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Biodiversity of the Upper Slope Demersal Community in the Eastern Mediterranean: Preliminary Comparison BetweenTwo Areas With and Without Trawl Fishing

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Abstract

Univariate diversity indices and multivariate analyses (cluster and multidimensional scaling (MDS) were performed in order to evaluate biodiversity in two neighbouring areas of the Eastern Mediterranean with different fishing intensity. Data were collected from two trawl surveys (July and August 2000) in two areas of the Ionian Sea. In the area off the South-eastern Italian coast, there is a trawl fishery at depths between 300 and 700 m that targets the deep-sea shrimps *Aristeus antennatus* and *Aristaeomorpha foliacea.* In the other area off Northern Greece, fishing is only carried out down to 400 m depth.

While diversity indices did not show convincing differences in the community structure between the two study areas considered as a whole, the multivariate analysis showed a clear pattern linked to depths and areas highlighting the distribution of abundance of the various species. Depth played the main role in the group differentiation, indicating the existence of two quite distinct bathyal faunal assemblages: one on the upper slope, the other on the middle slope. The results of the geographic characterization of the diversity and of the assemblage composition are discussed considering the different fishing intensity as well as the environmental conditions in the two areas of the same basin.

Key words: abundance, biodiversity, demersal community, environment, Mediterranean Sea

Introduction

The Ionian Sea is a basin of the Eastern Mediterranean, delimited westwards and eastwards by the Italian and Greek coasts, respectively. It communicates with the western Mediterranean through the Sicilian Channel, with the Adriatic through the Otranto Channel, and with the Aegean Sea through the three straits of the Western Cretan Arc. Such a position results in a complex hydrography owing to the occurrence of three main water masses, namely the Modified North Atlantic Water, the Levantine Intermediate Water, and the Eastern Mediterranean Deep Water (Theocharis *et al*., 1993; Rabitti *et al.*, 1994). Knowledge on the distribution and abundance of the demersal fauna in the Ionian basin comes mostly from the Italian side, where systematic surveys of the demersal resources have been carried out since 1985 (e.g. Tursi and D'Onghia, 1992; Matarrese *et al.*, 1996; D'Onghia *et al*., 1998). The demersal fish fauna of the Greek Ionian Sea, as well as the fauna of crustacean decapods and cephalopods, has only recently been studied (Anon., 1999; Anon., 2000; Politou *et al*., 2000). While along the Italian coasts the demersal resources have long been intensively exploited as deep as 800 m (Tursi *et al*., 1998), off Greece the commercial fishery is only carried out down to 400 m.

Although both the hydrographic features and the fishing intensity could affect the distribution and abundance of many species, thereby influencing the diversity in marine ecosystems, the faunistic assemblages on the two sides of the Ionian Sea (Italian and Greek) have never been compared. Furthermore, although in the last decade many studies on the effects of fishing on ecosystem structure and processes have been carried out (e.g. Jennings and Kaiser, 1998, and references therein; Hall, 1999, and references therein), knowledge of the effects of trawl fishing on the fish communities in the Mediterranean is still rather scanty (e.g. Stergoiu *et al*., 1997; Ungaro *et al*., 1998; Moranta *et al*., 2000; Pranovi *et al*., 2000).

The "INTERREG" project, funded jointly by the European Commission and the Italian and Greek governments, provided the opportunity to investigate two areas of the North Ionian Sea, which are subjected to different levels of fishing intensity. One is off the South-eastern Italian coast, where deep-water fishing occurs, and the other is off Northern Greece, where there is no deep trawl fishing. In this paper, observations concerning the faunal assemblages and the relative biodiversity are presented.

Materials and Methods

Data were collected during two trawl surveys (July and August 2000) carried out in two areas of the Ionian Sea (Eastern Mediterranean): one off the South-eastern Italian coast, the other off the Northern Greece (Fig.1). In the former trawl fishing occurs between 300 and 700 m targetting the deep-sea shrimps *Aristeus antennatus* and *Aristaeomorpha foliacea* (Tursi *et al*., 1998), in the latter fishing is carried out down to 400 m in depth.

A total of 14 hauls, each lasting 1 hour, were randomly taken in each area between 300 and 750 m. The same commercial fishing vessel equipped with a bottom trawl (Italian type, with 20 mm stretched mesh size in the cod-end) was used. Fishes, crustaceans, cephalopods and benthic species captured in each haul were sorted into species, counted and weighed. The data for each species were expressed as number and weight of individuals per hour of trawling. Each species was coded with a number. Hauls were coded by geographical area (I = Italy; G = Greece). Species recorded in a single or very few hauls and represented by few specimens (such as the strictly benthic invertebrates) were excluded from the computations. Species known to be typically pelagic were omitted, unless a frequent and abundant finding was observed with the gear used. Species diversity was computed using the following univariate ecological indexes: Shannon-Wiener diversity index H' (using $\log_e$); Margalef species richness D (using $\log_e$ transformation), and Pielou's evenness J (Magurran, 1991). Both abundance (N/h) and biomass (kg/h) data were used in index computation. The t-test was applied in order to detect significant differences between the two areas.

Matrices of the numbers- and weights-per-hour of each species from each station were compiled. Basic data were log-transformed to reduce the influence of the most abundant species. Classification and ordination were performed in order to identify demersal faunal assemblages in the two geographic study areas. The former was made by means of cluster analysis using the Euclidean distance coefficient and the complete linkage method (Ludwig and Reynolds, 1988), the latter through non-parametric multi-dimensional scaling analysis (Kruskal, 1964). All

Fig. 1. Investigated areas along Italian and Greek coast.

these analyses were carried out using Statistica software (StatSoft, 1995).

Results

According to the selection criteria, 101 species were collected in Italian waters and 112 in the Greek area. The average hourly abundance (N/h) and biomass (kg/h) for each of them are shown in Table1.

Teleost fishes were the dominant species in both areas (38 off Italy and 45 off Greece), followed by crustaceans (31 and 26 off Italy and Greece, respectively), cephalopods (11 along the Italian coasts and 14 along Greek ones), selachians (6 and 9 off Italy and off Greece, respectively) and other minor taxa.

Diversity indices for each station are reported in Table 2. H' ranged from 0.87 to 2.43 in Italian waters and from 1.2 to 2.67 in Greek area. Margalef species richness indexes D were between 2.88 and 3.76 in the Italian stations and 3.04 and 3.74 in Greek ones. Evenness values were between 0.25 and 0.74 off Italy and 0.33 and 0.79 off Greece. Although each index showed higher values for Greece than for Italy, the differences were not statistically significant ($p > 0.05$).

The cluster analysis showed that the abundance value (N/h) produced a better group separation than biomass (Kg/h), even though the results obtained were consistent. Concerning abundance, the resulting dendrogram between hauls indicated the presence of two main clusters related to depth (Fig. 2). One group is the uppermost stations (A), covering a depth range of 327–478 m, with a mean depth of 370 m. The other is related to deeper hauls (B), including the intermediate stations with depths between 513 and 683 m, and a mean of 572 m (B1), and the deepest stations, between 592 and 757 m, with a mean of 669 m (B2). For each of these clusters a lower distance (higher similarity) was shown within each geographic area. In fact, Italian and Greek hauls were well separated in each of them. However, in cluster B2 the deepest hauls of Italian and Greek waters showed a higher similarity than the shallowest in Italian waters (between 592–629 m).

The results of multidimensional scaling (MDS) (stress level = 0.05) are shown as a three dimensional representation in Fig. 3. The ordination of the 28 hauls was in agreement with clustering, confirming that the different stations fall into distinct groupings. In particular, MDS analysis highlights: a) a marked separation between the uppermost and middle slope stations; b) a marked geographic separation of the hauls in the uppermost slope; c) to a lesser extent, a geographic characterization of the stations in the middle slope.

On the basis of both clustering and MDS analysis, the uppermost assemblage in the Greek area was characterized by a great abundance of *Chlorophthalmus agassizii* and to a lesser extent by *Hymenocephalus italicus, Plesionika heterocarpus, Parapenaeus longirostris, Gadiculus argenteus*, *Argentina sphyraena*, *Capros aper*, *Caelorhynchus caelorhynchus*, *Peristedion cataphractum*, *Galeus melastomus*, *Merluccius merluccius*, *Pagellus bogaraveo*, *Micromesistius poutassou*, *Scyliorhinus canicula*, *Raya oxyrinchus* and *Squalus blainvillei*. A total of 67 species in this assemblage gave a diversity index (H') of 1.5. The dominant species in the uppermost assemblage of the Italian area were much less abundant than in Greece. They were: *Plesionika heterocarpus, Gadiculus argenteus*, *Hymenocephalus italicus, Nephrops norvegicus, Chlorophthalmus agassizii, Phycis blennoides, Helicolenus dactylopterus, Parapenaeus longirostris, Galeus melastomus* and *Micromesistius poutassou*. Apart from *G. melastomus* no elasmobranch species were found in this assemblage, which consisted of 51 species. Its computed diversity index (H') was 2.5.

The assemblages in the middle slope showed a greater similarity between the two areas. The diversity index computed for the deepest group of stations (B2) was 2.48 in both areas. However, in addition to the different distribution of the species abundance, *Aristaeomorpha foliacea* and *Helicolenus dactylopterus* dominated in Greek waters while *Plesionika martia* and *Aristeus antennatus* did so in Italian ones.

Discussion

The results of this study indicate that depth and geographical area are the main factors influencing the faunal assemblages in the North-eastern Ionian Sea.

Univariate diversity indices do not show significant differences between the community structure of the two study areas considered as a whole. Moreover, the diversity index H' was found to be higher in the uppermost assemblage from the Italian area where there is a trawl fishery. The smaller value

TABLE 1. List of the species collected in Italian and Greek areas with indications of average density (N/h) and biomass indices (Kg/h). For the colonial species *Isidella elongata* only the biomass index is reported.

Italy			Greece	
		SPONGES		
Kg/h	**N/h**		**N/h**	**Kg/h**
0.000	0.095	*Calthropella pathologica*	0.000	0.000
		CNIDARIANS		
0.042	2.747	*Actinauge richardi*	0.000	0.000
0.001	1.240	*Adamsia palliata*	0.286	0.000
0.000	0.000	*Calliactis parasitica*	0.500	0.000
0.000	0.000	*Caryophyllia smithi*	0.500	0.000
0.000	0.000	*Desmophyllum cristagalli*	0.357	0.000
0.000	0.000	*Funiculina quadrangularis*	0.143	0.000
0.000	0.000	*Isidella elongata*	-	0.092
0.003	2.000	*Kophobelemnon leukarti*	0.000	0.000
0.003	1.786	*Pennatula rubra*	0.000	0.000
		BRACHIOPODS		
0.000	0.262	*Gryphus vitreus*	2.643	0.016
		SCAPHOPODS		
0.001	0.571	*Dentalium sp.*	0.000	0.000
		GASTROPODS		
0.000	0.000	*Aporrhais pespelecani*	0.286	0.000
0.000	0.000	*Argobuccinum olearium*	0.071	0.000
0.003	0.143	*Cassidaria echinophora*	0.000	0.000
0.014	0.143	*Tethys fimbria*	0.000	0.000
		BIVALVES		
0.000	0.190	*Delectopecten vitreus*	0.000	0.000
		CEPHALOPODS		
0.000	0.071	*Abralia verany*	0.321	0.002
0.001	0.071	*Ancistroteuthis lichtensteinii*	0.000	0.000
0.001	0.071	*Brachioteuthis riisei*	0.000	0.000
0.013	0.143	*Histioteuthis reversa*	0.071	0.004
0.000	0.000	*Illex coindetii*	0.190	0.001
0.000	0.000	*Loligo forbesii*	1.524	0.364
0.001	0.071	*Neorossia caroli*	0.657	0.008
0.081	1.286	*Octopus salutii*	0.000	0.000
0.000	0.000	*Onychoteuthis banksii*	0.071	0.001
0.178	0.864	*Pteroctopus tetracirrhus*	0.679	0.293
0.000	0.000	*Rondeletiola minor*	0.286	0.000
0.020	0.286	*Rossia macrosoma*	0.714	0.021
0.003	0.214	*Scaeurgus unicirrhus*	0.190	0.003
0.000	0.000	*Sepia elegans*	1.714	0.016
0.000	0.000	*Sepia orbignyana*	0.190	0.003
0.034	7.286	*Sepietta oweniana*	9.429	0.032
1.074	3.238	*Todarodes sagittatus*	0.393	0.189

TABLE 1. (Continued). List of the species collected in Italian and Greek areas with indications of average density (N/h) and biomass indices (Kg/h). For the colonial species *Isidella elongata* only the biomass index is reported.

		SIPUNCULANS		
0.000	0.000	*Sipunculus nudus*	0.143	0.001
		CRUSTACEANS		
0.003	1.786	*Aegeon lacazei*	0.286	0.000
0.435	47.976	*Aristaeomorpha foliacea*	248.457	4.401
1.808	81.429	*Aristeus antennatus*	27.300	0.869
0.001	0.214	*Bathynectes maravigna*	0.964	0.009
0.016	11.929	*Chlorotocus crassicornis*	1.810	0.003
0.000	0.000	*Dardanus arrosor*	0.143	0.004
0.015	0.221	*Geryon longipes*	0.000	0.000
0.017	7.357	*Macropipus tuberculatus*	0.286	0.001
0.003	0.929	*Monodaeus couchii*	0.000	0.000
0.002	0.786	*Munida intermedia*	0.071	0.000
0.000	0.000	*Munida iris*	4.857	0.004
0.001	0.649	*Munida perarmata*	0.071	0.000
0.960	83.641	*Nephrops norvegicus*	4.395	0.290
0.005	0.786	*Pagurus alatus*	0.143	0.000
0.002	0.578	*Pagurus prideaux*	0.143	0.000
0.186	15.214	*Parapenaeus longirostris*	110.386	0.520
0.042	0.149	*Paromola cuvieri*	0.143	0.066
0.012	2.214	*Pasiphaea multidentata*	0.314	0.002
0.001	0.435	*Pasiphaea sivado*	0.086	0.250
0.002	1.381	*Plesionika acanthonotus*	6.393	0.007
0.000	0.143	*Plesionika antigai*	43.024	0.037
0.000	0.000	*Plesionika edwardsii*	10.750	0.100
0.016	10.714	*Plesionika gigliolii*	19.226	0.023
0.346	148.143	*Plesionika heterocarpus*	178.000	0.294
3.565	805.913	*Plesionika martia*	281.686	1.243
0.001	0.143	*Plesionika narval*	0.000	0.000
0.109	52.333	*Polycheles typhlops*	8.536	0.040
0.002	0.929	*Pontophilus spinosus*	0.000	0.000
0.000	0.214	*Pontophyllus norvegicus*	0.000	0.000
0.014	13.143	*Processa canaliculata*	0.000	0.000
0.002	0.429	*Rissoides pallidus*	0.000	0.000
0.000	0.299	*Sergestes arcticus*	0.171	0.000
0.000	0.214	*Sergestes corniculum*	0.338	0.000
0.044	22.877	*Solenocera membranacea*	0.000	0.000
		ECHINODERMS		
0.000	0.000	*Astropecten aranciacus*	0.071	0.014
0.000	0.000	*Astropecten irregularis pentacanthus*	0.071	0.000
0.016	1.500	*Brisingella coronata*	0.143	0.000
0.065	2.143	*Cidaris cidaris*	2.214	0.028
0.019	2.500	*Echinus acutus*	0.071	0.000
0.000	0.000	*Marginaster capreensis*	0.071	0.000
0.009	0.357	*Mesothuria intestinalis*	0.071	0.000
0.000	0.000	*Sclerasterias neglecta*	0.214	0.000
0.023	0.143	*Stichopus regalis*	0.000	0.000

TABLE 1. (Continued). List of the species collected in Italian and Greek areas with indications of average density (N/h) and biomass indices (Kg/h). For the colonial species *Isidella elongata* only the biomass index is reported.

		SELACHIANS		
0.149	0.775	*Chimaera monstrosa*	0.000	0.000
0.015	0.071	*Dalatias licha*	0.000	0.000
0.848	25.045	*Etmopterus spinax*	2.086	0.140
7.966	52.407	*Galeus melastomus*	57.564	6.150
0.000	0.000	*Heptranchias perlo*	0.286	0.229
0.000	0.000	*Mustelus mustelus*	0.214	1.200
0.035	0.214	*Raja circularis*	0.000	0.000
0.000	0.000	*Raja clavata*	0.238	0.152
0.016	0.078	*Raja oxyrinchus*	1.238	0.748
0.000	0.000	*Raja spp.* (juvenile forms)	0.286	0.188
0.000	0.000	*Scyliorhinus canicula*	1.333	0.204
0.000	0.000	*Squalus blainvillei*	1.000	0.850
		FISH		
0.004	0.864	*Antonogadus megalokynodon*	0.143	0.001
0.007	0.286	*Argentina sphyraena*	51.000	0.707
0.000	0.227	*Argyropelecus hemigymnus*	0.479	0.002
0.000	0.000	*Arnoglossus rueppelli*	2.571	0.012
0.002	0.095	*Benthocometes robustus*	0.000	0.000
0.000	0.000	*Benthosema glaciale*	0.929	0.001
0.143	12.381	*Caelorhynchus caelorhynchus*	44.857	0.503
0.000	0.000	*Capros aper*	40.857	1.186
0.000	0.000	*Centrolophus niger*	0.214	0.611
0.000	0.071	*Ceratoscopelus maderensis*	0.143	0.000
0.001	0.143	*Chauliodus sloani*	2.307	0.027
0.348	69.084	*Chlorophthalmus agassizii*	2031.690	17.114
0.694	1.000	*Conger conger*	2.000	0.043
0.000	0.000	*Diaphus holti*	0.086	0.000
0.000	0.000	*Diaphus metopoclampus*	0.071	0.001
0.000	0.071	*Diaphus rafinesquei*	0.000	0.000
0.000	0.000	*Epigonus constanciae*	0.714	0.014
0.005	0.214	*Epigonus telescopus*	0.000	0.000
0.344	117.000	*Gadiculus argenteus*	70.952	0.285
0.980	30.472	*Helicolenus dactylopterus*	40.788	6.249
1.936	34.323	*Hoplostethus mediterraneus*	45.021	2.950
0.626	193.017	*Hymenocephalus italicus*	281.343	1.039
0.047	4.551	*Lampanyctus crocodilus*	23.774	0.273
0.221	0.143	*Lepidopus caudatus*	0.000	0.000
0.076	2.500	*Lepidorhombus bosci*	9.500	0.877
0.000	0.000	*Lepidorhombus whiffiagonis*	1.202	0.315
0.000	0.000	*Lepidotrigla dieuzeidei*	7.024	0.230
0.180	0.857	*Lophius budegassa*	0.514	0.689
2.339	0.286	*Lophius piscatorius*	0.264	3.546

TABLE 1. (Continued). List of the species collected in Italian and Greek areas with indications of average density (N/h) and biomass indices (Kg/h). For the colonial species *Isidella elongata* only the biomass index is reported.

0.010	24.286	*Maurolicus muelleri*	10.667	0.010
1.090	2.292	*Merluccius merluccius*	24.717	2.626
0.000	0.000	*Microichthys coccoi*	0.071	0.000
0.714	5.571	*Micromesistius poutassou*	6.071	0.721
0.088	2.143	*Molva dipterygia*	0.857	0.200
0.412	20.019	*Mora moro*	5.400	0.337
0.000	0.071	*Myctophum punctatum*	0.571	0.000
0.001	0.071	*Nemichthys scolopaceus*	0.000	0.000
0.058	1.071	*Nettastoma melanurum*	4.586	0.242
1.363	114.561	*Nezumia sclerorhynchus*	42.543	0.468
0.033	2.221	*Notacanthus bonapartei*	0.000	0.000
0.001	0.095	*Oligopus ater*	0.000	0.000
0.000	0.143	*Ophidion barbatum*	0.000	0.000
0.000	0.000	*Pagellus acarne*	0.095	0.014
0.000	0.000	*Pagellus bogaraveo*	7.893	0.924
0.000	0.000	*Peristedion cataphractum*	37.190	0.859
2.726	42.630	*Phycis blennoides*	26.317	1.543
0.000	0.000	*Polyprion americanum*	0.071	0.279
0.001	0.071	*Stomias boa*	3.443	0.046
0.002	0.214	*Symbolophorus veranyi*	0.000	0.000
0.000	0.000	*Symphurus ligulatus*	0.214	0.001
0.001	0.143	*Symphurus nigrescens*	0.000	0.000
0.000	0.000	*Synchiropus phaeton*	4.357	0.016
0.000	0.000	*Trachurus trachurus*	0.095	0.052
1.269	5.143	*Trachyrhynchus trachyrhynchus*	0.000	0.000
0.000	0.000	*Trigla lucerna*	0.286	0.062
0.002	0.429	*Trigla lyra*	0.357	0.041

of H' shown in the Greek assemblage, made up of a higher number of species, is most probably due to the high dominance of one (*C. agassizii*) or few species. According to Murawski (2000), the greater H' value shown in Italian waters might be caused by exploitation giving rise to an increase in evenness and thus of diversity. At the deepest stations the computed diversity index indicates a similar structure of the assemblages in Italian and Greek waters, however it does not take into account the role of the different species in the two geographical areas.

On the contrary, multivariate analysis shows a clear pattern linked to depths and areas highlighting the distribution of abundance of the various species. In particular, depth plays the main role in the group differentiation, indicating the existence of two quite distinct bathyal faunal assemblages, which are separated by the 400–500 m bathymetric zone. These results are in agreement with previous observations made in the western Ionian Sea (D'Onghia *et al*., 1998) and in other Mediterranean areas (e.g. Abellò *et al*., 1988; Biagi *et al*., 1989; Cartes *et al*., 1994; Abella and Serena, 1995; Stefanescu *et al*., 1994; Ungaro *et al*., 1995). They confirm that the transition between an upper slope fauna and a strictly bathyal fauna is located at about 400-500 m (Pérès and Picard, 1964; Abellò *et al*., 1988; Mura and Cau, 1994).

Concerning the geographic characterization of the stations shown in this study, the question is whether such a characterization, as shown in several case

TABLE 2. Ecological index of Diversity (H'), Richness (D) and Evenness (J) calculated for each haul in the Italian and Greek areas.

Italy					Greece				
Haul	Depth (m)	H'	D	J	Haul	Depth (m)	H'	D	J
8	555	0.87	3.43	0.25	27	478	1.20	366	0.33
7	549	1.29	3.46	0.37	8	372	1.48	3.74	0.40
4	593	1.37	3.61	0.38	12	573	1.60	3.58	0.45
3	513	1.42	3.55	0.40	49	683	1.69	3.29	0.51
9	523	1.66	3.49	0.47	19	583	1.83	3.49	0.52
23	592	2.04	3.40	0.60	33	552	1.91	3.61	0.53
5	654	2.09	2.88	0.72	31	553	1.91	3.33	0.57
25	757	2.12	3.29	0.64	15	365	2.02	3.52	0.57
2	613	2.17	3.40	0.64	4	505	2.02	3.66	0.55
24	629	2.18	3.29	0.66	20	725	2.07	3.40	0.61
20	621	2.25	3.04	0.74	39	651	2.14	3.08	0.69
16	655	2.31	3.25	0.71	32	697	2.41	3.04	0.79
6	343	2.41	3.63	0.66	30	605	2.64	3.46	0.76
1	338	2.43	3.76	0.65	60	745	2.67	3.43	0.78
Average	**566.8**	**1.901**	**3.391**	**0.564**	**Average**	**577.6**	**1.971**	**3.449**	**0.576**

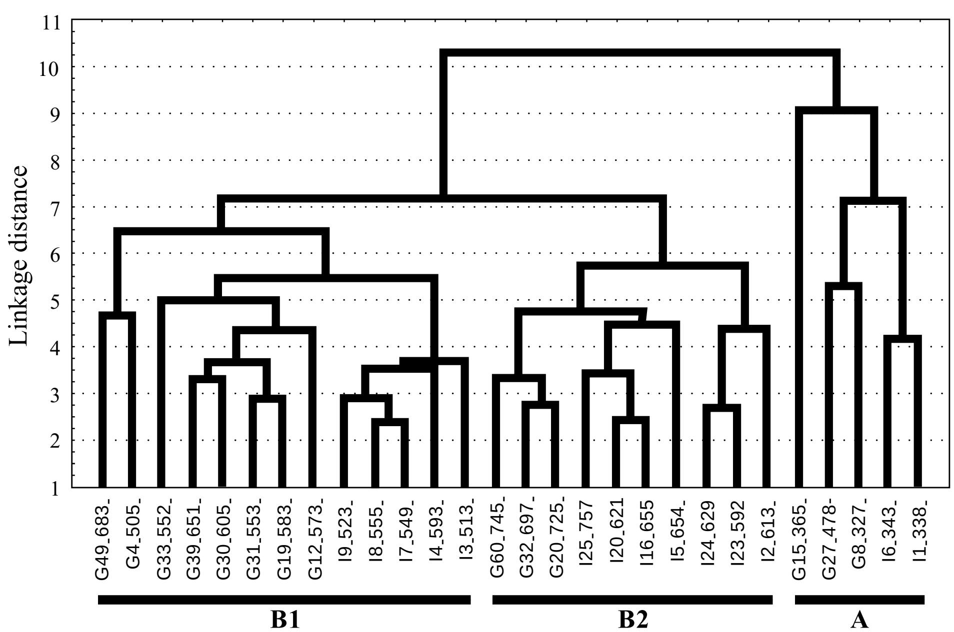

Fig. 2. Dendrogram related to the abundance values (N/h) of the species caught in the stations from Italian (I) and Greek (G) areas of the Ionian Sea (A = uppermost stations; B1 = intermediate stations; B2 = deepest stations).

studies (Hall, 1999, and references therein), is due to the different fishing intensity or to different environmental conditions.

At the upper slope depths, the lack of fishing pressure in the Greek area might explain the higher biomass computed for many species, the dominance

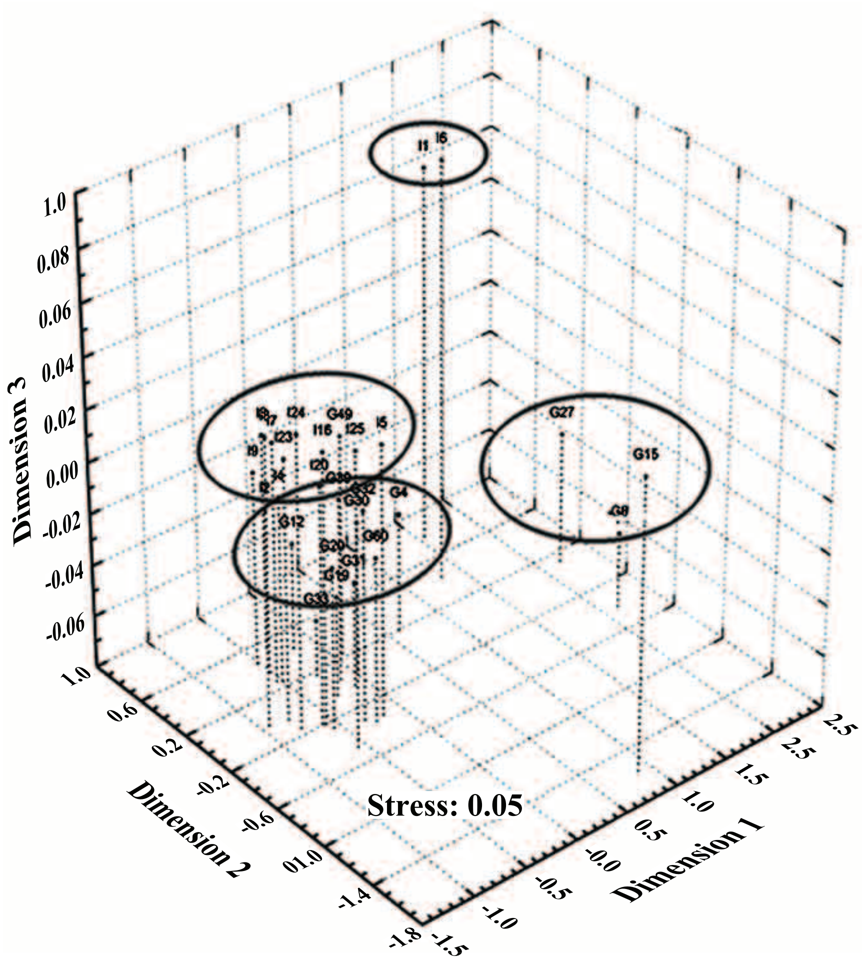

Fig. 3. Non-parametric multidimensional scaling (MDS) of different stations from Italian (I) and Greek (G) areas of the Ionian Sea.

of few species and the finding of a greater number of species and specimens of elasmobranchs. It is known that sharks are particularly vulnerable to over-exploitation because of their k-selected life-history strategy (e.g. Stevens *et al*., 2000). However, the fact that both *S. blainvillei* and *R. clavata* have not been found in the North-western Ionian Sea, along the Italian coasts, since 1985 (Matarrese *et al*., 1996), while they are frequently caught in the neighbouring Sicilian Channel (Relini *et al*., 2000), where demersal resources are intensively exploited, indicates that the local environmental conditions should also be considered in order to explain species occurrence and distribution. This can also be seen for other species, such as *Peristedion cataphractum*, which is abundant both along the Ionian coasts of Greece and in the Sicilian Channel (Pizzicori *et al*., 1995), while it is rarely found along the Ionian coasts of Italy (Matarrese *et al*., 1996).

On the middle slope, the geographic characterization of the abundance of *A. foliacea* and *A. antennatus* might be related to the different hydrography and fishing intensity in the two areas. Along the Greek coast the water masses are warmer and have high salinity while along the Italian coast they are colder and slightly less saline (Robinson and Golnaraghi, 1992; Theocaris *et al*., 1993, Rabitti *et al*., 1994). According to Ghidalia and Bourgois (1961) and Bombace (1975), *A. foliacea* would be mainly linked to the former whereas *A. antennatus* mostly to the latter. Although the hydrographic hypothesis of Ghidalia and Bourgois (1961) needs to be confirmed, the Mediterranean distribution of the two species would seem to be in agreement with it (Relini and Orsi Relini, 1987; Murenu *et al*., 1994; Ragonese, 1995). However, there are no studies that have established other specific hypotheses on the different distribution of these two companion species.

Concerning fishing, *A.foliacea* is considered to be more vulnerable to trawl fishing and less resilient than *A. antennatus* (Orsi Relini and Relini, 1985; Matarrese *et al*., 1997). In fact, while both juvenile and adult *A. foliacea* are almost exclusively distributed at depths where the bottom trawl fishing occurs, *A. antennatus* shows a wider vertical distribution. In addition to the deeper distribution and the lower availability to fishing of *A. antennatus* (Sardà, 1993), its higher density on the Italian side of the Ionian Sea and its higher fecundity (up to four times that of *A. foliacea* in the larger females, according to Orsi Relini and Semeria, 1983), seem to play an important role in the recovery of the stock. On the contrary, the lower density of *A. foliacea* along the Italian coasts together with its relatively shallower distribution and its low reproductive potential (Orsi Relini and Semeria, 1983), make it particularly vulnerable to trawling.

The lower abundance values recorded for *H. dactylopterus* in the Italian area seems to be a consequence of the exploitation of both the early life stages on the continental shelf and of the older stages on the slope where it completes its life cycle (D'Onghia *et al*., 1996). The higher similarity shown in the community structure of the two areas at the greatest depths might be explained by the presence of a large number of species whose depth distribution exceeds that of the trawl fishery, such as the macrourid fishes, *H. mediterraneus*, *P. blennoides* and *G. melastomus*, and therefore results in them being less vulnerable to fishing pressure.

Finally, although the present results are still preliminary, they seem to indicate that differences in biodiversity between the two study areas might be related to both fishing intensity and environmental conditions. Further data collection and analysis are required in order to evaluate the role of each process and how they interact.

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