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Analysis of demersal species assemblages from trawl surveys in the South Adriatic sea

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Abstract — Two trawl surveys were carried out in the summer months (June–July) of 1996 and 1997 along the whole South Adriatic area (Mediterranean sea) for the first time, using the same vessel and the same sampling gear (European Community Research Project 'MEDITS'); previous research data referred only to the south-western Adriatic side. A total list of 168 demersal species (fishes, cephalopods and crustaceans) was obtained during the surveys; species abundance data (individuals/trawling hour) were processed according to multivariate techniques in order to describe the composition and the distribution of the main species assemblages within the investigated area (10–800-m bathymetric range). Multivariate analysis of MEDITS survey catch data showed a strong relationship between fish assemblages and depth, while the influence of depth was lower with respect to cephalopod and especially crustacean assemblage distribution. © Ifremer/Cnrs/Inra/Ird/Cemagref/Elsevier, Paris

Trawl surveys / fish assemblages / depth / multivariate analysis / Adriatic sea

Résumé — Analyse des assemblages d'espèces démersales à partir des campagnes de chalutage effectuées en mer Adriatique. Deux campagnes de chalutage ont été conduites durant les mois d'été (juin-juillet) 1996 et 1997, dans le sud de la mer Adriatique, en utilisant pour la première fois le même navire de pêche et le même enfin de pêche (projet de recherche de la Communauté européenne, « MEDITS » ; les données antérieures se référaient uniquement à la zone sud-ouest Adriatique. Au total, une liste de 168 espèces démersales (poissons, crustacés et céphalopodes) a été établie durant ces campagnes ; les données d'abondance des espèces (nombre d'individus par heure de chalutage) ont été calculées au moyen d'analyses multivariées, afin de décrire la composition et la distribution des principaux assemblages dans la zone bathymétrique considérée (10–800 m). Les analyses multivariées des données de capture des campagnes MEDITS ont montré une forte relation entre l'assemblage des poissons et la profondeur ; tandis que l'influence de la profondeur est moins importante en ce qui concerne les céphalopodes et encore moins sensible pour les crustacés. © Ifremer/Cnrs/Inra/Ird/Cemagref/Elsevier, Paris

Campagnes de chalutage / assemblages / profondeur / analyse multivariée / mer Adriatique

1. INTRODUCTION

Trawl net fishery in the Mediterranean sea allows the collection of a large number of species living close to soft bottoms; some of these species have a commercial value, while others represent a contribution to the biological complexity of the environment.

The gear characteristics and the sampling methodology (wide investigated area per haul) permits the discrimination of the species pools only by means of the term 'assemblage', which describes a cluster of species available to sampling gear in a particular area [6] without any assumptions being made about the interactions among the same species; it was also stated by Wotton [21] for fishes: "the term assemblage describes all the fish species in a defined area irrespective of whether they interact or not'' (this statement means that the term 'assemblages' cannot be confused with other ecological terminology such as 'communities' or 'biocenosis').

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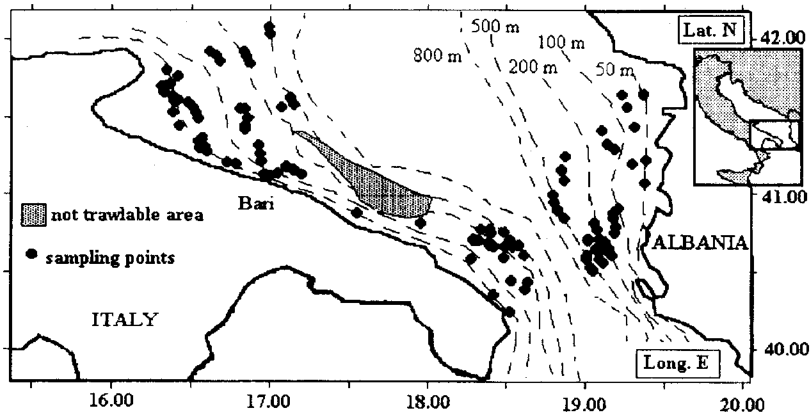

Figure 1. MEDITS 1996 and 1997 trawl surveys in the southern Adriatic sea: sampling area and geographic position of 112 hauls (72 and 40 samples on Italian and Albanian trawlable bottoms, respectively).

In recent years, studies on species assemblages collected by trawl net (generally fish and epibenthic species) were developed in different areas of the Mediterranean sea [1, 2, 3, 6, 8, 13, 16, 17, 20] in order to explain the space-time distribution patterns versus environmental characteristics (depth, substratum, etc.).

Regarding the research into this subject in the South Adriatic sea, until 1996 scientific information was reported only for the western side of the basin [18, 19]; from the summer of 1996, the European Community Research Project MEDITS (Mediterranean International Trawl Survey) has allowed acquisition of data on trawl net catches over the whole southern area of the Adriatic sea (south-western Adriatic – Italian side – and south-eastern Adriatic – Albanian side) using the same vessel and gear [5].

In the present paper catch data from 1996 and 1997 MEDITS trawl surveys were processed by multivariate analysis techniques in order to identify the main species assemblages in the above-mentioned basin for the most important fishery resource categories (fishes, cephalopods and crustaceans represent 'target' groups for Mediterranean trawl fishery and, in the meaning of the term 'assemblage', we chose to treat them separately).

2. MATERIALS AND METHODS

2.1. Data type and origin

Demersal species abundance data were obtained from trawl surveys carried out in the South Adriatic sea (Mediterranean sea). This area is characterised by a deep (1 230-m maximum depth) and large trench in the middle that virtually separates the western side (Italian) from the eastern one (Albanian). During the summers of 1996 and 1997, two surveys were carried out on the shelf and upper slope (from 10-m up to 800-m depths) trawlable bottoms of opposite sides of the basin; 112 stations (1 haul/60 square nautical miles) were sampled for each survey (72 hauls in the western area, 40 hauls in the eastern area each year) using an otter trawl net (length 40 m, wing spread 8 m) with a 10-mm mesh size at the cod-end.

The sampling design referring to the first survey (1996) was random stratified (five bathymetric strata: 10–50, 51–100, 101–200, 201–500 and 501–800 m) [5] and the chosen stations were re-sampled the following year (1997) (*figure 1*). The tow duration was 1 h on slope bottoms and half-an-hour on shelf bottoms.

All species caught (fishes, cephalopods and crustaceans) were identified and a list per haul was recorded; truly pelagic and epi-mesopelagic species [12] were later excluded from the lists because they were occasionally collected by this kind of gear.

Species abundance was standardised to trawling hour (number of individuals/trawling hour) and the data were double-root transformed to avoid a strong influence of the most dominant species in the samples [10].

2.2. Data analysis

'Species abundance × sampling stations' matrices, referring to collected fishes, crustaceans and cephalopods in the whole investigated area, were processed using multivariate techniques such as cluster analysis (hierarchical agglomerative clustering; group average) [15] and multidimensional scaling (MDS) ordination analysis [14]. Non-metric MDS was chosen because it permits summarisation of distances in a smaller number of dimensions than other ordination methods; the same technique has been shown to be better at recovering a known structure when the data set contains a large number of zero entries [4]. Both multivariate techniques could be useful for the best assemblage discrimination and, in particular, cluster analysis represents the first step (samples classification), while multidimensional scaling better explains the space ordination of the samples (in this paper, two-dimensional space ordination was used); moreover, stress values coming from MDS were utilised as an adequacy measure of representation for two-dimensional ordination (preservation of the original inter-sample relationships, increasing adequacy – decreasing stress value) in order to minimise data misinterpretation [11].

Finally, the agreement between cluster analysis and multidimensional scaling representations was useful for a better interpretation of results.

The similarity among samples was evaluated through the Bray-Curtis coefficient, after exclusion of the species with abundance value less than 1 % (from each sample, in order to minimise the elaboration 'noise'). Data analysis was carried out by means of PRIMER (Plymouth routines in multivariate ecological research) software [7].

The same analysis was performed for 'species mean abundance × depth strata' matrices according to the defined stratified sampling scheme (western and eastern areas, five depth strata as mentioned above) in order to summarise the information and detect possible differences in species assemblage distribution per depth and area.

Then, the biotic similarity matrices were related to the depth in order to identify possible statistical correlation (Spearman coefficient) [9].

3. RESULTS

3.1. Collected species

The two sampling surveys provided a total list of 168 species (104 fishes, 20 cephalopods and 44 crustaceans) although some of these were collected during one survey only (the species number per survey was 148 and 145 during 1996 and 1997, respectively). *Tables I* and *II* show the species list and mean abundance values per depth strata and sampling area (south-western and south-eastern Adriatic sea).

3.2. Multivariate analysis

Clustering of sampling stations (species abundance × sampling stations, whole investigated area) gave comparable and superimposable results in the two surveys; for this reason, species abundance mean values per sampling stations (over the two surveys) were later processed.

Sampling station classification per species category (whole investigated area; 30 % similarity threshold was arbitrarily chosen) showed three clusters for fish species (two main clusters, one secondary cluster), four clusters for cephalopod (three main clusters, one secondary cluster), seven clusters for crustacean (three main clusters, four secondary clusters) (*figure* 2). The depths related to the two main fish clusters ranged from 281 to 551 m and from 31 to 329 m, while the depths for the three main cephalopod clusters ranged from 315 to 547 m, from 16 to 407 m and from 281 to 538 m; the first cephalopod cluster included sampling stations on the Italian side only.

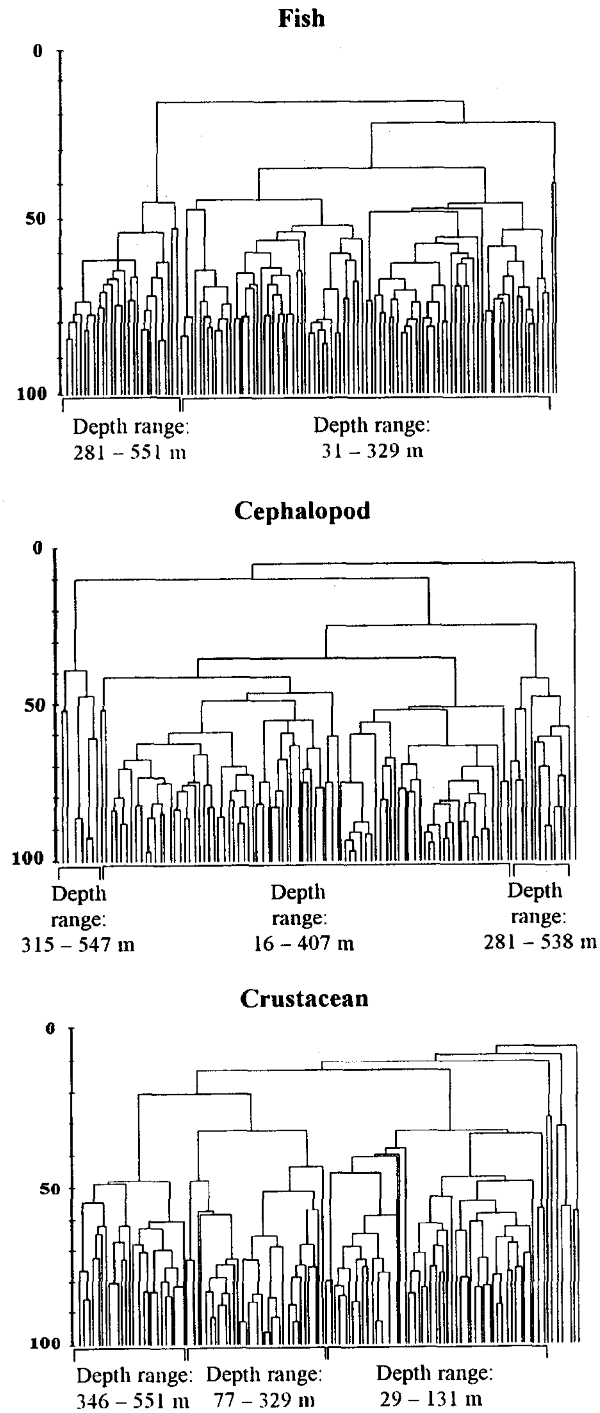

Figure 2. Clustering of sampling stations per species category (Bray Curtis similarity index). Depth ranges are shown for the main clusters at 30 % similarity.

The depths for the three main crustacean clusters ranged from 346 to 551 m, from 77 to 329 m and from 29 to 131 m.

Table I. Fish average abundance (number of individuals per trawling hour) per depth strata (a: 10–50 m; b: 51–100 m; c: 101–200 m; d: 201–500 m; e: 501–800 m) of fish species collected during sampling surveys (hypen symbol is indicative of zero value). A: Albanian side; I: Italian side.

	Aa	Ab	Ac	Ad	Ae	Ia	Ib	Ic	Id	Ie
Aphia minuta mediterranea De Buen, 1931	–	–	–	–	–	2	1	1	–	–
Argentina sphiraena Linnaeus, 1758	–	5	2	2	–	–	1	4	2	–
Ariosoma balearicum (Delaroche, 1809)	–	–	–	–	–	1	–	1	–	–
Arnoglossus laterna (Walbaum, 1792)	1	2	1	1	–	9	6	2	1	–
Arnoglossus rueppelli (Cocco, 1844)	–	–	–	–	–	–	–	1	3	–
Arnoglossus thori Kyle, 1913	–	–	–	–	–	–	1	–	–	–
Aspitrigla cuculus (Linnaeus, 1758)	–	1	2	1	–	–	1	1	25	–
Blennius ocellaris (Linnaeus, 1758)	–	1	–	–	–	–	1	–	–	–
Boops boops (Linnaeus, 1758)	5	53	1	1	–	11	8	2	–	–
Callionymus fasciatus Valenciennes, 1837	–	–	–	–	–	1	–	–	–	–
Callionymus maculatus Rafines. Schmaltz, 1810	1	1	1	1	–	1	4	4	1	–
Capros aper Linnaeus, 1758	–	1	2	7	1	–	–	1	1	–
Carapus acus (Brünnich, 1768)	–	1	1	1	–	–	–	–	—	–
Centrophorus granulosus (Bloch & Schn., 1801)		1	–	1	–	–	–	–	–	–
Cepola macrophthalma (Linnaeus, 1758)	–	17	14	8	–	3	4	3	–	–
Chimaera monstrosa Linnaeus, 1758	–	–	–	–	1	–	–	–	3	5
Chlorophthalmus agassizi Bonaparte, 1840	–	–	–	3	1	–	–	1	8	1
Citharus linguatula (Linnaeus, 1758)	6	5	1	1	–	–	–	–	–	–
Coelorinchus coelorincus (Risso, 1810)	–	–	–	1	1	–	–	–	6	6
Conger conger (Linnaeus, 1758)	–	1	1	1	1	–	1	1	1	1
Dalatias licha (Bonnaterre, 1788)	–	–	–	–	1	–	–	–	1	1
Dalophis imberbis (Delaroche, 1809)	–	–	–	–	–	–	1	–	–	–
Deltentosteus quadrimaculatus (Valenc., 1837)	1	1	–	–	–	1	1	1	–	–
Dentex dentex (Linnaeus, 1758)	1	–	–	–	–	–	–	–	–	–
Diplodus annularis (Linnaeus, 1758)	1	–	–	–	–	1	–	–	–	–
Echiodon dentatus (Cuvier, 1829)	–	–	–	–	–	–	–	1	4	1
Epigonus denticulatus Dieuzeide, 1950	–	–	–	–	–	–	–	–	1	1
Etmopterus spinax (Linnaeus, 1758)	–	–	–	–	16	–	–	–	13	14
Eutrigla gurnardus (Linnaeus, 1758)	–	1	1	1	–	1	3	1	–	–
Gadella maraldi (Risso, 1810)	–	–	–	–	–	–	–	–	1	1
Gadiculus argenteus argenteus Guichenot, 1850	–	–	1	33	1	–	–	15	20	1
Gaidropsarus megalokinodon (Kolombatovic, 1894)	–	1	1	1	1	1	3	2	2	1
Galeus melastomus Rafinesque, 1809	–	–	–	1	10	–	–	–	15	17
Glossanodon leioglossus (Valenciennes, 1848)	–	–	1	1	–	–	–	–	1	–
Gnathophis mystax (Delaroche, 1809)	–	–	1	1	–	–	–	–	1	–
Gobius niger jozo Linnaeus, 1758	2	1	–	–	–	1	1	–	–	–
Helicolenus dactylopterus (Delaroche, 1809)	–	–	11	14	1	–	–	3	13	4
Hoplostethus mediterraneus Cuvier, 1829	–	–	–	–	1	–	–	–	1	20
Hymenocephalus italicus (Giglioli, 1884)	–	–	–	–	38	–	–	–	9	17
Lappanella fasciata (Cocco, 1833)	–	–	–	–	–	–	–	1	1	–
Lepidorhombus boscii (Risso, 1810)	–	–	1	3	1	–	–	1	5	1
Lepidopus caudatus (Euphrasen, 1788)	–	3	88	57	1	1	1	29	11	–
Lepidotrigla cavillone (Lacepede, 1801)	21	57	6	4	–	1	1	1	1	–
Lepidorhombus whiffiagonis (Walbaum, 1792)	–	–	–	1	–	–	–	1	4	–
Lesueurigobius friesi (Malm, 1874)	–	8	7	13	–	4	5	8	5	–
Lesueurigobius sueri (Risso, 1810)	–	–	–	–	–	1	–	1	–	–
Lophius budegassa Spinola, 1807	1	3	2	2	1	1	1	4	2	1
Lophius piscatorius Linnaeus, 1758	–	1	–	1	1	1	1	1	1	1
Macroramphosus scolopax (Linnaeus, 1758)	–	1	13	8	–	–	1	1	6	—
Merlangius merlangus euxinus (Nordman, 1840)	–	–	–	–	–	1	–	–	–	–
Merluccius merluccius (Linnaeus, 1758)	25	58	138	88	1	57	69	62	66	2
Micromesistius poutassou (Risso, 1810)	–	–	14	10	1	–	–	203	178	2
Microchirus variegatus (Donovan, 1802)	–	–	–	–	–	–	–	1	–	–
Molva dypterigia macrophtalma (Rafin., 1810)	–	–	–	2	1	–	–	1	1	1
Monochirus hispidus Rafinesque, 1814	–	–	–	–	–	1	–	–	–	–
Mora moro (Risso, 1810)	–	–	–	–	1	–	–	–	–	1
Mullus barbatus Linnaeus, 1758	58	49	8	5	–	33	1	1	1	–
Mullus surmuletus Linnaeus, 1758	–	1	1	1	–	1	1	1	2	1
Mustelus mustelus (Linnaeus, 1758)	1	1	–	–	–	–	–	–	–	–

Table I. (Continued).

	Aa	Ab	Ac	Ad	Ae	Ia	Ib	Ic	Id	Ie
Nemichthys scolopaceus Richardson, 1848	–	–	–	–	1	–	–	–	–	–
Nettastoma melanurum Rafinesque, 1810	–	–	–	–	1	–	–	–	–	1
Nezumia sclerorhyncus (Valenciennes, 1838)	–	–	–	–	9	–	–	–	3	27
Notacanthus bonapartei Risso, 1840	–	–	–	–	–	–	–	–	1	1
Ophidion barbatum Linnaeus, 1758	–	–	–	–	–	–	–	1	–	–
Ophichthus rufus (Rafinesque, 1810)	–	–	–	–	–	–	–	1	–	–
Pagellus acarne (Risso, 1826)	1	1	–	–	–	1	1	1	1	–
Pagellus bogaraveo Brünnich, 1768)	–	–	1	1	1	–	–	–	1	1
Pagellus erythrinus (Linnaeus, 1758)	28	7	–	–	–	1	1	–	–	–
Pagrus pagrus pagrus (Linnaeus, 1758)	–	1	–	–	–	–	–	–	–	–
Peristedion cataphractum Linnaeus, 1758	–	–	–	1	–	–	–	–	–	–
Phycis blennoides (Brünnich, 1768)	–	–	7	10	7	–	1	4	47	7
Phycis phycis Linnaeus, 1766	–	–	–	1	–	–	–	–	–	–
Polyprion americanum (Bloch & Schneider, 1801)		–	–	–	1	–	–	–	–	–
Pomatoschistus marmoratus (Risso, 1810)	–	–	–	–	–	1	1	1	–	–
Psetta maxima (Linnaeus, 1758)	1	1	1	1	–	–	–	–	–	–
Raja asterias Delaroche, 1809	2	1	1	1	–	–	–	–	1	–
Raja circularis Couch, 1838	–	1	–	–	–	–	–	–	1	–
Raja clavata Linnaeus, 1758	–	–	–	–	–	–	–	1	1	–
Raja miraletus Linnaeus, 1758	3	1	–	–	–	–	–	–	2	–
Raja oxyrinchus Linnaeus, 1758	–	–	–	1	–	–	–	–	–	–
Scorpaena elongata Cadenat, 1943	–	1	–	–	–	–	–	1	1	–
Scorpaena loppei Cadenat, 1943	–	–	–	–	–	1	–	–	–	–
Scorpaena notata Rafinesque, 1810	1	1	–	–	–	2	1	1	–	–
Scorpaena porcus Linnaeus, 1758	–	–	–	–	–	1	1	–	–	–
Scorpaena scrofa Linnaeus, 1758	–	1	–	–	–	1	1	1	–	1
Scyliorhinus canicula (Linnaeus, 1758)	6	10	1	3	–	–	–	1	–	–
Serranus cabrilla (Linnaeus, 1758)	1	2	–	–	–	2	1	1	–	–
Serranus hepatus (Linnaeus, 1766)	10	40	–	–	–	3	6	1	–	–
Solea vulgaris Quensel, 1806	1	1	1	1	–	1	–	1	–	–
Spicara flexuosa Rafinesque, 1810	188	83	1	1	–	4	1	–	–	–
Spicara smaris (Linnaeus, 1758)	217	78	1	1	–	4	21	1	–	–
Squalus acanthias Linnaeus, 1758	–	–	–	–	–	–	–	1	1	–
Squalus blainvillei (Risso, 1826)	–	–	–	1	–	–	–	–	–	–
Symphurus nigrescens Rafinesque, 1810	1	1	1	1	1	–	1	1	1	1
Synodus saurus (Linnaeus, 1758)	–	–	–	1	–	–	–	–	–	–
Torpedo marmorata Risso, 1810	–	1	1	1	–	–	1	–	–	–
Trachinus draco Linnaaeus, 1758	–	–	1	1	–	–	1	1	–	–
Trachyrhynchus trachyrhynchus (Risso, 1810)	–	–	–	–	–	–	–	–	–	1
Trigloporus lastoviza (Bonnaterre, 1788)	1	1	–	–	–	–	1	1	–	–
Trigla lucerna Linnaeus, 1758	3	1	1	1	–	2	–	1	1	–
Trigla lyra Linnaeus, 1758	–	–	1	1	–	–	–	1	1	–
Trisopterus minutus capelanus (Lacep., 1800)	4	85	39	22	–	12	117	98	1	–
Uranoscopus scaber Linnaeus, 1758	–	1	–	–	–	1	1	1	–	–
Zeus faber Linnaeus, 1758	–	1	1	1	–	1	1	1	1	–

The spatial distribution of main clusters per species category was also mapped (*figure 3*). Data ordination (non-metric MDS) gave comparable results with respect to the cluster analysis.

According to the MEDITS project sampling scheme, classification and ordination of data referring to the defined bathymetric strata (species mean abundance × depth strata) per geographic area (Italian and Albanian sides: south-western, (SW) and south-eastern (SE) Adriatic sea) showed three clusters for fishes, three clusters for cephalopods, five clusters for crustaceans at 50 % similarity (*figure 4*).

The first fish cluster included SE and SW Adriatic 501–800-m bathymetric strata (mostly characterised by the presence of the elasmobranch fishes *Galeus melastomus* and *Etmopterus spinax*), the second cluster included SE and SW Adriatic 101–500-m bathymetric strata (mostly characterised by the presence of bony fishes *Trigla lyra*, *Helicolenus dactylopterus*, *Phycis blennoides*), the third cluster included SE and SW Adriatic 10–100-m bathymetric strata (mostly characterised by the presence of bony fishes *Boops boops*, *Scorpaena notata*, *Serranus hepatus* and the genus *Spicara*).

Table II. Crustacean and cephalopod average abundance (number of individuals per trawling hour) per depth strata (a: 10–50 m; b: 51–100 m; c: 101–200 m; d: 201–500 m; e: 501–800 m) of crustacean and cephalopod species collected during sampling surveys (hypen symbol is indicative of zero value). A: Albanian side; I: Italian side.

	Aa	Ab	Ac	Ad	Ae	Ia	Ib	Ic	Id	Ie
Crustaceans										
Alpheus glaber (Olivi, 1792)	–	–	–	–	–	1	1	1	1	–
Anamanthia rissoana (Roux, 1828)	–	–	–	–	–	1	–	1	–	2
Aristeus antennatus (Risso, 1816)	–	–	–	–	2	–	–	1	9	59
Aristaemorpha foliacea (Risso, 1827)	–	–	–	–	38	–	–	–	2	2
Bathynectes maravigna (Prestandrea, 1839)	–	–	–	–	1	–	–	–	1	3
Calappa granulata (Linnaeus, 1767)	–	–	–	1	–	–	–	–	–	–
Chlorotocus crassicornis (Costa, 1871)	–	–	–	1	1	–	–	1	17	–
Dardanus arrossor (Herbst, 1796)	–	1	1	–	–	1	1	1	–	–
Geryon longipes A. Milne Edwards, 1881	–	–	–	–	–	–	1	–	1	3
Goneplax rhomboides (Linnaeus, 1758)	1	–	–	–	–	3	3	1	1	1
Latreilla elegans Roux, 1830	–	–	–	–	–	–	–	1	–	–
Homola barbata (Fabricius, 1793)	–	1	–	–	–	–	–	1	–	–
Liocarcinus depurator (Linnaeus, 1758)	8	2	1	1	–	104	192	12	1	1
Macropodia longipes (A. Mil. Edw. & Bouv., 1899)	–	1	–	–	–	–	1	1	–	–
Macropipus tuberculatus (Roux, 1830)	–	–	1	7	1	–	1	14	25	1
Medorippe lanata (Linnaeus, 1767)	–	2	1	–	–	2	3	1	–	–
Monodaeus couchii (Couch, 1851)	–	–	–	–	2	–	–	–	1	1
Munida intermedia A. Mil. Edw. & Bouv., 1899	–	–	–	1	1	1	1	3	44	–
Munida perarmata A. Mil. Edw. & Bouv., 1894	–	–	–	–	1	–	–	–	1	1
Munida rugosa (Fabricius, 1775)	–	–	–	1	–	1	1	1	–	–
Nephrops norvegicus (Linnaeus, 1758)	–	–	1	9	4	1	2	10	26	3
Pagurus alatus Fabricius, 1775	1	1	–	–	–	1	3	1	–	1
Pagurus cuanensis Bell, 1846	–	–	–	–	–	1	–	–	–	–
Pagurus prideaux Leach, 1815	1	1	–	–	–	1	–	1	–	1
Palinurus elephas (Fabricius, 1787)	–	–	–	–	–	–	1	–	–	–
Parapenaeus longirostris (Lucas, 1846)	1	45	174	406	21	–	–	1	17	2
Paromola cuvieri (Risso, 1816)	–	–	–	–	–	–	–	–	1	–
Pasiphaea multidentata Esmark, 1866	–	–	–	–	1	–	–	–	1	1
Pasiphaea sivado (Risso, 1816)	–	–	–	1	920	–	–	–	816	215
Pilumnus hirtellus (Linnaeus, 1761)	1	–	–	–	–	–	–	–	–	–
Plesionika acanthonotus (S. I. Smith, 1882)	–	–	–	1	–	–	–	–	–	–
Plesionika antigai Zariquiey-Alvarez, 1955	–	–	–	–	1	–	–	–	–	–
Plesionika gigliolii (Senna, 1903)	–	–	–	2	3	–	–	–	1	–
Plesionika edwarsii (Brandt, 1851)	–	–	–	–	–	–	–	–	1	–
Plesionika heterocarpus (Costa, 1871)	–	–	–	107	14	–	–	15	20	3
Plesionika martia (A. Milne Edw., 1883)	–	–	–	–	101	–	–	–	15	153
Polycheles typhlops Heller, 1862	–	–	–	–	10	–	–	1	16	17
Pontophilus spinosus (Leach, 1915)	–	–	–	–	–	–	–	–	1	–
Processa canaliculata Leach, 1915	–	–	–	1	1	–	–	1	8	1
Rissoides desmaresti (Risso, 1816)	–	–	–	–	1	–	–	–	1	–
Rissoides pallidus (Giesbrecht, 1910)	–	–	–	–	–	–	–	–	1	–
Squilla mantis (Linnaeus, 1758)	1	1	–	–	–	3	–	–	–	–
Solenocera membranacea (Risso, 1816)	–	1	1	1	1	1	1	1	26	2
Xantho pilipes A. Milne Edw., 1867	–	–	–	–	–	–	–	–	1	–
Cephalopods										
Alloteuthis media (Linnaeus, 1758)	382	443	424	1	–	442	267	37	1	–
Alloteuthis subulata (Lamarck, 1798)	2	3	2	–	–	1	1	–	–	–
Eledone cirrhosa (Lamark, 1798)	–	2	14	6	1	–	1	4	1	–
Eledone moschata (Lamark, 1799)	10	2	–	–	–	1	1	–	–	–
Illex coindetii (Verany, 1839)	1	2	8	1	–	1	6	7	1	–
Loligo forbesi Steenstrup, 1856	–	–	–	1	–	–	–	–	–	–
Loligo vulgaris Lamarck, 1798	222	22	2	1	–	7	1	1	1	–
Neorossia caroli (Joubin, 1902)					1			1		1
Octopus salutii Verany, 1837				1	1		1	1	2	1
Octopus vulgaris Cuvier, 1797	1	1	1			1	1	1		
Octopus defilippi Verany, 1851										
Pteroctopus tetracirrhus (Delle Chiaje, 1830)		1		1	1					
Rondeletiola minor Naef, 1912									1	

Table II. (Continued).

	Aa	Ab	Ac	Ad	Ae	Ia	Ib	Ic	Id	Ie
Cephalopods										
Rossia macrosoma (Delle Chiaje, 1829)				1				1	1	
Scaeurgus unicirrhus (d'Orbigny, 1840)			3	1			1	1	1	
Sepia elegans Bainville, 1827	13	9	1							
Sepia officinalis Linnaeus, 1758						1				
Sepia orbignyana Ferussac, 1826		2	1					1	1	
Todaropsis eblanae (Ball, 1841)	1	5	6	14	1			1	2	
Todarodes sagittatus (Lamarck, 1798)					1				1	1

With reference to cephalopod assemblages, the first cluster (distinguished by the presence of *Neorossia caroli*) included SE and SW Adriatic 501–800-m strata, the second cluster (mostly characterised by the presence of *Illex coindetii*) included SE 201–500-m strata and the SW 101–500-m strata, the third cluster (represented mainly by the presence of the genus *Alloteuthis*) included SE 10–200-m strata and SW 10–100-m strata.

The first crustacean cluster (represented mainly by the presence of *Plesionika martia* and *Polycheles typhlops*) included SE 501–800-m strata and SW 201–800-m strata, the second cluster (represented mainly by the presence of *Plesionika heterocarpus* and *Nephrops norvegicus*) included SE 201–500-m strata and SW 101–200-m strata, the third cluster (represented mainly by the presence of *Liocarcinus depurator* and *Goneplax rhomboides*) included SW 10–100-m strata, the fourth cluster (mostly characterised by the presence of *Parapenaeus longirostris*) included SE 51–200-m strata and the fifth cluster (mostly characterised by the presence of *Pilumnus hirtellus*) included SE 10–50-m strata.

With regards to the spatial and bathymetric distribution of demersal assemblages, fish seemed to be more correlated to depth (weighted Spearman coefficient = 0.720) with respect to cephalopod (weighted Spearman coefficient = 0.561) and crustacean categories (weighted Spearman coefficient = 0.460).

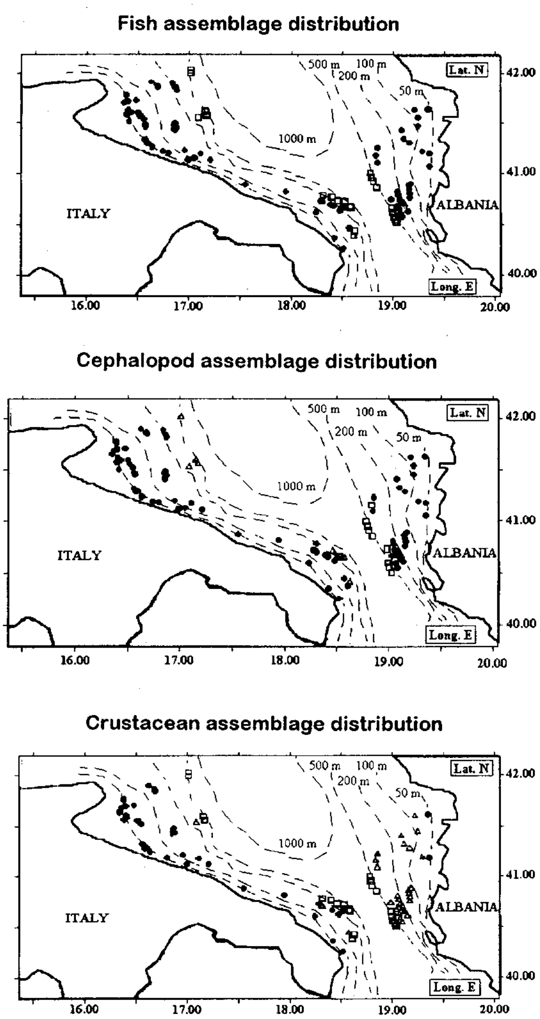

Figure 3. Map representations of main clusters per species category: Fish assemblage (two clusters; symbols ●, □); cephalopod assemblage (three clusters; symbols ●, □ and Δ); crustacean assemblage (three clusters; symbols ●, □ and Δ).

4. DISCUSSION AND CONCLUSION

Multivariate analysis of data coming from southern Adriatic sea trawl surveys provided some remarks on species assemblage distribution in the investigated area.

The surveyed demersal assemblages appeared to be rather stable over the 2 years [13, 18], although different spatial and bathymetric distributions were found among fish, cephalopod and crustacean categories. In particular, the present results confirm that fish assemblage structure and distribution in the Mediterranean sea (and often throughout the world's oceans) strongly depends on depth [2, 6, 18]. Two main depth-related fish clusters were identified corresponding to shelf and slope bottoms, without significant differences (in the structure and distribution of assemblages) between two opposite South Adriatic areas (south-western – Italian waters; south-eastern – Albanian waters); in fact, similarity between groundfish assemblages on both Albanian and Italian Adriatic trawlable bottoms was higher than 50 % at similar depths.

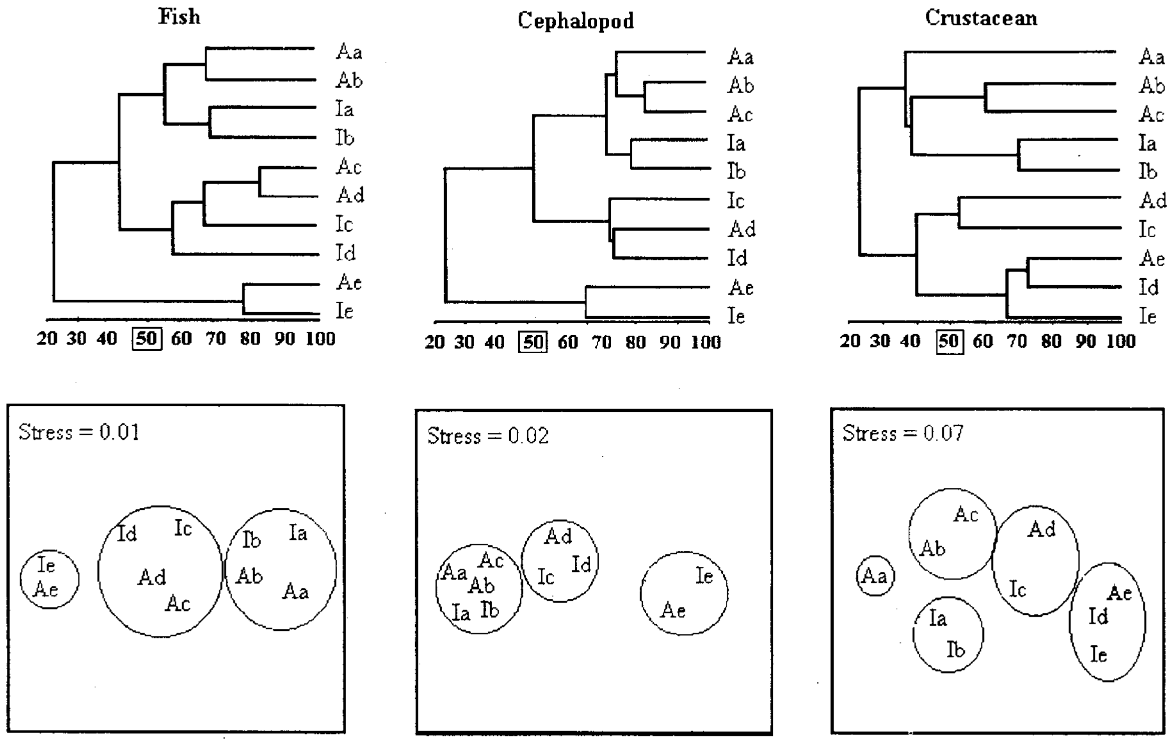

Figure 4. Classification (cluster analysis) and ordination (multidimensional scaling ordination analysis) of species assemblages on Adriatic sea trawlable bottoms (A: Albanian side; I: Italian side): mean abundance values per depth stratum (a: 10–50 m; b: 51–100 m; c: 101–200 m; d: 201–500 m; e: 501–800 m). The multidimensional scaling displayed circles represent interstrata similarity > 50 %.

Cephalopod assemblages appeared to be mostly conditioned by depth, but to a lesser extent with respect to fish. Crustacean assemblages appeared to be more distinguished and heterogeneously distributed on both the South Adriatic sides (trawlable bottoms), as was shown in the reported map (*figure 3*); as well as depth, influence of oceanographic features, such as bottom sediment structure, steepness of the bottom and light intensity, could be observed for this resource, as was supposed by other authors [3, 8]. Thus, the structure and heterogeneous distribution of crustacean assemblages in the investigated area could be related to the space patterns of these environmental factors [4].

The above-mentioned results on fish, crustacean and cephalopod assemblage distributions were supported by the stress values coming from multidimensional scaling ordination; the computed stress values (0.01 for fishes, 0.02 for cephalopods, 0.07 for crustaceans) could indicate that the original intersample relationships are well preserved in two-dimensional space ordination.

Taking into account the sampling methodology and data analysis, the achieved preliminary results on the structure and depth-related distribution of demersal assemblages from trawl surveys in the whole southern Adriatic sea could be useful as a 'preparatory step'; the next sampling survey in the southern Adriatic area should be carried out on both biotic and physical-chemical features for a better interpretation of the reported results.

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