.854	0.636	0.432	0.203	0.116	204.5
1982	15.708	3.590	3.143	1.290	0.258	0.191	0.088	183.8
1983	4.907	7.370	1.609	1.440	0.573	0.101	0.082	209.0
1984	5.260	2.359	3.412	0.708	0.656	0.253	0.040	175.1
1985	8.332	2.494	0.964	1.516	0.275	0.292	0.113	141.3
1986	3.863	4.027	1.079	0.388	0.681	0.110	0.134	133.2
1987	2.250	1.846	1.845	0.460	0.156	0.313	0.047	107.4
1988	3.523	1.076	0.776	0.847	0.201	0.064	0.143	82.7
1989	5.865	1.692	0.396	0.329	0.389	0.090	0.028	65.8
1990	9.086	2.764	0.663	0.125	0.132	0.176	0.041	71.1
1991	4.783	3.994	1.264	0.241	0.042	0.056	0.080	93.4
1992	5.609	2.326	1.921	0.598	0.111	0.017	0.026	96.8
1993	5.091	2.743	1.107	0.926	0.284	0.053	0.008	104.4
1994		2.499	1.311	0.537	0.449	0.138	0.025	

The calculations are accomplished by the traditional VPA without additional iterations of F_{st} .

Tables 58, 59 and Figure 21 show the results of the second variant of VPA.

TABLE 58.Whiting numbers ($\times 10^9$ sp.) and biomass ($\times 10^3$ tons) in the western part of the Black Sea during the period 1971-1994 ($M = \text{const.} = 0.70$; $F_{st} = 1/2F_{st \text{ of sprat}} - \text{II variant}$)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	∑1-6
1971	2.708	1.105	0.533	0.195	0.075	0.054	0.021	39.5
1972	1.096	1.340	0.541	0.260	0.095	0.036	0.026	44.8
1973	1.476	0.540	0.655	0.264	0.127	0.046	0.018	39.7
1974	2.734	0.730	0.262	0.321	0.129	0.062	0.022	36.8
1975	10.237	1.353	0.340	0.117	0.149	0.059	0.029	40.1
1976	10.210	5.071	0.657	0.158	0.052	0.070	0.027	87.3
1977	8.447	5.049	0.478	0.302	0.065	0.021	0.031	128.7
1978	4.561	4.189	2.427	1.155	0.117	0.021	0.009	147.2
1979	7.142	2.246	1.988	1.073	0.515	0.040	0.008	132.8
1980	9.165	3.524	1.023	0.743	0.366	0.192	0.016	118.9
1981	5.282	4.337	1.599	0.437	0.309	0.131	0.071	128.0
1982	10.005	2.602	1.912	0.667	0.159	0.129	0.052	113.6
1983	3.618	4.538	1.119	0.829	0.264	0.053	0.052	124.7
1984	3.250	1.718	2.006	0.465	0.353	0.100	0.016	103.2
1985	4.046	1.495	0.647	0.819	0.155	0.142	0.037	78.2
1986	2.583	1.899	0.584	0.231	0.335	0.050	0.060	66.4
1987	1.921	1.210	0.789	0.215	0.078	0.141	0.018	52.3
1988	2.406	0.913	0.461	0.323	0.080	0.026	0.057	41.3
1989	2.657	1.137	0.315	0.172	0.129	0.030	0.009	34.6
1990	4.092	1.171	0.389	0.086	0.054	0.047	0.011	31.2
1991	2.109	1.519	0.474	0.106	0.022	0.018	0.016	34.8
1992	3.247	0.999	0.693	0.206	0.044	0.008	0.007	36.6
1993	4.186	1.570	0.448	0.316	0.089	0.019	0.003	44.2
1994		2.050	0.749	0.210	0.146	0.041	0.009	

* Numbers and biomass of whiting after 5th iteration

It is seen from the above table that after the fifth iteration, the estimated whiting biomass is considerably lower than that obtained by traditional VPA. As was pointed out for shad and anchovy, the results mentioned were due to the fact that the second approach works on the assumption that values of F for the completely recruited age groups should be the same. This is why the estimates of F by age groups and the abundance of their corresponding year classes were respectively higher and lower with the second approach. Thus for instance, the F value for the 1982 year class was 0.0058 with the first approach, while the same value in the second approach is 0.0906, i.e. 15 times higher. Conversely, the abundance of the year class mentioned according to the first manner of computation was 15.708×10^9 specimens, and by the second - 10.085×10^9 specimens of 0+ year old fish. Taken as a whole, the trends for the two approaches are rather similar, despite some differences in the assessments of abundance for individual year classes. To a certain extent, this reflects on the estimates of the whiting biomass, which were significantly lower following the second approach. Besides, the maximum values for whiting biomass reached did not coincide in time. Thus for instance in the first variant the maximum biomass of 209.0 thousand tonnes was involved in 1983, but in the second approach a peak of 147.2 thousand tonnes was shown in 1978, i.e. its absolute value is lower by about 30% and is shifted temporally by 5 years.

TABLE 59. Fishing mortality rate of whiting (by age groups) in the western part of the Black Sea during 1971-1993 ($M = 0.70$; $F_{st} = 1/2 F_{st}$ of sprat II variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+
1971	0.0037	0.0142	0.0173	0.0207	0.0278	0.0183	0.0192
1972	0.0075	0.0152	0.0163	0.0147	0.0207	0.0266	0.0161
1973	0.0038	0.0249	0.0138	0.0186	0.0184	0.0243	0.0183
1974	0.0035	0.0640	0.1077	0.0674	0.0771	0.0765	0.0770
1975	0.0025	0.0227	0.0692	0.1007	0.0526	0.0698	0.0600
1976	0.0041	0.0162	0.0757	0.1882	0.2157	0.1258	0.1214
1977	0.0012	0.0324	0.0628	0.2467	0.4119	0.1862	0.1854
1978	0.0082	0.0456	0.1160	0.1072	0.3693	0.2873	0.1567
1979	0.0063	0.0864	0.2837	0.3749	0.2893	0.2378	0.2538
1980	0.0481	0.0905	0.1505	0.1792	0.3286	0.2935	0.1834
1981	0.0080	0.1193	0.1735	0.3120	0.1686	0.2207	0.1898
1982	0.0906	0.1441	0.1353	0.2268	0.4054	0.2193	0.2241
1983	0.0444	0.1162	0.1777	0.1548	0.2703	0.4779	0.1772
1984	0.0762	0.2765	0.1962	0.3974	0.2110	0.3024	0.2679
1985	0.0564	0.2402	0.3306	0.1935	0.4281	0.1663	0.2947
1986	0.0580	0.1787	0.2978	0.3849	0.1647	0.3296	0.2522
1987	0.0438	0.2651	0.1938	0.2923	0.4137	0.1997	0.2847
1988	0.0490	0.3640	0.2835	0.2194	0.2848	0.3186	0.2802
1989	0.1190	0.3737	0.5984	0.4526	0.3072	0.3286	0.4205
1990	0.2909	0.2040	0.5970	0.6472	0.4293	0.3572	0.4519
1991	0.0479	0.0855	0.1333	0.1810	0.3571	0.1510	0.1806
1992	0.0268	0.1012	0.0854	0.1364	0.1230	0.1863	0.1066
1993	0.0140	0.0405	0.0577	0.0688	0.0748	0.0636	0.0579

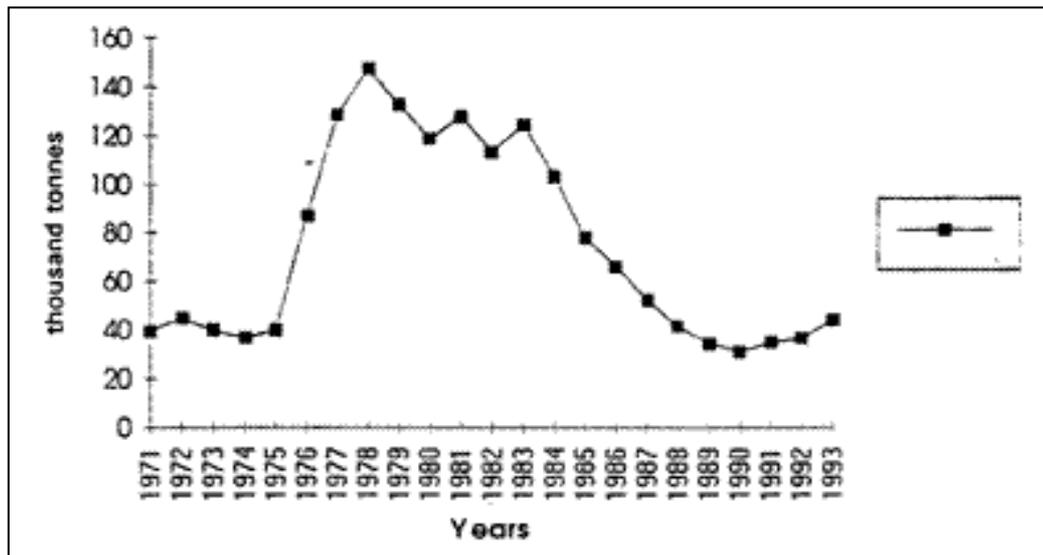


FIGURE 21.Whiting biomass (B_{1+} in thousand tonnes) in the western part of the Black Sea (II variant)

Tables 60, 61 and **Figure 22** present the results from the third variant of VPA are presented.

Whiting biomass ranged between 129.6 (1989) and 503.2 (1972) thousand tonnes. The common features of the variants considered is that in both of them the minimum biomass of whiting occurred in 1989. In relation to the maximum it has to be noted that it is shifted even earlier to 1972 in the third variant. With regard to the abundance of year classes the variations are identical with those existing in the first variant, but they are considerably higher in absolute values. This is related to the lower estimates of F_{st} used in the third variant.

In **Tables 62, 63** and **Figure 23** the results from the fifth variant are shown where M values between age groups differ.

The estimates of year classes abundance in this variant were similar to those found in the first variant, but the former had lower absolute values. The only difference is that with this approach the 1985 year class is stronger than the 1971 year class.

Table 64 gives the final result after the 6th iteration in the first, third and fifth variants, and in **Figure 24** only the last two variants, since the differences between the first 4 variants are negligible and can hardly be graphically differentiated. From the figure it is seen that the trends between the 4 variants mentioned and the 5th (M values among age groups) were equal (after the 6th iteration), and differences were related only to the absolute figures used during the period 1971-1993.

TABLE 60.Whiting numbers ($\times 10^{-9}$) and biomass ($\times 10^{-3}$ tons) in the western part of the Black Sea during the period 1971-1994 ($M = \text{const.} = 0.70$; $F_{st} = 1/5F_{st}$ of sprat - III variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	B ₁₊
1971	23.285	8.233	2.820	9.103	0.329	0.184	0.094	497.4
1972	4.379	11.558	4.076	1.396	4.518	0.162	0.091	503.6
1973	4.062	2.171	5.730	2.019	0.691	2.243	0.080	397.5
1974	6.196	2.014	1.071	2.841	1.000	0.342	1.113	300.1
1975	24.340	3.072	0.978	0.519	1.400	0.492	0.168	185.9
1976	20.988	12.074	1.510	0.474	0.252	0.692	0.242	263.5
1977	18.304	10.401	5.955	0.726	0.222	0.120	0.339	317.7
1978	10.052	9.084	5.085	2.882	0.328	0.099	0.058	338.0
1979	23.091	4.973	4.418	2.393	1.373	0.144	0.047	311.9
1980	26.985	11.444	2.377	1.948	1.019	0.617	0.067	342.8
1981	11.824	13.186	5.531	1.109	0.906	0.455	0.282	403.5
1982	29.327	5.851	6.305	2.619	0.492	0.426	0.213	358.6
1983	7.599	14.132	2.731	3.010	1.233	0.218	0.199	412.8
1984	9.138	3.695	6.769	1.265	1.435	0.581	0.098	344.1
1985	16.241	4.419	1.627	3.183	0.551	0.679	0.275	284.7
1986	6.491	7.955	2.035	0.717	1.508	0.246	0.326	274.1
1987	3.050	3.151	3.795	0.935	0.319	0.724	0.115	219.5
1988	6.117	1.473	1.423	1.815	0.437	0.145	0.346	166.4
1989	12.801	2.981	0.592	0.650	0.869	0.207	0.068	129.6
1990	20.317	6.208	1.301	0.222	0.291	0.415	0.099	155.4
1991	11.451	9.569	2.975	0.557	0.090	0.135	0.199	222.0
1992	13.811	5.637	4.690	1.448	0.268	0.041	0.066	235.3
1993	12.688	6.815	2.751	2.301	0.706	0.131	0.020	259.3
1994		6.272	3.353	1.354	1.132	0.347	0.064	271.7

* It is identical with variant I but the F_{st} value is equal to 1/5 of F_{st} instead of 1/2 F_{st} for sprat.

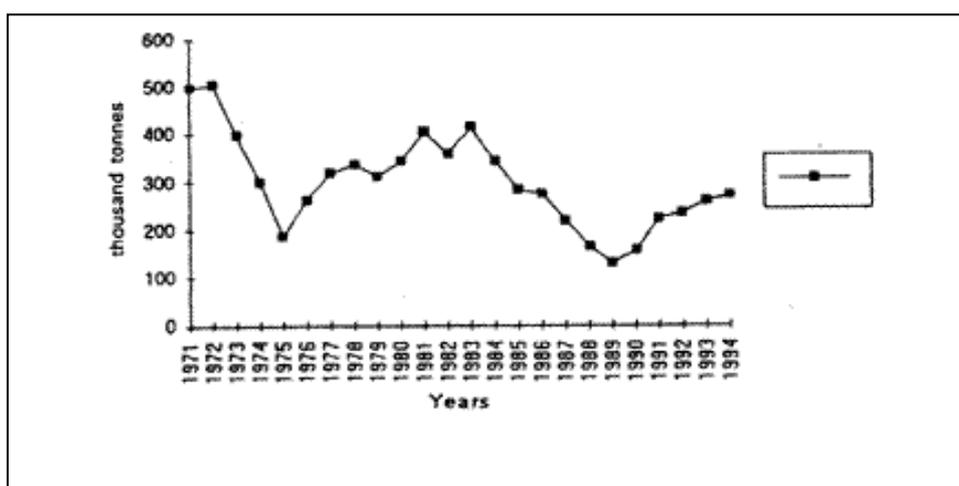


FIGURE 22.Whiting biomass (B_{1+} in thousand tonnes) in the western part of the Black Sea (III variant)

TABLE 62.Whiting numbers (x 10-9) and biomass (x 10-3 tonnes) in the western part of the Black Sea during the period 1971-1994 (M0+=0.70, M1=0.70, M2=0.55, M3=0.70, M4=0.90, M5=0.90, M6=0.90; Fst = Fst of sprat V variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	Â1+
1971	7.179	2.496	0.852	2.866	0.110	0.050	0.021	155.1
1972	1.631	3.560	1.232	0.487	1.421	0.044	0.020	157.8
1973	1.845	0.806	1.758	0.706	0.240	0.577	0.017	120.7
1974	2.948	0.914	0.394	1.009	0.348	0.096	0.234	94.7
1975	11.093	1.459	0.431	0.213	0.491	0.137	0.037	68.6
1976	10.631	5.496	0.710	0.236	0.100	0.196	0.054	108.4
1977	8.812	5.259	2.689	0.384	0.104	0.036	0.076	144.8
1978	5.321	4.373	2.531	1.470	0.158	0.033	0.013	165.1
1979	10.007	2.624	2.079	1.317	0.671	0.048	0.011	155.5
1980	11.571	4.947	1.211	0.933	0.486	0.216	0.016	153.1
1981	6.197	5.532	2.305	0.621	0.403	0.152	0.066	168.7
1982	12.951	3.056	2.505	1.192	0.250	0.143	0.050	154.3
1983	4.277	6.001	1.344	1.314	0.524	0.078	0.047	176.6
1984	4.445	2.046	2.732	0.677	0.593	0.185	0.023	147.1
1985	6.701	2.089	0.809	1.382	0.260	0.211	0.064	119.1
1986	3.239	3.217	0.878	0.368	0.615	0.081	0.076	109.3
1987	2.008	1.536	1.443	0.425	0.146	0.227	0.027	86.5
1988	2.713	0.956	0.622	0.757	0.184	0.047	0.081	68.2
1989	3.358	1.290	0.336	0.297	0.344	0.066	0.016	54.2
1990	4.789	1.519	0.464	0.117	0.116	0.125	0.023	46.8
1991	2.414	1.864	0.647	0.172	0.037	0.039	0.044	49.0
1992	2.876	1.150	0.864	0.341	0.077	0.012	0.015	48.9
1993	2.558	1.385	0.523	0.468	0.156	0.029	0.004	52.7
1994		1.242	0.657	0.288	0.222	0.061	0.011	53.6

TABLE 63. Fishing mortality coefficient of whiting (by age groups) in the western part of the Black Sea during the period 1971-1993 ($M_{0+}=0.70$, $M_1=0.70$, $M_2=0.55$, $M_3=0.70$, $M_4=0.90$, $M_5=0.90$, $M_6=0.90$; $F_{st} = F_{st}$ of sprat V variant)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+
1971	0.0014	0.0063	0.0101	0.0014	0.0207	0.0215	0.0216
1972	0.0050	0.0057	0.0067	0.0079	0.0015	0.0241	0.0232
1973	0.0030	0.0167	0.0048	0.0069	0.0106	0.0021	0.0202
1974	0.0033	0.0509	0.0658	0.0210	0.0305	0.0531	0.0078
1975	0.0023	0.0210	0.0506	0.0542	0.0172	0.0323	0.0500
1976	0.0039	0.0149	0.0653	0.1219	0.1179	0.0474	0.0655
1977	0.0012	0.0311	0.0539	0.1898	0.2623	0.1141	0.0779
1978	0.0070	0.0437	0.1036	0.0834	0.2888	0.1972	0.1103
1979	0.0045	0.0735	0.2508	0.2957	0.2357	0.2149	0.1973
1980	0.0379	0.0637	0.1174	0.1403	0.2613	0.2819	0.2013
1981	0.0068	0.0924	0.1096	0.2105	0.1388	0.2051	0.2246
1982	0.0693	0.1215	0.0950	0.1214	0.2640	0.2163	0.2551
1983	0.0375	0.0868	0.1361	0.0952	0.1402	0.3288	0.2166
1984	0.0552	0.2273	0.1312	0.2579	0.1320	0.1680	0.2008
1985	0.0337	0.1666	0.2385	0.1106	0.2591	0.1190	0.1759
1986	0.0460	0.1021	0.1763	0.2262	0.0949	0.2103	0.2105
1987	0.0419	0.2035	0.0950	0.1389	0.2226	0.1310	0.1996
1988	0.0433	0.3449	0.1890	0.0884	0.1259	0.1764	0.2093
1989	0.0931	0.3227	0.5088	0.2406	0.1153	0.1503	0.2430
1990	0.2438	0.1539	0.4417	0.4389	0.1992	0.1333	0.2053
1991	0.0418	0.0692	0.0898	0.1083	0.2196	0.0724	0.0690
1992	0.0303	0.0873	0.0635	0.0804	0.0753	0.1259	0.0585
1993	0.0230	0.0460	0.0460	0.0460	0.0460	0.0460	0.0460

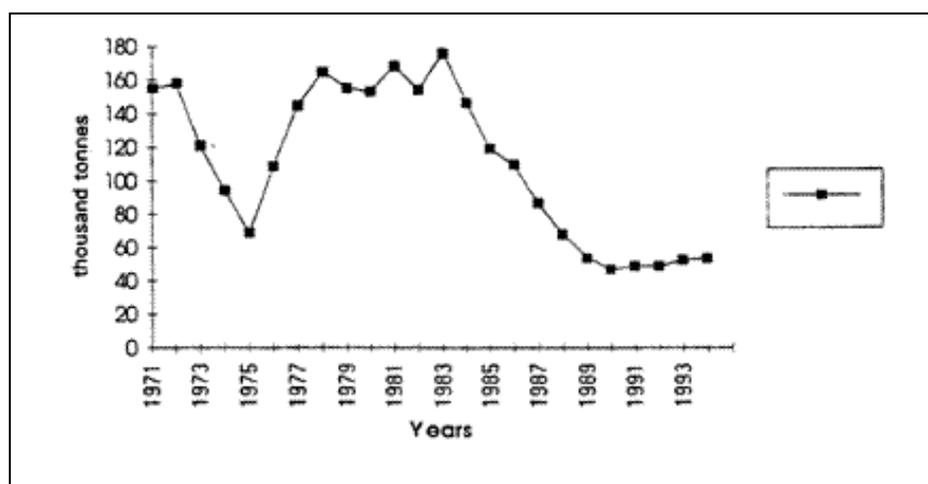


FIGURE 23. Whiting biomass (B_{1+} in thousand tonnes) in the western part of the Black Sea (V variant)

TABLE 64.VPA results after ad hoc tuning of the initial values of Fst for the oldest age group (6,6+)

Years	start *	start **	start ***	I ite- ration *	I ite- ration **	I ite- ration ***	II ite- ration *	II ite- ration **	II ite- ration ***
1971	197.3	497.4	155.1	80.0	165.4	95.2	49.7	78.4	85.6
1972	203.1	503.6	157.8	78.7	154.1	95.9	53.0	78.8	90.4
1973	162.7	397.5	120.7	62.0	115.3	77.5	45.5	65.3	77.1
1974	126.5	300.4	94.7	52.2	91.0	65.0	41.5	57.0	67.4
1975	85.6	185.2	68.6	51.7	83.7	60.9	45.0	59.2	66.6
1976	134.1	263.5	108.4	108.0	165.1	123.3	98.0	123.3	135.5
1977	174.4	317.7	144.8	157.9	232.9	177.0	142.8	174.6	189.5
1978	189.1	338.0	165.1	185.3	276.9	215.3	165.1	203.3	227.9
1979	174.2	311.9	155.5	167.0	247.6	198.5	148.8	182.0	208.6
1980	178.9	342.8	153.1	153.7	233.2	182.3	134.4	165.5	188.6
1981	204.5	403.5	168.7	172.9	270.1	199.8	144.8	178.9	196.9
1982	183.8	358.6	154.3	153.5	237.1	176.3	127.5	156.2	169.2
1983	209.0	412.8	176.6	167.7	250.6	196.6	141.0	176.9	184.1
1984	175.1	344.1	147.1	136.6	199.7	159.5	116.4	146.4	148.4
1985	141.3	284.7	119.1	105.0	156.1	123.5	89.8	117.1	114.9
1986	133.3	274.1	109.3	90.8	140.6	101.4	78.8	109.5	95.8
1987	107.4	219.5	86.5	72.3	115.1	74.5	62.9	89.8	71.8
1988	82.7	166.4	68.2	57.4	92.9	57.2	48.9	71.2	56.0
1989	65.8	129.6	54.2	48.4	81.8	46.1	40.6	59.0	46.2
1990	71.1	155.4	46.8	48.3	90.6	41.7	38.4	59.3	42.3
1991	93.4	222.0	49.0	57.2	113.1	46.4	44.4	71.2	47.3
1992	96.8	235.3	48.9	59.2	115.6	48.3	46.3	73.4	49.1
1993	104.4	259.3	52.7	70.2	132.8	57.4	55.2	86.2	57.6

* - I variant ; ** - III variant; *** - V - variant

Table 64 - continued

Years	III ite- ration *	III ite- ration **	III ite- ration ***	IV ite- ration *	IV ite- ration **	IV ite- ration ***	V ite- ration *	V ite- ration **	V ite- ration ***
1971	43.2	56.9	93.9	41.1	47.8	101.6	39.5	42.4	103.2
1972	48.9	62.1	102.0	46.5	52.7	108.0	44.8	47.4	108.3
1973	43.1	53.6	87.6	41.0	45.7	91.5	39.7	41.6	91.2
1974	37.8	47.7	75.5	36.8	41.3	77.8	36.8	38.3	77.2
1975	41.0	42.6	72.1	40.1	43.9	72.9	40.1	41.5	72.2
1976	88.7	102.5	138.8	87.3	93.8	137.0	87.3	90.3	136.3
1977	130.5	146.7	190.7	128.7	136.9	187.6	128.7	132.6	187.0
1978	149.5	168.4	225.8	147.2	157.9	221.9	147.2	152.2	221.7
1979	134.9	151.6	205.5	132.8	142.7	202.3	132.8	137.3	202.2
1980	121.0	138.4	184.1	118.9	129.2	181.8	118.9	123.5	182.0
1981	130.1	154.5	191.8	128.0	141.0	190.8	128.0	133.6	191.3
1982	115.1	137.7	164.9	113.6	125.0	164.7	113.6	118.4	165.3
1983	126.1	154.6	181.0	124.7	138.2	181.5	124.7	130.2	182.2
1984	104.2	127.9	146.6	103.2	114.1	147.3	103.2	107.6	147.8
1985	79.1	99.1	114.1	78.2	87.4	114.8	78.2	81.9	115.2
1986	67.6	87.3	96.0	66.4	75.6	96.6	66.4	70.0	97.0
1987	53.5	69.4	72.4	52.3	59.8	72.9	52.3	55.2	73.1
1988	42.3	54.7	56.6	41.3	47.3	57.0	41.3	43.6	57.1
1989	35.5	45.3	46.8	34.6	39.3	47.1	34.6	36.3	47.2
1990	32.3	44.0	43.0	31.2	36.7	43.3	31.2	33.1	43.3
1991	36.3	51.4	48.0	34.8	41.8	48.3	34.8	36.9	48.3
1992	38.0	53.4	49.8	36.6	43.4	50.0	36.6	38.4	50.0
1993	45.9	63.4	58.1	44.2	51.9	58.3	44.2	46.0	58.4

* - results from VPA (I variant) after 5th iteration

** - results from VPA (III variant) after 5th iteration

*** - results from VPA (V variant) after 5th iteration

In Table 65 the age composition of the whiting catches in the eastern part of the Black Sea is presented. These data were made available to us by V. Shlyakhov (YugNIRO, Ukraine). According to this author the whiting from the eastern part of the Black Sea reaches a length of 35 cm and age 8 years. In relation to size composition of the catches, the Turkish data are akin to those of the cited author, but differ radically in age structure.

TABLE 65. Age composition (x 10-6) of whiting catches (in tonnes) in the eastern part of the Black Sea

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	7,7+	8,8+	CW	W
1971	21.06	15.18	25.14	42.13	26.40	5.34	3.09	1.82	0.28	5954.8	42.4
1972	5.24	15.02	30.26	34.93	22.82	5.24	1.75	0.82	0.35	5064.6	43.5
1973	8.79	21.12	39.70	16.14	4.26	0.55	0.10	0.00	0.00	2257.5	24.9
1974	5.15	5.67	24.39	30.87	8.06	0.30	0.08	0.08	0.00	2648.3	35.5
1975	24.08	15.95	57.98	36.90	6.70	0.71	0.14	0.00	0.00	3818.0	26.8
1976	47.86	25.50	62.83	44.16	3.70	0.55	0.19	0.00	0.00	4213.3	22.8
1977	35.61	54.61	89.98	52.55	6.26	1.20	0.48	0.00	0.00	5726.3	23.8
1978	44.88	89.77	370.12	191.31	35.32	2.94	0.74	0.74	0.00	21265.2	28.9
1979	2.65	7.94	92.64	242.19	76.76	13.68	3.09	1.76	0.44	20778.0	47.1
1980	79.93	18.55	26.86	41.50	38.73	8.63	0.43	0.43	0.65	6838.0	31.7
1981	40.57	47.92	34.97	31.13	9.62	9.44	0.87	0.35	0.00	4669.0	26.7
1982	16.27	23.81	69.61	26.67	11.45	2.26	0.30	0.15	0.15	4264.0	28.3
1983	24.51	32.92	166.68	90.00	20.66	8.76	5.60	0.70	0.35	11696.0	33.4
1984	0.16	0.49	15.87	53.12	42.43	39.35	6.34	3.56	0.62	11595.0	71.6
1985	31.55	6.87	6.66	18.25	63.11	61.83	22.11	3.22	1.07	16036.0	74.7
1986	10.06	19.89	26.28	20.57	45.26	70.40	28.80	6.40	0.92	17738.0	77.6
1987	2.07	31.55	186.71	110.17	97.24	64.14	19.66	4.07	1.62	27103.0	52.4
1988	51.39	154.16	263.07	186.28	115.62	23.89	6.62	1.30	0.60	28263.0	35.2
1989	35.02	105.07	179.51	126.96	78.81	16.96	3.83	1.55	0.10	19283.0	35.2
1990	21.10	12.26	89.36	148.93	87.25	8.76	1.75	0.00	0.00	16259.0	43.9
1991	418.01	844.13	257.62	64.81	32.40	1.60	1.60	0.00	0.00	18956.0	11.7
1992	186.93	218.22	368.33	101.95	22.11	6.13	1.89	0.00	0.00	18320.2	20.2
1993	54.30	81.56	104.23	129.15	36.93	5.05	0.65	0.49	0.00	10000.0	24.3
1994	65.60	203.18	90.48	48.96	70.45	12.18	1.48	0.13	0.09	15000.0	30.5

CN - total catches (x 10-6); CW - total catches (in tonnes x 10-3); W - mean weight values (g)

The differences between the weights at x age are still greater, namely:

Age	Eastern part of Black Sea W (g)	Western part of Black Sea W (g)
0+	4.0	4.2
1	12.8	11.6
2	23.4	21.4
3	44.4	33.7
4	71.7	48.2
5	104.2	63.3
6	140.9	79.2
7	180.2	
8	222.0	

On the basis of these data for the western part of the basin the parameters of von Bertalanffy's equation were established:

$$W_{\infty} = 285.5 \text{ g} \quad k = 0.12715 \quad t_0 = - 2.31128$$

The pointed values do not differ significantly from those defined only on the basis of the Bulgarian data (Prodanov, 1984):

$$W_{\infty} = 231.9 \text{ g} \quad k = 0.135 \quad t_0 = - 2.412$$

When Shlyakhov's data for whiting growth in weight by ages in the eastern part of the Black Sea were used in the same manner, a value of $W_{\infty} = 2270.0 \text{ g}$ was obtained that is too high.

Table 66 and Table 67 show the results from VPA with tuning of the initial values of fishing mortality coefficient for the oldest age group (8 year olds). From Table 66 it is seen that whiting biomass in the eastern part of the Black Sea ranged from 73.0 (1990)/73.9 (1989) to 489.3 (1978) thousand tonnes. The fluctuations in the eastern population biomass coincided as a trend with those of the western population but the former had higher values when comparing their absolute values (on average, two-fold). These differences were due more to the heavier weights used for the whiting than the higher abundance, both relating to the eastern part of the Black Sea.

Figure 25 shows the VPA data for 0+ year old fish abundance and the ones obtained by trawl surveys carried out by YugNIRO (usually in May). It is seen from this Figure that the assessments of total 0+ year old fish abundance by the two methods had a similar trend and did not differ substantially in absolute values. Relatively higher differences were detected for the areas, primarily in 1982, since the estimates from trawl surveys showed that recruitment abundance in the western and the eastern parts of the basin was 5.3 and 14.1 x 10⁹ of specimens respectively, overall 19.4 x 10⁹ specimens and from VPA, 13.0 and 3.6, total 16.6 x 10⁹ numbers of specimens. Despite the differences, the coincidence as a whole is quite significant, especially for the recruit abundance in the entire Black Sea, and showed that VPA results could be used further for analysing the causes of whiting recruitment variations.

TABLE 66.Whiting numbers (x 10-9) and biomass (x 10-3 tonnes) in the eastern part of the Black Sea during the period 1971-1994

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	7,7+	8,8+	Å1+
1971	6.572	0.377	2.101	0.228	0.078	0.068	0.036	0.013	0.002	84.7
1972	24.968	3.249	0.196	1.194	0.106	0.021	0.024	0.010	0.003	114.9
1973	5.406	12.395	1.772	0.091	0.697	0.037	0.005	0.007	0.002	260.6
1974	9.331	2.679	6.787	0.993	0.043	0.343	0.015	0.002	0.000	278.4
1975	9.436	4.630	1.466	3.898	0.578	0.016	0.139	0.005	0.000	330.2
1976	30.744	4.669	2.529	0.802	2.335	0.283	0.006	0.046	0.000	360.7
1977	12.306	15.234	2.544	1.412	0.453	1.157	0.115	0.002	0.000	486.7
1978	7.520	6.086	8.321	1.400	0.816	0.221	0.470	0.038	0.000	489.3
1979	13.058	3.703	3.275	4.524	0.703	0.381	0.088	0.156	0.010	454.6
1980	9.796	6.408	2.027	1.820	2.558	0.297	0.147	0.028	0.042	460.4
1981	8.304	4.809	3.544	1.149	1.072	1.243	0.115	0.049	0.000	426.9
1982	3.607	4.096	2.604	2.019	0.673	0.526	0.500	0.038	0.013	386.2
1983	2.992	1.780	2.230	1.450	1.204	0.326	0.212	0.166	0.010	321.9
1984	3.434	1.469	0.953	1.162	0.810	0.584	0.127	0.068	0.045	251.8
1985	4.272	1.705	0.805	0.537	0.664	0.373	0.213	0.039	0.017	192.0
1986	4.356	2.300	0.930	0.460	0.312	0.287	0.114	0.059	0.009	149.6
1987	3.297	2.156	1.138	0.517	0.263	0.124	0.075	0.023	0.013	126.5
1988	2.430	1.636	1.160	0.517	0.230	0.066	0.014	0.015	0.005	100.3
1989	4.342	1.171	0.786	0.475	0.174	0.039	0.012	0.002	0.004	73.9
1990	8.969	2.132	0.567	0.321	0.192	0.035	0.006	0.000	0.000	73.0
1991	3.956	4.439	1.161	0.261	0.083	0.038	0.009	0.000	0.000	106.8
1992	4.343	1.678	1.829	0.479	0.109	0.020	0.014	0.000	0.000	97.5
1993	12.975	2.028	0.763	0.782	0.213	0.039	0.005	0.004	0.000	99.2
1994	6.081	6.377	1.046	0.356	0.369	0.079	0.013	0.001	0.001	158.7
1995		2.995	3.368	0.540	0.183	0.139	0.025	0.003	+	

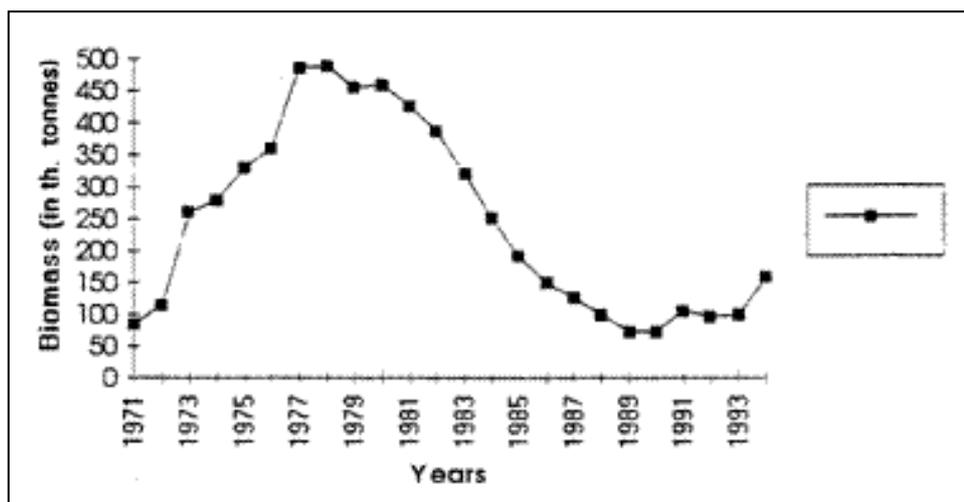


FIGURE 24.Whiting biomass (B1+ in thousand tonnes) in the eastern part of the Black Sea (data according to Table 66)

TABLE 67. Fishing mortality coefficients (by age groups) in the eastern part of the Black Sea
($M = \text{const.} = 0.70$)

Years	0+	1,1+	2,2+	3,3+	4,4+	5,5+	6,6+	7,7+	8,8+
1971	0.0045	0.0548	0.0157	0.2648	0.6088	0.1252	0.1514	0.2722	0.2413
1972	0.0003	0.0062	0.2216	0.0378	0.3475	0.4555	0.1241	0.1518	0.2501
1973	0.0023	0.0023	0.0295	0.2537	0.0085	0.0227	0.0308	0.0768	0.0768
1974	0.0008	0.0028	0.0047	0.0403	0.2989	0.0013	0.0090	0.0845	0.0000
1975	0.0036	0.0046	0.0527	0.0121	0.0162	0.0707	0.0017	0.0372	0.0000
1976	0.0022	0.0073	0.0328	0.0723	0.0022	0.0030	0.0538	0.0273	0.0000
1977	0.0040	0.0048	0.0470	0.0483	0.0194	0.0016	0.0069	0.0289	0.0000
1978	0.0083	0.0198	0.0594	0.1891	0.0618	0.0204	0.0026	0.0354	0.0000
1979	0.0003	0.0029	0.0374	0.0702	0.1630	0.0558	0.0594	0.0203	0.0815
1980	0.0114	0.0038	0.0174	0.02940.	0.0213	0.0450	0.0048	0.0282	0.02820.
1981	0.0068	0.0133	0.0129	0.350	0.0125	0.0116	0.0125	0.0130	0.0000
1982	0.0063	0.0078	0.0353	0.0169	0.0239	0.0065	0.0010	0.0071	0.0207
1983	0.0114	0.0249	0.1017	0.0818	0.0241	0.0414	0.0443	0.0076	0.0625
1984	0.0001	0.0004	0.0219	0.0597	0.0752	0.1070	0.0712	0.0978	0.0661
1985	0.0103	0.0054	0.0108	0.0440	0.1405	0.2823	0.1842	0.1549	0.1199
1986	0.0032	0.0127	0.0373	0.0584	0.2220	0.4472	0.5054	0.2102	0.1923
1987	0.0009	0.0196	0.2371	0.3110	0.6818	1.2627	0.5362	0.1721	0.6260
1988	0.0298	0.1330	0.3431	0.5909	1.0748	0.7769	0.9150	0.0375	0.7023
1989	0.0113	0.1262	0.3461	0.4065	0.9125	0.9581	0.6587	0.6587	0.6587
1990	0.0033	0.0077	0.2269	0.8440	0.9179	0.4625	0.5985	0.0000	0.0000
1991	0.1574	0.2869	0.3345	0.3729	0.7272	0.0656	0.3400	0.0000	0.0000
1992	0.0615	0.1879	0.2990	0.3104	0.3247	0.5864	0.2365	0.0000	0.0000
1993	0.0058	0.0548	0.1936	0.2329	0.2709	0.2147	0.2621	0.2536	0.0000
1994	0.0150	0.0430	0.1177	0.1865	0.2960	0.2543	0.2070	0.2172	0.2172

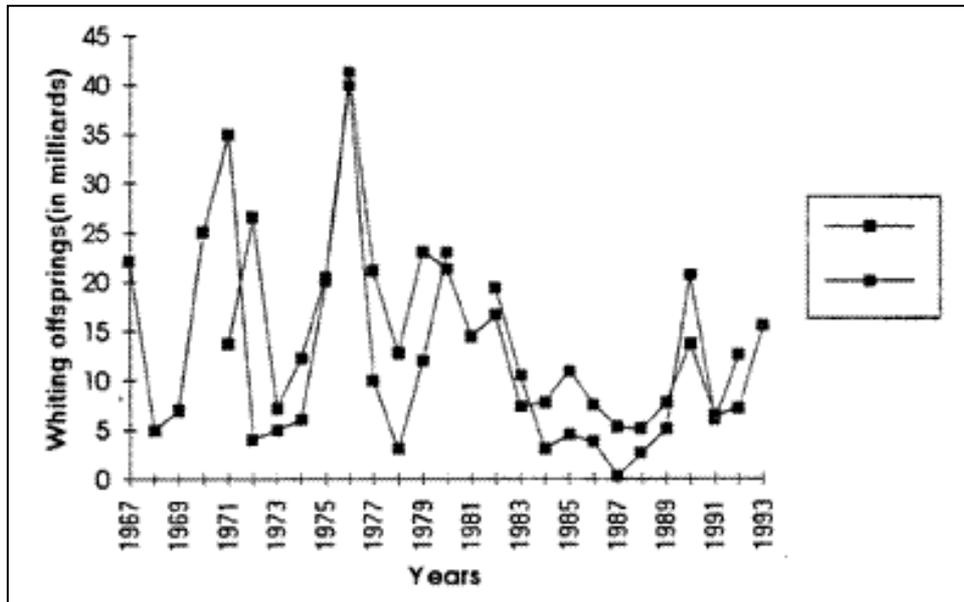


FIGURE 25. Number of whiting offsprings ($\times 109$) in the Black Sea during the period 1967-1993 (1-ichthyoplankton surveys; 2- VPA)