III. STOCK ASSESSMENT OF COMMERCIAL FISH SPECIES IN THE BLACK SEA

SPINY DOGFISH, *SQUALUS ACANTHIAS* LINNAEUS

The spiny dogfish, *Squalus acanthias*, is wide-spread in the Atlantic, the Mediterranean and the Black Sea, where a specialised fishery is carried out for this species.

Table 17 shows the landings by countries during the period 1967-1992. Total catches have ranged from 191.1 (1967) to 12 296.1 (1979); on average 4 011.5 tonnes. The greatest amounts are taken in Turkey whose average catch of 2 800.8 tons represents 69.82% of the total . The next country is the former USSR with 1 159.9 tonnes (28.91%). From the pointed out figures it is evident that the Bulgarian and Romanian yields are insignificant - 26.3 (0.66%) and 24.5 (0.61%) tons, respectively.

TABLE 17. Spiny dogfish catches (tonnes) in the Black Sea during 1967-1992

Year	Bulgaria	Romania	Former USSR	Turkey	Total
1967				191.1	191.1
1968				797.9	797.9
1969				207.3	207.3
1970				521.2	521.2
1971				2585.1	2585.1
1972	20.0		606.0	2081.6	2707.6
1973	9.0		1515.0	443.1	1967.1
1974	1.0	6.0	1000.0	1346.1	2353.5
1975	4.0	6.0	636.0	0.0	646.0
1976	4.0	3.0	1400.0	1178.4	2585.4
1977	18.0	1.0	1300.0	1214.3	2533.3
1978	21.0	4.0	1400.0	1127.9	2556.9
1979	6.0	3.0	1400.0	10887.1	12296.1
1980	10.0	3.0	1700.0	4702.0	6419.0
1981	27.4	8.0	1500.0	5602.0	7137.4
1982	20.0	19.0	1700.0	6750.0	8489.0
1983	52.0	93.0	1600.0	7161.0	8906.0
1984	53.2	134.0	1500.0	4588.0	6275.2
1985	67.5	77.0	2100.0	2598.0	4842.5
1986	152.6	52.0	2100.0	2581.0	4882.6
1987	90.3	49.0	1800.0	3139.0	5078.3
1988	50.9	25.0	1900.0	3261.0	5236.9
1989	27.7	30.0	300.0**	4558.0	4915.7
1990	16.4	45.0	1700.0	1059.0	2820.4
1991	16.0*	26.0	1500.0***	2017.0	3559.0
1992	16.0*	53.0	1500.0***	2220.0	3789.0
Average	26.3	24.5	1159.9	2800.8	4011.5
%	0.66	0.61	28.91	69.82	100.00

* Bulgarian catches in 1991 and 1992 are set at 6 tonnes but probably were considerably larger. After 1989 no fishery statistics data were available, so the latter is adopted as possibly its lowest level.

** Former USSR catches for 1989 after Ukrainian data are 300 tonnes.*** According to Kirsonova (1993) catches by Ukraine and the former USSR during the period 1983 - 1992 varied between 1500 and 2200 tonnes.

During the last 10 years the price of spiny dogfish grew rapidly, which led to heavy fishing of thisspecies. For lack of effective control, the prevailing quantities from the catches are not reported in the fishery statistics after 1989 for Bulgaria and Romania, and to some extent for Ukraine and the other former Soviet countries. All this hinders precise stock assessments, especially during the last few years. However, the Black Sea spiny dogfish has a long life span which is the reason for the smaller fluctuations in its biomass.

Table 18 presents the age composition of the total catches, based primarily on Ukrainian data.

TABLE 18. Age composition (x 10^{-3} specimens) of spiny dogfish catches during 1972-1992

Year	4	5	6	7	8	9	10	11	12
1972	0.28	1.93	2.85	5.04	6.68	12.98	24.26	30.05	55.46
1973	0.06	0.41	0.65	1.15	1.48	3.28	6.59	8.49	42.15
1974	0.18	1.24	1.84	3.26	4.30	8.48	16.02	23.07	45.13
1975	0.00	0.00	0.00	0.05	0.10	0.15	0.38	0.88	4.36
1976	0.15	1.08	1.61	2.85	3.78	7.19	14.06	20.59	38.89
1977	0.16	1.12	1.65	2.99	3.99	7.76	14.88	29.02	52.20
1978	0.15	1.04	1.54	2.79	3.67	7.50	14.39	23.70	47.83
1979	1.45	10.03	14.85	25.98	34.00	65.52	121.90	141.90	258.50
1980	0.65	4.35	6.43	11.31	14.73	28.69	54.00	68.70	129.60
1981	1.23	4.37	3.27	4.35	9.21	22.70	23.35	61.90	44.30
1982	2.30	6.92	20.83	51.87	46.98	134.20	73.16	48.80	117.90
1983	1.44	18.71	20.83	38.20	14.00	108.50	66.25	84.54	207.10
1984	0.31	2.22	2.93	5.96	7.61	9.92	6.96	19.18	73.65
1985	1.16	4.86	6.87	28.05	8.64	33.59	29.86	60.94	132.98
1986	1.16	2.63	12.83	13.13	12.78	66.02	34.82	52.96	78.46
1987	0.60	2.10	9.70	9.18	12.35	69.95	33.31	40.35	98.14
1988	0.86	3.68	18.35	28.65	53.73	190.40	120.50	104.30	121.30
1989	0.86	4.01	4.38	7.13	12.86	51.31	24.06	28.58	55.49
1990	0.28	2.32	5.40	6.12	10.83	38.72	26.73	38.41	50.72
1991	0.94	6.02	3.66	2.25	3.71	14.86	17.77	9.71	49.73
1992	1.03	7.76	15.78	20.12	6.83	26.97	45.93	52.47	37.83

TABLE 18 - continued

Year	13	14	15	16	17	18	19	C_N	W (g)
1972	92.44	76.96	78.16	32.03	10.85	1.66	0.41	432.11	6.27
1973	60.91	57.32	62.33	29.39	13.42	1.13	0.09	288.85	6.81
1974	77.51	67.29	70.38	30.53	11.87	1.40	0.27	362.77	6.49
1975	10.20	19.09	18.77	21.04	10.39	5.11	0.37	90.89	7.10
1976	74.43	78.71	100.21	47.63	16.54	1.61	0.23	409.56	6.31
1977	92.84	69.48	71.75	37.41	15.28	2.56	0.26	403.35	6.28
1978	83.45	74.58	79.31	35.65	14.86	1.51	0.22	392.19	6.52
1979	426.70	347.70	348.10	137.80	42.35	7.58	2.15	1986.51	6.19
1980	217.60	182.90	180.60	77.41	27.10	3.89	0.93	1008.89	6.36
1981	406.60	276.90	171.40	50.19	16.92	2.73	0.00	1099.42	6.49
1982	208.90	178.00	293.80	135.80	18.10	6.33	1.21	1345.10	6.31
1983	580.40	274.10	131.80	4.78	14.26	0.00	0.00	1564.91	5.69
1984	295.70	209.20	239.60	55.01	3.75	1.37	0.00	033.37	6.72
1985	135.36	135.15	129.65	56.67	24.14	1.53	0.08	799.53	6.13
1986	169.30	181.70	90.91	60.78	19.65	1.65	4.36	823.14	6.05
1987	95.74	167.20	182.50	57.51	16.36	10.15	0.00	805.14	6.31
1988	110.10	119.80	89.74	43.13	10.79	4.44	0.00	1019.77	5.14
1989	154.70	120.40	181.20	78.11	18.88	6.34	0.00	755.31	6.51
1990	87.43	48.46	109.50	31.92	8.03	2.44	0.00	467.31	6.04
1991	96.18	52.99	133.63	96.11	29.74	8.77	3.29	529.36	6.72
1992	59.87	65.63	46.19	79.63	48.12	11.53	3.96	549.65	6.89

Spiny dogfish ageing is done using the spines (Ukraine) and age readings are quite unreliable. For this reason only data on catch size composition for the rest of the countries during certain years were available. For these years the size - age composition key prepared by Ukrainian colleagues was used and for other years, the age composition of the former USSR catches only.

As a species with a long life span the spiny dogfish has a low natural mortality coefficient, being highest in the first year of life and lowest when attaining sexual maturity. According to Kirnosova (1990), the values of M, at the average for both sexes (by age groups), are as follows: (**Table 19**).

TABLE 19. Natural mortality coefficients (by age groups) of spiny dogfish

Age	M	Age	M	Age	M
4	0.24	10	0.07	16	0.42
5	0.20	11	0.05	17	0.60
6	0.14	12	0.09	18	0.92
7	0.12	13	0.16	19	2.84
8	0.10	14	0.49		
9	0.09	15	1.51		

According to this author the high natural mortality of the 15 year old fishes is attributed to the great mortality rate of the males for which this is the definitive age. The same applies to the females but at age 19 years. As with many other fish species, the lower survival of males is due to the earlier attainment of sexual maturity - at age 10-11 years, while females start spawning at age 13-14 years. At these ages their values of M ranged from 0.03 to 0.05.

Kirsonova and Shlyakhov (1988) found that the spiny dogfish exploited stock comprises fish from 8 to 19 years. The younger age groups inhabit areas where no trawl fishery is carried out. Therefore, the trawl surveys covering the shelf area account only for the older age groups in the exploited stock. The Turkish size compositions show that irrespective of their inconsiderable quantities, fish at age 4-7 years are available in the catches. For these ages the following values for partial recruitment to the exploited stock (after Ukrainian data) were adopted:

TABLE 20. Partial recruitment of spiny dogfish exploited stock

Age	Partial Recruitment	Age	Partial Recruitment	Age	Partial Recruitment
4	0.056	10	0.745	16	1.000
5	0.142	11	0.837	17	1.000
6	0.245	12	0.918	18	1.000
7	0.375	13	0.973	19	1.000
8	0.500	14	1.000		
9	0.640	15	1.000		

Table 21, **22** and **Figure 3** show the results of VPA performed by tuning of F_{st} for the oldest ages. From **Table 21** and **Figure 3** it is seen that the exploited stock has gradually increased till 1981 when it reached its maximum of 226.7 thousand tonnes and then slowly decreased to 90.0 thousand tonnes in 1992. The level of the mentioned stock was in accordance with that of its preys - whiting, sprat, anchovy and horse mackerel. The biomass of these species were at their maximum in 1978-1981 except for that of horse mackerel whose peak was in 1983-1985.

TABLE 21.Stock assessment (x 10^{-6} specimens and x 10^{-3} tonnes) of spiny dogfish in the Black Sea during 1972-1992

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Â4-19
1972	9.479	27.018	6.365	4.647	4.840	4.181	2.625	2.442	2.341	1.420	1.101	0.661	0.174	0.039	0.007	0.008	79.3
1973	19.868	7.456	22.119	5.531	4.117	4.373	3.809	2.424	2.294	2.086	1.125	0.615	0.113	0.089	0.014	0.002	85.9
1974	16.712	15.629	6.104	19.229	4.904	3.724	3.994	3.545	2.297	2.056	1.722	0.645	0.110	0.051	0.039	0.005	95.6
1975	13.464	13.146	12.795	5.305	17.051	4.433	3.395	3.708	3.349	2.056	1.681	1.003	0.113	0.047	0.020	0.015	133.4
1976	19.306	10.591	10.763	11.123	4.705	15.429	4.052	3.165	3.527	3.057	1.743	1.015	0.214	0.058	0.019	0.005	143.0
1977	19.597	15.187	8.670	9.355	9.863	4.254	14.094	3.764	2.991	3.186	2.536	1.007	0.182	0.102	0.020	0.007	166.0
1978	12.666	15.416	12.433	7.536	8.295	8.920	3.880	13.127	3.552	2.684	2.629	1.500	0.192	0.090	0.045	0.006	184.2
1979	14.945	9.963	12.620	10.807	6.681	7.502	8.146	3.604	12.463	3.201	2.210	1.553	0.298	0.098	0.039	0.017	198.4
1980	11.230	11.755	8.148	10.958	9.561	6.013	6.794	7.477	3.290	11.144	2.335	1.087	0.203	0.088	0.024	0.011	210.2
1981	4.242	8.834	9.620	7.078	9.708	8.637	5.468	6.282	7.045	2.883	9.295	1.289	0.166	0.072	0.029	0.000	226.7
1982	7.262	3.336	7.228	8.360	6.273	8.775	7.872	5.076	5.915	6.397	2.083	5.480	0.213	0.069	0.028	0.010	220.9
1983	4.448	5.711	2.725	6.265	7.366	5.632	7.892	7.269	4.781	5.594	5.258	1.139	1.087	0.036	0.000	0.000	206.4
1984	5.422	3.497	4.659	2.350	5.520	6.652	5.043	7.294	6.832	4.172	3.977	3.010	0.197	0.710	0.010	0.000	203.6
1985	10.695	4.265	2.861	4.047	2.078	4.989	6.070	4.695	6.920	6.174	3.282	2.275	0.564	0.086	0.387	0.003	186.4
1986	13.467	8.412	3.487	2.481	3.563	1.872	4.526	5.631	4.407	6.197	5.136	1.905	0.448	0.325	0.030	0153	176.2
1987	4.850	10.592	6.885	3.020	2.188	3.212	1.648	4.187	5.304	3.953	5.125	3.006	0.382	0.246	0.164	0.000	157.8
1988	4.540	3.814	8.670	5.976	2.670	1.968	2.869	1.505	3.943	4.754	3.280	3.010	0.587	0.205	0.123	0.000	134.0
1989	15.918	3.570	3.120	7.521	5.273	2.365	1.617	2.558	1.329	3.488	3.950	1.917	0.627	0.351	0.105	0.000	117.8
1990	17.526	12.521	2.922	2.711	6.667	4.768	2.145	1.501	2.425	1.199	2.922	2.387	0.409	0.392	0.188	0.000	112.9
1991	15.555	13.786	10.249	2.535	2.399	6.022	4.321	1.974	1.390	2.168	0.941	1.752	0.481	0.243	0.209	0.074	97.9
1992	11.586	12.235	11.282	8.907	2.246	2.167	5.490	4.011	1.868	1.223	1.759	0.535	0.331	0.239	0.112	0.078	90.0

TABLE 22. Fishing mortality rate of spiny dogfish during 1972-1992

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1972	0.0000	0.0001	0.0005	0.0012	0.0015	0.0033	0.0096	0.0127	0.0251	0.0730	0.0922	0.2517	0.2536	0.4532	0.4626	0.1675
1973	0.0000	0.0001	0.0000	0.0002	0.0004	0.0008	0.0018	0.0036	0.0194	0.0321	0.0665	0.2126	0.3759	0.2224	0.1355	0.1715
1974	0.0000	0.0001	0.0003	0.0002	0.0009	0.0024	0.0042	0.0067	0.0208	0.0416	0.0506	0.2305	0.4089	0.3609	0.0564	0.1825
1975	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0014	0.0054	0.0145	0.0368	0.2560	0.3333	0.4861	0.0779
1976	0.0000	0.0001	0.0002	0.0003	0.0008	0.0005	0.0036	0.0067	0.0116	0.0267	0.0587	0.2066	0.3151	0.4679	0.1384	0.1509
1977	0.0000	0.0001	0.0002	0.0003	0.0004	0.0019	0.0011	0.0079	0.0184	0.0320	0.0352	0.1458	0.2861	0.2186	0.2169	0.1242
1978	0.0000	0.0001	0.0001	0.0004	0.0005	0.0009	0.0038	0.0019	0.0142	0.0342	0.0365	0.1067	0.2550	0.2446	0.0523	0.1079
1979	0.0001	0.0011	0.0013	0.0026	0.0054	0.0092	0.0156	0.0412	0.0219	0.1554	0.2197	0.5247	0.8021	0.8057	0.3455	0.4277
1980	0.0001	0.0004	0.0008	0.0011	0.0016	0.0050	0.0083	0.0095	0.0421	0.0214	0.1039	0.3685	0.6111	0.5116	0.2781	0.2781
1981	0.0003	0.0005	0.0004	0.0007	0.0010	0.0028	0.0044	0.0102	0.0066	0.1652	0.0383	0.2864	0.4531	0.3642	0.1543	0.0000
1982	0.0004	0.0023	0.0031	0.0066	0.0079	0.0161	0.0097	0.0099	0.0211	0.0360	0.1139	0.1082	1.3598	0.4155	0.4155	0.4155
1983	0.0004	0.0036	0.0082	0.0065	0.0020	0.0203	0.0087	0.0120	0.0463	0.1261	0.0680	0.2457	0.0054	0.7096	0.0000	0.0000
1984	0.0001	0.0007	0.0007	0.0027	0.0014	0.0016	0.0014	0.0027	0.0113	0.0798	0.0687	0.1640	0.4119	0.0070	0.2375	0.0000
1985	0.0001	0.0013	0.0026	0.0074	0.0044	0.0071	0.0051	0.0134	0.0203	0.0240	0.0538	0.1154	0.1306	0.4567	0.0061	0.0807
1986	0.0001	0.0003	0.0040	0.0056	0.0038	0.0376	0.0080	0.0097	0.0188	0.0300	0.0457	0.0959	0.1806	0.0834	0.0880	0.0880
1987	0.0001	0.0002	0.0015	0.0032	0.0059	0.0230	0.0211	0.0099	0.0195	0.0266	0.0421	0.1232	0.2020	0.0923	0.0985	0.0000
1988	0.0002	0.0011	0.0023	0.0051	0.0214	0.1066	0.0445	0.0737	0.0327	0.0254	0.0472	0.0591	0.0940	0.0722	0.0566	0.0000
1989	0.0000	0.0004	0.0004	0.0005	0.0007	0.0077	0.0047	0.0036	0.0136	0.0171	0.0134	0.0338	0.0499	0.0228	0.0288	0.0000
1990	0.0000	0.0002	0.0020	0.0024	0.0017	0.0085	0.0130	0.0266	0.0221	0.0822	0.0212	0.0921	0.1000	0.0276	0.0200	0.0000
1991	0.0001	0.0005	0.0004	0.0009	0.0016	0.0026	0.0043	0.0051	0.0381	0.0492	0.0737	0.1567	0.2776	0.1757	0.0659	0.1404
1992	0.0001	0.0007	0.0015	0.0024	0.0032	0.0131	0.0087	0.0135	0.0214	0.0544	0.0634	0.1787	0.3441	0.3055	0.1689	0.1602

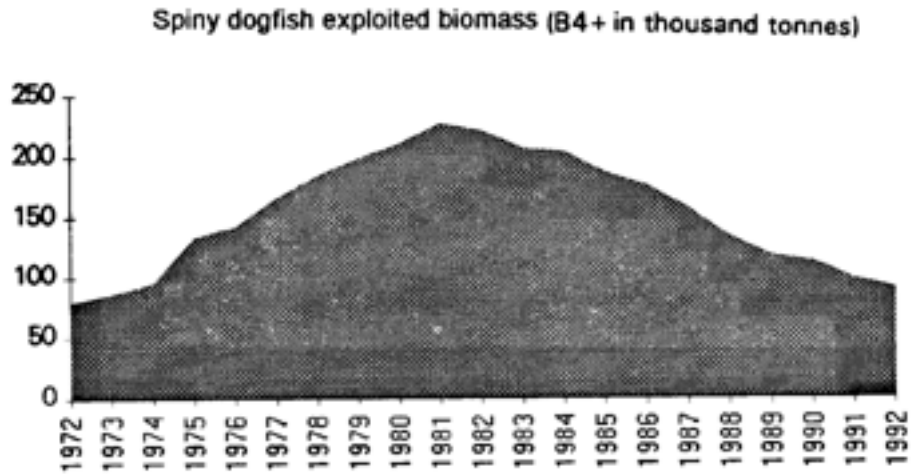

FIGURE 3. Spiny dogfish exploited biomass during 1972-1992

The intensification of the spiny dogfish fishery during the period 1979-1984, when the total catches ranged between 6 419 and 12 254 thousand tonnes with a mean of 8 254 thousand tonnes, has contributed also to its stock decline.

Kirsonova (1993) showed that the TAC for spiny dogfish had to vary from 5 to 6 thousand tonnes which corresponds to U = 0.12 (this assessment in related to the former USSR coast). The attainment of the level U = 0.18 would lead to sharp decrease of stocks and after 10 years it would be cut by half, maintaing the trend towards further decline. For this reason the spiny dogfish fishery statistical data for the real catches, especially after 1989 has to be available.

In **Table 23** are shown both the VPA and Kirsonova's results (1993).

TABLE 23. Spiny dogfish exploited biomass (thousand tonnes)

Year	Surveyed areas (x 10-3 km2)	Exploited biomass (thousand tonnes)	VPA results (thousand tonnes)
1983	37.5	39.0	206.4
1984	34.8	44.0	203.6
1985	36.8	45.6	186.4
1986	30.0	47.8	176.2
1987	29.4	42.1	157.8
1988	24.6	46.7	134.0
1989	22.3	58.5	117.8
1990	21.5	58.7	112.9
1991	7.6	17.2	97.9
1992	25.6	62.9	90.0

The results from VPA relate to the whole Black Sea. From the figures during the period considered, the exploited fish stock in the former USSR waters made up on average 31.2% of the 2total stock in the Black Sea. Bearing in mind the data of Kirsonova and Lushnikova (1990) for prey composition and quantities (by species) needed annually, the VPA results for the stock size of all fish species (reflecting the relationships predator-prey) were used in the multilinear correlation analysis to consider the impact of the various biotic and abiotic factors. The results are presented in a separate section where they are discussed in detail.