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.)

Analysis of demersal assemblages off the Tuscany and Latium coasts (north-western Mediterranean)*

FRANCO BIAGI[1], PAOLO SARTOR[2], GIAN DOMENICO ARDIZZONE[3], PAOLA BELCARI[1], ANDREA BELLUSCIO[3] and FABRIZIO SERENA[4]

[1] Dipartimento di Scienze dell'Uomo e dell'Ambiente, Università di Pisa, Via Volta 6, 56126 Pisa, Italy. E-mail: biagifra@discat.unipi.it
[2] Centro Interuniversitario di Biologia Marina ed Ecologia Applicata, Livorno, Italy.
[3] Dipartimento di Biologia Animale e dell'Uomo, Università di Roma "La Sapienza", Roma, Italy.
[4] Agenzia Regionale per l'Ambiente Toscana, Livorno, Italy.

SUMMARY: A four-year time series (1994-1997) of groundfish trawl surveys performed within the European Union Project "MEDITS" (Mediterranean International Trawl Surveys), was analysed to identify and describe the fish assemblages along the continental shelf and slope of Tuscany and Latium (Italy), in the north-western Mediterranean. Cluster analysis was used to group samples with similar species composition in terms of abundance, biomass and frequency of occurrence. Results allowed the identification of four to five broad assemblages along the depth gradient: a strictly coastal group (< 50 m depth), two groups in the upper and lower part of the continental shelf (essentially 50-200 m), an epibathyal group (200-450 m) and a group derived from hauls made at depths greater than 450 m. Each assemblage corresponded to a faunistic association with relatively homogeneous and persistent species composition, biomass and density indices.

Key words: assemblages, cluster analysis, demersal resources, western Mediterranean

INTRODUCTION

The fauna of the Mediterranean basin is characterised by a high biodiversity, i.e. by a high number of species, some endemic to the area, some with a wider geographical distribution and others recently immigrating into the Mediterranean waters (Maurin, 1962; Tortonese, 1987; Fredj *et al*., 1992). This aspect is mainly due to the geological evolution of the basin and to its ecological and climatic features. The existence of such biological diversity certainly contributes to the health of the Mediterranean fisheries.

*Received Novemver 7, 2000. Accepted February 14, 2002.

Classical stock assessment tools indicate in most cases a general state of overexploitation and overcapacity of the fishing fleets (Caddy and Sharp, 1986). However, monospecific approaches are usually the rule. In the last 15 years there has been a growing perception that it is often ineffective to base fisheries management policies exclusively on single species approaches. High levels of variability in productivity, in abundance, in size and species composition, are not predictable from single species models. However, problems can arise when choosing management options in a multispecies fishery context (Caddy and Sharp, 1986; Brugge and Holden, 1991).

A more holistic approach to resource management is evidently needed. In practice, management should be based on ecosystem principles: to maintain the full ensemble of species while sustaining the harvest of desired species (Tyler *et al.*, 1982; Tyler, 1988). Overexploitation alters not only the size of stocks but also the ecosystems through the successive removal of large long-lived species and large-sized specimens to the point where trophic linkages, biodiversity and resilience have all been lowered (Caddy and Sharp, 1986).

The aim of this work is to analyse the structure of demersal assemblages (finfish, crustaceans and cephalopods), on a temporal and spatial scale and to specify the set of species characterising each group and those species responsible for sample groupings. From this perspective, data arising from "MEDITS" trawl surveys carried out in the years 1994-1997 along the Tuscany and Latium coasts, were analysed. Some previous information about fish assemblages in this area has been analysed by Biagi *et al.* (1989) and Abella and Serena (1995a, b).

MATERIAL AND METHODS

This study was carried out within the framework of the Mediterranean International Trawl Surveys Programme ("MEDITS") (Bertrand *et al.*, 2000, 2002). Four experimental bottom trawl surveys were carried out in the years 1994-1997, in the spring-summer period (essentially from June to July). The investigated area encompassed 36,536 km^2, comprising the Italian coasts along Tuscany and Latium (Ligurian and Tyrrhenian seas). This area was subdivided into three sub-areas: from Magra River to Elba Island (sub-area 1), from Elba to Giannutri Island (sub-area 2) and from Giannutri to Garigliano River (sub-area 3) (Fig. 1).

In the first survey, each sub-area was fully covered on a random stratified sampling basis according to the following depth strata: stratum A: 10-50 m; stratum B: 50-100 m; stratum C: 100-200 m; stratum D: 200-500 m; stratum E: 500-800 m. The allocation of hauls was proportional to the surface of each

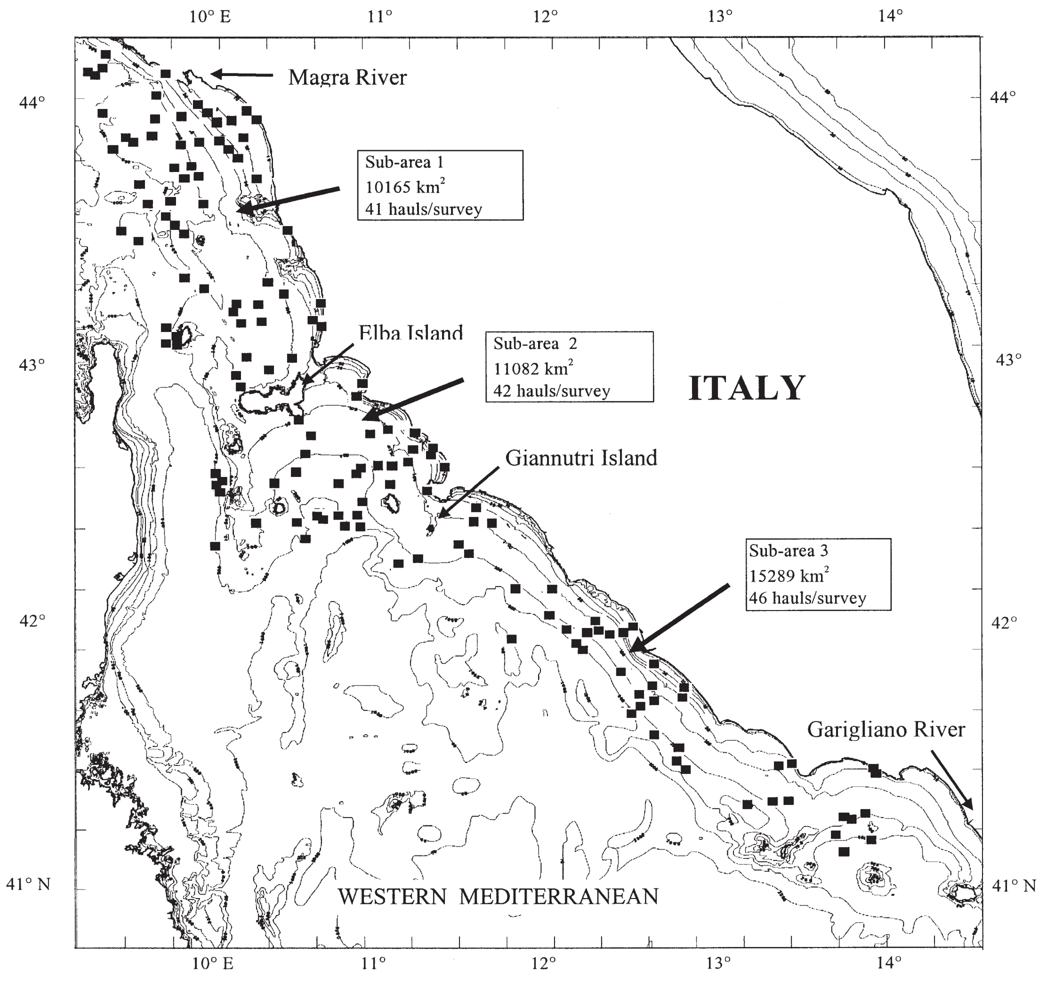

FIG. 1. – Map of the study area with the sampling stations.

bathymetric stratum. The same hauls were replicated in successive surveys. Globally, 129 hauls were made in day time hours in each survey, from 12 to 751 m of mean depth, distributed as follows according to the different depth strata: 18 hauls in stratum A, 18 in stratum B, 36 in stratum C, 33 in stratum D, and 24 in stratum E (Fig. 1).

Haul duration was 30 minutes at depths shallower than 200 m and one hour at depths greater than 200 m. All the surveys were carried out with the same otter bottom trawler and the same type of trawl net, having a cod end with stretched mesh sizes of 10 mm (knot to knot). Further information on the sampling design and on the characteristics of the gear is available in Bertrand *et al*. (2000, 2002).

The species composition of the different taxocoenosis (finfish, crustaceans and cephalopods) was studied by analysing abundance and biomass data coming from each survey. Raw catch data (biomass and number of specimens collected) of each haul were converted into abundance (number of specimens/km^2) and biomass indices (kg/km^2), utilising a specifically developed software (Souplet, 1996). In order to identify faunistic associations, cluster analysis was applied to the abundance and biomass species-stations matrices of each survey; occasional species (those caught only once time in each year) were not considered in this analysis. In addition, the strictly pelagic species (such as anchovy, *Engraulis encrasicolus,* and sardine, *Sardina pilchardus*) were eliminated from the analysis because, in most cases, they were assumed to be captured when the trawl gear was not sampling at the bottom; this could lead to some distortion in grouping the sampling into different assemblages.

Because the survey in 1994 was mostly aimed at standardising and calibrating the sampling gear, cluster analysis was performed using the data sets of the years 1995-1997. To reduce variability and skewness, data transformations were applied: double square root for the abundance data and log(x+1) for the biomass data.

Similarity levels between the stations were calculated through the Bray-Curtis index (Clifford and Stephenson, 1975). A group average fusion strategy, UPGMA, was used as clustering algorithm (Sneath and Sokal, 1973). Species composition of each assemblage was described in terms of percentage contribution of each species at the similarity level of each group. The above mentioned analyses were computed with the PRIMER statistical package (rel. 4.0) (Clarke and Warwick, 1994).

RESULTS

During the four surveys, a total of 253 species (32 Cephalopoda, 47 Crustacea, 21 Condrichthyes and 153 Osteichthyes) were collected (Table 1). Out of these, 165 species (65.6%) occurred in all the three sub-areas (71.0%, 68.1%, 52.4% and 63.8%, respectively for cephalopods, crustaceans, cartilaginous and bony fishes). A total of 194 species (12 exclusive) was collected in sub-area 1, 212 in sub-area 2 (15 exclusive) and 209 in sub-area 3 (9 exclusive).

The number of species caught in each haul ranged from a minimum of 10 to a maximum of 44. However, no evident bathymetric trend in number of species by haul was observed. Over the four years, the mean number of species per haul ranged between 20 and 40.

Four major clusters of stations recurrently appeared in the dendrograms calculated for each survey (Figs. 2 and 3). Each cluster was closely associated with bottom depths. Actually, it was possible to identify a group composed of strictly coastal hauls down to 50 m depth, another group derived from most of the hauls carried out on the continental shelf (essentially between 60 and 220 m depth), a third cluster based on the hauls made along the upper part of the continental slope (from 200 to 450 m depth) and the last group from the deepest hauls (mostly deeper than 450-500 m). Regarding the continental shelf group, a further subdivision into two sub-groups could be done: a shallower group, with most hauls taken at depths of less than 130 m, and another with the majority of hauls made at greater depths.

Cluster structure (regarding both biomass and abundance) remained essentially the same in the three years: about 90% of hauls was assigned to the same clusters over the studied period when four groups were retained, about 85% when five groups were considered (Table 2).

Although many species occurred in more than one group, each faunistic association was characterised by its own extent of species composition and catch rates (abundance and biomass) which distinguished them from each other. Moreover, these assemblages remained substantially unchanged over the study period for both data sets (abundance and biomass) (Table 3).

The coastal group was mostly characterised by *Trachurus mediterraneus*, *Diplodus annularis, Alloteuthis* spp., *Pagellus erythrinus, Arnoglossus later-*

TABLE 1. — List of the species collected during the surveys carried out in the period 1994-1997 off the Tuscany and Latium coasts. Cephalopod species names follow Mangold and Boletzky (1987), crustaceans follow Zariquiey Alvarez (1968) and fishes follow Whitehead *et al.* (1984, 1986).

CEPHALOPODA
Fam. Sepiidae
Sepia elegans
Sepia officinalis
Sepia orbignyana
Fam. Sepiolidae
Rossia macrosoma
Neorossia caroli
Heteroteuthis dispar
Stoloteuthis leucoptera
Rondeletiola minor
Sepietta oweniana
Sepiola intermedia
Sepiola ligulata
Fam. Loliginidae
Alloteuthis media
Alloteuthis subulata
Loligo forbesi
Loligo vulgaris
Fam. Ctenopterygidae
Ctenopterix sicula
Fam. Enoploteuthidae
Abralia verany
Fam. Octopoteuthidae
Octopoteuthis sicula
Fam. Histioteuthidae
Histioteuthis bonnellii
Histioteuthis reversa
Fam. Ommastrephidae
Illex coindetii
Todarodes sagittatus
Todaropsis eblanae
Fam. Onychoteuthidae
Ancistroteuthis lichtensteinii
Fam. Octopodidae
Bathypolypus sponsalis
Eledone cirrhosa
Eledone moschata
Octopus salutii
Octopus vulgaris
Pteroctopus tetracirrhus
Scaeurgus unicirrhus
Fam. Ocythoidae
Ocythoe tuberculata

CRUSTACEA
STOMATOPODA
Fam. Squillidae
Rissoides pallidus
Squilla mantis
DECAPODA
Fam. Solenoceridae
Solenocera membranacea
Fam. Aristeidae
Aristaeomorpha foliacea
Aristeus antennatus
Gennadas elegans
Fam. Penaeidae
Funchalia woodwardi
Penaeus kerathurus
Parapenaeus longirostris
Fam. Sergestidae
Sergestes arcticus
Sergestes robustus
Fam. Pasiphaeidae
Pasiphaea multidentata
Pasiphaea sivado
Fam. Alpheidae
Alpheus glaber
Fam. Hippolytidae
Ligur ensiferus
Fam. Processidae
Processa mediterranea
Fam. Pandalidae
Chlorotocus crassicornis
Plesionika acanthonotus
Plesionika antigai
Plesionika edwardsii
Plesionika gigliolii
Plesionika heterocarpus
Plesionika martia
Fam. Crangonidae
Philocheras echinulatus
Pontocaris cataphractus
Pontocaris lacazei
Pontophilus spinosus
Fam. Nephropidae
Nephrops norvegicus
Fam. Polychelidae
Polycheles typhlops
Fam. Axiidae
Calocaris macandreae
Fam. Palinuridae
Palinurus elephas
Palinurus mauritanicus
Fam. Paguridae
Pagurus alatus
Pagurus prideaux
Fam. Galateidae
Munida intermedia
Munida tenuimana
Fam. Dorippidae
Medorippe lanata
Fam. Geryonidae
Geryon longipes
Fam. Homolidae
Paromola cuvieri
Fam. Portunidae
Bathynectes maravigna
Liocarcinus depurator
Liocarcinus vernalis
Macropipus tuberculatus
Fam. Goneplacidae
Goneplax rhomboides
Fam. Majidae
Macropodia longipes
Maja crispata
Maja squinado

CHONDRICHTHYES
Fam. Hexanchidae
Hexanchus griseus
Fam. Scyliorhinidae
Galeus melastomus
Scyliorhinus canicula
Scyliorhinus stellaris
Fam. Oxynotidae
Oxynotus centrina
Fam. Squalidae
Centrophorus granulosus
Dalatias licha
Etmopterus spinax
Squalus acanthias
Squalus blainvillei
Fam. Torpedinidae
Torpedo marmorata
Torpedo torpedo
Fam. Rajidae
Raja asterias
Raja batis
Raja clavata
Raja miraletus
Raja montagui
Raja oxyrinchus
Fam. Dasyatidae
Dasyatis violacea
Fam. Myliobatidae
Myliobatis aquila
Fam. Chimaeridae
Chimaera monstrosa

OSTEICHTHYES
Fam. Clupeidae
Alosa fallax
Sardina pilchardus
Sardinella aurita
Fam. Engraulidae
Engraulis encrasicolus
Fam. Gonostomatidae
Gonostoma denudatum
Fam. Sternoptychidae
Argyropelecus hemigymnus
Maurolicus muelleri
Fam. Photichthyidae
Ichthyococcus ovatus
Fam. Chauliodontidae
Chauliodus sloani
Fam. Stomiidae
Stomias boa
Fam. Argentinidae
Argentina sphyraena
Glossanodon leioglossus
Fam. Synodontidae
Synodus saurus
Fam. Chlorophthalmidae
Chlorophthalmus agassizii
Fam. Myctophidae
Benthosema glaciale
Ceratoscopelus maderensis
Diaphus metopoclampus
Diaphus rafinesquei
Hygophum benoiti
Hygophum hygomii
Lampanyctus crocodilus
Lobianchia dofleini
Myctophum punctatum
Notoscopelus elongatus
Symbolophorus veranyi
Fam. Paralepididae
Notolepis rissoi
Paralepis coregonoides
Fam. Nemichthyidae
Nemichthys scolopaceus
Fam. Nettastomatidae
Nettastoma melanurum
Fam. Congridae
Conger conger
Gnathophis mystax
Fam. Ophichthidae
Dalophis imberbis
Echelus myrus
Ophisurus serpens
Fam. Notacanthidae
Notacanthus bonapartei
Fam. Macroramphosidae
Macroramphosus scolopax
Fam. Syngnathidae
Hippocampus guttulatus
Hippocampus hippocampus
Fam. Macrouridae
Coelorhynchus coelorhynchus
Hymenocephalus italicus
Nezumia sclerorhynchus
Trachyrhynchus trachyrhynchus
Fam. Merlucciidae
Merluccius merluccius
Fam. Gadidae
Antonogadus megalokynodon
Gadiculus argenteus
Gaidropsarus mediterraneus
Micromesistius poutassou
Molva dipterygia
Molva molva
Phycis blennoides
Phycis phycis
Trisopterus minutus capelanus
Fam. Moridae
Gadella maraldi
Lepidion lepidion
Mora moro
Fam. Trachichthyidae
Hoplostethus mediterraneus
Fam. Zeidae
Zeus faber
Fam. Caproidae
Capros aper
Fam. Serranidae
Polyprion americanus
Serranus cabrilla
Serranus hepatus
Fam. Moronidae
Dicentrarchus labrax
Fam. Apogonidae
Epigonus constanciae
Epigonus denticulatus
Epigonus telescopus
Fam. Cepolidae
Cepola rubescens
Fam. Pomatomidae
Pomatomus saltator
Fam. Carangidae
Trachurus mediterraneus
Trachurus picturatus
Trachurus trachurus
Fam. Sciaenidae
Umbrina cirrosa
Fam. Mullidae
Mullus barbatus
Mullus surmuletus
Fam. Sparidae
Boops boops
Dentex dentex
Diplodus annularis
Diplodus sargus
Diplodus vulgaris
Lithognathus mormyrus
Oblada melanura
Pagellus acarne
Pagellus bogaraveo
Pagellus erythrinus
Pagrus pagrus
Sarpa salpa
Sparus aurata
Spondyliosoma cantharus
Fam. Centracanthidae
Centracanthus cirrus
Spicara flexuosa
Spicara maena
Spicara smaris
Fam. Labridae
Acantholabrus palloni
Lappanella fasciata
Fam. Trachinidae
Trachinus draco
Trachinus radiatus
Fam. Uranoscopidae
Uranoscopus scaber
Fam. Trichiuridae
Lepidopus caudatus
Fam. Scombridae
Scomber japonicus
Scomber scombrus

Table 1 (Cont.). –- List of the species collected during the surveys carried out in the period 1994-1997 off the Tuscany and Latium coasts.

Fam. Gobiidae
Aphia minuta
Deltentosteus quadrimaculatus
Gobius geniporus
Gobius niger
Lesueurigobius friesii
Lesueurigobius suerii
Pomatoschistus marmoratus
Fam. Callionymidae
Callionymus maculatus
Callionymus risso
Synchiropus phaeton
Fam. Blenniidae
Blennius ocellaris
Fam. Bythitidae
Bellottia apoda
Fam. Ophidiidae
Benthocometes robustus
Fam. Centrolophidae
Centrolophus niger
Fam. Sphyraenidae
Sphyraena sphyraena
Fam. Mugilidae
Liza ramada
Liza saliens
Fam. Scorpaenidae
Helicolenus dactylopterus
Scorpaena elongata
Scorpaena notata
Scorpaena porcus
Scorpaena scrofa
Fam. Triglidae
Aspitrigla cuculus
Aspitrigla obscura
Eutrigla gurnardus
Lepidotrigla cavillone
Lepidotrigla dieuzeidei
Trigla lucerna
Trigla lyra
Trigloporus lastoviza
Fam. Peristediidae
Peristedion cataphractum
Fam. Citharidae
Citharus linguatula
Fam. Scophthalmidae
Lepidorhombus boscii
Lepidorhombus whiffiagonis
Psetta maxima
Scophthalmus rhombus
Fam. Bothidae
Arnoglossus imperialis
Arnoglossus laterna
Arnoglossus rueppelli
Arnoglossus thori
Bothus podas
Fam. Soleidae
Buglossidium luteum
Microchirus variegatus
Monochirus hispidus
Solea impar
Solea lascaris
Solea vulgaris
Fam. Cynoglossidae
Symphurus ligulatus
Symphurus nigrescens
Fam. Balistidae
Balistes carolinensis
Fam. Molidae
Mola mola
Fam. Gobiesocidae
Diplecogaster bimaculata
Fam. Lophiidae
Lophius budegassa
Lophius piscatorius

Table 2. – Characteristics of the clusters in terms of depth ranges and number of stations.

A) Considering 4 groups	Biomass data 1995	1996	1997		Abundance data 1995	1996	1997
Group 1				**Group 1**			
Depth range (m)	12-67	12-47	12-47	Depth range (m)	12-67	12-47	12-47
N° of stations	19	18	18	N° of stations	19	18	18
Stations always present in this group: 18 (94.7%)				Stations always present in this group: 18 (94.7%)			
Group 2				**Group 2**			
Depth range (m)	62-195	62-275	62-218	Depth range (m)	62-275	62-249	62-218
N° of stations	52	56	56	N° of stations	55	56	56
Stations always present in this group: 51 (91.0%)				Stations always present in this group: 52 (92.9%)			
Group 3				**Group 3**			
Depth range (m)	202-413	202-428	202-505	Depth range (m)	202-413	202-434	202-505
N° of stations	27	27	31	N° of stations	24	27	31
Stations always present in this group: 27 (87.1%)				Stations always present in this group: 24 (77.4%)			
Group 4				**Group 4**			
Depth range (m)	393-751	454-751	513-751	Depth range (m)	393-751	454-751	513-751
N° of stations	31	28	24	N° of stations	31	28	24
Stations always present in this group: 24 (77.4%)				Stations always present in this group: 24 (77.4%)			

B) Considering 5 groups	Biomass data 1995	1996	1997		Abundance data 1995	1996	1997
Group 1				**Group 1**			
Depth range (m)	12-67	12-47	12-47	Depth range (m)	12-67	12-47	12-47
N° of stations	19	18	18	N° of stations	19	18	18
Stations always present in this group: 18 (94.7%)				Stations always present in this group: 18 (94.7%)			
Group 2a				**Group 2a**			
Depth range (m)	62-131	62-123	62-131	Depth range (m)	62-123	62-133	62-165
N° of stations	31	30	28	N° of stations	28	31	33
Stations always present in this group: 27 (87.1%)				Stations always present in this group: 26 (78.8 %)			
Group 2b				**Group 2b**			
Depth range (m)	131-195	131-275	133-218	Depth range (m)	118-275	118-249	131-218
N° of stations	21	26	28	N° of stations	27	25	23
Stations always present in this group: 19 (67.9%)				Stations always present in this group: 20 (74.1%)			
Group 3				**Group 3**			
Depth range (m)	202-413	202-428	202-505	Depth range (m)	202-413	202-434	202-505
N° of stations	27	27	31	N° of stations	24	27	31
Stations always present in this group: 27 (87.1%)				Stations always present in this group: 24 (77.4%)			
Group 4				**Group 4**			
Depth range (m)	393-751	454-751	513-751	Depth range (m)	393-751	454-751	513-751
N° of stations	31	28	24	N° of stations	31	28	24
Stations always present in this group: 24 (77.4%)				Stations always present in this group: 24 (77.4%)			

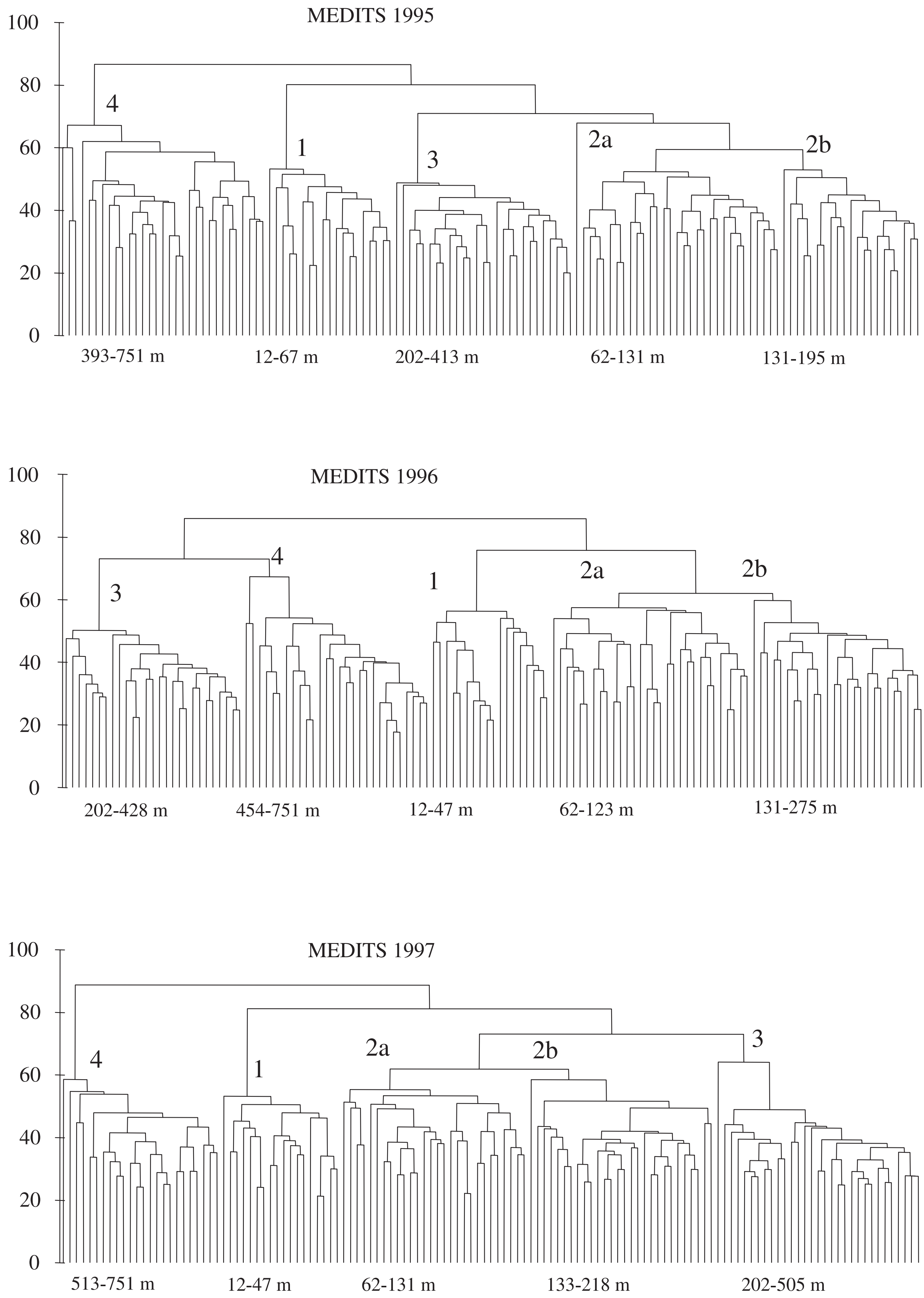

FIG. 2. – Dendrograms showing the groups of stations of each survey. Biomass data. Depth ranges within each major group are presented.

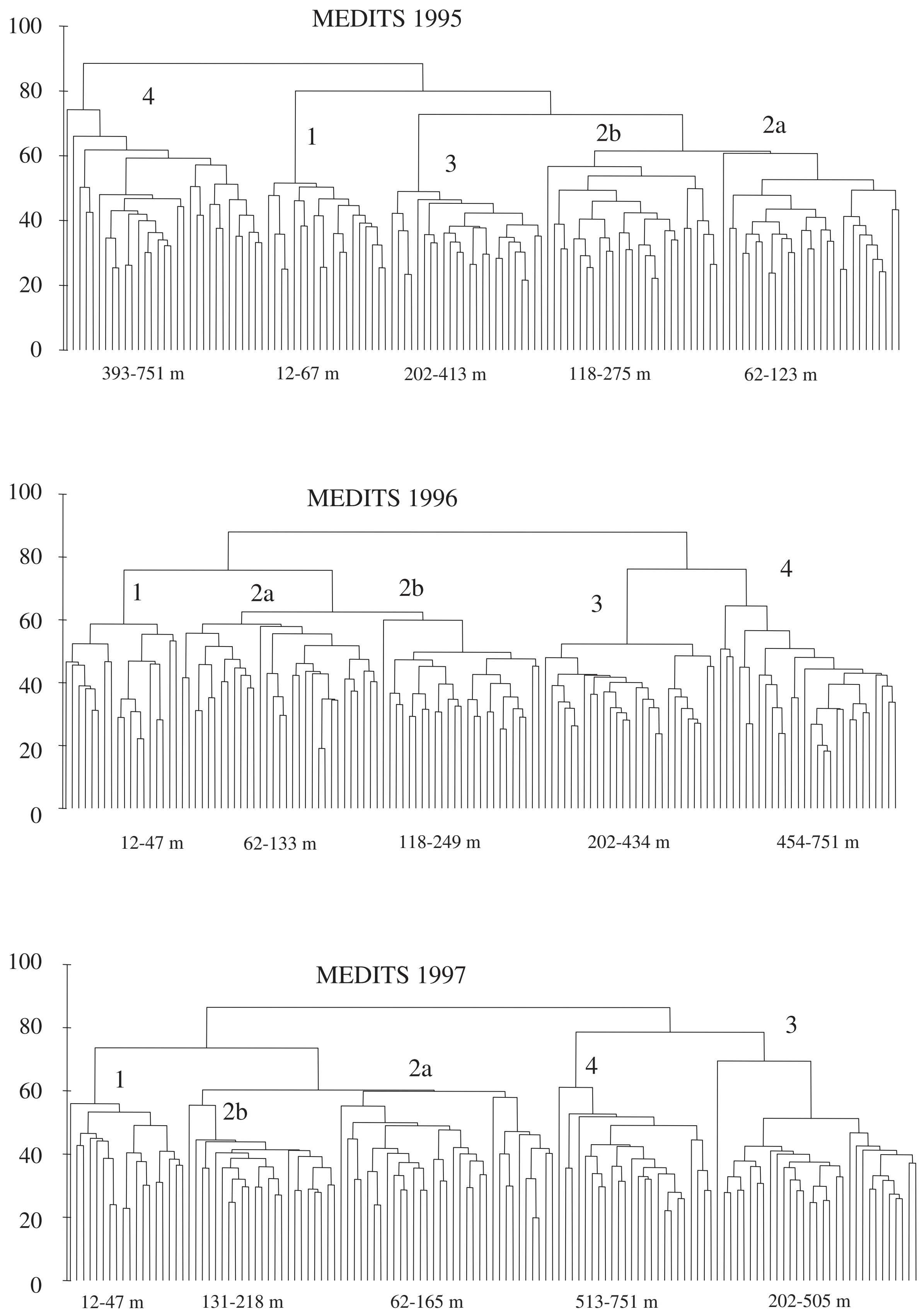

FIG. 3. – Dendrograms showing the groups of stations of each survey. Abundance data. Depth ranges within each major group are presented.

TABLE 3. – The eight most important species, in terms of percentage contribution to the group similarity, listed for each group resulting from the cluster analysis. Biomass and abundance data.

Group 1	Biomass % Sim	kg/km²	Species	Abundance % Sim	kg/km²
D. annularis	8.0	39.6	*T. mediterraneus*	10.8	1549.9
Alloteuthis spp.	7.7	4.4	*Alloteuthis* spp.	10.1	1671.1
P. erythrinus	7.6	12.6	*D. annularis*	9.3	1226.1
A. laterna	6.9	1.6	*S. flexuosa*	8.2	1737.8
T. mediterraneus	6.8	34.4	*P. erythrinus*	6.6	422.7
T. lucerna	5.3	2.1	*A. laterna*	5.8	119.9
L. vulgaris	5.2	3.5	*M. barbatus*	5.4	909.7
M. barbatus	4.7	28.6	*T. lucerna*	5.3	169.3
Group 2a					
M. merluccius	12.2	29.4	*M. merluccius*	12.2	2108.1
E. cirrhosa	6.8	13.5	*T. trachurus*	10.0	2549.7
Alloteuthis spp.	6.6	2.0	*T. m. capelanus*	6.8	1175.1
T. m. capelanus	6.3	10.5	*I. coindetii*	6.1	156.7
T. trachurus	6.2	15.0	*Alloteuthis* spp.	5.9	458.7
I. coindetii	5.3	12.2	*E. cirrhosa*	5.6	141.0
A. laterna	4.6	1.2	*L. cavillone*	4.0	237.9
L. cavillone	3.5	3.3	*S. hepatus*	3.9	294.9
Group 2b					
M. merluccius	10.3	80.8	*M. merluccius*	13.5	8821.1
E. cirrhosa	6.6	16.7	*T. m. capelanus*	11.0	1956.6
T. m. capelanus	6.6	14.7	*C. aper*	6.0	1012.3
I. coindetii	5.6	6.7	*I. coindetii*	6.0	219.9
C. aper	5.1	6.8	*E. cirrhosa*	5.5	174.1
T. trachurus	4.8	8.1	*A. sphyraena*	4.7	509.1
A. sphyraena	4.8	2.2	*T. trachurus*	4.3	1305.9
P. longirostris	4.4	3.5	*M. scolopax*	4.3	788.0
Group 3					
N. norvegicus	7.4	11.4	*G. a. argenteus*	12.4	8675.8
G. a. argenteus	7.0	20.2	*S. oweniana*	6.6	831.3
E. cirrhosa	6.4	19.9	*M. merluccius*	5.7	4493.4
M. merluccius	6.3	42.6	*P. blennoides*	5.3	478.4
P. blennoides	5.9	7.6	*C. agassizi*	5.2	854.7
M. poutassou	5.0	7.4	*N. norvegicus*	4.9	225.8
S. oweniana	4.5	2.6	*P. longirostris*	4.4	166.4
P. longirostris	4.5	1.8	*E. cirrhosa*	4.2	97.8
Group 4					
G. melastomus	11.9	51.1	*H. italicus*	10.0	747.8
P. blennoides	9.9	9.3	*P. blennoides*	9.3	738.1
H. italicus	6.7	1.8	*P. martia*	8.0	348.5
E. spinax	6.6	5.1	*G. melastomus*	7.6	316.1
N. norvegicus	6.2	7.3	*N. norvegicus*	6.8	249.5
P. martia	5.7	2.7	*L. crocodilus*	5.6	282.8
N. sclerorhynchus	5.7	6.0	*N. sclerorhynchus*	5.2	294.2
A. foliacea	5.0	7.2	*E. spinax*	4.7	93.7

na and *Mullus barbatus*. These species presented high catch rates, especially in the case of *T. mediterraneus* and *D. annularis*, with, respectively, about 34 and 40 kg and 1,550 and 1,226 specimens per square kilometre.

In the shallower group of the continental shelf assemblage (group 2a), the aforesaid species were partially substituted by *Merluccius merluccius*, *Eledone cirrhosa, Illex coindetii*, *Trachurus trachurus,* and *Trisopterus minutus capelanus*. The biomass in this group was quite fairly distributed among these species, while the highest abundance values were registered for *T. trachurus* and *M. merluccius*.

Group 2b was dominated by *M. merluccius*, both in terms of biomass and abundance. Other important species were *E. cirrhosa*, *T. m. capelanus*, *Capros aper* (especially in terms of abundance), *Illex coindetii*, *Argentina sphyraena* and *T. trachurus.*

Species characterising Group 3 were *Gadiculus a. argenteus, M. merluccius*, *Phycis blennoides* and

Micromesistius poutassou, together with *Nephrops norvegicus, E. cirrhosa* and *Sepietta oweniana* (particularly important in terms of abundance). This group had the highest number of species in comparison to the others, essentially due to the fact that this depth range is a border line, being the upper bathymetric limit for some species and the lower for others.

The deepest group was characterised by *Galeus melastomus* with biomass index of about 51 kg/km^2, *P. blennoides*, *Nezumia sclerorhynchus* and *Hymenocephalus italicus, Etmopterus spinax, Plesionika martia, Aristaeomorpha foliacea* and *N. norvegicus.* In this last group most of the biomass caught corresponded to species or specimens without any commercial value.

DISCUSSION

One of the results of the "MEDITS" programme was its important contribution to the faunistic knowledge of the investigated areas. However, in most cases, the fact that one species was collected only in one sub-area does not always indicate a particular restricted geographic distribution. Generally, this aspect concerned species with a wide geographical distribution but only occasionally caught because of their low abundance and/or their reduced availability to the gear. In some cases, however, the presence of a species in only one sub-area is certainly due to its pattern of distribution. Particularly interesting is the case of the cephalopod *Bathypolypus sponsalis,* which was recorded in small numbers (less than 30 specimens per survey in the depth range 300-600 m) only in sub-area 1. This is in agreement with observations during ten years of national trawl surveys, which revealed its presence only north of the Island of Elba (Belcari, 1999). *B. sponsalis* is present in Atlantic and Mediterranean waters, but in the Italian Seas it shows an unhomogeneous distribution (Lumare, 1970, Würtz, 1979; Jereb *et al*., 1989; Mannini and Volpi, 1989; D'Onghia *et al*., 1993).

The spring-summer fish assemblages identified fit well in the general picture that the main biogeographic contours on continental shelves and slopes are strongly aligned with depth (Fager and Longhurst, 1968; Tyler *et al.*, 1982; Overholtz and Tyler, 1985; Abelló *et al.,* 1988; Biagi *et al*., 1989; Mahon and Smith, 1989; Sánchez *et al*., 1998; Demestre *et al*., 2000). Moreover, our results show a substantial agreement with previous works carried out in sub-sectors of the same area but with distinct sampling protocol and gear (Biagi *et al*., 1989; Abella and Serena, 1995 a and b).

Classificatory analysis of trawl data encompassing a period of three years indicated a high degree of spatial consistency in the clustering pattern of stations and in the species composition that characterise each cluster.

Persistence, i.e. the ability of an assemblage to maintain its species composition over time, is an important requirement for assemblage validity and, in addition, is an essential issue for management purposes (Pimm and Hyman, 1987; Tilman, 1996). The identification of such biological units, named by some authors APU (Assemblage Production Unit, Tyler *et al*., 1982), is basic to select a set of species that, due to their relative importance, might play an important role in the trophic relationships of the whole community. In a further step, functional trophic links among those species should be identified, so hence biological interactions (e.g. predator-prey relationships) would be incorporated in fishery management, based on a Multispecies Virtual Population Analysis (MSVPA, Helgason and Gislason, 1979; Pope, 1979; Daan and Sissenwine, 1991).

The present work should be seen as a useful data source to identify the appropriate spatial scale for a multispecies fishery study. Thus, this definition of broad geographic areas, characterised by a relatively homogeneous and persistent biological composition, represents the first step to deal with before trying to incorporate an ecosystem approach into practical fishery management advice.

A natural evolution of the present work should analyse assemblage structure by examining size spectrum composition. Moreover, theoretical studies indicate that for exploited systems, multiple equilibrium states of community structure are possible and, therefore, changes in structure are unlikely to be reversible. There is thus an important need to monitor the structure of faunistic assemblages over the time.

ACKNOWLEDGEMENTS

We wish to thank Dr. Mario Mori for his significant help in the identification of crustaceans. We also thank the crew of the fishing vessel "Francesco Padre" and all the scientists that, in different ways, contributed to the success of the surveys.

REFERENCES

Abella, A. and F. Serena. – 1995a. Definition of the groundifsh assemblages caught off the Tuscanian coasts for fisheries purposes. *Rapp. Comm. int. Mer Médit*., 43: 235.

Abella, A. and F. Serena. – 1995b. Definizione di assemblaggi demersali nell'Alto Tirreno. *Biol. Mar. Medit*., 2(2): 451-453.

Abelló, P., F.J. Valladares and A. Castellón. – 1988. Analysis of the structure of decapod crustacean assemblages off the Catalan coast (north-west Mediterranean). *Mar. Biol.,* 98: 39-49.

Belcari, P. – 1999. *Bathypolipus sponsalis*. In: G. Relini, J. Bertand and A. Zamboni (eds.), *Synthesis of the knowledge on bottom fishery resources in central Mediterranean (Italy and Corsica). Biol. Mar. Medit*., 6 (suppl): 733-736.

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.

Biagi, F., S. De Ranieri, M. Mori, P. Sartor and M. Sbrana. – 1989. Preliminary analysis of demersal fish assemblages in the northern Tyrrhenian Sea. *Nova Thalassia,* 10 (suppl. 1): 391-398.

Brugge, W.J. and M.J. Holden. – 1991. Multispecies management: a manager's point of view. *ICES Mar. Sci. Symp.,* 193: 353-358.

Caddy, J.F. and G.D. Sharp. – 1986. An ecological framework for marine fishery investigations. *FAO Fish. Tech. Pap.,* 283: 1-152.

Clarke, K.R. and R.M. Warwick. – 1994. *Change in marine communities: an approach to statistical analysis and interpretation*. Natural Environmental Research Council - Plymouth Marine Laboratory, U.K.

Clifford, H.T. and W. Stephenson. – 1975. *An introduction to numerical classification.* Academic Press, New York.

Daan, N. and M.P. Sissenwine. – 1991. Multispecies models relevant to management of living resources. *ICES MSS,* 193: 1-358.

Demestre, M., P. Sánchez and P. Abelló. – 2000. Demersal fish assemblages and habitat characteristics on the continental shelf and upper slope of the north-western Mediterranean. *J. mar. biol. Ass. U.K*., 80: 981-988.

D'Onghia, G., A. Tursi, A. Matarrese and P. Panetta. – 1993. Some aspects of the biology of *Bathypolypus sponsalis* (Mollusca, Cephalopoda) in the North Aegean Sea (Eastern Mediterranean Sea). *Vie Milieu,* 43 (2-3): 161-164.

Fager, E.W. and A.R. Longhurst. – 1968. Recurrent group analysis of species assemblages of demersal fish in the Gulf of Guinea. *J. Fish. Res. Bd*., 25(7): 1405-1421.

Fredj, G., D. Bellan-Santini and M. Meinardi. – 1992. État des connaissances sur la faune méditerranéenne. *Bull. Inst. Océanogr. Monaco,* special issue 9: 133-145.

Helgason, T. and H. Gislason. – 1979. VPA-analysis with species interaction due to predation. *ICES C.M.,* 1979/G/52: 1-10.

Jereb. P., R. Baino, S. Ragonese and P. Mannini. – 1989. *Bathypolypus sponsalis* (P. et H. Fisher, 1892). *Nova Thalassia,* 10 (suppl. 1): 513.

Lumare. F. – 1970. Nota sulla distribuzione di alcuni Cefalopodi del Mar Tirreno. *Boll. Pesca Piscic. Idrobiol*., 25(2): 313-344.

Mahon, R. and R.W. Smith. – 1989. Demersal fish assemblages on the Scotian shelf, north-west Atlantic: spatial distribution and persistence. *Can. J. Aquat. Fish. Sci*., 46: 134-152.

Mangold, K and S.V. Boletzky. – 1987. Cephalopodes. In: W. Fisher, M.L. Bauchot and M. Schneider (eds.), *Fiches FAO d'identification des espèces pour les besoins de la pêche. (Revision 1). Mediterranée et Mer Noir. Zone de pêche 37. Volume I. Invertebrés*, pp. 633-714. Rome, FAO.

Mannini, P. and C. Volpi. – 1989. Nota sulla presenza e distribuzione di alcuni Cefalopodi del Tirreno settentrionale. *Oebalia,* 15(2): 693-701.

Maurin, C. – 1962. Étude des fonds chalutables de la Méditerranée occidentale (écologie et pêche). Résultats des campagnes des navires océanographiques "Président Théodore Tissier" 1957 à 1960 et "Thalassa" 1960 et 1961. *Rev. Trav. Inst. Peches Marit., Paris,* 26(2): 163-218.

Overholtz, W.J. and A.V. Tyler. – 1985. Long-term responses of the demersal fish assemblages of George's Bank. *Fish. Bull*., 83: 507-520.

Pimm, L.S. and J.B. Hyman. – 1987. Ecological stability in the context of multispecies fisheries. *Can. J. Fish. Aquat. Sci.,* 44**:** 84-94.

Pope, J.G. – 1979. Stock assessment in multispecies fisheries, with special reference to the trawl fisheries in the Gulf of Thailand. SCS/DEV/79/19. South China Sea Fisheries Development and Coordinating Programme, Manila, 106 pp.

Sánchez, P., P. Belcari and P. Sartor. – 1998. Composition and spatial distribution of cephalopods in two north-western Mediterranean areas. *S. Afr. J. mar. Sci*., 20: 17-24.

Sneath, P.H.A. and R.R. Sokal. – 1973. *Numerical taxonomy. The principles and practice of numerical classification.* W.H. Freeman and Company, San Francisco.

Souplet, A. – 1996. Calculation of abundance indices and length frequencies in the MEDITS survey. In: J.A. Bertrand *et al.* (eds.), *Campagne internationale de chalutage demersal en Mediterranee. Campagne 1995.* EU Final Report, Vol. III.

Tilman, D. – 1996. Biodiversity: population versus ecosystem stability. *Ecology* 77: 350-363.

Tortonese, E. – 1987. Pesci nel Mediterraneo. Recenti studi intorno alla sistematica e distribuzione. *Quad. Istit. Idrob. Acquac. "G. Brunelli", Roma*: 1-111.

Tyler, A.V. – 1988. Biological basis for management of groundfish resources in the west coast of Canada. In: W.S. Wooster (ed.), *Fishery Science and management: objectives and limitations,* pp. 217-232. Springer-Verlag, Berlin.

Tyler, A.V., W.L. Gabriel and W.J Overholtz. – 1982. Adaptive management based on structure of fish assemblage of northern continental shelves. *Can. Spec. Publ. Fish*., 59: 149-156.

Whitehead, P.J.P., M.L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese. – 1984. *Fishes of the north-eastern Atlantic and Mediterranean (FNAM),* Vol. 1. UNESCO, Paris.

Whitehead, P.J.P., M.L. Bauchot, J.C. Hureau, J. Nielsen and E. Tortonese. – 1986. *Fishes of the north-eastern Atlantic and Mediterranean (FNAM).* Vols. 2-3. UNESCO, Paris.

Würtz, M. – 1979. I cefalopodi raccolti in mar Ligure durante la campagna di pesca batiale 1977/1978. *Atti Soc. Tosc. Sci. Nat. Mem. Ser. B,* 86: 374-377.

Zariquiey Álvarez, R. – 1968. Crustáceos decápodos ibéricos. *Inv. Pesq*., 32: 1-510.