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MEDITERRANEAN MARINE DEMERSAL RESOURCES: THE MEDITS INTERNATIONAL TRAWL SURVEY (1994-1999).
P. ABELLÓ, J.A. BERTRAND, L. GIL DE SOLA, C. PAPACONSTANTINOU, G. RELINI and A. SOUPLET (eds.)

Distribution of *Mullus barbatus* and *M. surmuletus* (Osteichthyes: Perciformes) in the Mediterranean continental shelf: implications for management*

GEORGE TSERPES[1], FABIO FIORENTINO[2], DINO LEVI[2], ANGELO CAU[3], MATTEO MURENU[3], ADA ZAMBONI[4] and COSTAS PAPACONSTANTINOU[5]

[1]Institute of Marine Biology of Crete, P.O. Box 2214, 71003 Iraklion, Greece. E-mail: gtserpes@imbc.gr
[2]Istituto di ricerche sulle Risorse Marine a l'Ambiente (IRMA-CNR), Via Luigi Vaccara 61, 91026 Mazara del Vallo (TP), Italy.
[3]Dipartimento di Biologia Animale ed Ecologia, viale Poetto 1, 09126 Cagliari, Italy.
[4]Dipartimento per lo Studio della Terra e delle sue Risorse, Laboratori di Biologia Marina ed Ecologia Animale, University of Genova, Via Balbi, 5 -16126 Genova, Italia.
[5]National Centre for Marine Research, Aghios Kosmas, Helliniko, 16604 Athens, Greece.

SUMMARY: The present work attempts to study the spatio-temporal distribution of *Mullus barbatus* and *M. surmuletus* in the Mediterranean Sea by using a time series of data from an international bottom trawl survey that covered a wide area of the Mediterranean Sea. The experimental surveys were accomplished annually from 1994 to 2000 on approximately 1000 pre-defined sampling stations distributed in 15 major areas. Selection of stations was based on a depth-stratified random sampling scheme that included five depth strata: 10-50, 50-100, 100-200, 200-500 and 500-800 m. The examined species were found throughout the studied region, mostly in depths down to 200 m. Abundance differences among major areas were found to be statistically significant and were attributed to the different exploitation patterns, as well as the different abiotic and biotic conditions prevailing in each area. Although both species undergo high fishing pressure, results did not demonstrate any decreasing trends in their abundance indices suggesting the existence of a good stock-recruitment relationship over the studied period. However, the dominance of young fish that has been found, makes the stocks highly vulnerable to recruitment changes; hence protection of spawning and nursery areas seems to be essential for their conservation.

Key words: red mullet, striped red mullet, *Mullus barbatus, Mullus surmuletus*, distribution, Mediterranean.

INTRODUCTION

The red mullet (*Mullus barbatus* L., 1758) and the striped red mullet (*Mullus surmuletus* L., 1758) are common demersal fish of the Mediterranean Sea, mostly found in depths down to 200 m. The red mullet inhabits sandy and muddy bottoms and is distributed all around the Mediterranean basin, including the Black Sea, and also in the eastern Atlantic from Scandinavia to Senegal (Fischer *et al.*, 1987). The striped red mullet is generally found on bottoms with heterogeneous granulometry and often in *Posidonia* beds. Apart from the Mediterranean, it inhabits the Eastern Atlantic from the North Sea to Senegal (Fischer *et al.*, 1987).

Both species have a high commercial value and are the main target species of many demersal fisheries operating in the Mediterranean Sea (Hadjis-

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tephanou, 1992; Stergiou *et al.*, 1992; Caddy, 1993; Fiorentini *et al.* ,1997; Relini *et al.*, 1999). It is generally considered that their stocks undergo high fishing pressure, which is in most cases directed towards young fish (Larrañeta and Rodríguez Roda, 1956; Hadjistephanou, 1992; Stergiou *et al.*, 1992; Vassilopoulou and Papaconstantinou, 1992a, b; Vrantzas *et al.*, 1992; Farrugio *et al.*, 1993; Demestre *et al.*, 1997; Voliani *et al.*, 1998b).

In the past, several authors have studied the distribution of *M. barbatus* and *M. surmuletus* in different Mediterranean areas and have commented on their bathymetrical distribution (Suau and Vives, 1957; Gharbi and Ktari, 1979; Vassilopoulou and Papaconstantinou, 1992a; Golani, 1994; Tursi *et al.*, 1994; Machias *et al.*, 1998; Reli-

TABLE 1. – List of the major areas covered by the surveys.

Area Code	Area name
111	Alborán Sea
112	Alicante sector
113	Catalan Sea
114*	Morocco
121	Gulf of Lions
131	Corsica
132	Ligurian and N Tyrrhenian Sea
133	Sardinia
134	Sicily and S Tyrrhenian Sea
211	N Adriatic
221	S Adriatic and W Ionian Sea
222	E Ionian Sea
223	Argosaronikos
224	N Aegean Sea
225	S Aegean Sea

*Area 114 was not included in the analysis as only one-year data were available

TABLE 2. – *Mullus barbatus*: Mean abundance (in number of individuals per square km) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 10000 individuals/km^2 are presented in bold.

		1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	113	675	109	0	0	93	2573	32	0	0	103	534	6	0	0
112a	Alicante	0	241	0	0	0	427	639	177	0	0	106	328	52	0	0
113a	Catalan Sea	34	822	1803	0	0	39	854	508	0	0	155	660	383	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	22	163	281	0	0	51	478	793	0	0	430	881	489	0	0
121b	E Gulf of Lions	156	22	57	0	0	77	83	197	0	0	687	126	511	0	0
131a	NE Corsica	*	1510	844	83	0	*	50	3750	0	0	*	2079	1379	0	0
131b	SE Corsica	*	8862	2340	0	0	*	4731	0	0	0	*	6992	1977	0	0
132a	N Ligurian Sea	643	482	333	0	0	2061	638	327	0	0	427	396	391	0	0
132b	E Ligurian Sea	422	533	385	21	0	743	958	468	49	0	918	1368	1140	75	0
132c	N Tyrrhenian Sea	1910	21	36	0	0	4643	38	118	0	0	3967	3	227	4	0
132d	Centr. Tyrrhenian	34	7	95	0	0	192	0	160	2	0	168	7	438	3	0
133a	SE Sardinia	242	1337	1536	11	0	226	1109	2355	0	0	1354	55	183	20	0
133b	NE Sardinia	0	657	11	0	0	0	739	0	0	0	13	217	225	0	0
133c	N Sardinia	0	1151	0	6	0	16	57	0	0	0	24	8187	0	0	0
133d	NW Sardinia	0	9955	168	0	0	*	815	210	0	0	0	246	26	0	0
133e	W Sardinia	914	0	415	0	0	493	806	428	30	0	684	126	233	0	0
133f	SW Sardinia	0	522	80	93	0	**10636**	1180	224	64	0	649	495	182	0	0
133g	S Sardinia	200	0	0	0	0	671	*	453	0	0	308	0	155	0	0
134a	SE Tyrrhenian	1821	64	0	0	0	1286	47	88	1	0	1226	157	112	0	0
134b	SW Tyrrhenian	872	3955	553	0	0	3101	2427	880	3	0	1657	2436	949	0	0
134c	Sicilian Channel	24	109	151	0	0	134	183	87	1	0	172	611	160	1	0
211a	N Adriatic Sea	58	427	*	*	*	154	1268	*	*	*	261	696	*	*	*
211b	Central Adriatic	570	171	221	2	0	340	205	322	2	0	163	241	89	32	0
211c	N Adriatic-Slov	*	0	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adriatic-Croat	*	0	*	*	*	*	*	*	*	*	465	1199	407	0	*
221a	E Sicily	1325	649	266	0	0	**11319**	938	42	0	0	745	896	40	0	0
221b	NW Ionian Sea	1839	1796	157	0	0	4657	958	335	0	0	5139	577	440	0	0
221c	N Ionian Sea	63	8	0	0	0	86	0	0	0	0	962	0	0	0	0
221d	N Ionian Sea	*	0	49	0	0	922	0	100	0	0	0	0	175	0	0
221e	SW Adriatic Sea	0	6	27	0	0	*	0	21	0	0	0	0	3	0	0
221f	SW Adriatic Sea	0	0	0	0	0	8	0	0	0	0	7	0	0	0	0
221g	SW Adriatic Sea	100	0	42	*	0	0	0	0	*	0	0	0	0	*	0
221h	SW Adriatic Sea	69	0	57	0	0	49	0	26	5	0	1147	0	0	23	0
221i	SE Adriatic Alban	*	0	*	*	*	*	*	*	*	*	1307	427	101	1	0
222a	E Ionian Sea	103	1103	0	0	0	35	635	272	0	0	563	620	23	0	0
223a	Argosaronikos	19	0	144	0	0	5271	26	0	18	0	1849	855	144	0	0
224a	N Aegean Sea	1374	768	385	0	0	514	350	403	11	0	1267	454	398	0	0
225a	S Aegean Sea	907	1633	466	3	0	356	388	234	22	0	252	1290	242	70	0

ni *et al.*, 1999; Tserpes *et al.*, 1999; Lombarte *et al.*, 2000). However, the use of different sampling schemes did not allow direct spatio-temporal comparisons that would give a much better picture of their distribution pattern in broad Mediterranean areas. In general, the horizontal distribution of Mediterranean fish populations has been poorly studied and the existing information is scarce (Farrugio *et al.*, 1993).

The main objective of the present work is to examine the distribution of *M. barbatus* and *M. surmuletus* in the Mediterranean through the utilisation of a time series of data from a standardised international Mediterranean bottom-trawl survey (MEDITS). Our findings are discussed in relation to a rational management scheme for the Mediterranean *M. barbatus* and *M. surmuletus* resources.

MATERIALS AND METHODS

Sampling

Within the frame of the "MEDITS" project (Bertrand *et al.*, 2000, 2002), six annual bottom trawl surveys were performed from 1994 to 1999 in the Mediterranean Sea, covering 40 sub-areas localized in 15 major areas (Table 1). The surveys, which were mainly aimed at obtaining estimates of relative abundance indices for a series of target species, were accomplished from late spring to middle summer and each included sampling at approximately 1000 pre-defined stations. Trawling was made by means of a standard net GOC 73 having a cod-end mesh opening of 20 mm. Selection of stations was based on a depth-stratified sampling scheme that included

TABLE 2 (Cont.). – *Mullus barbatus*: Mean abundance (in number of individuals per square km) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 10000 ind./km^2 are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	154	121	69	0	0	84	615	81	0	0	144	233	21	0	0
112a	Alicante	37	270	145	0	0	544	336	29	0	0	636	254	155	13	0
113a	Catalan Sea	14	231	307	0	0	165	371	1287	*	0	190	446	599	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	0	5	0	0	0
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	520	30	18	0	0
121a	W Gulf of Lions	108	199	452	0	0	70	558	224	16	0	146	578	1234	0	0
121b	E Gulf of Lions	198	37	153	0	0	532	88	398	0	0	445	72	500	37	*
131a	NE Corsica	*	94	*	10	0	*	**14887**	636	0	0	*	3603	874	1	0
131b	SE Corsica	*	0	0	0	*	*	**14250**	175	0	0	*	4384	2044	0	0
132a	N Ligurian Sea	563	1560	24	0	0	2464	127	519	0	0	2568	720	295	0	0
132b	E Ligurian Sea	1447	858	721	15	0	1864	1447	1097	1	0	1851	1734	1200	15	0
132c	N Tyrrhenian Sea	4199	46	165	0	0	1443	43	184	0	0	5475	12	112	0	0
132d	Centr. Tyrrhenian	180	25	202	1	0	371	136	301	0	0	315	3	170	2	0
133a	SE Sardinia	44	0	565	0	0	276	2296	0	0	0	773	428	39	0	0
133b	NE Sardinia	0	1017	297	0	0	26	175	1357	0	0	0	359	326	0	0
133c	N Sardinia	0	1663	0	0	0	123	596	0	0	0	6710	5566	0	0	0
133d	NW Sardinia	0	651	194	0	0	0	222	424	0	0	0	290	174	0	0
133e	W Sardinia	307	208	219	0	0	66	135	614	0	0	500	146	924	0	0
133f	SW Sardinia	1459	4022	290	0	0	2407	1540	106	0	0	7132	2452	707	0	0
133g	S Sardinia	0	0	211	0	0	0	4614	464	0	0	17	2654	378	0	0
134a	SE Tyrrhenian	1050	193	61	1	0	3151	621	264	0	0	2028	503	89	0	0
134b	SW Tyrrhenian	1249	4564	279	0	0	2144	2551	642	0	0	1308	868	156	0	0
134c	Sicilian Channel	299	256	132	5	0	197	211	271	6	0	194	426	205	1	0
211a	N Adriatic Sea	143	652	*	*	*	28	934	*	*	*	5937	986	*	*	*
211b	Central Adriatic	208	545	72	0	0	139	236	113	47	*	**12524**	772	70	4	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	139	*	*	*	*
211d	NE Adriatic-Croat	1224	1547	760	0	*	594	884	393	0	*	0	*	*	*	*
221a	E Sicily	397	711	401	0	0	1884	1234	987	11	0	175	364	244	0	0
221b	NW Ionian Sea	408	719	256	0	0	1085	1258	583	0	0	274	280	431	12	0
221c	N Ionian Sea	52	0	0	0	0	252	44	0	3	0	15	7	0	0	0
221d	N Ionian Sea	606	0	0	0	0	88	240	0	0	0	51	0	8	0	0
221e	SW Adriatic Sea	0	80	31	0	0	0	0	11	0	0	0	75	19	0	0
221f	SW Adriatic Sea	0	0	0	0	0	0	38	0	0	0	**19317**	0	0	0	0
221g	SW Adriatic Sea	0	0	0	*	0	0	0	0	*	0	8491	0	0	*	0
221h	SW Adriatic Sea	0	0	0	12	0	0	0	0	6	0	4342	4	72	110	0
221i	SE Adriatic Alban	58	673	70	0	0	484	545	379	0	0	417	638	279	0	0
222a	E Ionian Sea	4020	666	0	0	0	2779	1987	706	0	0	1420	1623	1314	11	0
223a	Argosaronikos	**10176**	1929	21	0	0	4236	1913	565	109	0	3550	2744	222	115	0
224a	N Aegean Sea	820	819	426	0	0	2778	683	867	0	0	1183	840	398	9	0
225a	S Aegean Sea	**24334**	510	258	16	0	**54076**	3533	447	149	0	**113895**	1568	467	30	0

TABLE 3. – *Mullus barbatus*: Mean biomass (in kg / km^2) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 200 kg/km^2 are presented in bold.

		1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	5.2	22.5	7.3	0.0	0.0	2.7	101.1	2.2	0	0	3.5	18.0	0.1	0	0
112a	Alicante	0.0	7.6	0.0	0.0	0.0	15.3	21.5	6.9	0	0	5.1	12.5	2.3	0	0
113a	Catalan Sea	0.8	22.4	41.7	0.0	0.0	1.2	27.2	17.8	0	0	4.3	24.6	15.0	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0.9	8.0	15.6	0.0	0.0	1.6	17.4	27.1	0	0	12.3	24.5	13.1	0	0
121b	E Gulf of Lions	3.1	0.8	3.5	0.0	0.0	2.5	2.2	7.7	0	0	16.7	3.3	16.7	0	0
131a	NE Corsica	*	53.7	57.3	1.8	0.0	*	0.8	132.9	0	0	*	47.0	49.6	0	0
131b	SE Corsica	*	**249.0**	95.6	0.0	0.0	*	112.7	0.0	0	0	*	**218.5**	75.5	0	0
132a	N Ligurian Sea	17.6	21.9	19.9	0.0	0.0	52.9	27.3	12.1	0	0	5.0	13.2	11.5	0	0
132b	E Ligurian Sea	22.3	23.3	23.5	2.0	0	26.4	28.6	23.9	3.7	0	28.5	35.6	44.7	5.5	0
132c	N Tyrrhenian Sea	53.9	0.9	2.5	0	0	144.6	1.6	7.0	0	0	125.2	0.1	11.0	0.3	0
132d	Centr. Tyrrhenian	1.5	0.2	6.3	0	0	7.4	0	8.2	0.2	0	7.8	0.3	19.0	0.2	0
133a	SE Sardinia	10.2	71.6	19.1	1.0	0	6.7	45.2	81.5	0	0	37.0	3.3	17.1	1.6	0
133b	NE Sardinia	0	24.7	0.5	0	0	0	26.8	0	0	0	0.6	11.3	16.1	0	0
133c	N Sardinia	0	72.9	0	0.8	0	0.1	4.0	0	0	0	1.2	191.4	0	0	0
133d	NW Sardinia	0	**293.6**	8.4	0	0	*	25.7	8.8	0	0	0	8.5	1.4	0	0
133e	W Sardinia	39.8	*	21.1	0	0	13.4	31.4	25.6	2.0	0	33.9	5.4	7.5	0	0
133f	SW Sardinia	0	16.9	4.6	5.2	0	**286.6**	34.6	9.8	3.2	0	21.2	13.5	8.6	0	0
133g	S Sardinia	4.5	0	0	0	0	26.0	*	16.8	0	0	0.7	0	4.7	0	0
134a	SE Tyrrhenian	54.5	1.5	0	0	0	40.1	1.2	3.5	0.1	0	36.6	5.3	5.2	0	0
134b	SW Tyrrhenian	24.3	164.3	25.5	0	0	69.0	64.5	26.8	0.1	0	40.6	58.8	30.8	0	0
134c	Sicilian Channel	1.4	5.3	4.5	0	0	4.1	8.5	4.0	0	0	6.4	21.6	6.6	0	0
211a	N Adriatic Sea	1.6	13.5	*	*	*	3.6	32.2	*	*	*	7.6	18.9	*	*	*
211b	Central Adriatic	10.0	7.0	8.2	0.1	0	8.4	5.0	10.1	0	0	5.1	8.5	3.5	3.1	0
211c	N Adriatic-Slov	*	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adriatic-Croat	*	*	*	*	*	*	*	*	*	*	17.1	40.2	15.4	0	*
221a	E Sicily	29.6	29.5	19.4	0	0	**292.7**	24.4	1.6	0	0	24.8	26.8	1.4	0	0
221b	NW Ionian Sea	54.6	62.8	5.2	0	0	102.6	25.3	11.9	0	0	124.1	17.4	11.6	0	0
221c	N Ionian Sea	2.6	0.8	0	0	0	2.8	0	0	0	0	23.5	0	0	0	0
221d	N Ionian Sea	*	0	11.0	0	0	21.0	0	8.1	0	0	0	0	14.1	0	0
221e	SW Adriatic Sea	0	0.2	2.8	0	0	*	0	2.5	0	0	*	0	0.4	0	0
221f	SW Adriatic Sea	0	0	0	0	0	0.2	0	0	0	0	0.3	0	0	0	0
221g	SW Adriatic Sea	3.2	0	1.7	*	0	0	0	0	*	0	0	0	0	*	0
221h	SW Adriatic Sea	0.1	0	3.9	0	0	0.2	0	1.5	0.4	0	2.0	0	0	1.5	0
221i	SE Adriatic Alban	*	*	*	*	*	*	*	*	*	*	35.4	14.7	5.3	0	0
222a	E Ionian Sea	1.3	55.8	0	0	0	1.7	28.4	9.3	0	0	14.1	19.0	1.1	0	0
223a	Argosaronikos	0.3	0	6.5	0	0	**223.5**	1.2	0	2.1	0	51.5	25.3	7.4	0	0
224a	N Aegean Sea	8.1	21.1	15.8	0	0	17.0	10.0	13.7	0.9	0	39.5	11.8	16.7	0	0
225a	S Aegean Sea	20.0	53.3	30.2	0.1	0	8.2	14.1	10.7	1.2	0	1.7	41.2	13.2	4.4	0

five depth zones: 10-50, 50-100, 100-200, 200-500 and 500-800 m. Collected data included number, weight, gonad maturation stage and total length measurements for the target species. The same sampling protocol was used in all cases (see Bertrand *et al.*, 1997, 2000, 2002, for details).

Data analysis

From the collected data, relative abundance indices by sub-area, year and depth stratum were computed for both *M. barbatus* and *M. surmuletus,* and expressed in terms of both number and weight per square kilometre. In addition, based on the total length (cm) measurements taken from a representative number of animals, the summary statistics together with the percentage length frequency distributions were estimated by year, sub-area and major depth stratum (10-200, 200-800 m). Estimates were made by means of specifically developed software taking into account the surface of each sub-area and depth stratum (Souplet, 1996). The above estimates indicated that the abundance of both species was negligible in waters deeper than 200 m (Tables 2-5). This was particularly true for *M. barbatus* where abundance indices had zero values in more than 60% of the total cases. For this reason further analysis was confined to depth strata up to 200 m (three in total: 10-50, 50-100 and 100-200 m).

In order to examine the effects of year and major area on abundance, and identify overall trends, the detailed relative abundance indices, i.e. catch per unit effort (CPUE) by sub-area and depth stratum, were standardised using General Linear Model (GLM) techniques (Gulland, 1956; Kimura, 1981). CPUE indices were expressed in g/km^2 and the gen-

TABLE 3(Cont.). – *Mullus barbatus*: Mean biomass (in kg / km^2) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 200 kg/km^2 are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	6.9	4.5	3.9	0	0	3.1	25.8	5.4	0	0	5.1	9.5	1.6	0	0
112a	Alicante	2.0	16.2	11.4	0	0	32.2	16.3	1.6	0	0	25.7	12.3	8.4	0.5	0
113a	Catalan Sea	0.7	10.8	14.8	0	0	6.9	16.9	49.5	*	0	6.7	18.3	25.0	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	0.3	0	0	0
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	24.3	1.8	1.4	0	0
121a	W Gulf of Lions	2.7	7.2	23.8	0	0	1.9	17.5	6.9	3.3	0	3.6	19.4	44.0	0	0
121b	E Gulf of Lions	5.5	1.4	7.5	0	0	15.4	2.9	16.2	0	0	8.2	2.1	19.2	1.7	*
131a	NE Corsica	*	4.8	*	2.0	0	*	**405.6**	20.5	0	0	*	100.1	32.3	0.2	0
131b	SE Corsica	*	0	0	0	*	*	**605.6**	6.1	0	0	*	131.4	68.0	0	0
132a	N Ligurian Sea	17.6	60.7	1.5	0	0	111.0	6.7	23.3	0	0	88.8	20.0	16.8	0	0
132b	E Ligurian Sea	43.1	28.7	31.5	1.1	0	65.9	47.0	55.2	0.2	0	58.9	60.7	75.0	1.9	0
132c	N Tyrrhenian Sea	132.8	1.7	9.2	0	0	54.0	1.5	9.9	0	0	**266.9**	0.7	6.8	0	0
132d	Centr. Tyrrhenian	8.2	0.9	9.4	0	0	13.3	5.3	11.8	0	0	12.8	0.1	8.9	0.2	0
133a	SE Sardinia	1.1	0	36.1	0	0	8.2	88.1	0	0	0	19.5	11.8	3.9	0	0
133b	NE Sardinia	0	40.0	22.0	0	0	0.7	6.7	113.9	0	0	0	18.5	23.7	0	0
133c	N Sardinia	0	72.2	0	0	0	4.9	25.9	0	0	0	**232.4**	188.8	0	0	0
133d	NW Sardinia	0	27.9	11.4	0	0	0	7.7	20.6	0	0	0	13.2	7.6	0	0
133e	W Sardinia	12.3	11.9	13.4	0	0	3.5	4.1	153.1	0	0	45.4	4.1	43.4	0	0
133f	SW Sardinia	32.9	121.9	13.1	0	0	88.8	48.4	6.3	0	0	193.6	73.8	38.7	0	0
133g	S Sardinia	0	0	10.8	0	0	0	184.6	14.3	0	0	0.7	53.6	10.0	0	0
134a	SE Tyrrhenian	33.1	6.4	2.0	0	0	83.8	13.2	10.0	0	0	54.4	17.4	4.3	0	0
134b	SW Tyrrhenian	44.3	112.3	10.4	0	0	60.5	79.6	22.6	0	0	41.8	36.5	7.7	0	0
134c	Sicilian Channel	10.1	9.7	4.6	0.2	0	7.0	8.5	10.2	0.3	0	7.2	18.1	8.3	0.1	0
211a	N Adriatic Sea	4.3	22.4	*	*	*	0.8	29.6	*	*	*	115.6	18.9	*	*	*
211b	Central Adriatic	5.2	18.0	3.2	0	0	4.0	7.7	5.4	3.8	*	149.0	20.9	1.1	0.4	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	3.7	*	*	*	*
211d	NE Adriatic-Croat	46.5	64.4	26.4	0	*	20.6	37.9	16.2	0	*	0	*	*	*	*
221a	E Sicily	13.6	23.7	17.0	0	0	28.9	30.3	38.3	0.4	0	6.1	16.7	10.7	0	0
221b	NW Ionian Sea	9.8	21.8	9.6	0	0	28.2	34.4	20.1	0	0	9.7	9.8	19.4	0.8	0
221c	N Ionian Sea	1.6	0	0	0	0	10.4	1.7	0	0.4	0	0.4	0.1	0	0	0
221d	N Ionian Sea	21.6	0	0	0	0	2.2	17.5	0	0	0	1.0	0	0.1	0	0
221e	SW Adriatic Sea	*	3.6	2.2	0	0	*	0	0.9	0	0	*	4.2	2.0	0	0
221f	SW Adriatic Sea	0	0	0	0	0	0	2.2	0	0	0	88.1	0	0	0	0
221g	SW Adriatic Sea	0	0	0	*	0	0	0	0	*	0	28.2	0	0	*	0
221h	SW Adriatic Sea	0	0	0	1.2	0	0	0	0	0.5	0	49.3	0	4.3	9.6	0
221i	SE Adriatic Alban	0.5	23.0	3.3	0	0	13.1	13.1	17.5	0	0	10.9	11.6	10.6	0	0
222a	E Ionian Sea	33.1	30.3	0	0	0	72.4	60.8	27.5	0	0	51.3	50.0	45.9	0.9	0
223a	Argosaronikos	**288.2**	52.9	1.1	0	0	146.2	68.7	29.1	7.2	0	150.4	83.6	8.2	5.5	0
224a	N Aegean Sea	23.1	25.8	17.5	0	0	82.2	16.1	24.3	0	0	40.3	25.5	12.0	0.4	0
225a	S Aegean Sea	105.5	21.8	12.7	1.7	0	109.3	65.5	18.0	7.0	0	342.0	47.0	15.5	1.6	0

eral model used was of the form:

$$\ln(CPUE_{ijk} + 1) = \mu + A_i + Y_j + D_k + \text{interaction} + \varepsilon_{ijk}$$

where μ: overall mean

A_i: effect of major area i

Y_j: effect of year j

D_k: effect of depth stratum k

Interaction: any possible combination of two effect interaction

ε: error term assumed to be distributed normally

As the surveys did not strictly coincide in all areas and were accomplished at the end, or just after the reproduction period, full recruitment to the fishery of the newly born individuals was not performed and could be traced only in some areas in certain years. For this reason, the use of biomass indices was preferred as they are expected to be less sensitive to spatio-temporal fluctuations, than number indices owing to the irregular presence of recruits. The constant 1 was added to all CPUE rates to account for few zero observations and the surface of the corresponding sub-area depth stratum was used as a weighting factor in order to take into account the relative size importance of each sub-area.

The measure of goodness of fit of the models was the coefficient of determination (R^2) and the proportion of the variation attributed to each factor was indicated by the eta-square statistic (Dixon and Massey, 1985) All statistical inferences were based on the 95% confidence level.

The percentage length frequency distribution of the catches was calculated on an annual basis, separately for each major area, from the corresponding sub-area estimates using as weighting factors the

TABLE 4. – *Mullus surmuletus*: Mean abundance (in number of individuals / km²) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 3000 individuals /km² are presented in bold.

		1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	38	473	0	3	0	0	568	51	2	0	184	285	107	1	0
112a	Alicante	384	24	6	0	0	173	72	418	17	0	41	112	0	25	0
113a	Catalan Sea	6	42	8	0	0	16	56	27	0	0	14	42	42	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0	28	10	0	0	3	15	19	2	0	0	2	0	0	0
121b	E Gulf of Lions	0	2	9	6	0	0	3	18	0	0	16	0	14	10	0
131a	NE Corsica	*	122	157	0	0	*	36	184	2	0	*	319	59	4	0
131b	SE Corsica	*	377	8	0	0	*	361	485	0	0	*	1169	80	0	0
132a	N Ligurian Sea	0	0	0	2	0	0	48	6	0	0	0	8	0	0	0
132b	E Ligurian Sea	3	3	25	3	0	9	10	35	2	0	141	0	30	4	0
132c	N Tyrrhenian Sea	12	46	2	5	0	25	21	6	4	1	0	25	4	0	0
132d	Centr. Tyrrhenian	0	0	3	0	0	0	13	12	1	0	11	0	12	0	0
133a	SE Sardinia	139	245	12	0	0	43	623	52	7	0	8	144	0	4	0
133b	NE Sardinia	0	169	0	0	0	0	230	0	0	0	251	28	118	49	0
133c	N Sardinia	30	389	0	0	0	32	57	540	0	0	16	144	7	0	0
133d	NW Sardinia	2822	83	0	0	0	*	0	43	21	0	488	10	32	0	0
133e	W Sardinia	239	0	35	6	0	783	0	69	23	35	150	25	11	6	0
133f	SW Sardinia	0	49	0	159	0	**3501**	511	14	179	0	549	296	209	163	0
133g	S Sardinia	0	0	0	13	0	159	*	0	3	0	**6177**	0	0	0	0
134a	SE Tyrrhenian	6	0	0	2	0	17	0	7	1	0	0	0	0	0	0
134b	SW Tyrrhenian	0	32	7	5	0	0	0	17	7	0	6	0	3	1	0
134c	Sicilian Channel	48	153	195	61	2	34	246	87	70	1	11	347	125	472	7
211a	N Adriatic Sea	1	0	*	*	*	0	0	*	*	*	0	0	*	*	*
211b	Central Adriatic	0	4	3	4	0	0	0	4	0	0	0	2	0	2	0
211c	N Adriatic-Slov	*	0	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adriatic-Croat	*	0	*	*	*	*	*	*	*	*	0	0	0	0	*
221a	E Sicily	450	0	7	44	0	81	33	7	66	0	102	288	182	0	0
221b	NW Ionian Sea	0	0	0	0	0	12	0	11	0	1	11	0	58	0	0
221c	N Ionian Sea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221d	N Ionian Sea	*	0	0	0	0	105	0	12	0	0	21	38	40	0	0
221e	SW Adriatic Sea	0	64	5	0	0	*	42	13	0	0	0	15	0	0	3
221f	SW Adriatic Sea	80	14	4	0	0	38	7	4	0	0	0	0	0	0	0
221g	SW Adriatic Sea	75	11	0	*	0	0	0	0	*	0	0	0	0	*	0
221h	SW Adriatic Sea	32	4	3	17	0	13	0	3	45	2	8	4	0	52	0
221i	SE Adriatic Alban	*	0	*	*	*	*	*	*	*	*	0	0	0	0	0
222a	E Ionian Sea	240	0	0	0	0	0	0	8	0	0	13	0	0	0	0
223a	Argosaronikos	**10824**	0	7	0	0	2405	171	5	0	0	185	78	42	43	0
224a	N Aegean Sea	10	0	10	0	0	153	4	29	0	0	313	2	145	10	0
225a	S Aegean Sea	**5696**	449	607	1	0	27	41	145	30	0	**5523**	556	269	46	0

sub-area surface and relative abundance (number/km²). Subsequently, by averaging the annual estimates the mean percentage length frequency distribution for the sampled period was estimated. Finally, summary statistics, including minimum, maximum, mean and standard deviation were calculated by major area and year.

RESULTS

Abundance indices

The applied GLMs explained 45% and 61% of the total variance for *M. barbatus* and *M. surmuletus,* respectively. The Analysis of Variance (ANOVA) results revealed that differences among major areas were highly significant for both species (Table 6). The same was true for the depth-major area interaction, indicating that the species did not follow the same depth distribution pattern in all major areas. Differences among years and depth strata were also significant in the case of *M. barbatus* as well as the year-major area interaction in the case of *M. surmuletus.* The latter indicated that the inter-annual CPUE pattern differed among major areas.

The computed eta-squared statistics showed that, for both species, the highest proportion of the variation in the CPUE indices was attributed to differences among major areas. This was particularly true in the case of *M. surmuletus* where major area explains as much as 43% of the total variation.

Overall yearly fluctuations seemed to be greater for *M. barbatus* than for *M. surmuletus* (Fig. 1).

TABLE 4 (Cont.). – *Mullus surmuletus*: Mean abundance (in number of individuals / km^2) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999). Not sampled strata are indicated by '*'. Values higher than 3000 individuals /km^2 are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	77	13	75	0	0	63	117	220	0	0	0	95	29	0	0
112a	Alicante	164	20	23	0	0	0	68	88	1	0	562	31	95	8	1
113a	Catalan Sea	7	63	32	0	0	4	50	28	*	0	9	27	4	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	0	0	35	0	0
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	414	426	3	0	0
121a	W Gulf of Lions	5	18	18	0	0	3	31	2	24	0	6	10	7	5	0
121b	E Gulf of Lions	0	0	26	3	0	0	3	7	0	0	11	0	92	5	*
131a	NE Corsica	*	94	*	0	0	*	853	47	0	0	*	126	332	6	0
131b	SE Corsica	*	0	0	0	*	*	509	17	0	0	*	844	47	5	0
132a	N Ligurian Sea	724	8	24	1	0	33	7	0	0	0	43	21	0	0	0
132b	E Ligurian Sea	153	6	20	3	0	3	9	14	0	0	0	3	252	1	0
132c	N Tyrrhenian Sea	24	20	2	3	0	260	40	4	21	1	2543	27	6	1	1
132d	Centr. Tyrrhenian	234	7	9	0	0	22	4	12	0	0	0	0	10	0	0
133a	SE Sardinia	192	43	0	0	0	0	2203	115	4	0	118	360	19	52	7
133b	NE Sardinia	2336	125	33	0	0	1308	324	330	3	0	0	988	568	41	0
133c	N Sardinia	60	78	0	0	0	106	69	82	0	0	117	294	2044	90	0
133d	NW Sardinia	2092	8	23	0	0	1883	245	228	0	0	864	0	123	127	10
133e	W Sardinia	100	194	93	0	0	81	135	256	6	0	559	**3317**	160	0	0
133f	SW Sardinia	13	246	42	0	0	1210	347	746	15	0	387	216	606	103	0
133g	S Sardinia	2188	0	11	141	0	43	369	41	59	0	43	0	269	3	0
134a	SE Tyrrhenian	76	4	0	0	0	11	0	0	0	0	11	3	4	1	0
134b	SW Tyrrhenian	0	5	7	0	0	0	6	3	0	0	0	0	38	0	0
134c	Sicilian Channel	62	418	193	51	2	17	504	79	32	1	0	254	14	3	5
211a	N Adriatic Sea	0	0	*	*	*	1	0	*	*	*	197	0	*	*	*
211b	Central Adriatic	0	10	4	13	0	8	0	2	0	*	90	15	3	14	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	362	*	*	*	*
211d	NE Adriatic-Croat	0	0	0	0	*	10	5	46	10	*	0	*	*	*	*
221a	E Sicily	0	0	47	25	0	0	11	92	36	0	0	0	59	0	0
221b	NW Ionian Sea	0	0	0	0	0	0	0	74	7	0	11	0	43	0	0
221c	N Ionian Sea	0	0	0	0	0	0	0	21	3	0	0	0	0	0	0
221d	N Ionian Sea	43	0	53	0	1	88	0	231	54	1	0	0	60	17	0
221e	SW Adriatic Sea	0	22	3	0	0	0	15	3	0	0	0	22	0	0	0
221f	SW Adriatic Sea	24	0	9	0	0	72	23	0	0	0	255	0	13	0	0
221g	SW Adriatic Sea	0	0	0	*	0	33	8	7	*	0	1063	0	0	*	0
221h	SW Adriatic Sea	18	0	7	50	0	47	11	12	15	0	13	19	28	218	0
221i	SE Adriatic Alban	0	2	2	0	0	0	2	0	0	0	46	5	5	0	0
222a	E Ionian Sea	0	3	0	0	0	7	0	0	2	0	0	2	0	9	0
223a	Argosaronikos	1862	203	42	2	0	372	29	274	15	0	7	24	326	275	0
224a	N Aegean Sea	4	2	119	2	0	4	0	285	4	0	0	0	38	2	0
225a	S Aegean Sea	**8372**	195	817	30	0	**57552**	101	450	135	2	**59198**	159	116	123	0

The spatial distribution of both species followed a rather complex pattern and there were noticeable fluctuations among areas particularly for *M. surmuletus* (Fig. 2). *M. barbatus* was more abundant than *M. surmuletus* in all major areas and particularly in the northern Adriatic, eastern Ionian and northern Aegean seas. The lowest indices for *M. barbatus* were computed for Alicante, Sardinia, southern Adriatic and western Ionian seas and the highest for the northern and southern Aegean seas, as well as, the waters of Corsica. *M. surmuletus* was far less abundant in the Adriatic and Ionian seas while the highest indices were estimated for two areas of the eastern basin, the Argosaronikos gulf and the southern Aegean Sea.

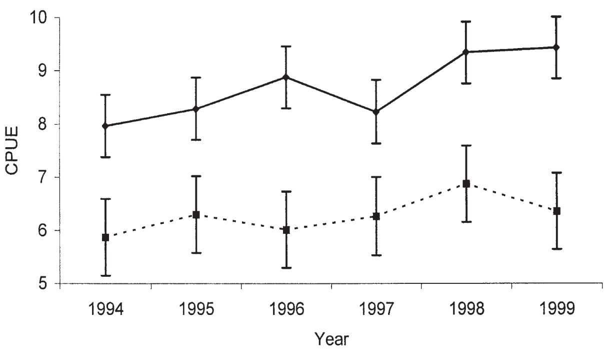


FIG. 1. – Standardised CPUE estimates by year, for *Mullus barbatus* (continuous line) and *Mullus surmuletus* (dashed line). Estimates are expressed in ln (g/km^2) and vertical lines indicate their 95% confidence intervals.

The highest abundance index of *M. surmuletus* was estimated for the deepest stratum (100-200) of the shelf zone while *M. barbatus* seemed to prefer the more coastal strata (Fig. 3).

TABLE 5. – *Mullus surmuletus*: Mean biomass (in kg/km²) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999).Not sampled strata are indicated by '*'. Values higher than 100 kg/km² are presented in bold.

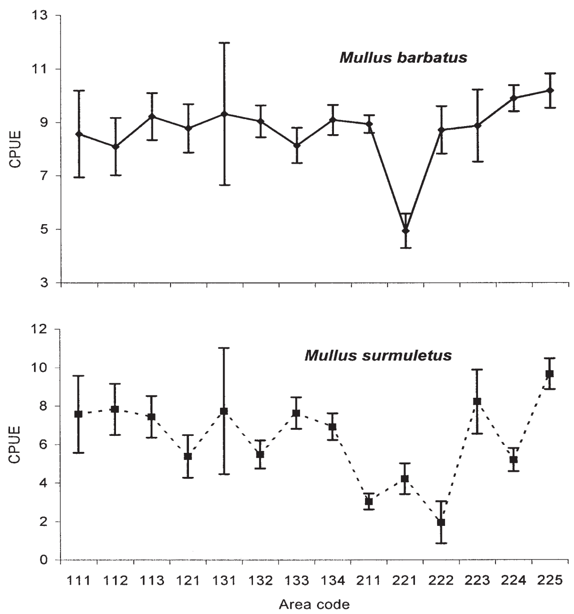
		1994 Depth (m)					1995 Depth (m)					1996 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	2.2	50.9	0	0.8	0	0	34.7	3.0	0.7	0	8.9	31.4	26.7	0.1	0
112a	Alicante	18.1	2.5	1.1	0	0	10.0	6.4	35.2	2.7	0	2.4	10.8	0	4.4	0
113a	Catalan Sea	0.2	2.9	0.9	0	0	1.7	5.6	2.7	0	0	0.8	4.0	5.8	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
121a	W Gulf of Lions	0	3.4	1.7	0	0	0.3	1.6	1.5	0.7	0	0	0.1	0	0	0
121b	E Gulf of Lions	0	0.2	1.7	1.7	0	0	0.7	2.9	0	0	1.4	0	2.8	1.1	0
131a	NE Corsica	*	9.4	9.1	0	0	*	1.2	4.1	0.4	0	*	22.1	2.2	1.2	0
131b	SE Corsica	*	12.0	0.4	0	0	*	13.6	32.3	0	0	*	36.4	4.3	0	0
132a	N Ligurian Sea	0	0	0	0.1	0	0	3.4	1.3	0	0	0	0.8	0	0	0
132b	E Ligurian Sea	0.2	0.2	0.7	0.3	0	0.1	0.5	2.1	0.2	0	2.4	0	2.4	0.3	0
132c	N Tyrrhenian Sea	1.4	2.7	0.4	1.0	0	2.8	1.9	1.5	0.4	0	0	2.3	0.5	0	0
132d	Centr. Tyrrhenian	0	0	0.4	0	0	0	1.1	1.8	0.3	0	0.7	0	1.7	0	0
133a	SE Sardinia	8.8	12.3	1.8	0	0	1.5	32.3	4.7	0.6	0	0.5	8.9	0	0.4	0
133b	NE Sardinia	0	8.2	0	0	0	0	13.5	0	0	0	16.1	1.9	10.7	5.9	0
133c	N Sardinia	1.9	23.5	0	0	0	2.1	3.4	39.7	0	0	0.9	8.2	0.7	0	0
133d	NW Sardinia	**167.0**	4.5	0	0	0	*	0	3.7	3.1	0	24.4	0.7	3.9	0	0
133e	W Sardinia	11.7	*	3.0	0.6	0	45.8	0	5.3	2.2	5.2	9.2	1.9	0.8	1.1	0
133f	SW Sardinia	0	3.2	0	17.5	0	**154.7**	22.3	1.1	11.3	0	29.9	17.8	16.1	22.0	0
133g	S Sardinia	0	0	0	1.5	0	2.7	*	0	0.8	0	18.3	0	0	0	0
134a	SE Tyrrhenian	0.3	0	0	0.2	0	0.7	0	0.4	0.1	0	0	0	0	0	0
134b	SW Tyrrhenian	0	2.2	0.6	0.5	0	0	0	1.1	0.8	0	0.6	0	0.3	0.4	0
134c	Sicilian Channel	2.1	9.8	11.5	8.0	0.1	2.1	17.0	5.6	5.3	0.1	1.2	20.8	8.1	34.4	0.5
211a	N Adriatic Sea	0	0	*	*	*	0	0	*	*	*	0	0	*	*	*
211b	Central Adriatic	0	0.3	0.2	0.2	0	0	0	0.4	0	0	0	0.2	0	0.2	0
211c	N Adriatic-Slov	*	*	*	*	*	0	*	*	*	*	0	*	*	*	*
211d	NE Adriatic-Croat	*	*	*	*	*	*	*	*	*	*	0	0	0	0	*
221a	E Sicily	18.9	0	0.4	6.0	0	5.7	1.3	0.5	5.6	0	6.9	18.5	15.5	0	0
221b	NW Ionian Sea	0	0	0	0	0	0.6	0	0.8	0	0.1	0.2	0	9.3	0	0
221c	N Ionian Sea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
221d	N Ionian Sea	*	0	0	0	0	7.3	0	1.3	0	0	1.2	1.9	3.0	0	0
221e	SW Adriatic Sea	0	5.0	1.1	0	0	*	2.9	1.9	0	0	*	1.3	0	0	0.3
221f	SW Adriatic Sea	4.4	1.2	0.2	0	0	2.1	0.5	0.3	0	0	0	0	0	0	0
221g	SW Adriatic Sea	3.9	0.9	0	*	0	0	0	0	*	0	0	0	0	*	0
221h	SW Adriatic Sea	2.1	0.1	0.1	2.7	0	1.1	0	0.2	6.9	0.2	0.5	0.3	0	8.2	0
221i	SE Adriatic Alban	*	*	*	*	*	*	*	*	*	*	0	0	0	0	0
222a	E Ionian Sea	10.6	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0
223a	Argosaronikos	**175.5**	0	0.1	0	0	62.4	13.2	0.6	0	0	9.2	5.7	3.1	4.5	0
224a	N Aegean Sea	0.3	0	0.7	0	0	3.2	0.2	1.2	0	0	14.1	0.1	7.1	0.8	0
225a	S Aegean Sea	24.6	23.2	41.7	0.1	0	1.0	2.2	8.9	2.7	0	14.9	34.0	13.1	3.6	0

TABLE 6. – ANOVA table for the GLMs fitted to the CPUE (g/km²) indices.

Source	Sum of Squares	Df	Mean Square	F	Sig.	Eta Squared
M. barbatus (R^2 = 0.45)						
Intercept	39.5*10⁶	1	39.5*10⁶	3478.55	.00	
Year	230190.14	5	46038.02	4.06	.00	0.04
Depth	98180.25	2	49090.12	4.32	.01	0.02
Major area	2.1*10⁶	13	159698.44	14.08	.00	0.27
Year * Depth	109717.99	10	10971.79	0.96	.47	0.02
Year * Major area	818904.40	65	12598.52	1.11	.27	0.12
Depth * Major area	905510.05	25	36220.40	3.19	.00	0.14
Error	5.7*10⁶	508	11340.40			
Corrected Total	10.4*10⁶	628				
M. surmuletus (R^2 = 0.61)						
Intercept	20.6*10⁶	1	20.6*10⁶	1192.84	.00	
Year	65992.88	5	13198.57	0.76	.58	0.01
Depth	45601.94	2	22800.97	1.31	.29	0.01
Major area	6.5*10⁶	13	500274.80	28.84	.00	0.43
Year * Depth	294280.21	10	29428.02	1.69	.08	0.03
Year * Major area	2.28*10⁶	65	34007.61	1.96	.00	0.20
Depth * Major area	1.7*10⁶	25	67492.42	3.89	.00	0.16
Error	8.8*10⁶	508	17341.08			
Corrected Total	22.6*10⁶	628				

TABLE 5 (Cont.). – *Mullus surmuletus*: Mean biomass (in kg/km^2) estimated from the MEDITS trawl surveys per depth stratum, geographical sector and year (1994-1999).Not sampled strata are indicated by ‘*’. Values higher than 100 kg/km^2 are presented in bold.

		1997 Depth (m)					1998 Depth (m)					1999 Depth (m)				
Sector code	Sector	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800	10-50	50-100	100-200	200-500	500-800
111a	Alborán Sea	5.0	1.0	12.9	0	0	2.9	9.0	30.3	0	0	0	9.8	4.6	0	0
112a	Alicante	17.1	2.8	3.1	0	0	0	6.0	8.5	0.2	0	37.3	3.5	7.6	1.2	0.3
113a	Catalan Sea	0.9	5.7	4.0	0	0	0.2	4.3	3.0	*	0	0.8	3.1	0.5	0	0
114a	W Morocco	*	*	*	*	*	*	*	*	*	*	*	0	6.5	0	0
114b	E Morocco	*	*	*	*	*	*	*	*	*	*	34.3	63.6	0.6	0	0
121a	W Gulf of Lions	0.5	2.0	2.1	0	0	0.1	4.6	0.2	10.3	0	0.5	1.3	1.0	2.9	0
121b	E Gulf of Lions	0	0	5.3	0.4	0	0	0.3	1.0	0	0	0.9	0	17.6	0.7	*
131a	NE Corsica	*	3.9	*	0	0	*	30.1	2.6	0	0	*	4.1	3.3	0.5	0
131b	SE Corsica	*	0	0	0	*	*	17.4	0.7	0	0	*	46.0	2.6	1.1	0
132a	N Ligurian Sea	0.3	0.5	2.1	0.1	0	2.2	0.1	0	0	0	2.1	2.9	0	0	0
132b	E Ligurian Sea	1.3	0.6	1.7	0.3	0	0.2	0.4	2.0	0	0	0	0.2	18.5	0.1	0
132c	N Tyrrhenian Sea	3.1	1.8	0.2	0.6	0	5.2	3.1	0.4	2.4	0.1	4.1	2.7	0.7	0.3	0.2
132d	Centr. Tyrrhenian	1.4	0.4	1.0	0	0	1.8	0.4	1.5	0	0	0	0	1.3	0	0
133a	SE Sardinia	2.6	1.6	0	0	0	0	**116.0**	9.2	0.4	0	5.9	19.1	1.5	9.5	1.4
133b	NE Sardinia	**126.8**	7.2	3.3	0	0	64.9	23.8	20.7	0.3	0	0	64.8	53.7	6.0	0
133c	N Sardinia	4.5	7.6	0	0	0	8.4	3.9	5.2	0	0	6.3	15.1	**204.0**	10.1	0
133d	NW Sardinia	**128.7**	0.5	2.0	0	0	**123.9**	10.3	20.1	0	0	37.0	0	12.1	12.9	1.2
133e	W Sardinia	5.1	16.4	7.1	0	0	4.7	7.4	20.4	0.6	0	30.3	**185.7**	12.2	0	0
133f	SW Sardinia	0.6	12.6	4.4	0	0	63.2	17.0	47.6	2.5	0	16.8	10.8	42.2	11.2	0
133g	S Sardinia	6.9	0	0.8	17.5	0	2.2	17.3	2.5	11.0	0	2.2	0	24.1	0.4	0
134a	SE Tyrrhenian	0.5	0.2	0	0	0	0.3	0	0	0	0	0.7	0.2	0.3	0.1	0
134b	SW Tyrrhenian	0	0.3	0.5	0	0	0	0.3	0.1	0	0	0	0	2.5	0	0
134c	Sicilian Channel	4.5	27.5	12.5	4.4	0.1	1.4	35.0	5.7	2.9	0	0	19.1	1.4	0.2	0.3
211a	N Adriatic Sea	0	0	*	*	*	0.1	0	*	*	*	5.1	0	*	*	*
211b	Central Adriatic	0	0.4	0.3	2.0	0	0.9	0	0.2	0	*	1.6	0.9	0.3	2.1	*
211c	N Adriatic-Slov	0	*	*	*	*	0	*	*	*	*	22.8	*	*	*	*
211d	NE Adriatic-Croat	0	0	0	0	*	0.5	0.3	2.5	1.4	*	0	*	*	*	*
221a	E Sicily	0	0	5.9	2.1	0	0	0.6	6.3	4.0	0	0	0	3.0	0	0
221b	NW Ionian Sea	0	0	0	0	0	0	0	12.2	1.0	0	0.6	0	4.3	0	0
221c	N Ionian Sea	0	0	0	0	0	0	0	1.0	0.4	0	0	0	0	0	0
221d	N Ionian Sea	1.3	0	6.7	0	0.1	6.6	0	16.4	3.5	0	0	0	3.0	1.1	0
221e	SW Adriatic Sea	*	1.4	0.3	0	0	*	0.8	0.3	0	0	*	2.6	0	0	0
221f	SW Adriatic Sea	1.6	0	0.5	0	0	2.9	1.3	0	0	0	6.4	0	1.5	0	0
221g	SW Adriatic Sea	0	0	0	*	0	1.6	0.4	0.4	*	0	61.4	0	0	*	0
221h	SW Adriatic Sea	0.8	0	0.5	6.9	0	3.3	0.6	0.7	1.0	0	0.5	0.7	2.8	24.1	0
221i	SE Adriatic Alban	0	0.1	0.4	0	0	0	0.1	0	0	0	0.9	0.2	0.5	0	0
222a	E Ionian Sea	0	0.2	0	0	0	0.4	0	0	0.2	0	0	0.1	0	1.5	0
223a	Argosaronikos	**121.0**	15.9	2.2	0.1	0	23.5	1.2	14.3	1.1	0	0.5	1.2	23.2	20.2	0
224a	N Aegean Sea	0.2	0.1	6.8	0.2	0	0	0	10.6	0.3	0	0	0	1.8	0.2	0
225a	S Aegean Sea	56.2	13.1	43.6	2.7	0	**178.8**	2.2	24.2	9.5	0.3	**185.0**	4.2	6.2	9.1	0



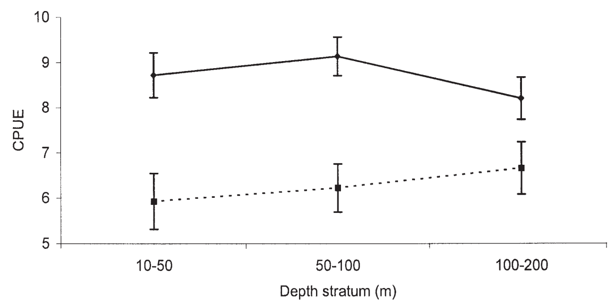


FIG. 3. – Standardised CPUE estimates by depth stratum, for *Mullus barbatus* (continuous line) and *Mullus surmuletus* (dashed line). Estimates are expressed in ln (g/km^2) and vertical lines indicate their 95% confidence intervals.

FIG. 2. – Standardised CPUE estimates by area, expressed in ln (g/km^2). Area codes correspond to the area names mentioned in Table 1. Vertical lines indicate their 95% confidence intervals.

Length frequencies

Mullus barbatus

The mean percentage length-frequency distributions by area are shown in Figure 4. Results indicated that in most cases more than 70% of the catches was composed of animals lesser than 15 cm of total length.

In the western Mediterranean, length distributions appeared to be generally uni-modal and positively skewed, with the exception of the Alborán Sea, where three components could be identified. The length distribution patterns in the eastern Mediter-

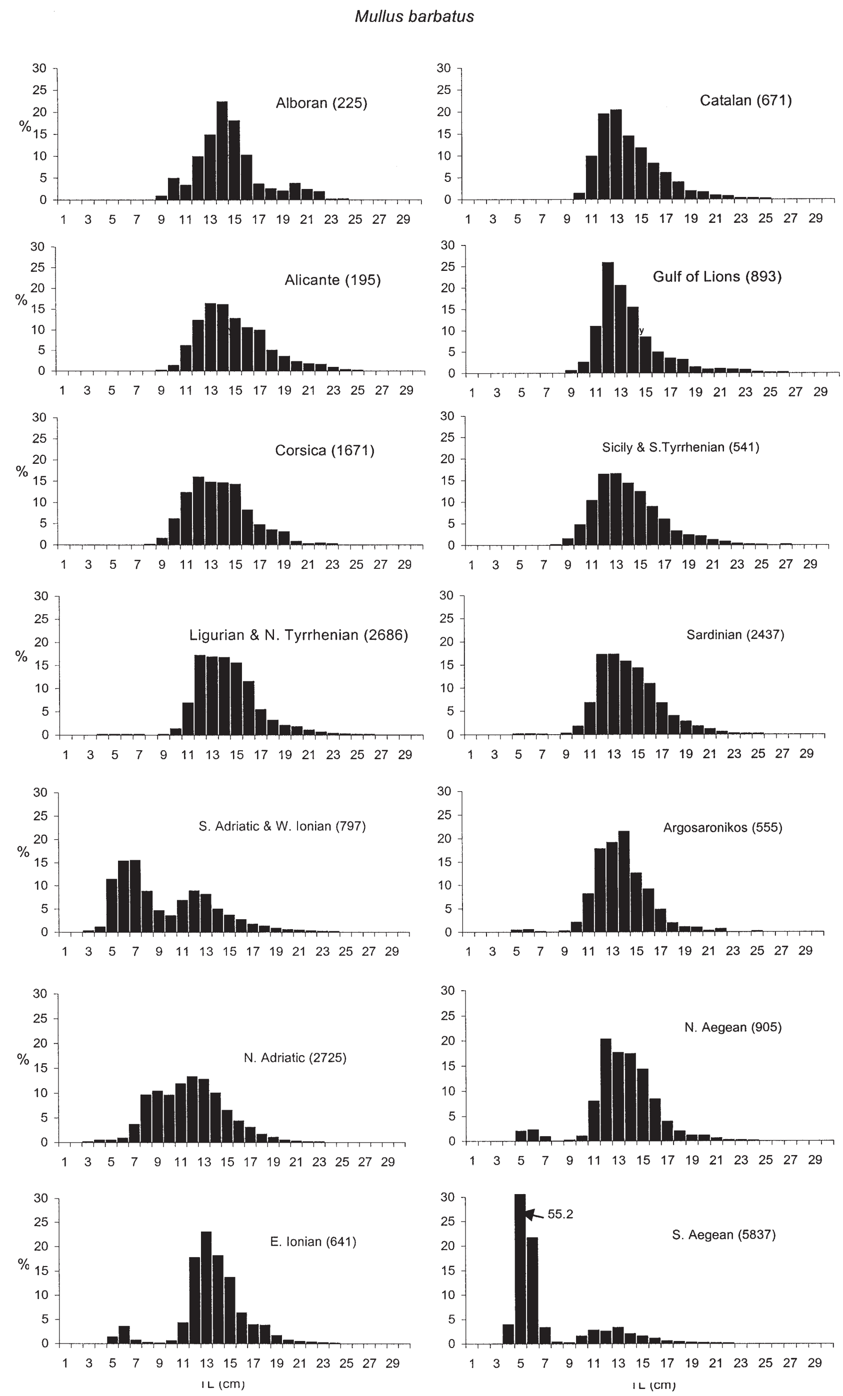


FIG. 4. – Mean percentage length frequency distributions (TL, cm), of *Mullus barbatus* by major areas. Numbers in brackets indicate the mean relative abundance for the sampled period expressed in number of individuals /km^2.

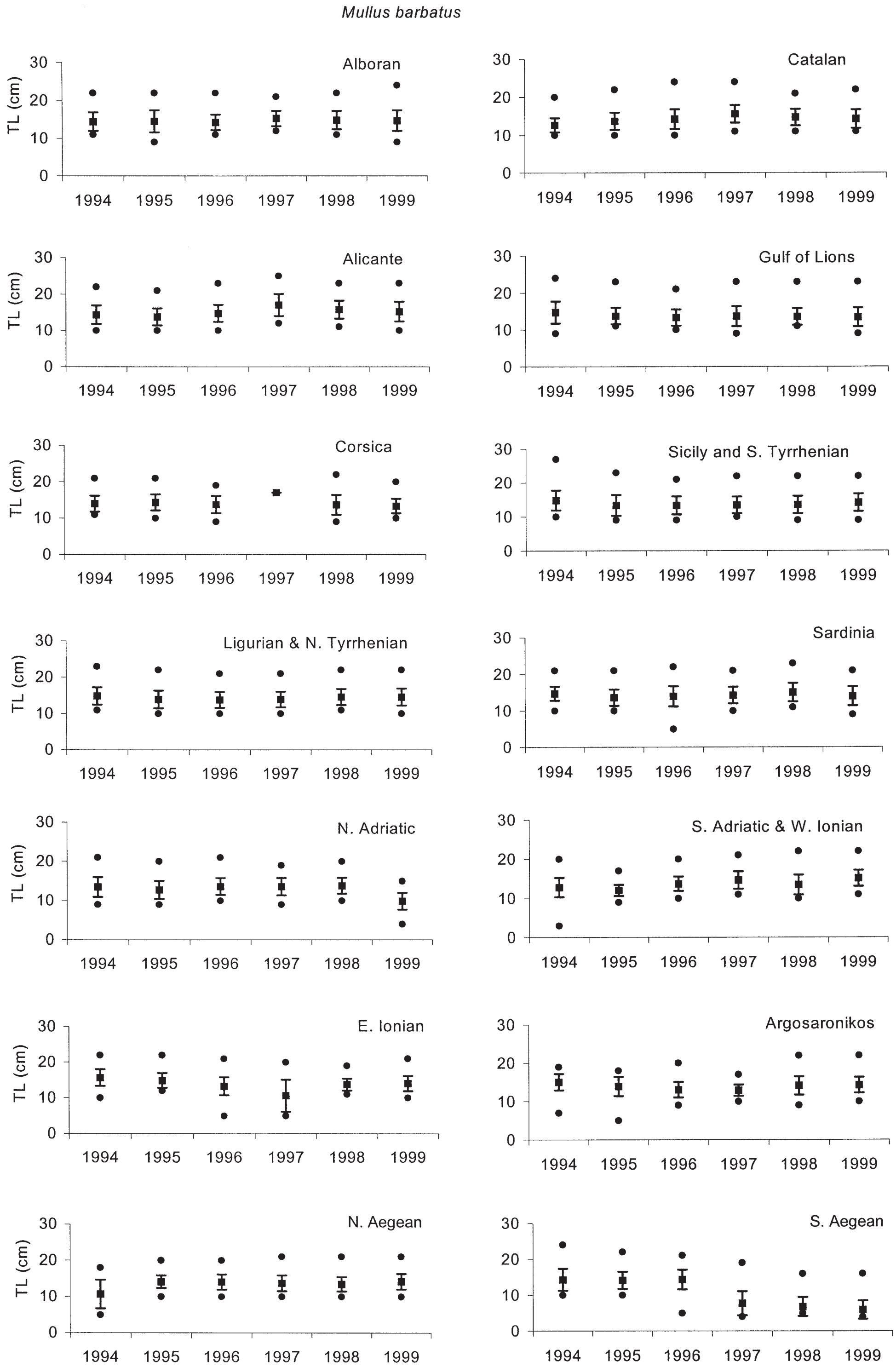


FIG. 5. – Minimum, maximum and mean length estimates (TL, cm) for *Mullus barbatus* by major area and year. Vertical lines indicate the standard deviation of the corresponding mean estimates.

ranean were more complex, with the occurrence of two modal classes. The smallest modes corresponded to young of the year, i.e. recruits, while the largest ones to relatively older animals. The highest percentage of recruits was recorded in the southern Aegean followed by those of western Ionian and southern Adriatic. Signs of recruitment could be perceived in the samples from the eastern Ionian, northern Aegean and Argosaronikos. Finally, a remarkable shape characterised the northern Adriatic distribution, where two modal classes of similar strength, were observed at 9 and 12 cm, respectively.

Time series of minimum, maximum and mean lengths by year and area in the western and eastern Mediterranean are shown in Fig 5. In the West, minimum values ranged between 9 and 11 cm, with the exception of Sardinia in 1996. The high value recorded in Corsica in 1997 was based on a very scanty sample of only 6 specimens. In the East, generally lower minimum sizes were recorded, ranging mostly from 4 to 10 cm.

Maximum lengths ranged between 15 and 27 cm and were generally higher in the western Mediterranean areas. In most of the cases values ranged from 20-24 and 18-22 cm in the western and eastern Mediterranean, respectively.

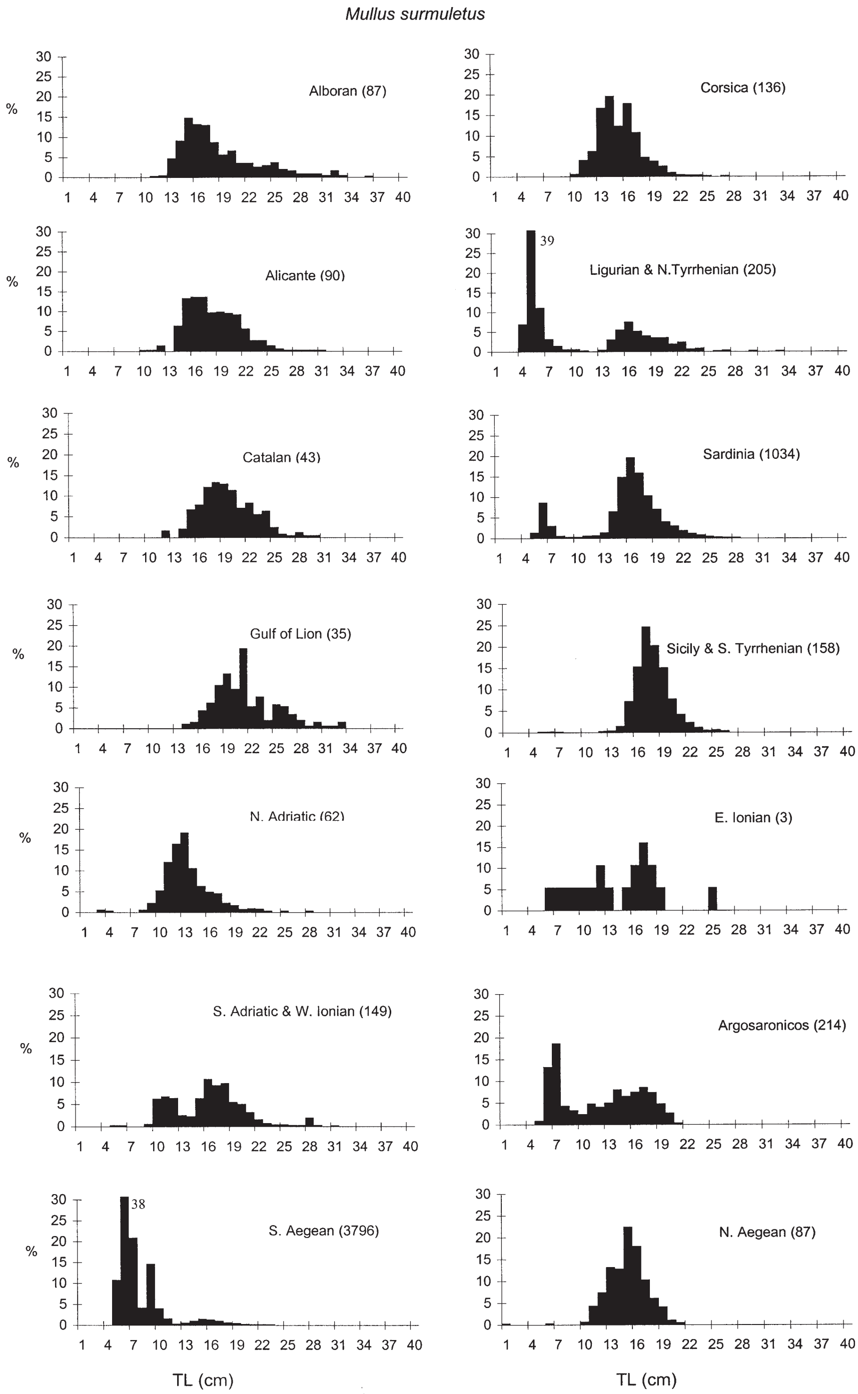


FIG. 6. – Mean percentage length frequency distributions (TL, cm), of *Mullus surmuletus* by major areas. Numbers in brackets indicate the mean relative abundance for the sampled period expressed in number of individuals / km^2.

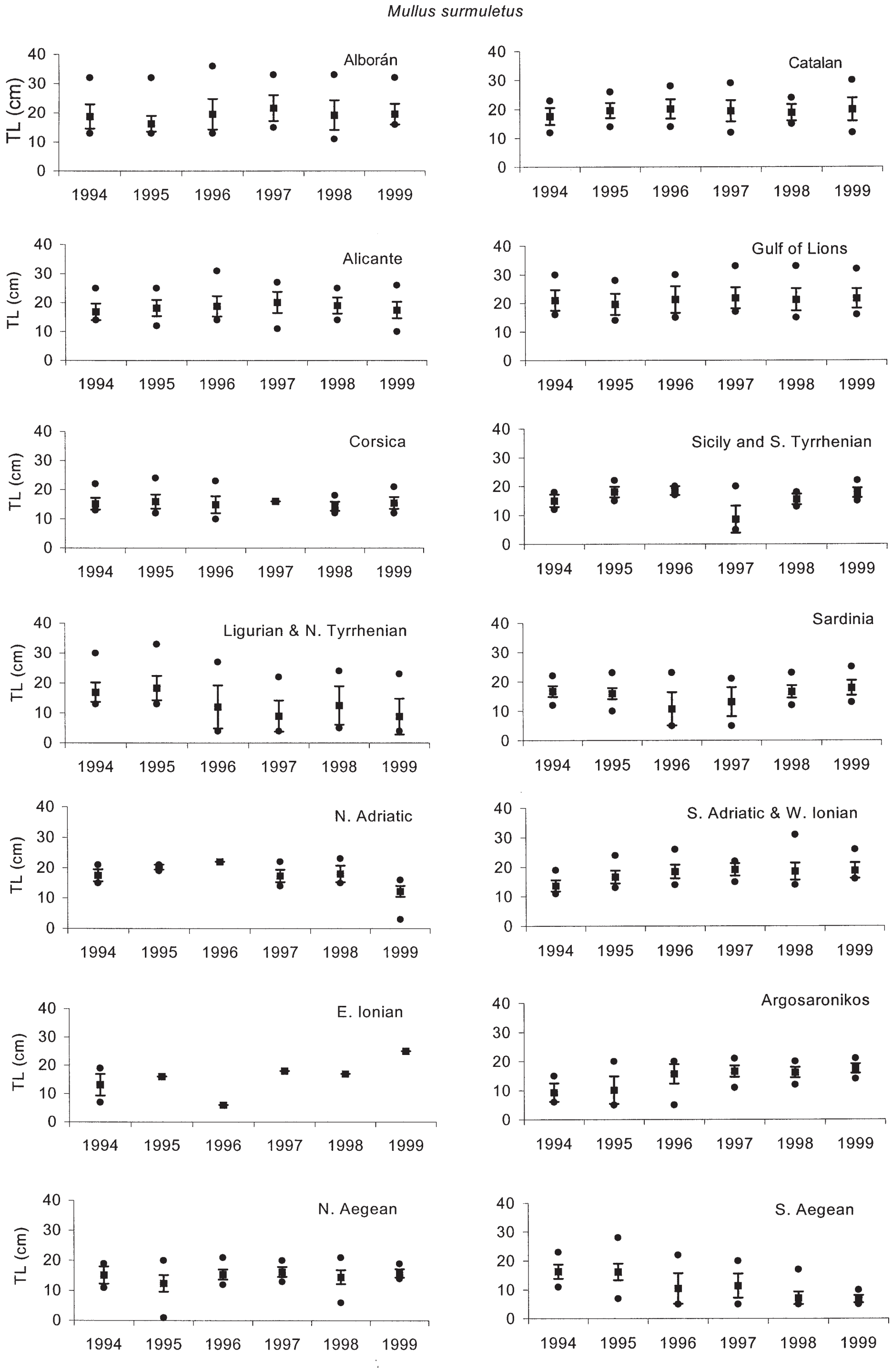


FIG. 7. – Minimum, maximum and mean length estimates (TL, cm) for *Mullus surmuletus* by major area and year. Vertical lines indicate the standard deviation of the corresponding mean estimates.

Mean lengths ranged mostly between 13 and 15 cm. Smaller mean lengths ought to the high presence of recruits were evident in certain eastern Mediterranean areas, such as southern Adriatic, eastern Ionian and southern Aegean seas.

No trends over time were identified regarding minimum, maximum and mean lengths.

Mullus surmuletus

The mean percentage length-frequency distributions by area are shown in Fig. 6. The main bulk of catches, which was more than 80% in several areas, was composed of animals having a total length up to 17 cm.

The western Mediterranean length distributions generally appeared to be polymodal. However, apart from Ligurian, northern Tyrrhenian and Sardinian regions, where recruits were clearly distinguishable, in the other areas only relatively older animals were found.

Similarly, in the eastern Mediterranean, length distributions were also polymodal and the presence of recruits was clearly evident in all areas except the northern Adriatic and northern Aegean seas. The presence of recruits is responsible for the generally higher mean abundance indices -in terms of number/km^2 - that were observed in the above areas.

Time series of minimum, maximum and mean lengths by year and area in the western and eastern Mediterranean are shown in Figure 7. Apart from the cases where recruits were found, minimum values mostly ranged from 10 to 17 cm. The presence of recruits was much more common in the eastern Mediterranean and particularly in the southern Aegean Sea.

Maximum lengths were higher in the western Mediterranean, ranged mostly from 22 to 33 cm. The corresponding range for the eastern Mediterranean was 15 to 28 cm.

Mean lengths mostly ranged from 15 to 21 and 15 to 19 cm in the central and eastern Mediterranean areas, respectively. Smaller mean lengths ought to the high presence of recruits were evident in certain years, particularly in Ligurian, northern Tyrrhenian and southern Aegean seas. As in the case of *M. barbatus*, no time trend was identified on minimum, maximum and mean lengths.

DISCUSSION

The common sampling scheme followed in the present study gave, for the first time, the opportunity for a global study of the distribution of *M. barbatus* and *M. surmuletus* in the Mediterranean waters. In addition, the computation of standardised abundance indices permitted direct spatio-temporal comparisons as it removed effects that could bias nominal indices (Hilborn and Walters, 1992).

The spatial distribution pattern of both species was rather complex and, at least to a certain extent, this can be attributed to the different biotic and abiotic conditions prevailing in each area. Past studies have shown that certain geological characteristics, such as the structure of the shelf, affect the species distribution. *M. surmuletus* prefers rough substrates, while *M. barbatus* is more abundant in muddy bottoms (Hureau, 1986; Fischer *et al.*, 1987). Lombarte *et al.*, (2000), who studied the spatial segregation of *M. barbatus* and *M. surmuletus* in the western Mediterranean, have also reported that *M. barbatus* shows a clear preference for the areas where the shelf becomes wider, while *M. surmuletus* prefers narrow shelf areas with rocky or sandy bottoms. In addition, ecomorphological studies suggest the existence of adaptive morphological and anatomical characteristics that allow *M. barbatus* to exploit better than its congeneric species resources from muddy and turbid bottoms (Lombarte and Aguirre, 1997).

Apart from the habitat characteristics, the level of the different fishing activities should also affect the spatial distribution pattern of the species. For instance, the particularly long-lasting intense fishing exerted in some productive areas, such as the Adriatic (Papaconstantinou and Farrugio, 2000) may be responsible for the low indices computed for those areas. On the other hand, the groundfish trawling prohibition up to one mile from the coastline, operating in Greece since the mid 1960's, may at least partially explain the high abundance indices observed in the 0-50 m depth stratum of an area of low primary production such as the southern Aegean Sea (Dugdale and Wilkerson, 1988).

Maximum lengths in the western Mediterranean were generally higher than those recorded in the eastern part. Similar findings for other demersal species were also reported in the past and attributed to productivity differences among areas (Azov, 1991; Stergiou, 1993). Indeed, oceanographic studies have shown that the primary production in the western basin is double of that in the eastern (Margalef, 1985; Dugdale and Wilkerson, 1988).

The MEDITS results indicated that *M. barbatus* was more abundant than *M. surmuletus* in all examined areas. However, this may not always be true, as the abundance of *M. surmuletus* may have been underestimated due to its preference for rough bottoms not always accessible by a trawl net. Although both species were found in all shelf strata, *M. surmuletus* showed maximum abundance in the 100-200 m depth stratum while *M. barbatus* showed maximum abundance in the 50-100 m depth stratum.. This finding is in agreement with the statement that *M. surmuletus* has a wider bathymetric range (Lombarte *et al.*, 2000).

Past growth studies suggested that *M. barbatus* and *M. surmuletus* individuals of lengths up to 15 and 17 cm, respectively, have not completed their second year of life (Andaloro and Prestipino Giarritta, 1985; Livadas, 1988; Morales-Nin, 1991; Levi *et al.*, 1992, 1993; Vassilopoulou and Papaconstantinou, 1992a, 1992b; Vrantzas *et al.*, 1992; Ardizzone *et al.*, 1994; Relini *et al.*, 1994; Spedicato and Lembo, 1994; Tursi *et al.*, 1994, 1996; Reñones *et al.*, 1995; Demestre *et al.*, 1997; Fiorentino *et al.*, 1998a; Voliani *et al.*, 1998a; 1998c). The high presence in the samples of fish up to those lengths implies that they were mainly composed of one and two year old fish.

Assuming that the size composition of our catches was representative of the population at sea it can be concluded that young fish dominated the stocks. Such a dominance, that makes the *Mullus* stocks extremely vulnerable to recruitment fluctuations, may be, at least partially, attributed to the high fishing pressure historically applied on the Mediterranean shelf area (Caddy, 1993; Farrugio *et al*., 1993).

Our data failed to demonstrate any overall time trends on the abundance indices of both species suggesting the presence of at least stable recruitment rates during the studied period. Overall, it seems that the stocks are under a "stable overfishing" condition. The durability of some fisheries that are largely based on massive catches of juvenile fish is not rare in the Mediterranean and can be explained by the hypothesis of a good stock-recruitment relationship for low levels of spawning stock biomass (Farrugio *et al*., 1993). In the present case, it can be speculated that the increased productivity of the Mediterranean basin during recent years (Papaconstantinou and Farrugio, 2000) has supported recruitment rates that compensate for the high fishing pressure. The ability of some *Mullus* species, such as *M. barbatus,* to delay their settlement until they reach suitable substrates (Kendall *et al*., 1984), may also contribute towards successful recruitment

Although no decreasing trends were identified, neither in the abundance indices nor in the maximum and modal lengths, the fact that *Mullus* stocks are so highly dependent on recruitment, makes the employment of measures to protect spawning and nursery areas necessary. Measures that include closed areas and seasons to bottom-trawl fisheries, and an increase of the mesh size of the net, would be beneficial and have also been suggested by several past authors (Hadjistephanou, 1992; Stergiou *et al.*, 1992; Levi *et al.*, 1993; Demestre *et al.*, 1997). The employment of such measures gave promising results in certain areas of the Italian seas (Potoschi *et al.*, 1995; Pipitone *et al.,* 1996; Relini *et al.*, 1996; Ardizzone, 1998; Fiorentino *et al.*, 1998b). Consequently, it is expected that the recently applied ban of trawling in European Mediterranean waters at depths of less than 50 m, and the increase of the trawl cod-end mesh size, will favour the recruitment of *Mullus* species.

Areas of recruitment could not be traced from the presently collected data, as the surveys were accomplished (depending on the area and year) within or just after the reproductive period, occurring from May to July for *M. barbatus* (Larrañeta and Rodríguez Roda, 1956; Livadas, 1988; Vrantzas *et al.*, 1992; Tursi *et al.*, 1994) and April to June for *M. surmuletus* (Morales-Nin, 1991; Vassilopoulou and Papaconstantinou, 1992b). Consequently, recruitment was not generally evident, apart from certain years, in eastern Mediterranean areas.

REFERENCES

Andaloro, F. and S. Prestipino Giarrita. – 1985. Contribution to the knowledge of the age and growth of the striped mullet, *M. barbatus* and red mullet, *M. surmuletus*, in the Sicilian Channel. *FAO Fish. Rep.*, 336: 89-92.

Ardizzone, G.D. – 1998. Un tentativo di valutazione delle condizioni di *Merluccius merluccius* e *Mullus barbatus* nei mari italiani. *Biol. Mar. Medit*, 5 (2): 151-168.

Ardizzone, G.D., A. Belluscio and P. Schintu. – 1994. Considerazioni sullo stato di sfruttamento delle risorse demersali (Isola di Giannutri -Foce del Garigliano). *Biol. Mar. Medit*, 1(2): 43-46.

Azov, Y. – 1991. Eastern Mediterranean – a marine desert? *Mar. Poll. Bull*., 23: 225-232.

Bertrand, J., L. Gil De Sola, C. Papaconstantinou, G. Relini and A. Souplet. – 1997. An international bottom trawl survey in the Mediterranean: the MEDITS programme. *ICES Annual Conference*, CM 1997/Y03: 16 pp.

Bertrand, J.A., L. Gil de Sola, C. Papaconstantinou, G. Relini and A. Souplet. – 2000. An international bottom trawl survey in the Mediterranean: the MEDITS programme. In: J.A. Bertrand and G. Relini (eds.), *Demersal resources in the Mediterranean, Proceedings of the Symposium held in Pisa, 18-21 March 1998, Actes de Colloques* 26, pp. 76-93. IFREMER, Plouzané.

Bertrand, J., L. Gil de Sola, C. Papaconstantinou, G. Relini and A. Souplet. – 2002. The general specifications of the MEDITS surveys. *Sci. Mar.*, 66 (Suppl. 2): 9-17.

Caddy, J.F. – 1993. Some future perspectives for assessment and management of Mediterranean fisheries. *Sci. Mar.*, 57(2-3): 121-130.

Demestre, M., M. Sbrana, F. Álvarez and P. Sánchez. – 1997. Analysis of the interaction of fishing gear in *Mullus barbatus* fisheries of the Western Mediterranean. *J. Appl. Ichthyol.*, 13: 49-56.

Dixon, W.J. and F.J. Massey Jr. – 1985. *Introduction to Statistical Analysis*. 4th ed. McGraw-Hill Co, London.

Dudgale, R.C. and F.R. Wilkerson. – 1988. Nutrient sources and primary production in the Eastern Mediterranean. *Oceanol. Acta*, 9: 179-184.

Farrugio, H., P. Oliver and F. Biagi. – 1993. An overview of the history, knowledge, recent and future research trends in Mediterranean fisheries. *Sci. Mar.*, 57: 105-119.

Fiorentini, L., J.F. Caddy and J.I. De Leiva. – 1997. Long and short-term trends of Mediterranean fishery resources. *Stud. Rev. C.G.P.M.,* 69: 1-72.

Fiorentino, F., A. Zamboni, M. Rossi and G. Relini. – 1998a. The growth of the red mullet (*Mullus barbatus*, L. 1758) during the first years of life in the Ligurian Sea (Mediterranean). *Cah. Opt.*

Médit., 35: 65-78.
Fiorentino, F., A. Zamboni, M. Rossi and G. Relini. – 1998b. Relazioni “adulti-reclute” in *Mullus barbatus* (L., 1758) (Osteichthyes - Mullidae) del Mar Ligure: uno studio preliminare. *Biol. Mar. Medit.,* 5 (1): 308-316.
Fischer, W., M.L. Bauchot and M. Schneider (rédacteurs). – 1987. *Fiches FAO d'identification des espèces pou les besoins de la peche*. *(Révision 1). Mediterranée et Mer Noire. Zone de peche 37.* ***2.*** *Vertébrés.* FAO, Rome.
Gharbi, H. and M.H. Ktari. – 1979. Régime alimentaire des rougets (*Mullus barbatus* Linnaeus, 1758 et *Mullus surmuletus* Linnaeus, 1758) du golfe de Tunis. *Bull. Inst. Natl. Sci. Tech. Océanogr. Pêche Salammbô*, 6: 41-52.
Golani, D. – 1994. Niche separation between colonizing and indigenous goatfish (Mullidae) along the Mediterranean coast of Israel. *J. Fish Biol*., 45: 503-513.
Gulland, J.A. – 1956. On the fishing effort in English demersal fisheries. *Fish. Invest. London series,* 2(20): 1-41.
Hadjistefanou, N.A. – 1992. Assessment of five demersal marine fish stocks of Cyprus for the year 1989. *FAO Fish. Rep.,* 477: 23-34.
Hilborn, R. and C.J. Walters. – 1992. *Quantitative fisheries stock assessment*. Chapman and Hall, London.
Hureau, J.C. – 1986. Mullidae. In: P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese (eds.): *Fishes of the North-eastern Atlantic and the Mediterranean Vol. II*, pp. 877-882. UNESCO, Paris.
Kimura, D.K. – 1981. Standardized measures of relative abundance based on modelling log(CPUE), and their application to Pacific Ocean perch (*Sebastes alutus*). *J. Cons. Int. Explor. Mer*, 39: 211-218.
Kendall, A.W., E.H. Ahlstrom and H.G. Moser. – 1984. Early life history stages of fishes and their characters. In: H.G. Moser, W.J. Richards, D.M. Cohen, M.P. Fahay, A.W. Kendall, Jr., and S.L. Richardson (eds.) *Ontogeny and Systematics of Fishes*, pp. 11-22. Am. Soc. Ichthyol. Herpetol., Spec. Publ. No 1. Allen Press Inc, Lawrence.
Larrañeta, M.G. and J. Rodríguez Roda. – 1956. Contribución al conocimiento de la pesquería del salmonete de fango (*Mullus barbatus* L.) de las costas de Castellón. *Inv. Pesq*., 3: 45-68.
Levi D., G. Andreoli and G.B. Giusto. – 1993. An analysis based on trawl-survey data of the state of the “Italian” stock of *Mullus barbatus* in the Sicilian Channel, including management advice. *Fish. Res.*, 17: 334-341.
Levi, D., G. Andreoli and P. Rizzo. – 1992. Growth curves from representative samples of fish population as possible hints for the identification of unit stocks. The case study of red mullet from the Sicilan Channel. In: G. Colombo, I. Ferrari, V.U. Ceccherelli and R. Rossi (eds.), *Marine Eutrophication and Population Dynamics. Proceedings 25th EMBS*, pp 296-306. Olsen & Olsen, Denmark.
Livadas, R.J. – 1988. A study of the growth and maturity of striped mullet (*Mullus barbatus* L.,), in waters of Cyprus. *FAO Fish. Rep.,* 412: 44-51.
Lombarte, A. and H. Aguirre. – 1997. Quantitative differences in the chemoreceptor systems in the barbels of two species of Mullidae (*Mullus surmuletus* and *M. barbatus*) with different bottom habitats. *Mar. Ecol. Prog. Ser*., 150: 57-64.
Lombarte, A., L. Recasens, M. Gonzalez and L. Gil de Sola. – 2000. Spatial segregation of two species of Mullidae (*Mullus surmuletus* and *M. barbatus)* in relation to habitat. *Mar. Ecol. Prog. Ser*., 206: 239-249.
Machias, A., S. Somarakis and N. Tsimenides. – 1998. Bathymetric distribution and movements of red mullet *Mullus surmuletus. Mar. Ecol. Prog. Ser.,* 166: 247-257.
Margalef, R. – 1985. Introduction to the Mediterranean. In: R. Margalef (ed.). *Key Environments: Western Mediterranean*, pp 1-16. Pergamon Press, Oxford.
Morales-Nin, B. – 1991. Parámetros biológicos del salmonete de roca *Mullus surmuletus* (L. 1758), en Mallorca. *Bol. Inst. Esp. Oceanogr*., 7(2): 139-147.
Papaconstantinou, C. and H. Farrugio. – 2000. Fisheries in the Mediterranean. *Medit. Mar. Sci.* 1(1): 5-18.
Pipitone, C., F. Badalamenti, G. D'Anna and B. Patti. – 1996. Divieto di pesca a strascico nel Golfo di Castellammare: alcune considerazioni . *Biol. Mar. Medit.*, 3 (1): 200-204.
Potoschi, A., G. Cavallaro, P. Sturiale and G. Lo Duca. – 1995. Effetti del decreto regionale del 31/5/90 sui rendimenti di pesca di *Mullus barbatus* (L. 1758), catturato con rete a strascico nel Golfo di Patti (ME). *Biol. Mar. Medit.*, 2 (2): 505-507.
Relini, G., J. Bertrand and A. Zamboni. – 1999. Synthesis of the knowledge on bottom fishery resources in Central Mediterranean (Italy and Corsica). *Biol. Mar. Medit*., 6 (suppl.1): 276-299.
Relini, G., L. Orsi Relini, F. Fiorentino, D. Massi and A. Zamboni. – 1994. Considerazioni sullo stato di sfruttamento delle risorse demersali (Ventimiglia-Foce del Magra). *Biol. Mar. Medit.*, 1 (2): 11-21.
Relini, G., A. Zamboni, D. Massi and F. Fiorentino. – 1996. Un esempio di incremento della produzione ittica in seguito ad una maggiore protezione della fascia costiera nella Liguria Orientale. *Biol. Mar. Medit.*, 3 (1): 222-229.
Reñones, O., B. Massutí and B. Morales-Nin. – 1995. Life history of the red mullet *Mullus surmuletus* from the bottom-trawl fishery off the Island of Majorca (north-west Mediterranean). *Mar. Biol.*, 123: 411-419.
Souplet, A. – 1996. Calculation of abundance indices and length frequencies in the MEDITS survey. In: *J.* Bertrand (coord.): *Campagne internationale de chalutage demersal en Méditerranée (MEDITS). Campagne 1995. Rapport final Vol. III.* Raport de contract CEE-IFREMER-IEO-SIBM-NCMR (MED/93/020, 018,006,004): 5-9.
Spedicato, M.T. and G. Lembo. – 1994. Considerazioni sullo stato disfruttamento delle risorse demersali (Fiume Garigliano - Capo Suvero). *Biol. Mar. Medit.*, 1 (2): 47-59.
Stergiou, K.I. – 1993. Nutrient-dependent variation in growth and longevity of the red bandfish, *Cepola macrophthalma*, in the Aegean Sea. *J. Fish Biol*., 42: 633-644.
Stergiou, K.I., G. Petrakis and C. Papaconstantinou. – 1992. The Mullidae (*Mullus barbatus*, *M. surmuletus*) fishery in Greek waters, 1964-1986. *FAO Fish. Rep.,* 477: 97-113.
Suau, P. and F. Vives. – 1957. Contribución al estudio del salmonete de fango (*Mullus barbatus* L.) del Mediterráneo occidental. *Inv. Pesq*., 9: 27-118.
Tserpes, G., P. Peristeraki, G. Potamias and N. Tsimenides. – 1999. Species distribution in the southern Aegean Sea based on bottom-trawl surveys. *Aquat. Liv. Res*., 12 (3): 167-175.
Tursi, A., A. Matarrese, G. D'Onghia and L. Sion. – 1994. Population biology of red mullet (*Mullus barbatus* L.) from the Ionian Sea. *Mar. Life*, 4 (2): 33-43.
Tursi, A., A. Matarrese, G. D'Onghia, L. Sion and P. Maiorano. – 1996. The yield per recruit assessment of hake (*Merluccius merluccius* L. 1758) and red mullet (*Mullus barbatus* L. 1758) in the Ionian Sea. *FAO Fish. Rep.* 533, suppl.:127-141.
Vassilopoulou, V. and C. Papaconstantinou. – 1992a. Aspects of the biology and dynamics of red mullet (*Mullus barbatus*) in the Aegean Sea. *FAO Fish. Rep.,* 477: 115-126.
Vassilopoulou, V. and C. Papaconstantinou. – 1992b. Preliminary biological data of the striped mullet (*Mullus surmuletus*) in the Aegean Sea. *FAO Fish. Rep.,* 477: 85-96.
Voliani, A., A. Abella and R. Auteri. – 1998a. Some considerations on the growth performance of *Mullus barbatus. Cah. Opt. Médit*., 35: 93-106.
Voliani, A., A. Abella, R. Auteri and R. Silvestri. – 1998c. Nota sui parametri biologici di *Mullus surmuletus* L., 1758 nell'Arcipelago Toscano. *Biol. Mar Medit*. 5 (1): 864-868.
Voliani, A., A. Abella and F. Serena. – 1998b. Problematiche inerenti lo stato di sfruttamento di *Mullus barbatus*. *Biol. Mar. Medit*, 5 (2): 169-183.
Vrantzas, N., M. Kalagia and C. Karlou. – 1992. Age, growth and state of stock of red mullet (*Mullus barbatus* L., 1758) in the Saronikos Gulf of Greece. *FAO Fish. Rep*., 477: 51-67.