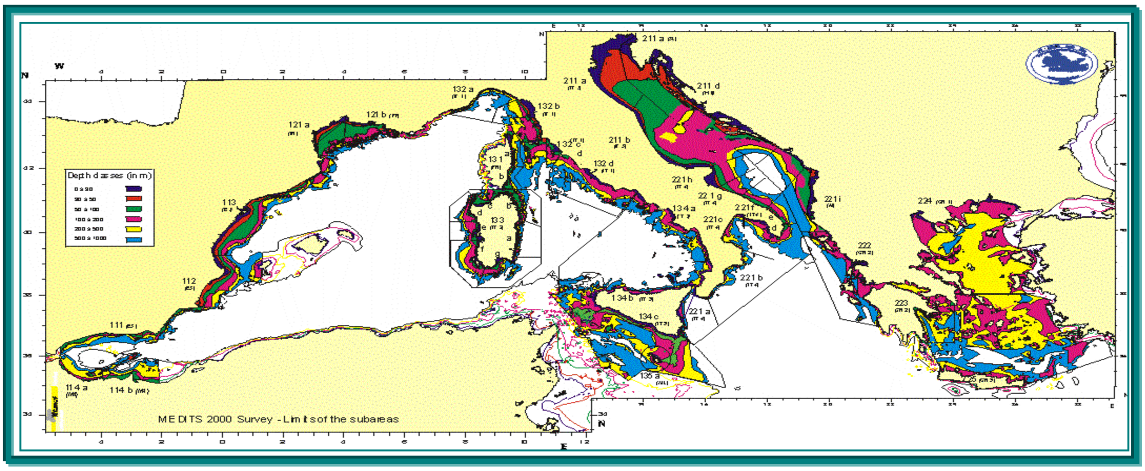
International bottom trawl surveys in the Mediterranean (MEDITS)



The MEDITS survey 2000 and 2001 data analysis

Volume ❶
General report

Final report

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The MEDITS programme is conducted owing to the financial support from the European Commission (DG XIV) and the following partners, the IEO for Spain, Morocco, the Ifremer for France, the Italian Minister of forest, agricultural and food resources (DG fisheries and aquaculture) for Italy as well as Slovenian, Croatian, Albanian and Maltese areas, the NCMR for Greece.

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These teams have managed a collaboration with the NIB (Slovenia), the IOR (Croatia) and the MAF Albania) to enlarge the programme in the Adriatic Sea and MAF (Malta) to cover the waters around this country.

In Spain, collaborations were arranged with the CSIC from Barcelona, the University of Alicante (Department of Statistics) and the INRH in Casablanca through FAO-COPEMED project.

In Greece, As during the last few years, three institutes expressly collaborated within the programme in 1998: the NCMR (Athens), the IMBC (Iraklion) and the NAGREF-FRI (Kavala).

Furthermore, the collaborations have been extended owing to the scientists who contributed in the survey (cf. the boarding tables) and who took part in the meetings (cf. the reports of the meetings).

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Summary

English:

The MEDITS programme began in 1993 with the definition of a standardized protocol for large scale bottom trawl surveys in the Mediterranean. Then common surveys applying this protocol have been carried out every year in the north-west Mediterranean since 1994 up to now. Concurrently, the scientific teams involved in the programme have analysed in different ways the obtained data such as to improve the biological knowledge about the demersal resources in the area, in view of supporting sustainable fishery policies in the Mediterranean.

During the years 2000 and 2001, different activities have been managed in the frame of the MEDITS programme. Two yearly surveys have been carried out with the same partners as during the previous years (Morocco, Spain, France, Italy, Slovenia, Croatia, Albania, Greece), and including Malta for the first time in 2000. Furthermore, the analysis and interpretation of the data have been reinforced through complementary initiatives.

The report presents the survey carried out in 2000 as well as the results obtained by different working groups devoted to (i) analyse the performances of the sampling gear, (ii) define fishery areas for management purpose, (iii) identify the nursery areas of some reference species, and (iv) characterize the trends in the abundance and biomass indices through statistical analyses from the data obtained during the available series of MEDITS surveys.

The descriptions presented show that the main related characteristic is the very high diversity of situations among the species and the areas, which have been confirmed by statistical analyses. Some species present very high variations in space-time distribution and abundance. For most of them, the strongest relationships are identified between spatial distribution and bathymetry. Furthermore, a longitudinal trend from the western to the eastern basins is often described, with the highest values in one or the other basin, depending of the species and parameter.

The wide diversity of distribution patterns between the species faces the question on the definition of limits for biogeographical units in the Mediterranean. To try to solve this problem, different approaches have been proposed from species assemblage analyses. The application of multitable analyses on different MEDITS subareas confirmed their usefulness to study the spatial and temporal organization of the marine communities. They have permitted to evidence some species-richness gradients and differences in the trophodynamics of the megafaunal assemblages related to geographical parameters, such as the bathymetry or the influence of the Atlantic waters entering the Mediterranean.

The strength of the first year-classes have been estimated for some species from the calculation of a specific cut-off length by year and management unit. The estimated data allowed the drawing of a first picture of the nursery areas from the highest occurrence probabilities of the recruits. So, for the hake, the highest densities of recruits throughout the examined period were found along the coasts of the Ligurian and Tyrrhenian Sea, the Catalan Sea, the Gulf of Lions and around the Sardinia, mainly on the outer shelf-upper slope. The recruits of *Phycis blennoides* were mainly encountered in the central and western basins. In return, the juveniles of the crustacean *Parapenaeus longirostris* and the squid *Illex coindetii* were more concentrated in the central and eastern basins.

On a technical viewpoint, the analysis gave an information on the variability of the area swept by the sampling trawl during the standardized hauls, and confirmed the usefulness of trawl performance monitoring during every haul.

During the project, strong relationships have been maintained with other European projects, particularly the SAMED project with which intermediate results have been shared, and with the FIGIS project permitting the creation of a specific GIS extension for geographical analyses of the MEDITS data.

To favour the spreading of the knowledge obtained from the MEDITS surveys, the partners of the MEDITS programme have been incited to take part in a monograph of the scientific journal *Scientia Marina* entirely dedicated to describe the *Mediterranean marine demersal resources* from the available MEDITS data series. A lot of the studies implemented during this project will be published in this special volume. In the same time, the MEDITS web site has been maintained.

Finally, this project has confirmed the strength of the partnership developed through the MEDITS programme, and its usefulness as a basis for the implementation of a scientific network related to the assessment of the demersal fishery resources in the Mediterranean.

French:

Le programme MEDITS a débuté en 1993 par la définition d'un protocole standard pour la conduite de campagnes de chalutage de fond à grande échelle en Méditerranée. Puis une campagne commune mettant en œuvre ce protocole a été effectuée chaque année dans le nord-ouest de la Méditerranée depuis 1994. Simultanément les équipes scientifiques partenaires du programme ont analysé selon différentes voies les données obtenues afin d'améliorer les connaissances biologiques sur les ressources démersales de cette zone, dans une perspective de soutien à la gestion soutenable des pêches en Méditerranée.

Pendant les années 2000 et 2001, différentes activités ont été organisées dans le cadre du programme MEDITS. Deux campagnes annuelles ont été réalisées avec les mêmes partenaires que durant les années antérieures (Maroc, Espagne, France, Italie, Slovénie, Croatie, Albanie et Grèce). Pour la première fois, Malte a contribué au programme en 2000. De plus, les analyses des données ont été renforcées selon différentes approches complémentaires.

Ce rapport présente la campagne conduite en 2000 ainsi que les résultats obtenus par différents groupes de travail dédiés à (i) l'analyse des performances de l'engin d'échantillonnage, (ii) la définition d'aires de référence pour la gestion des pêches, (iii) l'identification d'aires de nourriceries de quelques espèces importantes et (iv) la caractérisation statistique des tendances des indices d'abondance et de biomasse issues des séries de données de campagnes MEDITS.

Les résultats présentés, confirmés par les analyses statistiques, montrent que la principale caractéristique relevée est la très grande diversité de situations selon les espèces et les zones. Quelques espèces présentent de très grandes variations spatiales et temporelles de distribution et d'abondance. Pour la plupart d'entre elles, les plus fortes relations sont établies avec la distribution spatiale et la bathymétrie. De plus, une tendance associée à la direction de la longitude est souvent décrite, les plus fortes valeurs apparaissant dans l'un ou l'autre des bassins selon l'espèce et le paramètre.

La grande diversité des schémas de distribution selon les espèces pose la question de la définition des limites des unités biogéographiques en Méditerranée. Pour tenter de résoudre le problème, différentes approches ont été proposées à partir d'analyses des assemblages d'espèces. L'application d'analyses multitableaux à différentes zones géographiques couvertes par les campagnes MEDITS a confirmé leur utilité pour étudier l'organisation spatiale et temporelle des communautés marines. Ces analyses ont permis de mettre en évidence des gradients de richesse spécifique et des différences trophodynamiques dans les assemblages d'espèces, en relation avec des paramètres géographiques comme la bathymétrie ou l'influence des eaux Atlantiques pénétrant en Méditerranée.

La force des premières classes d'âge a été estimée pour quelques espèces par le calcul d'une taille limite selon l'année et l'unité de gestion. Les valeurs ainsi estimées permettent d'établir une première représentation des zones de nourriceries à partir des probabilités de plus forte présence des recrues. Ainsi, pour le merlu, les plus fortes densités de recrues relevées sur l'ensemble de la période étudiée ont été observées le long des côtes Ligures, en mer Tyrrhénienne et mer Catalane, dans le golfe du Lion et autour de la Sardaigne, principalement en bordure externe du plateau et le long de la partie supérieure de la pente continentale. Les recrues de *Phycis blennoides* ont été principalement rencontrées dans le bassin central et dans le bassin occidental. En revanche, les juvéniles du crustacé *Parapenaeus longirostris* et du calmar *Illex coindetii* étaient plus concentrés dans le bassin central et dans le bassin oriental.

Les études techniques menés sur les performances du chalut ont donné une information sur la variabilité de l'aire balayée par l'engin d'échantillonnage pendant les traits standardisés. Elles ont confirmé l'utilité d'un contrôle systématique de la trajectoire, de la géométrie et de la posée de l'engin.

Durant le projet, des très fortes relations ont été maintenues avec d'autres projets européens, et en particulier le projet SAMED avec lequel des résultats intermédiaires ont pu être partagés. Le rapprochement avec le projet FIGIS a permis la création d'une extension SIG spécifique pour une analyse spatiale des données MEDITS.

Afin de favoriser la diffusion des connaissances acquises, les partenaires du programme se sont mobilisés pour préparer une monographie du périodique scientifique *Scientia marina* entièrement dédiée à la description des ressources démersales marines de Méditerranée à partir des séries de données des campagnes MEDITS. Beaucoup des études menées au cours du présent projet seront publiées dans ce volume spécial. Dans le même temps, le site web du programme a été entretenu.

Finalement, ce projet a confirmé la force du partenariat développé à travers le programme MEDITS et l'utilité de ce programme pour la mise en œuvre d'un réseau scientifique sur les ressources halieutiques démersales en Méditerranée.

Foreword[1]

During the last decade, the need for a rationalization of the fishery management systems in the Mediterranean has been emphasized in several forums. In the European Union, this concern was particularly expressed during the Diplomatic conferences on fishery management in Crete (1994) and Venice (1996). The requirements clearly reflected the orientations of international conventions as the Convention on Biodiversity (1995), the Code of Conduct for Responsible Fishery (FAO, 1995) and the Convention of Barcelona (1995) which underlined the need for the implementation of fishery management towards the objective of sustainable fisheries exploitation integrating ecosystem approaches.

In this context, the paradigms for fishery research have been strongly updated. One of the main objectives of this research is focused on description, understanding and monitoring the biological systems under the effects of fishery, natural variations and other human activities. From the new paradigms, various approaches may be taken into consideration notably under the following topics: biodiversity, relationship with hydro-climate, biomass dispersion, food webs, and essential habitats. In any case, the validity of scientific studies conducted to progress towards these outlooks strongly depends on the generalization of the approaches and the continuity in the observation systems.

In the Mediterranean area, the coastal economy is firmly turned to the sea. The fishery industry is very diversified and scattered, specially for the demersal and benthic species that form about 55% of the total catch, and usually much more in value. For most of these resources, the general trend, worsened by fishing power increase, is going toward overfishing. In some areas, this situation is illustrated by a tendency to fish size reduction and high fishing pressure on juveniles.

In the past, most of the demersal resources were assessed and managed at local scale, according to the limits of exploitation units. Only in some areas, and since the 1980s, specific programmes were devoted to observation of these resources from standardized trawl surveys. Nevertheless, most of the assessments were still done using information gathered from the fishing activity, according to local conditions and opportunities. So, it was very difficult to draw a global view of the state of these resources. There was a necessity to encourage common research so as to take a full advantage of the tremendous research activity spread out in a large number of institutes and laboratories all along the Mediterranean coast.

The incitement from the European Commission (Directorate for Fisheries, 1993) who wished for a common bottom trawl survey to support the Common Fishery Policy in the Mediterranean gave a fantastic opportunity to progress towards the development of a standardized observation network on demersal resources in this area. The request was strictly assigned to the assessment of species exploited by bottom trawlers with the aim to produce scientifically validated advises for fishing regulation. So far, the MEDITS programme (International bottom trawl survey in the Mediterranean) was clearly oriented towards this objective since its beginning in 1994. It was designed to contribute directly to the Fisheries monitoring system in the Mediterranean by organizing periodic large scale bottom trawl surveys, and producing assessments of the demersal resources to serve as references for their sustainable management.

At the start, the priority of the survey programme was to elaborate and build a common data bank on the trawlable exploited species, independently of the data obtained from the exploitation systems. Then the intention was to contribute to the assessment of the demersal species by characterisation of their distribution, abundance and demographic features. By repetition of the surveys with time, it was proposed to build year after year indicators on trends concerning these resources. From an enlargement of the surveys to target a wider range of species than the ones presently exploited, the data collected in this series of trawl surveys might favour studies on relationships between fishery and ecosystem. So far, the MEDITS programme intended to contribute to the reduction of data deficiency often highlighted in the area, and to the development of scientific collaborations in view of improving assessments of the demersal resources as well as on the exploited ecosystems.

During the first few years (1994-1996), the programme was mainly devoted to set down the foundations for the common database and its enlargement in the Adriatic. Urgently, the interest for a full valorization of the data and spreading of the results was strengthened. A first international symposium in Pisa (Italy) in 1998 constituted a first milestone on that direction. During the years 2000 and 2001, an improvement in the estimates of abundance and population parameters of a large amount of target species was carried

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[1] This text is the foreword of the *Scientia Marina monograph* presented in the annexe 1 of this report. It refers to the contents of the *Scientia marina* volume. Nevertheles, its meaning largely applies to this report, as a large amount of the articles to be published in the *Scientia Marina* volume come from the work done within the present project.

out through the European funded project SAMED (Stock assessment in the Mediterranean). The present volume intends to reach a new step with this purpose.

After an introductory chapter presenting the common objectives and methodology, two main sections constitute the core of this volume. The bulk of the book is formed by a series of directed papers intending to provide an overall view of the distribution patterns, abundance and population characteristics of the main target species for the Mediterranean trawl fishery throughout the study geographical range. Then, different approaches contributing to build biological and ecological knowledge on these resources are presented. The volume is completed by a series of useful appendixes, such as the list of all previously published references using totally or partially MEDITS data, or generated by the MEDITS surveys.

In many cases, the MEDITS series is still too short for identifying consistent time trends in abundance of the demersal resources in the Mediterranean. Nevertheless, for the first time, it has given a lot of new information on the distribution of these species at a large scale in the basin. It is the reason why the first priority for research inside the MEDITS programme was to describe the present status of the species, including the distribution of their nurseries.

The global descriptions proposed in the volume show that the main related characteristic is the very high diversity of situations among the species and the areas. Some species present very high variations in space-time distribution and abundance. For most of them, the strongest relationships are identified between spatial distribution and bathymetry. Furthermore, a longitudinal trend from the western to the eastern basins is often described, with the highest values in one or the other basin, depending of the species and parameter.

The wide diversity of distribution patterns between species faces the question on the definition of limits for biogeographical units in the Mediterranean. To try to solve this problem, different approaches have been proposed from species assemblage analyses during the symposium in Pisa and in this volume. They are a first step before application at the full MEDITS scale.

Differences in demographic structures may be due to variations in exploitation patterns and hydrological and ecological conditions. In some situations, the sampling scheme may amplify the effects of these factors due to the seasonal nature of biological parameters (*e.g.* full survey timing according to local moments of species recruitment). It will be necessary to strengthen the characterization and quantification of relationships between the observed demographic structures and their environment, including fishing activity. Different approaches to solve this question were proposed in Pisa and in this volume. The perspectives are huge, and we may anticipate a lot of promising research as well as about monitoring reinforcement. Indeed, as the MEDITS surveys constitute the first large scale network for monitoring the living resources in the Mediterranean, we may anticipate that it should also offer in the future a useful support for a enlargement towards a more integrated ecosystem approach.

Establishing the database has mobilized competency and willingness of a large number of scientists in the involved countries. All the partners should be warmly thanked for their collaboration. Actually, it is them who have built the databank which presently contains almost 213 000 recordings of species abundance at about 1 100 stations distributed in the northern part of the Mediterranean basin from the Alboran Sea to the Aegean Sea (an area of more than 516 000 km²), and studied in the course of eight yearly surveys. Their activity has been made possible thanks to the full support and encouragements given by the European Commission (Directorate for Fisheries), all the countries and institutes involved in the programme, and other organizations as COPEMED, which contribution was completely decisive for enlargement of the programme in the south.

The Scientific, Technical and Economic Committee for Fisheries (STECF-EU, February 2000) has set the MEDITS survey in the highest priority group of survey data to be collected for monitoring the fisheries of the European Union referring to the Council Regulation establishing the Community programmes for the collection of data in the fisheries sector. Activity inside MEDITS has been guided by quest for quality of the data collected owing to a high level of international collaboration, the scientific progress they allow about demersal resources state and ecology in the Mediterranean, and their usefulness for improving fishery management. We wish that the results obtained in these ways will work as an incitement to uphold support for continuation the data series and development of research activity in this field.

Jacques A. BERTRAND

Introduction

The MEDITS programme began in 1993 with the definition of a standardized protocol for large scale bottom trawl surveys in the Mediterranean. Then, common surveys applying this protocol have been carried out every year in the north-west Mediterranean since 1994 up to now. Concurrently, the scientific teams involved in the programme have analysed in different ways the obtained data such as to improve the biological knowledge on the demersal resources in the area.

The results have been systematically presented in annual reports at the end of each survey. Furthermore, specific actions have been done through the life of the survey programme to incite more deep analyses and the spreading of the results. So, a specific symposium has been held in Pisa in 1998 on the A*ssessment of demersal resources by direct methods in the Mediterranean and the adjacent seas*. Links have been maintained with other European projects as the FIGIS project (*Fisheries Geographic Information Systems*; co-ordinator G. Le Corre) and the MEDLAND project (*Mediterranean landings*; co-ordinator: A. Tursi) devoted to define pilot procedures to sample the commercial landings.

During the years 2000 and 2001, different activities have been managed in the frame of the MEDITS programme. Two yearly surveys has been carried out with the same partners as during the previous years (Morocco, Spain, France, Italy, Slovenia, Croatia, Albania, Greece), and including Malta for the first time in 2000. Furthermore, the analysis and interpretation of the data have been reinforced through different converging initiatives. Some of these activities are presented here, as related to the contracts identified in the front page of this report. Others were done through other projects. It is particularly the case for the survey 2001 (EC Projects 00/006, 00/041 and 00/010) and related stock assessments studies within the SAMED project (EC project 99/047; co-ordinator: G. Lembo).

As it has been done for the previous surveys, a basic information is given in this report (item 1) on the progress of the MEDITS 2000 survey, as well as on the abundance indices and length frequency distribution of the reference species.

The performances of the sampling gear is a permanent preoccupation in such a survey programme. Since the beginning of the MEDITS programme, different approaches have been done to better know the significance of the biological samples collected during the surveys. During the period covered by this report, a further study has been done to better characterize the functioning of the gear (item 2).

During 2001, specific tasks in this contract were devoted to (i) define fishery areas for management purpose (item 3), (ii) to identify the nursery areas of some reference species (item 4), and (iii) to better characterize the trends in the abundance and biomass indices through statistical analyses (item 5) from the data obtained during the seven first surveys.

To favour the spreading of the knowledge obtained from the MEDITS surveys, the members of the MEDITS group have been incited to take part in a monograph of the scientific review *Scientia Marina* dedicated to describe the *Mediterranean marine demersal resources* from the available MEDITS data series (annexe 1). This volume will contain a list of all the scientists involved in the programme since its beginning as well as a list of published articles based on the data and material generated by the MEDITS surveys. This volume will be published in 2002. In the same time, the MEDITS web site has been maintained at the following address: (http://gorilla.bio.uniroma1.it/MEDITS/index.htm).

Another extra job done beyond the terms of reference of the contracts, but with strong links with the FIGIS project is the creation of an Arcview extension aimed to establish a basic cartography covering the MEDITS area, to create shape files representing different biomass and density indices and to enable a MEDITS information interface with statistics and geostatistics softwares. Their authors have introduced this tool to the MEDITS group during the general meeting held in Cagliari (Italy) in November 2000. Its user's guide is presented in the annexe 2 of this report.

The quality of the data included in the data bank strongly depends on the effectiveness of the different teams involved in the survey in applying exactly the same pertinent methodology. To ensure this objective, the *instruction manual* has been revised taking into account the need for preserving the continuity of the observations and translated in English (volume 2 of this report).

The activity inside the MEDITS programme in 2000 and 2001 has continued through the strengthening of a very high degree of collaboration between the participating countries and involved bodies, as much for the managing of the surveys as for the analysis of the data and research activities. Finally, the MEDITS surveys have confirmed that they are a fantastic means not only for developing biological knowledge aimed to support policies for a sustainable development of the fishery sector, but also to sustain and stimulate the collaboration between the scientists in the Mediterranean countries. Actually, for the first time, the opportunity to create in common basic data allows that scientists from the different contries may collaborate in depth for the development of shared knowledge concerning the demersal resources in the Mediterranen. The International Workshop on *Stock assessment and production of demersal resources in the Mediterranean* organized jointly through the MEDITS/SAMED dynamics, and held in Rome in March 2002 under the auspices of the FAO-GFCM has clearly demonstrated the present progress in that way.

[1] The MEDITS survey 2000

During 2000, the MEDITS survey has been conducted with the same general organisation as the one adopted since 1996, comprising now nine countries, Malta being included due to the Italian co-operation.

This part of the report presents the results of the MEDITS survey 2000. It includes the technical reports for each country and general biological outcomes for each of the three groups of species (fish, Crustaceans and Cephalopods) as written during a general meeting held in Cagliari (Italy) in November 2000.

1.1 Technical report - MEDITS 2000 survey

The works done at sea for the MEDITS 2000 survey have been conducted from 29/04/2000 till 03/08/2000, occupying 324 ship-days in operation. Eleven vessels have been used for this survey (table 1). Ten of them are the same as for the ‘99 survey. One has been replaced in Greece, area G1. The general calendar of the survey is presented in the figure 1.

The survey has covered exactly the same areas as for the last previous ones (fig. 2) except its extension to the waters around Malta. It has been conducted in the different regions using the same protocols as for the ‘99 survey (cf. « Manuel des protocoles de la campagne MEDITS 95 », the addenda for the surveys 1996 and 1997 and the English translation, Volume 1 of this report). As far as possible, the sea temperature has been systematically recorded during the hauls.

A total of 1177 hauls have been done in the whole area (Table 2).

At the end of the survey, all the data have been checked and validated by each of the teams, using the CHECKMED program (a specific program defined for the project). The data have been grouped in Ifremer-Sète to produce the common data bank. The data of each region have been sent back to each of the respective regional co-ordinators after a second validation. Furthermore, as for the previous ones, the corresponding computer files will be deposit in five places (to the EC-DG XIV and each of the members of the Co-ordination committee) to ensure their protection. All these data will be managed by the tool defined within the MDMS project.

Owing to the progress done by the different teams to manage the rough data, the procedure of grouping and validation of the data was finished by the middle of October, that means a very few months after the end of the survey. A first global run to produce biomass/abundance estimators as well as length frequency distributions for the species included in the reference list might be made available to the Steering committee members early in November, to help the preparation of the biological analysis at a global level.

We may underline that the checking of the data before their grouping at the general level and through the common analyses done during the general meeting in Cagliari (November 2000) have confirmed the good qualification of the teams involved in the project to produce such data.

Technical reports written by the respective regional co-ordinators are presented below. They set out the conditions whereby the 2000 survey has been conducted in their region.

1.1.1 Technical Report for Morocco

by Ali Srairi

The MEDITS survey undertaken along the Moroccan shelf (MEDITS_MA 0005) took place from the 18th of May to the 4th of June 2000. A total of 55 hauls were carried out with the R/V ‘Charif Al Idrissi’ from Ceuta to Saidia: 27 hauls in Western Sector from Ceuta to Al hoceima (5°19’ W-03°55’ W), 28 hauls in Eastern Sector from Al Hoceima to Saidia (03°55’ W-02°13’ W).

Besides a total of 12 fishing days, two others days at technical break in the port of Al Hoceima gave us the opportunity to meet and explain results to fishing association and also to replace the scientific crew members. During the survey, the weather conditions were very good except for three windy days. No particular problems were met during the survey.

Scientific participants came from the INRH Laboratory of Casablanca and the Regional Center of INRH in Nador (North of Morocco), the scientific team is composed of fifth biologists and two technicians (see the list below). For only some hauls, the Scanmar was used in order to show the geometry of the trawl (horizontal and vertical opening of the trawl) and the temperature. During some hauls, especially where the substrate was hard, gear was damaged particularly at haul number 66. It has not been possible to carry out the haul in the stratum 10-50 m especially in the western part of the region. During the survey, the data were input on computer by using the DAME program.

The species in the catches were fish, crustaceans, mollusc including cephalopods and others invertebrate species. Determination, numbering, weighting of each species, length frequency, sexual and maturity index of the principal species have been made.

The species of the reference list which were most abundant in weight were: *Micromesistius poutassou*, *Hoplostethus mediterraneus*, *Galeus melastomus*, *Helicolenus dactylopterus*, *Scyliorhinus canicula*, *Plesionika sp*, *Parapenaeus longirostris* and *Octopus vulgaris*. The species of *Sparidae* and cephalopods occur mostly between 10 and 100 m. depth. The crustacean and selaciens were abundant in high depths.

The Scientific team:
- INRH Casablanca: Ali SRAIRI (Biologist of fisheries), Aziz CHAGHIF (Technician) and Mohamed TOUNANI (Technician aboard the R/V)
- CRRH Nador: Rachida HOUSSA (Biologist ; Sector 114 a), Abdelouhab SLIMNANI (Biologist ; Sector 114 b), Abdelbaki RAKBI (Biologist) and Najib EL OMMARI (Biologist).

1.1.2 Technical Report for Spain

By María Gonzalez and Luis Gil de Sola

The MEDITS ES survey took place from the 21st of May to the 24th of June 2000. A total of 117 hauls were carried out with the R/V «Cornide de Saavedra» from the Strait of Gibraltar to Cape Creus: 38 hauls in the Alboran sea and gulf of Vera, 27 in the Alicante area and 46 in the Catalan sea. 3 hauls were not valid.

Participant scientists came from the laboratories of the IEO of Málaga and Madrid, from the ICM-CSIC of Barcelona, from the University of Alicante , University of Barcelona, Gerona and University Autonoma of Madrid. The scientific team was composed of biologists and technicians. Teresa Bottari and Florinda Damele scientists from Italy (C.N.R. of Messina and University of Cagliari), and Eloumari Najib, from the I.N.R.H. of Nador (Morocco) stayed on board during two weeks.

Sampling activities were conducted without important difficulties. The geometry of the trawl was monitored during the whole survey using a Scanmar system, and the temperature, salinity and oxygen concentration at different depths was taken with a CTD measurement system. No haul was new. As in other years great catches of pelagic species were observed.

A total of 448 species were identified: 162 fishes, 87 crustaceans, 98 molluscs including 30 cephalopods, 40 echinoderms and 61 other invertebrate species. A systematic inventory of waste products present in the catch was made. Determination, numbering and weighting of each species, biological examination of the principal species, introduction of the data (characteristics of each haul, weight and number of the caught species, length and maturity index of the principal species) in the CAMP and DAME programs was made on board the vessel. The checking of the data and the calculation of the abundance indices and length frequencies with the CHECKMED3 and INDMED5 programs were made in the laboratory.

1.1.3 Technical Report for France

by Pierre-Yves Dremière and Arnauld Souplet

The MEDITS FR survey took place from the 30th of May to the 3rd of June 2000. The first part of the survey (30/05 - 07/06) has been conducted on the eastern coast of Corsica and the second part (08/05 - 03/07) in the Gulf of Lions. During the whole survey, the weather conditions were very good. One day (10/06) was lost for technical problems.

1.1.3.1 Observations on the behaviour of the gear

The geometry of the trawl has been monitored during the whole survey using a Scanmar device. As far as possible the rigging accorded with the latest version of the "Manuel des protocoles". Due to difficulties encountered in the previous years to make the trawl reach the contact with the bottom in biggest depths (more than 500 m), a trial has been made at the biggest depth (750 m) using bridles of 200 m instead of 150 m. The results have been very decisive and the trawl was well established after a relatively short time (around 30 min).

Nevertheless and in general, the gear specifications, as indicated in the "Manuel des protocoles", lead to a good efficiency of the trawl. At each haul it is however important to wait that the trawl geometry be well stabilised before to decide the beginning of the haul.

Related with some difficulties met by different teams to put and/or to hold the MEDITS trawl in good contact with the sea bottom in deep waters, some technical trials have been carried out during the 2000 MEDITS cruise on board the French vessel L'Europe.

These trials, conducted in the gulf of Lions on depths close to 750 m (haul n° 89), concerned together sweep length, depth / warp length ratio, and warp shooting speed. They have been achieved using a Scanmar system, with a permanent real time observation on board. Due to available time and cost, it was not possible to test separately each one of these three parameters. All the other parameters were kept at their standard value, as recommended in the MEDITS « Manuel des protocoles ».

With some slight adjustments, positive results were obtained in July 2000, 23 different species (around 39 kg in total) being caught during that haul (1 h). In comparison, the same haul carried out in 1998 had no result at all, the trawl continuously flying above the bottom, in spite of three attempts to put it on the same soundings and area (during 1999, no haul was achieved in this area, due to heavy weather).

1.1.3.1.1 Sweep length

On soundings deeper than 200 m, a sweep length of 150 m is normally used, according to the « Manuel des protocoles ».

A sweep length of 200 m has been successfully used during the 2000 trials (main result is indicated above).

It could be useful to consider, for the next cruises, the possible use of 200 m sweeps for depths deeper than 500 m.

1.1.3.1.2 Warp length / depth ratio

It seems important to remember that, for this ratio, the working depth to be taken into account is the one of the MEDITS trawl, and not the sounding underneath the vessel.

The warp length MEDITS protocol has been established for mean values of steel wire weight per length unit. Due to wire manufacturer, some variations around that weight mean value can have a noticeable effect in deep waters, the warp weight in water being sometimes much less (or more) important than specified.

Some adjustments can be consequently useful, in order to facilitate the descending motion of the trawl (particularly in case of a lighter weight per length unit) and its good contact with the bottom. Some allowance is therefore possible in deep waters, with regard to the mean curves and tables given in the « Manuel des protocoles ».

During our trial on board L'Europe, conducted on a relatively falling slope (around 730 to 850m), we have successfully shot regularly 50 additional metres (16 mm in diameter), to put as fast as possible, and correctly, the trawl on the bottom.

1.1.3.1.3 Warp shooting speed

When shooting additional warp length, on several occasions (on a falling bottom), some different shooting speeds have been tested, to estimate their effect. There is a strong evidence that the faster is the shooting speed, the faster and best the trawl contact with the bottom is.

1.1.3.1.4 Conclusions

Every one of the three complementary adjustments have play a part in the results obtained in 2000. The effect of the adjustments lied more in the good and continuous contact of the trawl with the sea bottom (real length of the swept area) than in the mean MEDITS trawl shape.

Looking at these results, we may suggest to the MEDITS group to consider, for the future, the possibility of a slight adjustment for two of the present protocol standards (warp length/depth ratio and sweep length, the warp shooting speed being not standardized). This could lead towards a best efficiency of the MEDITS trawl in deep waters, without very noticeable effect on the net geometry itself.

1.1.3.2 Survey's progress

This year no damages to the gear occurred during the survey. As previously, the shallowest strata in Corsica (13101 and 13106, between 10 and 50 m) have been considered as not trawlable due to very large quantities of algae, sea urchins and eel grass (*Posidonia sp.*). During the '2000 survey, 92 hauls have been made: 69 in the Gulf of Lions and 23 in Corsica.

1.1.3.3 Other observations

For all hauls, the MICREL ichtyometre has been used, together with the DAME program written by G. Delmas. It should be noted that this program has not gone over the year 2000. A new one is currently under development under Access in the Ifremer laboratory in Boulogne-sur-Mer (author Franck Coppin). This software was not ready for the survey but we have been able to circumvent this difficulty. The data files have been checked and when necessary corrected immediately after the survey. It is remembered that the coding of the year in the files records and the files names have been changed accordingly to the Steering Committee meeting held in Genoa in May 2000. Some trials have been made to compare the temperature from the Scanmar device and from the MINILOG one. They showed a systematic difference of 0.8°C but some further experiment in controlled tanks showed also that these differences are not linear in case of increasing temperature. Although the MINILOG probe was broken during the haul n°43, the study of this experiment will be continue.

In addition to the normal biological observations, a systematic inventory of waste products present in the codend (glass, plastic, metal, etc.) has been made. This inventory showed the importance of waste concentration near the biggest harbours (Marseilles, Bastia) and on the ferries routes between Corsica and the mainland.

1.1.4 Technical report for Italy - area M1 - Ligurian and Tyrrhenian Seas

by G.D. Ardizzone and A. Belluscio

In the M1 region the 2000 MEDITS survey was carried out from May 23 to 27 July using the professional trawler "Francesco Padre". A total of 153 valid hauls were carried. A total of 45 fishing days, 8 day of bad weather brake and 13 days of technical break were spent.

No particular technical problems were met during the survey. As far as possible, all stations have been made at the same positions as in the previous years.

Scientific participants came from the laboratories of the “Consorzio Interuniversitario di Biologia Marina” of Livorno, from the “Agenzia Regionale per la Protezione Ambientale della Toscana” of Livorno, from the University of Genova and from the University of Rome “La Sapienza”.

A Minilog instrument has been used to collect data on surface and bottom water temperature. The file (tdit00m1.txt) was created. Water temperature close the bottom ranged from 13.8°C (slope hauls) to 17.2°C (shelf hauls).

The data were insert on board in a PC using the DAME program and checked using the CHECKMED2 routines. Abundance indices and length frequencies have been calculated using the INDMED4 program.

The species of the reference list which were most abundant in weight were, in order: Trachurus mediterraneus *Merluccius merluccius*, *Micromesistius poutassou, Galeus melastomus*, *Spicara smaris*, *Mullus barbatus*.

An increase in the catches of *Citharus macrolepidotus*, *Helicolenus dactylopterus*, *Spicara smaris*, *Galeus melastomus*, *Trachurus mediterraneus*, *Nephrops norvegicus*, *Parapenaeus longirostris*, *Eledone cirrhosa Illex coindetii* and a decrease of *Lophius piscatorius*, *Merluccius merluccius*, *Micromesistius poutassou*, *Mullus barbatus*, *Mullus surmuletus, Pagellus erythrinus, Phycis blennoides, Raja clavata, Solea vulgaris, Trigloporus lastoviza, Octopus vulgaris , Aristaeomorpha foliacea* was evident during the 2000 survey.

1.1.5 Technical report for Italy - area M2 - Sardinia

By M. Murenu, D. Cuccu, M. C. Follesa, A. Sabatini and A. Cau

From the 29th of June to the 24th of August a total of 123 hauls were carried out with the fishing vessel ”Nuovo Splendore” in seas surrounding Sardinia. Few shallower hauls (stratum 13316) have been considered as not trawlable due the presence of gill nets and for this reason cancelled.

This year the fishing activity has been conducted without particular problems, excepted for the bad weather condition. During the whole survey for twenty days sea conditions were bad and for 10 days it was impossible carry on the scheduled hauls. A total of 31 fishing days, 10 days of bad weather brake and 14 days of technical break were spent.

During some hauls, especially near the coast, where the substrata were irregular and hard, the gear was damaged to a certain extent. When the damage was not serious, some parts of the gear were changed; in other cases the reserve gear was utilised.

Unfortunately, SCANMAR equipment was not available system. Following the recommendations of the MEDITS protocol haul duration was recorded according to the average effective time on bottom as from previous trials with SCANMAR by Irpem-CNR technicians and the horizontal and vertical openings of the gear were estimated indirectly.

Minilog instruments was only available at the end of the survey due its damage occurred at the beginning of the survey.

A GPS system was connected with a nautical plotter where the hauls track log of the ’98 survey were recorded and, as far as possible, all stations were set at the same positions as in the previous years. Sometimes due to the presence of hauled gill nets and long lines near the coasts and in the open sea, we slightly changed the co-ordinates of some hauls, while remaining in the same bathymetric level.

Often in the shallower waters, large quantities of sea urchins, eel grass (Posidonia oceanica) and algae were encountered. Not many waste products were fished.

On board biological parameters were accurately performed according to the MEDITS protocol. At the end of the survey, in the laboratory, all data collected were recorded on the computer using a database program. The data were later checked and processed using the CHECKMED2 and INDMED4 routines. Abundance indices and length frequencies were calculated for target species and for some of the reference species.

A total of one hundred and seventy-nine species were identified: 130 fishes, 23 crustaceans and 26 cephalopods.

The species from the reference, which showed the highest biomass, were in the order: *Octopus vulgaris, Merluccius merluccius* and *Scyliorhinus canicula* (30<BI<60). Important biomass values (BI>20) were also showed for *Raja clavata* and *Eledone cirrhosa*.

As regards the number of individuals, the highest densities were recorded for *Trisopterus minutus capelanus* (DI= 3636,CV=42.5). The other target species that showed high density values (more than 500 N/km²) were in decreasing order: *Trachurus mediterraneus, M. merluccius, Sardina pilchardus*, *M. barbatus* and *Trachurus trachurus*.

In comparison with the previous year a decrease in the catches of *M. merluccius, Mullus barbatus, M. surmuletus* and *S. smaris* was evident.

1.1.6 Technical Report for Italian coasts and Maltese waters - Region M3

by D. Levi, M.T. Spedicato, G. Lembo, P. Carbonara, T. Silecchia, M. Contegiacomo, G. Costantino, R. Treleani,: S. Greco, P. Rinelli, F. Perdichizzi, D. Giordano, T. Romeo, T. Bottari, G. Florio, S. Ragonese, F. Fiorentino, G. Norrito, M.G. Andreoli, G. Garofalo, G. Bono, P. Rizzo, G.B. Giusto, S. Gancitano, M. Camilleri, B. Rosso

The 2000 MEDITS (hereby MED2000) survey in the M3 region was carried out from 25th May to 1st July 2000 using the professional stern trawler "Sant'Anna". In MED2000 for the first time also the Maltese waters (herein defined as sub-region M3d) were included in the survey. The first M3 sub-region, the region known as the Strait of Sicily (M3c), has been surveyed, from 25th May to 5th June, by the scientific staff of the "Istituto di ricerche sulle Risorse Marine e l'Ambiente, IRMA-CNR" of Mazara. Subsequently, the waters around Malta (M3d) were explored from 6th to 8th of June.

The second sub-region covered was the central part of M3 study region (M3b), i.e., the grounds of the Southern Tyrrhenian Sea off Calabria (Capo Suvero) and the Northern coasts of Sicily (Capo S. Vito). This sub-region has been surveyed, from 12th June to 18th June, by the scientific staff of the "Istituto Talassografico – CNR" of Messina.

Finally, the trawler moved to the northern side of the M3 study region, i.e., the grounds of the Central and Southern Tyrrhenian Sea facing Campania (Volturno river) and Calabria (Capo Suvero) regions respectively . This sub-region (M3a) has been surveyed, from 19th June to 1st July, by the scientific staff of the "COISPA – Tecnologia and Ricerca" of Torre a Mare (Bari).

An overall of 147 hauls were performed in the whole M3 region; in particular, 57, 28 and 56 hauls were performed along the Italian coasts (M3a, M3b and M3c respectively) whereas 6 hauls (1 not valid) were realised in Maltese waters (M3d). Some problems rose during the survey around the Maltese waters, due to the poor knowledge related to the trawlable bottoms. This required a preliminary exploration of the substrate and more than one trial in performing the tow. Notwithstanding, severe damage of the gear resulted in the invalidated haul (North of the Gozo Island, in the 200-500 m stratum). An attempt to recover this tow in the same stratum, but in a different zone (SSW Malta Island), failed after few minutes, due to the breakage of the footrope.

In all hauls, a miniature data logger (MINILOG-TD), recording both temperature and depth, was mounted on the head rope of the gear. It was not possible monitoring directly the gear performance (a Scanmar equipment was not available), but haul duration was recorded according to average effective time on bottom and the horizontal opening of the gear in each haul was estimated on the base of the formula derived from previous trials carried on by IRPEM-CNR (Ancona, Italy) technicians using Scanmar equipment.

Both haul registration and processing of biological samples were accurately performed according to MEDITS protocol.

1.1.7 Technical Report for Italy - area M4 (SW Adriatic and NW Ionian) and Albania

The MEDITS-IT & ALB 2000 survey was carried out from 29/04 to 10/07.

Total number of operative days was 73 (including MEDITS net setting, stand-by and transferring); the survey lasted 29 days in Ionian areas from Cape Passero to Cape of Otranto (2 Vessel and MEDITS net setting days, 3 transferring day, 24 full working days), 25 days for south-western Adriatic areas from Cape of Otranto to Vieste (2 days of stand-by and 23 full working days) and 19 days for south-eastern Adriatic areas from S. Johan to Saranda (4 transferring days, 1 day of stand-by and 14 full working days).

During the survey 186 hauls were carried out (Ionian areas = 74; south-western Adriatic areas = 72; south-eastern Adriatic areas = 40); the vessel "Pasquale e Cristina" was utilised by MEDITS-It M4 Unit in the whole research area.

Bad weather conditions affected the survey mostly between the end of May and June. During the survey 2000 the trawler didn't suffer any noticeable damages: a net and some net bowls were damaged at maximum trawled depths.

Biological data were recorded following MEDITS protocol options and formats; new version of CHECKMED and INDMED software were utilised successfully.

1.1.8 Technical report for Italy - area M 5 - Italy, Slovenia and Croatia

The MEDITS 2000 survey in the northern and central Adriatic Sea has been conducted on board the same vessel, “Andrea”, both in international waters and in the national waters of each concerned country.

The survey took place between the 5th of June and the 3rd of August. The survey lasted more for the formation of the mucilage in the Adriatic Sea.

Scientists of three laboratories (Split, Ljubljana and Fano) took part in the survey, with in general 3-4 scientists on board at the same time.

A total of 136 hauls were carried out: 86 in international and Italian territorial waters, 2 in the Slovenian waters and 48 stations located in the Croatian waters.

A Scanmar equipment was not available and the haul duration was recorded following the recommendation of the MEDITS protocol.

Haul registrations and first biological processing were performed on board; the more detailed biological analysis and computer data input were made in laboratory according to the MEDITS protocol.

1.1.9 Technical report for Greece - area G1 – North Aegean Sea

by A. Kallianiotis, K. Sophronidis, and P. Vidoris

The MEDITS GR1 survey for 2000 was carried out from 21 June to 28 July in the North Aegean Sea (North of 38 N), using «Evagelistria», a newly constructed commercial trawler that was used for the first time for the sampling operation. The research cruise lasted 38 days, 31 of which were spent on fishing and 7 days on stop due to bad weather conditions.

During the research cruise 65 hauls were carried out successfully. The Scanmar equipment was not available also this year. The temperature, salinity, and oxygen concentration have been recorded with the CTD measurement system. A Minilog instrument has also been used to collect continuous data on temperature and depth during the hauls.

Three Greek Post-graduate students, Scarpelis G., Baxevanis A. and Arsenoudi P. were participating for 3 days in the research cruise.

Weight and length measurements as well as maturity of the sampled fish were carried out on board. In the laboratory, data were recorded in the computer using the INDMED program and checked using the CHECKMED program.

Abundance indices were calculated for target species and for some of the reference species. The species from the reference list, which were most abundant in weight this year were, in the following order: *I. coindetii, S. pilchardus, E. encrasicolus, A. sphyraena, M. merluccius, M. barbatus, P. longirostris, M. poutassou, R. clavata, L. caudatus, , S. flexuosa, T. trachurus, P. blennoides, L. piscatorius* and *S. acanthias*. Comparatively, in ’99 survey the most abundant species in weight were: *S. pilchardus, M. poutassou, E. encrasicolus, M. merluccius, I. coindetii, A. sphyraena, R. clavata, L. caudatus, P. longirostris, S. canicula, L. budegassa, T. minutus capelanus, S. flexuosa, L. piscatorius* and *M. barbatus*.

Considering the number of individuals, the most abundant species were in order: *A. sphyraena, S. pilchardus, E. encrasicolus, P. longirostris, I. coindetii, M. barbatus, T. trachurus, T. minutus capelanus, S. flexuosa, M. merluccius, M. poutassou, C. linguatula, S. smaris, D. annularis* and *P. blennoides*. In comparison, the most abundant species in number of individuals, in the MEDITS’99 survey were: *S. pilchardus, E. encrasicolus, A. sphyraena, M. poutassou, P. longirostris, T. minutus capelanus, T. trachurus, M. merluccius, S. flexuosa, I. coindetii, C. linguatula, M. barbatus, L. cavillone, S. notata* and *S. canicula*.

The most widely distributed species were, in order: *I. coindetii* (present in 54 of 65 hauls effectuated), *M. merluccius* (52 hauls), *L. budegassa* (48 hauls), *P. longirostris* (43 hauls), *T. trachurus* (41 hauls), *S. canicula* (36 hauls), *T. minutus capelanus* (32 hauls), *R. clavata* (31 hauls), *P. blennoides* (31 hauls) and *E. cirrhosa* (28 hauls). In MEDITS’99 the order of the most wide distributed species were: *M. merluccius* (53 of 62 hauls), *L. budegassa* (49 of 64 hauls), *P. longirostris* (43 hauls), *S. canicula* (35 hauls), *T. trachurus* (35 hauls), *S. elegans* (32 hauls), *R. clavata* (31 hauls), *N. norvegicus* (30 hauls), *T. minutus capelanus* (27 hauls), *E. encrasicolus* (24 hauls).

1.1.10 Technical report for Greece - area G2 (Ionian Sea and Argosaronikos)

by C.-Y. Politou

In zone G2 (Argosaronikos and Ionian Sea), the sampling cruise started the 14th of June 1999 and ended the 8th of July 2000. Similarly to 1998 and 1999, the commercial trawler Demetrios was used.

A total of 53 hauls were effected (22 in Argosaronikos and 31 in the Ionian Sea). The weather conditions were generally good with some exceptions mainly in Argosaronikos.

As in the previous years, during the 2000 sampling period, a Scanmar system was used to observe the following parameters: fishing depth, horizontal and vertical opening of the gear and clearance. This system was connected with a GPS, which recorded the hauling speed and the track of the hauls.

The temperature during hauling and the hauling depth were also recorded using a Minilog device. Finally, as in the previous years, the temperature and salinity profiles were recorded by means of a CTD.

1.1.11 Technical report for Greece – area G3 - South Aegean Sea

By G. Tserpes and N. Peristeraki

The MEDITS G3 survey took place from the 9th of June to the 14th of July 2000, in the southern Aegean and the Cretan seas. The survey in the G3 area was carried out with the commercial trawler "Nautilos". The functioning of the gear was tested in the Gulf of Iraklion on the 7th and 8th of June.

The gear showed a generally homogeneous performance and the trawling speed ranged from 2.8 to 3.0 knots. Trawling with the highest speed was realized mostly in the deeper hauls and (or) on muddy bottoms. The electronic observation and recording of the track of the hauls was conducted by means of a GPS and a plotter. In this way, there was a complete representation of the haul (beginning, end, and change of direction). The temperature has been monitored during the hauls by a Minilog TDR sensor.

During the 2000 survey a total of 55 valid hauls were accomplished: 16 around the islands of the Cyclades complex, 24 in the area of the Dodecanesian islands and 15 in the Cretan Sea.

1.2 Biological results - MEDITS 2000 survey

Each of the regional teams has produced the set of biological data obtained in its area during the MEDITS 2000 survey. Then, a common analysis of these results has been done during a general meeting (Cagliari, 15-17/11/2000). The report written during this meeting is presented below[1]. A synthetic representation of the results is shown in figure 3.

1.2.1 Fish

1.2.1.1 Aspitrigla cuculus

This species was caught from 100 to 500 m in the whole Mediterranean surveyed area, mainly in the depth stratum 100-200m. It was almost never found at deeper bottoms. Maximum values of abundance and density indexes were computed for the Greek sector 225 at 100-200 m depths (B.I. = 52.0; D.I. = 5508).

Sizes (total length) ranged from 3 to 35 cm (whole MEDITS area). Juveniles were mostly found in the eastern Mediterranean areas.

1.2.1.2 Citharus linguatula

This species mostly occurred between 10 and 200 m both in eastern and western areas, showing a patch distribution. The highest value of abundance index was recorded for the Aegean Sea (33.6 kg/km^2 between 50 and 100 m in sector 223a), where the highest density was found also (D.I. = 2711).

Lengths ranged from 2 cm (sector 222) to 33 cm in the Tyrrhenian Sea.

1.2.1.3 Eutrigla gurnardus

The distribution pattern of this species showed a high spatial heterogeneity. *Eutrigla gurnardus* was mainly caught in the Gulf of Lions with a maximum abundance of 48.1 kg/km^2 between 100 and 200 m, while the highest density (D.I. = 2194) was recorded at 50-100 m stratum in the same sector. Except in the South western part of Sardinian coast, this species was rarely caught in all other areas surveyed by the MEDITS research project. Lengths ranged from 4 to 45 cm.

1.2.1.4 Helicolenus dactylopterus

It was mostly caught at depths greater than 100 m. In the Western Mediterranean the highest abundance index was computed for the French area 121 (123.1 kg/km^2 between 500 and 800 m in the area 121b; 73.0 kg/km^2 between 200 and 500 m in the area 121a). High values (55.7 kg/km^2) were also recorded in the sector 131a (North-East Corsica) between 500 and 800 m, in the sector 133c (North Sardinia) between 200 and 500 m with a value of 68.4 kg/km^2; in the same stratum a value of 56.6 kg/km^2 was registered in the sector 133e (West Sardinia). In the Eastern Mediterranean, the highest indexes were computed for the Southern Aegean Sea (sector 225: 54.1 kg/km^2).

High densities were observed in Alicante sector, Catalan Sea, in the North Ionian Sea and in North Sardinia.

Lengths ranged from 1 to 35 cm and the length distributions showed several modes. Juveniles were found in almost all MEDITS regions.

1.2.1.5 Lepidorhombus boscii

The four-spotted megrim was mainly found at depths greater than 100 m. In the 100-200 m depth zone the highest abundance (18.1 kg/km^2) was observed in the Gulf of Lions. With regard to 200-500 m depth stratum, high values were found in the Aegean Sea (around 10 kg/km^2), in the SW Adriatic Sea (9.3 kg/km^2), in the Gulf of Lions (17,1 kg/km^2), W-Sardinia (11.4 kg/km^2) and in the North Ionian Sea (13.6 kg/km^2). In the deepest stratum (500-800 m) the highest index was computed for the Sardinian area 133e (16.4 kg/km^2).

The presence of the species is rare in the South East and South West Tyrrhenian Sea, Sicilian Channel, Malta, North and Central Adriatic Sea and all Ionian sectors.

Density values confirm the trend observed for the abundance in the different areas.

Lengths ranged from 3 to 39 cm and the length distributions showed several modes.

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[1] In the following text, the term ''abundance'' will be used as a generic one, without reference to a specific unit. In return, the expressions ''index of density'' (or density index) and ''biomass index'' will be respectively reserved for the following indices: Index of density (DI) = N/km² and Biomass index (BI) = kg/km². So, when a value follows one of these two expressions, the unit (N/km² or kg/km²) is implicit and it is leaved out from the text.
Length units: fishes: total length; crustaceans: carapace length; cephalopods: mantle length

1.2.1.6 *Lophius budegassa*

It was widely distributed all over the Mediterranean Sea in all depth zones. The highest abundance index (290.3 kg/km^2) was obtained from the South West Adriatic Sea (sector 221f) in the 200-500 m depth zone. Concerning the values for the other sectors, highest abundance were for Argosaronikos and North Aegean Sea (respectively 58.3 kg/km^2 and 57.2 kg/km^2 at 50-100 m depths), West Gulf of Lions (60.7 kg/km^2 at 50-100 m depths and 57.7 kg/km^2 at 100-200 m depths) and in North-East Adriatic-Croatia (47.7 kg/km^2 at 200-500 m depths). Concerning the deepest stratum (500-800 m), a value of 18.4 kg/km^2 was registered in the East Ionian Sea (222a).

In the first stratum (10-50 m) the presence of the species was observed only in the eastern part of the Mediterranean Sea.

Lengths ranged from 3 to 93 cm; juveniles were found in all MEDITS regions.

1.2.1.7 *Lophius piscatorius*

Patchy distributed all over the Mediterranean basin but mostly in western areas at depths from 50 down to 800 m.

The highest abundance indexes were computed in West and South-East Sardinia (sectors 133e and 133a) (respectively 266.4 kg/km2 at 200-500 m and 135.4 kg/km2 at 500-800 m depth zone). In all the Sardinia sectors high abundance were observed also in the second stratum (50-100 m) ranging from 3 to 28 kg/km2. No catches were observed in the Alboran Sea, Alicante area, North east of Corsica, North and East Ionian Sea, and South-East Adriatic-Albanian Sea.

Lengths ranged from 6 to 99 cm and the length distributions showed several modes. Juveniles were found mostly in Catalan Sea and South Tyrrhenian Sea.

1.2.1.8 *Merluccius merluccius*

The species was widely distributed on the whole area, at depths between 50 and 500 m. The depth stratum between 100 and 200 m showed the highest abundance as a general rule. Particularly high values were recorded on shelf bottoms of a Greek sector (area 223 a), with abundance higher than 200 Kg/Km^2. Sardinian seas showed high values in all strata, mainly between 50 and 500 m with a maximum of about 180 Kg/Km^2 in the 100-200 m depth stratum.

High density values were found in Western Mediterranean areas (Spain and Gulf of Lions), mainly on the shelf bottoms.

Lengths ranged from 4 to 77 cm even if in all areas mostly of specimens were lesser than 20 cm of total length.

The length frequency distributions indicated the presence of young specimens in all the regions. Nevertheless, the high abundance reported in the Sardinian seas was mainly due to adult individuals.

1.2.1.9 *Micromesistius poutassou*

It was generally caught at depths greater than 100 m. The highest abundance indexes were obtained in 100-200 and in 200-500 m depth zones in Spanish and French waters; the same values were higher than 100 Kg/Km^2 (the maximum of 546.0 Kg/Km^2 has been recorded in the area 113a). Spanish waters presented the highest density values.

Species length frequency distributions varied among strata; juveniles appear in all countries in the 100-200 and 200-500 depth zones, while in Sardinian waters they are more concentrated in 200-500 depth stratum.

1.2.1.10 *Mullus barbatus*

The species was mainly caught at depth from 10 up to 200 meters. Among bathymetric strata, the higher abundance indexes were obtained in the first stratum (10-50 m) in the Northern Tyrrhenian Sea (102.3 kg/km^2) and in the second stratum (50-100 m) in the Northern part of Sardinia (107.7 kg/km^2), in Malta (145.8 kg/km^2) and in the Southern Aegean Sea (107.8 kg/km^2). If the whole shelf area is considered (10-200 m), the higher abundance and density indexes were obtained in the Northern Aegean Sea (B.I. = 62.6; D.I. = 1854), in the Southern Aegean Sea (B.I. = 60.3; D.I. = 2177) and in Malta sectors (B.I. = 52.2; D.I. = 1253),

Lengths ranged from 4 to 25 cm. On the shelf bottoms of the whole area a modal interval was found at 11-15 cm. In the Western Adriatic Sea a modal peak of juveniles (7 cm) was observed. In the slope biggest individuals (13-25 cm) were found.

1.2.1.11 *Mullus surmuletus*

This species was found at depths from 10 to 500 m, but main catches were obtained in the bathymetric range 10-200 m. The abundance were higher on the shelf areas of Sardinia (21.8 kg/km^2), particularly in the Eastern and Northern part, in Malta (26.0 kg/km^2) and in the Southern Aegean Sea (35.4 kg/km^2).

Similar results were obtained analysing density indexes, which were respectively 744, 535 and 4669 n/km^2. The maximum biomass indices were obtained in the 50-100 m bathymetric stratum in the Northern and Eastern part of Sardinia (334.7 kg/km^2 and 183.2 kg/km^2, respectively) and in Malta (82.3 kg/km^2), and in the 10-50 stratum in the Southern Aegean Sea (84.6 kg/km^2).

Length frequency distribution ranged from 4 to 32 cm in the whole surveyed area, with one or two modes depending from the regions; the first, when present, at 6-7 cm and the second from 14 to 19 cm. High concentration of juveniles were found in the southern part of Sardinia, in the southern Tyrrhenian Sea and in the southern Aegean Sea.

1.2.1.12 Pagellus acarne

The species showed a bathymetric distribution pattern extended from 10 to 500 m depths. The higher biomass indexes were obtained on the continental shelf of Alboran Sea (80.3 kg/km^2) and South Aegean Sea (52.3 kg/km^2). Regarding the continental slope, high indexes were found in the Gulf of Lion (upper slope, 67.5 kg/km^2) and Sardinia (Northern coast, 20.0 kg/km^2). The species was caught with very low yields at middle-slope bottoms (zone between 500-800 m) or it was not found. High density indexes were found in the coastal regions of South Aegean Sea (D.I. = 9605) and South Tyrrhenian Sea (D.I. = 8386) and in the zone 50-100 m in South Aegean Sea (D.I. = 5499). With regard to deeper waters, high density indexes were found in the Western Ionian Sea (zone 100-200 m, D.I. = 237) and Alboran Sea (D.I. = 223). The relative length frequencies shown a distribution of small individuals in the shallow coastal zone, with the smaller specimen (5 cm) caught in the North Tyrrhenian Sea and East Sicily and the larger (30 cm) in the zone of 100-200 m in the Alboran Sea and the Gulf of Lion.

1.2.1.13 Pagellus bogaraveo

This species was found with noticeable yields (> 5 kg/km^2) only in the Southern Aegean Sea (B.I. = 11.4) and Spanish Alboran Sea (B.I. = 7.5); the corresponding densities (D.I.) were 111 and 217 respectively. It occurred on both the continental shelves and slopes (mainly 2nd-5th stratum) of the mentioned regions, with highest indexes being recorded on the shelf of the latter (B.I. = 17.2; D.I. = 688) and the slope of the former region (B.I. = 17.8; D.I. = 173). Outstanding densities were also obtained in the 2nd stratum of the Spanish Alboran Sea and the North Coast of Sicily (D.I. of 1202 and 1355 respectively). The length distribution for the whole Mediterranean ranged from 8-23 cm on the shelves and 5-52 cm on the slopes. From the data of the Southern Aegean Sea, Spanish Alboran Sea and North Sicilian waters it was evident that the larger specimens were found on the slope (shelf modes: S. Aegean Sea = 17 cm; Spanish Alboran Sea = 13-15 cm; N. Sicilian waters = 13-14cm; slope modes: S. Aegean Sea = 21cm; Spanish Alboran Sea = 24-26cm; N. Sicilian waters = 17cm).

1.2.1.14 Pagellus erythrinus

This species was found in all surveyed areas with an abundance of at least 1 kg/km^2 on a regional level. Five regions had an abundance greater than 10 kg/km^2 with the Maltese waters in pole position with a B.I. of 29.0 kg/km^2 (D.I. = 400), followed by Argosaronikos with a B.I. of 15.3 (D.I. = 314). *Pagellus erythrinus* was particularly concentrated in the 1st and 2nd stratum throughout the Mediterranean, with the highest abundance for the 1st stratum being recorded in the above mentioned Greek area (B.I. = 127.2; D.I. = 2947), whilst the Maltese region proved to have the highest abundance of the 2nd stratum (B.I. = 208.3; D.I. = 2875).

The length distribution on the shelf generally had a range of 5-33 cm.

1.2.1.15 Phycis blennoides

The species was generally distributed over the slope, but it was also found in low quantities on the shelf. The abundance indices were, without exception, very low. The highest values were obtained for the Gulf of Lions (121b; 60.9 kg/km^2) between 200-500 m.

The modal range was from 8-13 cm on the shelf and from 10-11cm on the slope.

1.2.1.16 Solea vulgaris

This species was caught in low quantities and it was exclusively found in the continental shelf (10-100 m). With regard to the regional areas, the highest abundance value (14.1 kg/km^2) was found in SW-Sardinia. Nevertheless, was recorded an high abundance value of 16.5 kg/km^2 in the third depth stratum (100-200 m) of the Eastern Ionian Sea (sector 222); in the same area the density was quite low (D.I. = 32).

Lengths ranged from 7 to 39 cm in the whole MEDITS surveyed area.

1.2.1.17 Spicara flexuosa

This species was mostly found on the continental shelf. The highest abundance indexes were computed for the shelf areas of Malta (sector 135) and Corsica (sector 134) with values of 133.8 and 108.1 kg/km^2 respectively.

Total lengths ranged from 4 to 24 cm. The main modal lengths were, in most of the cases, between 10 and 14 cm.

1.2.1.18 *Spicara smaris*

This species was mostly found on the continental shelf. An exceptionally high abundance index was obtained from the Corsican shelf (sector 131) with a value of 1398.0 kg/km^2 while the second highest index (196.8 kg/km^2) was computed for the coastal area of Malta (sector 135). Lower abundance indexes were recorded for some areas of the western Mediterranean, such as the Gulf of Lions (sector 121) and the Alboran Sea (sector 111). Total lengths ranged from 1 to 20 cm. The main modal lengths were, in most of the cases, between 10 and 14 cm.

1.2.1.19 *Trachurus mediterraneus*

This species was mainly found on the shelf, and the maximum abundance indexes were computed for the Ligurian (sector 132) and the east Ionian Sea (sector 222) shelf areas. The corresponding values were 59.7 and 59.0 kg/km^2. With the exception of the east Ionian Sea the species was less abundant in the eastern Mediterranean. Total lengths ranged from 3 to 36 cm. Most of the collected specimens were between 12 to 18 cm.

1.2.1.20 *Trachurus trachurus*

It was present in all depth strata but the higher abundance was computed for the strata of the continental shelf. The species was generally more abundant in the western Mediterranean and the highest value (B.I. = 47.8) was estimated for the Gulf of Lions (sector 121). Total lengths ranged from 3 to 41 cm but most of the collected specimens were of length lesser than 15 cm.

1.2.1.21 *Trigloporus lastoviza*

Streaked gurnard was caught in all strata, except in stratum 200-500 m. The abundance was generally low. The highest abundance and density indexes were recorded in Argosaronikos area (B.I. = 7.0; D.I. = 170) and in Sardinian waters (B.I. = 6.0; D.I. = 180). Lengths ranged from 4 to 31 cm, with modal value between 12 and 15 cm.

1.2.1.22 *Trisopterus minutus capelanus*

Poor cod had an irregular distribution among the different areas and it has been mostly collected on the continental shelf. The highest abundance indexes were found in Gulf of Lions in stratum 50 – 100 m (161.8 kg/km^2), while the highest densities were observed in Sardinia sea in stratum 100 -200 m (D.I. = 31329).

Lengths ranged from 1 to 25 cm. Length frequency distribution pointed out a bimodal shape with peaks at 6-8 cm, and 14-15 cm.

1.2.1.23 *Zeus faber*

John dory showed an irregular distribution among the surveyed areas. It was caught mostly in continental shelf areas. The highest abundance index (B.I. = 121.2) was found in the stratum 100 -200 m in the sector 135 (Malta), while the highest density (D.I. = 755) was observed in south Aegean Sea (stratum 10 – 50 m). The species was scarcely found along Italian Adriatic coast.

Total body length ranged from 2 to 60 cm.

1.2.1.24 *Galeus melastomus*

It was present mostly in depths below 200 m in the whole Mediterranean surveyed area, showing a maximum abundance value of 194.1 kg/km^2 in the slope area of Alboran Sea, followed by 172.9 kg/km^2 in the Gulf of Lion. The lowest abundance value was found in the Malta area (0.8 kg/km^2), while the species was absent in the Northern Adriatic Sea and scarce in the Middle area of the same basin because of the negligible extension of slope bottoms.

Concerning the density, the maximum values were of 1703 and 1070 in the slope area of Corsica and Gulf of Lion respectively. The minimum density values were found in Malta area (D.I. = 4) and Northern-Middle Adriatic Sea (D.I. = 8).

Total lengths (TL) mostly ranged from 10 cm to 55 cm; the smallest specimens (9 cm) were collected in the Alboran and North Tyrrhenian Seas, while the longest one (64 cm) in the Gulf of Lion.

1.2.1.25 *Raja clavata*

This species was present in the whole bathymetric range (10 and 800 m), but it shown a patch geographic distribution. Higher abundance values were found in Malta (77.2 kg/km^2) and in Corsica (48.1 kg/km^2). The minimum values were found in Ligurian, Northern-Central Tyrrhenian Seas and Northern-Central Adriatic Seas (B.I. between 1.8 and 3.1 kg/km^2).

Highest density values (D.I.) of 98 and 76 were observed in the Southern Aegean Sea and Argosaronikos areas respectively.

It was absent in most of the depth strata of the Spanish area, Southern Adriatic Sea and Ionian Sea.

The smallest specimen (10 cm TL) was collected in the Argosaronikos area (Greek Sea), while the longest one (99 cm TL) in the Gulf of Lion.

1.2.1.26 Scyliorhinus canicula

This species was caught in the whole bathymetric range (10 and 800 m). The highest values, in abundance and density, were found in Catalan, Sardinia and Corsica areas in which the maximum value of 160.6 B.I. and 1015 D.I. was observed.

The lowest quantities (B.I. = 0.8; D.I. = 7) were found in the Southern Adriatic and Ionian Seas.

Total length mostly ranged from 10 cm to 50 cm; the smallest specimen (7 cm) was collected in the Alboran Sea, while the longest one (65 cm) in Sardinia waters.

1.2.2 Crustaceans

1.2.2.1 Aristeus antennatus

The red and blue shrimp was caught exclusively in the 5th stratum (500-800m) in all regions, but the Maltese waters, the Northern and Central Adriatic and the North Aegean Sea.

On the combined strata, the Biomass Indices (BI) were lower than 6 kg/km^2, with a maximum value (5.8; CV=53.5) observed in the Alboran Sea. Considering the Density Indices (DI), the maximum value was recorded in the Alboran Sea (538 N/ km^2; CV=54.6).

Considering only the slope (200-800 m), the BI fall in a wide range with a minimum value of 0.1 (CV=79.7) and a maximum value of 10.8 (CV=25.0) registered in Corsica and Sardinia respectively. Other good values (BI>5.0 kg/km^2) were observed in the Alboran Sea (8.2; CV=53.5) and in the Alicante Sector (9.4; CV=62.7).

In the slope, the highest Density Index resulted in the westernmost regions: the Alicante Sector (883; CV=64.2) and the Alboran Sea (767; CV=54.6). The third DI value was observed in the Sardinia slope (591; CV=20.9).

Taking into account the single strata, the only significant catch in weight in the upper slope (200-500 m) was obtained in the Alboran Sea (3.1; CV=117.8), whereas the maximum BI (57.7; CV=26.7) was registered in the deepest stratum (500-800 m) in the South-East Sardinia. High level of abundance of the species were also observed in the deep waters of the other Sardinia sub-regions: the BI ranged from 10.6 (CV=35.6) to 38.2 (CV=41.2) in the West and North sides respectively.

Considering the catch in number, very few specimens (DI<50) were generally observed in the upper slope (200-500 m) of nine sub-regions, with the exception of the Alboran Sea (377; CV=117.8). The maximum value in the deeper slope (500-800 m) was obtained in the South-East Sardinia with 2157 (CV=21.7). Density Indices higher than 1000 specimens were found in the Alboran Sea, the Alicante Sector, the other zones of Sardinia waters and the Ionian Sea.

The length frequency distributions (hereinafter LFD) of the blue and red shrimp did not showed any clear mode in almost all sub-regions. Besides a single shrimp of 38 mm of carapace length (CL) caught in the South-Western Adriatic Sea, the recorded maximum lengths ranged between 40 mm (Alicante Sector and North Ionian Sea) and 62 mm (North-West Ionian Sea). It is worth of note that 22 of the 27 sub-regional maximum lengths were between 50 and 62 mm with no geographical trends. As regards the minimum length, and excluding four specimens of 9 mm measured in the South of Sardinia, the resulted range was 15-27 mm. The minimum value of 40 mm was not considered given the few specimens caught in the North Tyrrhenian Sea.

1.2.2.2 Aristaeomorpha foliacea

The red giant shrimp was not caught in the westernmost part of the Mediterranean basin, with the exception of the occasional (very low) catches recorded in the Catalan Sea and the Gulf of Lions. In all other MEDITS regions, this species occurred on the slope showing a marked preference for the deepest stratum (500-800 m).

The overall (10-800 m) Biomass Indices were lower than 5 kg/km^2 in six regions. The highest values were obtained in the Southern Aegean Sea, with 23.8 (CV=70.8), and in the Southern Tyrrhenian Sea, including the Strait of Sicily, and the Maltese waters, with very quite similar values (11.5; CV= 13.7 and 11.1 respectively). The coefficient of variation was not computed for the Maltese waters given the few hauls (5) realised in the MEDITS2000 survey.

Considering the DI, the overall (10-800 m) values where higher than 100 specimens in eight regions, with a maximum value of 1272 (CV=80.6) observed in the South Aegean Sea.

In regarding to the deepest macro-stratum (200-800 m), the maximum value of BI was 36.7 with CV=70.8 (Southern Aegean Sea), whereas lower but very similar indices were obtained in the Sardinia waters (15.2; CV=36.5) as well as in the Southern Tyrrhenian Sea, including the Strait of Sicily, and the Maltese waters (18.9; CV=13.7; 20.0 respectively).

As concerns the DI on the slope (200-800 m) the maximum value was recorded in the Southern Aegean Sea (1975; CV=80.6). Relatively high abundance characterised Sardinia (849;CV=27.0), the Southern Tyrrhenian Sea, including the Strait of Sicily (816;CV=15.4), and the Maltese waters (DI=901).

Talking about the upper slope, the BI resulted scant (<5 kg/km^2), with the exception of a peak value in the West Sardinia (49.1; CV=43.2). The corresponding DI was 2090 (CV=43.2); always in this stratum it is worth of note the good value (1073;CV=38.0) observed in the Northern Ionian Sea.

Considering the fifth stratum (500-800 m), the BI showed a wide range with the highest value recorded in the Western Sardinia (170.2; CV= 43.9); conversely, the minimum values (0.1) were obtained in the South-Eastern Corsica and in the North Aegean Sea. A good BI value (66.9; CV=45.7) was also recorded in the South Aegean Sea. In other 12 sub-regions the average values ranged from 9 to 46.5 kg/km^2.

In the same deepest stratum the higher values of the density indices (DI; N/km^2) were obtained in the West Sardinian (5695; CV=43.7) and the Southern Aegean Sea (3583; CV=52.0). Density Indices higher than 2000 N/km^2 were obtained in the South Sardinia and Maltese waters.

Excluding the two occasional specimens measured in the Catalan Sea (35 mm of carapace length; CL) and in the Gulf of Lions (48 mm), the recorded maximum lengths for the different sub-regions varied between 39 mm (Eastern Sicily) and 70 mm (Strait of Sicily, also known as Sicilian Channel). It is worth to mention that large sizes, above 60 mm, occurred in 13 sub-regions (mostly referred to the Tyrrhenian sub-regions, Sardinia and Strait of Sicily). The minimum lengths were between 10-25 mm. Considering the LFD shape, up to 2-3 modes have been detected. Although some geographical variability was evident, the modal length ranged between 20-28, 33-36 and 44-47 mm for the first, second and third component, respectively.

1.2.2.3 Nephrops norvegicus

The Norway lobster occurred mainly from 200 to 800 m in most regions, whereas the highest presence on shallower grounds was observed in the North and Central Adriatic Sea (10 to 500 m). Occasional catches on the shelf (50-100 m) were also obtained in the Catalan Sea, Gulf of Lions, North-West Ionian Sea, South Adriatic Sea and North Aegean Sea. No specimens of Norway lobster were caught in the few hauls realised around the Maltese waters.

Considering the overall explored depth range (10-800 m) and each region, the Biomass Indices resulted generally lower than 5 kg/km^2, with the exception of the Corsica waters (39.5; CV=16.5), Gulf of Lions (16.0; CV=49.6) and Ligurian and North-Central Tyrrhenian Sea (5.5; CV=12.9). Taking into account the Density Indices, values above 200 N/km^2 were registered only in Corsica waters (942; CV=13.2), Gulf of Lions (443; CV=44.3) and the Catalan Sea (206; CV=44.2).

The highest values of density in numbers of individuals per unit surface area were found on the slope in the Gulf of Lions and Corsica, followed by the Catalan Sea. Low levels in this macro-stratum (200-800 m) were found in the Alboran Sea and the South Aegean Sea, broadly corresponding with areas with large modal sizes.

The highest biomass values were also found on the slope in the Gulf of Lions, Corsica, and the Catalan Sea, following the same pattern found in the density values. Low values were found in the North Aegean Sea, South Adriatic, North-East Ionian and Alboran Sea, following the same pattern found in densities.

Considering the single strata, the highest BI were specifically recorded in the 200-500 m stratum in the Gulf of Lions (179.3; CV=42.6), followed by the 500-800 m stratum in the Eastern Sardinia (115.8; CV=10.0).

The highest densities were specifically recorded in the 200-500 m stratum in the Gulf of Lions (5521; CV=35.7); other high DI values were observed in the deepest 500-800 m stratum of the Western Sardinia (2754; CV=13.0) and the Gulf of Lions (2075; CV=46.9).

The overall size range (carapace length; CL) of *Nephrops norvegicus* populations sampled in the MEDITS2000 ranged between 9 mm and 82 mm, recorded in the Northern Ionian Sea and the North Aegean Sea, respectively. Modal sizes ranged between a minimum value of 23 mm in the Central Adriatic Sea and a maximum of 45 mm in the North-West Ionian Sea. Low values of modal sizes (<30 mm) were found in the Catalan Sea (26 mm), South Sardinia (25 mm), Central (23 mm) and North-East Adriatic (25 mm) and North Ionian (25 mm). High values of modal sizes (>40 mm) were found in the North-West Ionian Sea (45 mm), Alboran (42 mm), North Aegean (42 mm) and North-East Sardinia (40 mm). Low modal sizes correspond to areas with known high values of exploitation rates, whereas areas with large modal values correspond to areas where exploitation levels are low. For example, in the Spanish sectors, the modal sizes markedly decrease from Alboran Sea (42 mm) through Alicante (33 mm) to the Catalan Sea (26 mm).

1.2.2.4 *Parapenaeus longirostris*

Considering the whole MEDITS area, the deep rose shrimp was found with remarkable quantities between 100 and 500 m. This species occurred also in the deepest stratum (500-800 m) in the North Tyrrhenian, the South-Western Sardinia, the Strait of Sicily and Maltese waters, off Croatian coasts and the Greek waters. In some sub-regions of the Eastern basin, this species showed a wider distribution, with remarkable presence of specimens also in the first stratum (10-50 m) in the South-East Adriatic and in the second one (50-100 m) in the Strait of Sicily, in the Ionian Sea and in the Northern Aegean Sea.

The Biomass Indices (BI) of *P. longirostris* on the overall depth range, varied between 0.1 (CV= 28.5), in the Gulf of Lions, and 16.7 in the Maltese waters. All the BI were lower than 5 kg/km^2, with the exception of the Strait of Sicily (BI=14.1; CV=11.9), the Maltese waters (16.7), the Eastern Ionian Sea (6.9; CV=31.8), Argosaronikos (15.3; CV=6.9), the Southern and Northern Aegean Sea (15.0; CV=20.4 and 8.1; CV=29.3 respectively).

The Density Indices (DI) for the combined strata, ranged from 5 N/km^2 (CV=28.5) in the Gulf of the Lions to 5587 (CV=71.7) in Argosaronikos. Remarkable values were obtained in the Maltese waters (2944), in the Strait of Sicily (2504; CV=14.4), in the North and South Aegean Sea (2417; CV=29.5 and 1486; CV=32.4 respectively).

Considering only the shelf, the species was absent in Corsica, while the highest BI were obtained in Argosaronikos (31.3; CV=70.9). Remarkable BI were found in the Strait of Sicily (8.2; CV=27.3), Maltese waters (13.0) and Northern Aegean Sea (19.1; CV=30.8). Along the shelf, the DI were comprised between 0 (Corsica) and 12720 (CV=76.8) in Argosaronikos. Some noteworthy values were found in the North Aegean Sea (3465; CV=41.6), the Maltese waters (2610) and in the Strait of Sicily (2445; CV=29.7).

The slope bottoms yielded BI ranging between 0.1 (CV=61.4) in the North Aegean Sea and 19.6 in the Maltese waters. Other remarkable BI were obtained in the Strait of Sicily (18.0; CV=13.2), in the Eastern Ionian Sea (13.3; CV=38.2), in the North and South Aegean Sea (11.2; CV=19.6 and 11.1; CV=31.4 respectively), in the North-Central Adriatic (7.5; CV=38.8), in Sardinia (6.7; CV=25.5), and the Ligurian and North-Central Tyrrhenian (5.2; CV=11.9).

Along the slope, the DI ranged between 16 (CV=78.1) in the Catalan Sea and 3211 in the Maltese waters. Other good values of DI were obtained in the Strait of Sicily (2542; CV=14.5), in the Eastern Ionian Sea (1782; CV=35.2) and North and South Aegean Sea (1435; CV=21.2 and 1890; CV=35.3 respectively).

Taking into account the single depth strata, the highest BI were observed in the fourth stratum (200-500 m) of the Strait of Sicily (49.0; CV=18.1) and in the third stratum (100-200 m) of Argosaronikos (44.7; CV=37.8). The highest DI resulted for the same sub-regions and strata, but with an inverted importance: 18145 (CV=41.0) and 7058 (CV=19.6) in the third stratum (Argosaronikos) and fourth stratum (Strait of Sicily) respectively.

Sizes (carapace length; CL) ranges in the Western and Eastern Basins were very similar: 6-43 mm and 6-42 mm respectively, with the exception of the Strait of Sicily where the smallest specimens (4 mm) were found.

Generally, the size increased according to the depth in most of the regions; an opposite pattern, however, occurred in the Argosaronikos Gulf and South Aegean Sea.

Considering the shape of the LFD, three patterns have been roughly identified in the Western basin: a) no clear modal class was evident (Alicante sector, North-Western Sardinia and North Ligurian Sea); b) one clear mode was identifiable, with main modal lengths ranging from 21 to 30 mm, although with an high variability among the sub-regions, and c) bi-modal distribution was recognised in the Southern Corsica and Western Sardinia; the modal lengths were 28 and 25 mm for the first mode (in the Southern Corsica and Western Sardinia respectively), whereas the second one was around 32 mm in both sub-regions.

A more similarity in LFD shape was evidenced in the sub-regions of the Eastern basin; except few cases where it was not possible to identify an evident modal class, the LFD showed a typical uni-modal distribution, which modal length ranging between 19 and 26 mm.

1.2.3 Cephalopods

1.2.3.1 *Eledone cirrhosa*

It was distributed in all depth strata, but more frequently found between 50 and 200m. A wider bathymetrical distribution was observed in the western Mediterranean, where the species was generally more abundant. The highest biomass indices were observed in Catalan Sea (28.81 kg/km^2), Gulf of Lions (26.05 kg/km^2), Sardinian coasts (21.03 kg/km^2), N. Tyrrhenian – Ligurian Sea (15.5 kg/km^2) and the region of Argosaronikos (8.85 kg/km^2). In terms of numbers of individuals the highest abundance indices were observed in Gulf of Lions (255 ind/km^2), Sardinian coasts (180 ind/km^2) and Catalan Sea (173 ind/km^2). The mantle length of the individuals caught ranged between 1 and 19 cm. The population showed bimodal length distribution almost in whole study area.

1.2.3.2 *Eledone moschata*

It was generally present on the continental shelf, but more abundant down to 100m. The highest abundance indices both in terms of biomass and number of individuals were observed on the continental shelf of Corsican coasts (36.16 kg/km^2, 135 ind/km^2), S. Aegean Sea (25.03 kg/km^2, 250 ind/km^2) and Adriatic Sea (13.34 kg/km^2, 135 ind/km^2). The mantle length of the species ranged between 2 and 17 cm, The length frequency distributions were generally bimodal.

1.2.3.3 *Illex coindetii*

The species was present in all depth strata, but more frequently found between 50 -500m. The highest mean biomass indices were observed in N. Aegean Sea (91.8kg/km^2) and in Argosaronikos Gulf (67.12kg/km^2). The highest abundance indices in terms of numbers were observed in the areas of N. Aegean (2440ind/km^2), Alicante (1459ind/km^2) and Malta (1324ind/km^2). The species was generally more abundant on the shelf, apart from the areas of Corsica and Aegean Sea where it was more abundant on the slope.

The dorsal mantle length ranged from 1 to 31 cm, but the main bulk of the specimens were of lengths between 6-23 cm. A relatively greater percentage of small individuals (DML between 4-9 cm) was caught in Tyrrhenian, N. Adriatic, E. Ionian, S. Aegean Seas and Alicante region.

1.2.3.4 *Loligo vulgaris*

It was found mainly on the shelf, being more abundant in depths up to 100m. The abundance of the species was generally low, the biomass indices ranging from 0.08 to 2.72 kg/km^2 , except for the Ionian Sea, where average biomass index was much higher (11.49kg/km^2). Abundance index in terms of numbers also had the highest values in the Ionian Sea (879ind/km^2) due to the high recruitment observed in this area (dominant modal length: 5 cm).

The overall mantle length of the caught specimens ranged between 1 and 43 cm, but most of them were smaller than 10 cm.

1.2.3.5 *Sepia officinalis*

The species was mainly found on the continental shelf, being more abundant in the stratum 10-50 m. The highest values of both biomass and abundance indices were estimated in the continental shelf of South Aegean Sea (20.30 kg/km^2, 402 ind/km^2), coasts of Malta (13.22 kg/km^2, 31 ind/km^2), and Sardinian coasts (5.57 kg/km^2, 33 ind/km^2). The modal length of the dominant cohort, identified in these areas, varied between 6 and 11 cm. The mantle length of sepia caught in the whole study area ranged between 1 and 19 cm.

1.2.3.6 *Octopus vulgaris*

Octopus vulgaris is a typical inhabitant of the littoral waters, existing up to upper slope. The highest abundance indices calculated for the continental shelf of Alicante area (117.04 kg/km^2 , 106 ind/km^2), the Alboran Sea (81.58 kg/km^2 ,106 ind/km^2) and the Sardinian coasts (94.27 kg/km^2, 158 ind/km^2). The overall ventral mantle length range was 2-26 cm, extending the 19 cm only in Spanish waters.

Table 1. MEDITS 2000 List of the vessels used

Country code	Region	Vessel Name	Code	Length (m)	Tonnage (GRT)	Power (kW)	N° of hauls	Operative days
ALB		Pasquale e Cristina	PEC	33.1	159	923	40	17
ESP		Cornide de Saavedra	COR	66.7	1524	1651	114	30
FRA		L'Europe	LEU	29.6	260	690	92	25
GRC	G1	Evagelistria	EVA	26.1	86	386	65	29
GRC	G2	Demetrios	DEM	27.8	78	537	53	25
GRC	G3	Nautilos	NAU	28.4	138	600	55	22
HRV		Andrea	AND	29.5	211	1300	48	2
ITA	M1	Francesco Padre	FRP	25.0	88	660	153	42
ITA	M2	Nuovo Splendore	NUS	29.4	135	685	123	31
ITA	M3	Sant'Anna	SAN	32.2	97	1357	141	31
ITA	M4	Pasquale e Cristina	PEC	33.1	159	923	146	43
ITA	M5	Andrea	AND	29.5	211	1300	85	13
MAL		Sant'Anna	SAN	32.2	97	1357	141	2
MOR		Charif Al Idrissi	CHA	41.0	397	808	55	11
SLO		Andrea	AND	29.5	211	1300	2	1

MEDITS 2000 - Stratification scheme *(ordered by stratum number)*

Country	Stratum No	Sub Area	Depth (m)	Surface (km²)	Area	Year	Haul No
ESP	11101	a	10-50	510	Alboran Sea	2000	10 25
ESP	11102	a	50-100	2081		2000	1 15 19 22 23 34
ESP	11103	a	100-200	1218		2000	2 9 21 26 38
ESP	11104	a	200-500	3682		2000	3 6 8 16 18 20 24 28 32 33 35 36 39
ESP	11105	a	500-800	5262		2000	4 5 7 11 12 13 14 17 27 29 30 31 37
ESP	11201	a	10-50	1130	Alicante sector	2000	40 55 109
ESP	11202	a	50-100	4095		2000	41 42 43 44 52 53 56 104 105 107 112 114
ESP	11203	a	100-200	3302		2000	48 51 54 106 108 113
ESP	11204	a	200-500	4242		2000	45 47 50 111
ESP	11205	a	500-800	3159		2000	46 49 110
ESP	11301	a	10-50	1896	Catalan Sea	2000	71 78 94 98 99 100
ESP	11302	a	50-100	7219		2000	57 59 61 62 64 65 72 74 77 83 89 93 95 96 97 101 102 103
ESP	11303	a	100-200	3587		2000	58 60 63 66 67 73 79 81 82 84 87 90
ESP	11304	a	200-500	2477		2000	70 75 76 80 86 88 91
ESP	11305	a	500-800	1399		2000	68 69 85 92
MAR	11402	a	50-100	444		2000	23
MAR	11403	a	100-200	487		2000	54 71
MAR	11404	a	200-500	3580		2000	1 2 3 4 5 6 10 24 25 39 41 42 44 55 56 57 58 59 70
MAR	11405	a	500-800	1108		2000	26 28 29 30
MAR	11406	b	10-50	878	East Morocco	2000	12
MAR	11407	b	50-100	1098		2000	13 60 61 63 64 69
MAR	11408	b	100-200	938		2000	37 50 66 68 75
MAR	11409	b	200-500	3507		2000	31 38 45 46 47 49 51 52 53 67
MAR	11410	b	500-800	1446		2000	19 20 21 22 34 35 48
FRA-F1	12101	a	10-50	1482	West Gulf of Lions	2000	29 53 54 77 78 81 82 84
FRA-F1	12102	a	50-100	3911		2000	27 44 45 46 55 56 57 64 67 68 69 70 71 72 73 74 75 79 80 83 87 88 91
FRA-F1	12103	a	100-200	819		2000	25 26 65 76
FRA-F1	12104	a	200-500	709		2000	58 61 66 90 92
FRA-F1	12105	a	500-800	660		2000	59 62 63
FRA-F1	12106	b	10-50	696	East Gulf of Lions	2000	30 50 51 52
FRA-F1	12107	b	50-100	2610		2000	31 32 33 47 48 49 85 86
FRA-F1	12108	b	100-200	1734		2000	34 35 36 39 40 41 42 43
FRA-F1	12109	b	200-500	653		2000	24 37 60
FRA-F1	12110	b	500-800	586		2000	38 89
FRA-F2	13102	a	50-100	521	North East Corsica	2000	21 22
FRA-F2	13103	a	100-200	234		2000	19 20
FRA-F2	13104	a	200-500	920		2000	1 2 3 17 18 23
FRA-F2	13105	a	500-800	867		2000	14 15 16
FRA-F2	13107	b	50-100	524	South East Corsica	2000	5 11 12
FRA-F2	13108	b	100-200	153		2000	7 8
FRA-F2	13109	b	200-500	383		2000	4 10 13
FRA-F2	13110	b	500-800	960		2000	6 9

MEDITS 2000 - Stratification scheme (cont.)

Country	Stratum No	Sub Area	Depth (m)	Surface (km²)	Area	Year	Haul No
ITA-M1	13201	a	10-50	657	North Ligurian Sea	2000	138 149
ITA-M1	13202	a	50-100	729		2000	130 132 151
ITA-M1	13203	a	100-200	658		2000	131 143 150
ITA-M1	13204	a	200-500	1737		2000	133 135 136 137 139 144 152
ITA-M1	13205	a	500-800	2093		2000	134 140 141 142 145 146 147 148 153
ITA-M1	13206	b	10-50	2053	East Ligurian Sea	2000	119 120 121 122 123 124 128 129
ITA-M1	13207	b	50-100	1598		2000	89 92 93 117 118 127
ITA-M1	13208	b	100-200	3186		2000	90 91 95 99 100 101 102 103 104 114 116 125 126
ITA-M1	13209	b	200-500	2449		2000	94 96 97 98 105 107 111 112 113 115
ITA-M1	13210	b	500-800	879		2000	106 108 109 110
ITA-M1	13211	c	10-50	945	North Tyrrhenian Sea	2000	47 48 49 87
ITA-M1	13212	c	50-100	1506		2000	51 52 60 61 86 88
ITA-M1	13213	c	100-200	2732		2000	50 57 58 59 62 63 75 76 84 85
ITA-M1	13214	c	200-500	2828		2000	53 54 56 64 65 66 69 70 77 82 83
ITA-M1	13215	c	500-800	3071		2000	55 67 68 71 72 73 74 78 79 80 81
ITA-M1	13216	d	10-50	2107	Central Tyrrhenian Sea	2000	11 14 20 21 28 29
ITA-M1	13217	d	50-100	2159		2000	12 15 19 31 45 46
ITA-M1	13218	d	100-200	4302		2000	5 6 13 16 17 18 26 30 32 36 42 43 44
ITA-M1	13219	d	200-500	3573		2000	1 2 4 7 8 22 27 35 37 38 40 41
ITA-M1	13220	d	500-800	3148		2000	3 9 10 23 24 25 33 34 39
ITA-M2	13301	a	10-50	822	South East Sardinia	2000	1 3 13
ITA-M2	13302	a	50-100	382		2000	2 12
ITA-M2	13303	a	100-200	351		2000	4 6 8
ITA-M2	13304	a	200-500	589		2000	5 9
ITA-M2	13305	a	500-800	502		2000	7 11 98
ITA-M2	13306	b	10-50	910	North East Sardinia	2000	14 16 25 27
ITA-M2	13307	b	50-100	1592		2000	20 26 28 30 31 32
ITA-M2	13308	b	100-200	839		2000	17 29
ITA-M2	13309	b	200-500	765		2000	15 19 24
ITA-M2	13310	b	500-800	855		2000	18 21 22 23
ITA-M2	13311	c	10-50	627	North Sardinia	2000	36 37 42
ITA-M2	13312	c	50-100	796		2000	35 40 41
ITA-M2	13313	c	100-200	512		2000	33 34 38
ITA-M2	13314	c	200-500	500		2000	39 44
ITA-M2	13315	c	500-800	242		2000	43 45
ITA-M2	13317	d	50-100	541		2000	79 80 81
ITA-M2	13318	d	100-200	896		2000	49 50 53 82
ITA-M2	13319	d	200-500	471		2000	46 52
ITA-M2	13320	d	500-800	335		2000	47 48 51
ITA-M2	13321	e	10-50	1096	West Sardinia	2000	84 88 97
ITA-M2	13322	e	50-100	446		2000	83 87
ITA-M2	13323	e	100-200	927		2000	54 77 78 89 99
ITA-M2	13324	e	200-500	412		2000	85 86
ITA-M2	13325	e	500-800	260		2000	55 56

MEDITS 2000 - Stratification scheme (cont.)

Country	Stratum No	Sub Area	Depth (m)	Surface (km²)	Area	Year	Haul No
ITA-M2	13326	f	10-50	783	South West Sardinia	2000	72 92
ITA-M2	13327	f	50-100	987		2000	68 69 76 113
ITA-M2	13328	f	100-200	2335		2000	66 70 71 91 93 100 110 111 112
ITA-M2	13329	f	200-500	1620		2000	90 94 95 96 109 116
ITA-M2	13330	f	500-800	1041		2000	73 74 75 108 114 115 117
ITA-M2	13331	g	10-50	705	South Sardinia	2000	60 102 123
ITA-M2	13332	g	50-100	350		2000	57 103
ITA-M2	13333	g	100-200	768		2000	64 65 67 101 107 122
ITA-M2	13334	g	200-500	1060		2000	58 63 104 105 119 120
ITA-M2	13335	g	500-800	1227		2000	10 59 61 62 106 118 121
ITA-M3	13401	a	10-50	1194	South East Tyrrhenian Sea	2000	85 86 87 95
ITA-M3	13402	a	50-100	1224		2000	88 89 90 91 92 93
ITA-M3	13403	a	100-200	2095		2000	94 96 97 98 99 100 101 102 103 104 141
ITA-M3	13404	a	200-500	3238		2000	105 106 107 108 109 110 111 112 113 114 115 116 117 118 119
ITA-M3	13405	a	500-800	5248		2000	120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
ITA-M3	13406	b	10-50	622	South West Tyrrhenian Sea	2000	57 58 59 60
ITA-M3	13407	b	50-100	1003		2000	61 62 63 64
ITA-M3	13408	b	100-200	1224		2000	65 66 67 68 69 70
ITA-M3	13409	b	200-500	1966		2000	71 72 73 74 75 76 77
ITA-M3	13410	b	500-800	2441		2000	78 79 80 81 82 83 84
ITA-M3	13411	c	10-50	3145	Sicilian Channel	2000	2 13 14 15
ITA-M3	13412	c	50-100	6610		2000	1 3 18 44 45 46 47 48
ITA-M3	13413	c	100-200	9866		2000	9 10 11 12 25 26 27 28 29 43
ITA-M3	13414	c	200-500	13424		2000	4 5 6 7 8 16 20 21 30 31 32 42 49 50 51
ITA-M3	13415	c	500-800	15653		2000	17 19 22 23 24 33 34 35 36 37 38 39 40 41 52 53 54 55 56
MAL-na	13501	a	10-50	152	Sicilian Channel-Malta	2000	1
MAL-na	13502	a	50-100	1473		2000	4
MAL-na	13503	a	100-200	3076		2000	5
MAL-na	13504	a	200-500	3353		2000	3
MAL-na	13505	a	500-800	2526		2000	2
ITA-M5	21101	a	10-50	17300	North Adriatic Sea	2000	1 2 3 4 6 19 20 21 22 23 24 25 26 27 28 29 30 31 32 36 37 38 39 40 41
ITA-M5	21102	a	50-100	8200		2000	5 7 8 9 10 11 12 13 16 17 18 57
ITA-M5	21106	b	10-50	4700	Central Adriatic Sea	2000	42 45 46 47 73 75 76 78
ITA-M5	21107	b	50-100	10350		2000	14 15 43 44 48 54 55 56 58 74 77
ITA-M5	21108	b	100-200	14950		2000	33 34 35 49 50 51 59 60 61 62 63 64 65 71 72 79 80 81 82 83 84
ITA-M5	21109	b	200-500	3900		2000	52 53 66 67 68 69 70 85
SLO	21111	c	10-50	184	North Adriatic-Slovenia	2000	1 2

MEDITS 2000 - Stratification scheme (cont.)

Country	Stratum No	Sub Area	Depth (m)	Surface (km²)	Area	Year	Haul No
HRV	21116	d	10-50	7308	North East Adriatic-Croatia	2000	31 37 38 39 40 41 42 43 44 45
HRV	21117	d	50-100	14785		2000	1 2 3 4 5 6 9 10 27 28 29 30 32 33 34 35 36 46 47 48
HRV	21118	d	100-200	7225		2000	7 8 11 14 15 16 17 18 19 20 21 22 23 24 25 26
HRV	21119	d	200-500	2409		2000	12 13
ITA-M4	22101	a	10-50	259	East Sicily	2000	1 10 11
ITA-M4	22102	a	50-100	224		2000	4 16
ITA-M4	22103	a	100-200	584		2000	2 5 6
ITA-M4	22104	a	200-500	1098		2000	3 7 8
ITA-M4	22105	a	500-800	1273		2000	9 22
ITA-M4	22106	b	10-50	306	North West Ionian Sea	2000	12 37
ITA-M4	22107	b	50-100	278		2000	27 28
ITA-M4	22108	b	100-200	258		2000	26 36
ITA-M4	22109	b	200-500	886		2000	25 29 35
ITA-M4	22110	b	500-800	989		2000	13 14 15 17 18 19 20 21 23 24 30 31 32 33 34
ITA-M4	22111	c	10-50	455	North Ionian Sea	2000	45 51 52
ITA-M4	22112	c	50-100	305		2000	39 46 50
ITA-M4	22113	c	100-200	357		2000	47 49
ITA-M4	22114	c	200-500	972		2000	40 41 44 48
ITA-M4	22115	c	500-800	1032		2000	38 42 43
ITA-M4	22116	d	10-50	677	North Ionian Sea	2000	74
ITA-M4	22117	d	50-100	524		2000	72
ITA-M4	22118	d	100-200	1009		2000	70 71 73
ITA-M4	22119	d	200-500	874		2000	59 60 63 66 69
ITA-M4	22120	d	500-800	1160		2000	53 54 55 56 57 58 61 62 64 65 67 68
ITA-M4	22122	e	50-100	509		2000	75 76 88
ITA-M4	22123	e	100-200	1348		2000	79 81 83 84 89 90 93 95
ITA-M4	22124	e	200-500	332		2000	77 82 85 92 94
ITA-M4	22125	e	500-800	860		2000	78 86 87 91
ITA-M4	22126	f	10-50	329	South West Adriatic Sea	2000	80 99 100
ITA-M4	22127	f	50-100	599		2000	101 104 105
ITA-M4	22128	f	100-200	1809		2000	97 102 103 106 107
ITA-M4	22129	f	200-500	472		2000	96
ITA-M4	22130	f	500-800	350		2000	98
ITA-M4	22131	g	10-50	290	South West Adriatic Sea	2000	109 115
ITA-M4	22132	g	50-100	689		2000	108 112 114
ITA-M4	22133	g	100-200	1214		2000	110 111 113
ITA-M4	22135	g	500-800	336		2000	116
ITA-M4	22136	h	10-50	1702	South West Adriatic Sea	2000	117 118 119 120 121 122 123 124 125
ITA-M4	22137	h	50-100	1307		2000	126 127 128 129 130 131
ITA-M4	22138	h	100-200	1407		2000	132 133 134 135 136 137 138
ITA-M4	22139	h	200-500	707		2000	139 140 141 142
ITA-M4	22140	h	500-800	492		2000	143 144 145 146

MEDITS 2000 - Stratification scheme (end)

Country	Stratum No	Sub Area	Depth (m)	Surface (km²)	Area	Year	Haul No
ALB	22141	i	10-50	568	South East Adriatic-Albania	2000	1 2 3
ALB	22142	i	50-100	2231		2000	4 5 6 7 8 9 10 11 12 13
ALB	22143	i	100-200	2186		2000	14 15 16 17 18 19 20 21 22 23
ALB	22144	i	200-500	1840		2000	24 25 26 27 28 29 30 31
ALB	22145	i	500-800	1910		2000	32 33 34 35 36 37 38 39 40
GRC-G2	22201	a	10-50	2916	East Ionian Sea	2000	26 28 50
GRC-G2	22202	a	50-100	4365		2000	25 27 29 31 32 39 44 45 51 52
GRC-G2	22203	a	100-200	2536		2000	30 33 36 46 48 49
GRC-G2	22204	a	200-500	3158		2000	34 40 41 42 43 47
GRC-G2	22205	a	500-800	3848		2000	23 24 35 37 38 53
GRC-G1	22401	a	10-50	8645	North Aegean Sea	2000	1 4 37 47 63
GRC-G1	22402	a	50-100	8489		2000	2 5 6 23 42 43 44 45 46 48 49 51 60
GRC-G1	22403	a	100-200	15823		2000	3 7 8 13 14 15 16 20 26 31 34 38 50 59 61 62 65
GRC-G1	22404	a	200-500	19774		2000	9 11 17 18 19 21 22 25 27 29 32 33 35 36 39 40 41 52 53 54 55 57 64
GRC-G1	22405	a	500-800	15426		2000	10 12 24 28 30 56 58
GRC-G3	22501	a	10-50	4918	South Aegean Sea	2000	24 25 44 53
GRC-G3	22502	a	50-100	4090		2000	10 14 23 42 43 48 52
GRC-G3	22503	a	100-200	13269		2000	6 9 11 12 13 16 19 39 49 50 51 54 55
GRC-G3	22504	a	200-500	18100		2000	1 2 3 4 5 7 8 17 18 20 21 22 28 32 33 34 35 37 38 40 41 45 46 47
GRC-G3	22505	a	500-800	22224		2000	15 26 27 29 30 31 36

Figure 1. MEDITS 2000 General calendar

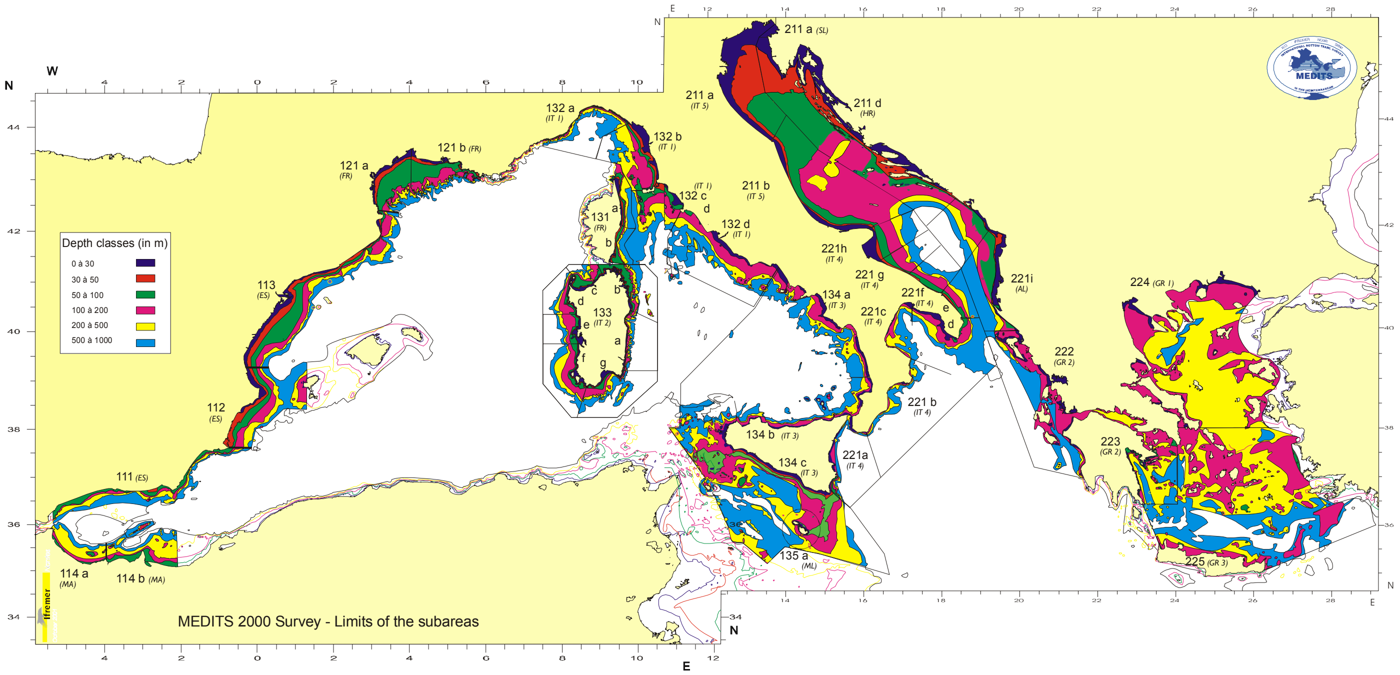
Month	May																														
Ship	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
CHA																				■	■	■	■	■	■	■	■	■	■	■	■
COR																						■	■	■	■	■	■	■	■	■	■
LEU																															■
FRP																										■	■	■	■	■	■
NUS																													■	■	■
SAN																										■	■	■	■	■	■
PEC		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
AND																															
EVA																															
DEM																															
NAU																															

Month	May																													
Ship	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
CHA																														
COR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■							
LEU	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
FRP	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
NUS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SAN	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
PEC	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
AND								■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
EVA																					■	■	■	■	■	■	■	■	■	■
DEM												■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
NAU		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Month	May																														
Ship	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
CHA																															
COR																															
LEU	■	■																													
FRP	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■									
NUS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■										
SAN	■																														
PEC																															
AND	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
EVA	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
DEM	■	■	■	■	■	■	■	■																							
NAU	■	■	■	■	■	■	■	■	■	■	■	■	■																		

Plus two days, 1st and 2nd of August for the vessel Andrea (AND).

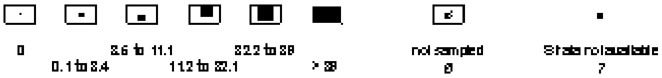
Figure 2. MEDITS 2000 Stratification scheme

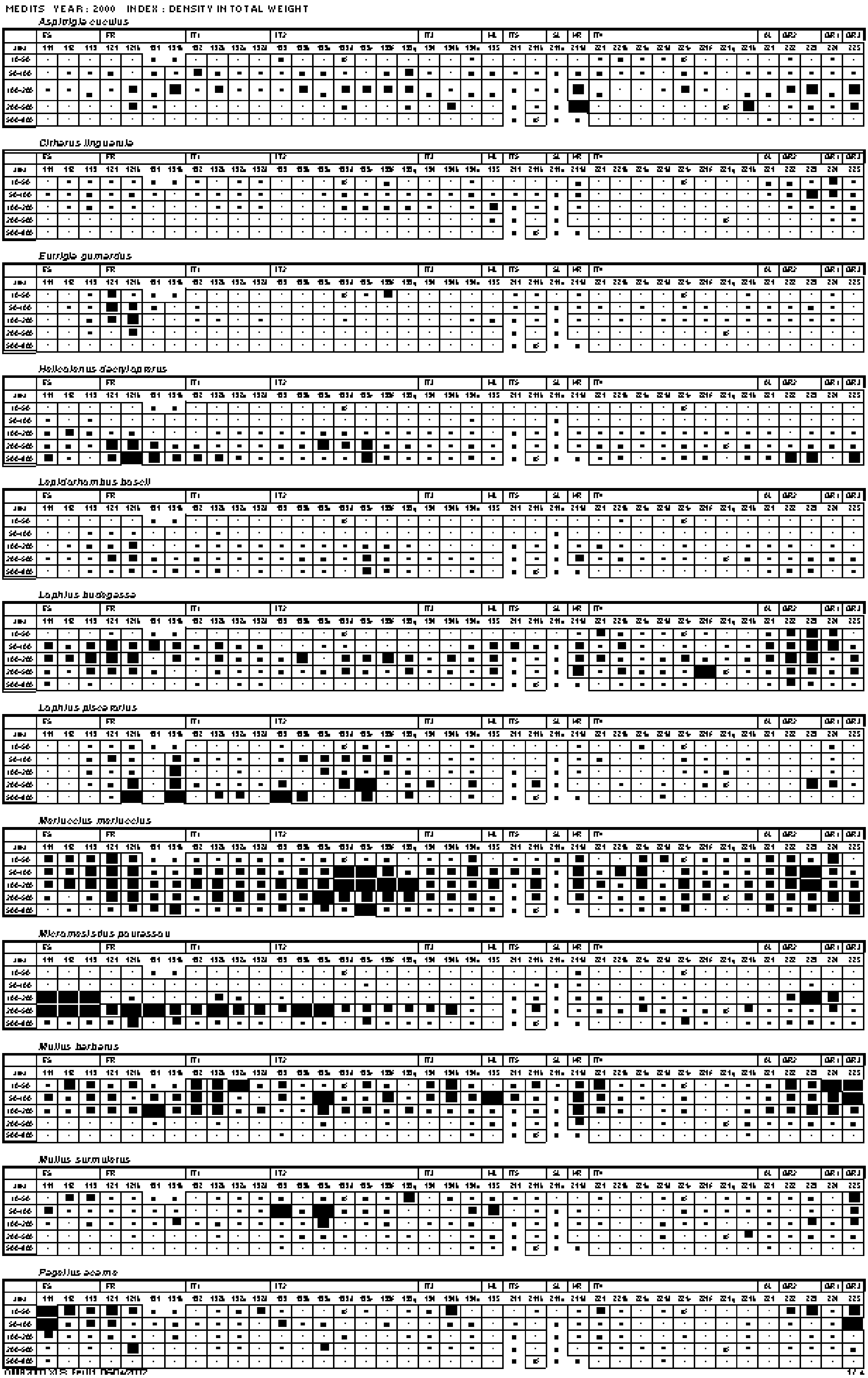


Warning: *The depths of 10 and 800 meters have been replaced by the nearest available (respectively 30 and 1000 m) on the map used.*

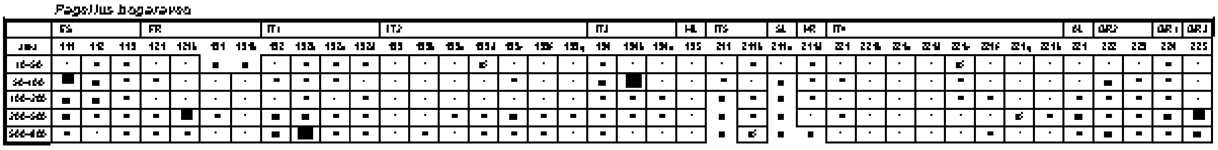
Figure 3. Biomass classes (survey 2000)
(cf. the three pages below)

In all the figures, the relative biomass indices (B.I.) are presented with the following six classes:

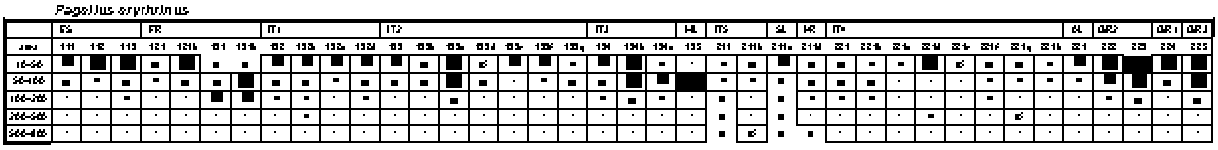



MEDITS YEAR : 2000 INDEX : DENSITY IN TOTAL WEIGHT
Aspitrigla cuculus
Citharus linguatula
Eutrigla gurnardus
Helicolenus dactylopterus
Lepidorhombus boscii
Lophius budegassa
Lophius piscatorius
Merluccius merluccius
Micromesistius poutassou
Mullus barbatus
Mullus surmuletus
Pagellus acarne

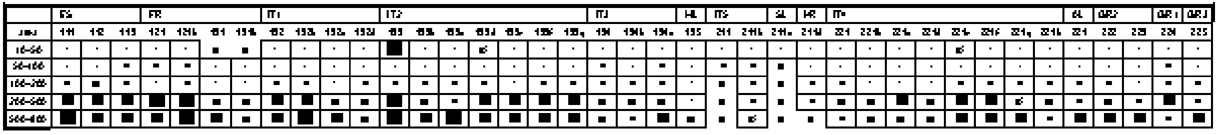
Pagellus bogaraveo



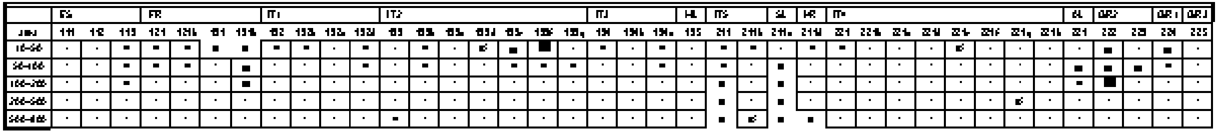
Pagellus erythrinus



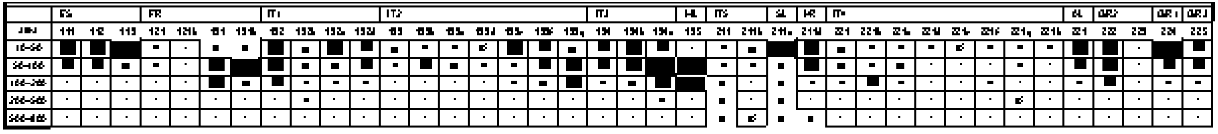
Phycis blennoides



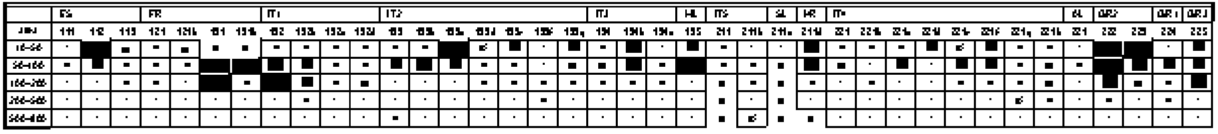
Solea vulgaris



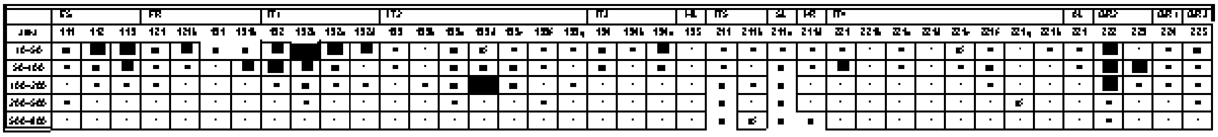
Spicara flexuosa



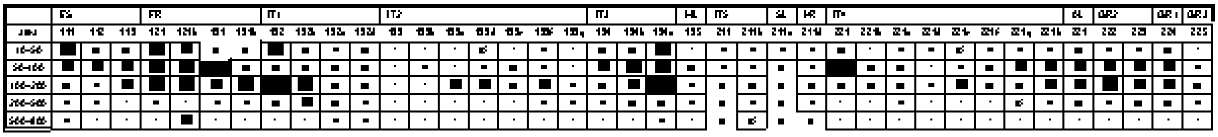
Spicara smaris



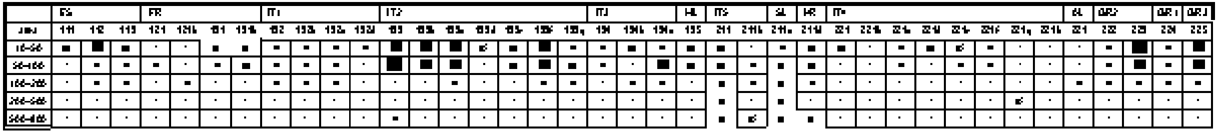
Trachurus mediterraneus



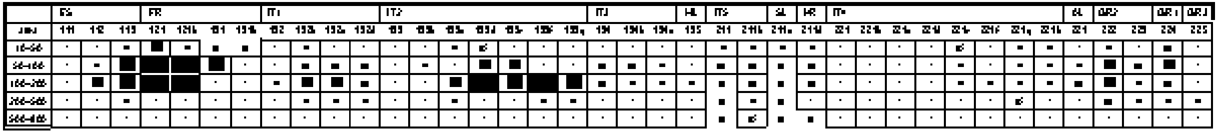
Trachurus trachurus



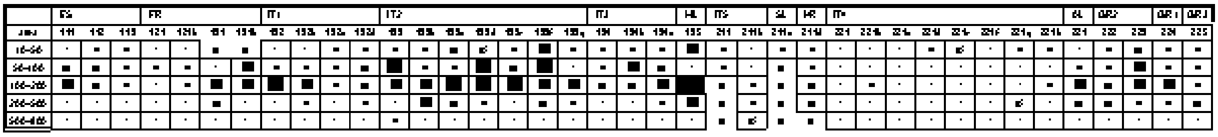
Trigloporus lastoviza



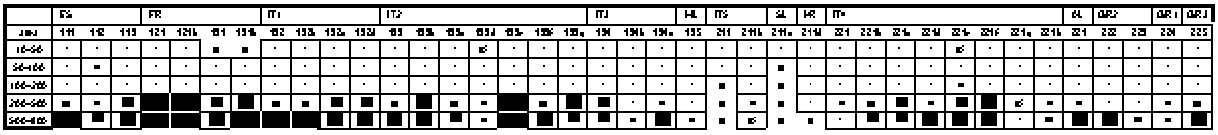
Trisopterus minutus capelanus

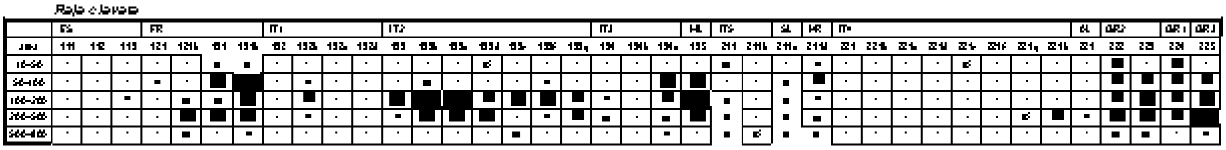


Zeus faber

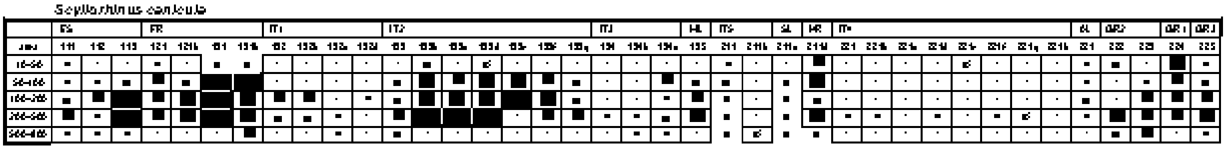


Galeus melastomus

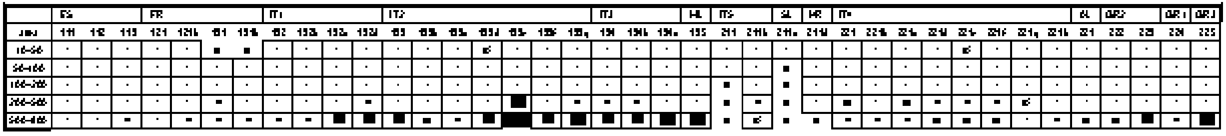




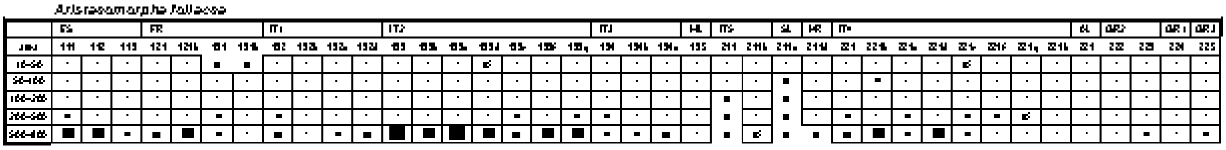
Raja clavata



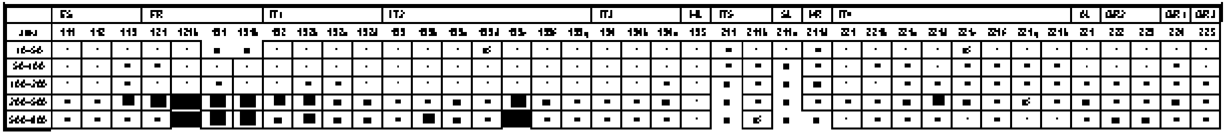
Scyliorhinus canicula



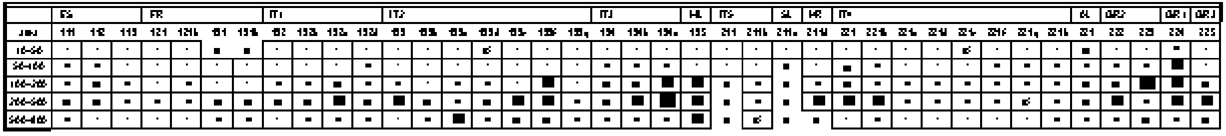
Aristeus antennatus



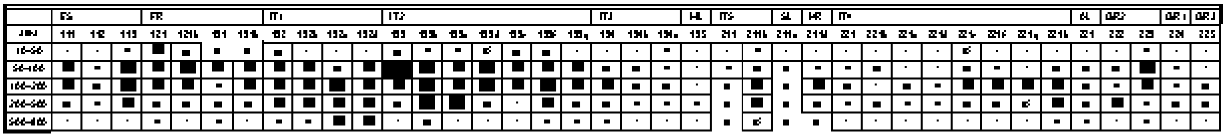
Aristaeomorpha foliacea



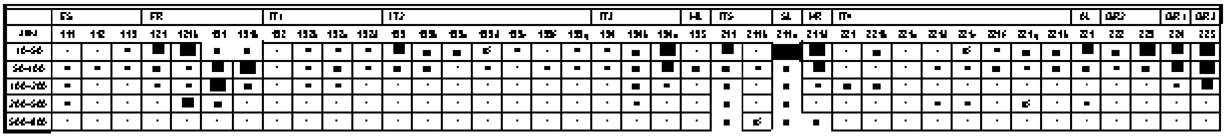
Nephrops norvegicus



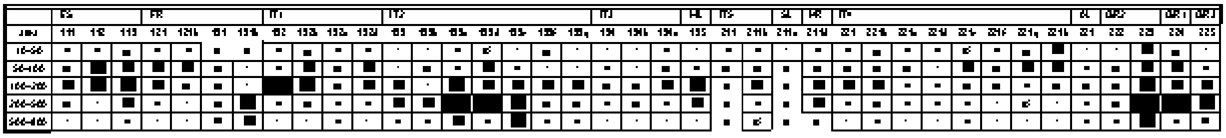
Parapenaeus longirostris



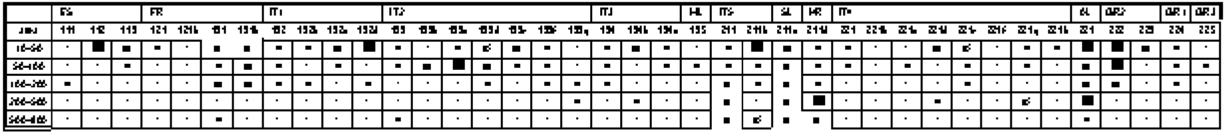
Eledone cirrhosa



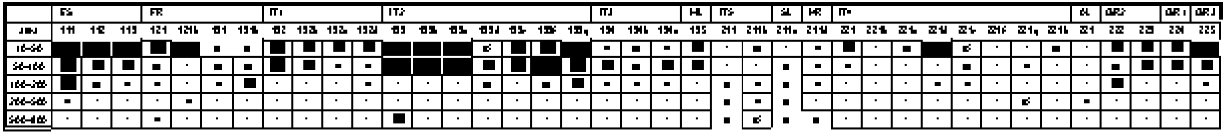
Eledone moschata



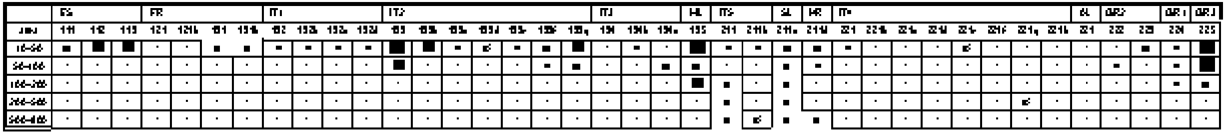
Illex coindetii



Loligo vulgaris



Octopus vulgaris



Sepia officinalis

[2] Depth trajectory and performance of a trawl used for an international bottom trawl survey in the Mediterranean

J.A. Bertrand[*], I. Leonori[**], P.Y. Dremière[***] & G. Cosimi[**]

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Preliminary version - Not to be cited without permission of the authors

2.1 Introduction

Knowledge of the abundance of fish stocks and exploited ecosystems is obtained primarily by analysing commercial catch data and from research vessel surveys, the second source providing a wider scope of biological data. Nevertheless, the results of bottom trawl surveys are also inherent variables. Some of the variability is associated with the natural patterns in distribution and behaviour of the population sampled by the trawl gear (Godø, 1994). Additional variability is introduced by survey protocols (Byrne *et al.*, 1981). An important part of the measurement variability is due to the performances of the gear. Actually, the trawl is a very complex tool sensible to a lot of factors linked with the vessel, the operating procedure and the environment of the gear (bottom sediment, current, depth, etc.) (Walsh & McCallum, 1995).

Swept area is an important parameter which influences the abundance estimates from bottom trawl surveys (Doubleday & Rivard, 1981; Engås, 1994; Godø & Engås, 1989). This swept area is defined by the geometry of the gear (for instance door or wing spread) and the distance really covered by the gear in contact with the bottom. Since the availability of autonomous acoustic devices to follow up the trawl geometry (Engås & West, 1987; Wathne, 1977), a lot of studies have been done on the trawl performances (Lauth *et al.*, 1998; Lin *et al.*, 1996; Marteinsson, 1992; McCallum & Walsh, 1995). Main of them are devoted to trawl geometry, especially to the relationship between door and wing spread and the height of the mouth (vertical distance between the middle of the headrope and the footrope level, once the bottom trawl put on the sea ground). Trawl geometry has been studied to improve the reliability of bottom trawl surveys (Engås & Godø, 1986; Fiorentini *et al.*, 1996). In Italy, Fiorentini *et al*. (Fiorentini & Cosimi, 1981; Fiorentini *et al.*, 1998; Fiorentini *et al.*, 1994) have studied performance and geometry of the trawls used in a national survey programme (GRUND) covering the whole Italian coast. Nevertheless, fewer information is available on the effective distance covered by the trawl in contact with the bottom.

In the Mediterranean, an international bottom trawl survey programme has been carried out every year since 1994 to assess the benthic and demersal resources along the coasts of the western and northern part of the basin (Bertrand *et al.*, 2000b). The different vessels involved in the survey programme are using the same standardized gear and sampling protocol since the beginning of the project. A technologist team[1] has been associated with the programme since its beginning. After conceiving and setting the sampling trawl, this team has already analysed different items linked with the performances of the gear, like its efficiency (Fiorentini *et al.*, 1999) and escapement from its main body (Dremière *et al.*, 1999). The results obtained have been used to involve the common sampling protocols.

The aim of this paper is to analyse the trajectory (in a vertical plane) of the trawl during the MEDITS survey, to give some information on the geometry of the gear, to look at the effects on abundance indices, and formulate some recommendations for inclusion of the obtained results when assessing demersal resources from trawl surveys.

2.2 Material and methods

2.2.1 Source of data

2.2.1.1 Depth trajectory characterization

The data related to trawl trajectory came from hauls carried out during routine MEDITS trawl surveys, using the standard protocols defined for these surveys (Anon., 1998) according to the manual distributed to the teams before the surveys, and their later improvements (Anon., 1999) taking into account first analysis of the gear efficiency (Dremière et al., 1999; Fiorentini et al., 1999). The trawl used for these surveys is the GOC73 made with two panels and sides, with a footrope of 28.2 metres. The protocol related to the standard gear used by all the survey vessels includes all the materials and their rigging arrangement from the doors (type Morgère WH S) to the codend. The same gear and rigging are used for all the survey areas, from 10 to 800 metres depth, except the sweeps which are 50 metres longer down to 200 metres depth. Furthermore, the standard tow duration is 30 minutes up to 200 metres depth and 60 minutes downwards. In the protocol, the standard speed of the gear over the ground is fixed at 3 knots.

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Nevertheless, when speed indication is not available, the officer has to adjust the vessel speed to the best of his ability.

Some indications are given to the watch officer to standardize the end of shooting operation in order to ensure a good contact of the trawl with bottom since the start of haul. The official start of haul is defined as the moment when the gear geometry is stabilized on the bottom. Aboard vessels without equipment to watch in real time the gear geometry, this moment is let to the watch officer's appreciation, as well as the ship speed during shooting and the warp shooting speed itself.

2.2.1.2 Gear stabilization and geometry

The data used to analyse the stabilization delay of the MEDITS gear were obtained from tests carried out in Sicilian Channel (MEDITS area IT-M3) (fig. 1, tab. 1) in May 1995 on board the professional stern trawler Sant'Anna (1000 HP). These tests were part of a study (Fiorentini et al., 1996) devoted to properly set the sampling trawl used for the MEDITS surveys. During this study, checks have been made aboard each of the Italian vessels involved in the international survey. For these tests, the gear was rigged following the 1995 MEDITS protocol (Anon., 1998); the hauls were carried out at different bottom depths ranging from 38 metres to 420 metres.

Fig. 1; table 1

The other data used to analyse the geometry of the MEDITS trawl came from recordings collected aboard different vessels involved in the MEDITS programme during the 1994, 1995 and 1996 cruises, particularly in Spain (Cornide de Saavedra) and in France (L'Europe) (tab. 1).

Since 1998, the use of Minilog system (Vemco) has been generalized to record a posteriori water temperature at the trawl level. The records may also be used to check the net trajectory. The recorder is fixed on the central upper panel of the gear, just behind the headrope bosom. Detailed depth/time data from Minilog operated aboard some vessels during routine surveys in 1998, 1999 and 2000 have been used for this study. The data taken into account are continuous from the start of shooting to the end of warps retrieving (and later on), with one record each 30 seconds to 2 minutes depending on the vessel.

Complementary, two types of data available from the navigation bridge have been taken into account: the official times of start and end of the hauls, and the depth recorded from the navigation bridge sounder at the official start and end of haul.

For the trajectory component of this study, a total of 831 hauls distributed from different vessels and areas of the MEDITS zone (tab. 1; fig. 1) have been analysed. Aboard most of those vessels, the official start of haul was defined in relation with the end of warp shooting (more or less close to the corresponding time, according to the depth). Only for one vessel (the r/v L'Europe) the official start of haul was defined from direct follow-up of the trawl motion, by using a system to control the gear geometry (a Scanmar device).

2.2.2 Methods

2.2.2.1 Depth trajectory characterization

The Minilog recordings, available since 1998, allow to follow up the whole motion of the gear in the water column from the start of shooting to the end of hauling. From the resultant curve and the information available from the bridge, the following series of points and values have been considered to characterize the trawl trajectory during a haul (fig. 2).

t1 Trawl shooting start

t2 Trawl descent start (corresponding roughly to doors immersion)

t3 Trawl (footrope bosom) first contact with bottom

t4 Official start of haul

t5 Official end of haul

t6 Trawl (footrope bosom) last contact with bottom

t7 End of warp rewinding

Δt_1: $t_3 - t_2$: Descent duration

Δt_2: $t_4 - t_3$: Gap between first contact of trawl with bottom and official start of haul (positive if t_3 occurs before t_4, and negative in the opposite situation)

Δt_3: $t_6 - t_5$: Latent period

Δt_4: $t_5 - t_3$: Effective haul duration

Δt_5: $t_5 - t_4$: Official haul duration

Fig. 2

In some cases, the position of point t_3 does not appear clearly on the trajectory line. In these cases, a personal and subjective choice is done for the analysis. Furthermore, the contact with bottom may be not permanent during the whole haul duration inducing an uncertainty on the exact contact duration.

When studying relationship between trajectory parameters, different fittings have been tested. Finally, the one used is the linear. Actually, the polymodal did not give better fittings. The fittings have been made excluding atypical points, *i.e.* those which are strongly far from the regression line.

All the figures in a same set are presented using the same scale. Nevertheless, hauls carried out on shelves or on slopes (limit at 200 metres depth) were considered separately in the analyses, taking into account the difference in the official sampling duration (30 / 60 minutes).

2.2.2.2 Gear stabilization and geometry

Underwater instruments (Scanmar system) have been used to control the fishing operations in real time, and to measure the geometric characteristics of the MEDITS fishing gear. The parameters usually measured on the gear were: door spread, wing spread (i.e. horizontal net opening, defined as upper net wing-end spread), vertical net opening (defined as height of the headline centre above the sea bed) and net speed (in respect to water in a few cases, and to bottom in most of them, according to the vessel). The instruments were usually connected to a portable computer that recorded all measurements on a hard disk (about every 10 seconds, according to the vessel).

To analyse the delay for wing spread stabilization, we used the method including the following characteristic parameters (Fiorentini *et al.*, 1994). The time-zero point (fig. 3) corresponds to the moment when the warps were completely paid out and the winch stopped. The setting time of the gear (the time required by the trawl to reach the correct openings after the winch stop) was defined as the time to reach 95 % of the stabilized value (mean value during the haul). For each haul, the stabilized value was the average of the data registered after stabilization of gear performance (the achievement of optimal gear opening).

Fig. 3

The parameter used to assess the variability of horizontal gear opening aboard different vessels was the average wing spread estimated for each haul aboard these vessels from Scanmar recordings. Furthermore, a relationship between wing spread and depth has been estimated from the mean standard scope ratio defined in the MEDITS protocols (Anon., 1998) and the relationship between warp length and wing spread adopted by the MEDITS teams in swept area estimations when no direct observation in real time were available as wing spread value. This relation was calculated through the following asymptotic von Bertalanffy function (Souplet, 1995):

$E = 17.45613\ (1\text{-}e^{-0.33243((L/100)+3.60468)})$

with E: wing spread (m) and L: warp length (m).

2.3 Results

2.3.1 Global results on the vertical haul trajectory

The official duration of a majority of hauls (76 %) agreed exactly with the standard haul durations defined in the MEDITS protocols (30 minutes and 60 minutes, according to the depth; fig. 4) (Anon., 1998). The other values corresponded to hauls shortened by the watch officer due to particular reasons (bottom obstruction, sudden depth variation, etc.).

Fig. 4

The official duration values were most often higher than the effective ones; actually, without Scanmar device, it was common to declare the official start of haul before the first contact of the trawl with the bottom. So far, down to 200 metres depth (haul duration 60 minutes), the mean effective duration of hauls was 28 % less than the foreseen one (mean = 45 minutes; S.D. = 12 minutes). On the shelves (up to 200 metres, haul duration 30 minutes), the discrepancy is strongly smallest (16 %; mean = 28 minutes; S.D. = 4 minutes).

This general trend integrated different types of situations that can be identified from analyses done vessel by vessel. The main variations may be highlighted from analysis of the gear descent from the sea surface to the bottom (Δt_1), and the gap between effective and theoretical first contact of the trawl with bottom (Δt_2).

Usually, the regression of the gear descent duration (Δt_1) vs. depth was good (R^2 in general better than 0.90; fig. 5), when excluding a few atypical long durations. The importance of unexpected values, variable, kept between 0 and 11 percent (mean 6 %) of the total number of hauls by series, according to the vessel and year. The average descending speed of the trawl between the surface to 500 metres depth was 21 m/min from the eight available data series. The average speeds were set between the extreme values of 17 and 30 m/min depending on vessel and year. On small depth, the results may be altered by inaccuracy in equipment calibration between the bridge sounder (particularly transducer draught) and clock, and the ones of the Minilog sensor (also in time and depth). Even on relatively small depth areas (less than 200 metres), a dispersion of the Δt_1 values around the mean might be observed.

Fig. 5

In most of the studied cases, the watch officer fixed the official start of haul before the trawl had begun to be in contact with the bottom (negative values of Δt_2; fig. 6). Furthermore the gap strongly increased with depth. This situation may directly induce a cutting down of the effective haul duration (cf. fig. 4). Even when excluding atypical points that evidently corresponded to «bad» tows, the correlation between the two parameters is most often poor (R^2 usually less than 0.75). The bad relationship for the r/v *L'Europe* may be associated with the determination of official start of haul from Scanmar data, and not only from the end of warp unwinding. Furthermore, mainly due to crew and watch officer habits during shooting, the slope of the regression was variable when comparing boats and/or years.

Fig. 6

The gap between the official and the effective starts of haul was in general a few minutes close to zero in the shallowest waters. It might strongly increase, with big variations between vessels, for the deepest bottoms. So far, for 500 metres depth, the advance of official start of haul (Δt_2) was on average 15 minutes, with a very small gap (close to zero) for some vessels (e.g. *Nautilos* and particularly *L'Europe*) and a bigger one (up to almost 50 percent of the total haul duration) for others. Probably linked with an increase of the gear descent speed (from 18 to 24 m/min in average), the gap between the official and the effective start of haul has been reduced between 1998 and 1999 aboard the *Pasquale e Cristina* (approximately 25 percent of gap reduction at 500 metres depth).

2.3.2 Specific haul trajectories

The trajectory of hauls with a small gap between official and effective starts (fig. 7a and b) was usually consistent with the standard trajectory previously described (fig. 2). For the other hauls, different situations might occur. In the figures 7c to g, some particular situations encountered during the surveys are presented. One very extreme and atypic case is the one of hauls during which the trawl was never in contact with the bottom. An example of such a situation is given on figure 7c. In this case, the descending motion of the gear stopped 50 metres up to the bottom. It finished its descending with changing in the warp tension at the beginning of warp rewinding. The trajectory presented on figure 7g illustrates a situation where no contact with the bottom has been got, even at the beginning of rewinding. Sometimes, the gear has normally reached the bottom, eventually with delay according to the official start of haul, then the trawl flew up (fig. 7d) before stabilized trajectory. Some trajectories show that, particularly on deep waters, the descending speed of the trawl may be irregular, with a fastest speed at the beginning and a slowing one later on. Such situations may be identified on the trajectories shown on figure 7c with a strong slowing up from 300 metres downwards, as well as in figure 7d from 400 metres.

Fig. 7

It may happen that hauls have to be carried out on bottom with a sharp slope. In some areas, for instance in the Gulf of Lions where the upper slope is crossed by deep canyons, the only available way for trawling is to make them in the main slope direction (fig. 7e). Then, the warp length has to be adjusted all during the haul to ensure the good scope ratio, taking into account that the depth recorded by the bridge echo sounder may be far before the one at the trawl level. In other places, it is possible to maintain the vessel along a contour line. In this situation, it may occur that the gear slips laterally towards deeper places than the ones flown over by the vessel. The trajectory presented in figure 7f may illustrate this kind of situation that may significantly introduce a gap between the effective haul depth and the one registered at the bridge sounder.

2.3.3 Gear stabilization and geometry

The example given on figure 3 shows how more time is required after the warps are completely paid out and the winch stopped, before the horizontal net opening reaches stabilized measures around the mean value. In the study case, the time needed for stabilization of the net opening was a few minutes (usually less than ten minutes; fig. 8). This time was strongly affected by the warp length. It increased with warp length and then with bottom depth.

Fig. 8

After stabilization, the average wing spread appeared variable between hauls for a same vessel. These intra-vessel variations were partly in relation with depth (fig. 9a), but not in all the cases. For instance, virtually no relation with depth might be identified for the *Cornide de Saavedra* (fig. 9b). The main intra-vessel variability is a haul to haul one. So far, at the same depth, it had varied as much as 5 metres, that is to say almost 30 percent of the average wing spread for most of the study vessels. We may emphasize that this situation is not general. For instance, very few haul to haul variations occurred down to 200 metres for the two vessels *L'Europe* and *Ioannis Rosso* in 1996 (fig. 9c). Not surprisingly, the variations in wing spread were inversely correlated with the corresponding vertical opening values, due to normal trawl distortions. For instance, when the mean wing spread was 19 metres aboard the Cornide de Saavedra in

1995, the vertical net opening was approximately 2 metres. Inversely, with a smaller mean wing spread (13 metres), the vertical opening was about 3 metres aboard the same vessel in 1997.

Fig. 9

Beyond this intra-vessel/cruise variability, a variability between vessels and years also occurred (fig. 10). This variability was in the same scale of size as the haul to haul variations. The standard curve calculated from the von Bertalanffy function indicated earlier is located between the curves drawn from the Scanmar recordings.

Fig. 10

2.4 Discussion

Compared with other available devices, the basic principles of trawl make this gear very attractive to sample a wide diversity of demersal and benthic species over soft bottom (Fernö & Olsen, 1994). Despite the worry about fish behaviour in front of the trawl (Godø, 1994), and that the gear does sample their whole distribution volume for part of the species caught (Bertrand et al., 2000a), the concept of swept area as an approximation of filtered volume offers facilities to build quantitative biological estimators. These advantages linked with crew competencies in operating this king of gear have incited scientists to extensively use trawls for routine fishery surveys. So, only for the North Atlantic zone and the Mediterranean, we have identified more than twenty outstanding trawl survey series. Nevertheless, the investigations conducted during the last three decades thanks to the availability of gear instrumentation have drawn the attention on the variability of trawl performances and their effect on the quality of demersal resources assessment.

Despite the efforts done to standardize the sampling trawl, its rigging and handling, the MEDITS programme does not avoid this problem. Actually, the results presented above emphasize the need to take the highest care when handling the sampling gear, in order to reduce the uncontrolled variability in estimating the swept area parameters.

Trawl measurements from tows during routine surveys may identify the frequency of ''bad'' tows, i.e. tows for which the gear was not fully spread or was not on the bottom for a substantial part of the haul. So far, a relative high percentage of bad tows is documented in the literature: 17 % (Engås & Godø, 1986) and 23 % (Engås & West, 1987) in the Barents Sea, 29 % during Pacific cruises off California (Wathne, 1977). The estimate of 6 % of very “bad” hauls from the present trajectory analysis is set inside these values. Nevertheless, it takes into account only one of the parameters contributing in swept area estimates. To improve the swept area estimates, and consequently species abundance and distribution estimates, the variability of each contributing parameter has to be carefully managed and controlled.

The score ratio given in the standard MEDITS protocols (Anon., 1998) has been established for mean values of steel wire weight per length unit and an ordinary bottom. This ratio has to be considered as a guide. Nevertheless, some adjustments can be useful in order to facilitate the descending motion of the trawl and its good contact with bottom. Actually, the type of bottom may justify this kind of adjustment. For instance, on soft bottom conditions, shooting extra warp length in the shallow areas may compensate the higher spreading force to the doors (Godø & Engås, 1989).

A mean value of trawl descent speed, calculated from shooting start to first contact of the net with bottom, may hide some speed variation with depth. The descent speed can decrease with increasing depth, particularly down to 300 metres (fig. 7c & d). Even if the shooting mode seems to be more determinant, the net descent speed can be also partly determined by the differential in density between the seawater (and particularly the deep ones) and the polyamide used to make the standard trawl, these two density values being close each other. A trawl built in polyester (density = 1.38), instead of polyamide (density = 1.14), should perceptibly decrease the net descent time, but its cost would be much more expensive. In some occasions, and probably due to salinity and temperature close to the sea ground, the trawl may seem as lying over a layer of water surmounting the bottom (fig. 7c). Crossing this limit to reach the bottom may require some specific bridge/deck operations. For all the deep hauls, the doors undoubtedly reached the bottom a more or less long time before the net itself.

When shooting additional warp length, some different shooting speeds have been tested on several occasions (on a falling bottom) aboard the r/v *L’Europe* during the MEDITS 2000 survey to estimate their effect. There was strong evidence that the faster was the shooting speed, the faster and best was the trawl contact with bottom. For the time being, the information is only qualitative. Nevertheless, the results are really promising. From another viewpoint, in some occasions the officer may reduce the descending motion of the gear close to the bottom by reduction of the warp shooting speed, to limit the risk for sticking the doors in muddy bottom. No suggestion was given up to now in the MEDITS protocol concerning the vessel speed during shooting, and the warp shooting speed itself.

Bad estimates in descending speed may induce considerable disagreement between the time of first bottom contact as recorded by field sensors and as determined in the conventional way by the watch officer. In deep water (as far as 600 metres depth), discrepancies as much as 10 minutes were documented (Engås, 1994; Godø & Engås, 1989). This delay is close to the present average of 15 minutes between 200 and 800 metres depth.

Waiting periods, commonly of 5 to 10 minutes or more, to allow the trawl to be fully stabilized, is cited in literature (Walsh & McCallum, 1995). The same discrepancies were observed from the present analysis (fig. 8). To decrease setting time (Δt_1), trials have been achieved within the MEDITS program (Fiorentini *et al.*, 1996), and shooting suggestions have been added to the MEDITS protocol (Anon., 1999), mostly dedicated to vessels without any Scanmar or equivalent device.

During this study, no particular approach has been done on the trawl's delay in coming off bottom at haulback. Actually, from our data, it was not possible to clearly separate in the latent period (Δt_3 on fig. 2) the one during which the trawl was still fishing (continuation of tow) and the one when the trawl was not efficient on the bottom, the gear speed being quite equal to zero. Some authors (West, 1985) (*in* Engås 1994) from observations in other areas, suggest that this delay may be very variable and unpredictable, ranging from no delay to as much as 5 minutes. In the Mediterranean, due to the usual operating mode, particularly on board of commercial vessels, we can anticipate that the trawl does not have efficient speed during warp retrieving. Anyway, the variability of this parameter is probably of a very weak importance regarding the other parameters introduced in the swept area calculation.

To better estimate the haul duration and covered distance, the MEDITS protocols (Anon., 1998) anticipated the use of a system to separate the codend in different parts by a remote-controlled closing system, in order to control strictly the start and end of haul. Unfortunately, the foreseen device was not yet operational for the present experiments. For a better control of the effective towed distance, and when unavailability of direct information on the trawl performance, a trajectory curve could be systematically drawn from depth/time continuous recorders fixed on the net (suggested cadence of recording: one record per minute). This *a posteriori* curve should be interpreted after each haul to calculate the effective haul duration in contact with bottom. The start of haul should be get as the time of first contact with bottom, taking into account the delay of gear stabilization (cf. below). The definition of haul end would take into account an eventual continuation of the tow after the beginning of warp rewinding. Furthermore, estimate of swept distance by the trawl from towed duration would imply the availability of data to reconstruct the vessel shipping lane minute per minute.

After lot of studies in different areas (Doubleday & Rivard, 1981; Engås, 1994; Godø & Engås, 1989), the present analysis has highlighted that, even in case of standardized sampling gear design from doors to codend, its rigging and handling, a real wing spread variability may occur at different levels: (i) inside tows in the same soundings aboard one vessel during the same survey/experiment, (ii) inside surveys/periods for the same vessel on the same area, in terms of average wing spread values as far as in terms of inside tows variability, and (iii) inside vessels.

These variabilities have been recognised by many researchers during the few last decades, and several methods have been employed to maintain constant trawl geometry at all fishing depths aboard different vessels (Engås, 1994). One option, as done in the MEDITS survey, was to increase the length of the sweeps (connecting the doors to the spreaders). By this way, it is theoretically possible, but not always confirmed (Hagström, 1987), to hold wing spread constant in spite of increasing door spread. However, area swept by the sweeps and spreaders may contribute in the total area swept by the gear. So far, sweep length may have an effect on catching efficiency for different length groups of fish (Engås & Godø, 1989). Another possibility is to adjust the warp length on a case by case basis. This method implies the availability of direct door or wing spread observation. Finally, to reduce the wing spread variability with depth and vessel, different authors (Engås, 1994; Engås & Ona, 1991; Fréchet, 2000; Rose & Nunnallee, 1998) have suggested and successfully tested the use of a line affixed between the towing warps ahead of the doors to restrict the ability of the trawl to open further when more warp is deployed.

In the Barents Sea, variations in swept area were more associated with variation in depth than with ship-effect (Godø & Engås, 1989). The major external factors responsible for between tows variability were differences in bottom and/or current conditions (Carrothers, 1981; Godø & Engås, 1989). In other experiments in different areas, an actual ship (or captain) effect has been pointed out (Anon., 1990; Walsh & McCallum, 1995).

On the shelf (depth up to 200 metres), the distance effectively swept by the trawl in contact with bottom was very similar to the one sailed by the vessel, and no correction has to be done on the distance data recorded. The situation was different for deeper depths for which a difference in distance is quite common. Except a few exceptional particular cases where the trawl flew continuously far above the bottom (and producing only catch of pelagic species), the other results showed a species composition including demersal and/or benthic species in variable proportions. Thus, it should be strongly insufficient to consider the results only in terms of pelagic or demersal species to appreciate the quality of trawl contact with bottom. But also the abundance index estimates are strongly affected.

One of the main objectives of standardized bottom trawl surveys is the production of data series to estimate trends on biological parameters as abundance indices and length distribution. To take into account the need for maintaining the series consistency, one option should be to leave the survey perpetually in their imperfect state. Some arguments may convince that this approach condones inefficiency (Cotter, 1997). Furthermore, nothing but addition of gear instrumentation may be enough to induce imperceptible changes in its control, and in its performances. So far, if improvements are decided, they have to be carefully managed, strictly avoiding not well documented rough adjustments which could prevent from a clear reconstitution of the series. Furthermore, a schedule should be defined to allow intercalibration between the old and the new survey designs. For this aim, different methods may be applied, from specific intercalibration surveys (Pelletier, 1998) to partial overlap between the two series designs (Cotter, 1997).

2.5 Conclusion

Different authors (Byrne *et al.*, 1981; Carrothers, 1981; Godø & Engås, 1989; Walsh & McCallum, 1995) have convincingly shown that failure to monitor trawl performance can result in an increase in the unsatisfactory levels of error in survey indices. Variations of 23 and 37 % in the abundance indices were estimated in relation to swept area estimates (Godø & Engås, 1989). They have emphasized that direct observations of trawl geometry during all tows seem to be crucial for controlling the swept area in bottom trawl surveys series and improve abundance index estimates. Actually, permanent checking as well as restricting evolution of the standard survey trawls to avoid differences in trawl components are expected to contribute into a reduction of bias and variability in the catching efficiency of various species and size groups (Godø & Engås, 1989; Walsh & McCallum, 1995).

This analysis illustrated and confirmed (i) the need for systematic identification of non-valid hauls and their exclusion for biological studies, and (ii) the necessity for a better estimation of the effective swept area (distance covered in full contact with bottom and wing spread, specially in the deepest areas) to reduce towards more acceptable levels the measurement variability in abundance indices estimates.

When unavailability of other devices, *a posteriori* information as got from depth/time sensor continuous recorders should be systematically stored and used to rectify the haul's information picked up from the bridge. Furthermore, considering the high-uncontrolled variations in wing spread, potential advantage of using a constraining rope on the warps in front of the doors should be investigated. Nevertheless, all this approach would be considered as a compromise. Actually, from the state of art as well as present results, we emphasize that a quality strategy to be developed when applying trawl survey methodology for assessment of demersal resources would combine the use of rigorous protocols that cover all aspects of fishing, and systematic controlling and recording of all the main parameters allowing to characterize the trawl performance and the continuity of its contact with bottom. This approach would gain by jointly involving fishery technologists and biologists in charge of biological resource assessment.

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Item	Vessel Code	*Vessel*	Area	Year	Haul No
Trajectory	PEC	*Pasquale e Cristina*	Albania	1998	37
Trajectory	PEC	*Pasquale e Cristina*	Albania	1999	39
Trajectory	PEC	*Pasquale e Cristina*	Italy-M4	1998	71
Trajectory	PEC	*Pasquale e Cristina*	Italy-M4	1999	72
Trajectory	PAR	*Kapetan Paraschos*	Greece-G1	1999	47
Trajectory	NAU	*Nautilos*	Greece-G3	1999	53
Trajectory	LEU	*L'Europe*	France	1999	16
Trajectory	LEU	*L'Europe*	France	2000	42
Trajectory	FRP	*Francesco Padre*	Italy-M1	1998	74
Trajectory	FRP	*Francesco Padre*	Italy-M1	1999	108
Trajectory	SAN	*Sant'Anna*	Italy-M3	1998	119
Trajectory	SAN	*Sant'Anna*	Italy-M3	1999	153
Stabilization	SAN	*Sant'Anna*	Italy-M3	1995	16
Geometry	LEU	*L'Europe*	France	1994	85
Geometry	LEU	*L'Europe*	France	1995	74
Geometry	LEU	*L'Europe*	France	1996	77
Geometry	LEU	*L'Europe*	France	1997	69
Geometry	LEU	*L'Europe*	France	1998	90
Geometry	IRO	*Ioannis Rosso*	Greece	1994	85
Geometry	IRO	*Ioannis Rosso*	Greece	1996	37
Geometry	COR	*Cornide de Saavedra*	Spain	1995	111
Geometry	COR	*Cornide de Saavedra*	Spain	1996	107
Geometry	COR	*Cornide de Saavedra*	Spain	1997	101

Table 1. Hauls data used for the study.

Figure captions

Fig. 1. Localization of the areas cited in the paper.

Fig. 2. Standard trajectory of a gear from trawl shooting to end of warp retrieving.

Fig. 3. Characteristic parameters used to analyze wing spread stabilization (example from a haul aboard the *Sant'Anna* at 200 m depth; warp length 850 m).

Fig. 4. Relationship between official and effective haul duration for the whole hauls analysed in this paper (×: mean values for Δt_5 respectively equal to 30 and 60 minutes).

Fig. 5. Time between the moment at which the trawl begins to go down and the moment at which it is in first contact with the bottom (Δt_1; Atyp: atypical hauls referring to the parameter, values excluded for the regression).

Fig. 6. Time between the moment at which the trawl is in first contact with the bottom, and the time officially decided as the beginning of the haul (Δt_2; Atyp: atypical hauls referring to the parameter, values excluded for the regression).

Fig. 7. Some examples of standard and atypical trawl vertical trajectories in relation with time (on the main curve; the sharp curves indicate the official start and end of haul as well as the depth recorded by the bridge sounder at this moment).

Fig. 8. Observed time to reach 95% of the stabilized wing spread in relation with warp length (*Sant'Anna*, 1995).

Fig. 9. Haul to haul wing spreads recorded aboard some vessels during routine surveys.

Fig. 10. Average wing spreads of all the studied vessels/cruises (Std: standard relationship used by the MEDITS teams when no direct wing spread observation is available).


France
M1
Gulf of Lions
Italy
Albania
M4
Greece
G1
Spain
M3
Sicilian Channel
G3
Mediterranean Sea

Fig. 1

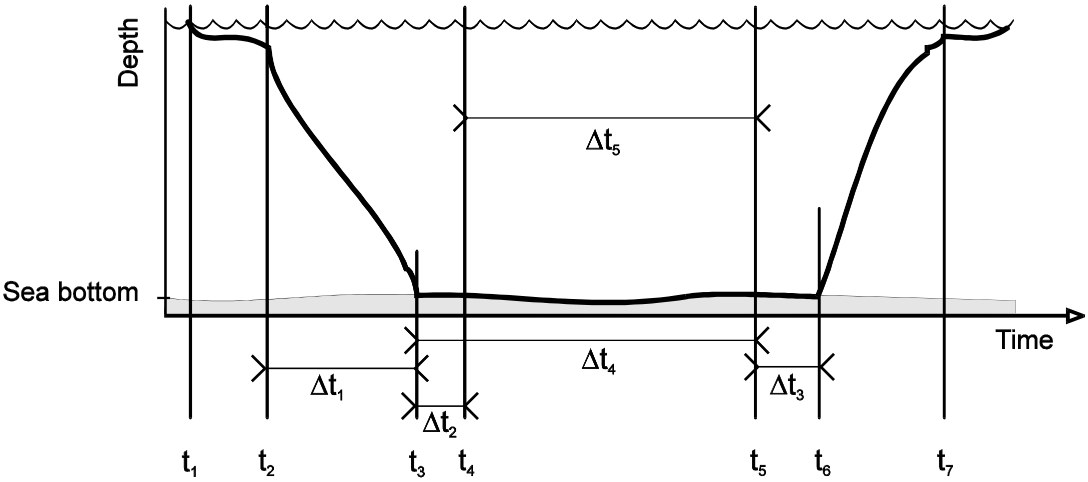

Depth
Sea bottom
Time
Δt5
Δt4
Δt1
Δt2
Δt3
Δt3
t1
t2
t3
t4
t5
t6
t7

Fig. 2

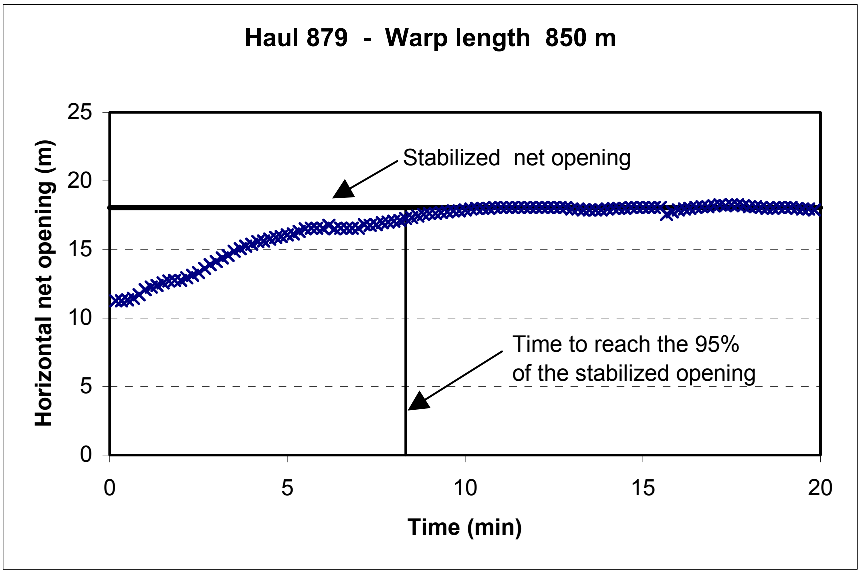

Haul 879 - Warp length 850 m
Horizontal net opening (m)
25
20
15
10
5
0
Stabilized net opening
Time to reach the 95% of the stabilized opening
0
5
10
15
20
Time (min)

Fig. 3

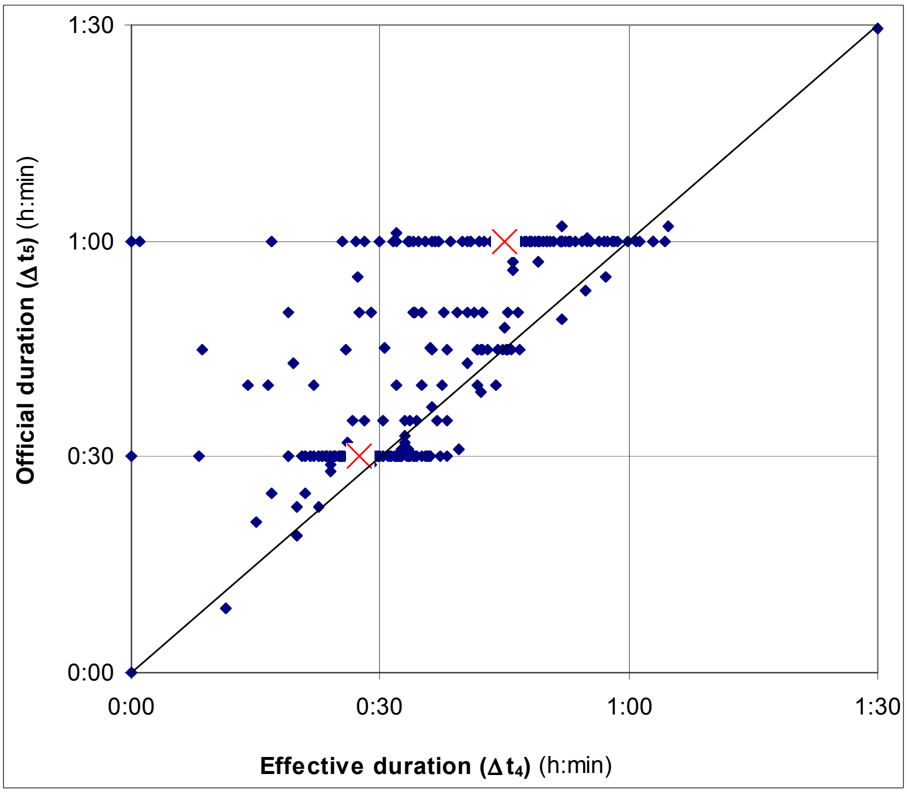

1:30
1:00
0:30
0:00
Official duration (Δt_5) (h:min)
0:00
0:30
1:00
1:30
Effective duration (Δt_4) (h:min)

Fig. 4

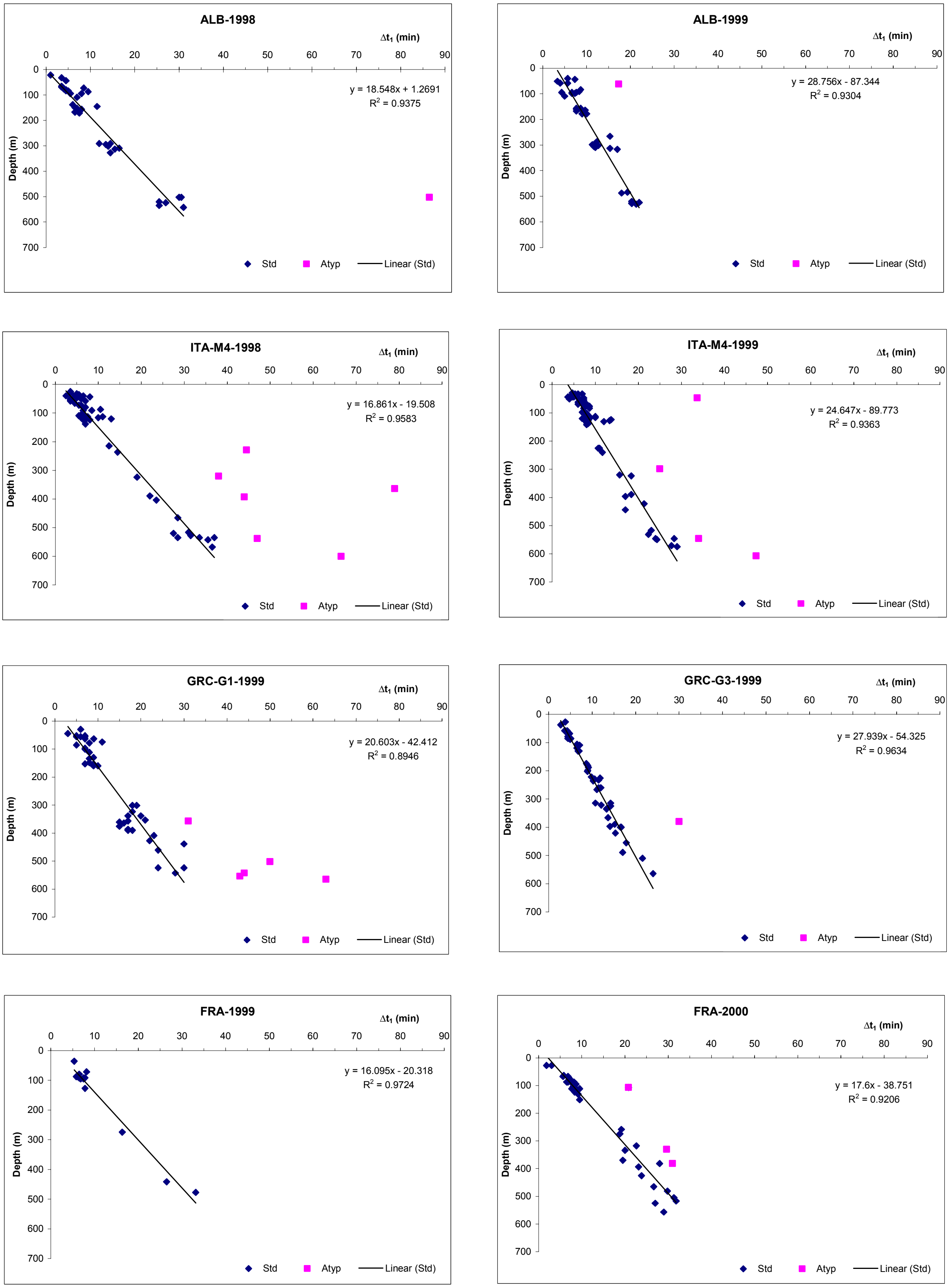

ALB-1998
Δt₁ (min)
Depth (m)
y = 18.548x + 1.2691
R² = 0.9375
ALB-1999
y = 28.756x - 87.344
R² = 0.9304
ITA-M4-1998
y = 16.861x - 19.508
R² = 0.9583
ITA-M4-1999
y = 24.647x - 89.773
R² = 0.9363
GRC-G1-1999
y = 20.603x - 42.412
R² = 0.8946
GRC-G3-1999
y = 27.939x - 54.325
R² = 0.9634
FRA-1999
y = 16.095x - 20.318
R² = 0.9724
FRA-2000
y = 17.6x - 38.751
R² = 0.9206
0 10 20 30 40 50 60 70 80 90
0 100 200 300 400 500 600 700
◆ Std
■ Atyp
—— Linear (Std)

Fig. 5

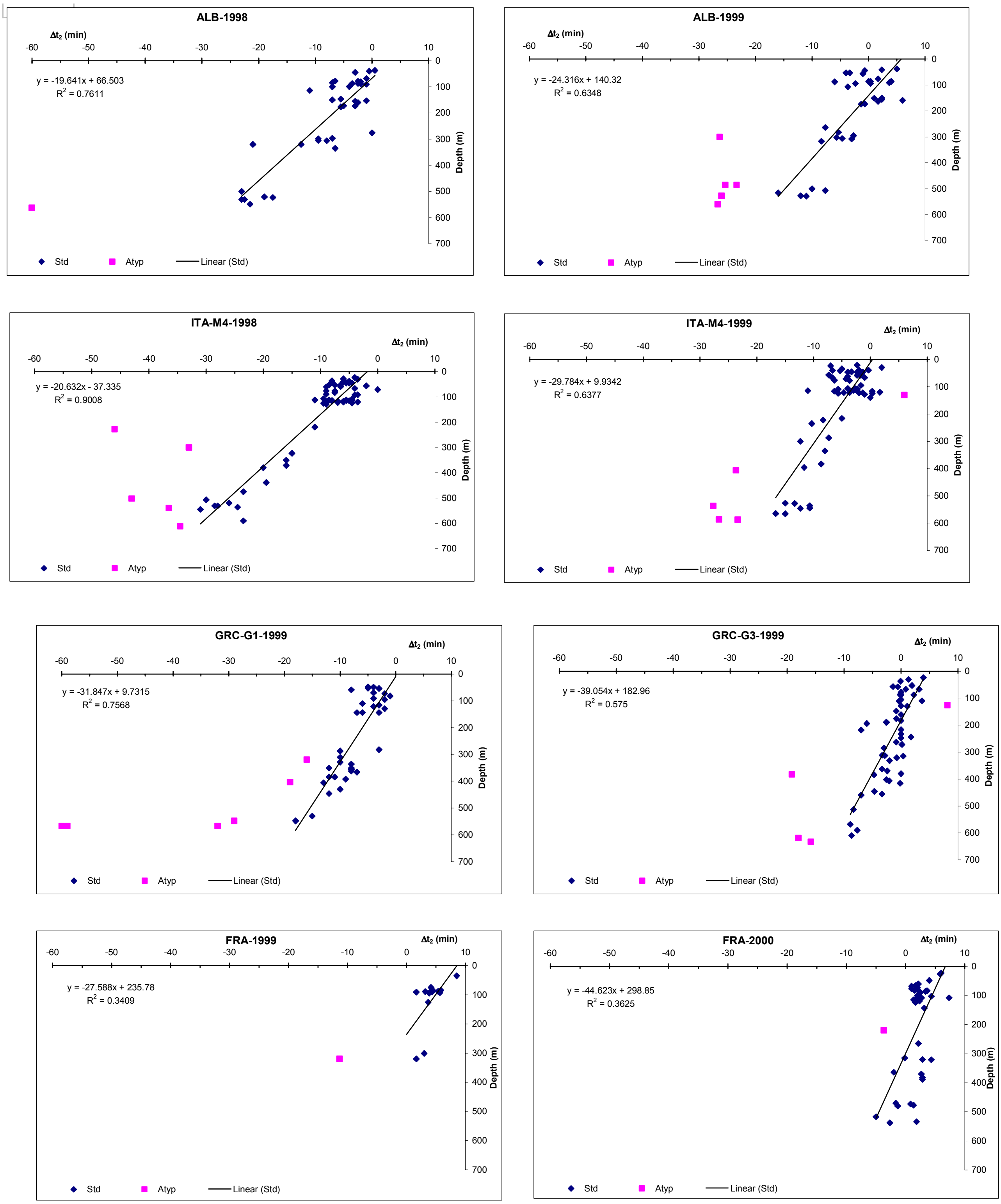

ALB-1998
Δt2 (min)
y = -19.641x + 66.503
R² = 0.7611
ALB-1999
Δt2 (min)
y = -24.316x + 140.32
R² = 0.6348
ITA-M4-1998
Δt2 (min)
y = -20.632x - 37.335
R² = 0.9008
ITA-M4-1999
Δt2 (min)
y = -29.784x + 9.9342
R² = 0.6377
GRC-G1-1999
Δt2 (min)
y = -31.847x + 9.7315
R² = 0.7568
GRC-G3-1999
Δt2 (min)
y = -39.054x + 182.96
R² = 0.575
FRA-1999
Δt2 (min)
y = -27.588x + 235.78
R² = 0.3409
FRA-2000
Δt2 (min)
y = -44.623x + 298.85
R² = 0.3625
-60
-50
-40
-30
-20
-10
0
10
Depth (m)
0
100
200
300
400
500
600
700
Std
Atyp
Linear (Std)

Fig. 6

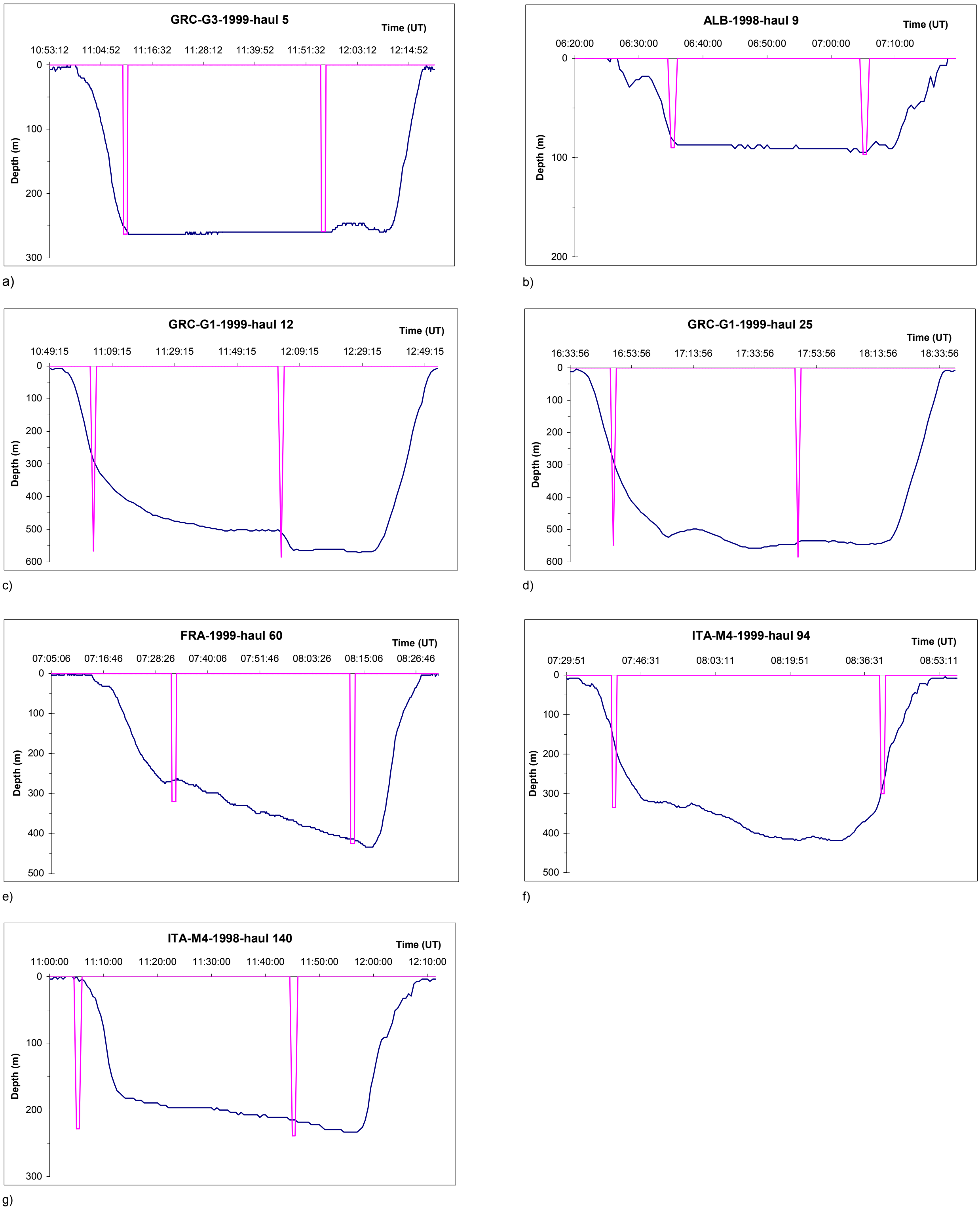

GRC-G3-1999-haul 5
Time (UT)
10:53:12
11:04:52
11:16:32
11:28:12
11:39:52
11:51:32
12:03:12
12:14:52
Depth (m)
0
100
200
300
a)
ALB-1998-haul 9
Time (UT)
06:20:00
06:30:00
06:40:00
06:50:00
07:00:00
07:10:00
Depth (m)
0
100
200
b)
GRC-G1-1999-haul 12
Time (UT)
10:49:15
11:09:15
11:29:15
11:49:15
12:09:15
12:29:15
12:49:15
Depth (m)
0
100
200
300
400
500
600
c)
GRC-G1-1999-haul 25
Time (UT)
16:33:56
16:53:56
17:13:56
17:33:56
17:53:56
18:13:56
18:33:56
Depth (m)
0
100
200
300
400
500
600
d)
FRA-1999-haul 60
Time (UT)
07:05:06
07:16:46
07:28:26
07:40:06
07:51:46
08:03:26
08:15:06
08:26:46
Depth (m)
0
100
200
300
400
500
e)
ITA-M4-1999-haul 94
Time (UT)
07:29:51
07:46:31
08:03:11
08:19:51
08:36:31
08:53:11
Depth (m)
0
100
200
300
400
500
f)
ITA-M4-1998-haul 140
Time (UT)
11:00:00
11:10:00
11:20:00
11:30:00
11:40:00
11:50:00
12:00:00
12:10:00
Depth (m)
0
100
200
300
g)

Fig. 7

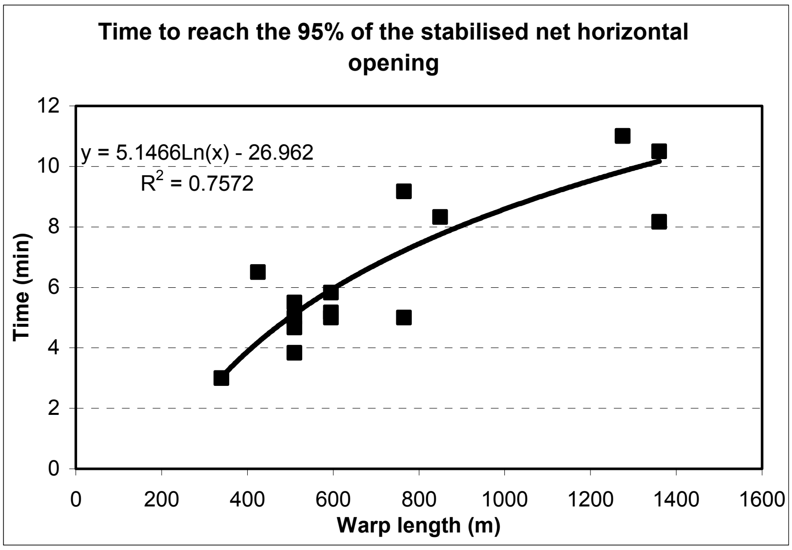
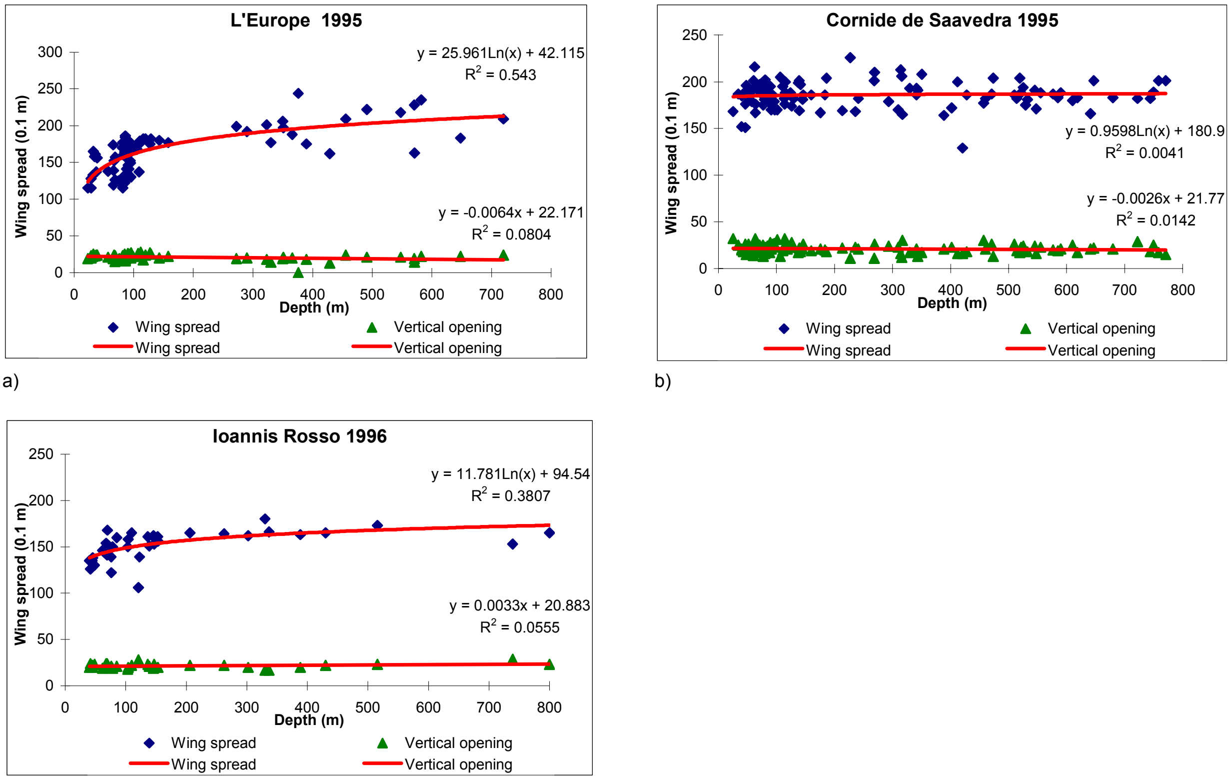


Fig. 8



a)

b)

c)

Fig. 9

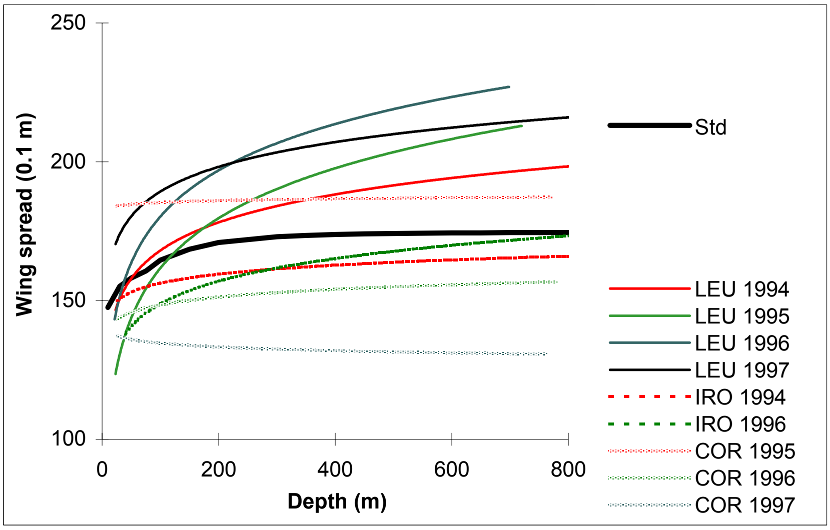

250
200
150
100
Wing spread (0.1 m)
0
200
400
600
800
Depth (m)
Std
LEU 1994
LEU 1995
LEU 1996
LEU 1997
IRO 1994
IRO 1996
COR 1995
COR 1996
COR 1997

Fig. 10

[3] Working Group on the definition of biogeographical units for trawl fishery management purpose

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3.1 General Introduction

The fishery management objectives have been strongly updated during the last decade. Indeed, due to the multispecies nature of most of the trawl fisheries, a management by single-species quota control often appeared difficult (Daan, 1987). Thus, after a long tradition of single-species assessment as the main basis of fish stock management, fishery science has moved into a new era where multispecies approaches receive an increasing attention (Mercer, 1982). The concept of multispecies assessment recognizes that fish species do not exist independently of each other, and that they are not harvested independently (Daan, 1987; Mahon and Smith, 1989). In this context, multispecies approaches are usually based on the definition of fishery management units in time and space, such as catch with a specific type of fishing gear exhibit an homogeneous species composition (Tyler, *et al.*, 1982; Murawski, *et al.*, 1983; Overholtz and Tyler, 1985; Gabriel, 1992).

As far as the UE is concerned, there is a increasing request for a bringing together between the fishery and the environment policies (Anon. 2001). This final goal is then to progress towards a more integrated approach through the concept of exploited ecosystem management (FAO 2001). So, defining biogeographical areas as reference for management purpose first requires to describe the spatio-temporal organization of fish assemblages and to better understand its determinism (Gabriel and Murawski, 1985; Mahon and Smith, 1989; Auster, *et al.*, 1995; Langton, *et al.*, 1995; Mahon, *et al.*, 1998). The perspective here is that the community, i.e. a fish assemblage (sensu Tyler, *et al.*, 1982), is the basic unit of analysis, and that changes over time are best understood by following changes, both in composition and in spatial distribution, within the community (Gomes, *et al.*, 1995). On this basis, using the MEDITS data, the work conducted by the present working group constituted a preliminary attempt in view to the definition of biogeographical units for trawl fisheries management purpose.

The activity of the working group towards the definition of biogeographical units was organized around two successive stages. A first stage aimed to propose a formal methodological approach with a view to improve our understanding about the determinism of the organization of demersal assemblages in the north of the Mediterranean sea. A detailed presentation of this methodological approach is developed in the first section of this report. A second stage consisted to carry out preliminary works at different spatial scales in order to illustrate some of the potential contributions of the proposed approach. Each of these works, conducted by specific teams within the MEDITS group, was described in independent sections. To incite a general diffusion of these works, each of the corresponding sections (i.e. from section two to seven) has been organized following the standard format of a scientific publication.

3.2 SECTION I: The approach

J.C. Gaertner[1], L. Gil de Sola, A. Kallianiotis, N. Ungaro

From a deep analysis of the international literature, we propose an approach to define *in fine* “biogeographical units for management purpose”. By biogeographical units we mean geographic entities featured by specific assemblages whose the spatio-temporal organization is clearly identified. In this context, the methodological approach defined by the present working group can be divided into three successive steps:

1. Definition of assemblages and identification of their spatial distribution boundaries.
2. Monitoring the temporal evolution of the assemblage structuring.
3. Characterizing and quantifying the main processes acting on their origin and persistence.

Indeed, identifying the relative strength of biogeographical discontinuities constitutes a preliminary, but essential basis for defining spatial (or ecosystem) management units (Tyler, *et al.*, 1982; Biagi, *et al.*, 1989; Gabriel, 1992; Mahon, *et al.*, 1998). Furthermore, once the assemblages have been defined and their spatial distribution clearly identified (step 1), it is necessary to deal with their temporal persistence (step 2). If the assemblage structuring in a given area does not exhibit a common organizational pattern from one survey to another, it is not possible to use them as management units (Overholtz and Tyler, 1985; Mahon and Smith, 1989). Furthermore, the definition of regions that are stable in species composition constitutes a source of information on the organization of the fleet concerned (Bianchi, 1991; Weinberg, 1994; Taquet, *et al.*, 1997). In addition, analyses of resources stability or variability in time is useful to assess the reaction of communities to natural or anthropogenic disturbances (Gomes, *et al.*, 1995; Aldebert, 1997; Gaertner, *et al.*, 1998). More generally, understanding the causes of observed assemblage patterns may help managers to anticipate the influence of anthropogenic and natural processes on resources availability in the future.

Moreover, in exploited ecosystems, the identification of associations between the species and their environment (step 3) constitutes a major step towards incorporating the effects of environmental variability into abundance indices and reducing by-catch problems (Rose and Legett, 1988; Rakocinski, *et al.*, 1992; Perry, *et al.*, 1994). According to Perry *et al.* (1994). Such knowledge will significantly reduce the amount of noise associated with environmental variability and produce abundance indices that are more sensitive to the detection of real changes in species' abundance. So, apart from the definition of areas for management purposes, the proposed approach could also help to progress in several important fields of fisheries ecology. More generally, it contributes to support a growing conviction in fisheries ecology: in addition to the information on the commercially demersal assemblages, the management units must include information on other communities, taxa and environmental components of the ecosystem (Caddy, 1993; Lévêque, 1995; Gaertner, *et al.*, 1999).

The proposed approach reveals some technical and methodological constraints. From a practical viewpoint, defining geographical units requires to collect data concerning both commercial and non commercial species. For this reason, numerous works used data from experimental trawling surveys in order to deal with the analysis of the spatial and temporal organization of demersal fish communities (Colcovocoresses and Musick, 1984; Overholtz and Tyler, 1985; Mahon and Smith, 1989; Biagi, *et al.*, 1989; Bianchi, 1991; Gomes *et al.*, 1992; Loneragan and Potter, 1990; Abella and Serena, 1995a and 1995b; Wantiez, 1996; Aldebert, 1997; Fariña *et al.*, 1997; Ungaro *et al.*, 1998; Jennings *et al.*, 1999; Garcia *et al.*, 1998; Kallianiotis *et al.*, 2000, Jukic-Peladic *et al.*, 2000). In comparison with traditional approaches based on commercial landing data, using experimental surveys provides fishery-independent indices for target species, and basic knowledge on the abundance and organization of non-commercial species.

Moreover, the comparisons between data coming from (1) a unique area but performed at different periods (necessary to reach the step 2 of our approach), or (2) the same period but in different areas (step 3) can be only assessed using a set of standardized surveys. Unfortunately, if the standardization of the sampling design is usually correct in the first case it is yet uncommon in the second one. In the Mediterranean Sea, the MEDITS programme (International Bottom Trawl Survey in the Mediterranean; Bertrand and Relini, 2000) may well meet all these requirements. Indeed, this programme, which has been carried out annually from 1994 to now in several areas of the Mediterranean Sea, is featured by a high effort to standardize the sampling design between the different surveyed regions (Bertrand and Relini, 2000; Bertrand, *et al.*, 2000). So, in addition to direct assessment of the commercial species, the

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data collected during this programme provide a unique basis to better understand the spatio-temporal organization of demersal assemblages at the scale of the North-Mediterranean Sea.

From a methodological viewpoint, monitoring temporal evolution of assemblages (step 2) and quantifying the main processes responsible for their organization (step 3) requires combined analysis of different data tables. Until recently, the treatment of three-dimensional data sets (stations-species-time or stations-species-areas) failed because of methodological problems (Centofanti *et al.*, 1989; Dolédec and Chessel, 1989; Gaertner, 1997). Referring to fishery ecology purpose, Mahon *et al.* (1998) pointed out the subjective aspect of traditional approaches and concluded that it limited the value of works focused on this field. However, this situation is changing. Numerous statistical approaches have been developed during the last two decades to describe patterns of multivariate structures (Ter Braak, 1987; Lebreton, *et al.*, 1991; Clarke and Ainsworth, 1993; Borcard and Legendre, 1994; Thioulouse, *et al.*, 1995; Legendre, *et al.*, 1997; Underwood and Chapman, 1998). Among them, constrained analyses, such as Canonical Correspondence Analysis (CCA; Ter Braak, 1986; Palmer, 1993) or Principal Component Analysis on Instrumental Variables (PCAIV; Rao, 1964; Sabatier, *et al.*, 1989), widely used in several fields of terrestrial and marine ecology (Yoccoz and Chessel, 1988; Lebreton, *et al.*, 1991; Borcard and Legendre, 1994; Belgrano, *et al.*, 1995; Mazouni, *et al.*, 1998) have also found some applications in demersal assemblages studies (Fariña, *et al.*, 1997; Pech and Laloë, 1997; Gaertner, *et al.*, 1999). Moreover, the recent development of multitable analyses (Lavit, *et al.*, 1994; Escoffier and Pagès, 1994; Chessel and Hanafi, 1996; Gaertner, *et al.*, 1998), which offers a theoretical frame to compare several data tables, showed their usefulness to study the spatial and temporal organization of marine communities (Gaertner, *et al.*, 1999; Mazouni, *et al.*, 2000).

Consequently, both the progress of statistical tools and the existence of a set of standardized experimental surveys gave the opportunity to investigate each of the three steps necessary to define biogeographical units in the Mediterranean demersal fisheries. In this frame, the following sections of this report aimed to give illustrations of analyses focused on each of the three above-mentioned steps. Definitions of assemblages and identification of their spatial distribution boundaries (step 1) were mainly considered at a regional scale (e.g. at the one of the MEDITS operational areas) using several kinds of multivariate methods such as clusters, factorial analyses and multidimensional scaling. Monitoring of temporal evolution of the assemblages structuring (step 2) has been investigated at a regional scale using multitable analyses such as the STATIS method. This work also contributed to characterize the main processes taking effect on the origin and persistence of the observed patterns (step 3). In addition, the step 3 has been specifically investigated on the basis of inter-regional comparisons using Multitable methods in order to give a better insight of the determinism of assemblages organization at the MEDITS global scale.

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3.3 SECTION II *Feeding guilds of western Mediterranean demersal fish and crustaceans: an analysis based in a spring survey*

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SUMMARY: The MEDITS-99 sampling was performed along all the Iberian Peninsula coasts of the western Mediterranean (from the Alborán Sea to Cape Creus) in a space-scale of 1000 Km N-S, at depths ranging between 27-790 m. Fish and decapod crustaceans were dominant in the megafaunal compartment sampled by trawling. In base both to the fish and to the decapod crustacean composition, a comparison of trophic guilds has been attempted, being fish and decapods classified as: 1) migrator macroplankton feeders (mM), 2) non-migrator macroplankton feeders (nmM), 3) nektobenthos-suprabenthos feeders (NS), 4) epibenthos feeders (Epib), 5) large detritus-scavengers (Sca), 6) infaunal feeders (Inf), 7) deposit feeders (Dep) and 8) small detritivorous (Det). Multivariate techniques evidenced the following differences in the trophodynamics of the megafaunal assemblages along the coasts of the Iberian Peninsula: 1) crustaceans (mainly decapods) have different trophic structure on the shelf and on the slope; 2) on the slope, fish evidenced more clear changes as a function of the geographical gradient than crustaceans; and 3) trophodynamics of bathyal fish showed some geographic variations between the Alborán Sea, the Catalano-Balearic Basin, and the Algerian Basin (Vera Gulf and Alicante sectors), with a progressive north-south increase in planktofagous species.

3.3.1 INTRODUCTION

Demersal fisheries along the Mediterranean coasts have been directed to a variety of resources, including fish, decapod crustaceans and cephalopods (Bertrand and Relini, 2000). Trawling is the main fishing activity below the 50 m isobath, with an important increase in deep-water fisheries (deeper than 150 m) which has been operating for a long time (Bas *et al.*, 1955) on important target species such as the shrimps *Parapenaeus longirostris* and *Aristeus antennatus,* the Norway lobster *Nephrops norvegicus*, or fish species such as hake *Merluccius merluccius* or *Phycis blennoides*. These fisheries can reach down to 800 m.

During recent years, the sustainable use of natural resources has been increasingly enhanced. Deep-water communities have received increasing attention at a global scale because of the interest in new fishing grounds and fisheries at bathyal depths (Hopper, 1994; Merrett and Haedrich, 1997). However, deep-water ecosystems have lower energetical turnovers than shallow-water or littoral systems and their carrying capacity is expected to be lower. Since most of the target species are slow growing, overexploitation can be detected in deep-sea fisheries only after some years or decades after the beginning of a fishery (Atkinson, 1994; Bowering and Brodie, 1994; Koslow, 1997).

In addition to indexes such as abundance, or harvest-induced mortality (Hutchings and Myers, 1994), to quantify changes and the impact in the carrying capacity of a system, trophodynamic aspects can be studied (Petersen and Curtis, 1980; Robinson and Ware, 1994; Christensen, 1995, among others). Trophodynamic studies constitute the base of mass-balance models (i.e. ECOPATH models), which have increasingly been considered for the study and management of marine ecosystems (Robinson and Ware, 1994; Wolff, 1994; Christensen, 1995; Pauly and Christensen, 1995). In practice, however, great difficulties exist to develop such models in deep-water systems, because only scarce data have been published on important quantitative aspects such as secondary production (Cartes and Sorbe, 1999; Cartes *et al.*, 2000), and daily rations (Maynou and Cartes, 1997; 1998; Cartes and Maynou, 2001), with only some preliminary trophic balances constructed for the mid-slope depths (Cartes and Maynou, 1998). Trophodynamic studies in deep-sea systems have often focused on species of commercial interest (Macpherson, 1985; Bulman and Koslow 1992, Maynou and Cartes 1997), whereas by-catches and studies on the lowest trophic levels, i.e. those compartments that sustain the trophic webs and fisheries, have received, in general, little attention (Christensen, 1995; Cartes and Maynou, 2001).

Even at stable environments such as the deep sea, local changes in the food supply and productivity may affect the trophic structure and dynamics of marine ecosystems which is reflected for instance in the zonation pattern of species with depth (Haedrich and Merrett, 1990; Maynou and Cartes, 2000). It is, thus, often delicate to extrapolate the results obtained in a concrete area to a wider geographic scale. As an alternative to the lack of the integral sampling of trophic webs, comparative studies on trophic guilds composition with depth and geographic gradients can give information on changes in the ecosystem structure and functioning because changes in feeding guilds composition may reflect differences in the structure of trophic webs and in the energy flow. Thus, Koslow (1997) defined a distinct guild of fish species that aggregate around seamounts in Australian waters where *Hoplostethus atlanticus* is the main target species. This guild is characterized by high levels of pelagic-food consumption and strong swimming performance. Recently, important differences were evidenced between the trophic guilds of bathyal crustaceans inhabiting the Catalan Sea and the SW Balearic Islands, with dominance of non-migrator macroplankton feeders (mainly composed by *Plesionika* spp. shrimps) in the SW Balearic Islands, and higher abundance of infaunal and deposit feeders in the Catalan Sea area (Cartes *et al.*, 2000; Maynou and Cartes, 2000). Plankton and benthos may, thus, support distinctly trophic chains in relatively neighbouring areas. Our objective in this study is to compare and identify zones with different food-web structure (i.e. more or less supported by plankton or benthos productivity), along the wide geographic area prospected in MEDITS cruises in a space-scale of 1000 Km. Plankton and benthos are two contrasting food sources in marine environments as evidenced, for instance, from results obtained using $\delta^{13}C$ stable isotope analysis (Jennings *et al.*, 1997).

3.3.2 MATERIAL AND METHODS

The MEDITS-ES99 cruise (May-June 1999) comprised a total of 116 trawls performed between 27 to 790 m depth along the coasts of the Iberian Peninsula (western Mediterranean) from the Straits of Gibraltar to Cape Creus (Fig.1). Fish and crustaceans (mainly megabenthic decapods) were sampled with a especially designed bottom trawl (cf. Bertrand *et al.*, 2000), equipped with 2 doors, 2 trawl warps, and a 100 m long bridle, with an horizontal aperture of *ca.* 18 m and a vertical height of *ca.* 2 m. The codend mesh size was 10 mm. In previous studies on MEDITS cruises (Abelló *et al.*, 2000, in present volume; Carbonell *et al.*, 2000), this area was divided into 8 geographical sectors: (1) Western Alborán Sea (WALB), from Gibraltar to Nerja; (2) Eastern Alborán Sea (EALB), from Nerja to Cape Gata; (3) Vera Gulf (VERA), from Cape Gata to Cape Palos; (4) Alicante (ALIC), from Cape Gata to Cape La Nao; (5) Valencia (VALE), from Cape La Nao to Castelló; (6) Ebro delta region (DELT), from Castelló to Tarragona; (7) Northern Catalonia (NCAT), from Tarragona to Cape Creus, and (8) Eivissa island (EIV) (Fig. 1). We adopted this same nomenclature to the *a posteriori* labelling of our sampling stations in the multivariate analysis results.

Feeding guilds were established for fish and crustaceans. Both fish and crustacean species were classified within the following feeding groups (or guilds): 1) migrator macroplankton feeders (mM), 2) non-migrator macroplankton feeders (nmM), 3) nektobenthos-suprabenthos (=vagile fauna) feeders (NS), 4) epibenthos (= non vagile fauna) feeders (Epib), 5) large detritivorous-scavengers (Sca), 6) infaunal feeders (Inf), 7) deposit feeders (Dep), and 8) small detritivorous (Det). Guilds 1, 2, 4 and 6 are both common to fish and decapods, guild 3 is described only for fish, while guilds 5, 7 (deposit feeders) and 8 (small detritivorous) only existed among crustaceans (see Table 1).

Trophic guilds have been already defined in previous studies both among fish (e.g. Gartner *et al.*, 1997) and Mediterranean decapod crustaceans (Cartes, 1998; Maynou and Cartes, 2000). In our study, guilds are defined based on detailed information both on crustaceans and on bathyal-fish diets in the western Mediterranean (Cartes, 1991; 1994; 1998; Cartes and Abelló, 1992; Macpherson, 1977, 1979; Carrasson and Matallanas, 1990; Carrasson *et al.*, 1992; Carrasson, 1994; Stefanescu and Cartes, 1992 and references cited therein). In addition, summery diets of a total of seven decapod species, not previously documented, have been included in Table 2. The established guilds incide in the dependence of fish/crustaceans to the exploitation of benthic or pelagic food resources which may indicate local changes in the trophic structure of trophic webs. It is also well known that, even in a relatively stable environment such as the deep sea, fish have seasonal changes in their diet. The temporal effect is minimized in our study given the practically simultaneous sampling of an extense area covered in the MEDITS cruise. We also assume that feeding preferences of species did not vary along the geographical gradient covered in the MEDITS cruise (see discussion below).

Crustacean feeding guilds were studied throughout the bathymetric range sampled. Fish, however, were only considered at bathyal depths, due to: (i) the gaps existing for dietary studies in an important proportion of shelf fishes in our area; and (ii) we consider delicate to extrapolate the results of dietary studies made in other areas, in view to the high habitat and food-source heterogeneity reported for shelf-living fishes (see for instance Jennings *et al.*, 1997). Bathyal hauls for the fish-guilds study were selected after a clustering analysis was performed on the matrix of species composition. These matrix was constructed in base to 185383 specimens pertaining to 114 species captured in the 116 trawls. Species occurring with < 5 specimens were removed from the data matrix and the captures were standardized to 1 h of trawling. Pearson correlation coefficient (1-r) was used as distance and the UPGMA as the algorithm of aggregation (Statistica 4.5), after log transformation of values to linearize data. The cluster analysis (Fig. 2) evidenced a major fish-faunistic discontinuity situated around 325-341 m, separating the group of bathyal trawls (down to 790 m) from the group including the shelf-fish assemblages (27 to 325-341 m). Within this last group, a secondary homogeneous cluster was identified containing trawls between 240 to 341 m. As a consequence, those trawls exceeding 300 m depth were selected in this study for trophic guild analysis thus avoiding the excess of heterogeneity in the samples. Under this criteria, a total of 18533 specimens pertaining to 53 bathyal species captured in 42 trawls were selected.

Once feeding groups were established, clustering methods were applied (1-r / UPGMA) to the crustacean and fish matrix feeding groups. For crustaceans, species occurring with < 5 specimens, and trawls where < 8 individuals were captured were removed from the data matrix, resulting in a total of 97 valid trawls. Clustering analysis evidenced two main assemblages separating the continental shelf and the slope samples (see below). Multidimensional scaling (MDS) techniques were applied to the similarity matrix generated by clustering (1-r measure) to obtain a 2-dimensional representation of the trophic guild composition of: 1) crustaceans from the continental shelf; 2) bathyal fish from those trawls exceeding 300 m depth (see above); and 3) bathyal crustaceans, which were only considered from trawls exceeding 300 m to give a more reliable comparison between fish and crustaceans. The objective was to explore other factors than depth (especially geographical variations) which may contribute to the ordination of trophic guilds along interpretable dimensions.

3.3.3 RESULTS

Qualitative data on the diet of seven decapod crustaceans has been obtained in base to stomach content analysis. Species were included in their corresponding feeding guild based on this information (Table 2).

Cluster analysis revealed a clear separation in trophic-guild composition among crustaceans (mainly decapods) collected, with low r (of *ca.* 0) separating the two main groups of samples (Fig. 3). These groups were clearly formed as a function of depth, revealing quite different trophic composition and probably trophodynamics on the continental shelf and on the slope: G1 comprised hauls performed between 27 and 138 m (excluding a single haul performed at 302 m); G2 comprised hauls between 118 and 790 m depth (with the single exception of a haul performed at 98 m). Within G2 further depth separation exist with a deeper homogeneous group which was almost exclusively composed of hauls performed between 311 and 790 m (Fig. 3; G_S). Similar results, at least concerning the identification of G1 and G2 groups, were attained using the Euclidean distance and Ward algorithm (not included).

We tried to identify some other gradient (e.g. geographical) within the shelf (trawling depths between 27 and 118 m; 44 samples) and the slope (> 300 m depth; 42 samples) groups: Among crustaceans, MDS based in the 1-r similarity matrix did not reveal any clear subgrouping neither within the shelf nor the slope groups. The shelf samples were ordered (stress = 0.154) in a two dimensional space, as in the case of slope samples (stress = 0.160). The 44 shelf samples were not grouped as a function of any geographical gradient (Fig. 4a). Shelf samples from the area around the Ebro river delta (DELT sector) and the Alborán Sea occupied the extremes of the gradient in the MDS plot, which suggests that some ordination probably takes place in the continental shelf as a function of small-scale changes in the sediment characteristics (a non-measured parameter in the present study). Among the 42 slope samples, 6 samples corresponding to the Catalan Sea area (NCAT sector) showed some separation. Also, certain gradient of north-south ordination can be observed along the first axis (factor 1), with some northern (NCAT), and southern (WALB) samples placed in the extremes of the axis (Fig. 4b). However the rest of bathyal samples did not show any ordination.

Among bathyal fish, both the clustering and the MDS, based also in the 1-r similarity matrix, gave some separation of samples. Cluster analysis (Fig. 5) revealed a first homogeneous group of 7 trawls performed in the Alborán Sea (Alb) dissimilar (1-r = 0.84) from the rest of samples. Some new groupings were also detected between trawls performed north and south from Cape La Nao (Fig. 5). Gs included 18 trawls, 15 of them performed south from Cape La Nao, whereas Gn included 15 trawls, 10 of them collected in the Catalano-Balearic Basin, north from Cape La Nao. Furthermore, the fact that some samples collected in a same sector (i.e. NCAT, WALB, EIVI....) were further grouped suggest small-scale or local spatial trends in the changes and distribution of trophic guilds. The MDS (stress = 0.150) separated the Alb group of 7 samples (Fig. 6) from the rest. Within this last group, Gs, containing most of the samples from VERA, ALIC sectors, and also samples from EALB not included in the Alb group, can be identified in the top of Axis 2. The Gn group (Axis 2: bottom) is characterized by the dominance of samples from VALE, DELT, and NCAT sectors and the total absence of EALB-WALB samples. It is interesting to compare the MDS results obtained for bathyal crustaceans and fish (Figs. 4b and 6), with a clearer geographical gradient detected among bathyal fish with some differences in the composition of guilds basically north and south from Cape La Nao.

Trophic guilds composition for crustaceans has been detailed in Table 3. On the continental shelf, crustacean assemblages were dominated by non-migrator macroplankton feeders (nmM; 54.8%), and by epibenthos feeders (Epi; 25.0%), both accumulating *ca.* 80% of abundance. The pandalid shrimps *Plesionika heterocarpus* and *Chlorotocus crassicornis* were the dominant species among nmM, while portunid crabs (*Liocarcinus depurator* and *Macropipus tuberculatus*) dominated among Epi. On the slope (>300 m depth), migrator macroplankton feeders (mM), and non-migrator macroplankton feeders (nmM), dominated accumulating *ca.* 86% of abundance (Table 3). *Pasiphaea sivado* and *Sergestes arcticus* dominated among the mM, and *Plesionika* spp. among the nmM. Infaunal feeders (Inf; i.e. *Parapenaeus longirostris* and *Aristeus antennatus*) reached also some importance at this level (9.4%).

Bathyal-fish assemblages were dominated by non-migrator macroplankton feeders (nmM) and Infaunal feeders (Inf), accumulating *ca.* 70% of abundance (Table 4). The dominant species were the shark *Galeus melastomus*, the bony fishes *Gadiculus argenteus* and *Hoplostethus mediterraneus* among nmM, and *Phycis blennoides* and *Coelorhynchus coelorhynchus* within the Inf group. Geographical changes detected in trophic guilds among fish consisted in a higher percentage of abundance of Inf group in the Catalano-Balearic Basin (47.5%), while nmM were dominant in G2 (Algerian Basin south of La Nao cape; 43.8%) and in the Alborán Sea group (50%) (Table 4). One-way ANOVAs and *post-hoc* Scheffé test indicated higher significant differences in the mean density (ind./h; n=42) of some trophic guilds between the three geographical areas deduced from multivariate analysis of bathyal fish. The density of the mM guild in the Alborán Sea (Alb) was significantly higher than in the Algerian Basin (AB) and in the Catalano-Balearic Basin (CBB)($p<0.05$), while the density of nmM feeders was only significant between Alb and CBB ($p<0.01$). The density of the NS guild in the Alborán Sea (Alb) was also significantly higher than in the Algerian Basin (AB) and in the Catalano-Balearic Basin (CBB)($p<0.001$). Between the AB and the CBB significant differences were only recorded comparing the density of the mM guild ($p<0.05$).

3.3.4 DISCUSSION

The analysis of the feeding guilds may evidence differences in the trophic structure and ecosystem dynamics, and therefore they may have implications in the management of fisheries (Koslow, 1997). Along the coasts of the Iberian Peninsula, fish and crustacean communities evidenced different trophic structure depending not only on the taxa considered, but also on the depth of occurrence (shelf and slope assemblages) and on a geographical gradient. Shelf crustacean guilds prey more on benthos (42%) than bathyal crustacean guilds (11%), while zooplankton resources were more consumed by bathyal crustaceans (86%) than by shelf species (55%). Crustaceans, however, are a secondary taxa in shelf communities (mean density: 100.1 ind/h), where fishes widely dominate (mean density: 1604 ind/h). As in the case of crustaceans, bathyal fish assemblages are also dominated by zooplanktophagous species (61.4%) with some geographical variations (see below). The dominant shelf species were *Capros aper*, *Maurolicus muelleri* or small *Merluccius merluccius* (see Table 5) which also are well-natatory species preying on plankton resources (Macpherson, 1977; Withehead *et al.*, 1986), attaining similar dominance (> 68.5% of abundance) than that of bathyal fishes. These species are among the dominant fish in previous samplings conducted in the same area (Lloris *et al.*, 2000).

Considering fish and crustaceans together, the plankton/benthos consumers ratio would be situated ~2.3/1 in the continental shelf, increasing to ~ 4/1 at the slope, which suggests a higher dependence on pelagic trophic resources by bathyal communities. This results are generally consistent with the available data both on zooplankton and macrobenthos (available prey) distribution on the shelf and slope in the study area. Thus, Sabatés *et al.* (1989) reported a major density of zooplankton offshore in the shelf-slope break, associated to the permanent termohaline front in the Catalan Sea area (Catalano Balearic Basin). Similar frontal systems are also described in the mainland margins of the Algerian Basin (Millot, 1987). In contrast, benthos resources had higher importance as food-source in shelf communities, which is also consistent with a generally admitted decrease in benthos biomass with depth (Rowe, 1983) . In the western Mediterranean, biomass and diversity of megafaunal invertebrates, such as echinoderms, were higher in the shelf (Pérès, 1985), a fact that was also observed in the present sampling (pers. obs.). In the Catalano-Balearic Basin, macrofaunal benthos biomass is 2.04 gAFDW/m^2 at shelf depths (Guille, 1971), decreasing to 0.37 gDW/m^2 at bathyal depths (400-600 m) off Barcelona (authors unpubl. data).

Trophic guilds are widely defined and employed in macrobenthos studies (i.e. polychaetes; Fauchald and Jumars, 1979). Although this concept is less used in megafaunal studies, some authors also defined trophic guilds for fish (Gartner *et al.*, 1997) using also equivalent functional feeding terms, such as trophic groups (Cartes, 1998) or feeding associations (Macpherson and Roel, 1987) both for fish and for large decapod crustaceans. The fact of including a species within a concrete feeding group or guild may be submitted to some criticisms since fish (and decapods) are euryphagous with a mixed diet, mainly, but not strictly, based on benthos or plankton prey (Macpherson and Roel, 1987; Mauchline and Gordon, 1991; Cartes, 1998). Furthermore, even in a relatively stable environment such as the deep sea, fish and invertebrates have changes in the diet depending on size and season (Macpherson and Roel 1987; Cartes, 1994; 1998).

Our study has basically a comparative value, since the MEDITS-99 cruise was performed in May-June, the period after the peak of primary production when a higher plankton biomass is available, thus probably biassing the diet of fish and crustaceans. We also assume that feeding preferences of species do not vary along the geographic gradient covered, this seeming reasonable when comparing the diet of some representative species from distant geographical areas. Thus, the red shrimp *Aristeus antennatus* preys mainly on polychaetes, bivalves and small peracarid crustaceans in the Catalan Sea (Cartes, 1994), in the Ligurian Sea (Relini Orsi and Würtz, 1977), and in the Atlantic coast of Morocco (Lagardère, 1972). A similar case is that of the shrimp *Aristaeomorpha foliacea* which has a similar diet, based on pandalid shrimps and euphausiids, off the Balearic Islands (Cartes, 1995), off Morrocco (Lagardère, 1972) and also probably in Australian waters, where this shrimp preys on midwater crustaceans (Rainer, 1992). The Norway lobster *Nephrops norvegicus* preys on similar resources (polychaetes, decapod crustaceans and fish) at bathyal depths in the Bay of Biscay (Lagardère, 1977) and in the deep-Mediterranean (Cristo and Cartes, 1998; unpubl. data), with small changes only among secondary prey. Among fishes, bathyal species such as *Helicolenus dactylopterus* or vicariant *Merluccius* spp. (among many others) have also similar diets, concerning feeding guilds, in the western Mediterranean and off Namibia (Macpherson, 1977; Macpherson and Roel, 1987). There are numerous similar examples, not only restricted to commercial species (cf. Cartes, 1991, 1995), which generally support the assumption that feeding preferences of species do not vary along their geographical distribution covering similar habitats, particularly at bathyal environments.

Along the geographical gradient covered in this study, fish showed the most clear variations in trophodynamics in contrast to the almost unexistent changes detected for crustaceans. A latitudinal gradient on the trophic structure of marine ecosystems has already been cited, with energy flow being distinctly partitioned between benthos/plankton production from subarctic to tropical waters, thus supporting more demersal or pelagic fisheries (Petersen and Curtis, 1980). At our spatial scale, similar trends seem to occurr only within bathyal fish assemblages, with an increase in macroplankton feeders in the Algerian Basin (southern Cape La Nao). Among crustaceans, distinct trophic guild composition has been detected previously comparing bathyal assemblages off the Catalan Sea and the SW Balearic Islands (off Eivissa), with higher dominance of the non-migrator macroplankton feeders (maily composed by *Plesionika* spp.) off the SW Balearic Islands, and infaunal and deposit feeders in the Catalan Sea (Cartes *et al.*, in press). These changes were probably not observed here because none of the Iberian coast sectors sampled have the characteristics of an open-sea area (i.e low river discharges, absence of large submarine canyons....) occurring in the SW Balearic Islands.

Changes in the trophic structure detected among fish, may probably be related to their higher trophic level (TL) in comparison to decapods. Further to dietary studies which confirm that large fish (i.e sharks, *Mora moro*, *M. merluccius*) prey on decapods, thus occupying a higher TL (i.e. Carrasson *et al.*, 1992), recent data on δ^{15}N stable isotopic composition confirm this same trend (Polunin *et al.*, in press). Rex (1977) postulate more rapid changes in marine species substitution with depth with increasing trophic level, a hypothesis that has also been documented among deep-sea decapod crustaceans (Cartes, 1998). An extrapolation of this hypothesis at an “horizontal” spatial scale may explain why only fish, situated in a higher TL than decapods, showed geographical changes in their trophic guilds composition. Changes in deep-demersal fish communities at similar spatial scales than ours have been already documented off New Zealand (McClatchie *et al.*, 1997), correlated to regional changes in surface phytoplankton production, while bottom subtratum is also important in the distribution of continental shelf and upper slope fish assemblages off the Catalan coasts (Demestre *et al.*, 2000). The Alborán Sea has an unusual high primary production in comparison to other neighbouring Mediterranean areas, as can be observed in base to satellite imagery. This feature may support a similar conclusion than that discussed for deep fish communities off New Zealand (McClatchie *et al.*, 1997).

In summary, we evidenced in the present study the following trends in the trophodynamics of the megafaunal assemblages along the coasts of the Iberian Peninsula depending on depth, taxa and the geographical gradient: 1) crustaceans (mainly decapods) have different trophic structure on the shelf and on the slope; 2) on the slope, fish evidenced more clear changes as a function of the geographical gradient than crustaceans; and 3) trophodynamics of bathyal fish showed some geographical variations between the Alborán Sea, the Catalano-Balearic Basin, and the Algerian Basin (basically VERA-ALIC sectors), with a progressive north-south increase in planktophagous species. More detailed and smaller spatial-scale studies on these trends (and their possible causes) may confirm whether the future management of these ecosystems should be considered under the depth and geographical strata here suggested.

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Table 1.- Classification of the main abundant species (crustaceans and bathyal fish) in trophic guilds: 1) migrator macroplankton feeders (mM), 2) non-migrator macroplankton feeders (nmM), 3) nektobenthos-suprabenthos feeders (NS), 4) epibenthos feeders (Epib), 5) large detritus-scavengers (Sca), 6) infaunal feeders (Inf), 7) deposit feeders (Dep), 8) small detritivorous (Det).

Sources: (1) Dietary information obtained from references included in the reference list or in the present study (see Table 2); (2) from other concrete references not included in the reference list; (3) from general information obtained from the Fishbase (*http://ibs.uel.ac.uk/fishbase/*) dataset, and from Withehead *et al.* (1986); (4) own upublished data; (5) diet assumed from neighbouring species.

Fish

		source
Myctophum punctatum	mM	(2)
Lampanictus crocodilus	mM	(1)
Argyropelecus hemigimnus	mM	(2)
Symbolophorus veranyi	mM	(2)
Notoscopelus elongatus	mM	(2)
Benthosema glaciale	mM	(2)
Stomias boa	mM	(2)
Maurolicus muelleri	mM	(2)
Ceratoscopelus maderensis	mM	(3)
Mora moro	nmM	(1)
Etmopterus spinax	nmM	(1)
Capros aper	nmM	(1)
Scyliorrhinus canicula	nmM	(1)
Alepocephalus rostratus	nmM	(1)
Micromesistius poutassou	nmM	(1)
Macroramphosus scolopax	nmM	(1)
Epigonus denticulatus	nmM	(1)
Hoplostethus mediterraneus	nmM	(1)
Gadiculus argenteus	nmM	(1)
Galeus melastomus	nmM	(1)
Lepidopus caudatus	nmM	(1)
Trisopterus minutus capelanus	NS	(1)
Ophichtus rufus	NS	(3)
Lophius budegasa	NS	(1)
Molva dipterygia	NS	(1)
Conger conger	NS	(1)
Nezumia aequalis	NS	(1)
Serranus hepatus	NS	(3)
Hymenocephalus italicus	NS	(1)
Merluccius merluccius	NS	(1)
Chorophthalmus agassizi	NS	(3)
Pagellus acarne	NS	(3)
Notacanthus bonapartei	Epib	(1)
Helicolenus dactylopterus	Epib	(1)
Symphurus ligulatus	Inf	(1)
Antonogadus megalokinodon	Inf	(1)
Arnoglossus laterna	Inf	(3)
Arnoglossus rueppelli	Inf	(3)
Phycis blennoides	Inf	(1)
Lepidorhombus boscii	Inf	(1)
Coelorhynchus coelorhynchus	Inf	(1)
Chimaera monstrosa	Inf	(1)
Trachyrhynchus trachyrhynchus	Inf	(1)
Symphurus nigrescens	Inf	(1)

Crustaceans

		source
Gennadas elegans	mM	(1)
Pasiphaea multidentata	mM	(1)
Pasiphaea sivado	mM	(1)
Sergestes arcticus	mM	(2)
Sergestes henseni	mM	(4)
Sergia robusta	mM	(1)
Parapandalus narval	nmM	(4)
Plesionika acanthonotus	nmM	(1)
Plesionika antigai	nmM	(5)
Plesionika edwardsii	nmM	(1)
Plesionika giglioli	nmM	(1)
Plesionika heterocarpus	nmM	(1)
Plesionika martia	nmM	(1)
Natatolana borealis	Sca	(4)
Munida intermedia	Sca	(1)
Munida iris	Sca	(4)
Munida tenuimana	Sca	(1)
Pagurus alatus	Sca	(1)
Pagurus excavatus	Sca	(1)
Pagurus prideauxi	Sca	(5)
Dardanus arrosor	Sca	(5)
Polycheles typhlops	Epib	(1)
Bathynectes maravigna	Epib	(5)
Ligur ensiferus	Epib	(1)
Liocarcinus depurator	Epib	(2)
Macropipus tuberculatus	Epib	(2)
Polybius henslowi	Epib	(3)
Squilla mantis	Epib	(3)
Rissoides pallidus	Epib	(5)
Aristeus antennatus	Inf	(1)
Chlorotocus crassicornis	Inf	(1)
Calappa granulata	Inf	(1)
Geryon longipes	Inf	(2)
Goneplax rhomboides	Inf	(4)
Medorippe lanata	Inf	(5)
Monodaeus couchii	Inf	(2)
Nephrops norvegicus	Inf	(1)
Parapenaeus longirostris	Inf	(1)
Philocheras echinulatus	Inf	(1)
Pontocaris cataphracta	Inf	(5)
Pontocaris lacazei	Inf	(1)
Pontophilus spinosus	Inf	(1)
Processa canaliculata	Inf	(1)
Processa nouveli	Inf	(1)

Table 1 (cont.).- Classification of the main abundant species (crustaceans and bathyal fish) in trophic guilds: 1) migrator macroplankton feeders (mM), 2) non-migrator macroplankton feeders (nmM), 3) nektobenthos-suprabenthos feeders (NS), 4) epibenthos feeders (Epib), 5) large detritus-scavengers (Sca), 6) infaunal feeders (Inf), 7) deposit feeders (Dep), 8) small detritivorous (Det).

Fish			*Crustaceans*		
		source			source
			Solenocera membranacea	Inf	(1)
			Atelecyclus rotundatus	Inf	(5)
			Calocaris macandreae	Dep	(1)
			Alpheus glaber	Dep	(4)
			Meganyctiphanes norvegica	Det	(4)
			Pandalina profunda	Det	(4)
			Lophogaster typicus	Det	(4)

Table 2.- Diets of different decapod species dominant in the present sampling. (n): number of individuals analyzed; TG: trophic guild assigned. (*) from MEDIT-99 cruise.

Species	prey items	n	TG	observations
Gennadas elegans	calanoids	7	mM	
Sergia robusta	calanoids, euphausiids, chaetognaths	18	mM	R1 cruise: April 1990
Plesionika gigliolii	euphausiids, Sergestes sp., siphonophora	16	nmM	R3 cruise: March 1991
*Plesionika heterocarpus**	euphausiids	9	nmM	euphausiids: 100% volume
Ligur ensiferus	Gammaridean amphipods, echinoderms	40	Epib	R2 cruise: December 1991
Chlorotocus crassicornis	euphausiids, molluscs	15	nmM	probably pelagic molluscs
Calappa granulata	bivalves, foraminiferans	3	Inf	

Table 3.- Abundance (Ind/h) and percentage of the different trophic guilds for crustaceans deduced from cluster analysis. n: number of samples.

	shelf			slope	
	n=44			n=42	
	ind./h	(%)		ind./h	(%)
nmM	56.3	54.8	mM	671.3	55.9
EpB	25.7	25.0	nmM	360.1	30.0
InfB	11.2	10.9	InfB	113.2	9.4
Sca	6.9	6.7	Sca	13.4	1.1
mM	0	0	EpB	9.4	0.8
TOTAL	101.1			1167.4	

Table 4.- Abundance (Ind/h) and percentage of the different trophic guilds among bathyal fish by geographical area, deduced from cluster and MDS analysis. *Algerian Basin excluding the Alborán Sea area. n: number of samples.

	Catalano-Balearic Basin			Algerian Basin*			Alborán Sea	
	n=12			n=15			n=7	
	ind./h	(%)		ind./h	(%)		ind./h	(%)
infB	106.2	47.5	nmM	184.8	43.8	nmM	309.9	50.0
mM	81.5	36.5	mM	125.7	29.8	vB	188.7	30.4
nmM	20.2	9.0	infB	85.1	20.2	infB	60.4	9.7
vB	9.7	4.3	vB	17.8	4.2	EpB	35.6	5.7
EpB	3.0	1.3	EpB	4.1	1.0	mM	22.7	3.7
TOTAL	220.6			422.5			617.3	

Table 5.- Main fish species caught from shelf depths ordered by their decreasing order of abundance (Ind/h) during the MEDITS–99 sampling. %D: percentage of density.

Species	D(ind./h)	%D
Capros aper	296.5	18.5
Maurolicus muelleri	230.2	14.4
Merluccius merluccius	186.1	11.6
Cristallogobius linearis	136.1	8.5
Trachurus trachurus	105.8	6.6
Sardina pilchardus	99.8	6.2
Trisopterus minutus capelanus	67.0	4.2
Macroramphosus scolopax	45.7	2.8
Boops boops	45.1	2.8
Spicara smaris	40.5	2.5
TOTAL	1603.5	78.1

Fig. 1

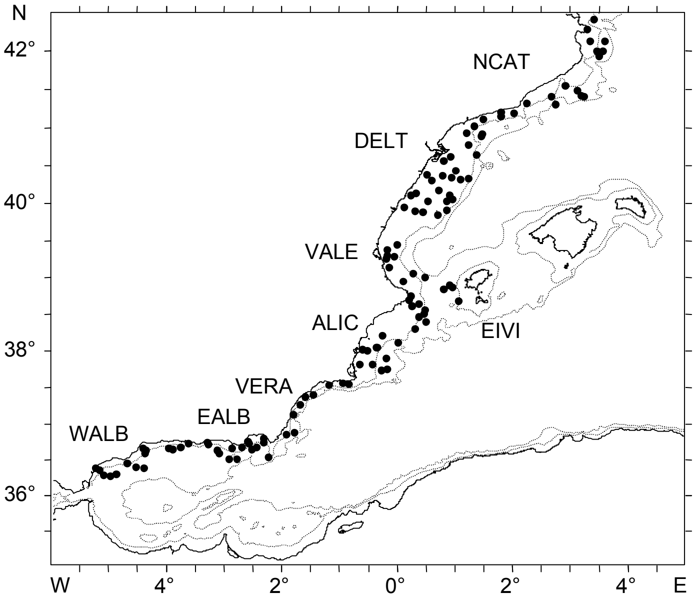

Fig. 1.- Map of the study area off the Mediterranean Iberian Peninsula, showing the trawl location and the sectors in which the coast was divided.

Fig. 2

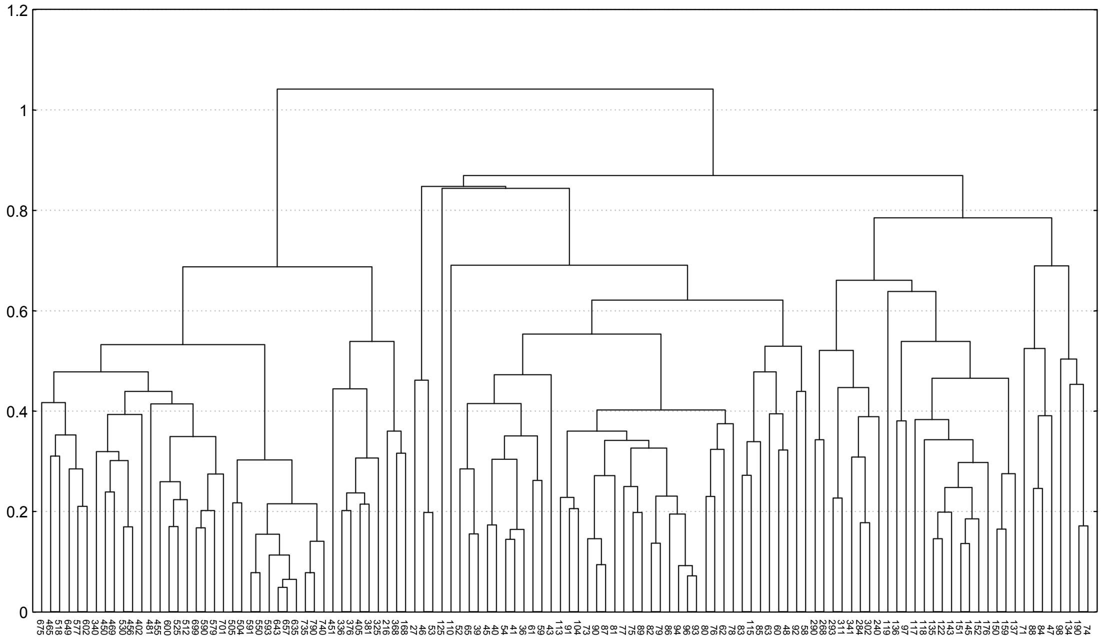

Fig. 2.- Clustering analysis perfomed on the matrix of fish species composition standardized to 1 h of trawling (1-r; UPGMA).

Fig. 3

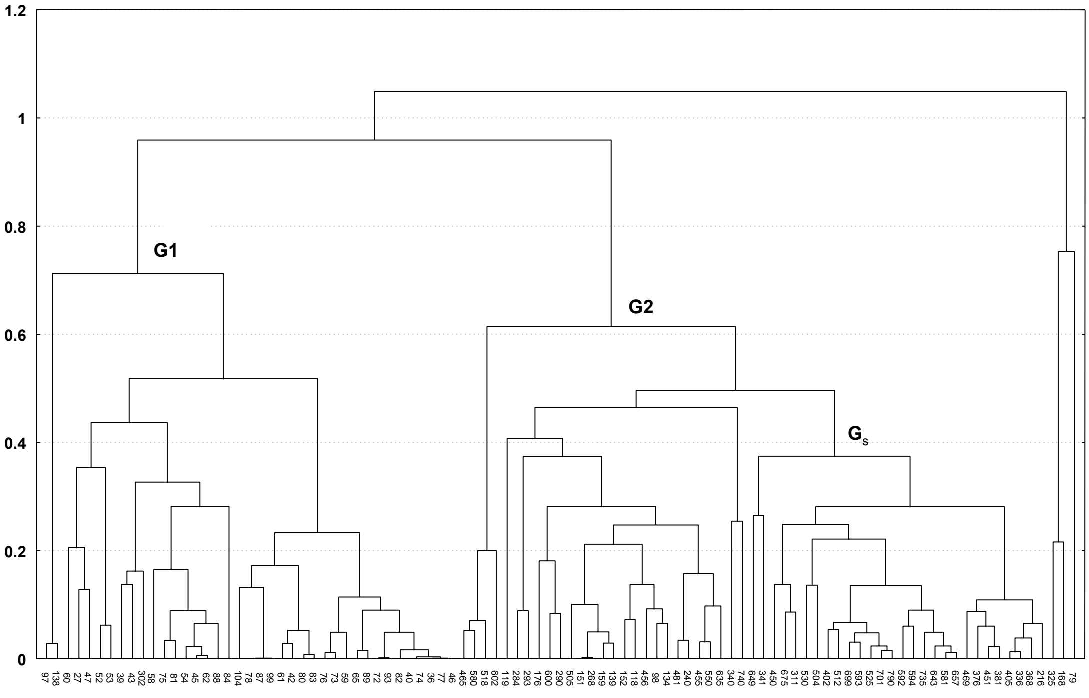

Fig. 3.- Cluster for crustacean tophic guilds showing the shelf (G1) and the slope (G2) groups. 1-r (Pearson correlation) was the distance used and UPGMA was the aggregation algorithm.

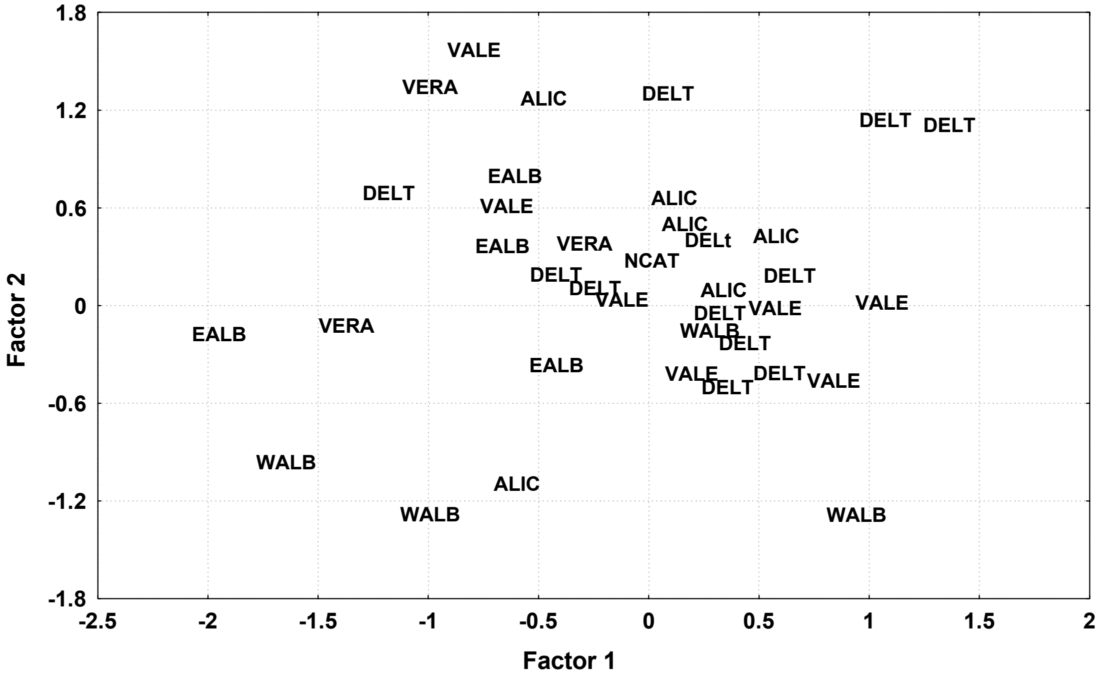

Fig. 4a.- MDS for crustacean trophic guilds; (a): shelf species; (b) slope species.

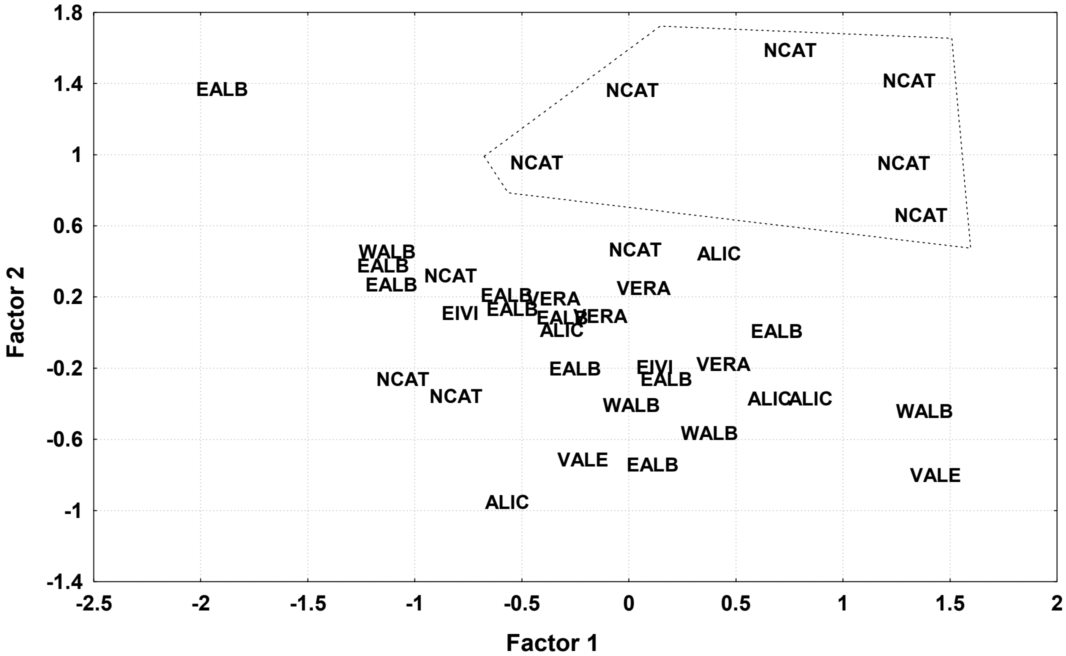

Fig. 4b.-MDS for crustacean trophic guilds; (a): shelf species; (b) slope species.

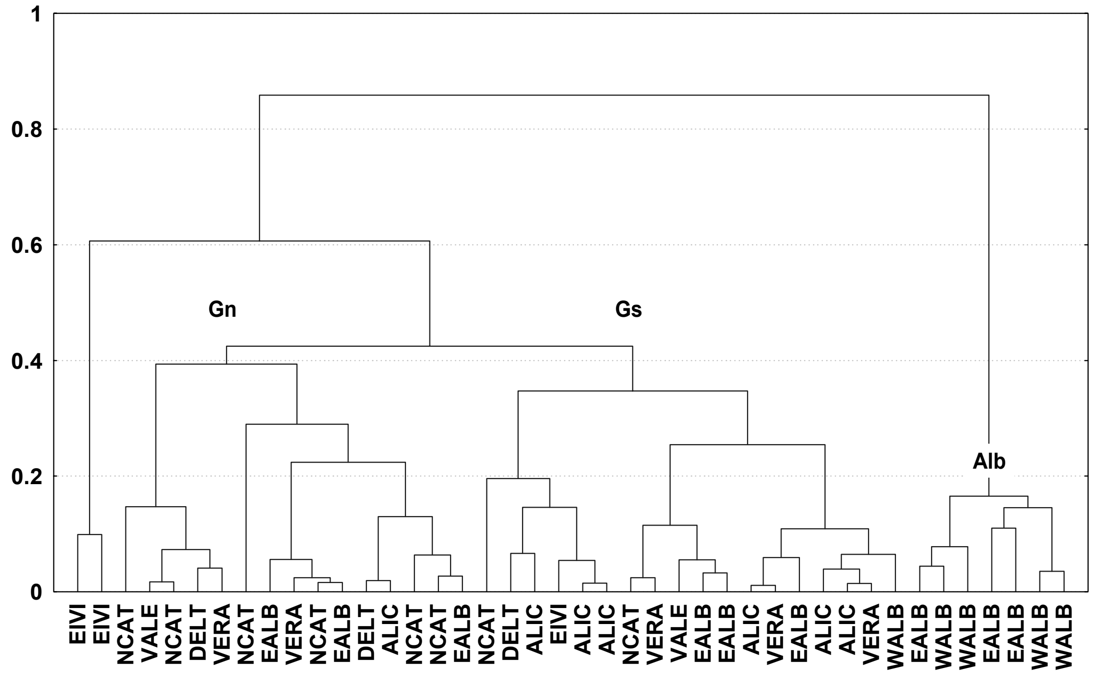

Fig. 5.- Cluster for the trophic guilds of bathyal fish (1-r / UPGMA), showing the formation of groups for the Catalano-Balearic Basin (Gn), the Algerian Basin (Gs), and the Alborán Sea (Alb).

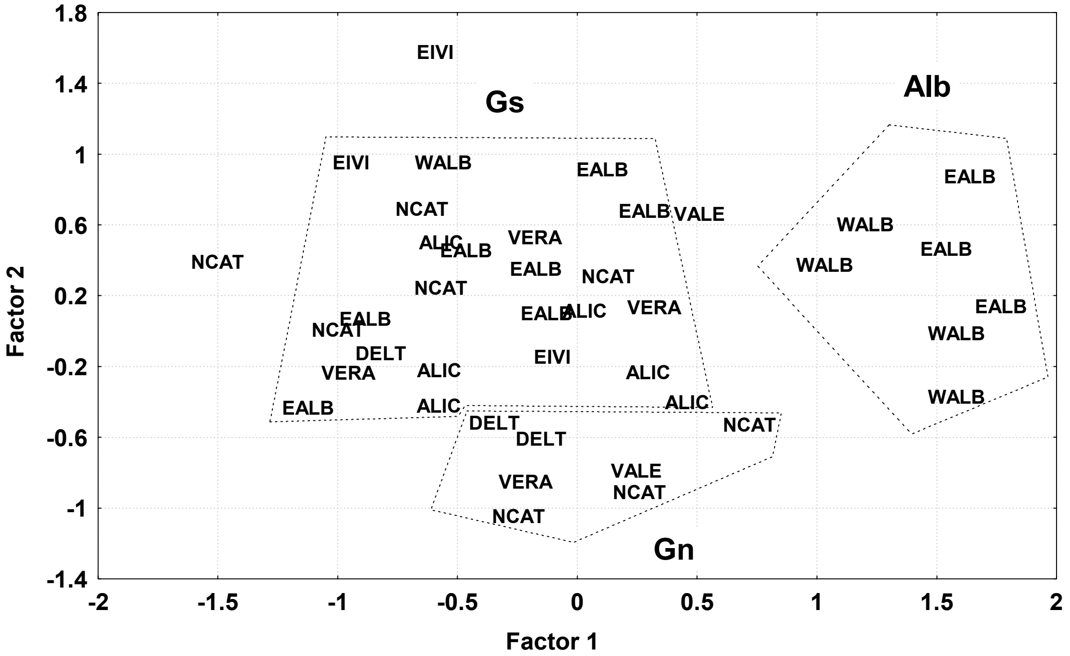

Fig. 6.- MDS analysis showing the distribution of groups of samples for the Catalano-Balearic Basin (Gn), the Algerian Basin (Gs), and the Alborán Sea (Alb).

3.4 SECTION III *Biogeography of epibenthic crustaceans on the shelf and upper slope off the Iberian Peninsula Mediterranean coasts: implications for the establishment of natural management areas*

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SUMMARY: The patterns of occurrence and bathymetric distribution of epibenthic crustaceans on the continental shelf and upper slope down to a depth of 800 m are analysed based in data gathered during six demersal trawl surveys performed annually in spring along the Mediterranean coasts of the Iberian Peninsula (from the Straits of Gibraltar to Cape Creus) between 1994 and 1999. A total of 598 valid samples have been studied which have provided a total of 108 species of decapods, two stomatopods, one euphausiid, one mysid and one isopod crustacean. The study area has been subdivided in seven sectors according to their geomorphological characteristics. The patterns of occurrence and abundance by depth have been analysed separately for each of the sectors. Detailed data on bathymetric distribution is presented for each species. Two main biogeographical areas can be discerned along the study area, which can approximately be separated in Palos Cape: the Alborán Sea to the southwest, and the northwestern Mediterranean (Levantine and Catalan Seas) northwest of Palos Cape. The continental shelf in the Alborán Sea (the westernmost area of the Mediterranean) is extremely narrow whereas it is much wider in the northwestern Mediterranean. The influence of Atlantic waters entering the Mediterranean is particularly strong in the Alborán Sea which therefore shows a particularly high species richness with Atlantic affinity. The Alborán Sea shows therefore important faunistic characteristics so as to think of it as a possible separate natural management area for demersal fisheries within the context of the western Mediterranean.

3.4.1 INTRODUCTION

Epibenthic crustaceans are one of the most valuable resources of the Mediterranean demersal fishery. Some of them are widely known and heavily exploited along most of their distribution range, such as the Norway lobster (Nephrops norvegicus), the shrimps Aristeus antennatus, Aristaeomorpha foliacea and Parapenaeus longirostris or the stomatopod Squilla mantis (e.g. Ardizzone *et al.*, 1990; Abelló and Martín, 1993; Demestre and Lleonart, 1993; Sardà, 1998; Carbonell *et al.*, 1999). The species richness of epibenthic crustaceans in the Mediterranean is high, especially that of decapod crustaceans (Sardà and Palomera, 1981; Tunesi, 1986; Abelló *et al.*, 1988; Relini *et al.*, 1986; Mura and Cau, 1994; Falciai, 1997). They constitute an important part of the total biomass throughout the continental shelf and slope, especially in the middle and lower slope (Cartes, 1993; Cartes and Sardà, 1992, 1993; Cartes *et al.*, 1993, 1994). Well over a hundred decapod crustacean species have been reported on the trawlable bottoms of the Mediterranean (Relini *et al.*, 1986; Tunesi, 1986; Abelló *et al.*, 1988; Mura and Cau, 1994; etc.). Faunistic studies constitute essential tools to understand the dynamics of exploited communities. Food webs can be much better understood, as well as other interspecific relationships, competence mechanisms, changes in relative abundance of the species, interannual changes in community structure and dynamics, etc.

The samplings performed within the frame of the MEDITS international trawl survey (Bertrand *et al.*, 2000) have provided a unique opportunity to study and delimit with a high degree of accuracy the geographical and bathymetric distribution of many species, as well as their interrelationships, given the large geographical area surveyed, the bathymetrical intensity of sampling, which encompassed the trawlable bottoms between 25 and 800 m depth, and the time duration of the surveys over several (1994-1999) years.

The identification of major geographical areas with communities sharing similar specific composition may provid an insight into their characterization as ecological assemblages sharing similar problems. Thus, from the management point of view, their identification should be taken into account when designing specific policies for the sustainable management of regional fisheries. The marked geomorphological differences between different Mediterranean basisns and regions, may provide or facilitate the differentitaion of a reasonably large number of relatively isolated subpopulations within species, especially so in those with short planktonic larval life. Boundaries such as sills, capes and associated stable or semipermanent hydrographical circulation features (frontal zones, anticyclonic and cyclonic gyres, eddies, etc.) may constitute the effective semipermeable boundaries able to differentiate communities and population units.

The main objectives of the present work are to provide detailed information on the patterns of geographical and bathymetric distribution of decapod crustaceans on the trawlable bottoms of the continental shelf, upper and middle slope off the Mediterranean coasts of the Iberian Peninsula, and to geographically analyse and delimitate the main biogeographical faunistic assemblages, especially aimed at the identification of natural management areas, recognized as one of the key issues in Mediterranean management (Caddy, 1998).

3.4.2 MATERIAL AND METHODS

The information presented herein was obtained from a total of six trawl surveys performed annually in spring (May-June) from 1994 to 1999 using the research vessel "Cornide de Saavedra". The study area encompassed the Mediterranean sector of the Iberian Peninsula from Gibraltar to Cape Creus, excluding most of the Balearic islands (Fig. 1). An overall area of 45.331 km^2 was surveyed. A total of 598 valid samples were obtained (Table 1). The depths sampled ranged between 25 and 798 m.

A depth stratified random sampling taking into account the surface area of each depth interval and geographical sector was used (MEDITS protocol) (Bertrand *et al.*, 2000, and in present volume). The samples were obtained with a bottom trawl model GOC-73 with a 4 m vertical opening and 20 mm codend mesh size, trawled at a speed of 3 knots. Hauls performed at depths of less than 200 m had a duration of 30 minutes; those performed deeper had a duration of 60 minutes.

All crustaceans in the samples were identified, counted and weighed. Their patterns of distribution are analysed as a function of depth stratum and geographical sector. Nomenclature of the decapod crustacean species has mainly followed d'Udekem d'Acoz (1999). Intervals of 50 m depth down to 200 m and of 100 m on the slope were used to analyse the distribution patterns of occurrence (Table 2). The narrower depth strata of the shelf zone were selected to account for the greater steepness of the environmental gradients associated with depth variations within this zone. The study area was additionally divided into eight geographical sectors, according to their different geographical and geomorphological characteristics: (1) Western Alborán Sea (WALB), from Gibraltar to Nerja; (2) Eastern Alborán Sea (EALB), from Nerja to Cape Gata; (3) Vera Gulf (VERA), from Cape Gata to Cape Palos; (4) Alacant (ALAC), from Cape Gata to Cape La Nao; (5) Eivissa island (EIVI); (6) Valencia (VALE), from Cape La Nao to Castelló; (7) Ebro delta region (DELT), from Castelló to Tarragona, and (8) Northern Catalonia (NCAT), from Tarragona to Cape Creus (Fig. 1, Table 1).

In order to ascertain biogeographical similarities among geographical sectors, cluster analysis based on the faunistic composition resemblance between geographical sectors has been performed using Yule's coefficient as a similarity index and UPGMA (Unweighted Pair Group Method using Arithmetic Averages) aggregation algorithm. Yule’s index has been chosen since it adequately summarizes presence/absence data in biogeographical analyses (Macpherson, 1991). Identical groupings were obtained using Jaccard’s similarity index. Species with less than three occurrences have been excluded from the analysis due to the little information afforded. Samples from the Eivissa island sector have also been excluded due to the extreme scarceness of samples taken on the continental shelf in that sector (Table 2) which would preclude a proper analysis of the data. A resulting matrix of 92 species and seven geographical sectors encompassing the whole Iberian Peninsula Mediterranean coasts has been used in the analysis.

3.4.3 RESULTS

A total of 115 crustacean species were identified during the six studied cruises (Table 3), of which 1 cirripede, 2 stomatopods, 1 mysid, 1 euphausiid, 1 isopod and 108 decapod crustacean species, of which 12 Dendrobranchiata, 26 Caridea, 1 Stenopodidea, 1 Eryonidea, 4 Palinuridea, 2 Nephropidea, 2 Thalassinidea, 19 Anomura and 41 Brachyura.

3.4.3.1 Bathymetrical patterns of occurrence

The depth range, mean depth of occurrence and the percentage occurrence of each species within each depth stratum are presented in Table 4. This table provides detailed information on the depth strata in which each species was most frequently found throughout the study area. Thus, for example, the portunid crab *Macropipus tuberculatus* was present in over 70% of the samples taken between 200 and 400 m, depth range that appears, from the present results, to be the preferred by this species; the species showed decreasing occurrence values at depths shallower and deeper than these strata, reaching zero values at the shallowest and deepest. As another example, the red shrimp *Aristeus antennatus* showed a clearly depth increasing occurrence trend, being absent at depths shallower than 400 m and reaching occurrences of 95.2% within the deepest sampled stratum (700-800 m).

From these data, information on the commonest species within each depth stratum can be obtained (Table 5). Thus, very few species were commonly found on the continental shelf bottoms, which were mainly dominated by the portunid crab *Liocarcinus depurator* and the hermit crab *Dardanus arrosor*. Caridean and penaeid shrimps, such as *Plesionika heterocarpus* and *Parapenaeus longirostris*, together with the portunid crabs *Liocarcinus depurator* and *Macropipus tuberculatus*, were the commonest species on the upper slope bottoms between 150 and 300 m. A large number of species with high occurrence values was present in the 300-400 m depth interval, in which nektobenthic and benthopelagic shrimps such as *Solenocera membranacea* and *Pasiphaea sivado*, together with the burrowing benthic lobster *Nephrops norvegicus*, were the most characteristic species. At depths of over 400 m, the nektobenthic shrimp *Plesionika martia* was the species most frequently found; other deep-sea species, such as the benthic *Polycheles typhlops*, the benthopelagic shrimp *Sergia robusta* or the nektobenthic shrimp *Plesionika acanthonotus* were also present with high occurrence values. Species such as the red shrimp *Aristeus antennatus*, the crab *Geryon longipes*, the benthopelagic shrimp *Pasiphaea multidentata* and the hermit crab *Pagurus alatus*, clearly increased their percentage occurrence towards the deepest strata.

Differences between the depth occurrence patterns among the different large groups of decapod crustaceans are clearly apparent when analysing the depth distribution range and the mean depth of occurrence of each species within each taxonomic group.

Dendrobranchiate shrimps (Fig. 2A) are clearly species living on the middle slope bottoms (400-800 m), with only three, out of twelve, species present on the continental shelf; two of those, however, *Parapenaeus longirostris* and *Solenocera membranacea*, presented their mean depth of occurrence in the upper slope (200-400 m). Some species, such as *P. longirostris, S. membranacea* or *Sergestes arcticus* presented large bathymetrical occurrence depth ranges.

Most caridean shrimps (Fig. 2A) showed large occurrence depth ranges and were clearly continental slope dwelling species, both in the upper (approx. 200-500 m) and in the middle slope (>500 m). Only three species (two of them occasional) presented their mean depth of occurrence on the continental shelf, of which the commonest was the crangonid *Aegaeon cataphractus*. It is worth noting the large number of pandalid and crangonid species occurring along the study area which often show a marked interspecific bathymetrical segregation which can be more clearly observed when analysing their percentage occurrence by depth strata (Table 4).

Anomuran crabs (hermit crabs and squat lobsters) were mainly a shallow continental shelf group of species (Fig. 2B). Only one hermit crab species (*Pagurus alatus*) and occasional specimens of *Dardanus arrosor* and *Pagurus prideaux* were present on the middle continental slope, at depths of over 400 m. Three species of the genus *Munida* were present on the continental slope, with a rather marked bathymetrical seggregation between them: *M. rutllanti, M. intermedia* and *M. tenuimana*.

Brachyuran crabs (Fig. 2C) are also a group of species typical of the continental shelf. Most of the species recorded in the present surveys presented their mean depth of occurrence within the continental shelf, some of the commonest being, for example, *Atelecyclus rotundatus, Pilumnus spinifer* or *Inachus dorsettensis*. Some species had their mean depth of occurrence on the continental shelf but were also rather commonly found on the upper slope and sometimes in the middle, such as *Medorippe lanata*, *Macropodia longipes*, *Liocarcinus depurator*, *Homola barbata* or *Calappa granulata*. A few species presented their mean depth of occurrence on the middle slope but were rather commonly found on the shelf and sometimes on the middle slope, such as *Goneplax rhomboides* and *Macropipus tuberculatus* or the benthopelagic crab *Polybius henslowi* whose distribution was restricted to the Alborán Sea. *Monodaeus couchi* was rather common throughout the middle and upper slope, but presented also some occurrences on the continental shelf. A few species appeared as characteristic of the middle slope, at depths of over 500 m, of which the commonest were *Geryon longipes*, *Dorhynchus thomsoni* and *Paromola cuvieri*. Some of these deep-sea species presented their distribution area exclusively (or almost exclusively) restricted to the Alborán Sea geographical sector (see next section), such as *Ergasticus clouei*, *Bathynectes maravigna*, *Rochinia carpenteri*, *Cymonomus granulatus* and *Euchirograpsus liguricus*.

Other crustacean taxonomic groups (Fig. 2D) presented a much lower number of species. Thus, eryoneid polychelid lobsters were only represented by *Polycheles typhlops*, present in the middle and, sometimes, upper slope. Palinurid lobsters appeared scarcely, the commonest species being *Palinurus elephas* on the continental shelf and *Palinurus mauritanicus* on the slope. Stenopodid shrimps (*Richardina fredericii*) were only recorded once in the middle slope. The commonest thalassinid shrimp was *Calocaris macandreae*, frequently recorded on the slope. Nephropid lobsters were mainly represented by *Nephrops norvegicus*, recorded mainly in the upper continental slope, with some occurrences on the shelf. Stomatopods were represented by *Squilla mantis* on the shelf, and by *Rissoides pallidus* on the upper slope. Other crustacean groups appeared more scarcely in the samples.

3.4.3.2 Biogeographical analysis

The geographical sector with the highest species richness was the Ebro delta sector, with 82 species, followed by Eastern Alborán and Vera Gulf sectors, with 79 species each of them (Table 6). Eivissa island was the sector with the fewest number of species, with 49 species recorded, but very few samples were obtained at depths shallower than 200 m in that sector (Table 2) and data were therefore not directly comparable. Alacant with 58 species was therefore the sector with the fewest species recorded.

The percentage occurrence of each species within each geographical sector (Table 6), allows the characterization of the geographical sector(s) in which a species was more frequently recorded. One main pattern was found, in which some species were only recorded in the westernmost geographical sectors: western and eastern Alborán Sea and Vera Gulf, being absent from the rest of Mediterranean sectors sampled. This group of species, exclusive from the Alborán Sea, was mainly formed by the crabs *Rochinia carpenteri, Polybius henslowi, Ergasticus clouei* and *Eurynome aspera*, and by the benthic shrimp *Alpheus platydactylus*. Some other, occasional species, such as the solenocerid shrimp *Hymenopenaeus debilis,* the axiid shrimp *Calocarides coronatus*, or the crabs *Cymonomus granulatus*, *Ebalia nux* and *Euchirograpsus liguricus* also belonged to this group of species. Other species, such as the portunid crab *Bathynectes maravigna*, were mainly, but not exclusively, recorded in this area. Conversely, rather common species in other sectors, such as the squat lobster *Munida tenuimana* or the crab *Medorippe lanata*, were very scarcely recorded in the westernmost geographical sectors, or not recorded at all, like the crangonid shrimp *Pontophilus norvegicus* or the crab *Paromola cuvieri*.

The peculiar faunistic characteristics of the Alborán Sea are further emphasized by the cluster analysis performed among geographical sectors based in the resemblance obtained by using the qualitative Yule's index, which is based in presence/absence analysis of the species by geographical sector (Fig. 3). By using this approach, two main groups of geographical sectors were clearly obtained: one, in which the two Alborán Sea sectors, plus Vera Gulf, are grouped together, and the other, which encompassed the rest of geographical sectors north of Palos Cape: Alacant, Valencia, Delta and northern Catalonia. Identical groupings were obtained using Jaccard's similarity index.

3.4.4 DISCUSSION

The detailed analysis of the patterns of occurrence of benthic and epibenthic crustaceans along the Mediterranean coasts of the Iberian Peninsula has allowed to properly delimitate the bathymetric distribution range of the commonest species, as well as to provide valuable information on scarcer species. Also, the wide geographical range of the samples studied, of well over a thousand km (from the Straits of Gibraltar in the south-west to Cape Creus in the north-east), has allowed to objectively delimitate biogeographical boundaries along the regional sectors studied. Thus, one of the most important findings of the present study has been the identification of the Alborán Sea as a biogeographically separate unit from the rest of the western Mediterranean analysed sectors, with the boundary laying around Palos Cape. Western and eastern Alborán Sea, together with Vera Gulf, share a number of geomorphological characteristics, namely the virtual absence of a continental shelf and the strong influence of the Atlantic currents entering the Mediterranean through the Straits of Gibraltar (Hopkins, 1985; Millot, 1987; García-Ladona *et al.*, 1996). The well-documented stable presence of the Almería-Orán hydrographical front (Millot, 1987, 1999; Font *et al.*, 1998) undoubtedly contributes to the biogeographical differentiation between the two identified areas, one southwest of Palos Cape, characterized by the occurrence of species with strong Atlantic affinities (*Rochinia carpenteri, Polybius henslowii, Ergasticus clouei, Bathynectes maravigna*, etc.), and the other northeast of that area. The present results provide therefore strong evidence for the Alborán Sea to be considered as a separate management unit when dealing with demersal fisheries from an ecosystem point of view (Caddy, 1998).

In addition to bathymetrical boundaries, which constitute the most evident results arising from crustacean faunistic assemblages studied at small geographical scales (e.g. Abelló *et al.*, 1988; Cartes, 1993; Cartes and Sardà, 1993; Cartes *et al.*, 1994; Haedrich *et al.*, 1975, 1980; Ungaro *et al.*, 1999), geographical and latitudinal boundaries have been identified in a much fewer number of studies dealing with distribution data over wider geographical scales (e.g. Mas-Riera *et al.*, 1990; Macpherson, 1991; ******). Indeed, important faunistic differences, dealing mainly with different relative abundance composition of both faunistic groups and feeding guilds, have been identified at scales of a few hundreds of km (Moranta *et al.*, 1998; Maynou and Cartes, 2000) in the western Mediterranean. On the other hand, seasonality may also affect the faunistic composition and structure of demersal assemblages (e.g. Wenner and Wenner, 1989; Demestre *et al.*, 2000).

In agreement with previous faunistic analyses restricted to the Catalano-Balearic Sea, the northernmost part of the Iberian Peninsula Mediterranean,(Abelló *et al.*, 1988; Cartes, 1993; Cartes and Sardà, 1993; Cartes *et al.*, 1994), the present results have shown that brachyuran crabs constitute the Infraorder of decapod crustaceans with the highest species richness along the coasts of the Iberian western Mediterranean, followed by caridean shrimps and anomuran crabs. Notwithstanding, neither of those species constitute an important fraction of commercial catches in the western Mediterranean and many of them are discarded. Only a few crab and *Plesionika* species are commercialized and hardly ever constitute the target species of any fishery (with the exception of *Plesionika edwardsi*, for which a targeted pot fishery takes place (García-Rodríguez *et al.*, 2000). The important target crustaceans in the Mediterranean belong to the Dendrobranchiata suborder, a decapod crustacean group that is not represented by many species in the Mediterranean (the coastal penaeid *Penaeus kerathurus* and the deep water shrimps *Aristeus antennatus*, *Aristeomorpha foliacea* and *Parapenaeus longirostris*), together with *Nephrops norvegicus* which belongs to the infraorder Nephropidea, with only two species occurring in the Mediterranean.

Concerning the depth distribution of the species, the present results support and expand the findings reported by several authors from the Catalano-Balearic Sea (e.g. Abelló *et al.,*1988; Cartes, 1993; Cartes and Sardà, 1992, 1993; Cartes *et al.*, 1993; Maynou and Cartes, 2000). Accurate data based on trawl surveys were practically missing from the Alborán Sea and the southern part of the Catalano-Balearic basin.

3.4.5 ACKNOWLEDGEMENTS

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3.4.6 REFERENCES

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Table 1.- Dates and number of samples taken in the six studied trawl surveys.

CRUISE NAME	YEAR	DATES	NUMBER OF SAMPLES
MEDITS_ES94	1994	28 May - 19 June	77
MEDITS_ES95	1995	22 April - 21 May	106
MEDITS_ES96	1996	2-26 May	105
MEDITS_ES97	1997	10 May - 3 June	101
MEDITS_ES98	1998	3-30 May	92
MEDITS_ES99	1999	4 May - 3 June	117

Table 2.- Distribution of the number of samples taken as a function of the geographical sector and depth stratum (MEDITS_ES94-99).

	Geographical sector								
Depth stratum (m)	WALB	EALB	VERA	ALAC	EIVI	VALE	DELT	NCAT	Total
0-50	6	5	2	12	–	4	19	8	56
50-100	19	12	5	30	–	27	66	28	187
100-150	8	5	2	11	2	13	16	26	83
150-200	3	2	4	11	–	1	2	4	27
200-300	7	4	6	8	5	–	1	4	35
300-400	13	4	4	7	1	4	1	10	44
400-500	5	9	3	11	5	–	2	9	44
500-600	10	11	4	14	7	–	3	14	63
600-700	17	8	1	–	4	–	1	7	38
700-800	8	1	3	–	2	6	–	1	21
Total	96	61	34	104	26	55	111	111	598

Table 3.- Crustacean species captured on the shelf, upper and middle slope along the Spanish Mediterranean during the MEDITS_ES cruises (1994-1999).

Subclass CIRRIPEDIA

O. **THORACICA**
Fam. SCALPELLIDAE
Scalpellum scalpellum Linnaeus, 1767

Subclass MALACOSTRACA

O. **STOMATOPODA**
Fam. SQUILLIDAE
Rissoides pallidus (Giesbrecht, 1910)
Squilla mantis (Linnaeus, 1758)

O. **EUPHAUSIACEA**
Fam. EUPHAUSIIDAE
Meganyctiphanes norvegica (M. Sars, 1857)

O. **MYSIDACEA**
Fam. LOPHOGASTRIDAE
Lophogaster typicus M. Sars, 1857

O. **ISOPODA**
Fam. CIROLANIDAE
Cirolana borealis Lilljeborg, 1851

O. **DECAPODA**
SO. **Dendrobranchiata**
Fam. ARISTEIDAE
Aristeomorpha foliacea (Risso, 1827)
Aristeus antennatus (Risso, 1816)
Gennadas elegans (S.I. Smith, 1882)
Fam. PENAEIDAE
Funchalia woodwardi Johnson, 1867
Parapenaeus longirostris (Lucas, 1846)
Penaeopsis serrata (Bate, 1881)
Penaeus kerathurus (Forskal, 1775)
Fam. SOLENOCERIDAE
Hymenopenaeus debilis S.I. Smith, 1882
Solenocera membranacea (Risso, 1816)
Fam. SERGESTIDAE
Sergestes arcticus Kröyer, 1855
Sergestes arachnipodus (Cocco, 1832)
Sergia robusta (S.I. Smith, 1882)

SO. **Caridea**
Fam. PASIPHAEIDAE
Pasiphaea multidentata Esmark, 1866
Pasiphaea sivado (Risso, 1816)
Fam. OPLOPHORIDAE
Acanthephyra eximia S.I. Smith, 1884
Acanthephyra pelagica (Risso, 1816)
Fam. PALAEMONIDAE
Periclimenes granulatus Holthuis, 1950
Fam. ALPHEIDAE
Alpheus glaber (Olivi, 1792)
Alpheus macrocheles (Hailstone, 1835)

Alpheus platydactylus Coutière, 1897
Fam. HIPPOLYTIDAE
Caridion steveni Lebour, 1930
Ligur ensiferus (Risso, 1816)
Fam. PROCESSIDAE
Processa canaliculata Leach, 1815
Processa nouveli Al-Adhub and Williamson, 1975
Fam. PANDALIDAE
Chlorotocus crassicornis (A. Costa, 1871)
Pandalina profunda Holthuis, 1946
Plesionika acanthonotus (S.I. Smith, 1882)
Plesionika antigai Zariquiey Álvarez, 1955
Plesionika edwardsii (Brandt, 1851)
Plesionika gigliolii (Senna, 1902)
Plesionika heterocarpus (A. Costa, 1871)
Plesionika martia A. Milne-Edwards, 1883
Plesionika narval (J.C. Fabricius, 1787)
Fam. CRANGONIDAE
Aegaeon cataphractus (Olivi, 1792)
Aegaeon lacazei (Gourret, 1887)
Philocheras echinulatus (M. Sars, 1862)
Pontophilus norvegicus (M. Sars, 1861)
Pontophilus spinosus (Leach, 1815)
SO. **Stenopodidea**
Fam. STENOPODIDAE
Richardina fredericii Lo Bianco, 1903
IO. **Eryonidea**
Fam. POLYCHELIDAE
Polycheles typhlops Heller, 1862
IO. **Palinuridea**
Fam. PALINURIDAE
Palinurus elephas (J.C. Fabricius, 1787)
Palinurus mauritanicus Gruvel, 1911
Fam. SCYLLARIDAE
Scyllarides latus (Latreille, 1803)
Scyllarus arctus (Linnaeus, 1758)
IO. **Nephropidea**
Fam. NEPHROPIDAE
Homarus gammarus (Linnaeus, 1758)
Nephrops norvegicus (Linnaeus, 1758)
IO. **Thalassinidea**
Fam. CALOCARIDIDAE
Calocaris macandreae Bell, 1846
Fam. AXIIDAE
Calocarides coronatus Trybom, 1904
IO. **Anomura**
Fam. GALATHEIDAE
Galathea dispersa Bate, 1859
Galathea intermedia parroceli Gourret, 1887
Galathea nexa Embleton, 1834
Munida intermedia A. Milne-Edwards and Bouvier, 1899
Munida rutllanti Zariquiey-Alvarez, 1952
Munida tenuimana G.O. Sars, 1872
Fam. PORCELLANIDAE
Pisidia longicornis (Linnaeus, 1767)
Fam. DIOGENIDAE
Calcinus tubularis (Linnaeus, 1767)
Dardanus arrosor (Herbst, 1796)
Dardanus calidus (Risso, 1827)
Paguristes eremita (Linnaeus, 1767)
Fam. PAGURIDAE
Anapagurus bicorniger A. Milne-Edwards and Bouvier, 1892
Anapagurus laevis (Bell, 1845)
Pagurus alatus (J.C. Fabricius, 1775)
Pagurus anachoretus Risso, 1827
Pagurus cuanensis Bell, 1845
Pagurus excavatus (Herbst, 1791)
Pagurus forbesii Bell, 1845
Pagurus prideaux Leach, 1815
IO. **Brachyura**
Fam. DROMIIDAE
Dromia personata (Linnaeus, 1758)
Fam. HOMOLIDAE
Homola barbata (J.C. Fabricius, 1793)
Paromola cuvieri (Risso, 1816)
Fam. LATREILLIIDAE
Latreillia elegans elegans P. Roux, 1830
Fam. CYMONOMIDAE
Cymonomus granulatus (Norman in Wyville Thomson, 1873)
Fam. MAJIDAE
Dorhynchus thomsoni Wyville Thomson, 1873
Ergasticus clouei A. Milne-Edwards, 1882
Eurynome aspera (Pennant, 1777)
Inachus communissimus Rizza, 1839
Inachus dorsettensis (Pennant, 1777)
Inachus thoracicus P. Roux, 1830
Macropodia linaresi Forest and Zariquiey Álvarez, 1964
Macropodia longipes (A. Milne-Edwards and Bouvier, 1899)
Macropodia rostrata (Linnaeus, 1761)*Maja crispata* Risso, 1827
Lissa chiragra (J.C. Fabricius, 1775)
Pisa armata (Latreille, 1802)
Pisa nodipes (Leach, 1815)
Rochinia carpenteri (Wyville Thomson, 1873)
Fam. DORIPPIDAE
Ethusa mascarone (Herbst, 1785)
Medorippe lanata (Linnaeus, 1767)
Fam. LEUCOSIIDAE
Ebalia cranchii Leach, 1817
Ebalia nux A. Milne-Edwards, 1883
Fam. CALAPPIDAE
Calappa granulata (Linnaeus, 1758)
Fam. ATELECYCLIDAE
Atelecyclus rotundatus (Olivi, 1792)
Fam. GERYONIDAE
Geryon longipes A. Milne-Edwards, 1882
Fam. PORTUNIDAE
Bathynectes maravigna (Prestandrea, 1839)
Liocarcinus arcuatus (Leach, 1814)
Liocarcinus corrugatus (Pennant, 1777)
Liocarcinus depurator (Linnaeus, 1758)
Liocarcinus maculatus (Risso, 1827)
Macropipus tuberculatus (Roux, 1830)
Polybius henslowi Leach, 1820
Fam. PARTHENOPIDAE
Parthenope angulifrons Latreille, 1825
Parthenope macrochelos (Herbst, 1790)
Parthenope massena (P. Roux, 1830)
Fam. XANTHIDAE
Monodaeus couchii (Couch, 1851)
Xantho incisus granulicarpus Forest, 1953
Fam. PILUMNIDAE
Pilumnus spinifer H.-M. Edwards, 1834
Fam. GONEPLACIDAE
Goneplax rhomboides (Linnaeus, 1758)
Fam. PINNOTHERIDAE
Nepinnotheres pinnotheres (Linnaeus, 1758)
Fam. GRAPSIDAE
Euchirograpsus liguricus H. Milne Edwards, 1853

Table 4.- Depth range, mean depth of occurrence, and percentage occurrence of each species within each depth interval. Species are presented alphabetically ordered.

%occurrence/depth stratum	DEPTH			DEPTH STRATUM										
SPECIES	MIN	MAX	MEAN	001-050	051-100	101-150	151-200	201-300	301-400	401-500	501-600	601-700	701-800	Occur-rences
Acanthephyra eximia	421	704	601.4	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	5.3	4.8	4
Acanthephyra pelagica	506	798	697.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	10.5	47.6	16
Aegaeon cataphractus	26	90	63.0	25.0	20.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52
Aegaeon lacazei	43	775	423.2	3.6	0.5	8.4	25.9	45.7	75.0	79.5	55.6	50.0	19.0	159
Alpheus glaber	33	704	286.4	12.5	20.9	18.1	22.2	31.4	77.3	50.0	36.5	13.2	4.8	163
Alpheus macrocheles	51	54	52.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Alpheus platydactylus	120	791	569.5	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	2.6	9.5	4
Anapagurus bicorniger	33	123	58.9	7.1	0.0	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5
Anapagurus laevis	55	81	70.5	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Aristeomorpha foliacea	453	600	527.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	7.9	0.0	0.0	7
Aristeus antennatus	414	798	618.7	0.0	0.0	0.0	0.0	0.0	0.0	18.2	52.4	76.3	95.2	90
Atelecyclus rotundatus	25	123	53.6	17.9	1.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15
Bathynectes maravigna	241	790	573.0	0.0	0.0	0.0	0.0	2.9	2.3	4.5	23.8	21.1	19.0	31
Calappa granulata	25	712	187.6	16.1	7.0	3.6	14.8	5.7	11.4	4.5	4.8	0.0	4.8	42
Calcinus tubularis	26	78	49.8	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Calocarides coronatus	553	760	658.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	4.8	2
Calocaris macandreae	316	775	545.2	0.0	0.0	0.0	0.0	0.0	15.9	47.7	54.0	47.4	28.6	86
Caridion steveni	96	98	97.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Chlorotocus crassicornis	80	526	270.7	0.0	1.6	12.0	25.9	57.1	63.6	13.6	1.6	0.0	0.0	75
Cirolana borealis	235	720	492.7	0.0	0.0	0.0	0.0	2.9	11.4	22.7	22.2	7.9	4.8	34
Cymonomus granulatus	562	621	592.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.6	0.0	2
Dardanus arrosor	25	698	165.8	76.8	57.2	42.2	48.1	51.4	68.2	38.6	12.7	10.5	0.0	275
Dardanus calidus	25	28	26.4	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
Dorhynchus thomsoni	447	754	609.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	4.8	7.9	9.5	9
Dromia personata	25	110	62.6	7.1	1.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9
Ebalia cranchii	58	187	123.0	0.0	0.5	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	2
Ebalia nux	519	563	538.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	2
Ergasticus clouei	475	661	565.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.6	2.6	0.0	3
Ethusa mascarone	25	53	37.8	16.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
Euchirograpsus liguricus	620	621	620.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	1
Eurynome aspera	52	124	86.6	0.0	1.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
Funchalia woodwardi	587	730	636.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	4.8	3
Galathea dispersa	80	97	89.7	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Galathea intermedia	33	82	53.4	10.7	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10
Galathea nexa	51	86	67.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Gennadas elegans	400	790	590.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	39.7	34.2	33.3	51
Geryon longipes	335	798	616.4	0.0	0.0	0.0	0.0	0.0	2.3	6.8	65.1	76.3	90.5	93
Goneplax rhomboides	29	671	245.0	44.6	25.7	18.1	14.8	25.7	61.4	52.3	31.7	15.8	0.0	177
Homarus gammarus	36	39	37.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Homola barbata	43	621	176.0	3.6	1.6	6.0	3.7	0.0	2.3	2.3	0.0	2.6	0.0	14
Hymenopenaeus debilis	668	679	673.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	0.0	1
Inachus communissimus	25	89	45.2	19.6	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13
Inachus dorsettensis	26	244	96.9	3.6	6.4	6.0	3.7	2.9	0.0	0.0	0.0	0.0	0.0	21
Inachus thoracicus	40	93	59.3	7.1	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8
Latreillia elegans	158	160	159.0	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	1
Ligur ensiferus	400	680	490.6	0.0	0.0	0.0	0.0	0.0	0.0	9.1	1.6	2.6	0.0	6
Liocarcinus arcuatus	25	82	51.7	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Liocarcinus corrugatus	44	54	47.8	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Liocarcinus depurator	25	740	158.5	64.3	82.9	63.9	59.3	68.6	75.0	38.6	11.1	7.9	9.5	346
Liocarcinus maculatus	33	43	38.3	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Lissa chiragra	26	28	27.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Lophogaster typicus	94	535	316.8	0.0	0.5	6.0	11.1	22.9	45.5	22.7	3.2	0.0	0.0	49
Macropipus tuberculatus	53	679	276.9	0.0	10.2	26.5	29.6	71.4	72.7	45.5	11.1	7.9	0.0	136
Macropodia linaresi	47	88	63.7	1.8	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Macropodia longipes	38	640	134.5	16.1	47.6	42.2	40.7	22.9	20.5	6.8	3.2	5.3	0.0	168
Macropodia rostrata	26	190	62.0	8.9	1.1	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	8
Maja crispata	25	49	32.5	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Medorippe lanata	26	651	104.2	53.6	35.3	10.8	7.4	5.7	9.1	9.1	1.6	2.6	0.0	119
Meganyctiphanes norvegica	75	780	406.8	0.0	0.5	0.0	7.4	34.3	43.2	36.4	20.6	7.9	9.5	68
Monodaeus couchii	44	760	465.9	1.8	1.6	6.0	0.0	20.0	38.6	47.7	54.0	39.5	28.6	109
Munida intermedia	118	641	379.3	0.0	0.0	3.6	7.4	31.4	50.0	52.3	12.7	2.6	0.0	70
Munida rutllanti	40	587	260.8	1.8	4.3	22.9	29.6	68.6	40.9	20.5	9.5	0.0	0.0	93
Munida tenuimana	286	798	551.6	0.0	0.0	0.0	0.0	2.9	4.5	45.5	46.0	18.4	38.1	67
Nephrops norvegicus	58	740	423.9	0.0	3.2	6.0	3.7	34.3	81.8	100.0	77.8	15.8	9.5	161
Nepinnotheres pinnotheres	43	83	63.5	1.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Paguristes eremita	25	139	52.8	37.5	5.3	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33
Pagurus alatus	187	791	574.4	0.0	0.0	0.0	3.7	0.0	11.4	31.8	55.6	81.6	61.9	99
Pagurus anachoretus	27	27	27.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Pagurus cuanensis	26	139	71.7	19.6	13.4	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38
Pagurus excavatus	26	378	92.1	41.1	36.9	26.5	22.2	5.7	6.8	0.0	0.0	0.0	0.0	125

Pagurus forbesii	40	49	43.5	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Pagurus prideaux	25	515	112.4	42.9	16.0	15.7	18.5	0.0	9.1	6.8	1.6	0.0	0.0	80
Palinurus elephas	41	78	61.8	1.8	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6
Palinurus mauritanicus	304	510	368.9	0.0	0.0	0.0	0.0	0.0	6.8	0.0	1.6	0.0	0.0	4
Pandalina profunda	238	605	404.2	0.0	0.0	0.0	0.0	8.6	15.9	15.9	4.8	2.6	0.0	21
Parapenaeus longirostris	64	588	249.7	0.0	7.0	15.7	59.3	74.3	63.6	22.7	1.6	0.0	0.0	107
Paromola cuvieri	452	747	595.6	0.0	0.0	0.0	0.0	0.0	0.0	2.3	9.5	5.3	9.5	11
Parthenope angulifrons	25	27	25.8	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3
Parthenope macrochelos	80	453	193.4	0.0	0.5	2.4	0.0	0.0	0.0	2.3	0.0	0.0	0.0	4
Parthenope massena	26	123	72.3	3.6	0.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4
Pasiphaea multidentata	235	798	591.3	0.0	0.0	0.0	0.0	2.9	2.3	34.1	77.8	81.6	90.5	116
Pasiphaea sivado	138	735	425.0	0.0	0.0	1.2	11.1	40.0	81.8	81.8	36.5	31.6	9.5	127
Penaeopsis serrata	469	469	469.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	1
Penaeus kerathurus	80	80	80.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Periclimenes granulatus	309	342	331.7	0.0	0.0	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0	3
Philocheras echinulatus	114	676	381.9	0.0	0.0	2.4	0.0	20.0	50.0	40.9	11.1	2.6	0.0	57
Pilumnus spinifer	25	188	54.7	30.4	5.9	1.2	3.7	0.0	0.0	0.0	0.0	0.0	0.0	30
Pisa armata	27	146	62.7	8.9	2.7	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12
Pisa nodipes	44	46	45.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Pisidia longicornis	25	80	47.8	25.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24
Plesionika acanthonotus	421	798	604.9	0.0	0.0	0.0	0.0	0.0	0.0	22.7	81.0	86.8	90.5	113
Plesionika antigai	98	477	241.3	0.0	0.5	6.0	25.9	40.0	11.4	4.5	0.0	0.0	0.0	34
Plesionika edwardsii	166	632	376.9	0.0	0.0	0.0	3.7	34.3	47.7	45.5	7.9	2.6	0.0	60
Plesionika gigliolii	235	681	428.5	0.0	0.0	0.0	0.0	45.7	75.0	81.8	49.2	13.2	0.0	121
Plesionika heterocarpus	45	468	222.0	3.6	8.6	49.4	88.9	85.7	79.5	27.3	0.0	0.0	0.0	160
Plesionika martia	267	798	538.5	0.0	0.0	0.0	0.0	8.6	50.0	97.7	100.0	97.4	100.0	189
Plesionika narval	64	403	248.7	0.0	1.1	4.8	11.1	22.9	18.2	2.3	0.0	0.0	0.0	26
Polybius henslowi	43	629	321.2	1.8	1.1	0.0	0.0	2.9	4.5	0.0	3.2	2.6	0.0	9
Polycheles typhlops	241	798	577.1	0.0	0.0	0.0	0.0	11.4	6.8	45.5	92.1	86.8	100.0	139
Pontophilus norvegicus	682	798	737.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	14.3	4
Pontophilus spinosus	69	663	300.8	0.0	4.3	6.0	11.1	28.6	52.3	25.0	4.8	2.6	0.0	64
Processa canaliculata	63	723	429.0	0.0	1.1	3.6	11.1	42.9	75.0	86.4	66.7	28.9	4.8	148
Processa nouveli	72	610	401.8	0.0	1.1	3.6	3.7	42.9	61.4	63.6	52.4	0.0	0.0	109
Richardina fredericii	545	545	545.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1
Rissoides pallidus	117	523	365.0	0.0	0.0	1.2	7.4	2.9	13.6	22.7	1.6	0.0	0.0	21
Rochinia carpenteri	132	791	584.4	0.0	0.0	1.2	3.7	2.9	4.5	4.5	19.0	50.0	38.1	46
Scalpellum scalpellum	80	607	240.0	0.0	1.1	0.0	3.7	0.0	0.0	0.0	1.6	0.0	0.0	4
Scyllarides latus	46	46	46.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Scyllarus arctus	26	367	196.5	1.8	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	2
Sergestes arachnipodus	279	620	484.6	0.0	0.0	0.0	0.0	5.7	13.6	20.5	28.6	5.3	0.0	37
Sergestes arcticus	160	798	495.0	0.0	0.0	0.0	3.7	11.4	59.1	81.8	71.4	47.4	38.1	138
Sergia robusta	309	798	589.7	0.0	0.0	0.0	0.0	0.0	4.5	40.9	87.3	92.1	95.2	130
Solenocera membranacea	43	790	386.4	3.6	13.4	10.8	14.8	54.3	93.2	86.4	76.2	57.9	9.5	210
Squilla mantis	26	367	62.9	50.0	18.2	4.8	0.0	0.0	2.3	0.0	0.0	0.0	0.0	67
Xantho incisus granulicarpus	51	54	52.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Number of samples/stratum				56	187	83	27	35	44	44	63	38	21	

Table 5.- Species whose percentage occurrence within each depth stratum is larger than 50%.

000-050 m		**050-100 m**		**100-150 m**		**150-200 m**		**200-300 m**	
Species	**%occ**	**Species**	**%occ**	**Species**	**%occ**	**Species**	**%occ**	**Species**	**%occ**
Dardanus arrosor	76.8	*Liocarcinus depurator*	82.9	*Liocarcinus depurator*	63.9	*Plesionika heterocarpus*	88.9	*Plesionika heterocarpus*	85.7
Liocarcinus depurator	64.3	*Dardanus arrosor*	57.2			*Liocarcinus depurator*	59.3	*Parapenaeus longirostris*	74.3
Medorippe lanata	53.6					*Parapenaeus longirostris*	59.3	*Macropipus tuberculatus*	71.4
Squilla mantis	50.0							*Liocarcinus depurator*	68.6
								Munida rutllanti	68.6
								Chlorotocus crassicornis	57.1
								Solenocera membranacea	54.3
								Dardanus arrosor	51.4
300-400 m		**400-500 m**		**500-600 m**		**600-700 m**		**700-800 m**	
Species	**%occ**	**Species**	**%occ**	**Species**	**%occ**	**Species**	**%occ**	**Species**	**%occ**
Solenocera membranacea	93.2	*Nephrops norvegicus*	100.0	*Plesionika martia*	100.0	*Plesionika martia*	97.4	*Plesionika martia*	100.0
Pasiphaea sivado	81.8	*Plesionika martia*	97.7	*Polycheles typhlops*	92.1	*Sergia robusta*	92.1	*Polycheles typhlops*	100.0
Nephrops norvegicus	81.8	*Solenocera membranacea*	86.4	*Sergia robusta*	87.3	*Polycheles typhlops*	86.8	*Sergia robusta*	95.2
Plesionika heterocarpus	79.5	*Processa canaliculata*	86.4	*Plesionika acanthonotus*	81.0	*Plesionika acanthonotus*	86.8	*Aristeus antennatus*	95.2
Alpheus glaber	77.3	*Pasiphaea sivado*	81.8	*Nephrops norvegicus*	77.8	*Pasiphaea multidentata*	81.6	*Plesionika acanthonotus*	90.5
Liocarcinus depurator	75.0	*Plesionika gigliolii*	81.8	*Pasiphaea multidentata*	77.8	*Pagurus alatus*	81.6	*Pasiphaea multidentata*	90.5
Aegaeon lacazei	75.0	*Sergestes arcticus*	81.8	*Solenocera membranacea*	76.2	*Geryon longipes*	76.3	*Geryon longipes*	90.5
Plesionika gigliolii	75.0	*Aegaeon lacazei*	79.5	*Sergestes arcticus*	71.4	*Aristeus antennatus*	76.3	*Pagurus alatus*	61.9
Processa canaliculata	75.0	*Processa nouveli*	63.6	*Processa canaliculata*	66.7	*Solenocera membranacea*	57.9		
Macropipus tuberculatus	72.7	*Goneplax rhomboides*	52.3	*Geryon longipes*	65.1	*Aegaeon lacazei*	50.0		
Dardanus arrosor	68.2	*Munida intermedia*	52.3	*Aegaeon lacazei*	55.6	*Rochinia carpenteri*	50.0		
Parapenaeus longirostris	63.6	*Alpheus glaber*	50.0	*Pagurus alatus*	55.6				
Chlorotocus crassicornis	63.6			*Monodaeus couchii*	54.0				
Processa nouveli	61.4			*Calocaris macandreae*	54.0				
Goneplax rhomboides	61.4			*Processa nouveli*	52.4				
Sergestes arcticus	59.1			*Aristeus antennatus*	52.4				
Pontophilus spinosus	52.3								
Munida intermedia	50.0								
Philocheras echinulatus	50.0								
Plesionika martia	50.0								

Table 6.- Percentage occurrence of the different species in the different geographical sectors. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia. (See Fig. 1 for location of the geographical sectors).

	SECTOR								
SPECIES	WALB	EALB	VERA	ALAC	EIVI	VALE	DELT	NCAT	Occurrences
Acanthephyra eximia	0.0	25.0	25.0	0.0	0.0	0.0	0.0	50.0	4
Acanthephyra pelagica	18.8	18.8	12.5	6.3	6.3	18.8	0.0	18.8	16
Aegaeon cataphractus	0.0	7.7	1.9	24.5	0.0	30.2	20.8	13.2	52
Aegaeon lacazei	23.8	14.4	8.8	13.1	7.5	1.3	5.6	25.6	159
Alpheus glaber	20.9	12.3	5.5	12.9	3.7	9.2	11.0	24.5	163
Alpheus macrocheles	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	1
Alpheus platydactylus	25.0	50.0	25.0	0.0	0.0	0.0	0.0	0.0	4
Anapagurus bicorniger	20.0	0.0	20.0	0.0	0.0	0.0	20.0	40.0	5
Anapagurus laevis	0.0	33.3	0.0	0.0	0.0	33.3	0.0	33.3	3
Aristeomorpha foliacea	0.0	0.0	0.0	42.9	57.1	0.0	0.0	0.0	7
Aristeus antennatus	17.8	16.7	12.2	15.6	10.0	6.7	2.2	18.9	90
Atelecyclus rotundatus	20.0	20.0	6.7	6.7	0.0	6.7	0.0	40.0	15
Bathynectes maravigna	54.8	32.3	0.0	6.5	3.2	3.2	0.0	0.0	31
Calappa granulata	4.8	14.3	31.0	19.0	0.0	9.5	4.8	16.7	42
Calcinus tubularis	0.0	33.3	0.0	33.3	0.0	0.0	0.0	33.3	3
Calocarides coronatus	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Calocaris macandreae	19.8	10.5	2.3	10.5	16.3	2.3	3.5	34.9	86
Caridion steveni	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	1
Chlorotocus crassicornis	16.0	9.3	10.7	29.3	4.0	10.7	2.7	17.3	75
Cirolana borealis	41.2	8.8	2.9	8.8	0.0	0.0	8.8	29.4	34
Cymonomus granulatus	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Dardanus arrosor	21.8	14.5	7.6	15.3	0.0	5.8	16.0	18.9	275
Dardanus calidus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	4
Dorhynchus thomsoni	22.2	44.4	0.0	0.0	33.3	0.0	0.0	0.0	9
Dromia personata	0.0	0.0	11.1	11.1	0.0	0.0	44.4	33.3	9
Ebalia cranchii	0.0	0.0	50.0	0.0	0.0	0.0	50.0	0.0	2
Ebalia nux	50.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	2
Ergasticus clouei	33.3	66.7	0.0	0.0	0.0	0.0	0.0	0.0	3
Ethusa mascarone	0.0	20.0	0.0	10.0	0.0	10.0	20.0	40.0	10
Euchirograpsus liguricus	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Eurynome aspera	16.7	50.0	33.3	0.0	0.0	0.0	0.0	0.0	6
Funchalia woodwardi	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	3
Galathea dispersa	0.0	0.0	0.0	33.3	0.0	0.0	33.3	33.3	3
Galathea intermedia	20.0	10.0	0.0	20.0	0.0	0.0	30.0	20.0	10
Galathea nexa	0.0	0.0	50.0	50.0	0.0	0.0	0.0	0.0	2
Gennadas elegans	15.4	7.7	7.7	15.4	15.4	5.8	3.8	28.8	51
Geryon longipes	33.3	22.6	4.3	14.0	12.9	7.5	0.0	5.4	93
Goneplax rhomboides	22.0	8.5	4.0	9.6	2.3	10.2	16.4	27.1	177
Homarus gammarus	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	1
Homola barbata	14.3	35.7	14.3	7.1	0.0	0.0	14.3	14.3	14
Hymenopenaeus debilis	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1
Inachus communissimus	7.7	23.1	0.0	15.4	0.0	7.7	23.1	23.1	13
Inachus dorsettensis	19.0	9.5	19.0	9.5	0.0	4.8	14.3	23.8	21
Inachus thoracicus	0.0	37.5	0.0	62.5	0.0	0.0	0.0	0.0	8
Latreillia elegans	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
Ligur ensiferus	0.0	33.3	0.0	16.7	0.0	0.0	0.0	50.0	6
Liocarcinus arcuatus	0.0	33.3	33.3	0.0	0.0	0.0	0.0	33.3	3
Liocarcinus corrugatus	0.0	0.0	66.7	33.3	0.0	0.0	0.0	0.0	3
Liocarcinus depurator	16.2	5.2	2.9	21.4	0.6	12.4	22.5	18.8	346
Liocarcinus maculatus	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	2
Lissa chiragra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1

Lophogaster typicus	30.6	10.2	14.3	14.3	8.2	2.0	8.2	12.2	49
Macropipus tuberculatus	10.9	5.8	10.2	21.2	6.6	3.6	24.8	16.8	136
Macropodia linaresi	0.0	33.3	0.0	66.7	0.0	0.0	0.0	0.0	3
Macropodia longipes	20.2	4.8	3.6	14.3	0.0	16.1	26.8	14.3	168
Macropodia rostrata	12.5	37.5	12.5	12.5	0.0	0.0	0.0	25.0	8
Maja crispata	0.0	33.3	0.0	0.0	0.0	0.0	0.0	66.7	3
Medorippe lanata	1.7	2.5	5.0	17.6	0.0	15.1	30.3	27.7	119
Meganyctiphanes norvegica	20.6	14.7	4.4	22.1	7.4	1.5	4.4	25.0	68
Monodaeus couchii	29.4	19.3	4.6	13.8	3.7	2.8	5.5	21.1	109
Munida intermedia	4.3	4.3	0.0	24.3	8.6	7.1	4.3	47.1	70
Munida rutllanti	13.8	2.1	14.9	33.0	9.6	5.3	20.2	1.1	93
Munida tenuimana	1.5	0.0	0.0	23.9	23.9	9.0	4.5	37.3	67
Nephrops norvegicus	16.1	11.8	2.5	21.1	9.9	5.0	9.3	24.2	161
Nepinnotheres pinnotheres	50.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	2
Paguristes eremita	0.0	9.1	0.0	21.2	0.0	0.0	48.5	21.2	33
Pagurus alatus	36.4	20.2	2.0	17.2	4.0	2.0	2.0	16.2	99
Pagurus anachoretus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1
Pagurus cuanensis	5.3	7.9	0.0	10.5	0.0	21.1	50.0	5.3	38
Pagurus excavatus	11.2	6.4	1.6	15.2	0.0	16.8	20.8	28.0	125
Pagurus forbesii	0.0	50.0	0.0	50.0	0.0	0.0	0.0	0.0	2
Pagurus prideaux	23.8	21.3	5.0	18.8	3.8	0.0	10.0	17.5	80
Palinurus elephas	0.0	16.7	16.7	16.7	0.0	33.3	0.0	16.7	6
Palinurus mauritanicus	0.0	25.0	50.0	0.0	0.0	0.0	0.0	25.0	4
Pandalina profunda	19.0	9.5	9.5	9.5	4.8	4.8	9.5	33.3	21
Parapenaeus longirostris	21.5	13.1	16.8	25.2	6.5	6.5	1.9	8.4	107
Paromola cuvieri	0.0	0.0	0.0	27.3	54.5	9.1	0.0	9.1	11
Parthenope angulifrons	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	3
Parthenope macrochelos	0.0	0.0	0.0	50.0	0.0	0.0	25.0	25.0	4
Parthenope massena	0.0	0.0	25.0	25.0	0.0	0.0	25.0	25.0	4
Pasiphaea multidentata	25.6	17.9	7.7	12.8	10.3	5.1	4.3	16.2	116
Pasiphaea sivado	33.1	14.2	8.7	14.2	5.5	1.6	5.5	17.3	127
Penaeopsis serrata	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1
Penaeus kerathurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	1
Periclimenes granulatus	0.0	33.3	33.3	0.0	0.0	0.0	0.0	33.3	3
Philocheras echinulatus	35.1	17.5	5.3	12.3	12.3	1.8	1.8	14.0	57
Pilumnus spinifer	10.0	20.0	6.7	30.0	0.0	6.7	6.7	20.0	30
Pisa armata	0.0	58.3	16.7	16.7	0.0	0.0	0.0	8.3	12
Pisa nodipes	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
Pisidia longicornis	16.7	12.5	4.2	16.7	0.0	12.5	8.3	29.2	24
Plesionika acanthonotus	23.7	18.4	8.8	17.5	11.4	5.3	2.6	12.3	113
Plesionika antigai	38.2	0.0	26.5	11.8	17.6	2.9	2.9	0.0	34
Plesionika edwardsii	14.8	18.0	18.0	32.8	4.9	6.6	4.9	0.0	60
Plesionika gigliolii	13.1	13.9	12.3	28.7	11.5	3.3	4.1	13.1	121
Plesionika heterocarpus	23.8	11.3	10.0	26.9	3.1	8.8	3.8	12.5	160
Plesionika martia	27.4	17.4	7.9	14.2	9.5	4.2	3.2	16.3	189
Plesionika narval	15.4	0.0	11.5	38.5	7.7	11.5	3.8	11.5	26
Polybius henslowi	88.9	11.1	0.0	0.0	0.0	0.0	0.0	0.0	9
Polycheles typhlops	26.6	13.7	2.2	15.8	11.5	5.0	3.6	21.6	139
Pontophilus norvegicus	0.0	0.0	0.0	0.0	25.0	50.0	0.0	25.0	4
Pontophilus spinosus	30.8	13.8	6.2	18.5	4.6	1.5	3.1	21.5	64
Processa canaliculata	23.5	12.8	6.7	19.5	7.4	2.0	4.7	23.5	148
Processa nouveli	20.0	20.9	12.7	12.7	5.5	1.8	7.3	19.1	109
Richardina fredericii	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	1
Rissoides pallidus	9.1	0.0	18.2	31.8	18.2	9.1	4.5	9.1	21
Rochinia carpenteri	69.6	30.4	0.0	0.0	0.0	0.0	0.0	0.0	46
Scalpellum scalpellum	0.0	0.0	0.0	0.0	0.0	0.0	25.0	75.0	4
Scyllarides latus	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	1
Scyllarus arctus	50.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	2

Sergestes arachnipodus	5.4	2.7	8.1	21.6	18.9	0.0	8.1	35.1	37
Sergestes arcticus	25.2	12.2	6.5	14.4	10.1	2.9	5.8	23.0	138
Sergia robusta	28.2	17.6	9.9	14.5	9.9	4.6	3.1	12.2	130
Solenocera membranacea	28.4	16.6	9.0	12.8	5.2	4.3	5.7	18.0	210
Squilla mantis	7.5	1.5	0.0	16.4	0.0	29.9	43.3	1.5	67
Xantho incisus granulicarpus	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	1
Number of samples	96	61	111	34	26	104	55	111	
Number of species present	71	79	79	58	49	67	82	68	

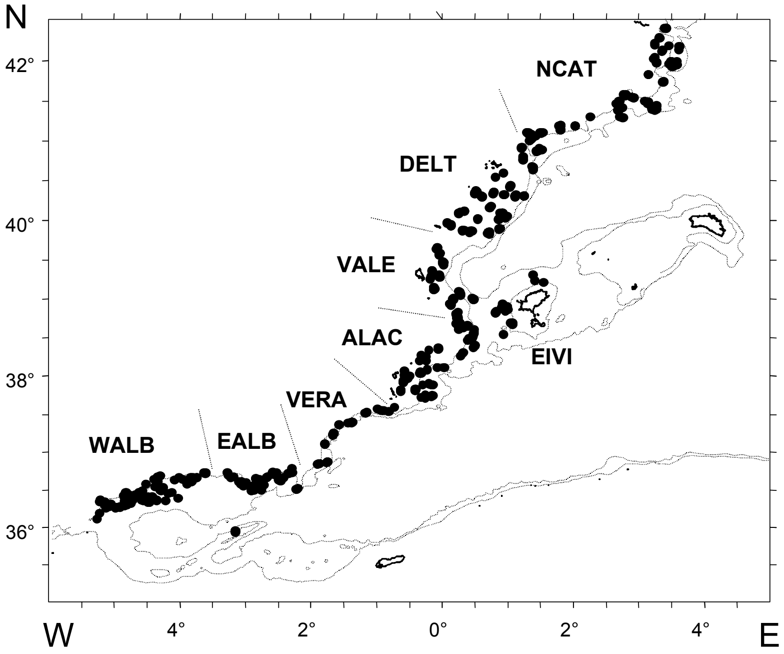

Fig. 1.- Geographical distribution of the samples taken and indication of the geographical sectors used in the present study. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia. 200 m and 1000 m isobaths are shown.

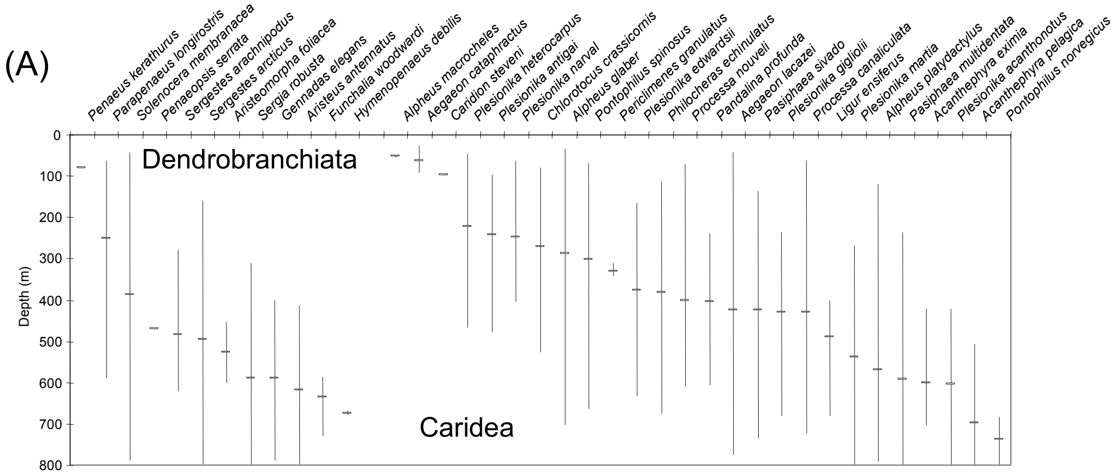

Fig. 2a.- Bathymetric distribution of the crustaceans collected during the MEDITS trawl surveys performed along the Iberian Peninsula Mediterranean coasts, ranked according to their mean depth of occurrence. (A) Dendrobranchiata and Caridea; (B) Anomura; (C) Brachyura; (D) Other Crustacea groups.

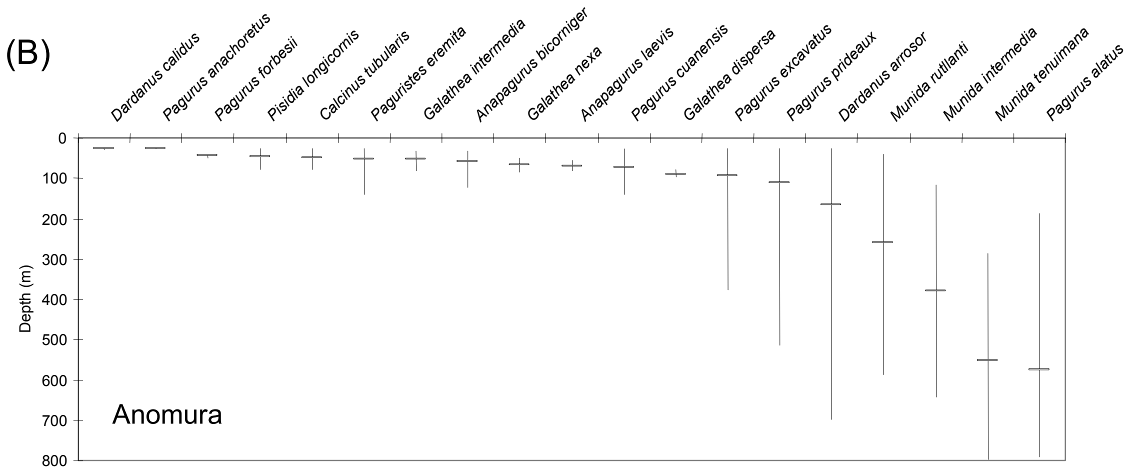

Fig. 2b.- Bathymetric distribution of the crustaceans collected during the MEDITS trawl surveys performed along the Iberian Peninsula Mediterranean coasts, ranked according to their mean depth of occurrence. (A) Dendrobranchiata and Caridea; (B) Anomura; (C) Brachyura; (D) Other Crustacea groups.

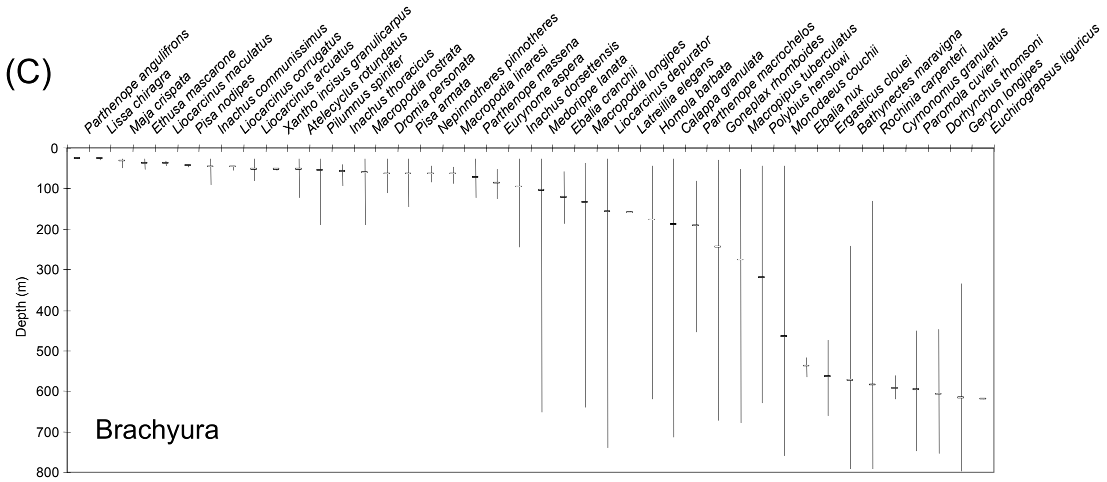

Fig. 2c.- Bathymetric distribution of the crustaceans collected during the MEDITS trawl surveys performed along the Iberian Peninsula Mediterranean coasts, ranked according to their mean depth of occurrence. (A) Dendrobranchiata and Caridea; (B) Anomura; (C) Brachyura; (D) Other Crustacea groups.

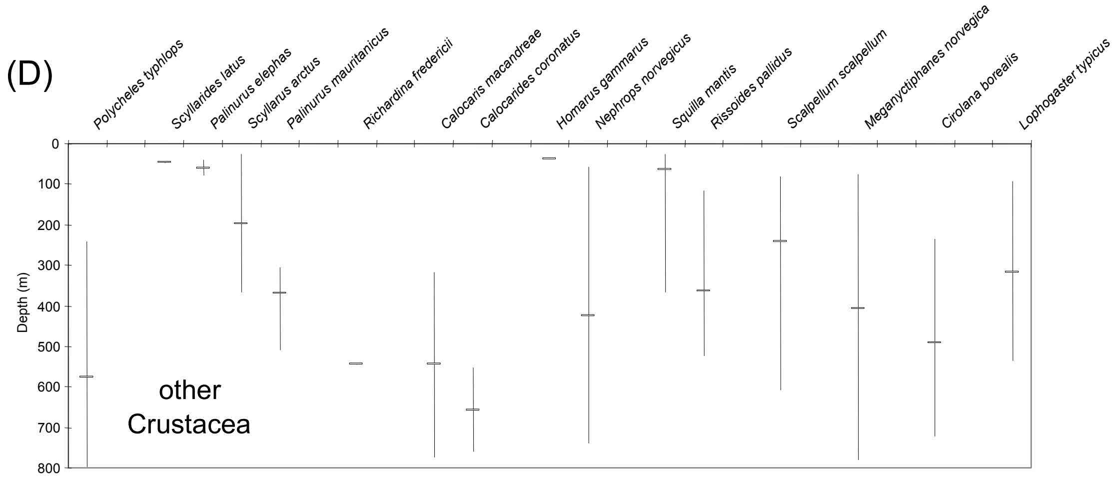

Fig. 2d.- Bathymetric distribution of the crustaceans collected during the MEDITS trawl surveys performed along the Iberian Peninsula Mediterranean coasts, ranked according to their mean depth of occurrence. (A) Dendrobranchiata and Caridea; (B) Anomura; (C) Brachyura; (D) Other Crustacea groups.

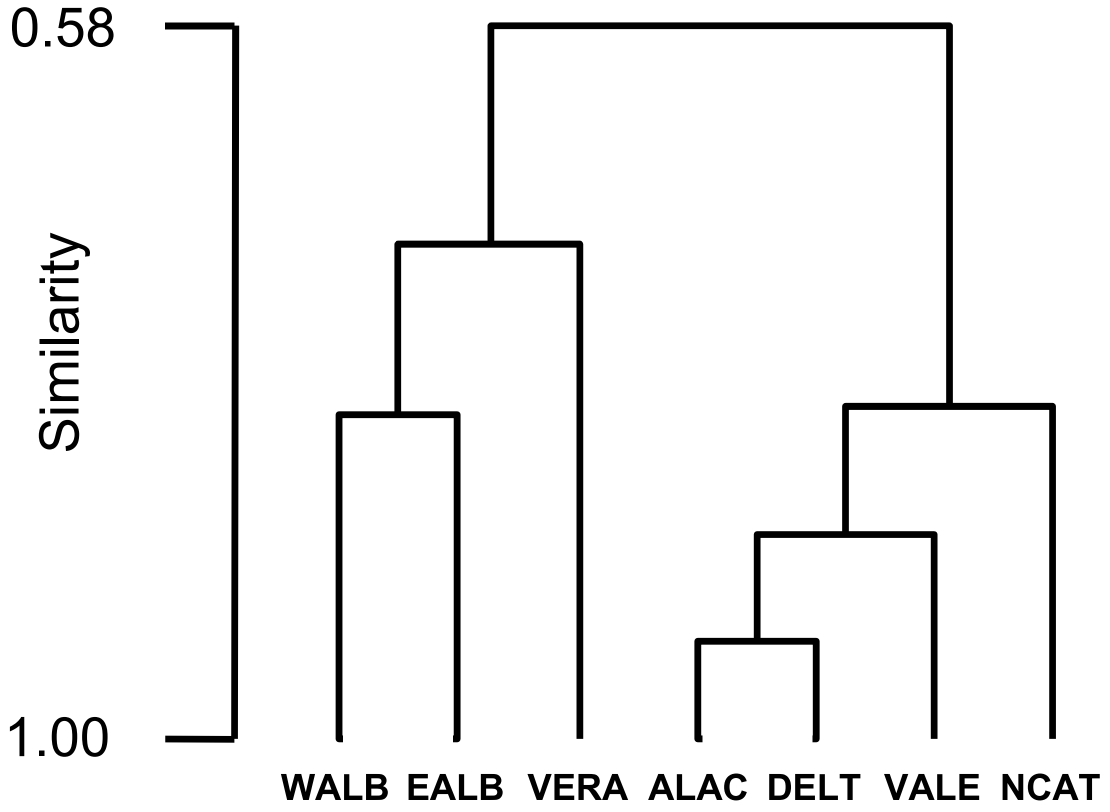

Fig. 3.- Dendrogram of similarities among geographical sectors based in their faunistic resemblance using Yule's similarity index and the UPGMA aggregation algorithm. WALB: Western Alborán Sea; EALB: Eastern Alborán Sea; VERA: Vera Gulf; ALAC: Alacant; EIVI: Eivissa island; VALE: Valencia; DELT: Ebro delta region; NCAT: Northern Catalonia.

3.5 SECTION IV *STATIS-CoA: A methodological solution to assess the spatio-temporal organization of species assemblages. Application to the demersal assemblages of the French Mediterranean Sea.*

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SUMMARY: The organizational patterns of demersal assemblages (fish, crustaceans and cephalopods) in the Gulf of Lions were investigated on the basis of a set of six bottom trawl surveys performed between 1994 and 1999 (MEDITS programme). The use of a recent multitable method (STATIS-CoA) provided a detailed representation of the stable and variable parts of the spatial organization of demersal assemblages during the studied period. We evidenced that demersal assemblages of the Gulf of Lions were organized along a coast-open sea gradient. At the scale of the gulf, we showed that this gradient can be split into three areas: 1) the coastal region and the continental shelf (10 to 200 m depth), 2) the upper slope (200 to 500 m) and 3) the deeper slope (500 to 800 m). Associated to this bathymetric structuring we found a species-richness gradient which decreases from the coast to the upper slope. Our analysis showed that this spatial organization pattern was highly persistent during the course of the study. However, some species caught in the slope area exhibited a strong variability of their spatial distribution mainly during the 1999 survey. From a methodological point of view, STATIS-CoA offers a rigorous theoretical frame for the simultaneous analysis of three-dimensional set of data. Applied in the field of fisheries ecology, this method (1) constitutes a relevant way to analyse the spatial organization of species assemblages and its pattern of changes and (2) could be of particular interest to treat the MEDITS data both at a local and at the North Mediterranean Sea scales.

Keywords: demersal assemblages; trawl surveys; MEDITS; STATIS-CoA; multitable analyses; Mediterranean Sea.

3.5.1 INTRODUCTION

Numerous experimental survey programmes have been conducted along the coast of the North Mediterranean Sea in order to provide fishery-independent indices to assess the demersal species (Biagi *et al.*, 1989; Liorzou *et al.*, 1989; Abella and Serena, 1995; Aldebert, 1997; Ungaro *et al.*, 1998; Kallianiotis *et al.*, 2000). Most of these experimental surveys were conducted independently in each area, without any standardization of the sampling processes. The only exception concerned, a Mediterranean International Trawling survey programme (the MEDITS programme; Bertrand and Relini, 2000; Bertrand *et al.*, in this volume) carried out annually from 1994 to 2000, in several areas of the Mediterranean Sea from Gibraltar to the Aegean Sea, and using a unique standardized sampling design. In addition to the direct assessment of the commercial species, the data collected during this programme provide a unique basis to better understand the spatio-temporal organization of the demersal assemblages at the scale of the North-Mediterranean Sea. Nevertheless, to reach such a goal, several works (Gabriel and Murawski, 1985; Mahon and Smith, 1989; Mahon *et al.*, 1998) evidenced that it is first needed, for each of the sampled regions: (1) to define assemblages, (2) to identify their spatial distribution boundaries and (3) to monitor their temporal evolution.

From a methodological viewpoint, these preliminary steps require, in each area, the simultaneous analysis of the data tables derived from each survey during the course of the study. Until recently, the treatment of such a three-dimensional data set (space-time-species) failed because of methodological problems (Centofanti *et al.*, 1989; Dolédec and Chessel, 1989; Gaertner, 1997). For fishery ecology purposes, Mahon *et al.* (1998) pointed out the subjective aspect of traditional methodological approaches and concluded that it limited the value of works focused on this field. However, during the last decade, the development of computer tools has stimulated the creation of new statistical methods. Among them, the multitable analysis family (Escoffier and Pagès, 1994; Lavit *et al.*, 1994; Chessel and Hanafi, 1996) appeared well suited to treat three-dimensional data.

In this paper, we used a recent multitable analysis specifically created to analyse the reproducibility of multivariate structures (Gaertner *et al.*, 1998). Our goal was to show if and how this method (1) constitutes a relevant way to analyse the spatial organization of species assemblages and its pattern of changes, and (2) could be of particular interest to treat the MEDITS data both at a local and at the full

MEDITS scales. In the present work we applied this technique on MEDITS data collected between 1994 and 1999 in the Gulf of Lions (Northwest Mediterranean).

3.5.2 MATERIAL AND METHODS

3.5.2.1 Data type and origin

The present work was based on a set of abundance indices collected in the Gulf of Lions (Fig. 1) during the French part of the international MEDITS programme (Bertrand and Relini, 2000; Bertrand *et al.*, in this volume). We worked with six bottom trawl surveys conducted yearly at the same period (June) between 1994 and 1999 by the Fishery Resources Laboratory of Ifremer, Sète.

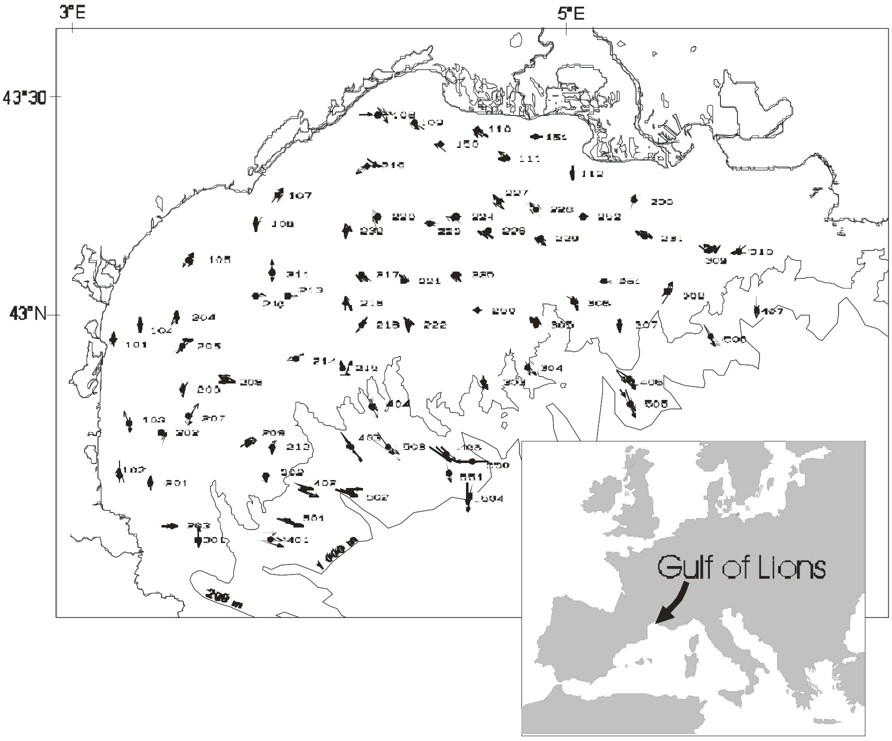

Figure 1.- Localisation of the study site: Gulf of Lions, showing location of stations used in the sampling design. The first print of each stations' label indicates the bathymetric strata (1 from 10 to 50 m depth; 2 from 50 to 100 m depth; 3 from 100 to 200 m depth; 4 from 200 to 500 m depth; 5 from 500 to 800 m depth).

For all the surveys, a unique depth stratified random sampling design with uniform sampling fraction was used (Table 1). Location of sample units was selected randomly within each stratum. Each haul was approximately carried out at the same location from one survey to the other (Anon., 1998). A bottom trawl with a vertical opening about 2.3 m was used. Tows were 30 min in duration when the depth was between 10 and 200 m, and 60 min when it was deeper (from 200 to 800 m). 69 of the species caught during the five surveys (Appendix) were sufficiently abundant to be included in the analysis (i.e. they were present in more than 5 % of the tows). For each tow, the densities in number of individuals were expressed for a same surface unit (hectare). The data were log-transformed before conducting the analysis to minimise the dominant effect of exceptional catches.

Table 1. Description of the stratification used in the sampling design. Strata, label of strata; Limits, bathymetric limits of each strata (m); Tows, number of tows conducted in each.

Strata	Limits (m)	Tows
1	10-50	14
2	50-100	35
3	100-200	10
4	200-500	7
5	500-800	8

3.5.2.2 Data analysis

The temporal monitoring of the spatial organization of the demersal assemblages during the course of the study required the combined analysis of the data tables issued from each survey. For that purpose, we carried out the STATIS-CoA multitable method (Gaertner *et al.*, 1998), which couples STATIS method (Lavit *et al.*, 1994), and Correspondence analysis (Hill, 1973).

The first stage of the CoA version of STATIS consists in calculating a matrix of scalar products between variables (i.e. species in the present case) for each table (i.e. trawl survey) in order to standardize the dimensions of the tables. This step make then possible to compare all the tables by calculation of a matrix of scalar products between tables (Escouffier and Robert, 1976). The diagonalization of this matrix provides eigenvectors. The k coefficients of the first eigenvector are used to weight the k tables in the calculation of a "compromise table". This weighting allows the construction of a compromise table that contains the common part of the studied structures. In other words, the compromise table is a linear combination of the k initial tables (i.e. the six surveys in the present case) calculated with the aim of constructing a mean table of maximum inertia. Thus, in the construction of the compromise table a greater importance is given to the tables which have similar structures and a limited one to the other tables. The analysis (CoA) of the compromise table define axes and components which express the common part of the structures studied (i.e. the common part of the spatial organization patterns of demersal assemblages during the course of the study).

Independently, a separate Correspondence Analysis of each of the six surveys was carried out. This step allows the projection of the first axes of the separate analyses of each survey onto the first axes of the compromise table. This representation indicates how much the main structures of each initial table are taken into account in the compromise (Lavit *et al.*, 1994). In the present study, it gives a better insight on the temporal stability of the main organizational patterns. In addition, the projection of the k initial tables onto the compromise allows us to draw the trajectories that represent the temporal variations of each species around the common structure. Technically, this involves projecting onto the axes of the compromise table, the factorial scores that each species obtains in each of the separate tables.

In comparison with the classical method of STATIS, the CoA version used in the present work is specifically suited to analyse the spatio-temporal organization of assemblages in term of species composition (Gaertner *et al.*, 1998) and it allows the optimal plot of temporal species trajectories (Dolédec and Chessel, 1989). This CoA version of STATIS may currently be performed with the ADE-4 software (Thioulouse *et al.*, 1996). This software is freely available at the following address: http://pbil.univ-lyon1.fr/ADE-4.html

Table 2. Description of the structure defined for each survey.

	Weight	Cos²
1994	0.40	0.79
1995	0.41	0.82
1996	0.42	0.87
1997	0.41	0.80
1998	0.41	0.82
1999	0.39	0.72

Weight, contribution of each table in the construction of the compromise,
Cos^2, fit of each table to the compromise.

3.5.3 RESULTS

The first results given by the use of STATIS-CoA (Table 2) showed that the contributions of the different surveys to the construction of the compromise table are similar (weights from 0.39 to 0.41). So, each of the six surveys played a similar role in the constitution of the STATIS compromise table. Moreover, the fit of each of the tables to the compromise table (Cos²) was homogeneous. The weakest values observed for 1999 (Cos² = 0.72), indicated that the structure of this survey was less well taken into account into the compromise table. However, the high similarity between the projections of the first and the second axes of the separate CoAs of each of the six surveys with the first two axes of the compromise table showed that the two main organizational directions expressed in the compromise table are common to each of the six surveys (Fig. 2). The weakest fit of 1999 to the compromise appeared only on the second axis of the separate Correspondence analysis. In short, these preliminary results suggested the existence of a strong inter-annual stability in the spatial organization of the demersal assemblages in the Gulf of Lions during the period studied, but with a limited variability during the 1999 survey.

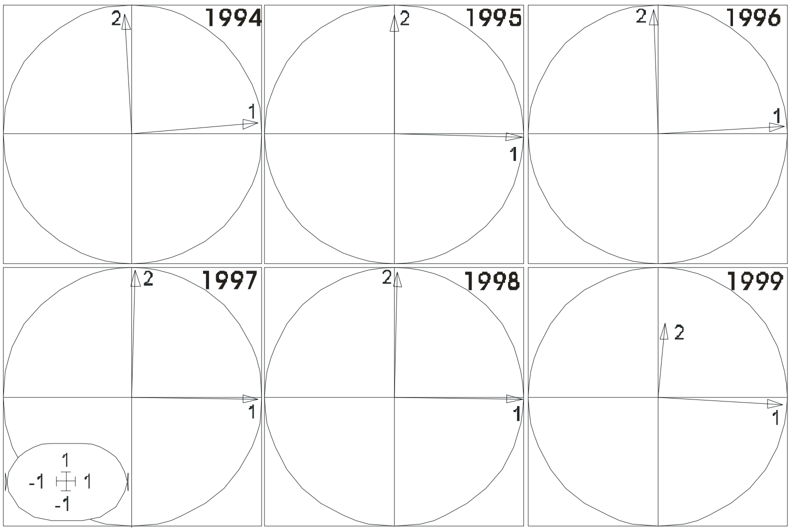

Figure 2.- Projection of the first two factorial axes of the separate Correspondence Analysis of each survey (arrows) on the two first factorial axes of the STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical).

The first two axes of the compromise of STATIS-CoA accounted for 26% and 11% of the total variability, respectively. The projection of the samples' factorial scores onto the first two axes of the compromise provided a representation of the stable part of the main spatial structures (Fig. 3). It showed a pattern of organization based on a coast-open sea gradient which can be divided into three main regions, each of them being characterized by specific assemblages. Species of the coastal area (stratum 1, between 10 and 50 m depth) and of the continental shelf (Strata 2 and 3, between 50 and 200 m depth) could be associated in a first assemblage. The upper slope (stratum 4, from 200 to 500 m) constituted a second homogeneous area in term of species composition, while the deeper slope (stratum 5, from 500 to 800 m) contained a third assemblage. A very sharp discrimination of the spatial boundaries of these three assemblages of species was found (Fig. 3a).

Moreover, we can notice that each station which belonged to one of the bathymetric regions was generally localised with stations of the same bathymetric region during the different surveys (Figure 3b). This result confirmed the strong reproducibility of the spatial structuring of the studied assemblages. However, an element of variation appeared during the survey conducted in 1999. It mainly affected some of the stations of the stratum 5 which were then reallocated with stations of stratum 4.

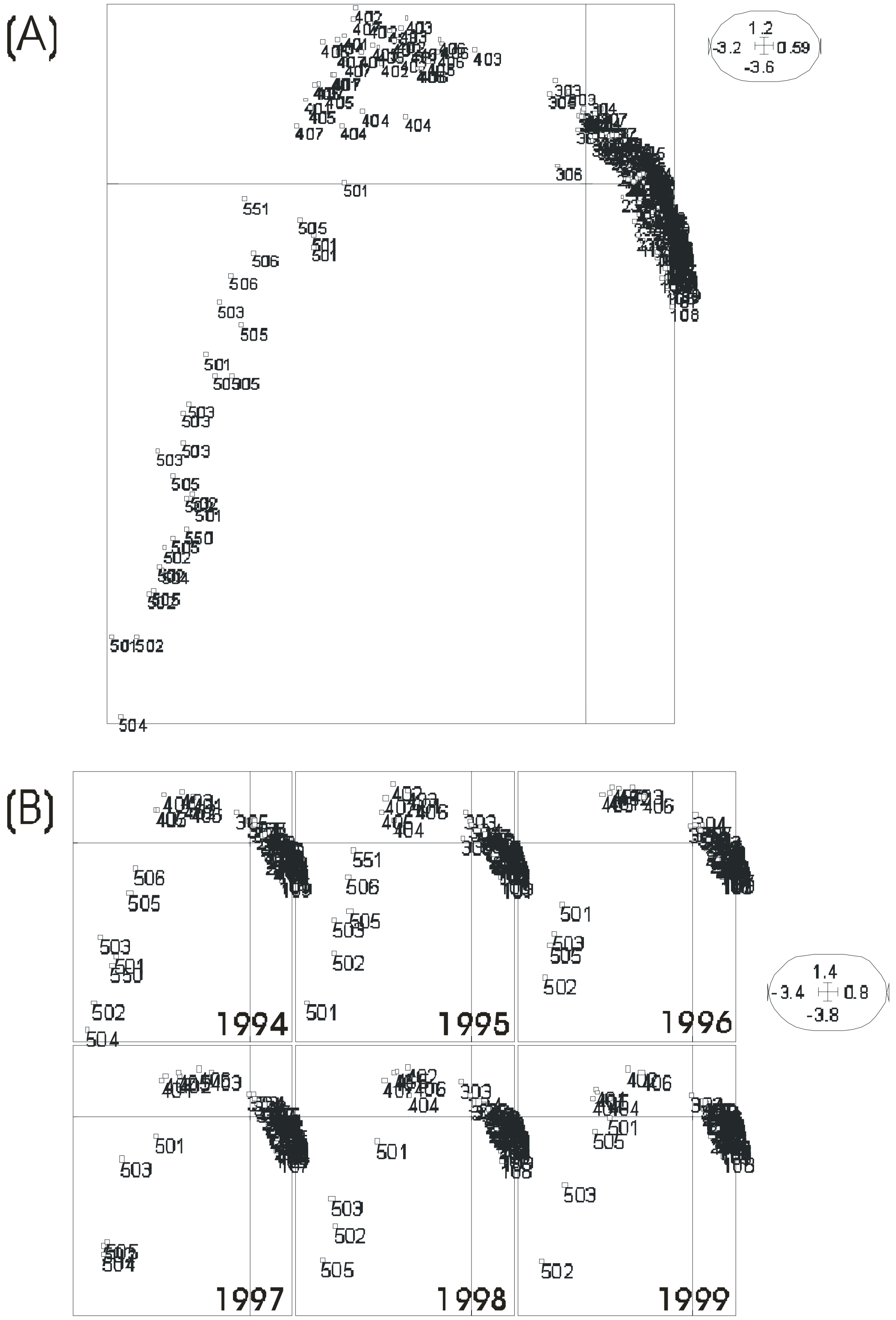

Figure 3.- Projection of the factorial scores of the stations (A) for the whole studied period and (B) for each separated survey on the two first factorial axes of the STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). Stations labelled as in Fig. 1

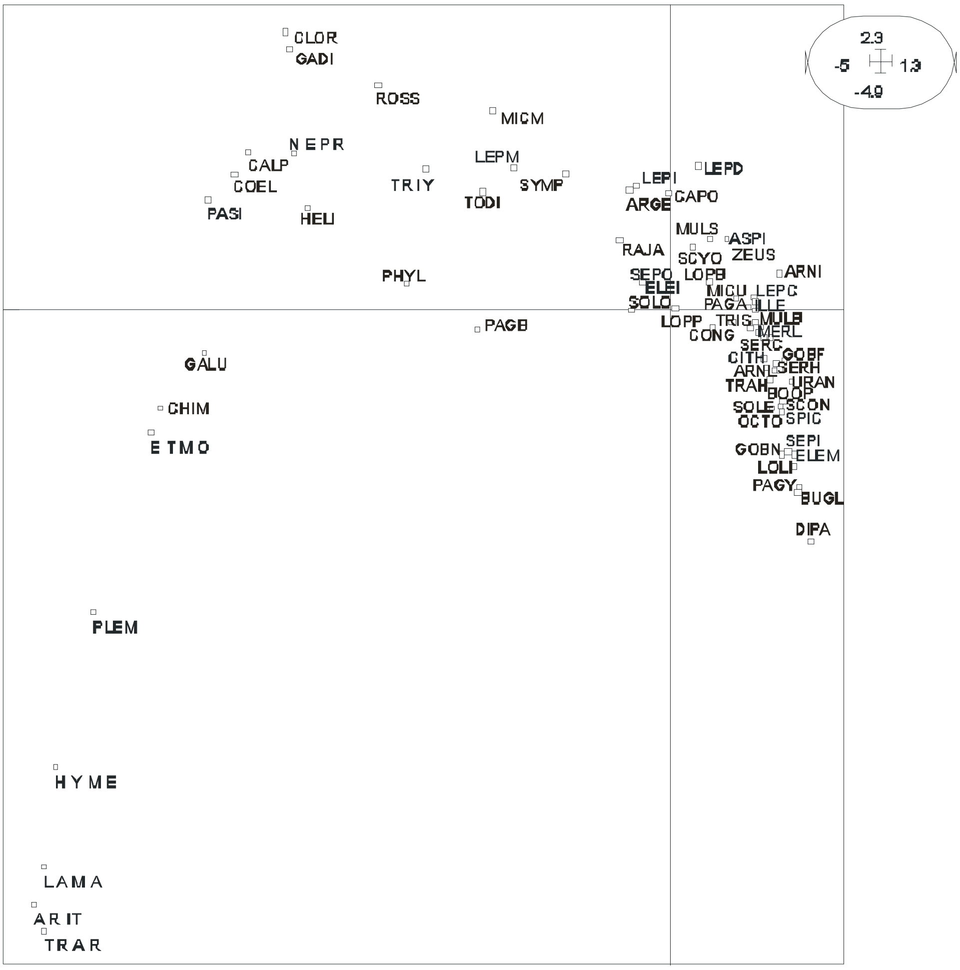

Figure 4.- Projection of the species on the first factorial plane of STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). Species codes as in Appendix.

Figure 4 detailed the organization pattern of all the species along the bathymetric gradient. It gave a typology of the species with reference to the common pattern observed in the course of the six surveys. A first assemblage linked fishes (*Diplodus annularis, Buglossidium luteum*, *Pagellus erythrinus, Boops boops*, *Solea vulgaris, Uranoscopus scaber*) and cephalopods (*Loligo vulgaris, Octopus vulgaris*) only caught in the coastal area (stratum 1). Fish species such as *Mullus barbatus, Pagellus acarne*, *Lophius piscatorius, Lophius budegassa*, *Zeus faber, Merluccius merluccius, Mullus surmuletus*, *Lepidotrigla dieuzeidei*, *Argentina sphyraena*, *Scyliorhinus canicula* and the cephalopod *Illex coindetii* found in the continental shelf also belonged to this assemblage.

The upper slope assemblage was characterized by fishes such as *Lepidorhombus boscii, Micromesistius poutassou, Trigla lyra, Gadiculus argenteus, Phycis blennoides, Helicolenus dactylopterus* and by a crustacean (Nephrops norvegicus). Other fishes such as *Galeus melastomus, Chimaera monstrosa, Etmopterus spinax, Trachyrhynchus trachyrhynchus* and crustaceans (*Aristeus antennatus* and *Plesionika martia*) belonged to the deeper slope assemblage. At the scale of the study, our results showed that this bathymetric gradient was associated with a species-richness gradient which decreased from the coast to the deeper slope.

Finally, the species' trajectories allowed to analyse the variability of the position of each taxon around the common structure (Figure 5). However, the strong overlap of the ranges of distribution observed complicates the analysis of the species trajectories. Consequently, the projection of only a few representative species of each assemblage was provided to illustrate their temporal variations (Figure 6). A generally weak variation of species around their reference position may be observed in the area which spread between the coast and the continental shelf (strata 1 to 3). This was also the case for some species of stratum 4 (*Lepidorhombus boscii*, *Gadiculus argenteus, Helicolenus dactylopterus*) and stratum 5 (*Galeus melastomus* and *Hymenocephalus italicus*). Nevertheless, some other species of these two latter assemblages exhibited a strong variability in relation to their reference position (see *Pagellus bogaraveo, Solenocera membranacea*, *Todaropsis eblanae*, *Chimaera monstrosa*, *Plesionika martia*, *Lampanyctus crocodilus* and *Aristeus antennatus*). Among them, we can note that the strong trajectories of *Solenocera membranacea*, *Todaropsis eblanae*, *Chimaera monstrosa* and *Lampanyctus crocodilus* mainly occurred during the survey conducted in 1999.

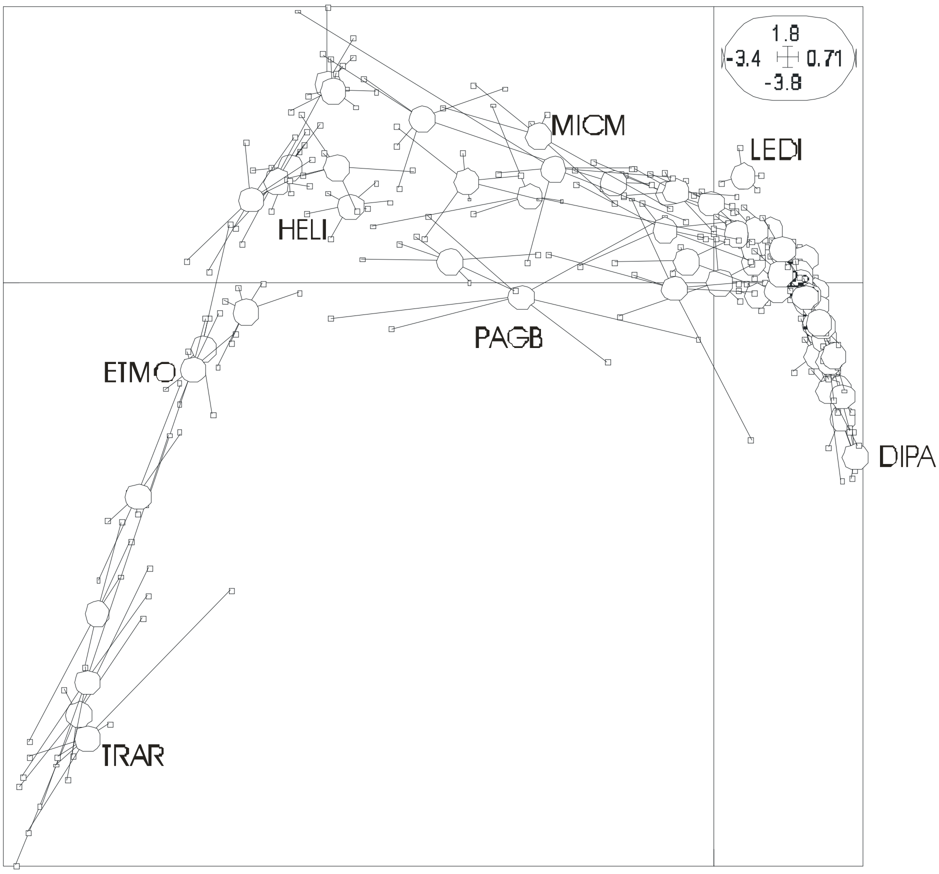

Figure 5.- Projection of the species' trajectories on the first factorial plane of STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). The position of a species in each survey (▫) is related to its position in the compromise (❍). Species codes as in Appendix.

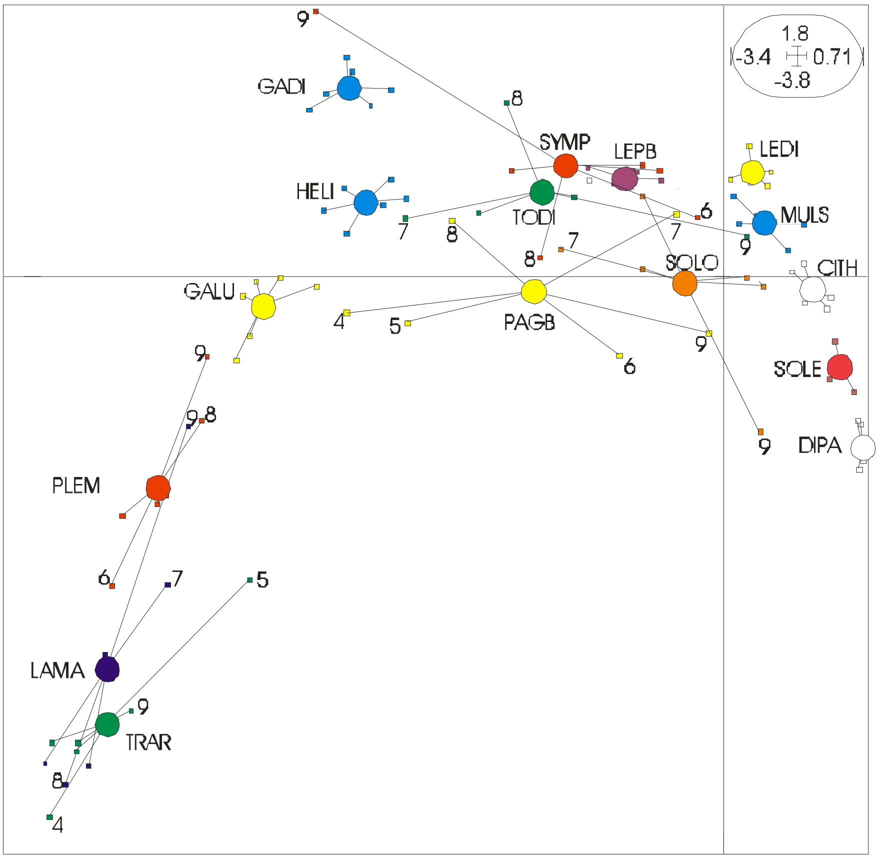

Figure 6.- Detail of the projection of the trajectories of some characteristic species on the first factorial plane of STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). Species codes as in Appendix. The code used for the trajectories refers to the corresponding survey (4: 1994; 5: 1995; 6: 1996; 7: 1997; 8 1998; 9:1999).

3.5.4 DISCUSSION

In the present study, we evidenced that demersal assemblages of the Gulf of Lions were mainly organized along a bathymetric gradient. At the scale of the gulf, we showed that this gradient can be split into three areas: 1) the coastal region and the continental shelf (10 to 200 m depth), 2) the upper slope (200 to 500 m) and 3) the deeper slope (500 to 800 m). Associated to this bathymetric structuring we found a species-richness gradient, which decreased from the coast to the upper slope. Our analysis showed that this spatial organization pattern was highly persistent during the course of the study. However, a few species caught in the slope area exhibited a strong variability of their spatial distribution mainly during the 1999 survey.

The preponderance of depth on the spatial organization of demersal assemblages has been commonly reported both in the study site (Maurin, 1968; Gaertner *et al.*, 1998) and in the world ocean (Fager and Longhurst, 1968; Mahon and Smith, 1989; Bianchi, 1991; Gordon and Bergstad, 1992; Weinberg, 1994; Fujita *et al.*, 1995; Gomes *et al.*, 1995; McClatchie *et al.*, 1997; Mahon *et al.*, 1998). Nevertheless, identification of the factors really responsible for the structuring of species along this gradient is difficult. In the literature, despite the diversity of the field experiments, some factors such as physical and chemical characteristics of the water (Fager and Longhurst, 1968; Mahon and Smith, 1989; Loneragan and Potter, 1990; Bianchi, 1992; Rakocinski *et al.*, 1992; Perry *et al.*, 1994) or other habitat features (Jones *et al.*, 1991; Bianchi, 1992; Jackson and Harvey, 1992; Auster *et al.*, 1995) were often described to influence the organizational patterns of groundfish assemblages. In the Gulf of Lions, a recent analysis, from a series of bottom trawl surveys carried on between 1985 and 1992 (the CHALIST surveys), suggested that demersal assemblages were partly linked with sediment type and composition of macrofauna communities (Gaertner *et al.*, 1999). In the present study, the lack of environmental data prevented us from neither validate nor complete our knowledge on this topic. This latter point highlights a present limit of numerous experimental resources assessment programmes to progress in that direction due to the frequent weakness of effort dedicated to get information on environmental descriptors (Perry *et al.*, 1994). The recent improvement of technological devices (satellite sensors, cameras, multiparameter probes, etc.) coupled with trawling could help to reverse this trend and thus might provide multicompartment data bases whose analysis is now possible owing to the new available statistical developments (Gaertner *et al.*, 1999; Mazouni *et al.*, 2001).

The strong stability of organizational pattern observed in the present study agrees with the conclusions of other works led on demersal assemblages (Colcovocoresses and Musick, 1984; Mahon and Smith, 1989; Gabriel, 1992; Gomes *et al.*, 1995; Gaertner *et al.*, 1998). Nevertheless, in strongly exploited ecosystems, stability periods can be followed by periods of great changes in species composition (see Gomes *et al.*, 1995). In numerous cases, these variations have been attributed to the direct and indirect effect of intensive trawling (Hutchings, 1990; Harris and Poiner, 1991; Thrush *et al.*, 1995). In the Gulf of Lions, the fishing activity - notably trawling fleet - is heavy. Nevertheless, the main changes occurred since the 1970's (Meuriot *et al.*, 1987; Taquet, *et al.*, 1997) and no major change in species composition eventually linked with fishery has been identified from our study. These preliminary results could suggest a weak influence of trawling on the composition of the demersal assemblages in the Gulf of Lions. However, the short length of our study (six years) did not permit us to really conclude on this point. Actually, available information on strong changes in exploited population abundance in this area (mainly on species belonging to the Selacians guild) have been obtained from longer series of data (Aldebert, 1997; Bertrand *et al.*, 2000). So far, only the pursue of the MEDITS surveys over a long period (even at a wider temporal scale) will allow to go more deeply into the analysis of the effects of trawling on assemblages organization.

The only element of variability observed during the studied period concerned the slope area in 1999. A part of this observed variability could be linked to the sampling. Indeed, by using a system which controls the trawl geometry (a Scanmar device), Bertrand *et al.* (in this volume) pointed out the potential influence of the variability of trawl performances on the catches, mainly in the slope area. At the present state of knowledge, it is not possible to quantify the respective part of the observed variability linked to sampling and the one corresponding to real changes in assemblages organization. Nevertheless, these results led us to suggest some improvements in the sampling methodology for the future MEDITS surveys. First, it pointed out the necessity to systematically use underwater instruments (such as Scanmar device) to control the fishing operations, and to stabilize the trawl performances. Secondly, it could incite to adjust the future sampling effort to the observed variability. Nevertheless, the management of this kind of adaptation may be difficult taking into account the diverse objectives of the survey

From an experimental viewpoint, the comparison of our results with previous works conducted in the same area leads to several comments. The bathymetric gradient estimated from the results of the surveys conducted in the Gulf of Lions between 1994 and 1999 (present analysis of the MEDITS data) was similar to the pattern previously observed on the basis of the surveys performed between 1985 and 1992 (CHALIST surveys; Gaertner, 1997; Gaertner *et al.*, 1998). However, in these previous works the split of the species into three assemblages was not so clear and the bathymetric boundaries were different. Moreover, 69 species were taken into account in the present analyses, whereas using the same selection criteria, only 45 were considered in the analyses based on the results of the CHALIST surveys (42 species are common to the two periods). Differences in the sampling performances (different vessels, gear and handling protocols) may probably explain a great part of these discrepancies.

In addition, contrarily to the MEDITS programme, the strata 5 (500 to 800 m) has not been sampled during the CHALIST programme. As a consequence, the global scale of observation was different in the two programmes. This problem has been highlighted by several authors who showed, both in marine and terrestrial ecosystem, that community structuring is a hierarchical concept strongly linked to the scales of observation (Connell and Sousa, 1983; Wiens, 1986; Rahel, 1990). More generally, this pointed out the importance of the scales in the perception of the factors acting on the community organization (Ricklefs, 1987; Wiens, 1989), and that there is not only one relevant scale of observation (Levin, 1992). In community ecology, numerous controversies on the determinism of assemblages were only linked to the lack of homogeneity between the scales used in the comparative studies (Wiens, 1989; Rahel, 1990; Levin, 1992). Thus, in the context of the MEDITS programme, in addition to the need to standardize all the technical elements of the sampling designs (vessel, gear, net mesh, etc.), it appears essential to use common scales of observation in view to develop inter-regional comparison approaches.

From a methodological point of view, the two approaches most commonly used for analysing the spatio-temporal organization of communities are based on clustering or simple factorial analyses. A first traditional approach is turned to comparative reading of typologies obtained separately for each of the surveys. It consists in roughly estimating the graphic similarities between the structures observed independently for each survey (Gabriel and Tyler, 1980; Overholtz and Tyler, 1985; Mahon and Smith, 1989; Gabriel, 1992; Rakocinski *et al.*, 1992; Fujita *et al.*, 1995; Mahon *et al.*, 1998). This procedure runs into difficulties whenever the tables to be compared are too numerous or extensive (Amanieu *et al.*, 1981; Gaertner, 1997). The second traditional approach involves carrying out multivariate analysis after pooling in a single table the data from different surveys. This method, used for the analysis of demersal fishes organization in numerous regions in the world (Mahon, 1985; Roel, 1987; Macpherson and Gordoa, 1992; Weinberg, 1994) can however result in a confusing mixture of spatial and temporal effects (Centofanti *et al.*, 1989; Gaertner, 1997).

In this context, multitable analyses as the one proposed by the STATIS-CoA offer an original solution to solve these problems. Indeed, specifically created to split the stable and variable parts of communities spatial organization, this approach proposes a rigorous theoretical frame for the simultaneous analysis of several data tables (see Gaertner *et al.*, 1998). Consequently, multitable analysis allow to circumvent the difficulties linked with the subjective aspects of the first traditional approach and the confusing interaction between spatial and temporal scales inherent to the second approach.

In conclusion, in the prospect of MEDITS developments, approaches using a multitable method should help the analysis of several concrete questions:

- At a local scale, (i.e. for each area surveyed by the programme), it can allow to characterize species assemblages, to identify their spatial distribution boundaries and to monitor their temporal evolution. The interest of this knowledge is double. Firstly, these findings are relevant to define spatial or ecosystem units in view to provide background for fisheries management (Tyler *et al.*, 1982; Gabriel and Murawski, 1985; Biagi *et al.*, 1989; Mahon *et al.*, 1998). Secondly, it constitutes the obligatory starting point before developing inter-regional comparative approaches (Gaertner, 1997).
- At a more global scale, and on the basis of the previous results, the method could be carried out in an original way to simultaneously compare the spatial organization of demersal assemblages in several regions. Applying multitable analysis for this purpose should help to improve our understanding on the determinism of demersal assemblages at the scale of the north of the Mediterranean Sea.

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Appendix. List of the species considered with detail on the abbreviated names used.

Label	Nom latin	Famille
ARGY	*Argentina sphyraena* Linnaeus, 1758	ARGENTINIDAE
ARIT	*Aristeus antennatus* (Risso, 1816)	PANDALIIDAE
ARNL	*Arnoglossus laterna* (Walbaum, 1792)	BOTHIDAE
ARNT	*Arnoglossus Thori* Kyle, 1913	BOTHIDAE
ASPI	*Aspitrigla cuculus* (Linnaeus, 1758)	TRIGLIDAE
BOOP	*Boops boops* (Linnaeus, 1758)	SPARIDAE
BUGL	*Buglossidium luteum* (Risso, 1818)	SOLEIDAE
CALP	*Synchiropus phaeton* Gunther, 1861	CALLIONYMIDAE
CAPO	*Capros aper* (Linnaeus, 1758	CAPROIDAE
CEPO	*Cepola rubescens* Linnaeus, 1766	CEPOLIDAE
CHIM	*Chimaera monstrosa* (Linnaeus, 1758)	CHIMAERIDAE
CITH	*Citharus linguatula* (Linnaeus 1758)	CITHARIDAE
CLOR	*Chlorophthalmus agassizi* Bonaparte, 1840	CHLOROPHTHALMIDAE
CONG	*Conger conger* (Linnaeus, 1758)	CONGRIDAE
DIPA	*Diplodus annularis* (Linnaeus, 1758)	SPARIDAE
ELEC	*Eledone cirrhosa* (Lamarck, 1798)	OCTOPIDAE
ELEM	*Eledone moschata* (Lamarck, 1799)	OCTOPIDAE
ETMO	*Etmopterus spinax* (Linnaeus, 1758)	SQUALIDAE
EUTR	*Eutrigla gurnardus* (Linnaeus, 1758)	TRIGLIDAE
GADI	*Gadiculus argenteus* Guichenot, 1850	GADIDAE
GALU	*Galeus melastomus* Rafinesque, 1809	SCYLIORHINIDAE
HELI	*Helicolenus dactylopterus* (Delaroche, 1809)	SCORPAENIDAE
HYME	*Hymenocephalus italicus* Giglioni, 1884	MACROURIDAE
ILLE	*Illex coindetii* (Verany, 1839)	TEUTHOIDEA
LAMA	*Lampanyctus crocodilus*	MYCTOPHIDAE
LEPI	*Lepidopus caudatus* (Euphrasen, 1788)	TRACHIURIDAE
LEPB	*Lepidorhombus boscii* (Risso, 1810)	SCOPHTALMIDAE
LECA	*Lepidotrigla cavillone* (Lacepède, 1801)	TRIGLIDAE
LEDI	*Lepidotrigla dieuzeidei* Audoin *in* Blanc and Hureau, 1973	TRIGLIDAE
LOLI	*Loligo vulgaris* Lamarck, 1798	LOLIGINIDAE
LOPB	*Lophius budegassa* Spinola, 1807	LOPHIIDAE
LOPP	*Lophius piscatorius* Linnaeus, 1758	LOPHIIDAE
MERL	*Merluccius merluccius* (Linnaeus, 1758)	MERLUCIIDAE
MICM	*Micromesistius poutassou (Risso, 1826)*	GADIDAE
MICU	*Microchirus variegatus (Donovan, 1802)*	SOLEIDAE
MULB	*Mullus barbatus* Linnaeus, 1758	MULLIDAE
MULS	*Mullus surmuletus* Linnaeus, 1758	MULLIDAE
NEPR	*Nephrops norvegicus* (Linnaeus, 1758)	NEPHROPIDAE
OCTO	*Octopus vulgaris Cuvier, 1797*	OCTOPODIDAE
PAGA	*Pagellus acarne* (Risso, 1826)	SPARIDAE
PAGB	*Pagellus bogaraveo (Brunnich, 1768)*	SPARIDAE
PAGY	*Pagellus erythrinus* (Linnaeus, 1758)	SPARIDAE
PHYI	*Phycis blennoides* (Brünnich, 1768)	GADIDAE
PLEM	*Plesionika martia* (A. Milne Edwards, 1883)	PANDALIDAE
RAJC	*Raja clavata* Linnaeus, 1758	RAJIDAE
ROSS	*Rossia macrosoma* (Delle Chiaje, 1829)	SEPIOLIDAE
SCON	*Scorpaena notata Rafinesque, 1810*	SCORPAENIDAE
SCYO	*Scyliorhinus canicula* (Linnaeus, 1758)	SCYLIORHINIDAE
SEPE	*Sepia elegans* Blainville , 1827	SEPIIDAE
SEPO	*Sepia orbignyana* Ferussac, 1826	SEPIIDAE
SERC	*Serranus cabrilla* (Linnaeus, 1758)	SERRANIDAE
SERH	*Serranus hepatus* (Linnaeus, 1766)	SERRANIDAE
SOLE	*Solea vulgaris (Quensel, 1806)*	SOLEIDAE
SOLO	*Solenocera membranacea* (Risso, 1816)	SOLENOCERIDAE
SPIC	*Spicara maena* (Linnaeus, 1758)	CENTRACANTHIDAE
TODI	*Todaropsis eblanae* (Ball, 1841)	TEUTHOIDEA
TRAH	*Trachinus draco* Linnaeus, 1758	TRACHINIDAE
TRIY	*Trigla lyra* Linnaeus, 1758	TRIGLIDAE
TRIS	*Trisopterus capelanus minutus* (Lacépede, 1800)	GADIDAE
TRIP	*Trigloporus lastoviza* (Bonnaterre, 1788)	TRIGLIDAE
URAN	*Uranoscopus scaber* Linnaeus, 1758	URANOSCOPIDAE
ZEUS	*Zeus faber* Linnaeus, 1758	ZEIDAE

3.6 Section V Species assemblages and geographical sub-areas in the North Aegean Sea

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3.6.1 Introduction

The research made until today in the Greek seas on the demersal fish assemblages is concentrated on the South Aegean Sea (Tsimenides *et al.*, 1991, Tserpes *et al.*, 1999, Kallianiotis *et al.*, 2000). In comparison to the southern Aegean, where the bathymetric morphology shows steep depth gradient, with limited continental shelf, the northern Aegean is characterized by an extensive continental shelf which has been formed by the discharge of the large rivers in the area. The physicochemical characteristics indicate that the northern Aegean is characterized by lower mean water temperature and salinity, which is due to the existence of the water inflow from the Black Sea and the inflow of several rivers such as Evros, Nestos, Strymonas, Axios, Aliakmon and Pinios. According to the MEDITS project as North Aegean was considered the part northern to the 38th parallel. In the context of this project, fauna composition and species abundance indices were used to determine species assemblages, their geographical distribution and their temporal variation.

3.6.2 Materials and Methods

Annual bottom trawl surveys were mainly conducted from late spring to mid summer in the Mediterranean Sea from 1994 to 2001 to obtain estimates of abundance indices for a series of target species. In the North Aegean Sea, Fisheries Research Institute was involved in the project since 1996, where approximately 65 hauls were made (Fig. 1) during each survey in the depth range 10-800 m, by means of a standard net GOC 73 having a cod-end full mesh opening of 20 mm. Selection of sampling stations was based on a depth-stratified sampling scheme that included five depth zones: 10-50, 50-100, 100-200, 200-500 and 500-800 m. The number of hauls per depth stratum was decided by taking into account the surface of each sub-area and depth stratum (Table 1). Catches were identified to species level for each haul. Specimens were counted and using the swept area method the species density per haul (individuals per km^2) was calculated.

Table 1. Surface and hauls per depth stratum in the study area.

Depth (meters)	Surface (km2)	No of hauls	Hauls by stratum
10-50	4918	6	1, 4, 23, 37, 47, 63
50-100	4090	13	2, 5, 6, 14, 42, 43, 44, 45, 46, 48, 49, 51, 60
100-200	13269	16	3, 7, 8, 13, 15, 16, 20, 26, 31, 34, 38, 50, 59, 61, 62, 65
200-500	18100	21	9, 11, 17, 18, 19, 21, 22, 27, 29, 32, 33, 35, 36, 39, 40, 42, 52, 53, 54, 55, 64
500-800	22224	9	10, 12, 24, 25, 28, 30, 56, 57, 58

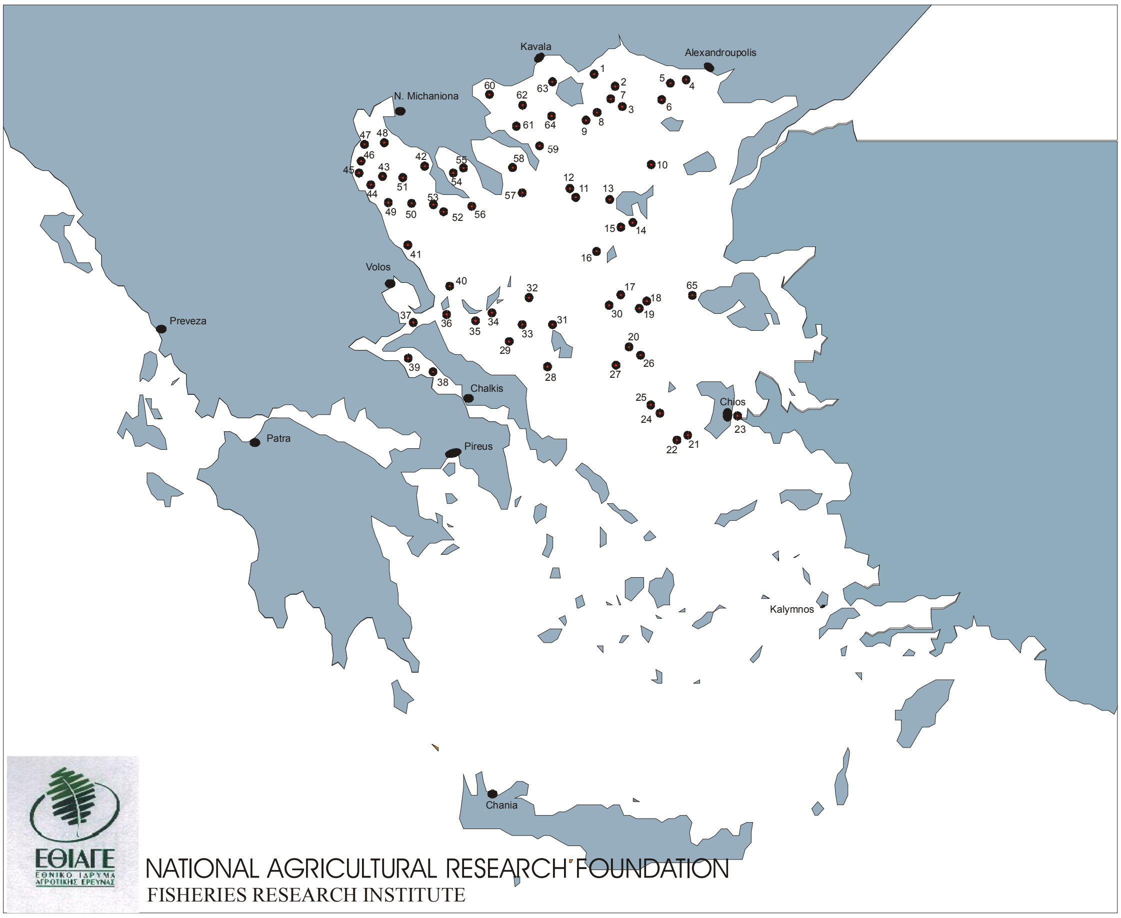

Fig.1. MEDITS hauls distribution in the North Aegean Sea.

3.6.3 Data analysis

A multivariate procedure, principal component analysis (PCA) was used to detect structure in the relationships between species, that is to identify species associations. The PCA approach has the assumption that species-grouping are defined by species that tend to co-occur and not by widespread species, even if they are relative abundant. Principal axes were produced by working with 41 species by the 325 stations matrix (65 hauls per 5 years). PCA was performed on the correlation matrix. Species loadings, that refer to the correlation of the stations with the principal components (PCs), were used to identify groups of species that tend to associate. According to the Kaiser criterion (Hakstian *et al.*, 1982), PCs with eigenvalues > 1 were only retained. Those PCs show the dimensions of subspace where the data lie and they are considered to represent the statistically significant groups of species. Varimax rotation of the normalized species loadings is aimed at maximizing the variances of the squared normalized species loadings, across species for each PC. Varimax-rotation also tends to find solution with few opposite loadings (positive or negative), thus facilitating interpretation of the PCs as groups of species. The criteria for the number of species used were their densities and their frequencies of occurrence in the total number of hauls. The species were considered present in the stations when their densities were more than 300 ind/km^2. Furthermore, the selected species must be found at least in the 5% of the total number of 325 stations. Because trawl survey data frequently have a skewed distribution, the density was log (x+1) transformed prior to statistical analyses. Several criteria were used before we conclude to the previous one, trying with different species density indices and frequencies of occurrence. It was observed that more species were taken into consideration in the analysis, less clear was the species association, because the same species were in more assemblages and the geographical distribution of the species assemblages were less distinct. The previous criteria for species elimination and the log-transformation of species densities minimized the dominant effect of uncommon catches giving more clear geographical units. Furthermore, the several data sub-sets which tried could not explain more than 69 % of the total variance.

PCA was performed on the correlation matrix. Species loadings, that refer to the correlation of the stations with the principal components (PCs), were used to identify groups of species that tend to associate. According to the Kaiser criterion (Hakstian *et. al.*, 1982), PCs with eigenvalues > 1 were only retained. Those PCs show the dimensions of subspace where the data lie and they are considered to represent the statistically significant groups of species. Varimax rotation of the normalized species loadings is aimed at maximizing the variances of the squared normalized species loadings, across species for each PC. Varimax-rotation also tends to find solution with few opposite loadings (positive or negative), thus facilitating interpretation of the PCs as groups of species. Species with loadings > 0.5 are considered the more close related species, the main species of the assemblage represented by that PC. The usual practice to use loadings of 0.5 as cut-offs, is not based on statistical significance; it is merely a convention (Mahon, 1998). Species with loading > 0.3 and < 0.5 are considered as the accompanying species of the assemblage.

Station scores on each Varimax rotated PC consider the representation of stations responses to the PCs. Thus group of stations can be defined on the basis of PC scores. Station score on PCs gives the correlation in station responses for the species correlated with the PCs (Digby and Kempton, 1987). High positive and negative station scores at each PC were used in the general interpretation of the group of species correlated with that PC. The characteristic stations for each assemblage were defined by selecting the stations, which every year were positively correlated with the assemblage.

In order to test the statistical significance between the means of scores of stations, for each PC, the variances were compared by one-way analysis of variance (ANOVA). Furthermore, the homogeneous group of stations was determined by *post hoc* comparisons of means using the Tukey honest significant difference (HSD) test with significant level *p*-value < 0.05 (Zar, 1984). The main stations for each PC, were considered the stations in first homogeneous group of stations with the higher positive mean station scores. The other positively correlated stations with the assemblage were considered as secondary related stations with the assemblage. Secondary stations were found when statistical differences between the means of station scores were calculated,

Multivariate analysis of variance (MANOVA) was used for testing differences in species assemblage variation among years according to the means of the species densities in the main stations where the assemblage found. Log-transformed species densities were used for the analysis. Next using canonical analysis, we compute the actual discrimination functions to see how the main species discriminate between years. A unweighted pair-group average (UPGMA) dendogram was also calculated based on the Mahalanobis distances between yearly species assemblages centroids. The statistical package STATISTICA for Windows (release 6) was used for the data analyses and the diagrams.

3.6.4 Results

Eleven principal axes were extracted from the principal component analysis and they account for the 67.1 % of the variance. The first eleven eigenvalues were calculated to be 20.2 %, 10.1 %, 7.6 %, 6.1 %, 4.8 %, 3.8 %, 3.7 %, 3.1 %, 2.9 %, 2.5 %, and 2.4 % of the total variance. Species with loadings > 0.3 on the Varimax-rotated PCs with eigenvalues >1 are shown in Table 2.

According to the species loadings, 40 species belong to one assemblage as main species and 1 species was found as accompanying one in the assemblages. Twenty-two species were only in one species assemblage as main species, seventeen species were in two assemblages as main and accompanying species, one species was in three assemblages as main and accompanying one and one species were in three assemblages only as accompanying one.

According to the station scores, 50 stations contribute to the grouping of species. There was no clear species association for the rest 15 stations; station 6 (zone 50-100 m); station 13, 50, 59 and 65 (zone 100-200 m); 36 and 39 (zone 200-500 m); all the stations from the zone 500-850 m, except the station 64. Analysis of variance of station scores shows that there was no statically difference between the stations which contribute to the second and eleventh assemblage.

The first species assemblage consists of the species *Arnoglossus thori*, *Serranus hepatus*, *Citharus linguatula*, *Deltentosteus (Gobius) quadrimaculatus*, *Spicara flexuosa*, *Mullus barbatus*, *Lepidotrigla cavillone*, *Sepia elegans*, *Scorpaena notata*, *Sardina pilchardus* and *Diplodus annularis*. According to the mean values of station scores, six stations, 4, 23, 37, 63, 5 and 42 were mainly found to be responsible for the grouping of species, while as secondary stations considered the 14, 51 and 60. Four of the main stations were in the depth zone 10-50 m and two stations were in the zone 50-100 m, while all the secondary stations were in the zone 50-100 m. The differentiation of the other two stations, 1 and 47 of the zone 10-50 m, may be due to their location in front of the deltas of two main rivers, Nestos and Pinios for the study area, which create different environments in comparison to the rest of the zone.

The second species assemblage consists of the species *Lophius budegassa, Lesueurigobius friesii, Engraulis encrasicolus, Symphurus nigrescens, Trisopterus minutus capelanus, Arnoglossus laterna* and *Trachurus trachurus*. This assemblage was mainly found in the depth zone 50-100 m, in the stations 51, 44, 46, 43, 49,45, 60 and secondary in the station 47 (zone 10-50 m). All the stations were in the Thermaikos Gulf, except the station 60, which was located in the Strymonikos Gulf.

The third statistically significant group of species consists of the species *Coelorhynchus coelorhynchus, Hymenocephalus italicus, Phycis blennoides, Nephrops norvegicus, Gadiculus argenteus,* *Chlorophthalmus agassizii, Lepidorhombus boscii* and *Parapenaeus longirostris*. This correlated group of species was mainly found in the station 18, 19, 29, 33, 17, 40, 32, 35 and 27 and secondary in the station 9, 52, 11 and 22. All the stations were in the bathymetric zone 200-500 m. The main stations, were located at the southern part of the study area, while the secondary ones at the northern part, which are influenced by the waters of the Black Sea and the big rivers in the area, Evros, Nestos, Strymonas, Axios and Pinios, with generally lower values in salinity and temperature, in comparison to the Southern part of the study area.

The fourth assemblage is composed of the species *Sepia orbignyana, Aspitrigla cuculus, Capros aper, Argentina sphyraena* and *Sepia elegans.* According to the mean station scores the grouping of species was mainly due to the stations 26, 16 and 20 and secondary due to the stations 21, 31 and 34. All the stations were in the depth zone 100-200 m, except the station 21 (zone 200-500 m) and were located in the Southern part of the study area (part of the Central Aegean Sea).

The fifth species assemblage consists of the species *Gobius niger, Trachurus mediterraneus, S. pilchardus, D. annularis, Arnoglossus laterna, Cepola rubescens* and *E. encrasicolus*. The main corresponding stations, for this grouping of species were the stations 1, 47, 37 and 48 and secondary the stations 46 and 14. The station 1 and 47 are those that were not found in the grouping of stations of the zone 10-50 m. The station 37, which was also found, as one of the main stations for the first species assemblage due to the species *S. pilchardus* and *D. annularis*, which are considered as accompanying species in the first assemblage. All the other stations were in the zone 50-100 m but two of them (stations 48 and 46) were located in the Thermaikos Gulf close to the station 47 of the zone 10-50 m.

The sixth statistically significant group of species, which correlated with the PC6 consists of the species *Eledone cirrhosa* and *Citharus linguatula*. The associated stations were mainly in the Thermaikos Gulf and southern, in the depth zone 50-100 m and deeper up to the zone 200-500 m, because of the high abundance indices of the only one strongly correlated species (loading >0.5), *E. cirrhosa*, with this PC.

The seventh group contains the species *Alloteuthis media, Trisopterus minutus capelanus, Merluccius merluccius, Parapenaeus longirostris, Trachurus trachurus, Lesueurigobius friesii* and *Argentina sphyraena*. The main responsible stations were in the three depth zones 50-100 m, 100-200 m and 200-500 m. The majority of them, eighth out of fourteen, belong to the depth zone 100-200 m (stations 3, 7, 8, 61, 15, 34, 62, and 38), three were in the zone 50-100 m (stations 60, 45 and 42) and three were in the zone 200-500 m (stations18, 19 and 55). As secondary stations were considered the stations 41 (zone 200-500 m), 49 and 51 (zone 50-100 m). The stations are not restricted to any particular geographic sub-area in the study area. However, it seems that the stations of the shallower zone were in areas with extensive continental shelf, while the stations of the deeper zone 200-500 m were in areas where plateau are formed.

The eighth statistical significant assemblage composed of the species *Scyliorhinus canicula, S. notata, C. rubescens* and *D. quadrimaculatus*. The main stations, which contributed to the formation of the assemblage, was the station 4, 5, 2 and 14. These stations with the secondary station 8 were located at northern part of the study area and primarily in the Thracian Sea in the zone 50-100 m.

The ninth assemblage consists of the species *Pagellus bogaraveo, Capros aper, Chlorophthalmus agassizii* and *Argentina sphyraena*. The assemblage mainly was in the station 11, 21 and 22 (zone 200-500 m) and station 20 (zone 100-500 m). The assemblage differentiate these stations from other ones in the same bathymetric stratum (PC3 and PC4), probably because in these stations the substratum was not just mud but we also found some coralliferous stones in the cod ends, according to the log-books of the hauls.

The tenth assemblage contains the species *Serranus cabrilla, L. cavillone, D. annularis* and *M. barbatus.* In this assemblage only the species *S. cabrilla* strongly correlated with the PC10, while all the other ones indicate weak association with the axis and the associated group of stations could be considered as a case of stations in the dept zones 10-50 and 50-100 m, where high density indices were calculated for this species.

The last statistical significant group of species consists of the species *Illex coindetii, Micromesistius poutassou* and *Gadiculus argenteus*. The associated stations were located in the north-eastern part of the study are and mainly in Gulfs; Thermaikos, Strymonikos and North Evoikos Gulf.

Multivariate analysis of variance (MANOVA) indicates that statistical significant difference in species assemblage variation among years was calculated for the second and seventh assemblage. For the second species assemblage, MANOVA presented a significant difference (MANOVA, Wilk's $\lambda=0.226$, F (28,102) = 1.862 , $p<0.0131$). Four pairwise contrasts between the five years were significant: year 1996 and 1997 ($p<0.0050$), 1996 and 1998 ($p<0.0017$), 1996 and 2000 ($p<0.0079$), 1998 and 1999 ($p<0.0177$). Using canonical analysis one discriminant function (axis) were calculated as statistically significant (p-level < 0.0121) that accounts for the 73.50 % of the explained variance. The axis discriminates the year 1996 and 1999 from the other ones (Table 4). According to the standardized coefficients (Table 4) the first discriminant function was weighted most heavily by the species *T. trachurus*, *E. encrasicolus*, *L.*

budegassa and *T. minutus capelanus*. This function was marked by negative coefficients for the species *T. trachurus* and *E. encrasicolus* and positive for the species *L. budegassa* and *T. minutus capelanus*. Thus the differences between the year 1996-1997, 1996-1998, 1996-2000 and 1998-1999 were due to the higher the density of *L. budegassa* and *T. minutus capelanus* and the lower the density of *T. trachurus* and *E. encrasicolus* during the survey of 1996 and 1998 in comparison to the years 1997, 1998 and 2000 (Table 2.).

From the UPGMA dendogram (Fig. 2) two major groups were observed. The first one consists of the years 1996 and 1999, while the second one from the years 1997, 1998 and 2000. From the second group the years 1997 and 2000 are closer.

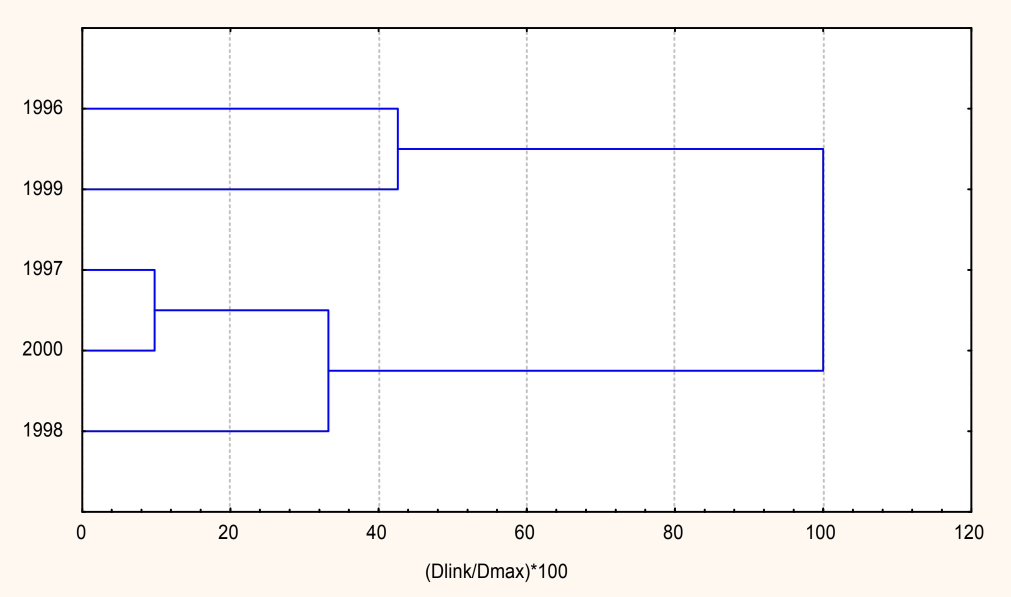

Fig. 2 Unweighted pair-group average dendogram for five years for the 2nd species assemblage. Dissimilarities from matrix based on Mahalanobis distances between years centroids. Y-axis represents the percentage of the range from the maximum to the minimum distance in the data.

For the seventh species assemblage, MANOVA presented a significant difference (MANOVA, Wilk's $\lambda=0.490$, F (28,214) = 1.670 , $p<0.0231$). Two pairwise contrasts between the five years were significant: year 1996 and 1998 ($p<0.0339$), 1996 and 1999 ($p<0.0056$). Using canonical analysis one discriminant function (axis) were calculated as statistically significant (p-level < 0.0227) that accounts for the 53.28 % of the explained variance. The axis discriminates the years1996 and 1997 from the other ones (Table 5). According to the standardized coefficients (Table 5) the first discriminant function was weighted most heavily by the species *A. media*, *T. trachurus*, *M. merluccius*, *T. minutus capelanus* and *P. longirostris*. This function was marked by negative coefficients for the species *A. media*, *T. trachurus* and *M. merluccius* and positive for the species *T. minutus capelanus* and *P. longirostris*. Thus the differences between the year 1996-1998 and 1996-1999 were due to the higher the density of *T. minutus capelanus* and *P. longirostris* and the lower the density of *A. media*, *T. trachurus* and *M. merluccius*, during the survey of 1996 in comparison to the years 1998 and 1999 (Table 2).

From the UPGMA dendogram (Fig. 3) two major groups were observed. The first one consists of the years 1996 and 1997, while the second one from the years 1998, 1999 and 2000. From the second group the years 1997 and 2000 are closer.

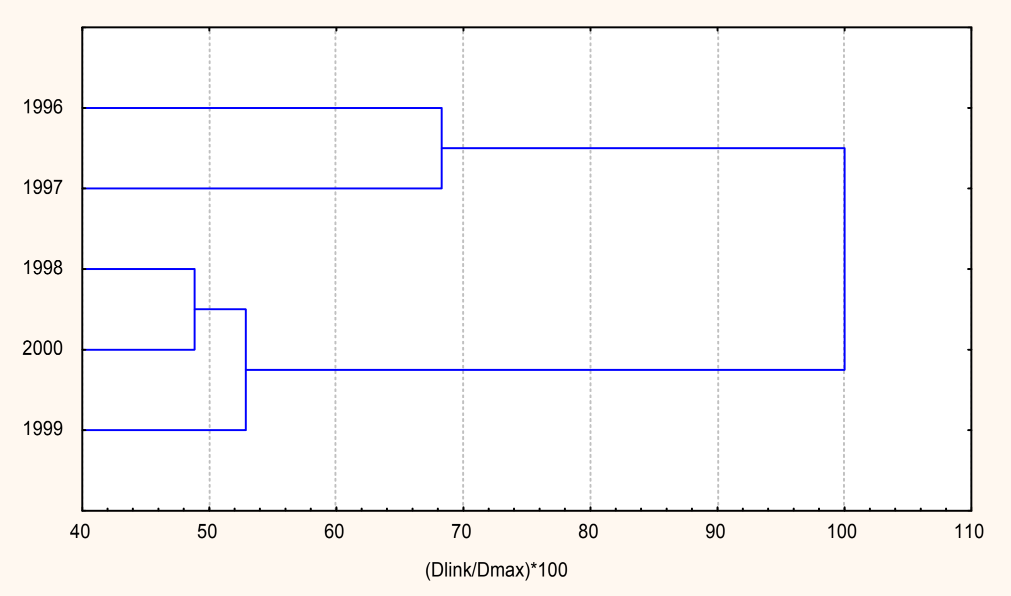

Fig. 3 Unweighted pair-group average dendogram for five years for the 7th species assemblage. Dissimilarities from matrix based on Mahalanobis distances between years centroids. Y-axis represents the percentage of the range from the maximum to the minimum distance in the data

3.6.5 Discussion

The most distinct hydrological feature in the North Aegean Sea is the intrusion of Black Sea origin less saline waters which occupy the whole surface layer and contribute to the maintenance of low salinity, (24 - 26 ppt) during the warm period (Theocharis and Georgopoulos 1993). The homogenization of the surface waters within the region covered by the main volume of Black Sea water, is limited to a maximum depth ranging between 20-80 m (Zodiatis 1994). Below these depths salinity reaches the usual values of the Aegean sea (about 38.8 ppt). The inflow is stronger during late spring and summer corresponding to the increase of river run-off and precipitation over the Black sea. The outflow of the three main rivers in the Thracian Sea (Strymonas, Nestos and Evros) does not disturb the total picture though some tongues of lower salinity are observed over the delta run-offs (Papaconstantinou *et al,* 1994). Following the general cyclonic circulation of the Aegean Sea the Black Sea water is directed to west and south affecting the northern and western part of the Aegean Sea (Lacombe *et. al.*, 1958).

Thermaikos Gulf, in the western part of the North Aegean Sea, is a shallow water area with a maximum depth of 50 m. The embayments form the inner part of an elongated continental shelf area, which terminates in a abrupt submarine escarpment and further seaward the seabed is dominated by a deep linear sub water canyon (Brooks & Ferentinos, 1980). Large river systems (Gallicos, Axios, Loudias and Aliakmon) discharge into the area with temporal variability in fluvial inputs.

The central part of the North Aegean Sea is characterized by a south-west to north-east oriented depression with a maximum depth up to 1500 m. The deep water mass of the Aegean Sea extends from a depth approximately 3000 m down to the bottom with a high oxygen content (4.0- 5.0 ml l^{-1}) and comparatively lower potential temperature (13.9-14.0 ^{o}C).

The North Evoikos Gulf in the eastern coast of the Greek peninsula is a semi enclosed area, which is limited in the North by the Oreos Channel with a maximum depth of 45 m and by the Euripos strait in the south with a maximum depth of 8 m. The North Evoikos is influenced by a relative cold water mass entering from the Oreos channel (Balopoulos and Papageorgiou, 1991) The two straits delimit the main Gulf with a maximum depth of 450 m.

According to these oceanographical characteristics, three main geographical areas are distinguished in the North Aegean Sea, the Thracian Sea, the Thermaikos Gulf and the southern part of the study area between the coast of Asian minor and the eastern coast of the Greek peninsula.

Statistical analysis indicate that PC1 and PC5, which explained 25 % of the total variance, discriminate the bathymetric zone 10-50 m and secondary the adjusted fishing grounds of the zone 50-100 m. The overlap between the geographical areas of the assemblages was observed mainly due to the species *S. pilchardus* and *D. annularis*, which were in both assemblages. The main species of the first assemblage *A. thori*, *S. hepatus*, *C. linguatula*, *D. quadrimaculatus*, *M. barbatus*, *L. cavillone*, *S. elegans*, *S. notata* are demersal species close related to the bottom, while in the other assemblage there were three pelagic species *T. mediterraneus, S. pilchardus* (main species) and *E. encrasicolus* (accompanying species), feeding on the bottom during the day. The main geographical differentiation of these two assemblages is due to, two of the stations of fifth assemblage were located in front of the deltas of two main rivers, Nestos and Pinios stations, which create different environments in comparison to the rest of the zone. The majority of species of the first assemblage were found mainly in the zone 50-100 m and secondary in the zone 10-50 m in Cretan Sea, South Aegean Sea (Kallianiotis *et al.*, 2000).

The second and eighth assemblages, which explained the 13.2 % of the total variance, were mainly in the zone 50-100 m in the Thermaikos Gulf, Strymonikos Gulf and Thracian Sea. The two Gulfs are more related in comparison to the Thracian Sea even if the Thracian Sea and the Strymonikos Gulf are adjacent geographical areas. The relation of the inner part of the two Gulfs indicates the role of Black Sea water in the North Aegean Sea, which mainly influence the Thracian Sea and the deeper zone of the Strymonikos Gulf. The main species of the second assemblage were *L. budegassa, L. friesii* and *E. encrasicolus* for the eighth assemblage the *S. canicula.* The species that joint the two sub-geographical areas were *S. canicula, S. notata* and *D. quadrimaculatus*. In the northern coasts of the study area the species *E. encrasicolus* is characteristic in the catches with bottom trawl nets in the zone 50-100 m, where newly recruited specimens in high abundance were caught (Table 2).

The third assemblage, with main species *C. coelorhynchus, H. italicus, P. blennoides, N. norvegicus, G. argenteus* and *C. agassizii* and the eleventh one, with main species *I. coindetii* and *M. poutassou*, characterize the bathymetric zone 200-500 m in the study area. These two assemblages explained 10.0 % of the total variance. Comparing the two assemblages the third one was mainly in the southern part, while the other one in the northern part of the study area. Analogous species assemblages found in the western Mediterranean in the zone 200-600 m (Moranta *et al.*, 1998) and in the Cretan Sea, South Aegean, in the zone 300-500 m (Kallianiotis *et al.*, 2000).

The fourth assemblage, with main species *S. orbignyana, A. cuculus* and *C. aper* was primarily in the depth zone 100-200 m in the southern part of the study area (part of the Central Aegean Sea).

The sixth statistically significant group of species, with one main species, *Eledone cirrhosa*, were widespread in the study area in the depth zone 50-500 m and mainly in the deeper extension of Thermaikos Gulf and North Sporades islands, because of the high abundance indices of the species in comparison to other stations. A similar depth distribution of the species was found in the Central Mediterranean (Belcari & Sartor, 1993).

The seventh group of species *A. media, T. minutus capelanus, M. merluccius, P. longirostris, T. trachurus, L. friesii* and *A. sphyraena* is the most widespread assemblage in three depth zones 50-100 m, 100-200 m and 200-500 m. It was not restricted to any particular geographic sub-area. However, it was primarily found in the shallower zone 100-200 m in areas with extensive continental shelf and in plateaus in the deeper zone 200-500 m. The four species, *T. minutus capelanus, M. merluccius*, *P. longirostris* and *T. trachurus*, are part of the main commercial catches for bottom trawling in the area (Stergiou *et al.*, 1997)

The ninth assemblage, *P. bogaraveo, C. aper, C. agassizii* and *A. sphyraena*. was mainly in the zone 100-500 m in the southern part of the study area. In comparison to other assemblages in the same bathymetry (PC3 and PC4), it was in stations, where the substratum was not just mud as in the other ones; according to the log-books of the hauls mud and coralliferous stones in the cod ends were found.

The tenth group of species, with only one main species, *S. cabrilla*, widespread in the zone 10-100 m, with no particular geographical significance in the study area. Its distinction is due to the high abundance indices of the main species in comparison to other stations in the same depth zone..

All the stations of zone 500-800 m except one were not found to determine the geographical distribution of the assemblages because the main species of the zone calculated with low density indices and excluded for the analysis.

Temporal variation was observed for the second and seventh assemblage. For the second assemblage the temporal variation was recorded due to the main species *E. encrasicolus* and *L. budegassa*. *E. encrasicolus* is short live small pelagic species with high variability in relation to the environmental conditions. Furthermore the fishing gears used is not the appropriate one for sampling small pelagic species. Also the other important species for the temporal variability of the assemblage is characterized by high variability of catches in general (Cannizzaro & Bono, 1999). The seventh assemblage temporal variation between the year was primarily due to the main species *T. minutus capelanus*, *A. media* and *M. merluccius*. The sampling period of MEDITS project coincide with the recruitments of both gadiforms *T. minutus capelanus* and *M. merluccius* in the main depth zone of assemblage distribution (Papaconstantinou & Stergiou, 1995, Colloca, 1999, Belcari & Sbrana, 1999)

Concluding the three defined geographical areas should be used in the future for multi-species fishery management purposes in relation to the particular environmental conditions in each geographical unit. Further research should be focused on the seasonal species distribution and the relation with the different substrata.

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Table 2. Species loadings on Varimax-normalized rotated PCs and mean density values per year and for the period 1996-2000. Bold type indicates species with loadings > 0.5.

	Loadings	Mean density					
		1996	1997	1998	1999	2000	1996-2000
PC1							
Arnoglossus thori	0,75	424	390	629	1320	666	686
Serranus hepatus	0,68	7656	11427	12611	12510	13147	11470
Citharus linguatula	0,67	885	868	1003	1195	2034	1197
Deltentosteus (Gobius) quadrimaculatus	0,64	544	186	1034	1674	571	802
Spicara flexuosa	0,63	5178	3962	3551	4156	5956	4561
Mullus barbatus	0,63	1725	1708	3448	1481	6208	2914
Lepidotrigla cavillone	0,60	566	441	872	898	553	666
Sepia elegans	0,60	179	238	426	716	306	373
Scorpaena notata	0,57	2235	1683	1988	1657	2403	1993
Sardina pilchardus	0,38	32521	14939	2830	32221	19365	20375
Diplodus annularis	0,32	2880	2178	3488	4873	2947	3273
PC2							
Lophius budegassa	0,79	658	92	0	528	294	322
Lesueurigobius (Gobius) friesii	0,59	1192	1814	407	4389	1612	1921
Engraulis encrasicolus	0,55	28468	181848	114376	69795	44575	87131
Symphurus nigrescens	0,49	140	54	50	311	40	121
Trisopterus minutus capelanus	0,48	17156	4450	5140	6913	2788	7345
Arnoglossus laterna	0,46	720	626	524	1400	578	776
Trachurus trachurus	0,35	9637	2803	823	1518	916	3199
PC3							
Coelorhynchus coelorhynchus	0,80	1477	2305	2054	1185	6830	2770
Hymenocephalus italicus	0,77	3094	2946	3341	3708	2789	3176
Phycis blennoides	0,76	573	388	231	259	788	448
Nephrops norvegicus	0,71	546	689	354	358	355	461
Gadiculus argenteus	0,65	19412	12358	24100	24163	52084	26423
Chlorophthalmus agassizii	0,61	486	1204	1215	632	2603	1228
Lepidorhombus boscii	0,47	68	221	113	158	273	166
Parapenaeus longirostris	0,35	3253	3731	4326	7548	4650	4702
PC4							
Sepia orbignyana	0,82	837	485	492	2748	186	673
Aspitrigla cuculus	0,82	945	2140	2417	3782	1337	1869
Capros aper	0,50	2291	2785	480	555	1507	1672
Argentina sphyraena	0,43	21264	12440	2850	403	241030	64089
Sepia elegans	0,31	0	145	313	807	235	222
PC5							
Gobius niger	0,78	1009	577	525	648	825	717
Trachurus mediterraneus	0,73	2119	9141	3541	938	141	3176
Sardina pilchardus	0,63	186077	43181	21871	108405	146527	101212
Diplodus annularis	0,61	4353	4890	4746	8333	4578	5380
Arnoglossus laterna	0,57	1394	2373	1399	1796	1387	1670
Cepola rubescens	0,44	0	313	169	264	411	232
Engraulis encrasicolus	0,36	3362	12300	159984	45319	10298	46253

(Table 2 continue)

	Loadings	Mean density					
		1996	1997	1998	1999	2000	1996-2000
PC6							
Eledone cirrhosa	0,79	324	606	427	117	0	285
Citharus linguatula	0,32	432	505	206	583	968	563
PC7							
Alloteuthis media	0,68	317	316	1011	1887	1548	1016
Trisopterus minutus capelanus	0,64	18957	1617	1677	4747	1743	5748
Merluccius merluccius	0,57	551	750	743	2189	739	994
Parapenaeus longirostris	0,49	7265	7852	6191	9440	11696	8489
Trachurus trachurus	0,47	5398	116	703	1552	2261	2006
Lesueurigobius (Gobius) friesii	0,46	466	459	185	946	641	539
Argentina sphyraena	0,44	3692	2719	1035	6410	2428	3257
PC8							
Scyliorhinus canicula	0,75	2120	747	788	1859	1589	1421
Scorpaena notata	0,49	2934	1985	2581	1944	3439	2576
Cepola rubescens	0,48	176	102	263	451	282	255
Deltentosteus (Gobius) quadrimaculatus	0,35	923	279	527	874	638	648
PC9							
Pagellus bogaraveo	0,79	48345	28174	26019	59869	83826	48688
Capros aper	0,51	12298	1704	2308	1336	1804	4025
Chlorophthalmus agassizii	0,42	199	1114	2566	1889	2844	1714
Argentina sphyraena	0,40	595	552	672	1921	799	854
PC10							
Serranus cabrilla	0,75	2108	781	773	317	632	922
Lepidotrigla cavillone	0,45	1265	1076	1665	1098	1369	1295
Diplodus annularis	0,35	679	2729	978	3340	882	1722
Mullus barbatus	0,33	938	1348	5460	2422	3763	2786
PC11							
Illex coindetii	0,83	987	510	191	1637	35956	7856
Micromesistius poutassou	0,54	24121	2441	983	37282	4717	13909
Gadiculus argenteus	0,41	13957	12308	18525	18223	11781	14959

Table3. Homogeneous groups of means of log-transformed station scores based on Tukey test. In each column 1, 2 and 3 homogeneous groups of means (those that are not significantly different from each other) are indicated by X in the respective rows. All means that are not identified as members of the same homogeneous group are significantly different from each other at *p*<0.05. Bold type indicate the main PCs stations.

	Station	Depth zone	Mean	1	2	3
PC1						
	63	50	3,37	xxxx		
	42	100	2,40	xxxx	xxxx	
	4	50	2,33	xxxx	xxxx	xxxx
	5	100	2,15	xxxx	xxxx	xxxx
	23	50	1,46	xxxx	xxxx	xxxx
	37	50	1,33	xxxx	xxxx	xxxx
	14	100	0,95		xxxx	xxxx
	51	100	0,49		xxxx	xxxx
	60	100	0,27			xxxx
PC2						
	51	100	2,50	xxxx		
	44	100	2,35	xxxx		
	46	100	2,33	xxxx		
	43	100	2,29	xxxx		
	49	100	1,48	xxxx		
	45	100	1,25	xxxx		
	60	100	0,94	xxxx		
	47	50	0,77	xxxx		
PC3						
	18	500	2,49	xxxx		
	19	500	2,35	xxxx	xxxx	
	29	500	2,26	xxxx	xxxx	
	33	500	2,21	xxxx	xxxx	
	17	500	1,77	xxxx	xxxx	xxxx
	40	500	1,74	xxxx	xxxx	xxxx
	32	500	1,59	xxxx	xxxx	xxxx
	35	500	1,40	xxxx	xxxx	xxxx
	27	500	1,21	xxxx	xxxx	xxxx
	9	500	1,15	xxxx	xxxx	xxxx
	52	500	0,95		xxxx	xxxx
	11	500	0,65			xxxx
	22	500	0,35			xxxx

	Station	Depth zone	Mean	1	2	3
PC4						
	26	200	4,49	xxxx		
	16	200	3,71	xxxx	xxxx	
	20	200	2,62	xxxx	xxxx	xxxx
	21	500	1,76		xxxx	xxxx
	31	200	1,40			xxxx
	34	200	1,12			xxxx
PC5						
	1	50	3,63	xxxx		
	47	50	3,03	xxxx		
	37	50	2,60	xxxx		
	48	100	2,58	xxxx		
	46	100	1,08		xxxx	
	14	100	0,72		xxxx	
PC6						
	49	100	3,21	xxxx		
	51	100	2,06	xxxx	xxxx	
	35	500	1,44	xxxx	xxxx	
	37	50	1,28		xxxx	
	53	500	0,90		xxxx	
	9	500	0,61		xxxx	
	60	100	0,48		xxxx	
	52	500	0,43		xxxx	
PC7						
	3	200	1,97	xxxx		
	7	200	1,83	xxxx		
	8	200	1,79	xxxx		
	61	200	1,76	xxxx		
	60	100	1,49	xxxx	xxxx	
	18	500	1,45	xxxx	xxxx	
	15	200	1,29	xxxx	xxxx	
	34	200	1,19	xxxx	xxxx	
	19	500	1,18	xxxx	xxxx	
	55	500	1,17	xxxx	xxxx	
	62	200	1,07	xxxx	xxxx	
	45	100	0,89	xxxx	xxxx	
	42	100	0,77	xxxx	xxxx	
	38	200	0,74	xxxx	xxxx	
	41	500	0,37		xxxx	
	49	100	0,32		xxxx	
	51	100	0,30		xxxx	

(Table 3. continue)

	Station	Depth zone	Mean	1	2	3
PC8						
	4	50	3,09	xxxx		
	5	100	3,08	xxxx		
	2	100	2,06	xxxx	xxxx	
	14	100	1,97	xxxx	xxxx	
	8	200	1,00		xxxx	
PC9						
	11	500	3,20	xxxx		
	21	500	2,35	xxxx	xxxx	
	20	200	2,22	xxxx	xxxx	
	22	500	1,42	xxxx	xxxx	
	15	200	0,86		xxxx	
	27	500	0,82		xxxx	
	38	200	0,41		xxxx	
	26	200	0,41		xxxx	
	24	650	0,40		xxxx	

	Station	Depth zone	Mean	1	2	3
PC10						
	23	50	4,06	xxxx		
	2	100	2,68	xxxx	xxxx	
	31	200	1,33		xxxx	xxxx
	1	50	1,07			xxxx
	37	50	0,68			xxxx
	62	200	0,21			xxxx
PC11						
	41	500	2,19	xxxx		
	64	500	2,16	xxxx		
	55	500	1,82	xxxx		
	38	200	1,78	xxxx		
	35	500	1,18	xxxx		
	53	500	0,96	xxxx		

Table 4. Canonical means for years and standardized coefficients for the log transformed density indices of the second species assemblages on the statistically significant axis.

Means of Canonical Variables (years)		Standardized Coefficients for Canonical Variables (species)	
Year	Axis 1	Species	Axis 1
1996	1.82	*L. budegassa*	0.80
1997	-0.91	*L. friesii*	0.26
1998	-1.31	*E. encrasicolus*	-0.16
1999	0.90	*S. nigrescens*	0.05
2000	-0.67	*T. minutus capelanus*	0.73
		A. laterna	0.05
		T. trachurus	-0.24

Table 5. Canonical means for years and Standardized coefficients for the log transformed density indices of the seventh species assemblage on the statistically significant axis.

Means of Canonical Variables (years)		Standardized Coefficients for Canonical Variables (species)	
Year	Axis	Species	Axis 1
1996	1.01	*A. media*	-0.77
1997	0.41	*T. minutus capelanus*	0.77
1998	-0.35	*M. merluccius*	-0.30
1999	-0.81	*P. longirostris*	0.14
2000	-0.26	*T. trachurus*	-0.40
		L. friesii	-0.26
		A. sphyraena	-0.12

3.7 SECTION VI Spatial organization of demersal assemblages in the continental shelf and upper slope of the North Mediterranean Sea: a multi-scale analysis

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3.7.1 Introduction

A central issue in fisheries ecology is to determine the various factors underlying spatial variation in community structure, and to place this knowledge into a predictive framework (Mahon and Smith, 1989; Menge and Olson, 1990). Indeed, the key to prediction and then to management lies in the elucidation of mechanisms underlying observed patterns. For that purpose, until recently, most of the research was focused on regional scale explanations of community patterns (Overholtz and Tyler, 1985; Biagi *et al.*, 1989; Mahon and Smith, 1989; Fariña *et al.*, 1997; Ungaro *et al.*, 1998; Gaertner *et al.*, 1999; Bertrand *et al.*, 2000; Kallianiotis *et al.*, 2000; etc.). On the opposite, studies carried out at other scales, such as biogeographical scale (Mahon *et al.*, 1998; Ungaro *et al.*, 1999; Jukic-Peladic *et al.*, 2000), and of course at multi-scales (Langton *et al.*, 1995) were uncommon. However, many ecological patterns and processes exist within a hierarchical framework, and one's perspective within the hierarchy can be crucial to understanding the pattern or process of interest (Allen and Starr, 1982, Rahel *et al.*, 1990; Levin, 1992). Because mechanisms underlying observed patterns operated at different scales, community organization should be analysed and interpreted at more than one scale.

In the Mediterranean Sea, the data collected by the MEDITS programme (Bertrand and Relini, 2000) offered the opportunity to conduct multiscale analyses. For that purpose, we proposed, as a preliminary work, to simultaneously investigate the spatial organization of the demersal assemblages at four different scales:

- the global MEDITS scale, which concerned the whole area covered by this programme in the North Mediterranean Sea (from Gibraltar Strait to Aegean Sea),
- the basin scale, which referred to the main hydrological and topographic basins. In the present study we divided the whole area covered by MEDITS in five main hydrological and topographic basins: Aegean Sea, Ionian Sea, Adriatic Sea, Tyrrhenian Sea and Western basin.
- the regional scale, which referred to each MEDITS operational areas. The limits of these operational areas were defined in the sampling design.
- the bathymetric scale, which referred to the bathymetric strata (three strata from 10m to 200m depth).

In the present work, we aimed to identify the main organizational patterns of demersal assemblages at these different scales using MEDITS data collected during the 1996 survey. To reach that goal, the STATIS-CoA multitable method, initially created to monitor the temporal evolution of multispecific structures (Gaertner *et al.*, 1998), has been adapted to give a theoretical frame for the comparative analysis of the spatial organization of demersal assemblages in the North Mediterranean Sea. This action directly contributed to the steps 1 and 3 defined in the approach described in the section I of the present document. It constituted a preliminary stage in view to give a better insight of the demersal assemblages organization.

3.7.2 Material and Methods

3.7.2.1 Data

The present work was based on a set of abundance indices collected in all the areas surveyed during the international MEDITS programme (Figure 1). Given to the results of previous works conducted at regional scales, which showed a strong temporal reproducibility of community structures (see for instances the work conducted in the Gulf of Lions described in the section IV of this document), we focused the present study on the analysis of a unique survey. Among the different years surveyed by the MEDITS programme, we choose 1996, because it constituted the first year where all the areas, including Eastern Adriatic sea (Slovenia, Croatia and Albania) were sampled.

For all the surveyed regions (i.e. each of the MEDITS operational areas), a unique stratified random sampling design was used, based on depth. Locations of sample units were selected randomly within each bathymetric stratum. The sampling design have been detailed in previous sections of this report. We only note that, for each tow, the densities in number of individuals were expressed for a same surface unit. Moreover, the data were log-transformed before conducting the analysis to minimise the dominant effect of exceptional catches.

To perform a comparative analysis of the demersal assemblages organization at the basin scale, it was necessary to affect each MEDITS operational areas to a specific basin. Table 1 indicated the correspondences between the MEDITS operational areas and the basins. In a limited number of cases, the geographical location of some operational MEDITS areas (North Ligurian sea, Strait of Sicily and Western Sardinian) were intermediary between two adjacent hydrological basins. For each of these three areas, their final affectation to a given basin was based both on their geographic location and on preliminary comparative analyses of the faunistic organization between all the areas of the adjacent basins.

Among the species caught during the 1996 MEDITS survey, 42 species (Appendix) were sufficiently abundant to be included in the analysis (i.e. they were present in more than 5 % of the tows in each of the surveyed areas). Finally, because of some uncertainties on the validity of the deepest stations (Bertrand *et al.*, *in press*), only stations carried out between 10 and 200m (strata 1 to 3) were analysed. The validation, presently still in progress, of the whole MEDITS data base should allow us to extend later the analysis of demersal community structuring until 800m depth.

Table 1. Description of the MEDITS operational areas

MEDITS	**operational area**	**Bathymetric strata**	**Region boundaries**	**Basin**	**Country**
Initial label	**new label**				
11101	EsW1	1	West Spain (Alboran- Vera)	West basin	Spain
11102	EsW2	2			
11103	EsW3	3			
11201	EsC1	1	Centre Spain (Alicante-Valencia)	West basin	
11202	EsC2	2			
11203	EsC3	3			
11301	EsE1	1	East Spain (Castellon-Cataluna)	West basin	
11302	EsE2	2			
11303	EsE3	3			
12101	LiW1	1	West Gulf of Lions	West basin	France
12102	LiW2	2			
12103	LiW3	3			
12106	LiE1	1	East Gulf of Lions	West basin	
12107	LiE2	2			
12108	LiE3	3			
13101	CoN1	1	North East Corsica	Tyrrhenian	
13102	CoN2	2			
13103	CoN3	3			
13106	CoS1	1	South East Corsica	Tyrrhenian	
13107	CoS2	2			
13108	CoS3	3			
13201	LigN1	1	(Vintimille - La Spezia)	West basin	Italy
13202	LigN2	2			
13203	LigN3	3			
13206	LigS1	1	(La Spezia – Elbe)	Tyrrhenian	
13207	LigS2	2			
13208	LigS3	3			
13211	N1	1	(Elbe – Giannutri)	Tyrrhenian	
13212	N2	2			
13213	N3	3			
13216	C1	1	(Giannutri – Garigliano)	Tyrrhenian	
13217	C2	2			
13218	C3	3			
13301	SaCE1	1	(Centre East Sardinia)	Tyrrhenian	
13302	SaCE2	2			
13303	SaCE3	3			
13306	SaNE1	1	(North East Sardinia)	Tyrrhenian	
13307	SaNE2	2			
13308	SaNE3	3			
13311	SaN1	1	(North Sardinia)	West basin	
13312	SaN2	2			
13313	SaN3	3			
13316	SaNW1	1	(North West Sardinia)	West basin	
13317	SaNW2	2			
13318	SaNW3	3			
13321	SaCW1	1	(Centre West Sardinia)	West basin	

13322	SaCW2	2			
13323	SaCW3	3			
13326	SaSW1	1	(South West Sardinia)	West basin	
13327	SaSW2	2			
13328	SaSW3	3			
13331	SaS1	1	(South Sardinia)	West basin	
13332	SaS2	2			
13333	SaS3	3			
13401	SE1	1	South East Tyrrhenian (F. Vulturno- C. Suvero)	Tyrrhenian	
13402	SE2	2			
13403	SE3	3			
13406	S1	1	South Tyrrhenian (C. Suvero - C.S. Vito)	Tyrrhenian	
13407	S2	2			
13408	S3	3			
13411	Si1	1	Strait of Sicily	Ionian	
13412	Si2	2			
13413	Si3	3			
21101	NW1	1	North West Adriatic (North Ancona)	Adriatic	
21102	NW2	2			
21103	NW3	3			
21106	CW1	1	Centre West Adriatic (South Ancona)	Adriatic	
21107	CW2	2			
21108	CW3	3			
22101	SW1	1	South West Ionian (Cap Passero - Rocella)	Ionian	
22102	SW2	2			
22103	SW3	3			
22106	CW1	1	Centre West Ionian Sea (Rocella - pointe Alice)	Ionian	
22107	CW2	2			
22108	CW3	3			
22111	NW1	1	North West Ionian Sea (Pte Alice - Taranto)	Ionian	
22112	NW2	2			
22113	NW3	3			
22116	N1	1	North Ionian Sea (Taranto - Otranto)	Ionian	
22117	N2	2			
22118	N3	3			
22121	S1	1	South West Adriatic (Otranto - Brindisi)	Adriatic	
22122	S2	2			
22123	S3	3			
22126	Sf1	1	South West Adriatic (Brindisi - Bari)	Adriatic	
22127	Sf2	2			
22128	Sf3	3			
22131	Sg1	1	South West Adriatic (Bari - Barletta)	Adriatic	
22132	Sg2	2			
22133	Sg3	3			
22136	Sh1	1	West Adriatic (Barletta - Vieste)	Adriatic	
22137	Sh2	2			
22138	Sh3	3			
21111	Slo1	1	North Adriatic	Adriatic	Slovenia
21112	Slo2	2			
21113	Slo3	3			
21116	Cro1	1	Centre East Adriatic	Adriatic	Croatia
21117	Cro2	2			
21118	Cro3	3			
22141	Alb1	1	South East Adriatic	Adriatic	Albania
22142	Alb2	2			
22143	Alb3	3			
22201	Gr1	1	East Ionian	Ionian	Greece
22202	Gr2	2			
22203	Gr3	3			
22306	Ar1	1	South West Aegean (Argosaronic area)	Aegean	
22307	Ar2	2			
22308	Ar3	3			
22401	N1	1	North Aegean	Aegean	

22402	N2	2	(North of 38°N)		
22403	N3	3			
22501	S1	1	South Aegean (South of 38° N)	Aegean	
22502	S2	2			
22503	S3	3			

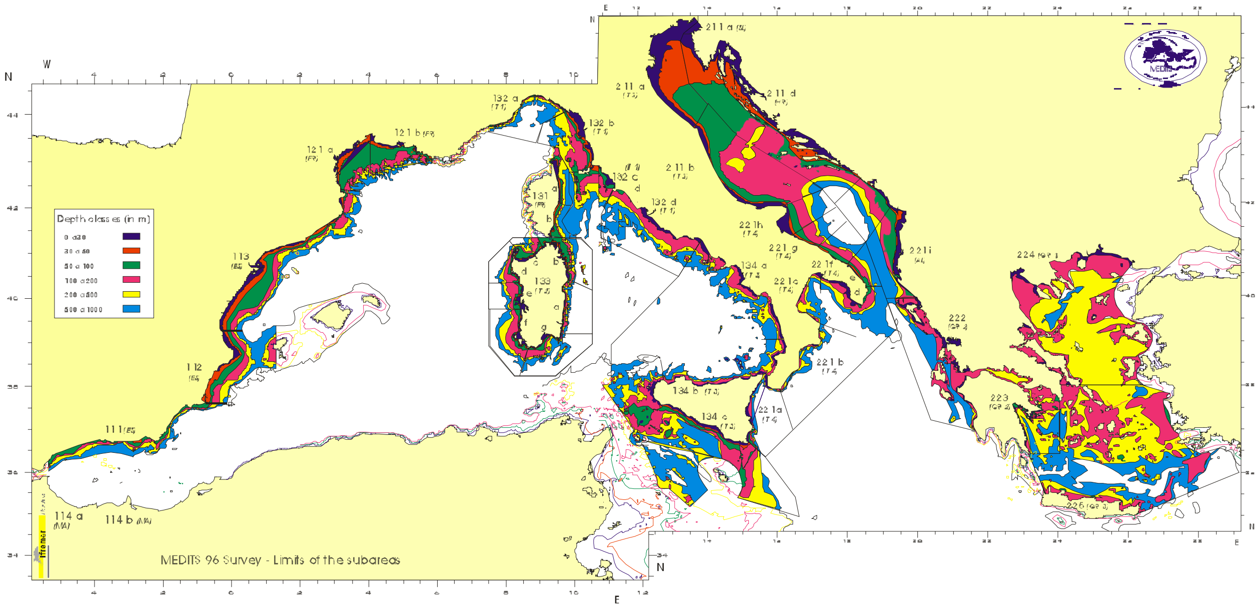

Figure 1.- The whole MEDITS area sampled during the 1996 survey.

3.7.2.2 *Statistical analysis*

The STATIS-Coa analysis was carried out in order to split the common and the specific parts of the spatial organization of the assemblages for each of the five main basins of the North Mediterranean Sea (West Mediterranean, Tyrrhenian, Ionian, Adriatic and Aegean). Doing this, we used the basin scale as the scale of reference. This choice was justified by several authors which highlighted the relevance of biogeographical scales in view to contribute to the management processes (Langton *et al.*, 1995; Mahon *et al.*, 1998). The detailed principle of functioning of STATIS-CoA was previously given in the present document (see the Material and Method part of the section IV in this report). This CoA version of STATIS may currently be performed with the ADE-4 software (Thioulouse *et al.*, 1996). This software is freely available at the following address: http://pbil.univ-lyon.fr/ADE-4.html.

3.7.3 *Results*

The preliminary results provided by the multitable analysis (Table 2) showed that the contributions (weights) of each basin to the construction of the compromise were similar (weighting 0.43 to 0.46). Moreover, the fit of each of the tables to the compromise evidenced both a common and a specific part of the assemblages organization in each of the five basins (Cos² between 0.43 to 0.62). The use of a separate Correspondence Analysis (CoA) carried out independently in each basin and the projection of the first two axes of these separate CoAs on the first two axes of the STATIS compromise precised this result (Figure 2). Indeed, the first axis of the compromise appeared strongly correlated to the first axis of each of the separate CoAs. So, the first organizational direction of the assemblages was strongly similar in each of the five basins. The second direction of organization of the assemblages in each basin (evidenced by the projection of the axis 2 of each separate CoAs) exhibited a stronger variability, which mainly concerned the Aegean basin. In short, these preliminary results (Table 2 and Figure 2) suggested that a strong part of the organization of the demersal assemblages was common to the different basins. However, it also showed that another part of the assemblage organization was specific to some basins. From this point of view, the Aegean Sea appeared the most specific of the five studied basins.

Table 2. Description of the structure defined for each basin. Weight, contribution of each basin in the construction of the compromise; Cos^2, fit of each basin to the compromise.

Basin	Weights	Cos^2
Adriatic	0.45	0.59
Aegean	0.43	0.43
Ionian	0.44	0.50
Tyrrhenian	0.46	0.62
Western	0.45	0.54

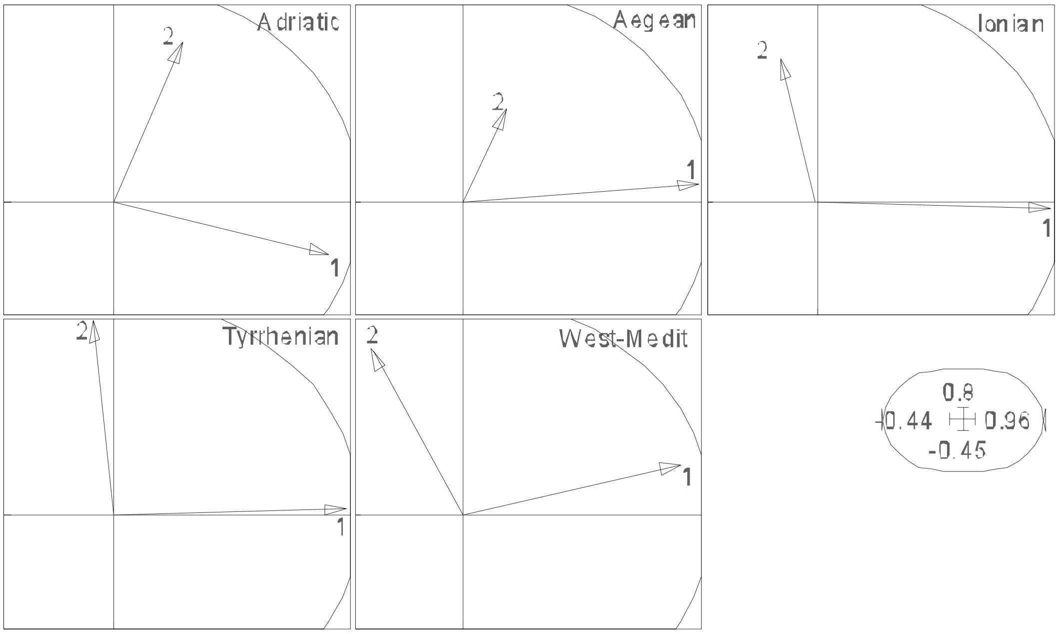

Figure 2.- Projection of the first two factorial axes of the separate Correspondence Analysis of each basin (arrows) on the two first factorial axes of the STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical).

The projection of the stations onto the first plane of the compromise allowed us to better understand the common and the specific parts of the assemblage organization not solely between the different basins, but also between the different regions, and the different bathymetric strata (Figure 3). At this stage, we could note one of the main advantages of the multitable methods, such as STATIS-CoA, which allowed the projection of the stations surveyed in the different basins in a unique referential (i.e. the first plane of the compromise).

In the present case, each station was labelled by using both several letters, which reminds to the corresponding operational area, and by a numeric code which refers to the corresponding strata (see Table 1). For instances, each of the stations sampled in the stratum 3 of the Argosaronic area of the Aegean basin and of the North-Eastern part of Sardinia were labelled Ar3 and SaNE3 respectively. The analysis of the first plane of the compromise evidenced a bathymetric gradient in each of the five basins. However, this gradient appeared strongly disturbed in the Aegean Sea where some stations from strata 1, 2 and 3 were associated. Thus, despite they have been sampled at very different depths, the faunistic composition observed in these stations showed some similarities.

Otherwise, in each basin, our results highlighted a strong heterogeneity of stratum 3 (100 to 200m depth), which produced a segmentation of the bathymetric gradient into two branches. A detailed analysis of the projection of the stations belonging to the stratum 3 showed that this heterogeneity occurred at several spatial scales. Indeed, the break down into two branches of these stations appeared both at a within-region scale (when some of the stations sampled in a unique MEDITS operational area were projected into each of the two branches of the stratum 3), and/or at a between-region scale (when all the stations of a given MEDITS operational area were only projected into one of the two branches of the stratum 3). For instances, in the Adriatic Sea, the between-region component of the heterogeneity of stratum 3 separated the stations from Croatia (Cro3) to the stations from Albania (Alb3), whereas the within-region component occurred for the stations sampled in the Center-Western part of the Adriatic Sea (CW3), which were projected into the two branches of the stratum 3.

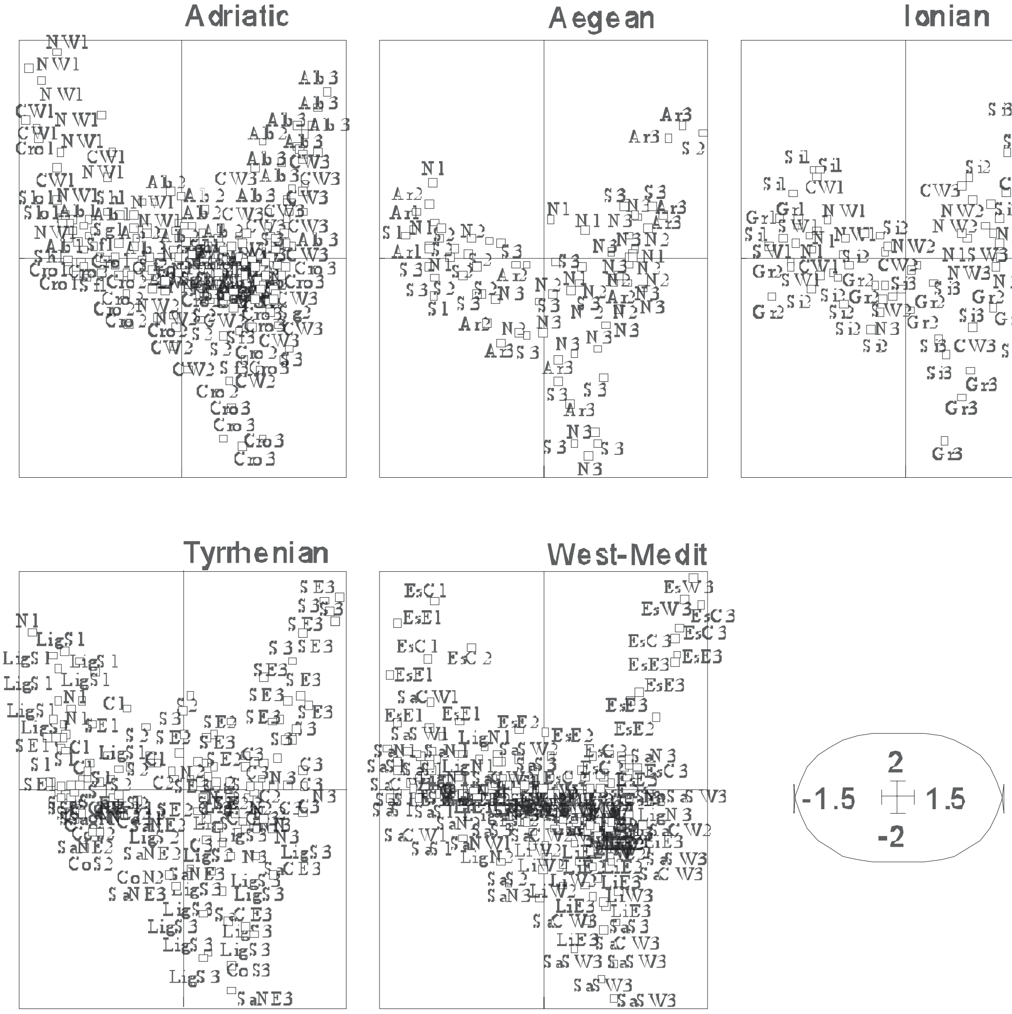

Figure 3.- Projection of the factorial scores of the stations on the first two factorial axes of the STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). Stations are labelled by using both several letters, which reminds to the corresponding operational area, and by a numeric code which refers to the corresponding bathymetric strata (see Table 1).

In some basins, such as the Adriatic Sea and the Ionian Sea, the heterogeneity of stratum 3 occurred at both these two scales. In other basins, this heterogeneity only appeared at one of these two scales. Thus, in the Tyrrhenian and West Mediterranean basins, the heterogeneity of stratum 3 only occurred at the between-region scale. Concerning the Tyrrhenian basin, this heterogeneity was mainly orientated towards an opposition between the northern (East Corsica, South Ligurian Sea, and East Sardinia) and the southern areas (S3 and SE3). This result highlighted that at the scale of the Tyrrhenian Sea, the demersal assemblages living in the stratum 3 were mainly organized along a latitudinal gradient.

In the Western Basin, the between-region component of the demersal organization occurred along a longitudinal gradient which split the three Spanish areas (EsW3, EsC3, EsE3) on one hand, and the Sardinian areas (SaN3, SaCW3, SaSW3, SaS3) and, at a lesser extent, the Gulf of Lions (LiE3 et LiW3) on the other hand. On the opposite, in the Aegean Sea the heterogeneity of the stratum 3 only occurred at a within-region scale. It means that very different faunistic assemblages can be found within the stratum 3 of each of the three MEDITS operational areas of this basin (Ar3, S3 et N3). This pattern of organization notably implied that in the Aegean Sea, assemblages were mainly affected by factors acting at a smaller spatial scale than in the Western basin.

More generally, the structuration of the demersal assemblages within the stratum 3 evidenced that in some cases, the faunistic similarities were more important between regions belonging to different basins than to regions from the same basin. For instances, despite they did not belong to the same basin, we can note, that stratum 3 from Albania (Adriatic Sea), Spain (Western Mediterranean Sea) and Southern Tyrrhenian Sea (TyS and TySE), showed a similar faunistic composition. This faunistic composition appeared very different from those found in the stratum 3 of Croatia (Adriatic Sea), Greek part of the Ionian Sea (GrIo) and ItLiS (Tyrrhenian Sea).

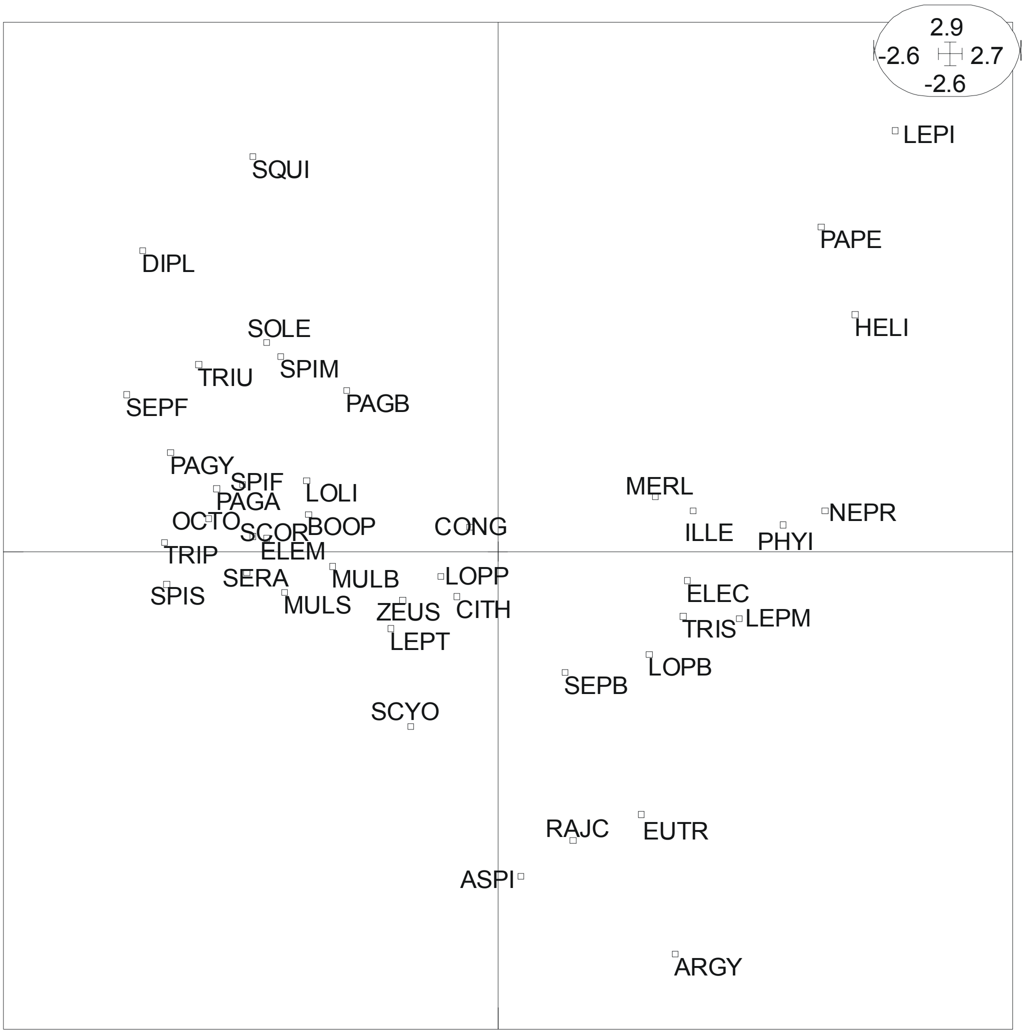

Figure 4.- Projection of the species onto the first factorial plane of STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). Species codes as in Appendix.

The projection of the species onto the first two axes of the compromise allowed to evidence the species responsible for the organizational pattern of the demersal assemblages at the scale of the North Mediterranean Sea (Figure 4). The most coastal assemblage (10 to 50m) was featured by species such as *Diplodus annularis* (Dipl), *Squilla mantis* (Squi), *Solea vulgaris* (Sole), *Trigla lucerna* (Triu), *Sepia officinalis* (Sepf), etc. The intermediate bathymetric strata (50 to 100m) was mainly marked by species such as *Loligo vulgaris* (Loli), *Boops boops* (Boop), *Serranus cabrilla* (Sera), *Mullus barbatus* (Mulb), *Mullus surmuletus* (Muls), *Zeus faber* (Zeus), *Citharus linguatula* (Cith), *Sepia orbignyana* (Sepb), *Lophius budegassa* (Lopb), etc. The two assemblages of the stratum 3 (100 to 200m) were characterized respectively by *Aspitrigla cuculus* (Aspi), *Argentina sphyraena* (Argy), *Raja clavata* (Rajc) et Eutrigla gurnardus (Eutr) on one hand and *Lepidopus caudatus* (Lepi), *Parapenaeus longirostris* (Pape), *Helicolenus dactylopterus* (Heli) on the other hand. Other species such as *Merluccius merluccius* (Merl), *Eledone cirrhosa* (Elec), *Trisopterus capelanus* (Tris), *Phycis blennoides* (Phyl) or even *Nephrops norvegicus* (Nepr) were also highly caught in stratum 3, but they were not specifically characteristic to one of the two previous assemblages.

Figure 5 showed the species' trajectories, which represented the variations, from one basin to another, of the position of each species within the assemblages. Each trajectory linked the position of a studied species within the assemblages in a given basin to its reference position. The reference position of a species referred to its "mean" position within the assemblages in the all five basins (STATIS compromise). In other words, the trajectory of a species indicated the variability of its co-occurrences with the other species between a given basin and the reference state.

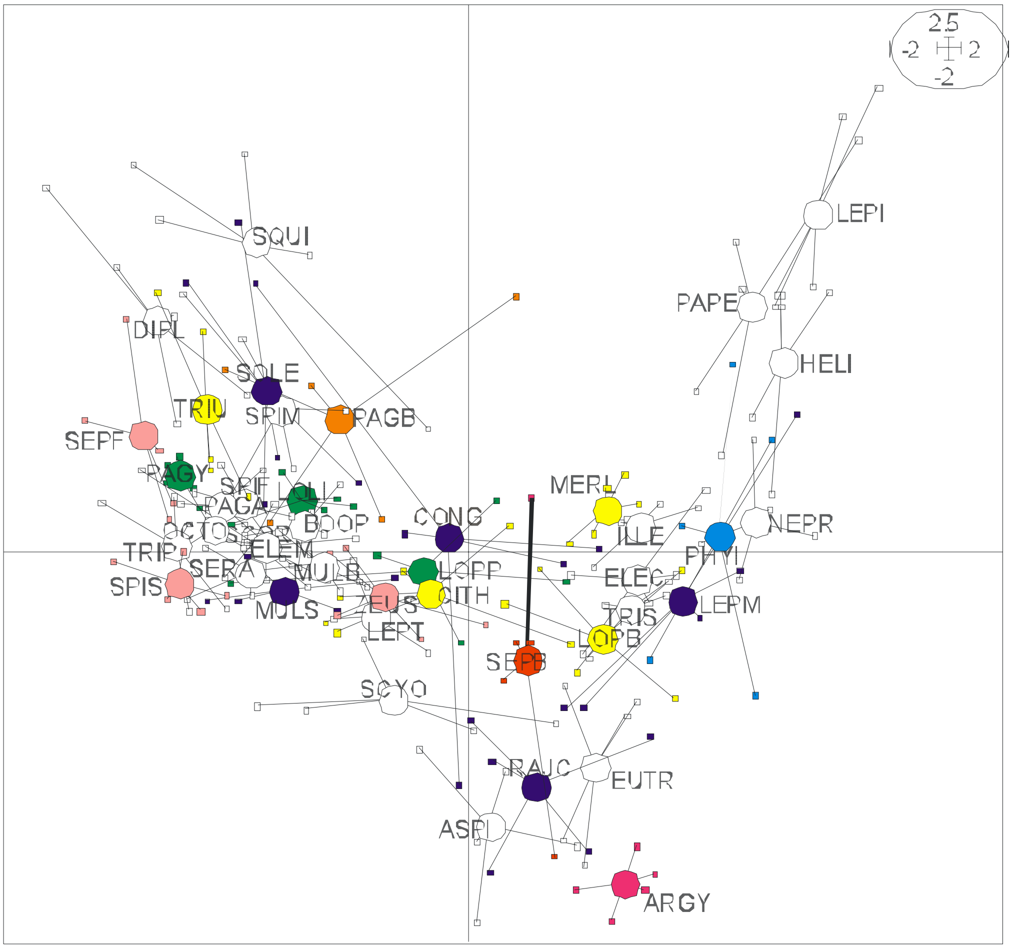

Figure 5.- Projection of the species' trajectories onto the first factorial plane of STATIS-CoA compromise (axis 1: horizontal; axis 2: vertical). The position of a species in each basin (□) is related to its position in the compromise (❍). Species codes as in Appendix.

In the present case, the analysis of species' trajectories allowed to split all the studied species into several groups in reference to the variability of their position within the assemblages in each of the five basins. Thus, we can notice that most of the studied species, such as *Nephrops norvegicus* (Nepr), *Argentina sphyraena* (Argy), *Merluccius merluccius* (Merl), *Illex coindetii* (Ille), *Lepidotrigla cavillone* (Lept), *Loligo vulgaris* (Loli), *Spicara smaris* (Spis), showed very low trajectories which implied that they lowly modified their co-occurrences with the other species from one basin to another. This was notably the case for the species of the two specific assemblages of stratum 3.

On the opposite, a limited number of species evidenced strong trajectories. Some of these species such as *Sepia orbignyana* (Sepb), *Phycis blennoides* (Phyl) and *Lepidorhombus boscii* (Lepm) stayed in the same bathymetric strata but they were associated to different assemblages from a basin to the other. This notably evidenced the important role of depth which constrained the structuration of these species in a specific bathymetric area. Some other species, such as *Conger conger* (Cong), *Pagellus bogaraveo* (Pagb), *Lophius piscatorius* (Lopp), *Scyliorhinus canicula* (Scyo), *Raja clavata* (Rajc) or *Squilla mantis* (Squi), appeared to be able to modify their pattern of distribution along the bathymetric gradient. This result suggested that depth play only a role of second importance in the spatial distribution of these species.

3.7.4 Discussion

The present work constituted a first attempt to analyse simultaneously the organization of the demersal assemblages of the North Mediterranean Sea at several spatial scales: bathymetric strata, MEDITS operational areas, hydrographical basins and North Mediterranean Sea. Using a multitable technique, our analysis revealed several important levels of heterogeneity at each of the studied scales. At the basin scale, we observed the dominance of a bathymetric gradient. Such a pattern, widely described in regional studies performed in the world ocean was thus logically found at the most global scale of the Northern Mediterranean Sea. However, our results also showed that this bathymetric gradient was far less marked in the Aegean Sea. Moreover, the species' trajectories evidenced that some species were weakly affected by depth. Thus, in the Mediterranean Sea, the traditional preponderance of depth on demersal assemblages structuring was altered in a few cases.

At the scale of the bathymetric stratum, we highlighted a strong heterogeneity of stratum 3 (100 – 200m depth), which allow to feature this bathymetric stratum by two different assemblages. While this structuration of the stratum 3 was reproducible from one basin to the other, it exhibited a strong variability at both between-regional and within-regional scales. The general strong reproducibility of the main organizational patterns observed from one basin to the other constituted a very important step in view to identify biogeographical entities. However, complementary studies are needed to improve our knowledge on the determinism of the observed patterns.

All the demersal organizational patterns observed in the present work might be due to several causes. Numerous studies have demonstrated that several environmental parameters, such as depth (Roel, 1987; Biagi *et al.*, 1989; Mahon and Smith, 1989; Gabriel, 1992; Gordon and Bergstadt, 1992; Fujita *et al.*, 1992; Wantiez *et al.*, 1996; Ungaro *et al.* 1998; Kallianiotis *et al.*, 2000, etc.), temperature (Maurin, 1968; Mahon, 1985; Mahon & Smith, 1989; Bianchi, 1992; Perry *et al.*, 1994), salinity (Quinn, 1980; Mahon, 1985; Loneragan & Potter, 1990; Rakosinski *et al.*, 1992), oxygen concentration (Bianchi, 1991, 1992; Rakosinski *et al.*, 1992) and other habitat features (Jones *et al.*, 1991; Bianchi, 1992; Jackson & Harvey, 1992; Auster *et al.*, 1995; Gaertner *et al.*, 1999) influenced the species composition of demersal assemblages. Furthermore, anthropogenic factors such as the direct and indirect impacts of fishing (Mahon and Smith, 1989; Hutchings, 1990, Scwinghammer *et al.*, 1996, etc.), could also strongly influence the organizational patterns of groundfish assemblages.

At the present state of knowledge, it is yet premature to specify which of the factors were really responsible for demersal patterns of organization observed in the North Mediterranean Sea. Nevertheless, developing multi-scale analyses, such as the present one, will allow us (1) to test hypotheses suggested by previous authors on the factors controlling the organization of demersal assemblages and (2) to generate new hypotheses as a basis for future studies. Indeed, the monitoring of how pattern and variability changed with the scale of description is a fruitful approach to better understand which factors really affected assemblages structuring (Lévin, 1992; Underwood and Chapman, 1998). The relative importance of physical and biotic factors in regulating community patterns appears to vary with spatial scale. For instances, on a local scale, physical and biotic factors interact to influence local patterns of community structure. Larger spatial scales are associated with increases in the relative influence of variation in environmental or climatic conditions (Menge and Olson, 1990).

Thus, studying both the reproducibility and the variability of the observed structures at different scales, will help us to focus our methodological investigations at relevant scales. Thus, the origin of the particularities of the Aegean Sea evidenced at the inter-basin scale should be found among factors acting at the scale of the whole basin (management regulations, fleet characteristics, general eutrophication level, etc.). On the opposite, the origin of smaller scale patterns such as the within-region component of the heterogeneity of stratum 3 will be find out among factors acting in a smaller scale such as the biotic interactions, local topography of the upper slope or the type of substratum. By this way, on the basis of the present work, and using other information describing each area from ecological and anthropogenic viewpoints, we could greatly improve our knowledge on the determinism of the community structuring. In this frame, the present study only constituted a first step along this approach which will allow *in fine* to define multispecific biogeographical entities in the North Mediterranean Sea.

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Label	Latin name	Family
ARGY	*Argentina sphyraena* Linnaeus, 1758	ARGENTINIDAE
ASPI	*Aspitrigla cuculus* (Linnaeus, 1758)	TRIGLIDAE
BOOP	*Boops boops* (Linnaeus, 1758)	SPARIDAE
CITH	*Citharus linguatula (*Linnaeus 1758)	CITHARIDAE
CONG	*Conger conger* (Linnaeus, 1758)	CONGRIDAE
DIPL	*Diplodus annularis (*Linnaeus, 1758*)*	SPARIDAE
ELEC	*Eledone cirrhosa (*Lamarck, 1798*)*	OCTOPIDAE
ELEM	*Eledone moschata* (Lamarck, 1799)	OCTOPIDAE
EUTR	*Eutrigla gurnardus* (Linnaeus, 1758)	TRIGLIDAE
HELI	*Helicolenus dactylopterus* (Delaroche, 1809)	SCORPAENIDAE
ILLE	*Illex coindetii* (Verany, 1839)	TEUTHOIDEA
LEPI	*Lepidopus caudatus* (Euphrasen, 1788)	TRACHIURIDAE
LEPM	*Lepidorhombus boscii* (Risso, 1810)	SCOPHTALMIDAE
LEPT	*Lepidotrigla cavillone* (Lacepède, 1801)	TRIGLIDAE
LOLI	*Loligo vulgaris* Lamarck, 1798	LOLIGINIDAE
LOPB	*Lophius budegassa* Spinola, 1807	LOPHIIDAE
LOPP	*Lophius piscatorius* Linnaeus, 1758	LOPHIIDAE
MERL	*Merluccius merluccius* (Linnaeus, 1758)	MERLUCIIDAE
MULB	*Mullus barbatus* Linnaeus, 1758	MULLIDAE
MULS	*Mullus surmuletus* Linnaeus, 1758	MULLIDAE
NEPR	*Nephrops norvegicus* (Linnaeus, 1758)	NEPHROPIDAE
OCTO	*Octopus vulgaris Cuvier, 1797*	OCTOPODIDAE
PAGA	*Pagellus acarne* (Risso, 1826)	SPARIDAE
PAGB	*Pagellus bogaraveo* (Brunnich, 1768)	SPARIDAE
PAGY	*Pagellus erythrinus* (Linnaeus, 1758)	SPARIDAE
PAPE	*Parapenaeus longirostris* (Lucas, 1846)	PENAEIDAE
PHYI	*Phycis blennoides* (Brünnich, 1768)	GADIDAE
RAJC	*Raja clavata* Linnaeus, 1758	RAJIDAE
SCOR	*Scorpaena notata Rafinesque, 1810*	SCORPAENIDAE
SCYO	*Scyliorhinus canicula* (Linnaeus, 1758)	SCYLIORHINIDAE
SEPF	Sepia officinialis *(Linnaeus, 1758)*	SEPIIDAE
SEPB	*Sepia orbignyana* Ferussac, 1826	SEPIIDAE
SERA	*Serranus cabrilla* (Linnaeus, 1758)	SERRANIDAE
SOLE	*Solea vulgaris (Quensel, 1806)*	SOLEIDAE
SPIF	Spicara flexuosa (Rafinesque, 1810)	CENTRACANTHIDAE
SPIM	*Spicara maena* (Linnaeus, 1758)	CENTRACANTHIDAE
SPIS	*Spicara smaris* (Linnaeus, 1758)	CENTRACANTHIDAE
SQUI	*Squilla mantis* (Linnaeus, 1758)	SQUILIDAE
TRIU	*Trigla lucerna* (Linnaeus, 1758)	TRIGLIDAE
TRIP	*Trigloporus lastoviza* (Bonnaterre, 1788)	TRIGLIDAE
TRIS	*Trisopterus capelanus minutus (*Lacépede, 1800*)*	GADIDAE
ZEUS	*Zeus faber* Linnaeus, 1758	ZEIDAE

Appendix. List of the species considered with detail on the abbreviated names used.

3.8 SECTION VII Distribution of demersal crustaceans in the southern Adriatic Sea

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SUMMARY: Information on occurrence, distribution and assemblages of crustacean's species in the southern Adriatic Sea was reported. Raw data came from five trawl surveys carried out in summer months (June-July) 1996, 1997, 1998, 1999 and 2000 along the whole southern Adriatic area (10 – 800 m bathymetric range, both the western and eastern zone), by using the same vessel and the same sampling gear (E.U. Project "MEDITS").

A total list of fifty-two benthic-epibenthic and nektonic crustaceans' species (three stomatopods, forty-nine decapods) was obtained during the surveys. Highest occurrence values were recorded for few species, as well as abundance indices.

Species density data (individuals / km^2) were processed according to multivariate techniques in order to describe the composition and the distribution of main species assemblages within the investigated area.

Multivariate analysis of MEDITS surveys catch data shown the persistence of crustaceans' assemblages in the investigated area, but some differences between western and eastern zones have been pointed out (mostly referring to shelf bottoms). The influence of oceanographic features (other than the depth) was discussed.

3.8.1 Introduction

In recent years studies about species distribution and assemblages collected by trawl net have been developed in different areas of the Mediterranean Sea (see Gaertner *et al.*, present volume) in order to explain the space-time distribution patterns of demersal species *versus* environmental characteristics (depth, substratum etc.) or anthropic impacts (fishery etc.).

Regarding the research on the demersal species assemblages in the southern Adriatic Sea, until 1996 scientific information was reported only for the Western side of the basin (Ungaro *et al.*, 1995; Ungaro *et al.*, 1998); from the summer 1996 the European Community research project MEDITS (Mediterranean International Trawl Survey) allows to gain data about 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 (Bertrand *et al.*, 1997), and some information are now available for the geographic zone (Ungaro *et al.*, 1999; Ungaro and Marano, 2001).

Crustaceans represent an important fraction of the total catches by trawl nets, both in the whole Mediterranean (e.g. Relini-Orsi and Relini, 1972; Abellò *et al.* 1988; Righini and Auteri, 1989; Cartes and Sardà, 1992; Mura and Cau, 1992; Pipitone and Tumbiolo, 1993; Tursi *et al.*, 1993; Spanò, 1998; Rinelli *et al.*, 1998) and in the southern Adriatic Sea (Petruzzi *et al.* 1988; Pastorelli *et al.*, 1996; Marsan *et al.*, 2000). The mentioned zoological group is strongly linked to the trophodynamics in the marine environment (see at Cartes *et al.*, present volume). Moreover, some of the collected species are valuable resources for fishery exploitation (e.g. *Nephrops norvegicus*, *Parapenaeus longirostris*, *Aristeus antennatus* and *Aristaeomorpha foliacea*) and they need assessment and management options (Relini *et al.*, 1999).

In the present paper data from 1996-2000 MEDITS trawl surveys were processed in order to list and quantify crustaceans species on south Adriatic trawlable bottoms and to identify the composition and distribution of the main assemblages. The achieved information could be useful to define the crustaceans' biodiversity and the "local" fishery assemblages (Tyler *et al.*, 1982; Overholtz and Tyler, 1985; Mahon and Smith, 1989), both important topics for the environmental management of the Mediterranean basin (Caddy, 1998).

3.8.2 Material and Methods

Crustacean samples were obtained from trawl-surveys carried out in Southern Adriatic Sea (Mediterranean Sea). This mentioned area is located at 39° / 42° North and 15° / 20° East geographic co-ordinates and it is characterised by a deep (1,230 m maximum depth) and large trench in the middle that virtually separates the trawlable bottoms of the western side (Italy) from the eastern ones (Albania). During the years 1996, 1997, 1998, 1999 and 2000 spring-summer surveys were carried out on shelf and upper slope (from 16 m up to 588 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 Western area, 40 hauls in Eastern area each year) by using an otter trawl net (length ≅ 40 m, wing spread ≅ 8 m) with 10 mm mesh size at cod-end. The overall surveyed area was around 24,000 km^2, and a total of 560 trawl hauls were performed during the investigated period.

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

All crustacean species collected by the net were identified according to Zariquiey-Alvarez (1968) and Falciai and Minervini (1992) and a list per haul was recorded (truly plankton species were excluded).

Species abundance data were standardised to the square kilometre (kg / km^2, n° / km^2) by swept-area method (Sparre and Venema, 1992).

Occurrence, biomass and density indices, as well as bathymetric range were calculated for each species. Moreover, species abundance x sampling stations matrices were processed using multivariate techniques such as cluster analysis (hierarchical agglomerative clustering; group average) (Legendre and Legendre, 1987) and multi dimensional scaling (MDS) (Kruskal, 1964); before processing, the data were double-root transformed to avoid the strong influence by the most abundant species in the samples (Clarke and Green, 1988). Non-metric MDS was chosen (Ardisson *et al.*, 1990) and the two-dimensional space ordination was performed.

The similarity among samples was evaluated through the Bray-Curtis coefficient, after the exclusion of the species with abundance value lesser than 1 % (from each sample, in order to minimise the elaboration “noise”). Data analysis was carried out by means of PRIMER software (Carr, 1996).

The same analysis were performed for “species mean abundance x 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 about species assemblages distribution per survey, depth and area.

3.8.3 Results

The five sampling surveys provided a total list of 52 crustacean species (3 stomatopods and 49 decapods) characterised by benthic or nektonic *habitus*. Thirty zoological families have been identified, and *Pandalidae*, *Galatheidae* and *Paguridae* were more represented (7, 4, and 4 species, respectively) (Table 1).

Occurrence values were processed for the pooled surveys over the whole area, together with mean biomass and density indices. Results highlight the prevalence of few species, such as the penaeid *Parapenaeus longirostris,* the caridean shrimps of the genus *Plesionika* as well as the portunid crabs *Liocarcinus depurator* and *Macropipus tuberculatus* and the astacidean *Nephrops norvegicus.* These species contribute for most of total biomass in the whole area (Fig. 2).

The just mentioned species have a different role by depth, and the crab *Liocarcinus depurator* characterises shelf bottoms while *P. longirostris*, *Plesionika* spp. and *M. tuberculatus* have been mostly found on shelf border and upper slope bottoms (Fig. 3).

The analysis was carried out separately for western and eastern areas of the southern Adriatic Sea and some differences have been pointed out. In fact, the western area was mostly characterised by the presence and abundance of *reptantia* or burrowing species such as *L. depurator* and *N. norvegicus*, while the eastern one was characterised by *natantia* species such as *P. longirostris* and *Plesionika* spp. (Figs. 4-5).

Clustering of sampling stations (whole investigated area) was performed using a “species density x sampling station” matrix. Density indices per station were averaged on the overall period (five surveys) in order to reduce the influence of the “occasional” catches. Results from multivariate analysis pointed out four main clusters at the second level of ramification. The first cluster included most of sampling stations deeper than 350 m (both on western and eastern sides), the second one mostly included shelf and upper-slope stations in the eastern zone of the southern Adriatic basin. The remaining two clusters included sampling stations in the western zone of the investigated area between 115 and 233 m and between 21 and 125 m depths respectively (Fig. 6).

According to the stratification of sampling scheme (MEDITS protocol), classification and ordination (MDS) of data referring to the defined bathymetric strata (species mean density x depth strata, pooled surveys) per geographic area (south-western and south-eastern Adriatic Sea) was performed also. The differences between western and eastern shelf areas were highlighted again, while slope zones appeared to be quite homogeneous (Fig. 7).

The same analysis was carried out for each yearly survey and small inter-annual variations in the distribution of main crustaceans' assemblages were detected, as it was shown in the figures 8 and 9 (survey 1996 *versus* survey 2000). Thus, the persistence of assemblages in the investigated area could be stated.

With regard to the most abundant species characterising the assemblages, the high occurrence on shelf bottoms of the western area of the crabs such as *Liocarcinus depurator* and *Goneplax rhomboides* and the abundance of *Parapenaeus longirostris* in the eastern area contributed to distinguish the opposite zones of the southern Adriatic basin. On the contrary, the homogeneity of slope bottoms was mostly due to the occurrence and abundance of species such as *Plesionika martia*, *Pasiphaea sivado*, *Aristaeomorpha foliacea* and *Polycheles typhlops* on both the western and eastern areas.

3.8.4 Discussion and conclusion

The reported species list agreed with bibliographic information from both the same geographic zone (Petruzzi *et al.* 1988; Vaso and Gjiknuri, 1993; Pastorelli *et al.*, 1996; Marsan *et al.*, 2000) and other Mediterranean areas, as well as the bathymetric ranges of distribution (Relini-Orsi and Relini, 1972; Abellò *et al.* 1988; Righini and Auteri, 1989; Cartes and Sardà, 1992; Mura and Cau, 1992; Pipitone and Tumbiolo, 1993; Tursi *et al.*, 1993; Spanò, 1998; Rinelli *et al.*, 1998). Moreover, all the collected species are included in the reference checklists regarding to the whole Mediterranean basin (Stevcic and Galil, 1994; Froglia, 1995).

Munida iris Zariquiey Alvarez, 1952 and *Calappa turkayana* n. sp. (Pastore, 1995; Pastore, pers. Comm.) resulted new findings for the investigated area. They are added to *Paromola cuvieri* (Risso, 1816) recently found in the same area (Ungaro, 2000).

Crustaceans' assemblages defined from multivariate analysis of data appeared to be rather stable over the years in the whole investigated area, as it was reported for most of demersal species groups (Gaertner *et al.*, 1998; Ungaro *et al.*, 1998; Gaertner *et al.*, present volume). Depth gradient could be very important for fish assemblages distribution in the southern Adriatic (Ungaro *et al.*, 1998; Ungaro *et al.*, 1999) as it often occurs in the Mediterranean Sea (see at the many references reported in the present volume), but the bathymetry partially explains the crustaceans' assemblages distribution in the same area. Slope assemblages were homogeneously distributed in the overall area, while western and eastern zones were mostly differentiated on the shelf bottoms, where the influence of other variables than the depth could be remarkable for crustaceans distribution; it was probably due to the oceanographic features of the Adriatic Sea, a semi-enclosed basin characterised by both latitudinal (south to north) and longitudinal (east to west) gradients (e.g. Zore-Armanda, 1968; Bregant *et al.*, 1992).

On the other hand, the link among crustaceans' species distribution and talassographic parameters has been supposed by other Authors (Abellò *et al.*, 1988; Cartes *et al.*, 1994; Ungaro *et al.*, 1999), and new information from the southern Adriatic area underlined the probable role of bottom temperature for crustacean species distribution also (Ungaro and Marano, submitted) (Fig. 10).

The reported results highlight the importance of researches and studies about the distribution of biological resources and the relationship with oceanographic features. The investigation on the just mentioned topics could improve the knowledge of the marine ecosystem in order to manage the environment and the exploitation of natural resources (e.g. fishery).

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Table 1. Crustaceans' species collected during MEDITS 1996-2000 surveys in the southern Adriatic Sea.

SUPERFAMILIA	**FAMILIA**	SPECIES
	Squillidae	*Rissoides desmaresti* (Risso, 1816)
		Rissoides pallidus (Gesbrecht, 1910)
		Squilla mantis (Linnaeus, 1758)
ASTACIDEA	**Nephropidae**	*Homarus gammarus* (Linnaeus, 1758)
		Nephrops norvegicus (Linnaeus, 1758)
BRACHYRHYNCHA	**Portunidae**	*Bathynectes maravigna* (Prestandrea, 1839)
		Liocarcinus depurator (Linnaeus, 1758)
		Macropipus tuberculatus (Roux, 1830)
	Geryonidae	*Geryon longipes* A.Milne Edwards, 1881
	Goneplacidae	*Goneplax rhomboides* (Linnaeus, 1758)
	Xanthidae	*Monodaeus couchii* (Couch, 1851)
		Philumnus hirtellus, (Linnaeus, 1761)
		Xantho pilipes A. Milne Edwards, 1867
CARIDEA	**Alpheidae**	*Alpheus glaber* (Olivi, 1792)
	Pandalidae	*Chlorotocus crassicornis* (Costa, 1871)
		Plesionika acanthonotus (S.I.Smith, 1882)
		Plesionika antigai Zariquiey Alvarez, 1955
		Plesionika edwarsii (Brandt, 1851)
		Plesionika gigliolii (Senna, 1903)
		Plesionika heterocarpus (Costa, 1871)
		Plesionika martia (A. Milne Edw., 1883)
	Pasiphaeidae	*Pasiphaea multidentata* Esmark, 1866
		Pasiphaea sivado (Risso, 1816)
	Crangonidae	*Pontocaris lacazei* (Gourret, 1887)
		Pontophilus spinosus (Leach, 1815)
	Processidae	*Processa canaliculata* Leach, 1915
DROMIACEA	**Homolidae**	*Homola barbata* (Fabricius,1793)
		Paromola cuvieri (Risso, 1816)
	Latreillidae	*Latreillia elegans* Roux, 1830
GALATHEIDEA	**Galatheidae**	*Munida intermedia* A.Mil.Edw.& Bouv., 1899
		Munida iris Zariquiey Alvarez, 1952
		Munida perarmata A.Mil.Edw.& Bouv., 1894
		Munida rugosa (Fabricius, 1775)
OXYRHYNCHA	**Majidae**	*Anamathia rissoana* (Roux, 1828)
		Macropodia longipes (A.Mil.Edw.& Bouv., 1899)
	Phartenopidae	*Parthenope macrocheles* (Herbst,1790)
OXYSTOMATA	**Calappidae**	*Calappa granulata* (Linnaeus, 1767)
		Calappa turkayana n. sp.
	Dorippidae	*Medorippe lanata* (Linnaeus, 1767)
PAGURIDEA	**Diogenidae**	*Dardanus arrossor* (Herbst, 1796)
	Paguridae	*Pagurus alatus* Fabricius, 1775
		Pagurus cuanensis, Bell 1846
		Pagurus excavatus (Herbst, 1791)
		Pagurus prideaux Leach, 1815
PALINURIDEA	**Palinuridae**	*Palinurus elephas* (Fabricius, 1787)
	Polychelidae	*Polycheles typhlops* Heller, 1862
PENAEIDEA	**Aristeidae**	*Aristeomorpha foliacea* (Risso, 1827)
		Aristeus antennatus (Risso, 1816)
	Penaeidae	*Parapenaeus longirostris* (Lucas, 1846)
	Solenoceridae	*Solenocera membranacea* (Risso, 1816)
SERGESTOIDEA	**Sergestidae**	*Sergestes robustus* S.I.Smith, 1882
		Sergestes articus (Kröier, 1855)

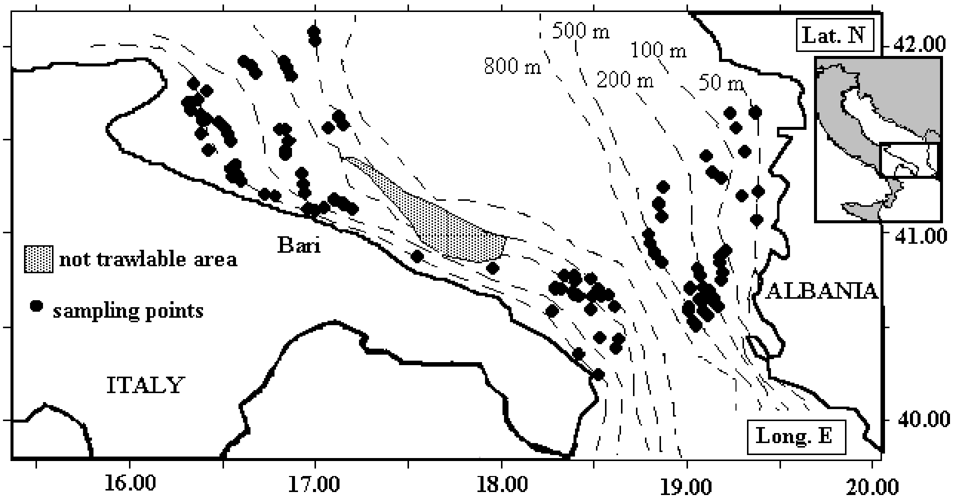


Fig. 1. - MEDITS 1996-2000 trawl surveys in the Southern Adriatic Sea: sampling area and geographic position of 112 hauls (72 and 40 samples on Western and Eastern trawlable bottoms, respectively).

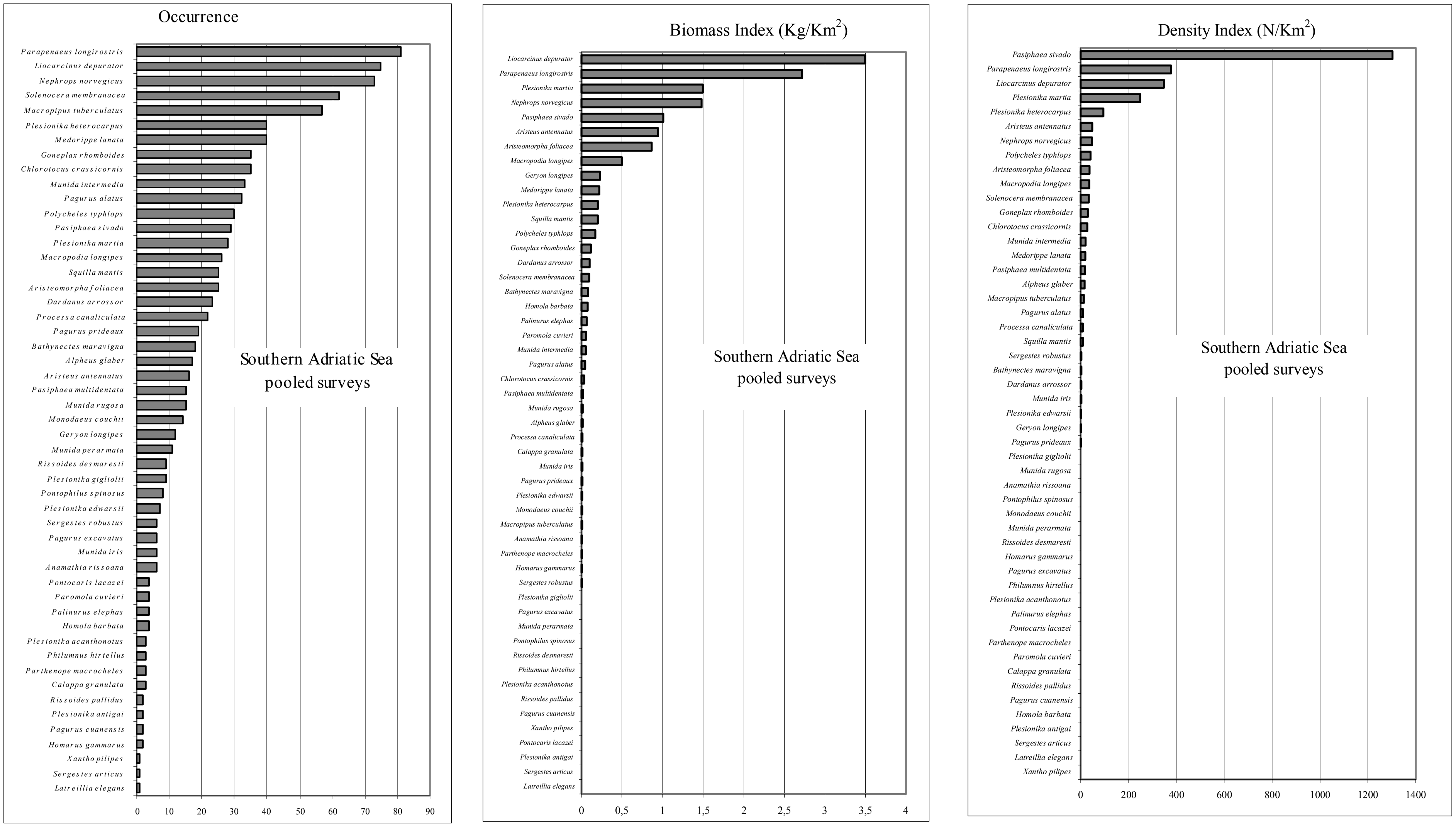


Fig. 2. – Southern Adriatic Sea: occurrence and abundance indices of the collected crustaceans’ species (pooled surveys).

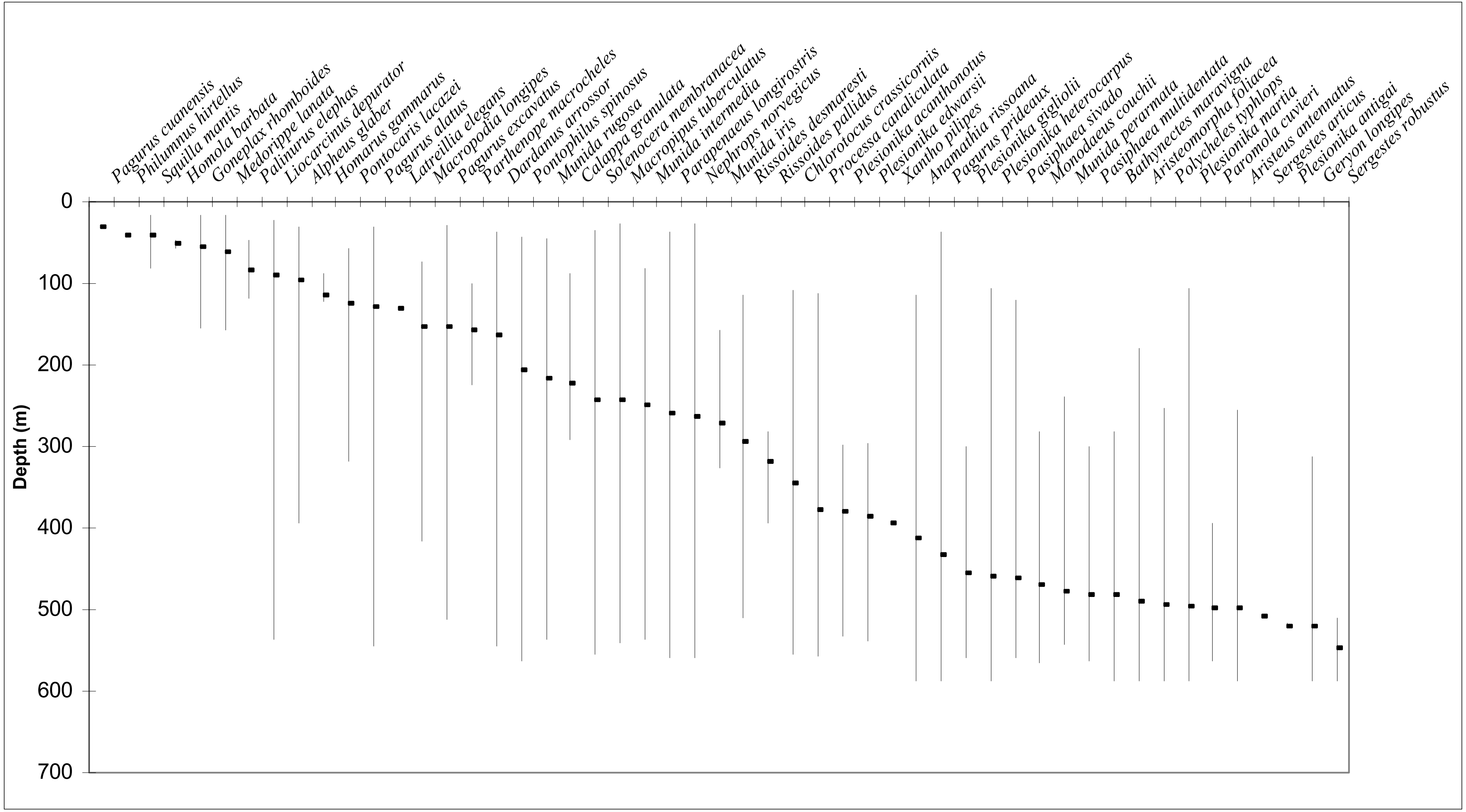


Fig. 3. – Southern Adriatic Sea: bathymetric ranges and centroid distribution of the collected crustaceans' species.

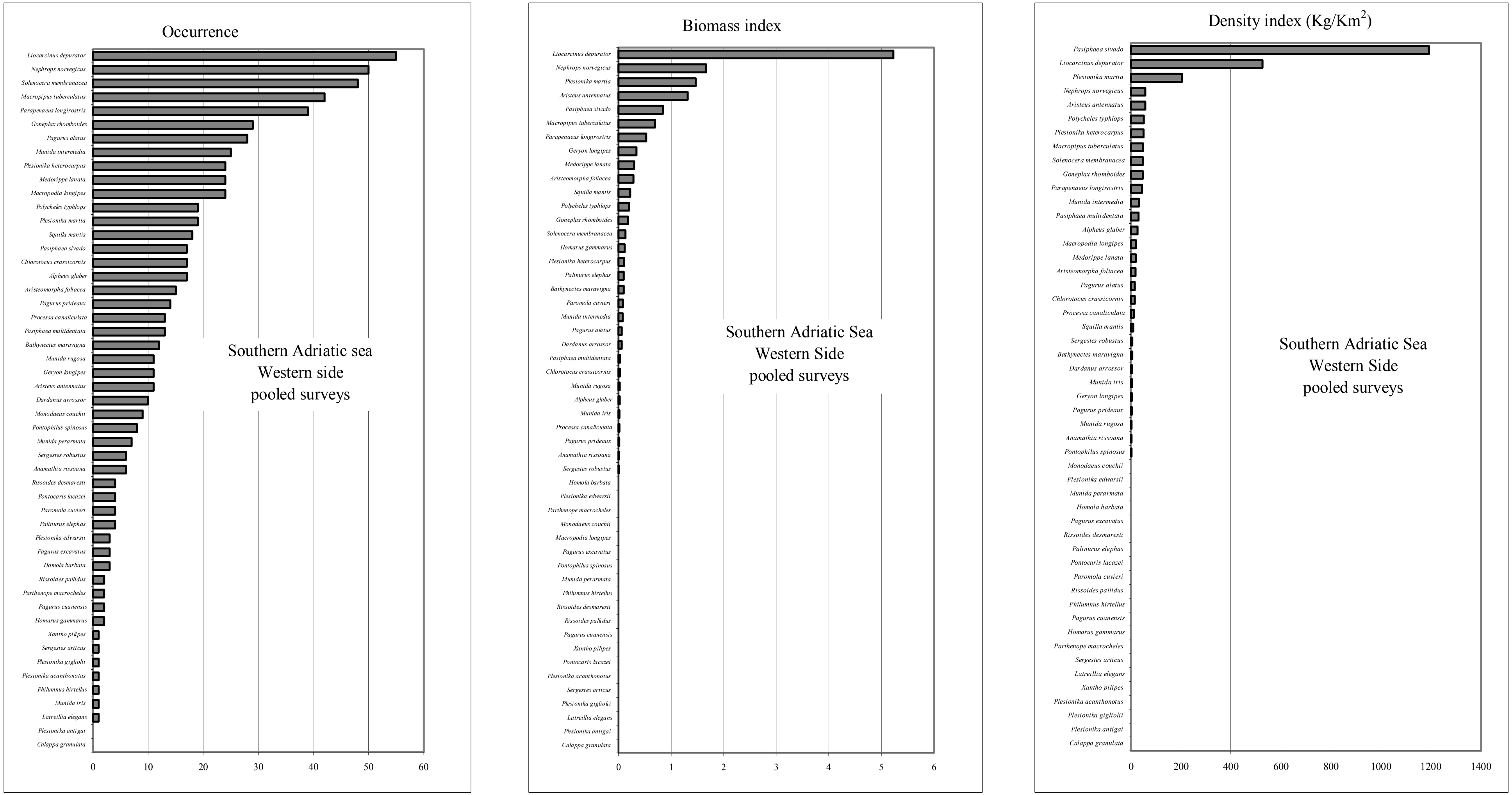


Fig. 4. – Southern Adriatic Sea, Western zone: occurrence and abundance indices of the collected crustaceans' species (pooled surveys).

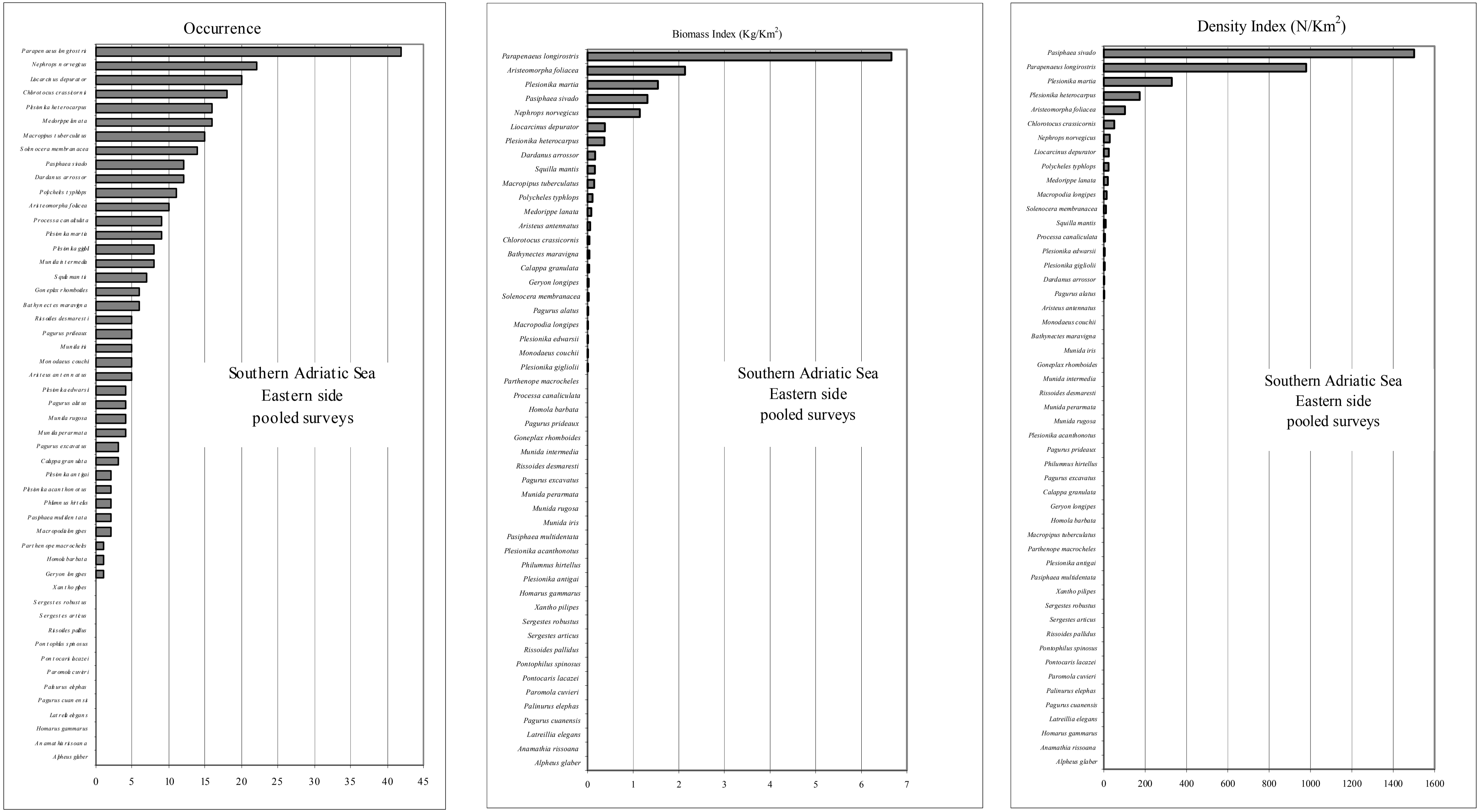


Fig. 5. – Southern Adriatic Sea, Eastern zone: occurrence and abundance indices of the collected crustaceans' species (pooled survey).

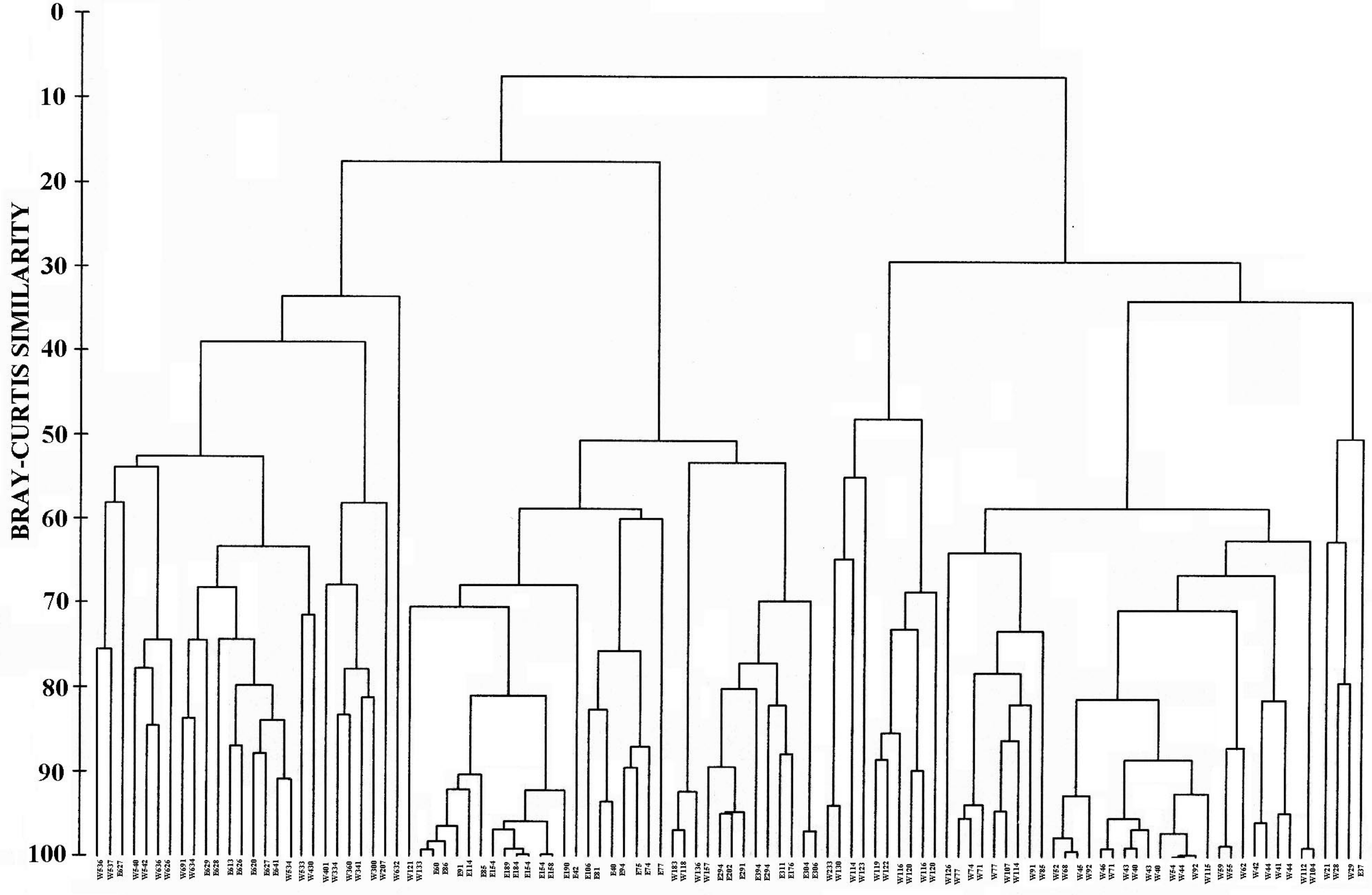
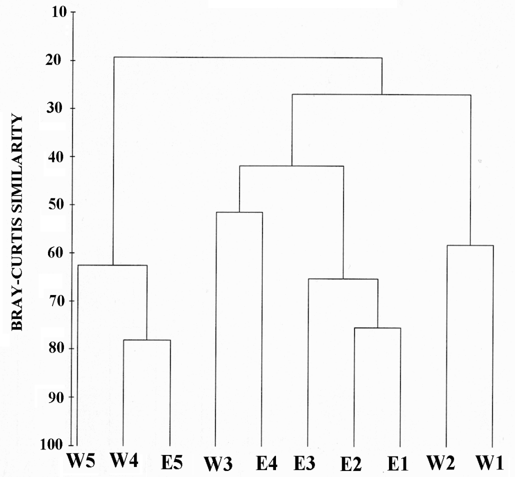


Fig. 6. – Southern Adriatic Sea: clustering of sampling stations from MEDITS 1996-2000 surveys. Crustaceans' density indices per station (n°/km^2) were averaged on the overall period (five surveys). Sampling stations are codified by mean depth and geographic area (W = western side; E = eastern side).



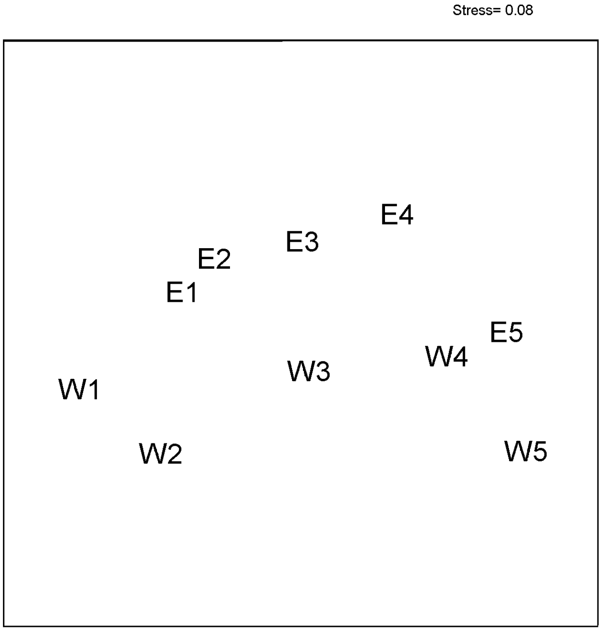


Fig. 7. - Classification (cluster analysis, picture above) and ordination (multi dimensional scaling, picture below) of crustaceans assemblages on trawlable bottoms of southern Adriatic Sea (E = Eastern side; W = Western side): mean density values per depth stratum (1 = 10-50 m; 2 = 51-100 m; 3 = 101-200 m; 4 = 201-500 m; 5 = 501-800 m). Data averaged on the overall period (five surveys).

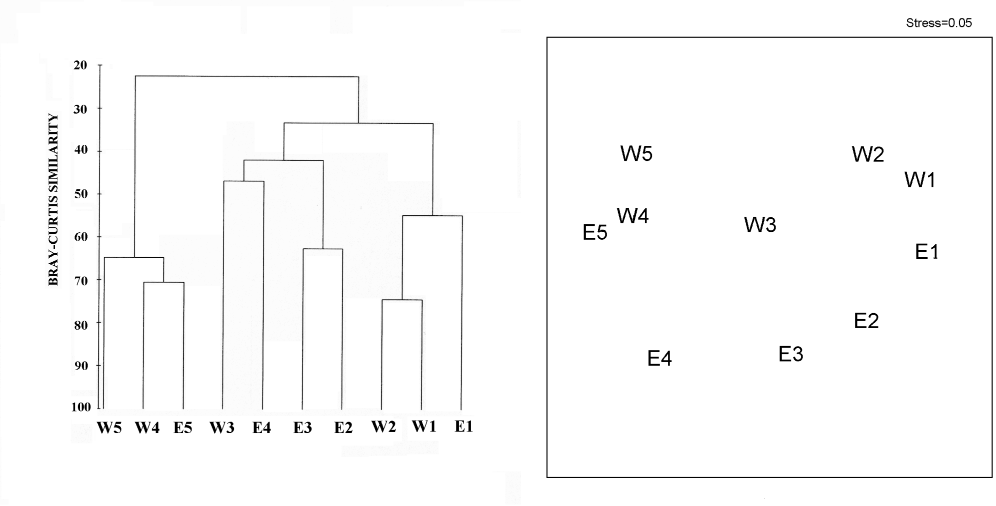


Fig. 8. - Classification and ordination of crustaceans assemblages on trawlable bottoms of southern Adriatic Sea (E = Eastern side; W = Western side): mean density values per depth stratum (1 = 10-50 m; 2 = 51-100 m; 3 = 101-200 m; 4 = 201-500 m; 5 = 501-800 m). Data from 1996 MEDITS survey.

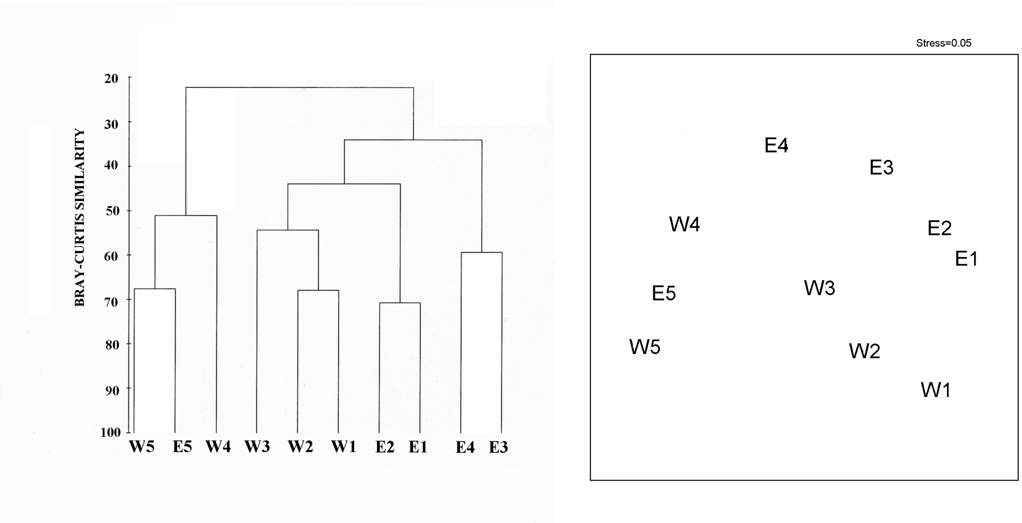


Fig. 9. - Classification and ordination of crustaceans assemblages on trawlable bottoms of southern Adriatic Sea (E = Eastern side; W = Western side): mean density values per depth stratum (1 = 10-50 m; 2 = 51-100 m; 3 = 101-200 m; 4 = 201-500 m; 5 = 501-800 m). Data from 2000 MEDITS survey.

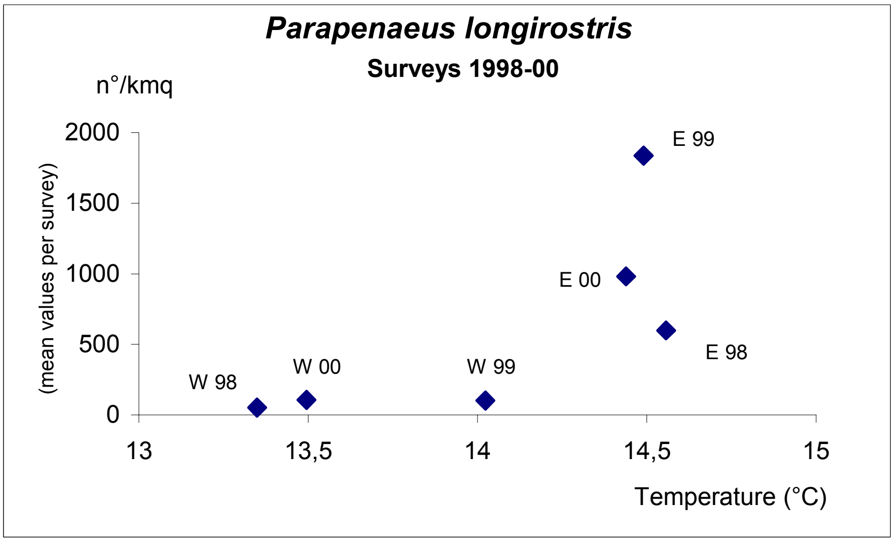


Fig. 10.- Southern Adriatic Sea: relationship between abundance of *P. longirostris* and bottom temperature (mean values per survey, depths below 100 m; W = western side, E = eastern side) (from Ungaro and Marano, submitted).

[4] Identifying the main nurseries of Hake, Greater Fork-beard, Deep Water Pink Shrimp and Broadtail Shortfin Squid in the Mediterranean using MEDITS trawl survey data

Working Group on Nursery Areas

Participants: F. Fiorentino (co-ordinator), J.A. Bertrand, E. Ferrandis, G. Garofalo, M. Gonzalez and C.Y. Politou

This paper has been presented at the International Workshop on Stock assessment and production of demersal resources in the Mediterranean organized jointly through the MEDITS/SAMED dynamics (Rome in March 2002) under the auspices of the FAO-GFCM. Its results will be submitted for publication in the proceedings of this workshop (FAO "Studies and Reviews").

4.1 Introduction

Understanding the recruitment processes is one of the most important challenge of the fishery science. Although it is only a part of more complex process involving both exploitation and environmental factors, the identification of areas where juvenile fish concentrate may represent an important concern for stock management. This is particularly true in region such as the Mediterranean, where the conservation of fishery resources is largely based on technical measures (minimum landing sizes, mesh size regulations, restrictions on fishing gears, and closed seasons and areas). In this frame an appropriate closure to fisheries of the areas where the young are concentrated can contribute to rebuilding of overexploited stocks by increasing the survival of these young individuals.

Most studies on the identification of nurseries may start from the availability of reliable indices of recruit abundance. Classically there are two main sources of data on the strength of the recruitment in demersal resources: estimation of youngest year class deriving from VPA, or similar approaches, on commercial data and abundance indices obtained by trawl surveys (Hilborns and Walters,1992).

In relation to the life stage being considered and the origin of the data, these indices can be defined as a number of individuals per unit sampling effort. Example might be numbers at age 1 from the catch at age analysis, numbers at age 0 derived from the trawl surveys or numbers entering the fishery from catch per unit effort data;

Considering the different sources of data usable for recruitment studies, trawl surveys are very adequate for studying the spatial distribution of the youngest fraction of many fish populations. Their first and strong advantage is due to the geo-referenced nature of the sampling. Another asset of these data consists of the possibility to express abundance in terms of numbers per surface unit, on the basis of the swept area method. A further advantage can arise from the use of very fine mesh size during the trawl surveys. This is situation with the MEDITS standard net, that have a 20 mm mesh opening in the cod-end, allowing the catch of very small sized fish. Some disadvantage in using trawl surveys data could derive from the season of the campaigns. Since one survey per year is generally carried out, it is difficult to find a period well fitting the specific recruitment season of several species.

A time series of data on abundance of the main demersal resources in the Mediterranean was built up from the International bottom trawl survey in the Mediterranean (MEDITS programme). It provided a very important basis for studying the inter-annual variability of abundance of the demersal stocks in the northern Mediterranean (Bertrand *et al.*, 2000a). A first synoptic picture on the distribution of juveniles for the main demersal resources over the whole MEDITS area, in depth strata from 10 up to 800 m was presented by Bertrand *et al.* (2000b).

Given that the identification of the nurseries is an aspect of the more general recruitment dynamics, the WG produced also some suggestions for further analyses on the MEDITS data-base to improve understanding of recruitment processes in the Mediterranean.

Identifying nurseries is one of the aspects of the recruitment problem, that is one of the major targets of fishery investigations, dealing with the income of new members in the exploited populations.

On the basis of the program and the availability of data, three main objectives were identified:

- Identification and quantification of the recruits (R) and juveniles (J), in terms of individuals belonging to the 0 age (younger than 1 year) and immature (whose sex is not recognizable, hereafter reported as stage 0, or gonads belonging to stage 1of MEDITS maturity scale), respectively,
- Figuring out an objective representation of the abundance of the youngest age groups (in terms of Density Index; n/km^2) in the whole MEDITS area;
- Individuation of the main discrete nurseries as those areas where the youngest age groups were consistently (year by year) and diffusely present, on the basis of a standardised index of exclusive richness of the youngest age groups.

The calculation of “the most accurate” density indices of recruits was performed adopting procedures taking into account the likely variability of the recruitment pattern among areas and years.

As a general rule an effort was done to standardise the terminology, to avoid the steady state approach and to adopt simple elaboration procedures.

4.1.1 Some definitions

First of all, it is useful to discuss and define briefly some terms that are topical for the argument under study, i.e. what we intend by “recruits”, “juveniles” and “nurseries”.

4.1.1.1 Recruits and juveniles

According to the aim of the research and the availability of data, recruits can be defined in several manners. However they represent the number of fish (or an index proportional to abundance) estimated at the youngest age-class or groups available in the exploitable population.

On the basis of the aims of the program, two categories of the youngest age groups were considered:

- The recruits (R), defined as the individuals belonging to the 0 age (younger than 1 year)
- The juveniles (J), defined as all the immature specimens according to the maturity condition of gonads(stage 0 and 1), regardless their putative age.

4.1.1.2 Nursery areas

Nurseries were considered as the areas where the highest density and exclusive presence of young specimens (recruits or juveniles according to the species) was found.

The identification of nurseries, could be an important tool for management of demersal resources, mainly in the Mediterranean, where no quota system is in force (Caddy, 1993). This information could allow the control of the fishing effort on the new entries into a population in a more effective way, bettering the exploitation status of the stock.

As a general rule, after recruits have been correctly identified and their indices of abundance geo-referenced, location and extent of nursery areas can be investigated by means of spatial analysis and GIS. Three main different approaches of this problem, reported with increasing order of analysis complexity are available:

Levi *et al.* (2000) identify the areas of highest concentration of recruits by pooling data from several years and plotting the relative densities calculated as ratio with respect to the maximum found in each year. Grouping of high values on the map allows an immediate rough estimate of persistent areas of recruitment. These areas can be delimited drawing the minimum convex polygon of each point set.

Sanchez & Gil (2000), Kavadas (2000), Aldebert *et al.* (2000) use ordinary kriging to estimate spatial distributions of abundance for different year-classes. Under this approach, it is assumed that abundance data are a realization of a random spatial function and a model of spatial variation of the random variable is estimated (semi-variogram function) (Isaaks and Srivastava, 1989). The definition of the semi-variogram requires that the intrinsic hypothesis is satisfied i.e. mean and variance of the differences between pairs of measurements a vector h apart, exist and are invariant within the study area. All authors except Sanchez & Gil (2000), use data from MEDITS International surveys and warn on some problems encountered in the application of the method due to the sampling scheme (few samples in some regions). In general, whenever data are sparse and/or large average distances exist between observations, the semi-variogram may result un-interpretable and the process may appear spatially uncorrelated (Goovaerts, 1997).

More sophisticated methods have been described by Corsi *et al.* (1998) which use an approach known as universal kriging with external drift and Lembo *et al.*(1998, 1998a) which apply co-kriging. Both methods are variants of basic kriging algorithms which account for secondary information when estimating the variable of interest; it is the depth in the mentioned studies. Gotway (1996) gave a good discussion about the conceptual difference between the two approaches: while a in the co-kriging model the secondary information is itself a random variable which is supposed cross-correlated with the primary data, in the kriging with external drift, it is considered as an indicator of a trend in the primary variable. In this sense the choice between the two models requires a biological knowledge of the process. As well as the previous works, Corsi *et al.* (1998) describe some problems linked to low sampling densities in some regions.

An extensive discussion about the several variants of kriging models and their performance comparison to the ordinary kriging estimator is found in Goovaerts (1997) who says that, “The estimation generally improves when additional and usually denser information is taken into consideration, particularly when the primary data are sparse or poorly correlated in space”. However, regarding the two approaches described above, some major issues are linked to the kriging with external drift: the difficulty in estimating the drift model and the constraint of knowing the auxiliary variable in an exhaustive manner; when this is not the case the secondary variable has to be interpolated first. In the work of Corsi *et al.* (1998), in fact, a major part is played by the development of a high level cartography of the study area which has allowed to obtain a Digital Terrain Model (DTM). Of course it is difficult that the same conditions are fulfilled on a Mediterranean scale.

On the contrary, in the co-kriging method, the secondary information may be non-exhaustively sampled and known at least in the sampling sites; the algorithm is however more demanding since two semi-variograms and a cross-variogram have to be estimated.

None of the mentioned studies attempts a performance comparison among the different kriging methods, neither they test other interpolation techniques. Since no interpolation method is universally superior and since assumptions required for valid application of geo-statistical methods may be easily violated, it would be useful to carry out a study aimed at investigating this issue in the framework of MEDITS data.

Regardless the approach used to obtain the spatial distribution of abundance, another problem is the identification of the threshold value in abundance that allows to distinguish a nursery from other areas. A method based on objective criteria is described by Corsi and Ardizzone (1997). The idea behind the method is to compare the frequency distribution of the observed abundance data sorted in decreasing order with the computed distribution corresponding to an uniform use of space (equal number of fishes in each sampling site). The point where the curves intersect corresponds to the threshold value which distinguishes a selective use of space from a uniform one. A modified version of the Kolmogorov-Smirnov test is used to test the difference between the two distributions.

4.1.2 The choice of the target species

Initially, all the target species (36 species) were considered in the analysis to check their relative importance in the different areas. Successively, only those species well sampled during the whole examined period (1994-1999) and characterised by high frequency of occurrence, good level of abundance, well known biological frame, and economic importance were chosen for the deeper analysis and mapping procedures.

In general, identifying recruits on a length basis should not present particular difficulties if the juveniles of a given year are fully recruited to the bottom before the start of the MEDITS survey. Conversely, some problems could arise if the juveniles are fully recruited to the bottom after the end of the MEDITS survey at a given year, appearing as older individuals in the following year survey samples. This is the case of those species, such as *Mullus barbatus* (Tserpes *et al.*, in press), in which the recruitment period (summer-autumn) is not compatible with the period in which the trawl surveys was carried out. Furthermore, the species with age at recruitment older than 1 year, such as *Aristeus antennatus* (Orsi Relini *et al.*,1998; Anon., 2001a) and *Nephrops norvegicus* (Mytilineou *et al.*, 1998), must also be excluded from the analysis.

After the preliminary analysis, which the results achieved in the UE funded SAMED program (Anon., 2001b) were also considered in, four target species, amongst those included in the MEDITS list, were chosen for further investigation: Hake (*Merluccius merluccius*), Greater Forkbeard (*Phycis blennoides*), Deep-water Pink Shrimp (*Parapenaeus longirostris*) and Broadtail shortfin squid(*Illex coindetii*).

4.1.3 The known biological frame on recruitment, juveniles dynamics and nurseries for selected species in the Mediterranean

Commonly studies on recruitment start by analysing the information on the reproductive patterns of the examined population. In general there is a gap of knowledge in processes relating the spawning to the recruitment (dispersion, growth and mortality during the larval and early post-larval phases) for most of the Mediterranean demersal species. However, the use of a fine mesh size cod-end in the Mediterranean trawling permitted to understand some aspects of the recruitment dynamics from the settlement onward for some species and some areas of the Mediterranean,

A selection of the main available biological information relevant to the recruitment process of the target species is reported below.

4.1.3.1 Hake

Hake *(Merluccius merluccius L., 1758)* is a necto-benthic species inhabits a wide depth range, from 20 to 1000 m. The smallest specimens are caught mainly on the outer shelf – upper slope (50-300 m), while the largest ones along the slope (>200m) (Colloca, 1999).

Recently Orsi Relini *et al.*, (in press) put the accent on the Mediterranean Hake taxonomic position. The Authors pointed out an amount of information, coming from general biology, meristics, population parameters and genetics, strongly suggesting to separate the Mediterranean Hake (*Merluccius merluccius smiridus* Rafinesque, 1810) (Cohen *et al.*, 1990) from the Atlantic one. The Authors also reported many evidences of differences between the Western and Eastern Mediterranean populations, those of the central sector being disomogenous with the Adriatic population very close to the North-western one. With respect to the recruitment pattern, Orsi Relini et al (in press) reported that the smallest hake of the 0 group, whit modal length ranging between 6 and 9 cm TL, were consistently sampled throughout the MEDITS trawl surveys on the shelf of the Western Mediterranean, whereas these small fish rarely appeared in the Eastern samples.

Considering the reproductive period, it is well known that *M. merluccius* spawns in the Mediterranean through a long period in the year. Bouhlal (1973) observed three spawning peaks off Tunisia in summer, winter and spring. Off the Balearic Islands the spawning period is from November to May (Bruno *et al.*, 1979). In the Tyrrhenian Sea two main peaks were found, in February-March and September (Biagi *et al.*,1995). Along the Catalan coast and in the Gulf of Lions the spawning season runs throughout all the year, with a peak in autumn (Recasens *et al.*, 1998). In the Eastern Mediterranean a variety of results resumed by Papaconstantinou and Stergiou (1995) showed that, in general, the spawning period is long, frequently all the year, with autumn-winter and spring peaks.

Although few data are available, spawning should occur in the outer shelf-upper slope. Eggs were found between 50 and 200 m depth in the Adriatic (Karlovac, 1956), like in the Atlantic where eggs and larvae are at 50-150 m depth (Coombs and Mitchell, 1982).

According to Orsi Relini *et al.* (1989), the distance between the spawning areas and nurseries, covered by the larval dispersion due to the current, may be important. Similar patterns were well known for other species belonging to the genus *Merluccius*, such as *M. productus* (Bailey, 1981, Babcock Hollowed and Bailey, 1989).

Settlement is a long process that, likewise reproduction, could present more than one peak. Zupanovic (1968) identified two peaks of recruitment, in spring and in autumn probably linked to summer and winter spawning peaks. Two main peaks were observed in the Ligurian Sea, in spring and autumn (Orsi Relini *et al.*, 1986; Orsi Relini, *et al.*, 1989). Although the smallest recruits (5 cm tl) settled at around 100 m depth throughout the year, data from the Ligurian Sea suggest that the settlement of very small hakes occurred at around 50 m depth in winter when the sea water is well mixed and the inshore transport current high (Orsi Relini *et al.*, 1989).

From the first settlement zone, the young fish spread over a wider area, forming the nurseries “stricto sensu”. That expansion occurs towards both shallow and deep waters in winter and only toward deeper bottoms in summer-autumn (Orsi Relini *et al.*, 1988). The depth range including the nurseries varies between 50 and 250 m, although age 0 fish could be found at lower depth (Eastern Ligurian Sea between 300 and 400 m) in certain areas and years.

In the Central Aegean Sea the recruitment of hake occurs from March but especially in June (Papaconstantinou and Stergiou, 1995). The young-of-the-year (age 0) are mainly abundant in the trawl catches in summer, September-November and early winter. In general, it has been found that the abundance of the 0-age group hake abruptly declines between September and early November in areas considered to be nursery grounds, as compared with areas where mature hake predominate. In these last areas, the decline of abundance is less evident (Papaconstantinou, 2000).

In the Greek waters, the *M. merluccius* recruits appear mainly at depths ranging from 100 to 230 m (Saronikos Gulf, Patraikos Gulf, Trikeri Channel), although in some areas recruitment takes place at depths down to 300 m (Ionian Sea and Korinthiakos Gulf, Kassandras Gulf, Aegean Sea) (Papaconstantinou, 2000).

In the Catalan Sea and Gulf of Lions, one fixed recruitment peak in spring is referred. Nevertheless, on occasion it may last during the summer and even in autumn (Recasens *et al.*, 1998).

It is generally believed that, after settlement, young hake grow without significant decrease in growth rate till about 2 years.

According to Fiorentino *et al.* (2000), the most reliable results on juveniles growth of hake in the Mediterranean were obtained with the Modal Progression Analysis approach. In the Ligurian Sea, a growth rate of 1.0 (0.9 – 1.1) cm per month for the spring cohort and 0.8 (0.7 – 0-9) cm per month for the autumn cohort was estimated in the period 1982-‘83 (Orsi Relini *et al.*, 1989). These growth rates were confirmed in later studies based on the spring cohorts of 1987 and 1988, with values ranging from 1.1 (0.8 – 1.4) to 1.2 (0.8 – 1.5) cm per month (Orsi Relini *et al.*, 1992). Similar results were found by Recasens (1992), with a mean growth of 1.1 cm per month in the Catalan Sea, and by Morales-Nin and Aldebert (1997) in the Gulf of Lions, with a mean growth of 1.15 cm per month. On the base of those growth rates, the mean length at age 1 in the Western Mediterranean should range between 9.6 and 14.4 cm, with a median value of 13.2 cm (Fiorentino *et al.*, 2000).

This estimate could also be reliable for the Eastern Mediterranean, since Papaconstantinou *et al.* (1992) found growth rates of 0.9-1 cm per month for the juveniles of Hake in the Aegean Sea, corresponding to about 12 cm TL at 1 year old.

Assuming that length of fish belonging to a given cohort are distributed according to a “gaussian” distribution (i.e. mean ± 1 standard deviation includes 66% of the frequencies), the use of the constant cut-off size at 12 cm tl to separate age 0 fish from the older hake (Ardizzone and Corsi, 1997; Ardizzone *et al.*, 1999; Bertrand *et al.*, 2000a; Lembo *et al.*, 1989; Lembo *et al.*, 2000) might underestimate severely the strength of the recruitment.

Considering the identification of nurseries, although mature individuals have been found throughout the Hellenic Seas, the nursery grounds are probably restricted to specific areas. In these areas the numerical percentage of the young-of-the-year is very high (e.g. Patraikos and Saronikos Gulfs: 76% and 86.5%) as compared with other areas (e.g. Ionian Sea: 7%; Korinthiakos Gulg: 3.5%). In the nursery grounds the abundance of hake of 130-160 mm TL sharply declines between late autumn and early winter (Papaconstantinou, 2000).

Ardizzone and Corsi (1997) and Ardizzone *et al.* 1999) have mapped the nurseries of Hake along the Italian coasts, on the basis of the GRUND Italian programs (1985-1987) and (1995-1996) (Relini, 2000). The main nurseries for the western basin were identified around the Tuscany Archipelagos, both on the basis of spring and autumn trawl surveys, whereas in the eastern basin the most remarkable nurseries were placed in the Pomo Pit and off the Gargano Promontory.

Lembo *et al.* (2000) investigated the nurseries areas, in terms of presence of individuals smaller than 12 cm TL, in the Italian Seas and in the eastern side of the Adriatic on the basis of 1995 and 1996 MEDITS data. The displacement of the nurseries occurred along the Tuscany coasts, on the north and on the south side of the Elba Island, and in the Central Tyrrhenian Sea, in the zone delimited by the Circeo Promontory and the Ischia Island). In these areas the most of the recruits was found between 100 and 200 m. Another important nursery area was off the Gargano Promontory, beyond the depth of 200 m. Less important areas were found nearby the Pomo Pit (Adriatic), as well in the Southern Adriatic Sea, in the southernmost part of the Ionian Sea (Gulf of Noto) and in the South-eastern side of the Sicily Strait. Two further nuclei of high probability to find nurseries were also localised on the West and Southwest side of the Sardinia.

4.1.3.2 Greater fork beard

Greater fork beard (*Phycis blennoides* (Brűnnich, 1768)) lives on sandy and muddy bottoms, mainly between 100 and 450m, even if large specimens are frequently found up to 1000-1200m, while the smallest specimens prefer the shallowest waters of the distribution range (Belcari and Biagi, 1999).

Taxonomic distinction between the Mediterranean and the Atlantic populations of *P. blennoides* are not sufficiently studied although, likewise the hake, existence of two different taxa could be expected.

The identification of the *P. blennoides* spawning period is still uncertain, given the low number of sexually mature females found (Belcari and Biagi, 1999). In the Catalan Sea, mature specimens were found in summer (Gallardo-Cabello and Gual-Frau, 1984) and December (Massuttì *et al.*, 1996). The development of male gonado-somatic indices in the Ligurian Sea suggests that spawning occurs from July to October with a maximum intensity in August and September (Fanciulli and Relini Orsi, 1979). On the basis of two mature females gathered during November and January, Tursi *et al.* (1995) proposed that the reproduction in the Ionian Sea occurs in autumn and early winter.

The Mediterranean populations of *Phycis blennoides* are characterized by a discrete recruitment in spring (Bilio, 1969; D'Onghia *et al.*, 1989; Biagi and Farnocchia, 1994; Massutì *et al.*, 1996). The recruitment period is consistent with the scanty data on reproduction. No presence of more than one pulse in recruitment is known for *P. blennoides* in the Mediterranean.

Concerning the length structure of the Mediterranean populations (Campillo, 1992; Belcari and Biagi, 1999), the spring recruits are clearly distinguished from the components of the parental stock.

According to Ragonese *et al.* (in press) recruit growth rates obtained in different areas of the Mediterranean from modal progression analysis show a high consistency. Young recruits collected by Bilio (1969) in the Eastern Ligurian Sea grew from 8.5 in April 1967 to 19.2 cm TL in December 1968, showing a mean growth rate of 1.07 cm per month. A very similar grow rate (1.12 cm per month) was found in the cohort recruited in April 1977 with 6 cm of modal standard length (SL), which showed a mode of 15 cm SL in December 1977 (Fanciulli and Relini Orsi,1980). An average rate of 1.2 cm per month was computed with data presented in D'Onghia *et al.* (1989) for the Ionian Sea, who reported a mode at 9 cm in April/May for the cohorts recruited in spring 1985, 1986 and 1987, and 15 cm TL in September/October. In the North Tyrrhenian Sea, Biagi and Farnocchia (1994) found a mean growth rate of about 1 cm per month in the cohorts recruited in April 1991 and April 1992. Off the Catalan coast, Massutì *et al.* (1996) found a mean rate of 0.99 cm per month in the cohort recruited in April 1991, with a mean of 7.3 cm TL, and reaching a mean of 15.2 cm TL in December 1991. Ragonese *et al.* (in press) reported a mean growth rate between 1.03 and 0.93 cm per month in the Strait of Sicily and the Southern Tyrrhenian Sea respectively. On the basis of above growth rates, the mean length of *P. blennoides* at age 1 in the Western Mediterranean should range between 11.2 and 14.4 cm, with a median value of 12.0 cm (Ragonese *et al.*, in press).

Likewise *M. merluccius*, the use of the constant cut-off size at 12 cm tl to discriminate the age 0 group in LFD of the Greater Fork Beard (Ardizzone and Corsi, 1997; Ardizzone *et al.*, 1999; Bertrand *et al.*, 2000) could underestimate severely the strength of the recruitment.

The only attempt to map the Greater fork beard nurseries is due to Ardizzone *et al.* (1997, 1999). The Authors have mapped the nurseries of along the Italian coasts, on the basis of the GRUND Italian programs (1985-1987) and (1995-1996) (Relini, 2000). By using spring trawl surveys data, the main nurseries in the western basin were identified in the Ligurian Sea, and in many and wide areas of the Central and Southern Tyrrhenian. Conversely the autumn surveys permit to identify nurseries between the Elba and the Giglio Island (North Tyrrhenian Sea). The most remarkable nurseries in the eastern basin were placed off the Gargano Promontory.

4.1.3.3 Deep sea Pink shrimp

Deep sea Pink shrimp (*Parapenaeus longirostris,* Lucas, 1846) lives between 20 and 700m depth, but it is common on sand-muddy bottoms between 100 and 400m. The depth distribution is related to size, being the smallest specimens caught mainly on the outer shelf (50-200 m), while the largest ones along the slope (>200m) (Tursi *et al.*, 1999).

A similar pattern, probably due to the migration of Juveniles from the continental shelf to slope (e.g. Held, 1938) is common in many species of the family Penaeidae and has been observed also in the central – southern Tyrrhenian Sea for *Parapenaeus longirostris* (Ardizzone *et al.*, 1990; Spedicato *et al.*, 1996). In this basin the adult fraction of the population mainly lives between 150 and 350 m, while juveniles are mostly observed between 100 and 180 m (Ardizzone *et al.*, 1990). Furthermore Spedicato *et al.*(1996), analysing data from different seasons and years, reported an average carapace length increasing significantly with depth. Comparable results are also mentioned by D'Onghia *et al.*(1998) for the Ionian Sea. The same relation between size and depth was found for this species in the Greek seas (Anon., 1998b; Politou *et al.*, 1998)

According to Levi *et al.* (1995) mature females occurred throughout the year in the Strait of Sicily. In the Central-southern Tyrrhenian the occurrence of mature females was observed in Spring, Summer and Autumn, with a higher relative frequency in Spring-Summer. Even though a continuous recruitment pattern was evidenced, a main pulse was observed in Autumn (Spedicato *et al.*, 1996).

The maximum mean length at 12 months was estimated as 24 mm CL for the Deep Water Pink Shrimp on the basis of Ardizzone *et al.* (1990), Levi *et al.* (1990), D'Onghia *et al.* (1998), Carbonara *et al.* (1998) and Anon. (1998b). Analogously to hake and greater fork beard, the threshold used in previous studies for *P. longirostris* (Ardizzone and Corsi, 1997; Lembo *et al.*, 2000; Bertrand *et al.*, 2000) to identify recruits still belonging to the first age group (age 0), i.e. all the individuals smaller than 20 mm CL, should underestimate the strength of recruitment.

Using the above mentioned length based criterion, Ardizzone *et al.* (1997, 1999) have mapped the nurseries of the Deep Water Pink Shrimp along the Italian coasts, on the basis of the data collected during the GRUND Italian programs (1985-1987) and (1995-1996) (Relini, 2000), finding a very scattered distribution.

Lembo *et al.* (2000) mapped the nurseries of *P. longirostris* in the central-southern Tyrrhenian sea using a geo-statistical approaches Studying the nursery areas, the conditional probability of exceeding a given threshold value of the variable was estimated by un-linear geo-statistics, namely the so-called disjunctive kriging technique. Two threshold values were adopted (2000 and 3000 individuals/km2) and four nursery areas were localised at the lower level of threshold value. When the more restrictive cut-off value (3000 individuals/km²) was used only one nursery area remained dominant.

4.1.3.4 Broadtail Shortfin Squid

Broadtail Shortfin Squid (*Illex coindetii* (Verany, 1839)) inhabits a wide range of bottom depths from surface to 1100m, the main concentration being between 100 and 300-400 m according to the different regions of Mediterranean. It performs daily vertical movements, living close to the bottom during the day and moving into the water column at night. In some areas the species performs also seasonal migrations, from the shallower waters in summer to the deeper ones in winter (Belcari, 1999).

Mature specimens, as well as maturing and immature specimens are found throughout the year. *I coindetii* is considered an intermittent spawner; females spawn several times during the spawning period with activity peaks. This features origin a continuous recruitment pattern, although not uniform (presence of more micro-cohorts) (Jereb & Ragonese, 1985; Papaconstantinou *et al.*, 1993; Papaconstantinou *et al.*, 1994).

The species is characterised by a fast growth rate. The estimated monthly absolute rate varied highly among the cohorts. Malgold–Wirz (1963) reported 1-1.7 cm for Banyuls sur Mer, Sanchez (1984) gave a rate between 1.0 and 1.3 for the Catalan Sea, and Jereb and Ragonese (1995) found a growth rate ranging from 1.0 to 1.4 cm mantle dorsal length in the Strait of Sicily.

All available literature assign a lifespan between 12 and 18 months, with a very high mortality after the spawning (Belcari, 1999).

On the basis of MEDITS data from the Strait of Sicily, adults and juveniles shared the same depth range, even though a major concentration of juveniles was detected on the shelf (< 200m) (Jereb *et al.*, 2001). Although a wide spread presence of the species was detected all over the area, the highest concentration was found in the central zone where in the spring 2000. The Authors outlined that the numerical abundance observed was remarkably different when considering the two years separately, that of 2000 spring being up to ten times that recorded in spring 1999. This difference was almost entirely due to an very high recruitment pulse (i.e. juveniles concentration), more evident in the central zone.

The high variability in growth rates and the peculiar short life span of this species make very difficult the interpretation of length frequency distribution based on yearly samplings (Arkhpikhin *et al.*, 2000).

4.2 Material and Methods

4.2.1 The data

The analyses were based on a series of six surveys carried out once a year since 1994 to 1999 in the frame of the MEDITS programme (Bertrand *et al.* 2000b). Thanks to a strong co-operation of teams from different countries, these surveys covered all the northern Mediterranean Sea, from Gibraltar to the Aegean Sea (fig. 1). To limit the overall duration of the whole surveys, they have been conducted aboard 8 to 11 vessels (depending on the year) working as much as possible during the same period.

Nevertheless, some discrepancies might occur between the sub-areas and years due to external constraints (technical, weather, etc.). Finally, the overall sampling period of the series lasted mainly during the late spring - early summer, with exceptional extensions from April to October.

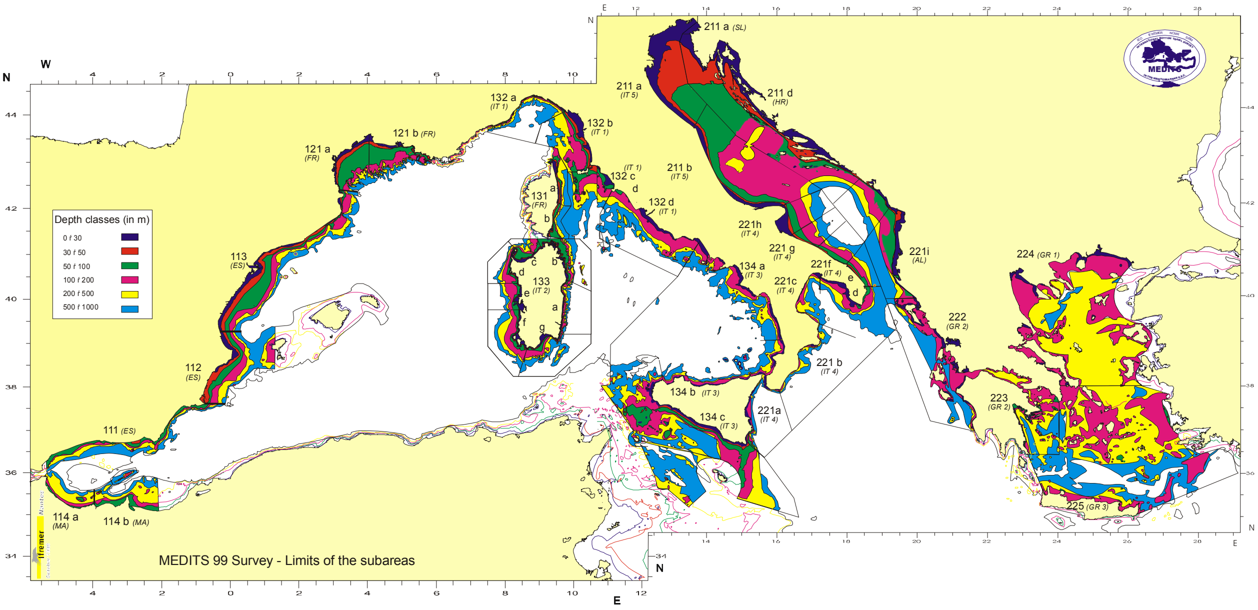


Fig. 1. Limits of the MEDITS areas.

During each survey, about one thousand hauls were performed using the same standardized sampling protocols (Anon. 1998). The sampling gear was a bottom trawl with stretched mesh size of 20 mm in the codend. The surveys covered all the trawlable areas from 10 to 800 meters depth. The duration of the hauls was 30 minutes over the shelves (up to 200 m), and one hour along the upper slopes.

The calculation of “the most accurate” density indices of recruits and juveniles was performed adopting procedures taking into account the likely variability of the recruitment pattern among areas and years. So, the proposed procedure allowed an estimation of the density of recruit usable for direct comparison of the recruitment strength among years and areas. This was possible as the length structure analysis let to identify a length cut-off by year and area, permitting to separate haul by haul fish belonging to the age 0 group. This gave a powerful tool to study nurseries, and more widely for investigation relating to the space-time dynamics of recruitment in the Mediterranean.

Commonly fishery biologists analyse recruitment using data derived from assessment units, assumed inhabited by discrete stocks, even if the populations may occur across or within these assessment units. So, most of the obtained estimates may be considered only as proxies for actual population and recruitment level. However, due to the lack of knowledge on stock units for most of the demersal resources in the Mediterranean, and taking into account the general recommendation to improve the consistency between the different spatialized approaches in the Mediterranean, the 38 MEDITS sub-regions (fig. 1) were grouped in the same larger and quite homogenous areas as for the ongoing SAMED project (Anon., 2001), and following a suggestion from the GFCM (tab. 1) (see also Garibaldi and Caddy, 1998). The identification of the length characteristics of the recruit was performed at the level of these areas, called Management Units (MU).

Tab. 1 – Geographical delimitation of the SAMED Management Units (MU) and the corresponding MEDITS sub-regions.

Geographical definition	SAMED Code	MEDITS Code
Waters off the Spanish continental coast C. de Gata - C. Creus	1.1.b	112;113
Alboran Sea Gibilterra - C. de Gata	1.1.d	111
Gulf of Lions C. Creus - Cassidaigne	1.2.e	121a,b
Waters surrounding Corsica	1.3.g	131a,b
Waters surrounding Sardinia	1.3.h	133a,b,c,d,e,f,g
Waters off Northern Sicily Capo Suvero - San Vito lo Capo	1.3.i	134b
Waters off the Italian continental coast, down to Strait of Messina Ventimiglia - Capo Suvero	1.3.j	132a,b,c,d;134a
Northern and Central Adriatic Sea	2.1.a	211,a,b,c,d
Southern Adriatic Sea, down to the Strait of Otranto Vieste - Capo d'Otranto	2.2.b	221e,f,g,h,i
Ionian Sea - Waters off the southeast Italian continental coast Roccella Ionica - Capo d'Otranto	2.2.c	221b
Ionian Sea - Waters off the western Greek continental coast	2.2.d	222
Waters off southern and eastern Sicily and Malta San Vito lo Capo - Roccella Ionica	2.2.e	134c, 221a
Aegean Sea	3.1.a	223,224
Waters surrounding Crete	3.1.b	225

To calculate the recruit density indices (R/ km^2) per sampling station, the following “length-based” criterion was adopted for splitting the recruits in species characterised by a medium or long life span, such as Hake, Greater Fork-beard, and Deep-water Pink Shrimp.

With regard to the Broadtail short-fin squid, due to the difficulties in splitting the LFD and assigning a putative age to the isolated groups, no recruit indices were calculated.

The following procedure was adopted:

The number of recruits per km^2 for Hake, Greater Fork-beard and Deep Water Pink Shrimp was calculated according to the three step based procedure (Levi *et al.*, 2000):

- preparing the “pooled strata” mean (LFD), standardised by 10 km^2 using the SAMED package (Lembo *et al.*, 2001), for each area and survey;
- analysing the “pooled strata” LFD in order to estimate the mean length ($\bar{l}$), the corresponding standard deviation (*sd*) and number of individuals of the 1st component from the poly-modal LFD using the Bhattacharya method as implemented in the MPA routine in the FiSAT package (Gayanilo *et al.*,1996).
- calculating the abundance in number per km^2 (Density Index = DI) of the recruits haul by haul as all specimens whose length was below the $\bar{l}$ + 1 *sd*. These values form the input for the spatial analysis.

The isolation of the 1st component for Hake and Greater Fork-beard in mean LFD per surface unit was done on data grouped in 1 cm length classes, after a three order smoothing, to reduce irregularity in the length structures. The Deep Water Pink Shrimp data were grouped in 2 mm length classes and processed without smoothing. The maximum mean length at 12 months, i.e. the end of the 1st year of life, for the three species derived from literature was used as the threshold for assigning a putative age to the normal components. On the basis of recent reviews a mean length of 14.4 cm TL was chosen for both the gadoids (Fiorentino *et al.*, 2000; Ragonese *et al.*, in press). The maximum mean length at 12 months was estimated as 24 mm CL for the Deep Water Pink Shrimp on the basis of Ardizzone *et al.* (1990), Levi *et al.* (1990), D'Onghia *et al.* (1998) and Carbonara *et al.*, (1998).

The presence of more than one micro-cohort, corresponding to more than one pulse of recruitment for the investigated species, area and year, was marked by an “asterisk” (*) in tables 2-4.

The number of individuals of the 1st component derived from Bhattacharya analysis were used directly to figure the mean Recruit Density Index per surface unit (RDI). When more than one micro-cohort was detected, the RDI was adjusted by summing the mean number per surface unit of the identified micro-cohorts.

When the mean LFD per surface unit did not allow a satisfactory splitting (for instance recruit scanty represented in some MU and years, remarked in grey in the table 2-4), a mean cut-off, weighed by number of recruits (the yellow cells in table 2-4), was calculated to estimate, in any case, the recruit indices.

The juveniles were identified as those specimens with gonads classified as “immature”, i.e. belonging to stage 0 and 1, during the MEDITS trawl surveys.

The geo-referenced abundance indices of recruits (R/km^2) and juveniles (J/km^2) by haul, represented the input data for identifying the nurseries of the target species.

4.2.2 Mapping of the nurseries in the whole MEDITS area

First of all an haul by haul exploratory mapping gave distribution pictures of the nursery areas for each of the surveys from 1994 to 1999 and for each of the four target species (*Merluccius merluccius, Phycis blennoides, Parapenaeus longirostris* and *Illex coindetii*).

For the exploratory mapping the representation through the bubble maps, with the density indices of the recruits and the juveniles reported as class of abundance, was chosen to figure out an objective representation of the distribution of the youngest age groups all over the MEDITS area year by year, showing both space and time variability of recruitment,

The density indices, in terms of number of recruits or juveniles per km^2, gives a picture of the areas with the highest densities of young individuals at the global MEDITS scale. They illustrate the level of variability of their presence between places, years and species.

4.2.3 The identification of the main nursery in some selected areas.

On the basis of the bubble maps and of abundance of the age 0 groups, resulted from the estimate of the first modal components in the mean LFD per surface unit, the Management Units, where the recruits and juveniles were consistently (throughout the investigated period) and diffusely present, were individuated. These areas were investigated more in depth for the nursery identification.

For a more effective recognition of the discrete nursery areas in the selected MUs, it was decided to combine the density index of recruits with a standardised index of “recruitment exclusively richness- RER”, calculated as the ratio between the number of recruits to that of the total catches for the species per km^2. This latter index contributes to the identification of areas exclusively occupied by the 0 group and to the exclusion of areas with the elders for each species.

Integrating information given from the densities of recruits together with their exclusive presence in space through a GIS approach allows identifying the most relevant nurseries in the examined Management Units according to some useful criteria.

The density index for the positive hauls by year were ranked in 4 quantiles, considering each year separately to take into account of the inter-annual variability. Hauls were ranked too according to the RER index. Two GIS layers were prepared and one map per year was produced to show those hauls considered as ”indicators” of the presence of the main nurseries.

Two main co-occurred qualities were chosen to characterise the hauls belonging to a nursery area inside a Management Unit (“nursery marker hauls”): density index belonging to the 4th quantile throughout time and the RER index equal or higher than 80%.

The areas in which the “nursery marker hauls” were consistently present along time were identified as main nurseries inside a given Management Unit.

4.3 Results

4.3.1 Recruit identification and quantification

The mean length and standard deviation, as well as the corresponding cut-off have been calculated for the first age group of *M. merluccius, P. blennoides* and P. longirostris respectively (tab. 2, 3 and 4). The cut-off was calculated only if the first component could be assigned to age 0. A special mention was given when more than one mode occurred in the first age group for the investigated species, area and year.

Table 2. The main results of the 1^{st} component, in terms of the estimated recruits, their mean length and standard deviation, and the corresponding cut-off for Hake

Geographical definition	**SAMED Code**	**MEDITS Code**			
Spanish continental coast	**1.1.b**	**112;113**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	***4.3.1.1 Remarks***
1994	17908	9,76	2,06	11,82	
1995	1604	10,76	1,54	12,30	*(4626 at 7,24cm)
1996	12367	9,73	1,85	11,58	
1997	21481	9,57	1,6	11,17	
1998	27030	10,76	2,17	12,93	
1999	21950	9,27	1,97	11,24	
mean	17057	9,98	1,87	**11,83**	
Alboran Sea	**1.1.d**	**111**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	1990	9,01	1,62	10,63	
1995	481	9,74	1,87	11,61	*
1996	3219	10,17	1,86	12,03	
1997	8069	9,3	1,65	10,95	
1998	1054	9,8	1,6	11,40	
1999	7904	11,8	2,54	14,34	flat LFD
mean	3786	9,97	1,86	**12,29**	
Gulf of Lions	**1.2.e**	**121a,b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	18256	8,67	1,56	10,23	
1995	23608	10,11	1,71	11,82	
1996	21483	8,39	1,4	9,79	
1997	8685	8,63	1,43	10,06	
1998	51929	11,66	2,64	14,30	
1999	9991	8,18	1,61	9,79	*(4382 at 12,19cm)
mean	22325	9,27	1,73	**11,97**	
Waters surrounding Corsica	**1.3.g**	**131a,b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	1380	14,96	1,24		4.3.1.1.1.1 Older than 1 year
1995	37	10,5	0,97	11,47	
1996	34	9,84	1,84	11,68	
1997	114	9,8	1,18	10,98	
1998	29	9,86	1,26	11,12	
1999	38	11,5	1,39	12,89	
mean	50	10,30	1,31	**11,45**	
Waters surrounding Sardinia	**1.3.h**	**133a,b,c,d,e,f,g**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	14303	11,9	1,84	13,74	
1995	2747	11,74	1,67	13,41	
1996	16074	12,67	2,15	14,82	
1997	1373	7,74	1,71	9,45	
1998	11691	11,58	2,01	13,59	
1999	11491	10,08	1,6	11,68	*(16278 at 13,98cm)
mean	9613	10,95	1,83	**13,48**	

Waters off Northern Sicily	**1.3.i**	**134b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	4003	9,21	1,44	10,65	
1995	14167	10,91	1,27	12,18	*(135 at 6,27cm)
1996	3417	11,37	1,57	12,94	*(1135 at 8,16cm)
1997	6298	10,48	1,72	12,20	
1998	4852	10,91	1,69	12,60	
1999	3563	12,3	2,12	14,42	*(1044 at 8,33cm)
mean	6050	10,86	1,64	**12,36**	
Ligurian and Tyrrhenian Sea	**1.3.j**	**132a,b,c,d;134a**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	8093	8,13	1,57	9,70	
1995	28285	9,05	1,64	10,69	
1996	20427	9,04	2,31	11,35	
1997	33766	10,06	2,26	12,32	
1998	54502	8,87	1,55	10,42	*(10000 at 12,28cm)
1999	32270	9,61	1,64	11,25	
mean	29557	9,13	1,83	**11,05**	
Northern and Central Adriatic Sea	**2.1.a**	**211,a,b,c,d**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	827	9,32	1,43	10,75	
1995	3019	8,74	2,86	11,60	
1996	4904	9,52	1,84	11,36	
1997	3842	10,56	1,92	12,48	
1998	3694	10,7	2,04	12,74	
1999	3941	13,64	2,15	15,79	
mean	3371	10,41	2,04	**12,70**	
Southern Adriatic Sea	**2.2.b**	**221e,f,g,h,i**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	899	10,21	2,06	12,27	
1995	3745	9,71	1,55	11,26	
1996	4567	9,91	2,06	11,97	
1997	2637	11,6	2,4	14,00	
1998	1759	9,63	1,54	11,17	
1999	1813	12,33	2,21	14,54	
mean	2570	10,57	1,97	**12,37**	
Ionian Sea - Italian coast	**2.2.c**	**221b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	168	9,03	1,46	10,49	
1995	274	8,12	1,4	9,52	
1996	1462	9,91	2,06	11,97	
1997	510	13,8	2,05	15,85	
1998	889	12,28	1,65	13,93	*(80 at 8,84cm)
1999	4145	8,97	1,78	10,75	
mean	1241	10,35	1,73	**11,67**	

Ionian Sea - Greek coast	**2.2.d**	**222**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	1153	10,85	1,57	12,42	
1995	4137	8,83	1,35	10,18	
1996	17936	12,94	2,34	15,28	
1997	6001	11,06	2,07	13,13	
1998	2709	12,46	2,35	14,81	
1999	2629	10,68	1,62	12,3	
mean	5761	11,14	1,88	**13,94**	
Strait of Sicily	**2.2.e**	**134c, 221a**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	6739	11,06	1,45	12,51	
1995	3988	12,22	1,76	13,98	*(389 at 8,33cm)
1996	3734	9,05	1,6	10,65	*(1311 at 12,43cm)
1997	6115	11,64	1,8	13,44	*(445 at 7,32cm)
1998	4616	10,68	1,83	12,51	
1999	4582	11,33	2,62	13,95	
mean	4962	11,00	1,84	**12,89**	
Aegean Sea	**3.1.a**	**223,224**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	274	10,74	2,87	13,61	
1995	651	9,08	1,72	10,8	
1996	2233	9,08	1,71	10,79	*(719 at 12,71cm)
1997	2044	10,8	2,14	12,94	
1998	932	12,93	1,97	14,9	
1999	3707	13,09	2,72	15,81	
mean	1640	10,95	2,19	**13,60**	
Waters surrounding Crete	**3.1.b**	**225**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	271	9,31	1,09	10,4	
1995	317	11,67	1	12,67	
1996	1532	10,73	1,1	11,83	
1997	3041	12,14	1,51	13,65	
1998	2429	9,54	1,3	10,84	*(1776 at 12,98cm)
1999	1854	10,76	2,45	13,21	
mean	1574	10,69	1,41	**12,42**	

Table 3. The main results of the 1st component in mean LFD per unit surface, in terms of the estimated recruits, their mean length and standard deviation, and the corresponding cut-off for Greater Fork-beard.

Geographical definition	**SAMED Code**	**MEDITS Code**			
Spanish continental coast	**1.1.b**	**112;113**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	4787	12,31	1,74	14,05	
1995	2614	8,95	1,96	10,91	
1996	4442	8,84	1,63	10,47	
1997	5192	9,95	1,76	11,71	
1998	8221	9,15	2,12	11,27	
1999	6846	10	1,65	11,65	
mean	5350	9,87	1,81	**11,70**	
Alboran Sea	**1.1.d**	**111**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	5662	10,81	1,68	12,49	
1995	n.e.	10,04	1,42	11,46	
1996	678	8,7	1,59	10,29	
1997	4618	10,1	1,67	11,77	
1998	4384	7,57	1,31	8,88	
1999	1584	10,01	1,67	11,68	
mean	3385	9,54	1,56	**11,19**	
Gulf of Lions	**1.2.e**	**121a,b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	612	10,15	1,52	11,67	
1995	1205	11,34	1,48	12,82	
1996	2553	10,57	1,46	12,03	
1997	1770	9,87	1,51	11,38	
1998	1347	10,68	1,61	12,29	
1999	4611	10,72	1,94	12,66	
mean	2016	10,56	1,59	**12,26**	
Waters surrounding Corsica	**1.3.g**	**131a,b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	728	8,38	1,45	9,83	
1995	1325	9,86	1,39	11,25	
1996	751	7,53	1,45	8,98	
1997	623	7,45	1,18	8,63	
1998	231	7,31	1,25	8,56	
1999	2322	8,09	1,54	9,63	
mean	997	8,10	1,38	**9,79**	
Waters surrounding Sardinia	**1.3.h**	**133a,b,c,d,e,f,g**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	2998	12,91	1,98	14,89	
1995	4765	11,34	1,53	12,87	
1996	5987	11,43	1,68	13,11	
1997	4877	11,93	1,96	13,89	
1998	4429	11,13	1,77	12,90	
1999	8718	11,07	1,89	12,96	
mean	5296	11,64	1,80	**13,29**	

Waters off Northern Sicily	**1.3.i**	**134b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	2550	11,44	1,8	13,24	
1995	2216	10,32	1,9	12,22	
1996	1537	11,58	1,48	13,06	
1997	1840	11,45	1,4	12,85	*(279 at 8,6cm)
1998	1856	10,47	1,46	11,93	
1999	5853	9,5	1,67	11,17	
mean	2642	10,79	1,62	**12,12**	
Ligurian and Tyrrhenian Sea	**1.3.j**	**132a,b,c,d;134a**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	2510	10,88	1,73	12,61	
1995	4310	10,59	1,64	12,23	
1996	2643	10,89	1,91	12,80	
1997	2092	11,16	1,88	13,04	
1998	1600	10,57	1,78	12,35	
1999	6969	10,68	1,91	12,59	
mean	3354	10,80	1,81	**12,57**	
Northern and Central Adriatic Sea	**2.1.a**	**211,a,b,c,d**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	160	9,86	1,8	11,66	
1995	967	9,09	1,47	10,56	
1996	712	11,83	1,69	13,52	*(181 at 8.26cm)
1997	715	10,81	1,97	12,78	
1998	831	11,65	2	13,65	
1999	339	14,65	1,96		**Older the 1 year**
mean	677	10,65	1,82	**12,46**	
Southern Adriatic Sea	**2.2.b**	**221e,f,g,h,i**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	253	11,54	1,62	13,16	
1995	874	10,24	1,53	11,77	*(426 at 14,18cm)
1996	1620	12,25	2,28	14,53	
1997	1485	12,19	1,94	14,13	
1998	1566	12,02	1,89	13,91	
1999	2770	13,15	1,77	14,92	
mean	1428	11,90	1,84	**14,15**	
Ionian Sea - Italian coast	**2.2.c**	**221b**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	1209	10,43	1,62	12,05	
1995	1596	9,27	1,45	10,72	*(388 at 12,58cm)
1996	1279	11,37	1,93	13,3	
1997	614	12,57	1,64	14,21	*(132 at 9,32cm)
1998	3002	9,69	1,94	11,63	
1999	6702	10,15	1,69	11,84	
mean	2400	10,58	1,71	**11,92**	

Ionian Sea - Greek coast	**2.2.d**	**222**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	475	13,23	1,7	14,93	*(28 at 9.4cm)
1996	not estimated				
1997	427	11,06	1,95	13,01	
1998	389	9,9	1,39	11,29	*(77 at 14.3 cm)
1999	552	12,19	1,58	13,77	
mean	461	11,60	1,66	**13,37**	
Strait of Sicily	**2.2.e**	**134c, 221a**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	883	12,83	1,7	14,53	
1995	1561	10,75	1,61	12,36	
1996	2554	11,75	2,06	13,81	
1997	776	11,99	1,7	13,69	
1998	2399	12,26	2,03	14,29	
1999	1943	10,31	1,83	12,14	
mean	1686	11,65	1,82	**13,43**	
Aegean Sea	**3.1.a**	**223,224**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	678	10,81	1,76	12,57	
1995	1400	10	1,6	11,6	
1996	1653	11,94	2,04	13,98	
1997	869	10,76	1,94	12,7	
1998	922	11,66	2,06	13,72	
1999	1107	10,84	1,76	12,6	
mean	1105	11,00	1,86	**12,90**	
Waters surrounding Crete	**3.1.b**	**225**			
	R per 10 km2	**mean TL (cm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	525	9,74	1,74	11,48	*(461 at 13,93cm)
1996	2044	12,11	1,72	13,83	
1997	not estimated				
1998	1163	9,66	1,38	11,04	
1999	152	11,51	1,35	12,86	*(118 at 8,14cm)
mean	971	10,76	1,55	**12,64**	

Table 4. The main results of the 1st component analysis in mean LFD per unit surface, in terms of the estimated recruits, their mean length and standard deviation, and the corresponding cut-off for Deep Water Pink Shrimp.

Geographical definition	**SAMED Code**	**MEDITS Code**			
Spanish continental coast	**1.1.b**	**112;113**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	478	13,05	2,87	15,92	
1996	not estimated				
1997	3743	23,1	2,41	25,51	*(295 at 10,00mm)
1998	351	16,37	3,51	19,88	
1999	1167	22,27	2,35	24,62	*(404 at 9,92mm and 468 at 14,37mm)
mean	1435	18,70	2,79	**24,19**	
Alboran Sea	**1.1.d**	**111**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	not estimated				
1996	944	23,11	1,57	24,68	*(121 at 11,41mm and 1289 at 18,03mm)
1997	3619	22,55	1,6	24,15	*(667 at 14,03mm and 1045 at 17,96mm)
1998	11988	19,48	2,41	21,89	*(6940 at 12,00mm)
1999	326	19,95	1,33	21,28	*(470 at 14,66mm)
mean	4219	21,27	1,73	**22,52**	
Gulf of Lions	**1.2.e**	**121a,b**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	not estimated				
1996	not estimated				
1997	not estimated				
1998	not estimated				
1999	1249	24,18	1,29	25,47	
mean					
Waters surrounding Corsica	**1.3.g**	**131a,b**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	510	23,95	3,08	27,03	
1995	not estimated				
1996	151	22,25	1,65	23,90	
1997	not estimated				
1998	658	21,46	2,64	24,10	*(284 at 14,61mm)
1999	1082	20,55	3,02	23,57	
mean	600	22,05	2,60	**24,47**	

Waters surrounding Sardinia	**1.3.h**	**133a,b,c,d,e,f,g**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	688	22,58	1,2	23,78	*(48 at 17,59mm)
1995	335	17,56	2,6	20,16	
1996	761	21,54	2,36	23,90	*(432 at 16,00mm)
1997	7707	18,77	2,13	20,90	
1998	12181	18,76	2,54	21,30	
1999	16671	23,43	3,13	26,56	*(735 at 14,38mm)
mean	6391	20,44	2,33	**23,59**	
Waters off Northern Sicily	**1.3.i**	**134b**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	823	16,92	2,39	19,31	
1995	1475	23,82	1,79	25,61	*(4445 at 15,78mm)
1996	4014	16,65	1,96	18,61	
1997	4395	24,45	2,85	27,30	*(7116 at 16,02mm)
1998	12733	20,86	3,34	24,20	
1999	12877	14,73	2,66	17,39	
mean	6053	19,57	2,50	**21,49**	
Ligurian and Tyrrhenian Sea	**1.3.j**	**132a,b,c,d;134a**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	78	14,47	1,34	15,81	
1995	610	16,17	2,63	18,80	*(181 at 10,32mm)
1996	460	15,72	3,01	18,73	*(102 at 10,79mm)
1997	722	24,47	2,82	27,29	*(2639 at 15,28mm)
1998	5344	21,17	3,8	24,97	*(491 at 12,85mm)
1999	2034	14,74	2,75	17,49	
mean	1541	17,79	2,73	**22,71**	
Northern and Central Adriatic Sea	**2.1.a**	**211,a,b,c,d**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	2350	25,05	2,67		**Older than 1 year**
1996	706	20,61	3,07	23,68	*(145 at 14,00mm)
1997	1040	13,84	2,08	15,92	
1998	216	18,98	1,74	20,72	
1999	301	17,95	2,62	20,57	*(56 at 9,87mm)
mean	923	19,29	2,44	**19,42**	
Southern Adriatic Sea	**2.2.b**	**221e,f,g,h,i**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	286	17,05	2,28	19,33	
1995	1267	28,43	3,63		**Older than 1 year**
1996	15473	21,52	3,43	24,95	*(974 at 14,05mm)
1997	4829	19,27	2,4	21,67	
1998	4114	23,26	1,73	24,99	*(614 at 12,21mm and 1227 at 17,72mm)
1999	400	17,69	2,96	20,65	
mean	4395	21,20	2,74	**24,19**	

Ionian Sea - Italian coast	**2.2.c**	**221b**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	10209	20,52	3,49	24,01	
1995	15321	22,17	2,38	24,55	*(2195 at 13,01mm)
1996	3673	12,12	1,67	13,79	
1997	12626	21,08	3,63	24,71	
1998	12665	23,69	2,47	26,16	*(2756 at 16,57mm)
1999	3133	16,46	2,68	19,14	
mean	9605	19,34	2,72	**23,86**	
Ionian Sea - Greek coast	**2.2.d**	**222**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	16186	17,48	3,19	20,67	*(1838 at 11,74mm)
1996	9671	22,82	2,86	25,68	*(1653 at 12,53mm and 35712 at 16,30mm)
1997	14385	18,26	2,97	21,23	
1998	3599	23,37	2,01	25,38	*(7180 at 15,98mm)
1999	7841	20,89	3,7	24,59	*(7226 at 13,70mm)
mean	10336	20,56	2,95	**22,69**	
Strait of Sicily	**2.2.e**	**134c, 221a**			
	R per 10 km2	**Mean CL (mm))**	**sd**	**cut-off**	**Remarks**
1994	3263	18,27	2,53	20,8	
1995	11669	20,26	2,8	23,06	*(2092at 12,19mm)
1996	13823	22,09	3,29	25,38	*(19671 at 15,08mm)
1997	6138	23,24	3,1	26,34	*(15512 at 16,68mm)
1998	39945	19,11	3,13	22,24	*(3970 at 12,71mm)
1999	38595	22	3,59	25,59	*(28802 at 14,05mm)
mean	18906	20,83	3,07	**24,03**	
Aegean Sea	**3.1.a**	**223,224**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	not estimated				
1996	19102	23,71	2,67	26,38	*(18456 at 17,69mm and 400 at 5,91mm)
1997	not estimated				
1998	not estimated				
1999	19443	22,73	2,1	24,83	*(17665 at 17,94mm and 3278 at 12,13mm)
mean	19273	23,22	2,39	**25,60**	

Waters surrounding Crete	**3.1.b**	**225**			
	R per 10 km2	**Mean CL (mm)**	**sd**	**cut-off**	**Remarks**
1994	not estimated				
1995	not estimated				
1996	38652	23,35	2,07	25,42	*(9912 at 14,01mm)
1997	6072	19,56	1,99	21,55	*(1256 at 10,50mm)
1998	25700	21,57	2,07	23,64	*(696 at 13,19mm)
1999	15531	23,11	1,25	24,36	*(32781 at 20,12mm and 9114 at 16,41mm)
mean	21489	21,90	1,85	**24,42**	

The presence of more than one micro-cohorts in the first age group was evident in some areas and years. This feature appeared more frequently in *P. longirostris*, followed by *M. merluccius* and at last *P. blennoides*. If one cohort by year and by area was expected, we should find 84 groups for each species in the whole examined period (1994-1999). Conversely 125, 97 and 93 groups, which can be considered as micro-cohorts belonging to the 0 age, were detected for *P. longirostris, M. merluccius* and *P. blennoides* respectively.

Limiting the analysis to the two gadoids, where the presence of micro-cohorts was limited, an immediate and rough picture of the relative concentration and stability of *M. merluccius* and *P. blennoides* recruits in the different areas and throughout the examined period was given by the comparison of the mean RDI (figures 2 and 3).

Density indices were adjusted for the second micro-cohort (see table 2 and 3). It is evident that, during spring and summer, the areas belonging to the western basin showed the highest densities of recruits for both the two studied gadoids.

An illustration of the variability in the cut-off length calculated for the 0 group (directly related to the mean length of the first pulse) of *M. merluccius, P. blennoides* and *P. longirostris* among the yearly surveys and areas is shown in the figures 4, 5 and 6. The observed variability could be due to various causes, such as time lag in the sampling period, different recruitment periods and/or growth rate in the juveniles.

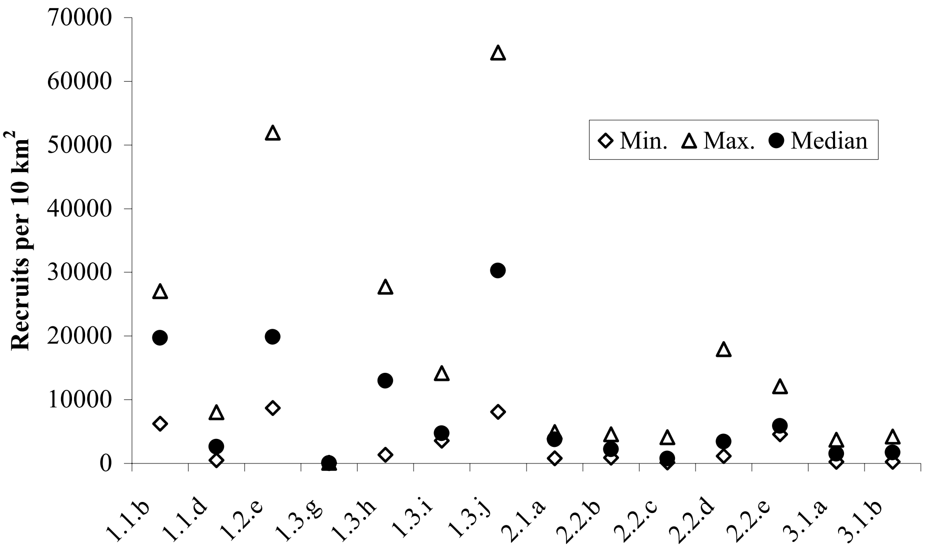


Figure 2. Variability in recruit density indices (RDI) of the age 0 group for *M. merluccius* (MEDITS surveys 1994-'99). The highest values were recorded in the Western basin (from 1.1.b to 1.3.j).

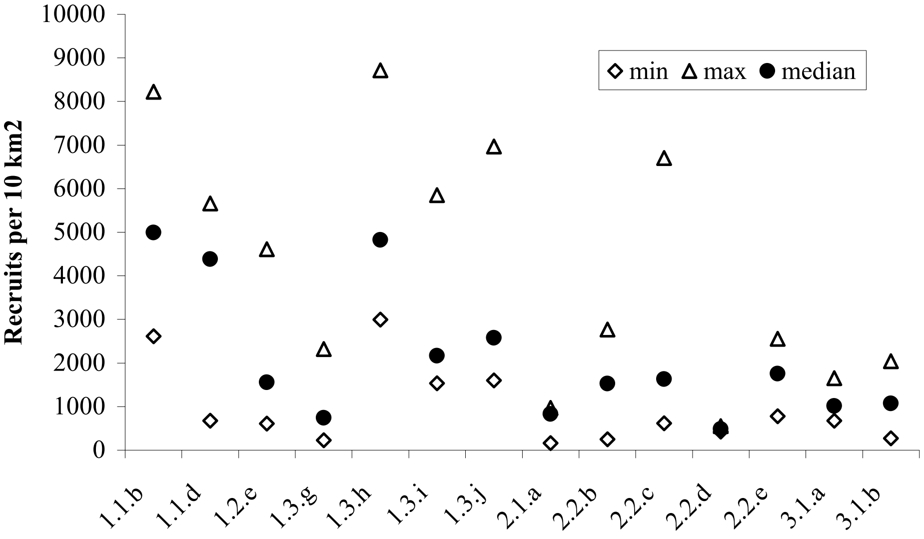


Figure 3. Variability in recruit density indices (RDI) of the age 0 group for *P. blennoides* (MEDITS surveys 1994-'99). The highest values were recorded in the Western basin (from 1.1.b to 1.3.j).

An attempt to evaluate the possible influence of the sampling period upon the mean length variability of *M. merluccius* and *P. blennoides* has been made through plots intersecting the main month during which the samplings have been carried out each year in each assessment unit and the 0 group mean length (figures 7 and 8). This plot illustrated a possible influence of the time lag in explaining the observed differences.

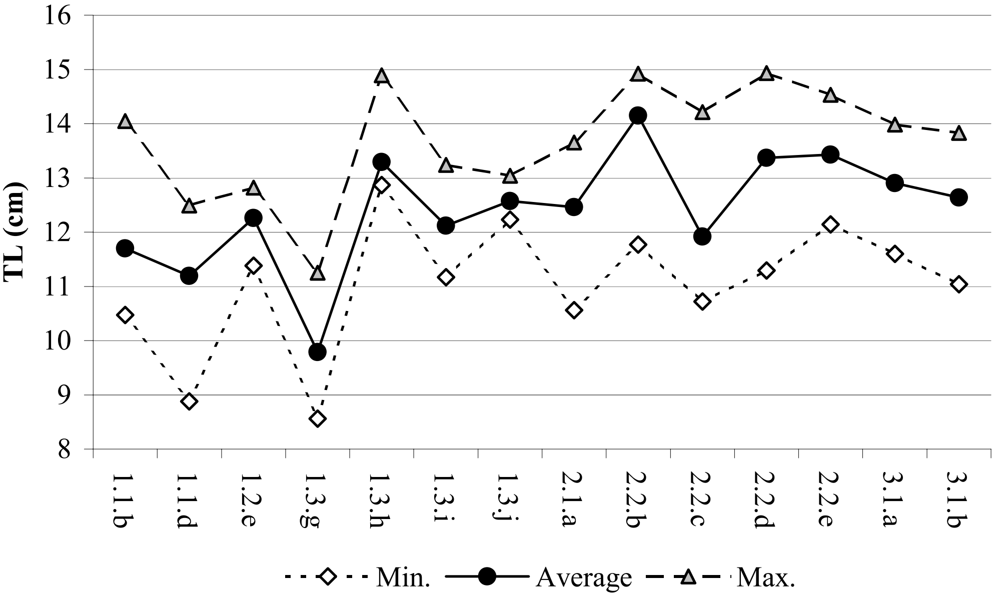


Figure 4 - Variability in the cut-off length of M. merluccius among years and areas (MEDITS surveys 1994-1999). The highest values were recorded in the Eastern basin (from 2.2.b to 3.1.b).

The time lag in the sampling period might also explain the differences in the strength of the recruitment derived from an analysis of the overall recruit indices for the gadoids species. From the present analysis, the differences in the density indices likely due to time lag resulted less evident than for the mean length (figures 9 and 10). The main result is that the indices from the western zones are systematically higher than those from the eastern ones, even if sampling occurred during the same period.

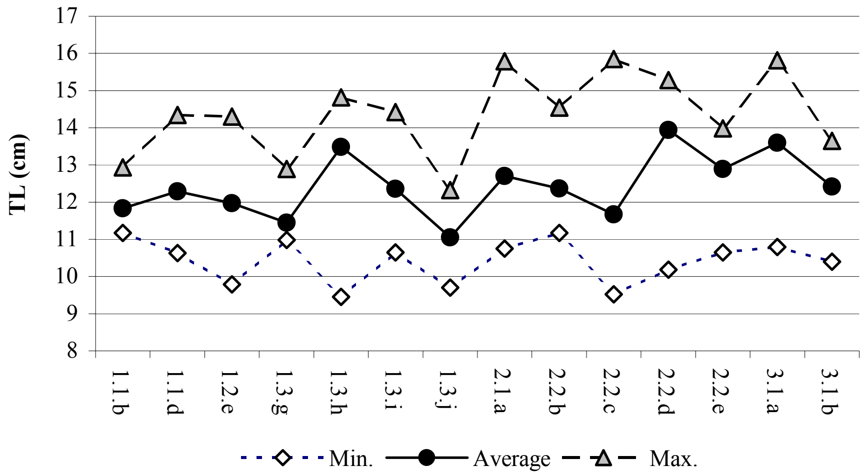


Figure 5 - Variability in the cut-off length of the P. blennoides among years and areas (MEDITS surveys 1994-1999). The highest values were recorded in the Eastern basin (from 2.1.a to 3.1.b).

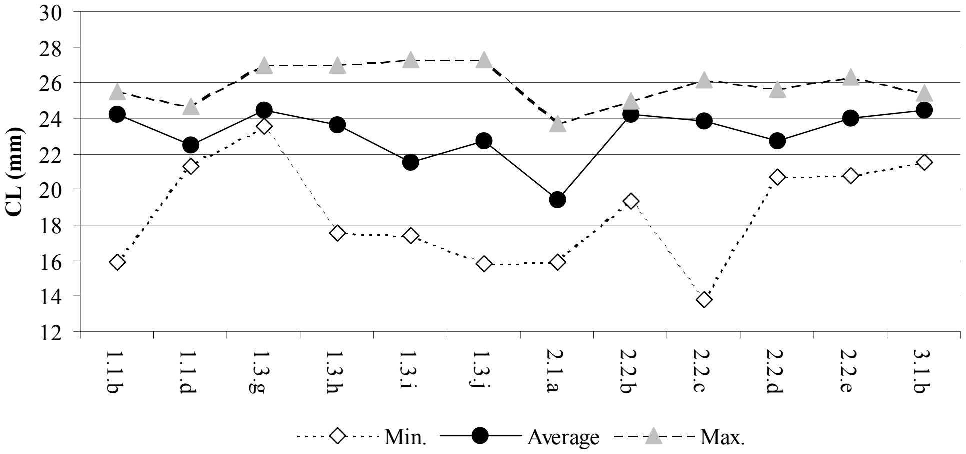


Figure 6 - Variability in the cut-off length of the P. longirostris among years and areas (MEDITS surveys 1994-1999).

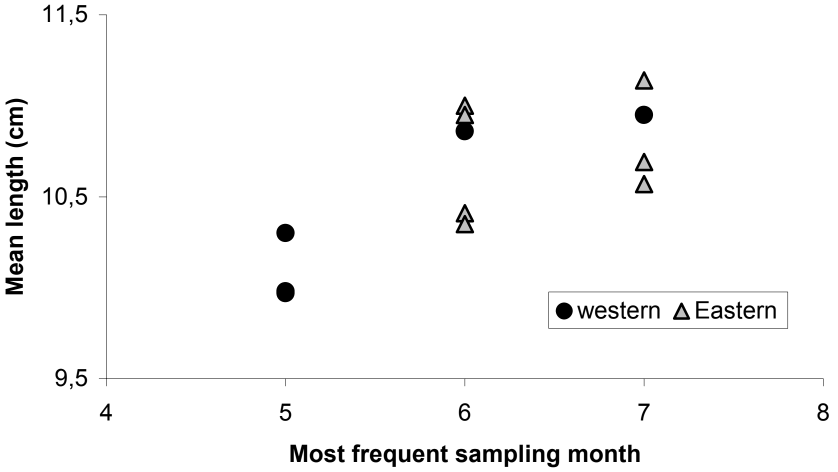


Figure 7 – Mean length of age 0 group in *M. merluccius* versus the most frequent sampling month by Management Unit and year (MEDITS surveys 1994-1999). Western (from 1.1.b to 1.3.i) and Eastern (from 2.1.a to 3.1.b) areas are distinguished.

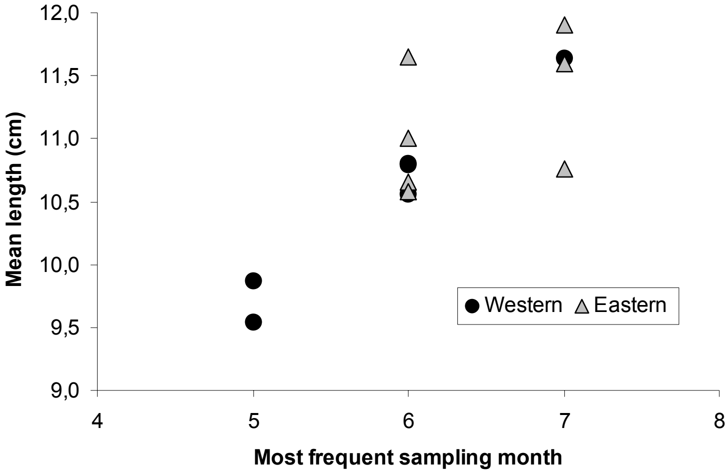


Figure 8 – Mean length of age 0 group in *P. blennoides* versus the most frequent sampling month by Management Unit and year (MEDITS surveys 1994-1999). Western and Eastern areas are distinguished.

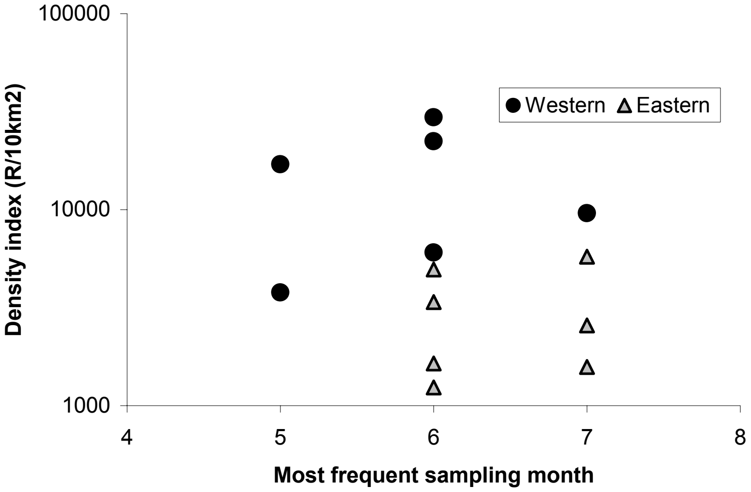


Figure 9. Density indices of the age 0 group of *M. merluccius* versus the main sampling month for each assessment unit and year (MEDITS surveys 1994-1999). Western and eastern areas are distinguished.

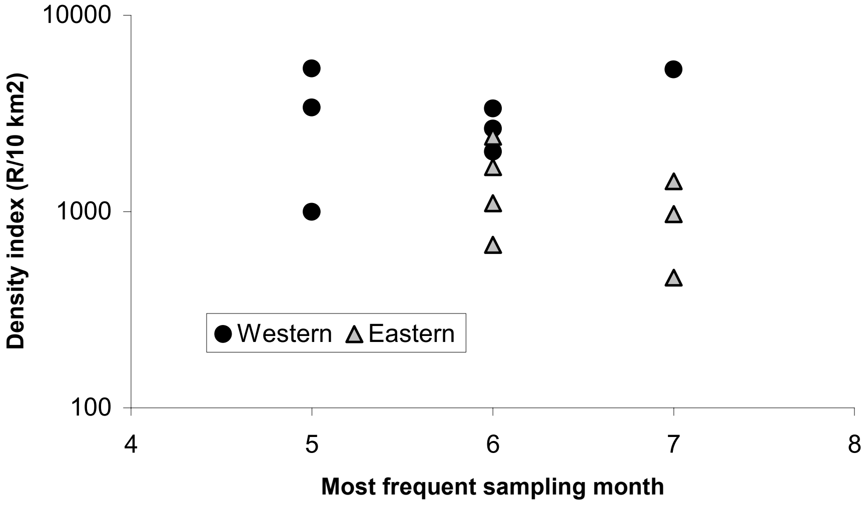


Figure 10. Density indices of the age 0 group of *P. blennoides* versus the main sampling month for each assessment unit and year (MEDITS surveys 1994-1999). Western and eastern areas are distinguished.

4.3.2 The synoptic view of the Mediterranean Nurseries

A synoptic view of the Mediterranean nurseries, in terms of highest presence of recruits and juveniles per km^2, is shown in figures 11, 12, 13, 14 and 15 through the “bubble maps”. Despite some high abundance variability between years, some general patterns of spatial distribution may be identified.

The highest densities of 0 group *Merluccius merluccius* (figure 11), were encountered in the central part of the area under study. The highest densities of recruits (more than 2000 individuals per km^2) throughout the examined period were found along the coasts of the Ligurian and Tyrrhenian Seas and around Sardinia. High densities of recruits of this species also occurred in the Southern Adriatic Sea and in different locations of the eastern basin (off the Spanish coasts, Gulf of Lions,...), depending on the year. Considering the juvenile hake (figure 12), the areas with highest density remained quite similar to the recruits’ ones but the presence of fish older 1 year was spread in a larger area, including a depth range wider than that occupied by the 0 group. On the whole these maps showed that the young hakes older than 1 year inhabited the shallow bottom too, while the 0 group preferred the outer shelf–upper slope.

The highest densities of the 0 group of *Phycis blennoides* (more than 800 individuals per km^2), shown in figure 13, mainly occurred in the central and western basins, along the upper slopes. The highest values were obtained in the Tyrrhenian Sea, in waters surrounding Sardinia and off the Spanish coasts. Other areas characterised by good level of recruitment were the Eastern Ionian and Southern Adriatic Seas.

The 0 group of *Parapenaeus longirostris* (figure 14), it is noteworthy more abundant in the central and eastern basins (with the exception of the Northern and Central Adriatic Sea). In particular the highest densities (more than 5000 individuals per km^2) were found in the Strait of Sicily, off the Albanian coasts, and in the Aegean Sea. It is worth to note that from 1997 to 1999 high density indices were detected along the western coast of Sardinia.

Almost the same distribution occurred for juveniles of *Illex coindetii* (figure 15), although with lower values and higher variability throughout time than *P. longirostris*. The highest values (more than 400 individuals per km^2) occurred in the Tyrrhenian sea, around the coast of Sardinia and in the Greek waters. The high densities of juveniles in the Adriatic Sea in 1999, that could be related with the delay in the trawl surveys (late summer instead of spring), due to the war in the Ex-Yugoslavia countries, must be mentioned.

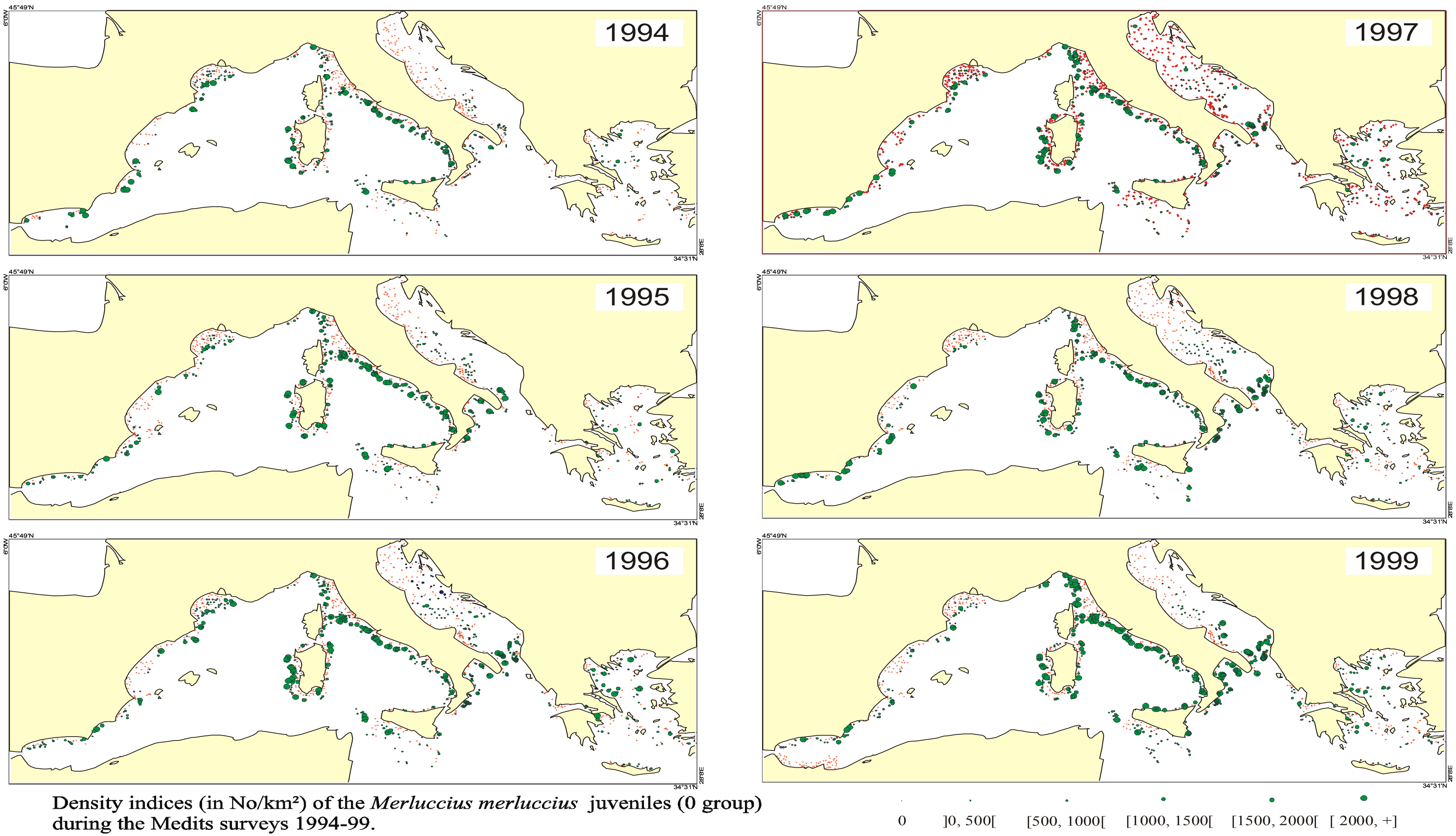


Figure 11 – Density indices (R per km^2) of the recruits of *M. merluccius* by year in the whole investigated area.

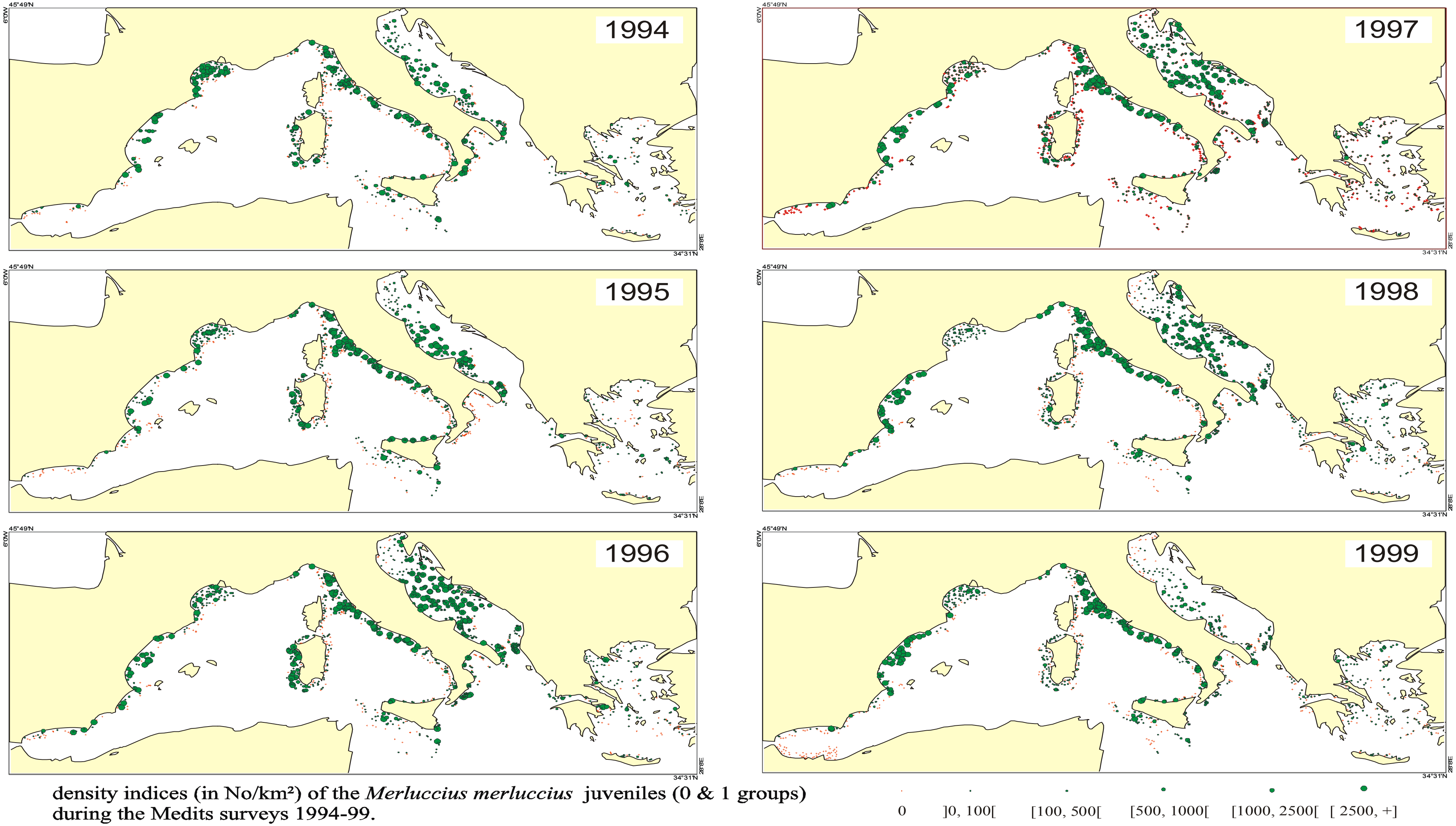
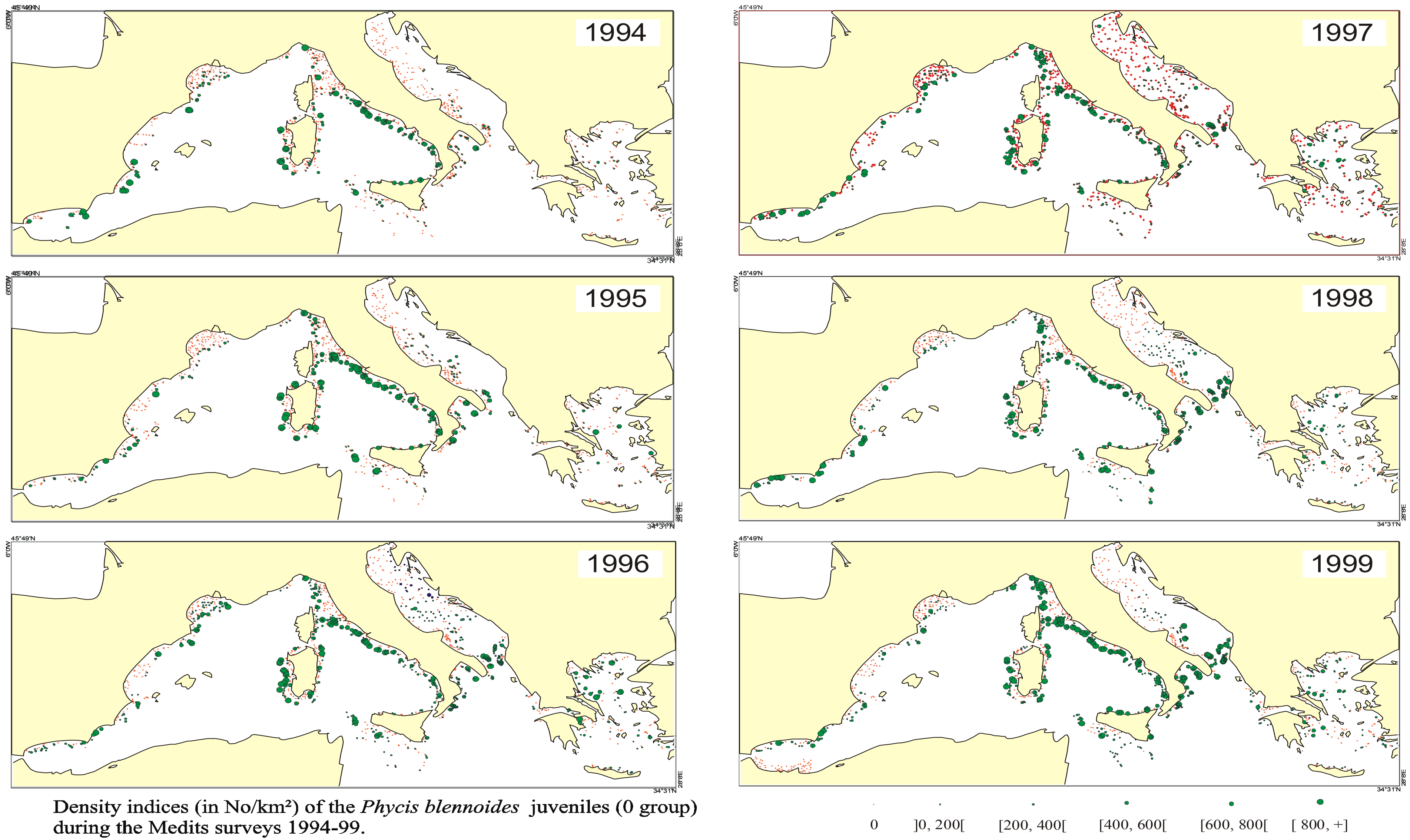
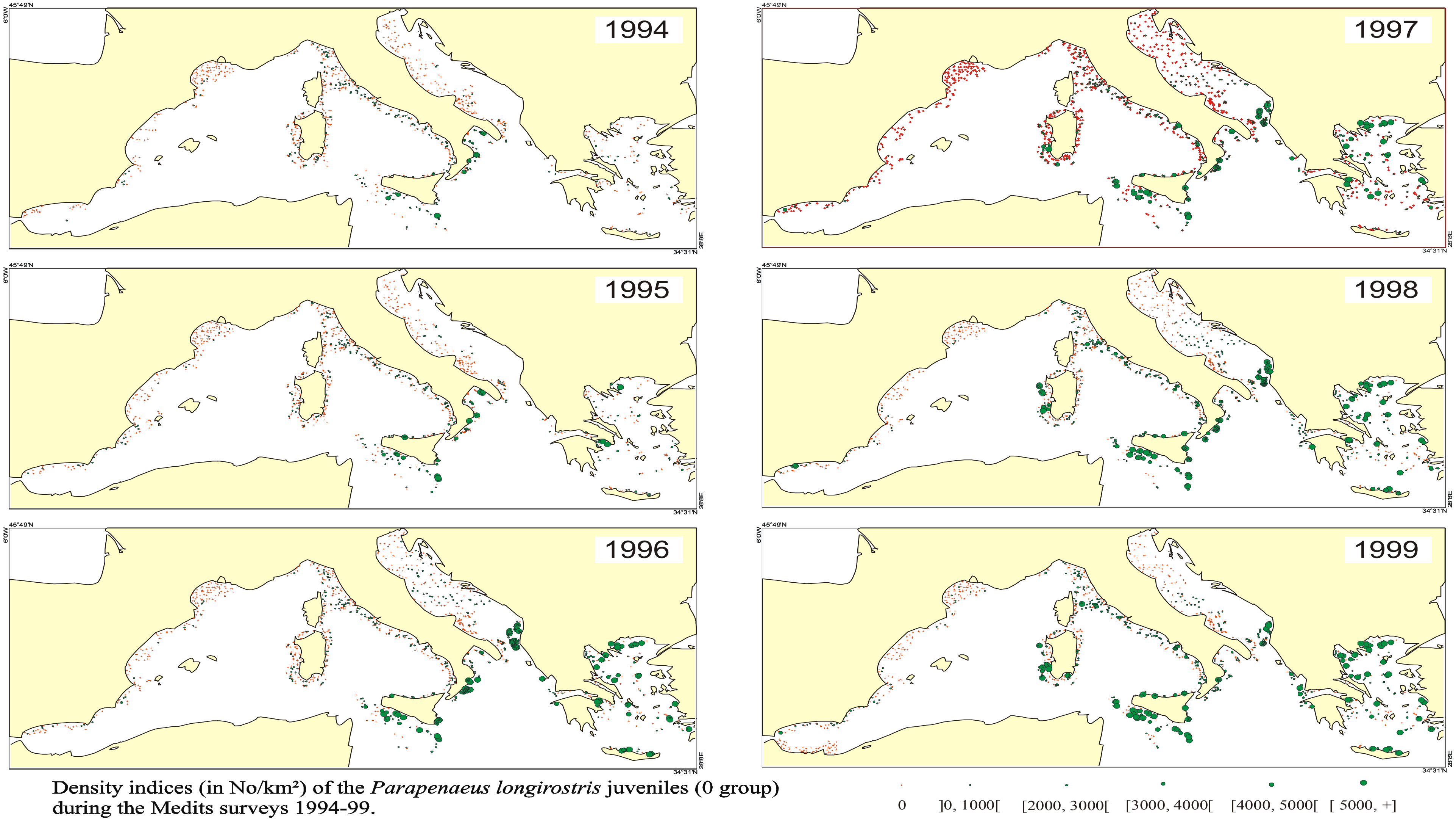


Figure 12 – Density indices (J per km^2) of the juveniles (0 and 1 stages of maturity scale) of *M. merluccius* by year in the whole investigated area.



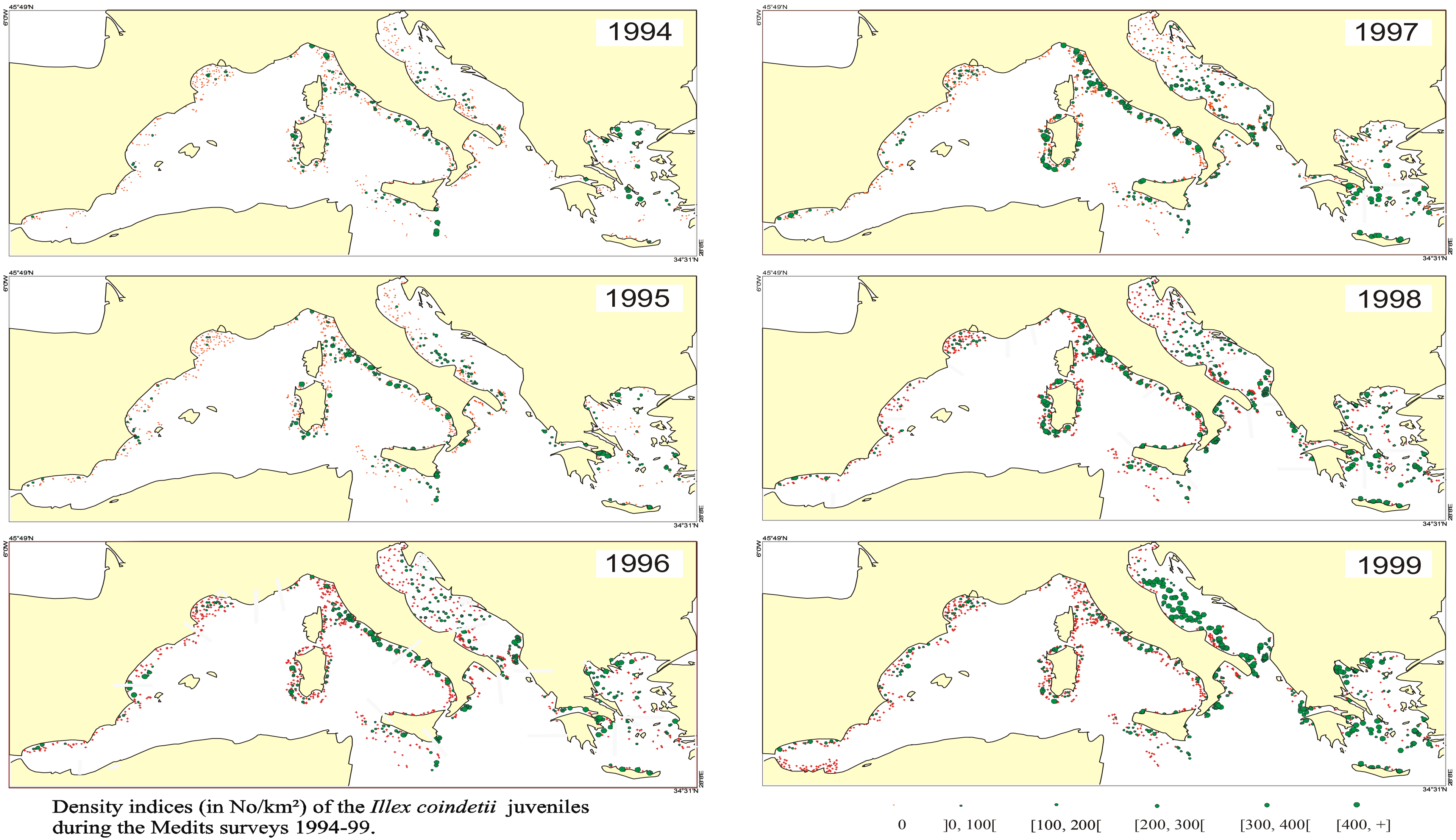
Density indices (in No/km²) of the *Phycis blennoides* juveniles (0 group) during the Medits surveys 1994-99.

Figure 13 – Density indices (R per km^2) of the recruits of *P. blennoides* by year in the whole investigated area.



Density indices (in No/km²) of the *Parapenaeus longirostris* juveniles (0 group) during the Medits surveys 1994-99.

Figure 14 – Density indices (R per km^2) of the recruits of *P. longirostris* by year in the whole investigated area.



Density indices (in No/km²) of the *Illex coindetii* juveniles during the Medits surveys 1994-99.

Figure 15 – Density indices (J per km^2) of the juveniles (0 and 1 stages of maturity scale) of *I. coindetii* by year in the whole investigated area.

4.3.3 The identification of the main nursery in some selected areas

The mean densities per surface unit together with the exploratory maps on the whole MEDITS area allowed selecting two Management Units by species, characterised by high presence of recruits or juveniles throughout the entire examined period, worthy to be analysed in deep way.

The following maps reported, by year and selected Management Units, the hauls characterised by the co-occurrence of high density and exclusive presence of recruits or juveniles, which permitted to identify the stable "nuclei" corresponding to the main nurseries areas in the examined region (figure 16, 17, 18, 19, 20, 21, 22 and 23).

4.3.3.1 Main Hake nurseries

The hauls characterised by the co-occurrence of high density and exclusive presence of recruits of *Merluccius merluccius* in the Management Unit 1.3.j (Ligurian Sea and North-Central Tyrrhenian) by years are shown in figure 16.

An overall of 73 hauls satisfying both the criteria were found. It is evident that 1996 (17 values), and 1997 (21), when the highest number of hauls fitted the co-occurrence criterion, showed nurseries occurring in most of the area under investigation. The lowest presence of hauls was detected in 1994 (only 7 values), and in 1995 (10). It is worth noting that in 1999 (15) the occurrence of the markers was concentrated in the Ligurian Sea and in the North Tyrrhenian Sea. Concerning the depth range, in which the exclusive presence of recruits was highest, it was mainly located between 100 and 200m, although some hauls could be up to 300 m. In only three cases out 73, the exclusive high presence of recruits was detected in bottom shallower than 100m.

Despite the observed variability among years, it is possible to identify some "nuclei" of hauls, indicating the exclusive presence of high concentrations of hake recruits, consistently throughout time. Two main nuclei were located in the Eastern Ligurian Sea, the first north to the Gorgona Isle (7 hauls in 5 out 6 years) and the second north-east and east to the Capraia Island (7 hauls only in 1996 and 1998).

Another important nucleus occurred north west the Giglio Island in the Northern Tyrrhenian Sea (17 hauls along all the examined time). It represented the most important area identified in the present study. On southward the next nuclei occurred off the mouth of Tevere river (8 hauls deriving from 4 years) and between Capo Circeo and Gaeta (8 hauls from 5 years).

The hauls characterised by the co-occurrence of high density and exclusive presence of juveniles of *Merluccius merluccius* along the Spanish coasts (Catalan Sea and Alicante sector – Management Unit 1.1.b) by year are showed in figure 17.

45 hauls satisfying both the criteria were found. Their occurrence was quite equally distributed through time (6-7 hauls per year), with exception of 1998 when about the double was detected (12 hauls).

Concerning the depth range, in which the exclusive presence of recruits was highest, the most stable nurseries are placed between 100 and 200m. Unlike the Ligurian and Tyrrhenian, many hauls "markers" of nurseries presence were found also in bottoms shallower than 100 m.

The most evident "nuclei" of hauls were found in the Catalan Sea, indicating the exclusive presence of high concentrations of hake recruits, consistently throughout time. The first was placed north-eastward Capo de Tortosa, while the second in the Gulf of Valencia.

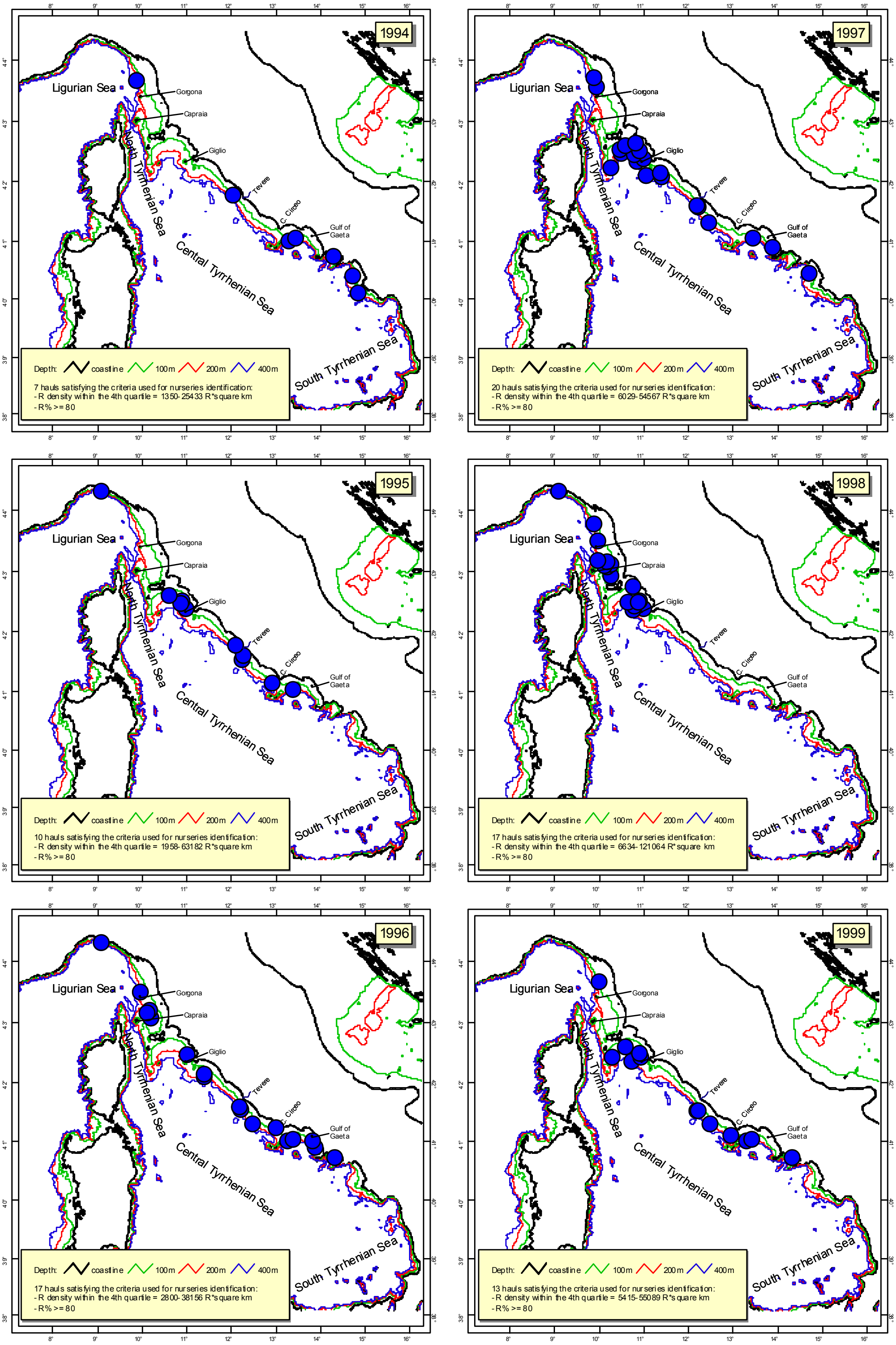


Figure 16. Nursery location of hake in the Management Unit 1.3.j according to the co-occurrence criterion of highest density and exclusive presence of recruits.

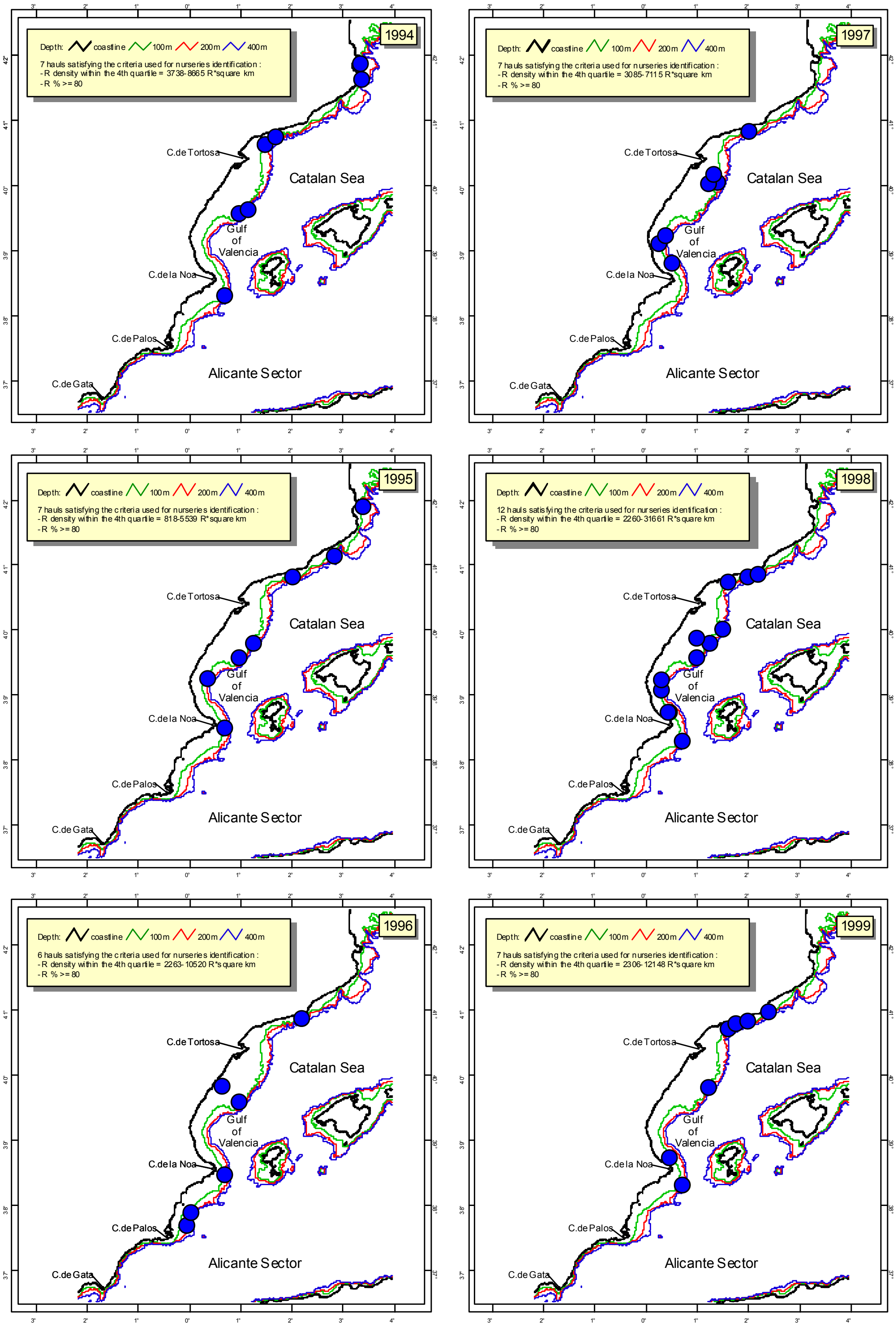


Figure 17. Nursery location of hake in the Management Unit 1.1.b according to the co-occurrence criterion of highest density and exclusive presence of recruits.

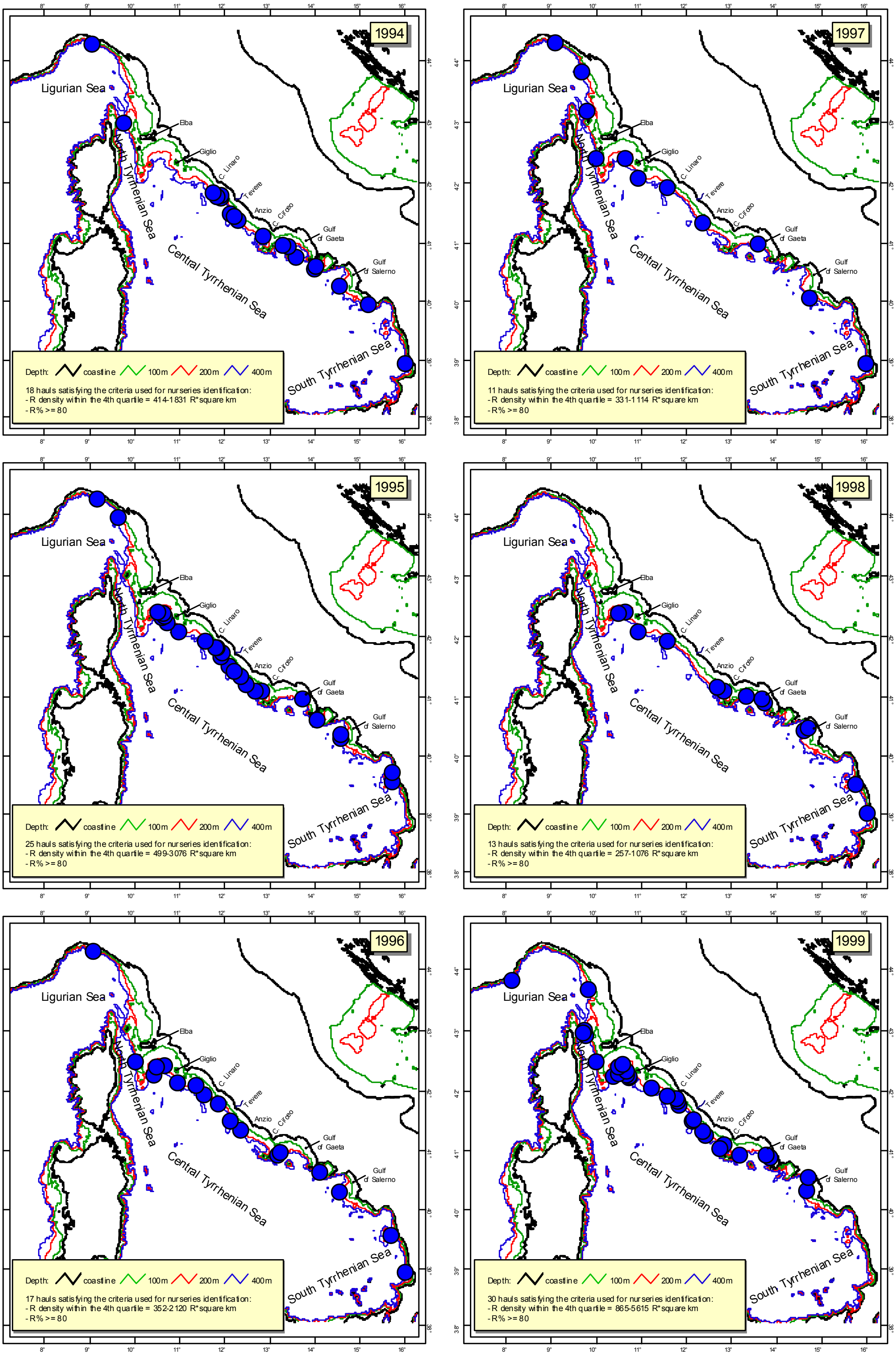


Figure 18. Nursery location of Greater Fork Beard in the Management Unit 1.3.j according to the co-occurrence criterion of highest density and exclusive presence of recruits.

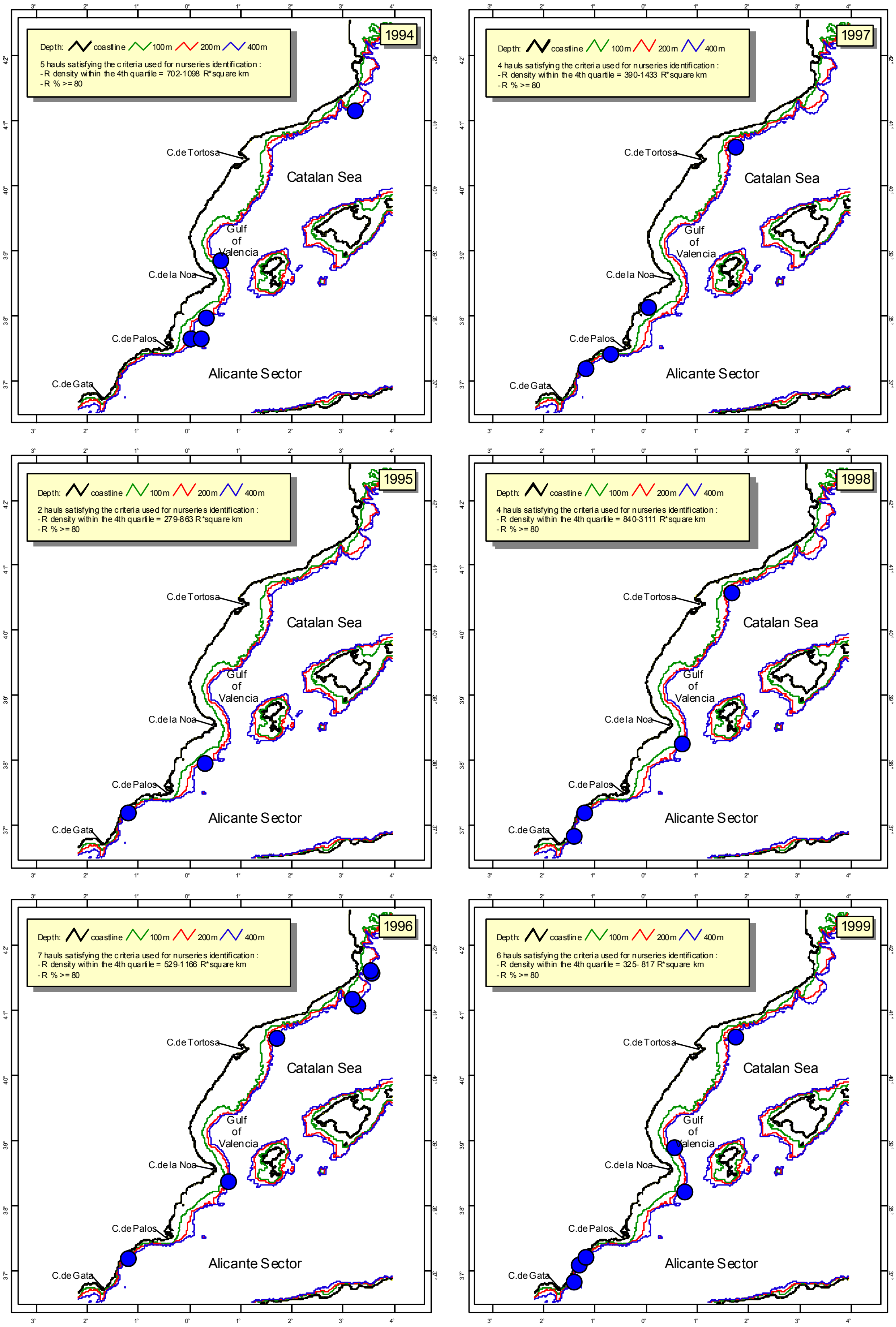


Figure 19. Nursery location of Greater Fork Beard in the Management Unit 1.1.b according to the co-occurrence criterion of highest density and exclusive presence of recruits.

4.3.3.2 Main Greater Fork-beard nurseries

The hauls characterised by the co-occurrence of high density and exclusive presence of *P. blennoides* juveniles in Management Unit 1.3.j (Ligurian Sea and North-Central Tyrrhenian)by years are showed in figure 18. Considering the whole area, 109 hauls satisfying the co-occurrence criterion were found. In general the variability among years was less than the other two species considered in the MU. The highest numbers of hauls were detected in 1994 (17 values), 1995 (23), 1996 (17) and 1999 (28).

The most important nurseries were located in the Northern and Central Tyrrhenian, showing the Ligurian Sea a remarkable nursery area only in 1999. It is worth noting that the nurseries were placed on bottoms deeper than Hake and Broadtail Short-fin squid, ranging from 200 to 400m. At least six main areas with high and exclusive presence of recruits throughout time can be identified. The main "nucleus" of hauls was located in the North Tyrrhenian Sea, southward the Elba Island and eastward the Giglio Island (19 values). All the other "nuclei" were placed in the Central Tyrrhenian, between Capo Linaro and the mouth of Tevere River (12), the mouth of Tevere River and Anzio (14) and Anzio and Capo Circeo (7), south-eastward Capo Circeo and Gaeta (11), and in the Gulf of Salerno (7).

The co-occurrence of high density and exclusive presence of juveniles of *Phycis blennoides* in the Management Unit 1.1.b (Catalan Sea and Alicante sector) by years is illustrated in figure 19. In the whole MU, 28 hauls considered as "markers" of nursery presence were found, ranging from 2 in 1995 to 7 in 1996. Concerning the depth range, the exclusive presence of recruits was highest off 200m depth.

Four most evident "nuclei", characterised by a high variability by year, were identified. The first was placed off Blanes and the second off Tarragona, both close to sub-marine canyons. The third nursery was located south-eastward Cape de la Nao, and the fourth between Capo de Palos and Capo de Gata.

4.3.3.3 Main Deep Water Pink Shrimp nurseries

The hauls characterised by the co-occurrence of high density and exclusive presence of *P. longirostris* recruits in the Management Unit 2.2.e (Sicilian side of the Strait of Sicily) by year are shown in figure 20. On the whole, 43 hauls satisfied the co-occurrence criterion.

As a general rule the variability among years was lower than that of the other two species considered in the MU. The highest number of "marker" hauls was detected in 1999 (9 values), while the lowest in 1994 (2). The most important nurseries were consistently located off Capo Rossetto (12 values throughout the examined time) and in the Eastern side of the Malta Bank, close to 200 m depth. Considering the Management Unit 3.1.a (Aegean Sea), shown in figure 21, 44 hauls fitted the marking nursery criteria. The highest number of hauls was detected in 1997 (11 values), and the lowest in 1994 (2).

At least 4 main areas with high and exclusive presence of recruits throughout time can be identified. The main "nucleus" of hauls was located in the Northern Aegean, in the Strymonikos Gulf (12 hauls) and between Tashos and Samotrhace Islands (7), followed by those placed in the South-eastern Aegean, north to Samos Island (5) and north-west the Rodes Island (4). Unlike the Strait of Sicily, the nurseries were located in a wider depth range from about 50 to 200m.

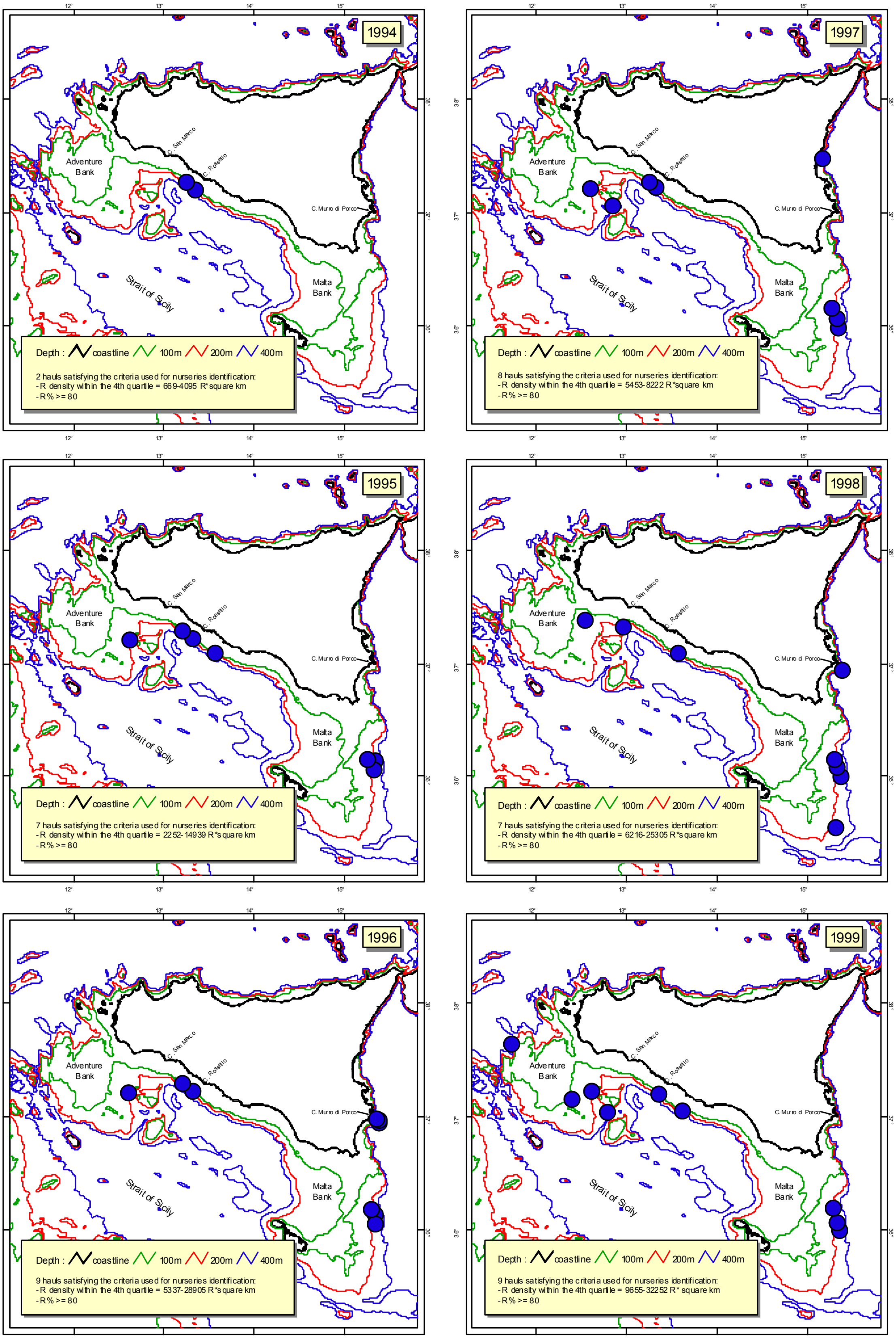
4.3.3.4 Main Broadtail Short-Fin Squid nurseries

The hauls characterised by the co-occurrence of high density and exclusive presence of juveniles of *Illex coindetii* by year in Management Unit 1.3.j (Ligurian Sea and North-Central Tyrrhenian) are shown in figure 22.

On the whole 79 "marker" hauls were found. 1996 (17 values), 1997 (19) and 1998 (16) showed a dispersion of juvenile on the widest area, the "indicator" of the nurseries occurring in most of the area under investigation. Conversely the more discrete presence of hauls was detected in 1994 (only 9 values), in the Ligurian Sea, the North and Central Tyrrhenian Sea, and in 1999 (8), in the North and the Central Tyrrhenian Sea. In all cases these hauls occurred in the depth range from 100 to 200m.

Although variability among years was observed, it is possible to recognize some "nuclei" of hauls consistently going on throughout time. They were located in the Eastern Ligurian Sea, southward Punta Mesco (8 values); in the North Tyrrhenian Sea, between the Elba Island and the Giglio Island (9), in the Central Tyrrhenian, between Cape Linaro and Anzio (15) and in the Gulf of Gaeta (9), and in the Salerno Gulf (7).

Considering the Management Unit 3.1.a (Aegean Sea), shown in figure 23, 51 hauls satisfied the marking nursery criteria. The highest number of hauls was detected in 1999 (13 values) and the lowest in 1995 (3). At least 4 main areas with high and exclusive presence of recruits throughout time could be identified. The main "nucleus" was located in the Southern Aegean, between Leros and Patmos Islands (10), off Giaros and Sira Islands (8) and north to Samos Island (5 hauls) followed by those placed in the Northern Aegean, in the Strymonikos Gulf (6). Likewise the Ligurian Sea, the North and Central Tyrrhenian Sea, the nurseries were located in the depth range from 100 to 200m.



2 hauls satisfying the criteria used for nurseries identification:
- R density within the 4th quartile = 669-4095 R*square km
- R% >= 80

8 hauls satisfying the criteria used for nurseries identification:
- R density within the 4th quartile = 5453-8222 R*square km
- R% >= 80

7 hauls satisfying the criteria used for nurseries identification:
- R density within the 4th quartile = 2252-14939 R*square km
- R% >= 80

7 hauls satisfying the criteria used for nurseries identification:
- R density within the 4th quartile = 6216-25305 R*square km
- R% >= 80

9 hauls satisfying the criteria used for nurseries identification:
- R density within the 4th quartile = 5337-28905 R*square km
- R% >= 80

9 hauls satisfying the criteria used for nurseries identification:
- R density within the 4th quartile = 9655-32252 R* square km
- R% >= 80

Figure 20. Nursery location of Deep water rose shrimp in the Management Unit 2.2.e according to the co-occurrence criterion of highest density and exclusive presence of recruits.

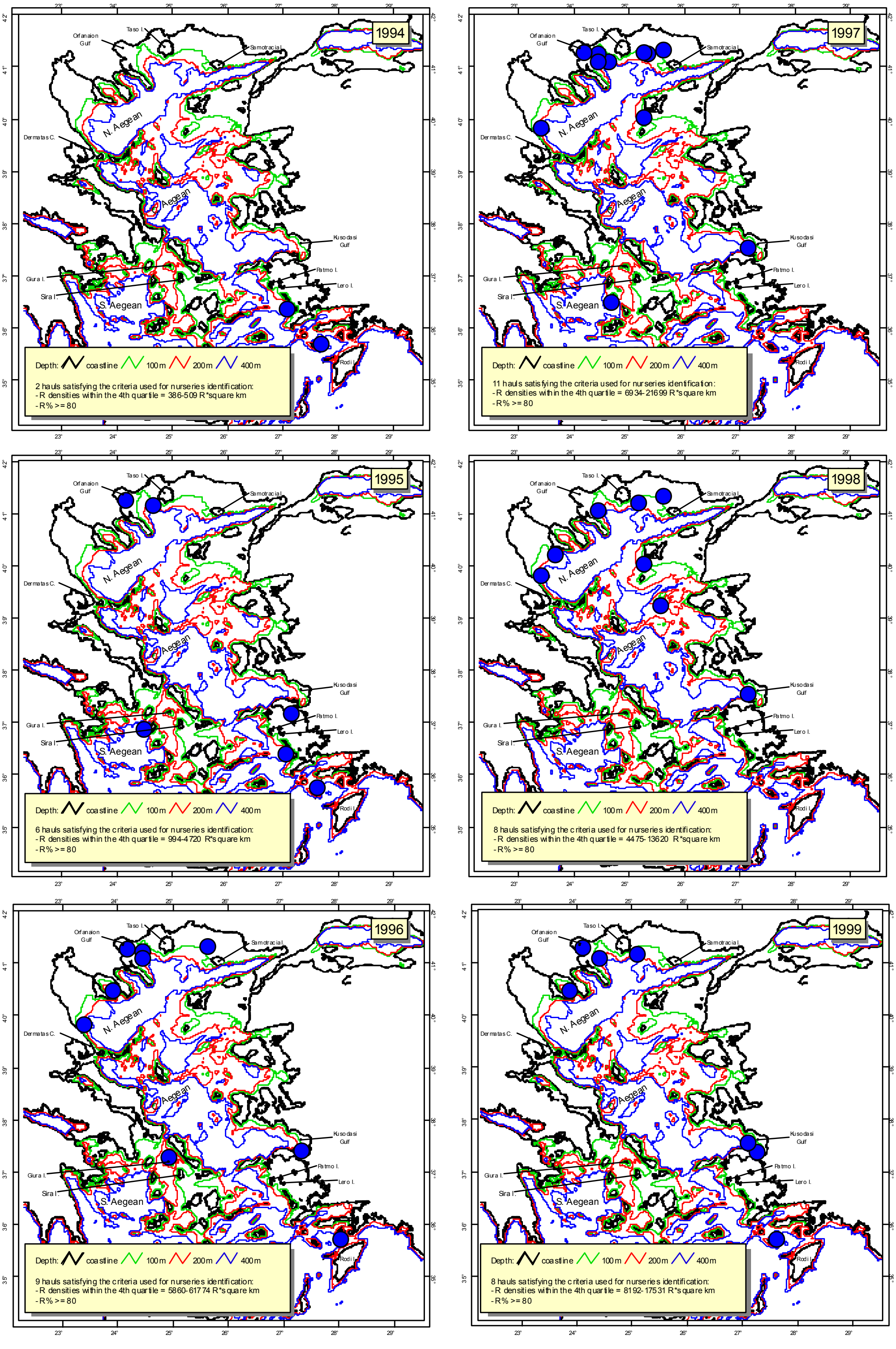


Figure 21. Nursery location of Deep water rose shrimp in the Management Unit 3.1.a according to the co-occurrence criterion of highest density and exclusive presence of recruits.

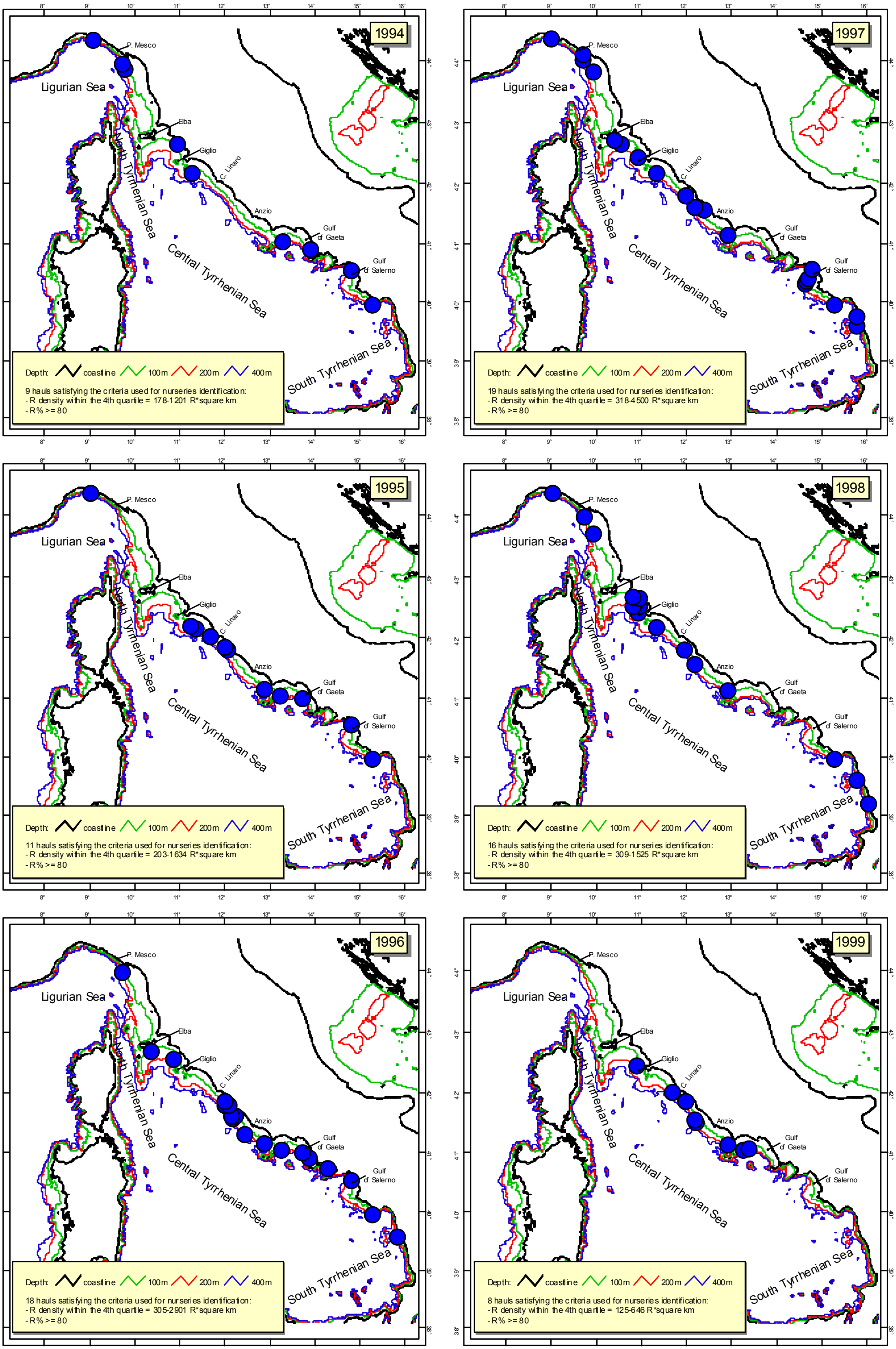


Figure 22. Nursery location of Broadtail Short-Fin in the Management Unit 1.3.j according to the co-occurrence criterion of highest density and exclusive presence of recruits.

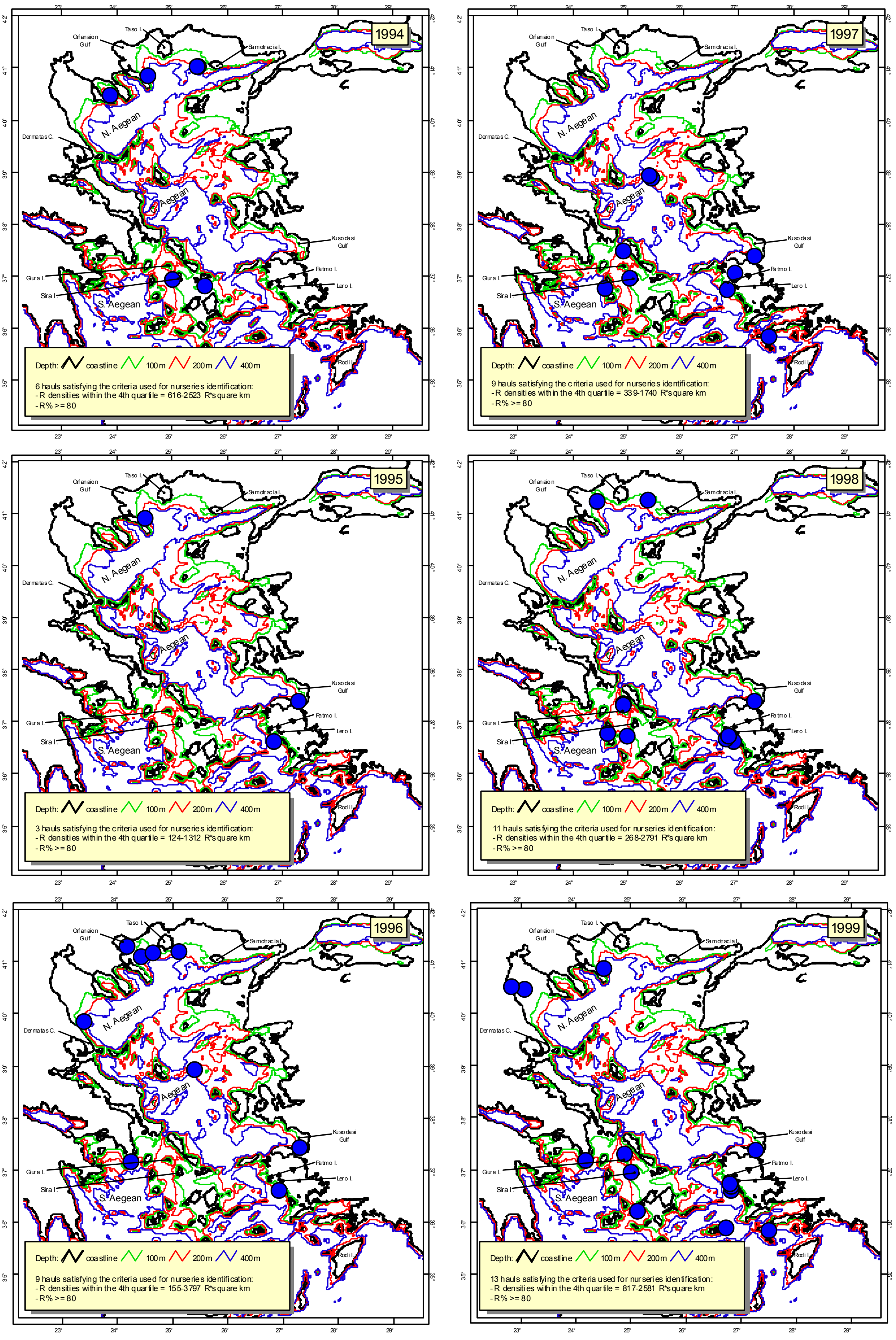


Figure 23. Nursery location of Broadtail Short-Fin in the Management Unit 3.1.a according to the co-occurrence criterion of highest density and exclusive presence of recruits.

4.4 Discussion and conclusions

The findings obtained by the working group can be useful for further and more refined studies. The main results, concerning both general aspects of the recruitment of the demersal species in Mediterranean and, more in particular, the nursery identification can be summarised in the following points:

1. MEDITS trawl surveys represented a “feasible sampling procedure” to give standardised recruitment indices to evidence differences among areas and years in recruitment patterns;
2. The comparison of the mean recruit density indices (RDI), derived directly from the analysis of mean LFD per surface unit, can give an immediate rough estimate of the relative strength of recruitment by Management Unit and its variability in the examined period;
3. The analysis of the LFD of Hake, Greater Fork-beard, and Deep Water Pink Shrimp allowed the calculation of a cut–off length by year and MU, which was useful to assign the specimens to the recruits, without utilizing a “pre-fixed” size threshold, constant through time and areas;
4. The differences in the length cut-off could be remarkable among the areas and the years, strongly suggesting to avoid the use of a “pre-fixed” size threshold, with no in depth analysis of the LFD;
5. The differences in length features and RDI in *M. merluccius* and *P. blennoides* between Western and Eastern areas might likely be due to the time lag in the sampling periods, but the observed patterns in both species might also be due to a different recruitment period in the two basins;
6. There is a substantial interannual variability in the spreading of the nursery areas. The present series of data obtained at the same period every year allows the drawing of a first picture of these areas from highest occurrence probabilities. These figures might be precised in the future through the enlargement of the time series;
7. The highest densities of *M. merluccius* recruits (age 0 group) were encountered in western-central part of the area under study. The highest densities of recruits (more than 2000 individuals per km2) throughout the examined period were found along the coasts of the Ligurian and Tyrrhenian Sea, the Catalan Sea, the Gulf of Lions and around the Sardinia, mainly on the outer shelf–upper slope;
8. The highest presence of *M. merluccius* juveniles, including also individuals older 1 year, was recorded in the same areas, but on a wider depth range, covering also the shallower bottoms;
9. The highest densities of *Phycis blennoides* recruits (more than 800 individuals per km^2), mainly occurred in the central and western basins, along the upper slopes. The highest values were obtained in the Ligurian and Tyrrhenian Sea, in waters surrounding Sardinia, off the Spanish coasts and in the Western Ionian Sea.
10. Considering the *Parapenaeus longirostris* recruits, the highest densities were found in the central and eastern basins (with the exception of the North and Central Adriatic Sea). In particular more than 5000 individuals per km^2 were registered in the Strait of Sicily, off the Albanian coasts, and in the Aegean Sea.
11. Juveniles of *Illex coindetii* were more concentrated in the same areas in which *Parapenaeus longirostris* showed the highest concentration, although with lower values, the highest class being more than 400 individuals per km^2, and with a higher variability throughout time.
12. Considering the Ligurian Sea and North-Central Tyrrhenian, the most important nurseries of *Merluccius merluccius* along the examined period was found north-westwards the Giglio Island in the Northern Tyrrhenian Sea. It represented the most important area identified in the present study. The depth, which the highest and exclusive presence of recruits was recorded in, ranged mainly between 100 and 200m, although some hauls could be down to 300 m. In only three cases out 73, the exclusive high presence of recruits was detected in bottom shallower than 100m.
13. Considering hake along the Spanish coasts (Catalan Sea and Alicante sector) the main nurseries, were placed in the Catalan Sea: the first off Tarragona and the second in the Gulf of Valencia. Concerning the depth range, the most stable nurseries are placed between 100 and 200m. Unlike the Ligurian and Tyrrhenian Sea, many hauls indicating the nurseries presence were found also in bottoms shallower than 100 m.
14. The nursery areas of *P. blennoides* in the Ligurian Sea and the North-Central Tyrrhenian, showed lower inter-annual variability than those of the other species. The most important nurseries were located in the North and Central Tyrrhenian. Likewise Hake, the main “nucleus” of hauls showing the nursery was located in the North Tyrrhenian Sea, southward the Elba Island and eastward the Giglio Island. It is worth noting that the nurseries of *P. blennoides* were placed deeper than those of hake, on bottoms ranging from 200 to 400m.
15. The co-occurrence of high density and exclusive presence of *P. blennoides* recruits in the Catalan Sea and Alicante sector were found in depths beyond 200m. Four most evident “nuclei”,

characterised by a high variability by year, were identified. The first was placed off Blanes and the second off Tarragona, both close to sub-marine canyons. The third nursery occurred south-eastward Cape de la Nao, and the fourth between Capo de Palos and Capo de Gata.

16. At least 4 main nurseries of *P. longirostris*, quite stable throughout time, were identified in the Aegean Sea. Two nurseries were located in the Northern Aegean, in the Strymonikos Gulf and between Thaso and Samotrhace Islands, followed by those placed in the South-eastern Aegean and north-west the Rodes Island. Unlike the Strait of Sicily, the nurseries were located in a wider depth range, from about 50 to 200m.
17. The main nurseries of *P. longirostris* in the Sicilian side of the Strait of Sicily were consistently located off Capo Rossetto and in the Eastern side of the Malta Bank, close to 200 m depth.
18. The juveniles of *Illex coindetii* in the Ligurian Sea and the North-Central Tyrrhenian showed a very typical pattern, being spread on the most of the area under investigation throughout the examined period. In any case, the hauls with co-occurrence of highest and exclusive presence of juveniles occurred in the depth range from 100 to 200m. The most important nurseries were placed in the Central Tyrrhenian, between Capo Linaro and Anzio.
19. The main nurseries of *I. coindetii* in the Aegean Sea were located in the Southern basin, between Leros and Patmos Islands, off Giaros and Sira Islands and north to Samos Island. Another area with high and exclusive presence of recruits was placed in the Srtymonikos Gulf (Northern Aegean). Likewise to the Ligurian Sea, the North and Central Tyrrhenian Sea, the nurseries were located in the depth range from 100 to 200m.

All the presented findings can provide useful information both for a deeper understanding of the biology of the studied species and for suggesting advises to fisheries management, especially when the nursery areas are included in the fishing grounds. The delimitation of such areas, taking into account not only the highest presence of recruits/juveniles but also their exclusive occurrence in the area, together with the assessment of recruit abundance may provide suitable base information for evaluating the protected zone spill-over effect in the spatial dimension.

The protection of nursery areas, through the limitation of the fishing pressure in critical season for an appropriate time according to local circumstances and range of species, could be considered as an effective complementary regulation tool, having, amongst others, effects comparable to increasing the mesh size. The closure of nurseries could be a flexible management tool, useful where conventional fisheries management strategies are difficult to apply, that is the condition often occurring in Mediterranean coastal area

The nurseries of the investigated species are mainly situated between 100 and 200m for Hake, Deep Water Pink Shrimp and Broadtail Short-fin Squid, while those of Greater Fork-beard were placed beyond 200m depth. These habitats although less vulnerable than the close to the coast shallow areas, could be damaged by dumping but also by too high trawling pressure.

Even though very preliminary due to the shortness of the temporal series available, the present results may constitute a stimulating starting point towards future fisheries population analysis and research in the area, both considering the influence of the spawning stock and of the environment on the recruitment processes.

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[5] Statistical study on temporal trends

At the end of the MEDITS 2001 survey, variations of the biomass indices from 1994 to 2001 have been presented for each reference species and each subarea (cf. the common report of the EC Projects 00/006, 00/041 and 00/010, MEDITS survey 2001, biological report). The aim of the following study was to propose and test on a few study cases the use of General Linear Models to characterize the significance of possible variations and trends in the biomass and abundance indices between areas and years.

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5.1 Methodology: standardized abundance indices

Within the framework of the 'MEDITS' project seven annual bottom trawl surveys were undertaken from 1994 to 2000 in the Mediterranean Sea, covering 40 MEDITS sub-areas, belonging in 15 major areas as defined by the GFCM.

The major areas used in the analysis in the sub-task of the statistical studies on temporal trends are based on those defined by the GFCM and presented in the following table:

Country	GFCM major areas	Geographical areas	Code
Greece	3.1.a	North Aegean Sea	
	3.1.b	South Aegean Sea (Crete Island)	
	2.2.d	Eastern Ionian Sea	
Italy	2.1.a	Northern Adriatic	A
	2.2.b	Southern Adriatic	B
	2.2.c	Western Ionian Sea	C
	2.2.e	Waters off Sicily and Malta	D
	1.3.j	Ligurian and North-Central Tirrenian Sea	E
	1.3.i	South - Central Tirrenian Sea	F
	1.3.h	Sardinia	G

The data analysed in the present sub-task by country are given in the following table.

	1994	1995	1996	1997	1998	1999	2000
Greece	+	+	+	+	+	+	+
Italy		+	+	+	+	+	

From the collected data abundance and biomass indices by each sub-area, depth stratum and year were estimated for the species *Mullus barbatus* and *Merluccius merluccius*, which are the main target species of the bottom trawl fishery in all countries. In addition to these estimates, abundance and biomass indices were also calculated for the total catch of the target species for Fish, Cephalopods and Crustaceans. The analysis was performed separately for each country; namely Italy and Greece in terms of both number (N/km2) and weight (kg/km2) of the examined species and categories. The abundance of *M. barbatus* in waters deeper than 200 m was negligible. Therefore, further analysis was restricted to depths up to 200 m (three depth zones in total).

The methodology used for estimating standardized catch per unit effort (CPUE) indices was the standard one of analysing a log-transformed response variable using General Linear Models, (GLM), as follows (Gavaris 1980, Kimura 1981):

$\log(\text{CPUE ki}) = \mu + \alpha i + \sigma k + (\alpha\sigma)ki + \varepsilon\ ki$

where:
i= year effect,
k=depth stratum effect
μ=mean
$(\alpha\sigma)_{ki}$= two-way interaction
ε_{ki}= error term
CPUE_{ki} = N/km^2 and kg/km^2 at depth stratum k, in year i

Standardisation was performed on CPUE values expressed in both kg/km^2 and number/km^2. The constant 1 was added to the CPUE values of *M. barbatus* and *M. merluccius* to account for the zero observations. Fitting the log-transformed variable to the factors selected by the analysis of variance using ordinary least squares arrives at the linear model, with the assumption of the log-normally distributed variable. The goodness of fit of the models will be determined by the coefficient of determination (r^2), at the 95% confidence level.

5.2 Results

5.2.1 Greece

5.2.1.1 Fish

5.2.1.1.1 Abundance indices

GLM explained a large proportion of the variance (51 %). The analysis of variance indicated that the differences among depth zones and years were always highly significant. The interactions of area-depth and depth-year were also significant ($P < 0.00$ in both cases), while the effect of area as well as area-year interaction was not significant ($P > 0.05$ in both cases), (Table 1). CPUE indices exhibited an increasing trend from 1994 to 1999, getting their highest values in 1996 and decreased in 2000. The highest values were estimated for the N. Aegean Sea, while Ionian and S. Aegean Seas exhibited lower estimates, but not significantly different. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at the depths between 10 to 50 m (Fig. 1 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. The N. Aegean was characterised by the highest values at depths from 50 to 500 m, the S. Aegean at the shallowest depths (10-50 m), while the Ionian at the deepest zone (500-800 m) (Fig. 2a).

The standardised year estimates by depth zones revealed that there is an increasing trend in the estimated values from 1994 to 2000 for all depths, with the exception of the deepest zone that exhibited a decreasing trend between 1994-1996 and increased sharply from 1997 onwards (Fig. 2b).

The standardised year estimates by area exhibited an increasing trend, although the values do not differ significantly between the different years by area (Fig. 2c).

5.2.1.1.2 Biomass indices

GLM explained a relatively lower proportion of the variance (31 %), when biomass was taken into consideration. The analysis of variance indicated that the differences among depth zones and years were always highly significant. The interactions of area-depth and depth-year were also significant ($P < 0.00$ in both cases), while the effect of area as well as area-year interaction was not significant ($P > 0.05$ in both cases), (Table 1). However, CPUE estimates exhibited quite similar trends with those observed when abundance was analysed.

CPUE indices exhibited an increasing trend from 1994 to 1998, and remained rather constant between 1998-2000. The highest values were estimated for the N. Aegean Sea, while Ionian and S. Aegean Seas exhibited lower estimates, but not significantly different. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at the depths between 50 to 100 m (Figures 3 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. The N. Aegean is characterised by the highest values at depths from 10 to 500 m and the lowest at the deepest zone (500-800 m). In the S. Aegean and Ionian the estimated CPUE values were higher at the deepest waters (500-800 m), while for the shallower depths the estimated values were rather similar for both areas (Fig. 4a).

The standardised year estimates by depth zones revealed that there is an increasing trend in the estimated values from 1994 to 2000, for depths between 10 to 100 m. A similar trend was also found for the depth zones of 100-500 m, with the exception of the years 1997 and 1998, when a decreasing trend was obvious before increasing sharply from 1998 onwards. The opposite was true for the deepest depth zone that exhibited a decreasing trend from 1994 to 1996 and increased sharply from 1997 to 2000 (Fig. 4b).

The standardised year estimates by area exhibited an increasing trend from 1994 to 2000, although the values do not differ significantly between the different years by area (Fig. 4c).

5.2.1.2 Cephalopods

5.2.1.2.1 Abundance indices

GLM explained 47 % of the variance of the cephalopod catches, when abundance was taken into consideration. The analysis of variance indicated that the differences among depth zones and years were always highly significant. The interactions of area-depth, area-year and depth-year were also significant

(P < 0.05), while the effects of area was not significant (P > 0.05), (Table 2). CPUE indices exhibited an increasing trend from 1995 to 2000, getting their lowest values in 1995. The highest values were estimated for the Ionian Sea and the lowest for the S. Aegean Sea, but these estimates were not significantly different. The CPUE estimates exhibited an increasing trend with depth down to 200 m, while decreased significantly at depths deeper than 200 m and the lowest estimates were found at the deepest depth zone (500-800 m) (Fig. 5 a-c)

The standardised major area estimates by depth zones revealed that the lowest values were recorded at depths between 500-800 m, for all areas. The estimates for the rest of the depth zones were more diverse for the Ionian Sea, while the variability was not very pronounced for the North and South Aegean Seas. However the highest estimates were recorded for the 100-200 m depth zone for all areas (Fig. 6a).

The standardised year estimates by depth zones revealed that in general there was an increasing trend in the estimated values from 1995 to 2000 for all depth zones. The highest estimates were found at depths between 100-200 m and the lowest at depths of 500-800 m (Fig. 6b)

The standardised year estimates by area exhibited significant fluctuations in all areas. In the N. Aegean Sea there is an increasing trend from 1996 to 2000, while for the Ionian and S. Aegean Seas followed a rather complex pattern and there were significant fluctuations among years (Fig. 6c).

5.2.1.2.2 Biomass indices

GLM explained 37 % of the variance of the cephalopod catches, when biomass was taken into consideration. The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interaction of depth-year was also significant (P < 0.00), while the effects of area-depth and area-year interactions were not significant (P > 0.05), (Table 2). CPUE indices exhibited an increasing trend from 1995 to 2000, getting their lowest values in 1995 and the highest in 2000. The highest values were estimated for the N. Aegean Sea and the lowest for the Ionian Sea. The CPUE estimates exhibited a decreasing trend with depth with a sharp decline at depths deeper than 500 m (Fig. 7 a-c).

The standardised major area estimates by depth zones revealed that the lowest values were recorded at depths between 500-800 m, for all areas. The estimates for the rest of the depth zones were more diverse for the S. Aegean Sea, while the variability was not very pronounced for the Ionian Sea. The highest estimates were recorded for the 10-50 m depth zone for the Northern and Southern Aegean Sea (Fig. 8a).

The standardised year estimates by depth zones revealed significant fluctuations for all depth zones. The lowest estimates were recorded at depths deeper than 500 m, while for the rest depth zones no clear pattern could be found. However, for most cases the highest estimates were found at the shallowest depths (10-50 m) (Fig. 8b).

The standardised year estimates by area exhibited significant fluctuations in all areas with the lowest values recorded in 1995. In the N. Aegean Sea there is an increasing trend from 1996 to 2000, while the lowest values were found mainly in the Ionian Sea (Fig. 8c).

5.2.1.3 Crustaceans

5.2.1.3.1 Abundance indices

GLM explained 25 % of the variance when abundance was taken into consideration. The analysis of variance indicated that the differences among depth zones and years were always highly significant. The interaction of depth-year was also significant (P < 0.00), while the effects of area as well as area-depth and area-year interactions were not significant (P > 0.05 in all cases), (Table 3). CPUE indices exhibited an increasing trend from 1994 to 1999, getting their highest values in 1999 and decreased slightly in 2000. The highest values were estimated for the N. Aegean Sea, while the Ionian and S. Aegean Seas exhibited lower estimates, but not significantly different. The CPUE estimates exhibited an increasing trend with depth down to 500 m, while decreased significantly at depths deeper than 500 m. However, the lowest estimates were found at the shallowest depth zone (10-50 m) (Fig. 9 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas, but the highest values were recorded at depths between 200-500 m. The N. Aegean is characterised by the lowest values at depths below 500 m, while for the Ionian and S. Aegean Seas the lowest values were at the 50-100 m depth zone. However, these differences were not statistically significant as indicated by the ANOVA test (Fig. 10a).

The standardised year estimates by depth zones revealed that there is an increasing trend in the estimated values from 1994 to 1996 and from 1997 to 1999 for depths between 200 to 500 m. An increasing trend was also found for the depth zones of 500-800 m, between 1995 and 2000. For the rest of the depth zones the fluctuations observed did not follow a clear pattern, but the lowest estimates were recorded at depths from 10 to 50 m (Fig. 10b).

The standardised year estimates by area exhibited in general an increasing trend from 1994 to 2000, although the values do not differ significantly between the different years by area (Fig. 10c).

5.2.1.3.2 Biomass indices

GLM explained 21 % of the variance for the crustacean catches when biomass was taken into consideration. The analysis of variance indicated that the differences among depth zones were always highly significant. The interaction of depth-year was also significant ($P < 0.00$), while the effects of area and year as well as area-depth and area-year interactions were not significant ($P > 0.05$ in all cases), (Table 3). CPUE indices exhibited an increasing trend from 1994 to 1999, with the exception of 1996, getting their highest values in 1999 and decreased slightly in 2000. The highest values were estimated for the N. Aegean Sea, while Ionian and S. Aegean Seas exhibited lower estimates, but not significantly different. The CPUE estimates exhibited an increasing trend with depth down to 500 m, while decreased significantly at depths deeper than 500 m. However, the lowest estimates were found at the shallowest depth zone (10-50 m) (Fig. 11 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. The highest values were recorded at depths between 200-500 m, and the lowest at the shallowest depth zone (10-50 m). The North and South Aegean are characterised by the highest values at depths between 200-500 m, while for the Ionian Sea the highest values were at the 100-200 m depth zone. However, these differences were not statistically significant as indicated by the ANOVA test (Fig. 12a).

The standardised year estimates by depth zones followed a rather complex pattern and there were significant fluctuations among years. The highest indices were estimated for the depths 200-500 m, and the lowest for the shallowest depths (10-50 m) (Fig. 12b).

The standardised year estimates by area revealed that in the N. Aegean Sea there is an increasing trend from 1995 to 2000. The lowest values were found in the Ionian Sea, while the S. Aegean Sea exhibited an intermediate position. However, the estimated values do not differ significantly between the different years by area (Fig. 12c).

5.2.1.4 M. merluccius

5.2.1.4.1 Abundance indices

GLM explained 27 % of the variance of *M. merluccius* catches, when abundance was taken into consideration. The analysis of variance indicated that the differences among area and depth zones were always highly significant. The interactions of area-depth and area-year were also significant ($P < 0.05$), while the effect of year as well as depth-year interaction was not significant ($P > 0.05$), (Table 4). CPUE indices exhibited low variability between years with their minimum values in 1997 and an increasing trend from 1997 to 2000. The highest values were estimated for the N. Aegean Sea and the lowest for the S. Aegean Sea. The CPUE estimates exhibited an increasing trend with depth down to 200 m, while decreased significantly at depths deeper than 200 m and the lowest estimates were found at the deepest depth zone (500-800 m) (Fig. 13 a-c).

The standardised major area estimates by depth zones revealed that the lowest values were recorded at the deepest zone (500-800 m) and the highest at depths between 100-200 m, for all areas (14 a).

The standardised year estimates by depth zones followed a rather complex pattern and there were significant fluctuations among years. The lowest estimates were recorded at the deepest zone (500-800 m), for all years and the highest indices were estimated for the depths 100-200 m (14 b).

The standardised year estimates by area exhibited in general an increasing trend for the N. Aegean Sea. The highest estimates were recorded in the Ionian Sea for the years 1995 and 1996, and for the N. Aegean Sea for the years 1997-1999. Although the lowest values were in general recorded in the S. Aegean Sea there is an increasing trend in the estimates from 1996 to 1999 (14c).

5.2.1.4.2 Biomass indices

GLM explained a relatively lower proportion of the variance (17 %), when biomass was taken into consideration. The analysis of variance indicated that the differences among area and depth zones were always highly significant. The interactions of area-depth, area-year and depth-year were also significant ($P < 0.05$), while the effect of year was not significant ($P > 0.05$), (Table 4). CPUE indices exhibited low variability between years, getting their minimum values in 1996 and showing an increasing trend from 1997 to 2000. The highest values were estimated for the N. Aegean Sea and the lowest for the S. Aegean Sea. The CPUE estimates exhibited an increasing trend with depth down to 500 m, while decreased significantly at the deepest depth zone (500-800 m) (15 a-c).

The standardised major area estimates by depth zones revealed that the lowest values were recorded at the deepest zone (500-800 m), with the exception of the S. Aegean Sea where the lowest estimates were found at depths from 50-100 m (16a).

The standardised year estimates by depth zones followed a rather complex pattern and there were significant fluctuations among years. The lowest estimates were recorded, in general, at the deepest zone (500-800 m), for almost all years and the highest indices were estimated for the depths 100-200 m and 200-500 m (16b).

The standardised year estimates by area exhibited an increasing trend for the N. Aegean Sea from 1995 to 1999, while the opposite was true for the Ionian Sea. Although the lowest values were in general recorded in the S. Aegean Sea there was an increasing trend in the estimates from 1996 to 1998 (16c).

5.2.1.5 M. barbatus

5.2.1.5.1 Abundance indices

GLM explained a low proportion of the variance (13 %), when *M. barbatus* abundance was taken into consideration. The analysis of variance indicated that the differences among depth zones and years were always highly significant. The interaction of area-depth was also significant ($P < 0.05$), while the effects of area as well as area-year and depth-year interactions were not significant ($P > 0.05$ in all cases) (Table 5).

CPUE indices exhibited an increasing trend from 1994 to 1998, and decreased steadily from 1998 to 2000. The highest values were estimated for the Ionian Sea, while North and South Aegean Seas exhibited lower estimates, but not significantly different. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at the depths between 10 and 50 m (Figures 17 a-c).

The standardised major area estimates by depth zones revealed that the lowest values were recorded at depths from 100 to 200 m for almost all areas. The N. Aegean is characterised by the highest values at depths from 10 to 50 m, and the lowest at depths between 50-100 m. In the S. Aegean and Ionian the estimated CPUE values were higher at depths from 50 to 100 m, while for the shallower depths the estimated values were rather similar for both areas (18a).

The standardised year estimates by depth zones revealed that there is an increasing trend in the estimated values from 1994 to 1998 for depths between 10 to 100 m. A similar trend was also found for the depth zone of 100-200 m, with the exception of the years 1995 and 1997, when a decreasing trend was obvious before increasing sharply in 1998 (18b).

The standardised year estimates by area exhibited in general an increasing trend from 1994 to 1998, for all areas, and decreased from 1998 to 2000. The highest estimates were recorded in the Ionian Sea and the lowest in the N. Aegean Sea although the values do not differ significantly between the different years by area (18c).

5.2.1.5.2 Biomass indices

GLM explained a low proportion of the variance (13 %), when *M. barbatus* biomass was taken into consideration. The analysis of variance indicated that the differences among depth zones and years were always highly significant. The interaction of area-depth was also significant ($P < 0.05$), while the effects of area as well as area-year and depth-year interactions were not significant ($P > 0.05$ in all cases) (Table 5).

CPUE indices exhibited an increasing trend from 1994 to 1998, and decreased steadily from 1998 to 2000. The highest values were estimated for the Ionian Sea, while North and South Aegean Seas exhibited lower estimates, but not significantly different. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at depths between 10 and 50 m (Figures 19 a -c).

The standardised major area estimates by depth zones revealed that the lowest values were recorded at depths from 100 to 200 m for almost all areas. The N. Aegean is characterised by the highest values at depths from 10 to 50 m, and the lowest at depths between 50-100 m. In the S. Aegean and Ionian the estimated CPUE values were higher at depths from 50 to 100 m, while for the shallower depths the estimated values were rather similar for both areas (Fig. 20a)

The standardised year estimates by depth zones revealed that there is an increasing trend in the estimated values from 1994 to 1998 for depths between 10 and 100 m. A similar trend was also found for the depth zone of 100-200 m, with the exception of the years 1995 and 1997, when a decreasing trend was obvious before increasing sharply in 1997 (Fig. 20b).

The standardised year estimates by area exhibited in general an increasing trend from 1994 to 1998, for all areas, and decreased from 1998 to 2000. The highest estimates were recorded in the Ionian Sea and the lowest in the N. Aegean Sea although the values do not differ significantly between the different years by area (Fig. 20c).

Table 1. Analysis of variance of the General Linear Model fitted to the total catches for the target fish species in the Greek waters, for the period 1994-2000

Abundance (R^2=0.51)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	1.57	2	0.78	2.56	0.08
Depth	196.50	4	49.12	160.37	0.00
Year	13.75	6	2.29	7.48	0.00
Area*Depth	9.29	8	1.16	3.79	0.00
Area*Year	4.66	12	0.39	1.27	0.23
Depth*Year	15.88	24	0.66	2.16	0.00
Residual	303.25	990	0.31		
Total (corrected)	614.54	1046			

Biomass (R^2=0.31)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	0.59	2	0.29	1.04	0.35
Depth	64.43	4	16.11	57.35	0.00
Year	6.36	6	1.06	3.77	0.00
Area*Depth	7.49	8	0.94	3.33	0.00
Area*Year	5.60	12	0.47	1.66	0.07
Depth*Year	20.27	24	0.84	3.01	0.00
Residual	278.02	990	0.28		
Total (corrected)	405.28	1046			

Table 2. Analysis of variance of the General Linear Model fitted to the total catches for the target cephalopod species in the Greek waters, for the period 1994-2000

Abundance (R^2=0.47)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	1.02	2	0.51	1.97	0.14
Depth	100.93	4	25.23	97.40	0.00
Year	22.24	6	3.71	14.31	0.00
Area*Depth	5.30	8	0.66	2.56	0.01
Area*Year	16.97	12	1.41	2.46	0.00
Depth*Year	11.07	24	0.46	1.78	0.01
Residual	238.06	919	0.26		
Total (corrected)	449.63	975			

Biomass (R^2=0.37)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	3.24	2	1.62	5.44	0.01
Depth	57.15	4	14.29	48.04	0.00
Year	12.62	6	2.10	7.07	0.00
Area*Depth	5.86	8	0.73	2.46	0.12
Area*Year	3.56	12	0.30	1.00	0.45
Depth*Year	28.32	24	1.18	3.97	0.00
Residual	273.33	919	0.30		
Total (corrected)	431.22	975			

Table 3. Analysis of variance of the General Linear Model fitted to the total catches for the target crustacean species in the Greek waters, for the period 1994-2000

Abundance (R^2=0.25)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	0.35	2	0.17	0.29	0.75
Depth	57.78	4	14.44	24.29	0.00
Year	13.56	6	2.26	3.80	0.00
Area*Depth	2.15	8	1.22	0.42	0.80
Area*Year	3.49	12	0.29	0.49	0.92
Depth*Year	32.66	24	1.36	2.29	0.00
Residual	397.83	669	0.59		
Total (corrected)	526.72	717			

Biomass (R^2=0.21)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	1.84	2	0.92	1.58	0.21
Depth	39.03	4	9.76	16.77	0.00
Year	6.46	6	1.08	1.85	0.09
Area*Depth	3.52	8	0.98	1.62	0.71
Area*Year	5.64	12	0.47	0.81	0.64
Depth*Year	32.91	24	1.37	2.36	0.00
Residual	385.74	669	0.58		
Total (corrected)	486.21	717			

Table 4. Analysis of variance of the General Linear Model fitted to the catches of *Merluccius merluccius* in the Greek waters, for the period 1994-2000

Abundance (R^2=0.27)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	6.92	2	3.46	4.12	0.02
Depth	136.48	3	45.49	54.18	0.00
Year	4.91	6	0.82	0.97	0.44
Area*Depth	41.76	6	6.96	8.29	0.00
Area*Year	23.42	12	1.95	2.32	0.01
Depth*Year	32.36	18	1.80	2.14	0.04
Residual	760.70	906	0.84		
Total (corrected)	1043.75	953			

Biomass (R^2=0.17)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	8.26	2	4.13	8.91	0.00
Depth	17.20	3	5.73	12.37	0.00
Year	1.77	6	0.30	0.64	0.70
Area*Depth	14.33	6	1.02	5.15	0.00
Area*Year	12.29	12	0.97	2.21	0.01
Depth*Year	17.53	18	0.46	2.10	0.01
Residual	419.89	906			
Total (corrected)	501.62	953			

Table 5. Analysis of variance of the General Linear Model fitted to the catches of *M. barbatus* in the Greek waters, for the period 1994-2000

Abundance (R^2=0.13)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	8.98	2	4.49	2.23	0.11
Depth	27.44	2	13.72	6.81	0.00
Year	36.93	6	6.16	3.05	0.01
Area*Depth	29.52	4	7.38	3.66	0.01
Area*Year	18.39	12	1.53	0.76	0.69
Depth*Year	13.08	12	1.09	0.54	0.89
Residual	1050.32	521	2.02		
Total (corrected)	1204.32	559			

Biomass (R^2=0.13)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	1.80	2	0.90	1.40	0.25
Depth	7.48	2	3.74	5.82	0.00
Year	12.71	6	2.12	3.30	0.00
Area*Depth	9.12	4	2.28	3.55	0.01
Area*Year	4.81	12	0.40	0.62	0.82
Depth*Year	5.59	12	0.47	0.73	0.73
Residual	334.54	521	0.64		
Total (corrected)	382.73	559			

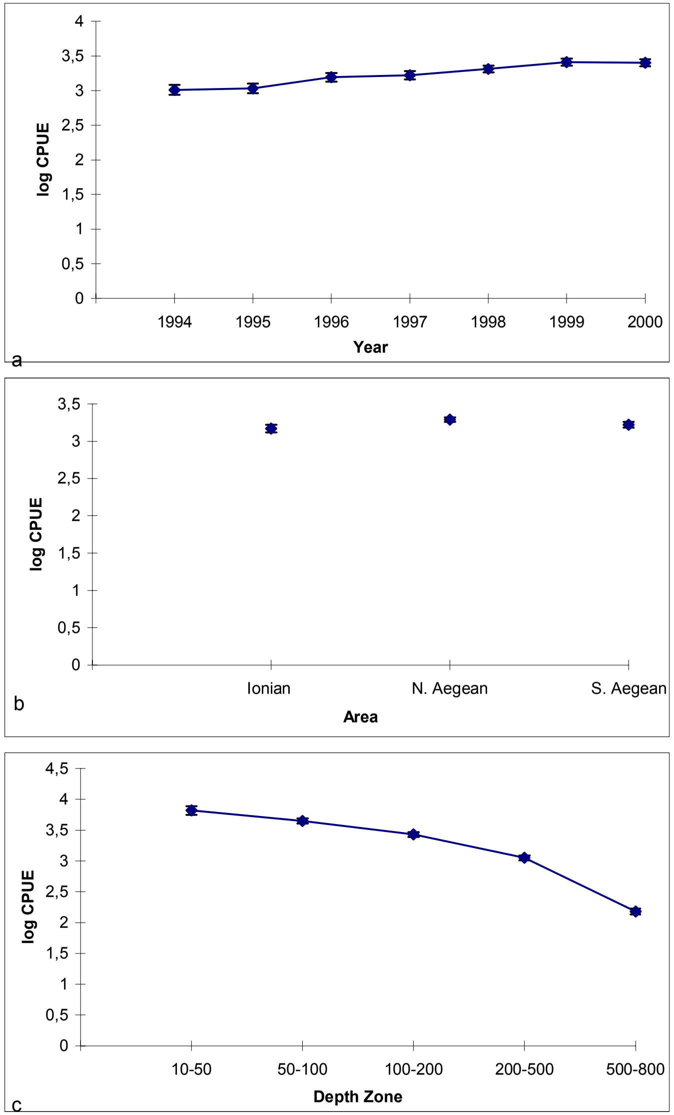

Fig. 1. Standardized CPUE estimates (abundance) for the target fish species in the Greek waters by a) Year, b) area and c) depth zone.

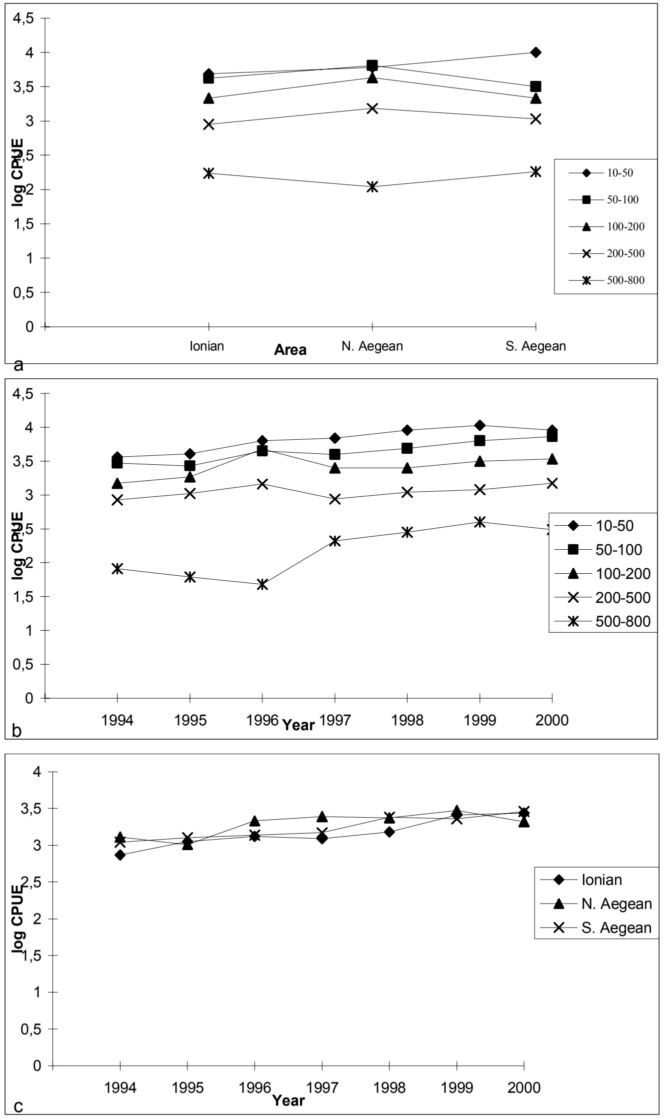

Fig. 2. Standardized CPUE estimates (abundance) for the target fish species in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

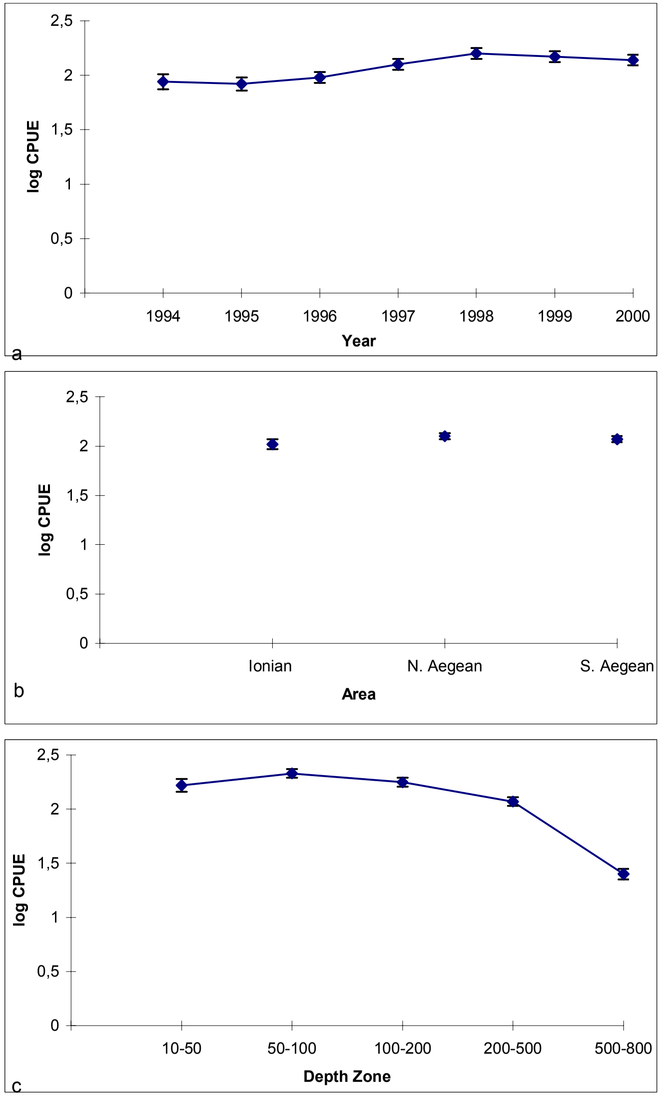

Fig. 3. Standardized CPUE estimates (biomass) for the target fish species in the Greek waters by a) Year, b) area and c) depth zone.

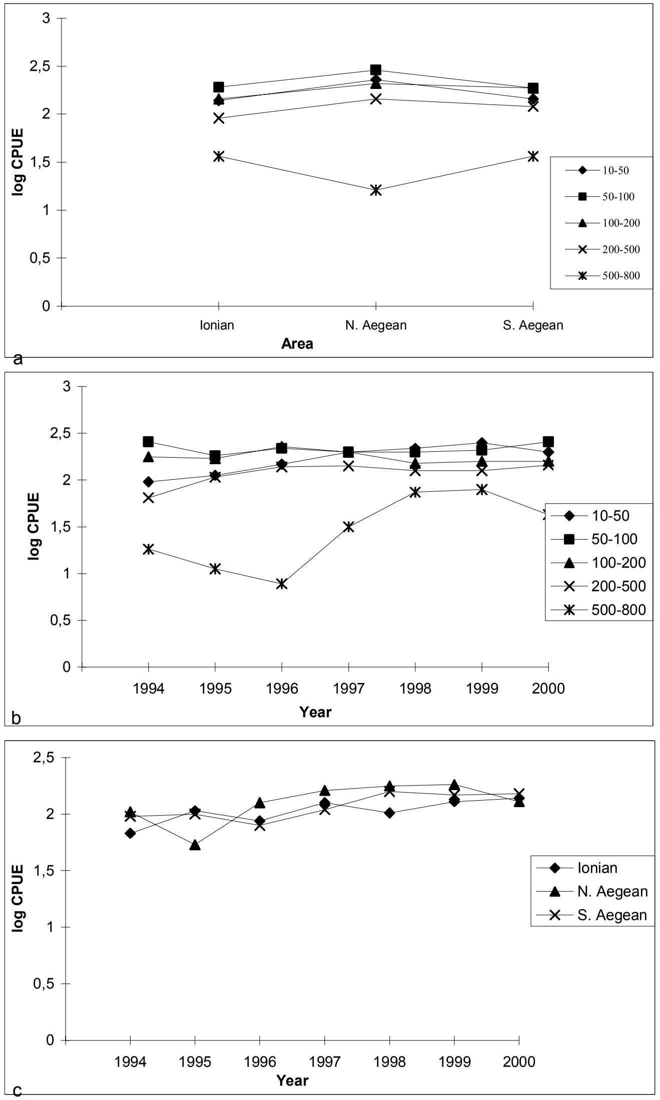

Fig. 4. Standardized CPUE estimates (biomass) for the target fish species in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

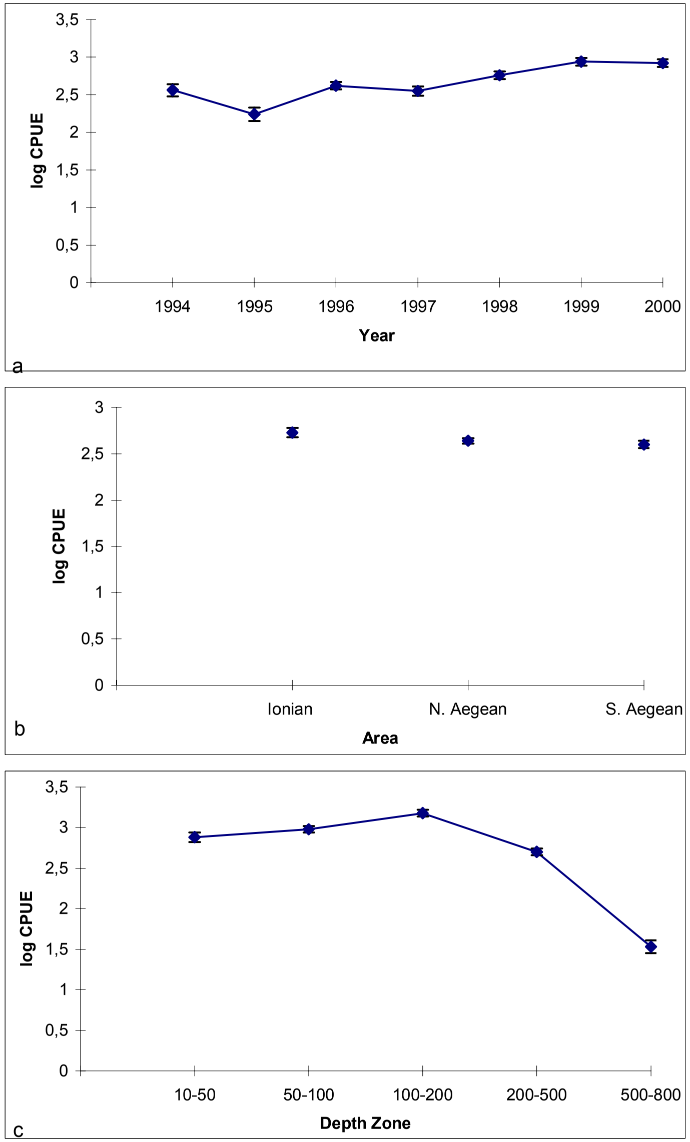

Fig. 5. Standardized CPUE estimates (abundance) for the target cephalopod species in the Greek waters by a) Year, b) area and c) depth zone.

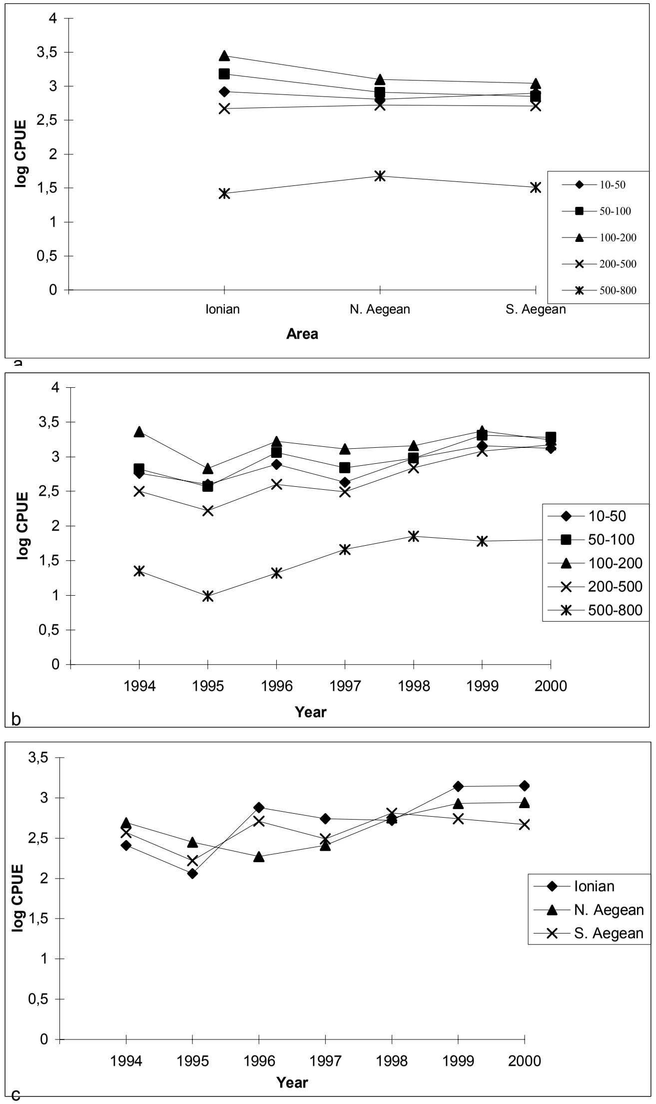

Fig. 6. Standardized CPUE estimates (abundance) for the target cephalopod species in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

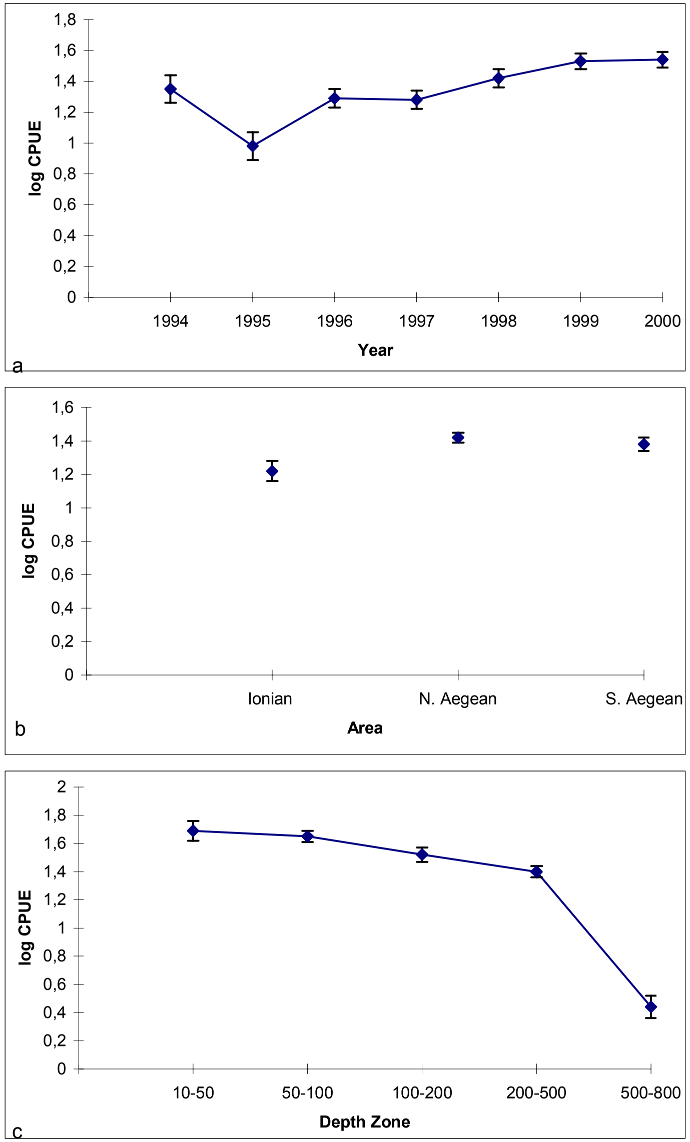

Fig. 7. Standardized CPUE estimates (biomass) for the target cephalopod species in the Greek waters by a) Year, b) area and c) depth zone.

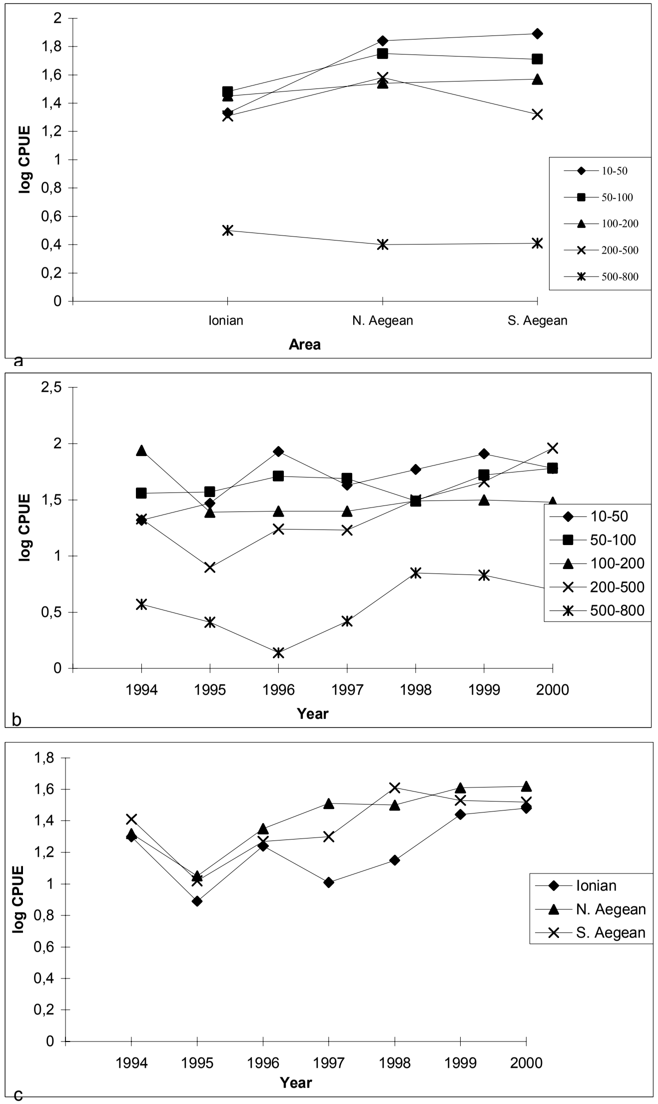

Fig. 8. Standardized CPUE estimates (biomass) for the target cephalopod species in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

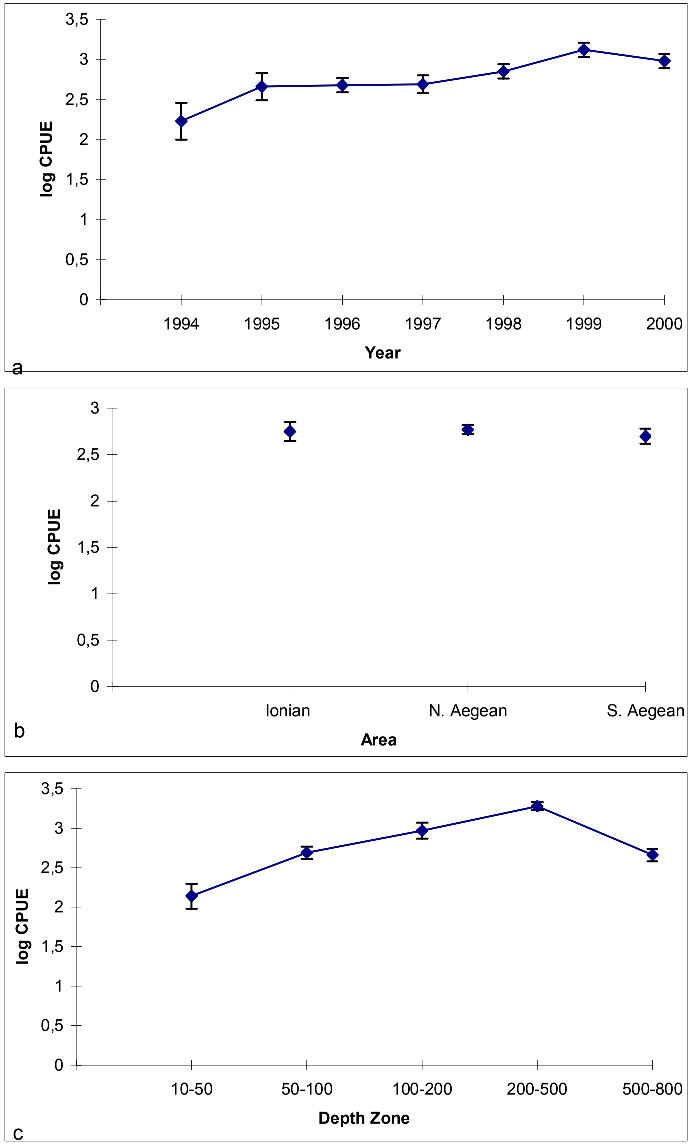

Fig. 9. Standardized CPUE estimates (abundance) for the target crustacean species in the Greek waters by a) Year, b) area and c) depth zone.

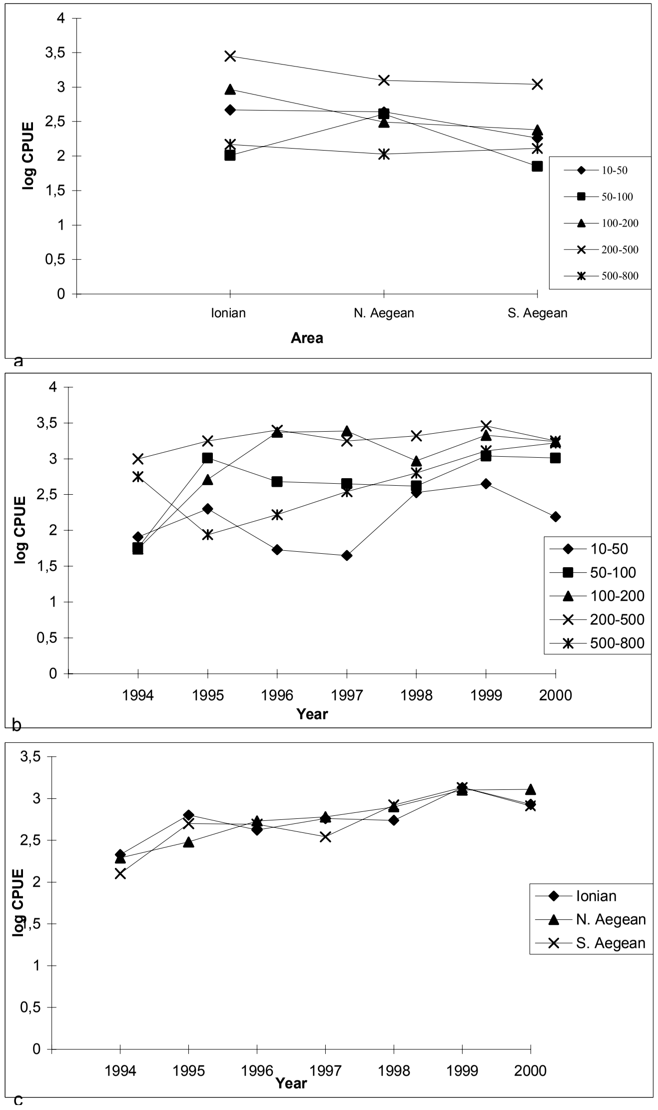

Fig. 10. Standardized CPUE estimates (abundance) for the target crustacean species in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

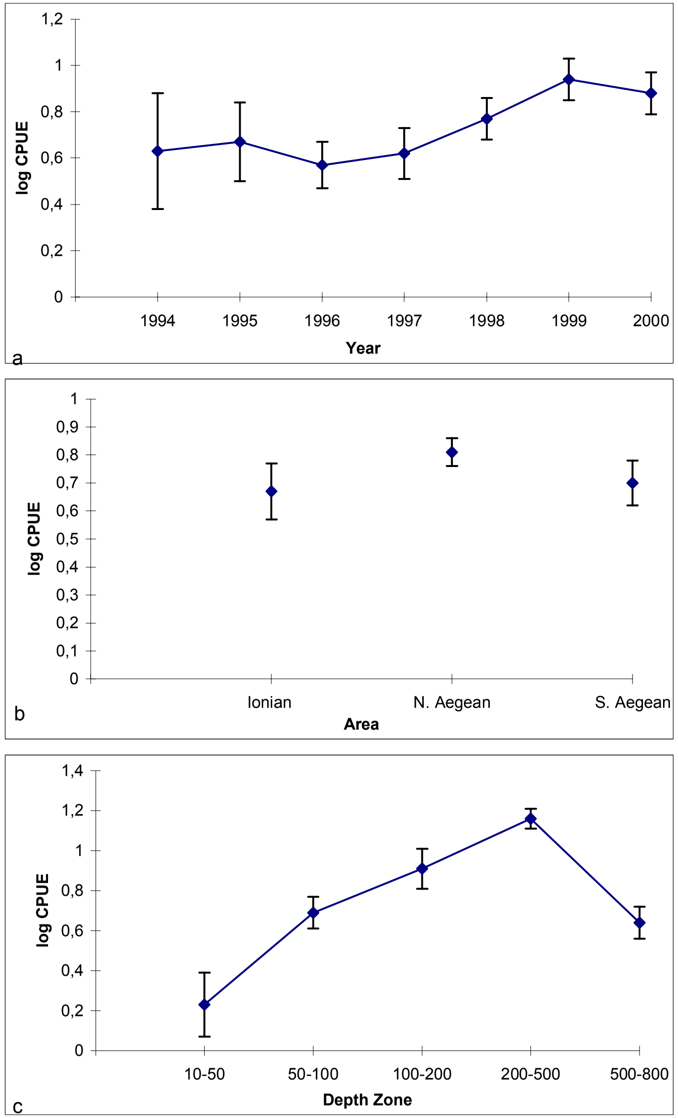

Fig. 11. Standardized CPUE estimates (biomass) for the target crustacea species in the Greek waters by a) Year, b) area and c) depth zone.

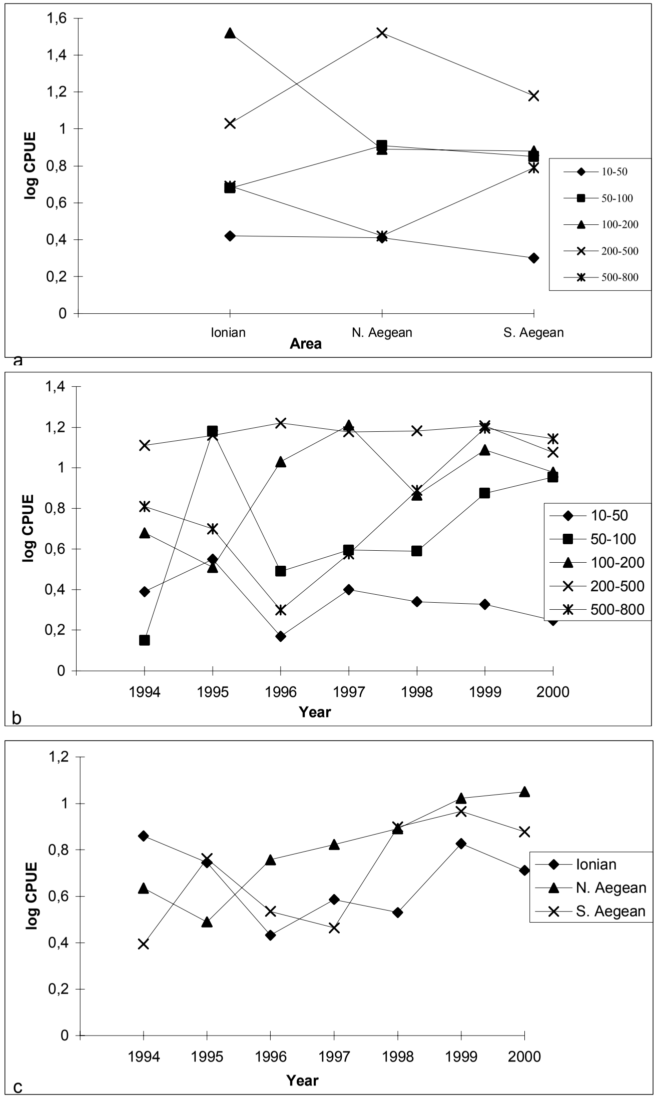

Fig. 12. Standardized CPUE estimates (biomass) for the target crustacea species in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

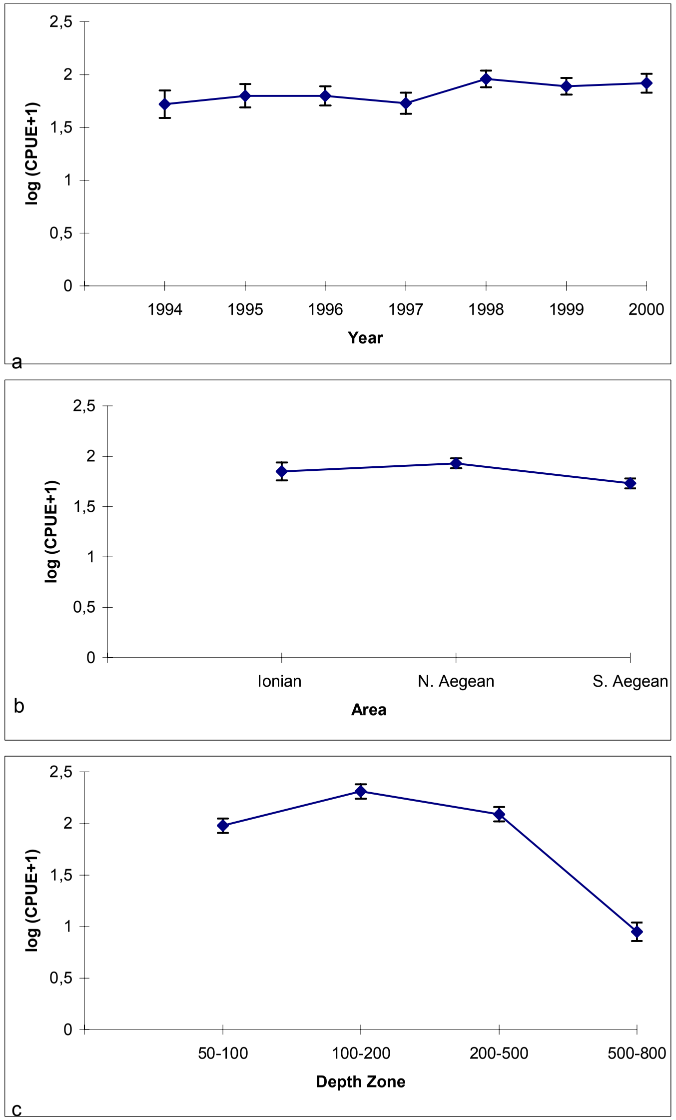

Fig. 13. Standardized CPUE estimates (abundance) for *M. merluccius* in the Greek waters by a) Year, b) area and c) depth zone.

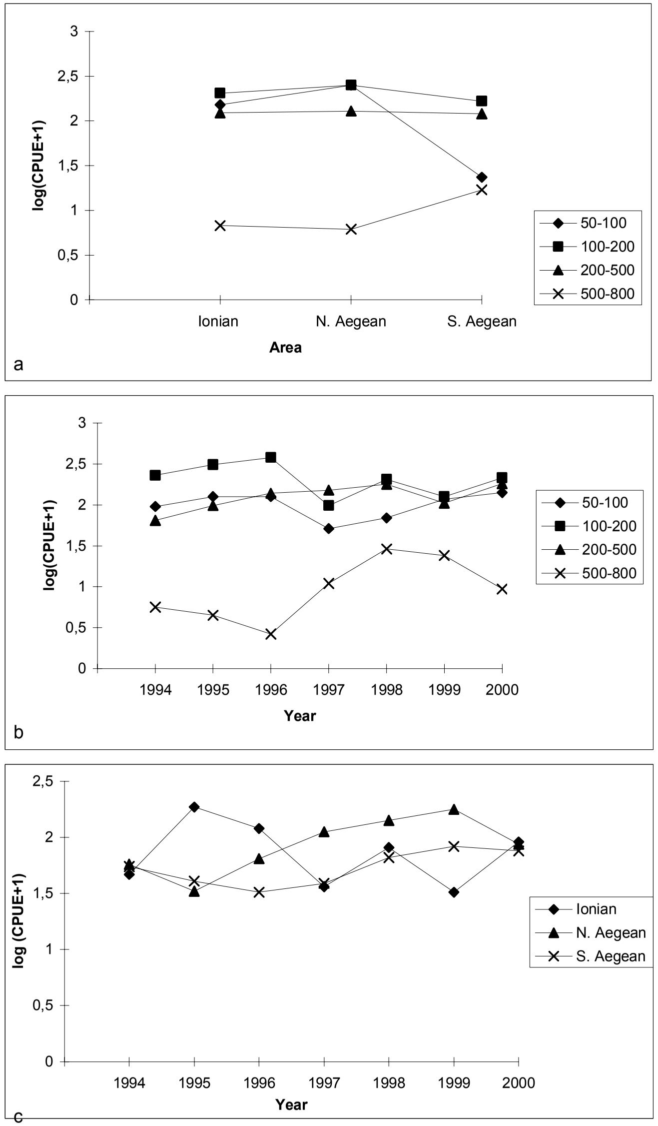

Fig. 14. Standardized CPUE estimates (abundance) for *M. merluccius* in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

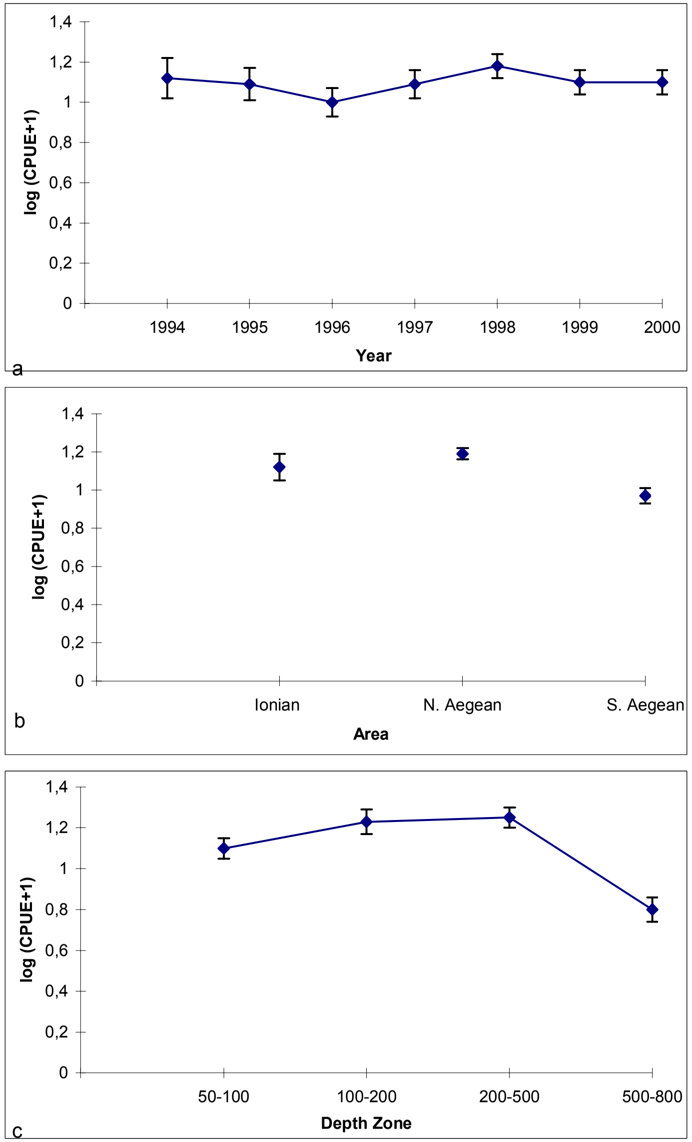

Fig. 15. Standardized CPUE estimates (biomass) for *M. merluccius* in the Greek waters by a) Year, b) area and c) depth zone.

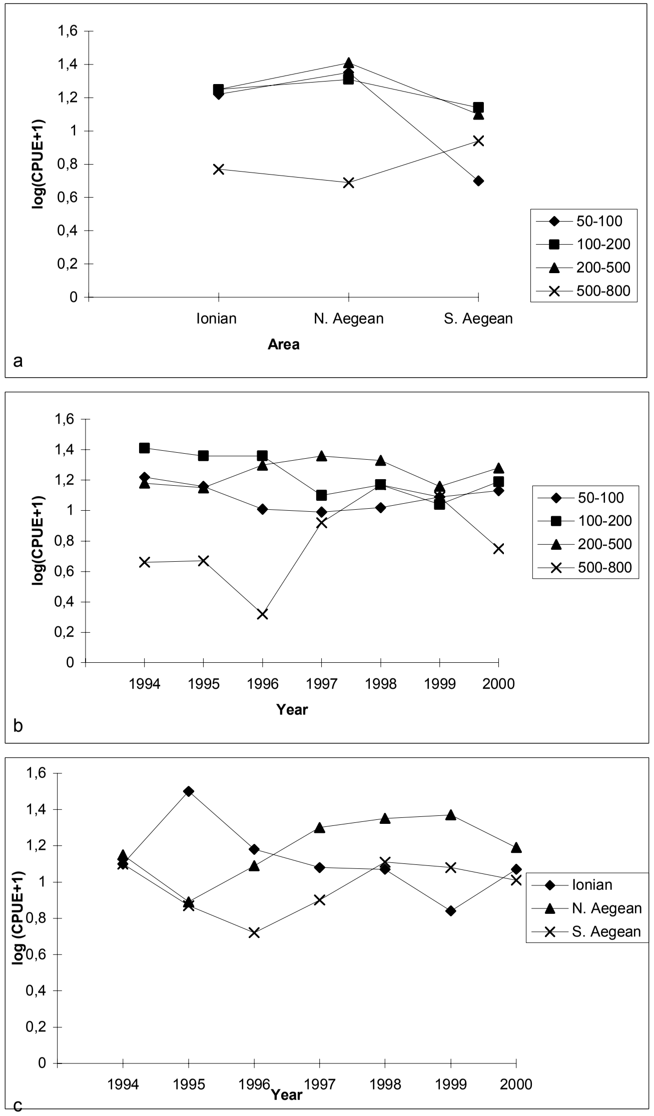

Fig. 16. Standardized CPUE estimates (biomass) for *M. merluccius* in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

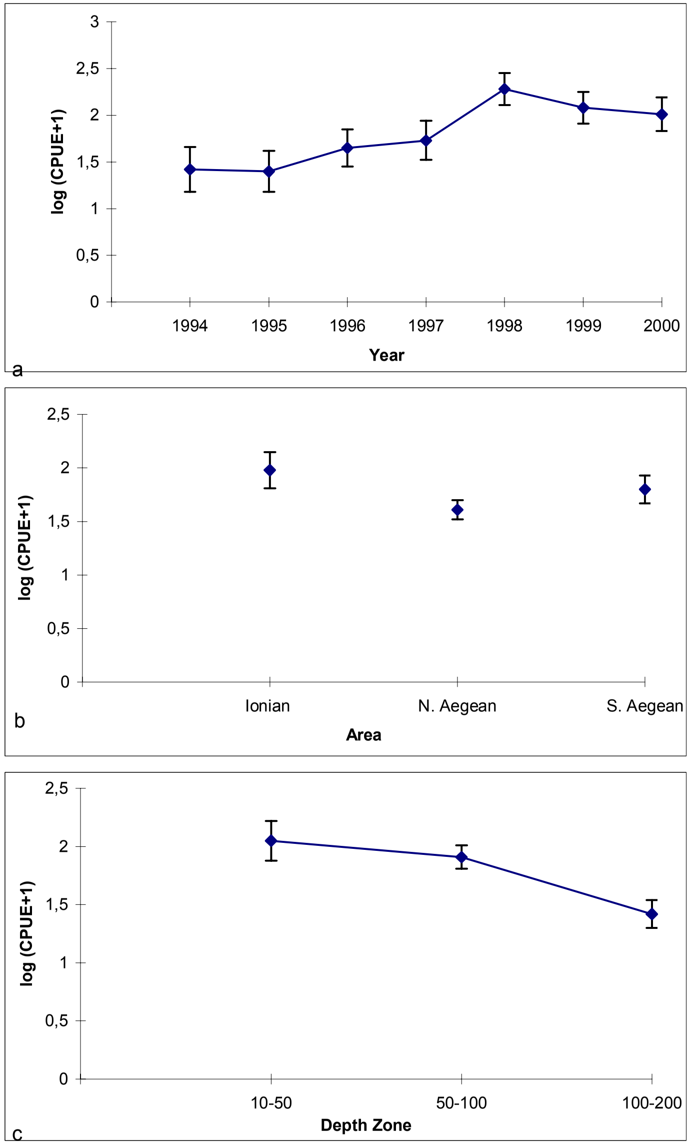

Fig. 17. Standardized CPUE estimates (abundance) for *M. barbatus* in the Greek waters by a) Year, b) area and c) depth zone.

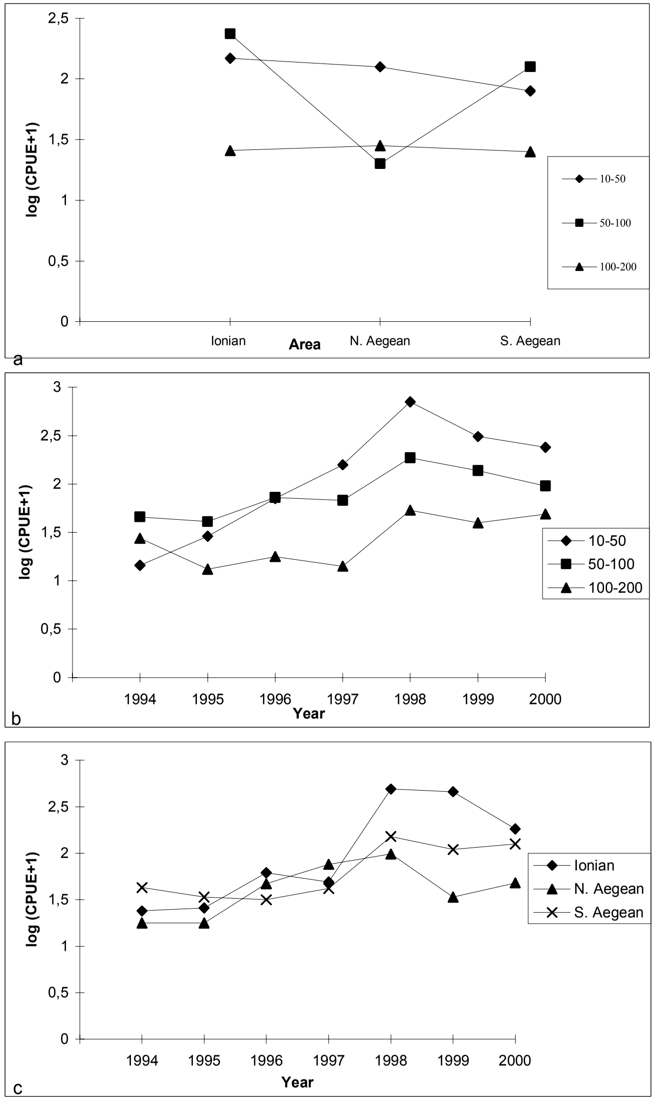

Fig. 18. Standardized CPUE estimates (abundance) for *M. barbatus* in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area.

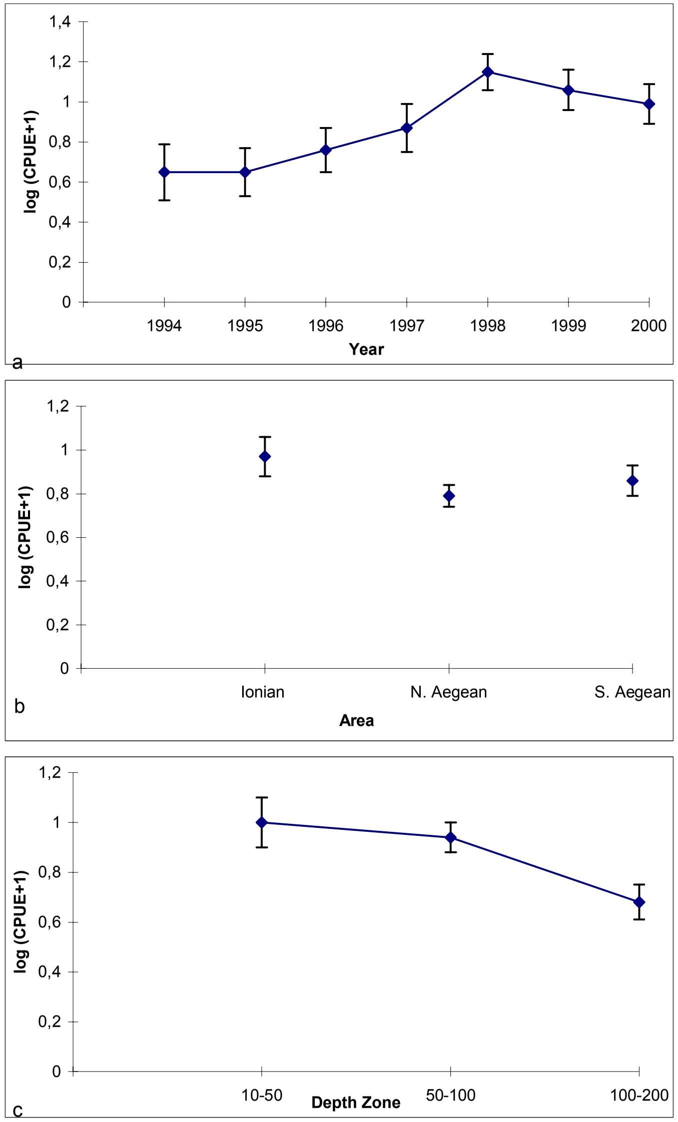

Fig. 19. Standardized CPUE estimates (biomass) *M. barbatus* in the Greek waters by a) Year, b) area and c) depth zone.

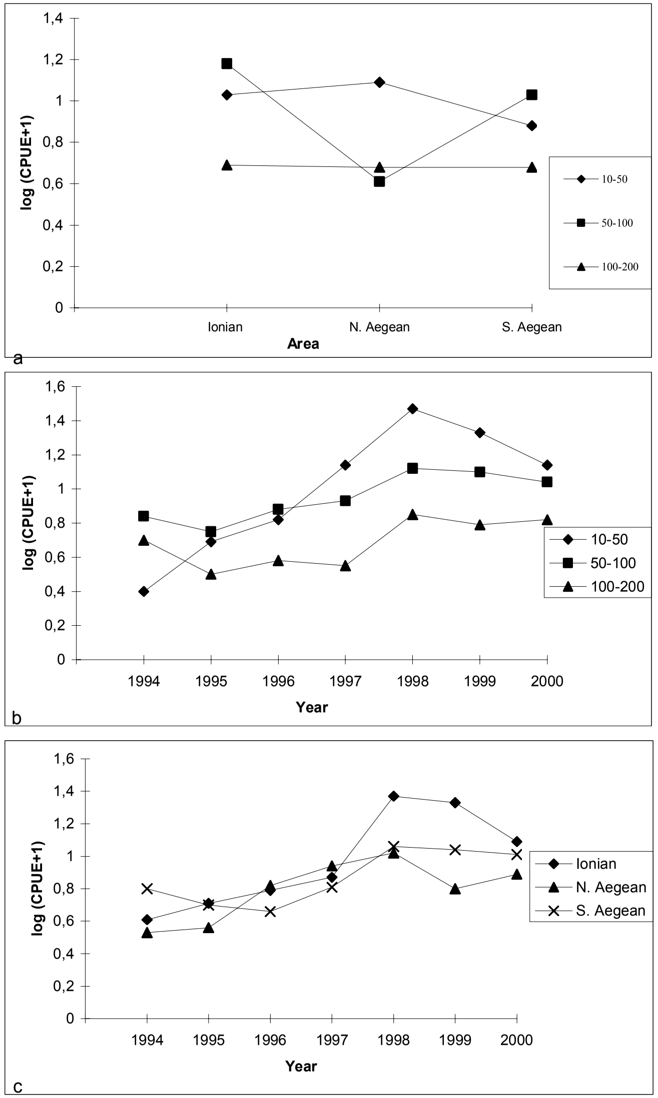

Fig. 20. Standardized CPUE estimates (biomass) for *M. barbatus* in the Greek waters by a) Area and depth zone, b) year and depth zone and c) year and area

5.2.2 Italy

5.2.2.1 Fish

5.2.2.1.1 Abundance indices

GLM explained a large proportion of the variance (48 %). The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth and area-year were also significant ($P < 0.00$ in both cases), while the effect of depth-year interaction was not significant ($P > 0.05$), (Table 1).

CPUE indices exhibited an increasing trend from 1997 to 1999, getting their lowest values in 1997 and increased in 1999. The highest values were estimated for Sardinia, while S. Adriatic Sea exhibited the lowest estimates. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at depths between 10 and 50 m and the lowest at the deepest zone (Fig. 1 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. However, the lowest values were recorded at depths between 500-800 m. The highest values were found at depths between 100-500 m, in the Adriatic Sea, and between 50-100 m in the South-Central Tyrrhenian Sea (Fig. 2a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1999 for all depths. The lowest estimates were recorded at depths below 500 m, while the highest estimates were recorded at depths between 100-200 m, during all years, with the exception of 1996 when the highest estimates were found at depths between 50-100 m (Fig. 2b).

The standardised year estimates by area exhibited a rather complex pattern and there were significant fluctuations among years in each area. The highest values were estimated in Sardinia throughout the years under study (Fig. 2c).

5.2.2.1.2 Biomass indices

GLM explained a relatively lower proportion of the variance (37 %), when biomass of the total fish catches was taken into consideration. The analysis of variance indicated that the differences among areas and depth zones were always highly significant. The interactions of area-depth, area-year and depth-year were also significant ($P < 0.00$ in all cases), while the effect of year was not significant ($P > 0.05$), (Table 1).

CPUE indices exhibited an increasing trend from 1995 to 1997, and decreased from 1997 to 1999, although the values do not differ significantly between the different years. The highest values were estimated for Sardinia, while the Western Ionian Sea exhibited the lowest estimates. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at depths between 10 and 100 m and the lowest at the deepest zone (Fig. 3 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. However, the lowest values were recorded at depths between 500-800 m. The highest values for depths between 10-200 m, were recorded in Sardinia and in the waters off Sicily and Malta (Fig. 4a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1999 for all depths, except that of 200-500 m. The lowest estimates were always recorded at depths below 500 m, while the highest estimates were recorded at depths between 50-100 m, during 1996-1998, and between 100-200 m in 1995 and 1999 (Fig. 4b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The highest values were estimated in Sardinia throughout the years under study (Fig. 4c).

5.2.2.2 Cephalopods

5.2.2.2.1 Abundance indices

GLM explained a large proportion of the variance (62 %). The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth, area-year and depth-year were also significant ($P < 0.00$ in all cases) (Table 2).

CPUE indices exhibited an increasing trend from 1995 to 1999, getting their highest values in 1999. The highest values were estimated for the Ligurian and N. Tyrrhenian Sea, the waters off Sicily and Malta and Sardinia, while the W. Ionian Sea exhibited the lowest estimates. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at the depths between 10 to 50 m and 100-200 m and the lowest at the deepest zone (Fig. 5 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. However, the lowest values were always recorded at depths between 500-800 m. The highest values were found at depths of 10-50 m and 100-200 m depending on the area (Fig. 6a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1999 for all depths. The lowest estimates were recorded at depths below 500 m during all years, while the highest estimates were recorded at depths between 10-50 m and 100-200 m (Fig. 6b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The lowest values were estimated in W. Ionian Sea throughout the years under study, while the highest estimates were recorded in Ligurian and N. Tyrrhenian Sea and the Northern Adriatic (Fig. 6c).

5.2.2.2.2 Biomass indices

GLM explained a relatively lower proportion of the variance (43 %), when biomass of the total cephalopod catches was taken into consideration. The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth, area-year and depth-year were also significant ($P < 0.00$ in all cases) (Table 2).

CPUE indices exhibited an increasing trend from 1995 to 1999, getting their highest values in 1999. The highest values were estimated for Sardinia, while the W. Ionian Sea exhibited the lowest estimates. The CPUE estimates exhibited a decreasing trend with depth, with the highest values at the depths between 10 and 200 m and the lowest at the deepest zone (Fig. 7 a-c).

The standardised major area estimates by depth zones revealed that fluctuations were always distinct among the areas. However, the lowest values were recorded at depths between 500-800 m. The highest values were found at depths of 10-50 m (Sardinia and South-Central Tyrrhenian Sea), 50-100 m (W. Ionian and waters off Sicily and Malta) and 100-200 m (Ligurian and N. Tyrrhenian Sea and S. Adriatic) (Fig. 8a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1999 for all depths. The lowest estimates were recorded at depths below 500 m during all years, while the highest estimates were recorded at depths between 10-50 m and 100-200 m (Fig. 8b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The lowest values were estimated in the W. Ionian Sea throughout the years under study, while the highest estimates were recorded in Sardinia throughout the study period (Fig. 8c).

5.2.2.3 Crustaceans

5.2.2.3.1 Abundance indices

GLM explained a large proportion of the variance (41 %). The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth and area-year were also significant ($P < 0.00$ in both cases), while the effect of depth-year interaction was not significant ($P > 0.05$), (Table 3).

CPUE indices exhibited an increasing trend from 1995 to 1998 and decreased in 1999. The highest values were estimated for the W. Ionian Sea followed by those of the Northern Adriatic and waters off Sicily and Malta. The CPUE estimates exhibited an increasing trend with depth between 10 and 200 m, decreased at 200-500 m with the highest values at the deepest waters (500-800 m) (Fig. 9 a-c).

The standardised major area estimates by depth zones revealed that although fluctuations were always distinct among the areas, the highest values were recorded at depths below 200 m (Fig. 10a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1999 for all depths. The lowest estimates were recorded at depths less than 200 m during all years, while the highest estimates were recorded at depths between 200 and 500 m (Fig. 10b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The lowest values were estimated in Sardinia, while the highest estimates were recorded in the Western Ionian Sea for most of the years (Fig. 10c).

5.2.2.3.2 Biomass indices

GLM explained a relatively lower proportion of the variance (36 %), when the biomass of the crustacean catches was taken into consideration. The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth and area-year were also significant ($P < 0.00$ in both cases), while the effect of depth-year interaction was not significant ($P > 0.05$), (Table 3).

CPUE indices exhibited an increasing trend from 1995 to 1998 and decreased in 1999. The highest values were estimated for the W. Ionian Sea followed by those of the waters off Sicily and Malta. The CPUE estimates exhibited a decreasing trend with depth between 10 and 100 m, slightly increased at 100-200 m, while the highest values were recorded at depths below 200 m (Fig. 11 a-c).

The standardised major area estimates by depth zones revealed that although fluctuations were always distinct among the areas, the highest values were recorded at depths below 200 m (Fig. 12a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1999 for all depths. The lowest estimates were recorded at depths less than 200 m during all years, while the highest estimates were recorded at depths between 200 and 500 m (Fig. 12b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The lowest values were estimated in the South-Central Tyrrhenian Sea from 1995 to 1998, while the highest estimates were recorded in the Western Ionian Sea during 1995 and 1996 (Fig. 12c).

5.2.2.4 M. merluccius

5.2.2.4.1 Abundance indices

GLM explained a large proportion of the variance (46 %). The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth and area-year were also significant ($P < 0.00$ in both cases), while the effect of depth-year interaction was not significant ($P > 0.05$), (Table 4).

CPUE indices exhibited a decreasing trend from 1995 to 1999. The highest values were estimated for the Ligurian and South-Central Tyrrhenian Sea and the lowest in the W. Ionian. The CPUE estimates exhibited an increasing trend with depth between 10 to 200 m and sharply decreased below 200 m (Fig. 13 a-c).

The standardised major area estimates by depth zones revealed that although fluctuations were always distinct among the areas, the lowest values were recorded at the deepest depth zone (500-800 m). The highest estimates were recorded at depths between 100-200 m, in all areas. (Fig. 14a).

The standardised year estimates by depth zones revealed that, in general, there is a decreasing trend in the estimated values from 1995 to 1999 for all depths. The lowest estimates were recorded at depths below 500 m during all years, while the highest estimates were recorded at depths between 100 and 200 m (Fig. 14b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The highest values were estimated in the N. Adriatic Sea from 1995 to 1997, while the lowest estimates were recorded in the South-Central Tyrrhenian Sea during 1996 and 1998 (Fig. 14c).

5.2.2.4.2 Biomass indices

GLM explained considerably lower proportion of the variance (26 %), when M. merluccius biomass was taken into consideration. The analysis of variance indicated that the differences among areas, depth zones and years were always highly significant. The interactions of area-depth and area-year were also significant ($P < 0.00$ in both cases), while the effect of depth-year interaction was not significant ($P > 0.05$), (Table 4).

CPUE indices exhibited a decreasing trend from 1995 to 1998 and increased slightly in 1999. The highest values were estimated for the Northern Adriatic Sea and the lowest in the South-Central Tyrrhenian Sea. The CPUE estimates exhibited an increasing trend with depth between 10 and 200 m and sharply decreased below 200 m (Fig. 15 a-c).

The standardised major area estimates by depth zones revealed that although fluctuations were always distinct among the areas, the lowest values were recorded at the shallowest depth zone (10-50 m) in the South-Central Tyrrhenian Sea. The highest estimates were recorded at depths between 200-500 m, in the Western Ionian Sea (Fig. 16a).

The standardised year estimates by depth zones revealed that, in general, there is a decreasing trend in the estimated values from 1995 to 1998 for all depths and increased in 1999. The lowest estimates were recorded at depths between 10-50 m during all years, while the highest estimates were recorded at depths between 100 and 200 m (Fig. 16b).

The standardised year estimates by area exhibited significant fluctuations among years in each area. The highest values were estimated in the N. Adriatic Sea from 1995 to 1998, while the lowest estimates were recorded in the South-Central Tyrrhenian Sea during all years (Fig. 16c).

5.2.2.5 M. barbatus

5.2.2.5.1 Abundance indices

GLM explained a low proportion of the variance (14 %). The analysis of variance indicated that the differences among areas and depth zones were always highly significant. The interactions of area-depth, area-year and depth-year were also significant ($P < 0.05$ in both cases), while the effect of year was not significant ($P > 0.05$), (Table 5).

CPUE indices exhibited small variations from 1995 to 1999, which were not statistically significant. The highest values were estimated for the South-Central Tyrrhenian Sea and the lowest in the Southern Adriatic. The CPUE estimates exhibited a decreasing trend with depth (Fig. 17 a-c).

The standardised major area estimates by depth zones revealed that although fluctuations were always distinct among the areas, the lowest values were recorded at depths between 100 and 200 m in all areas. The highest estimates were recorded at depths between 10-50 m, in the Southern Adriatic and Ligurian and North-Central Tyrrhenian Seas, while for the rest of the areas the highest values were found at depth between 50-100 m (Fig. 18a).

The standardised year estimates by depth zones revealed that, in general, there is an increasing trend in the estimated values from 1995 to 1998 for all depths and decreased in 1999 for depths deeper than 50 m. The lowest estimates were recorded at depths between 100 and 200 m during all years, while the highest estimates were recorded at depths between 10 and 100 m (Fig. 18b).

The standardised year estimates by area exhibited a rather complex pattern. The highest values were estimated in the South-Central Tyrrhenian Sea in 1998, while the lowest estimates were recorded in the Southern Adriatic Sea during 1995 (Fig. 18c).

5.2.2.5.2 Biomass indices

GLM explained a low proportion of the variance (11 %), when M. barbatus biomass was analysed. The analysis of variance indicated that the differences among areas and depth zones were always significant. The interactions of area-depth and depth-year were also significant ($P < 0.05$ in both cases). The effect of year as well as the interaction of area-year were not significant ($P > 0.05$), (Table 5).

CPUE indices exhibited small variations from 1995 to 1999, which were not statistically significant. The highest values were estimated for the South-Central Tyrrhenian Sea and the lowest in the Southern Adriatic. The CPUE estimates exhibited an increasing trend with depth up to 100 m an decreased at depths between 100-200 m (Fig. 19 a-c).

The standardised major area estimates by depth zones revealed that although fluctuations were always distinct among the areas, the lowest values were recorded at depths between 100-200 m for Northern Adriatic, South-Central Tyrrhenian and Sardinia. The highest estimates were recorded at depths between 50-100 m, for most areas (Fig. 20a).

The standardised year estimates by depth zones revealed that there is an increasing trend in the estimated values from 1995 to 1999 for depths between 10-50 m and a decreasing trend for depths deeper than 100 m. The lowest estimates were recorded at depths between 100-200 m, while the highest estimates were recorded at depths between 10 and 50 m during 1999 (Fig. 20b).

The standardised year estimates by area exhibited a rather complex pattern. The highest values were estimated in the South-Central Tyrrhenian Sea in 1998, while the lowest estimates were recorded in the S. Adriatic during 1995 (Fig. 20c).

Table 1. Analysis of variance of the General Linear Model fitted to the total catches for the target fish species in the Italian waters, for the period 1995-1999

Abundance (R^2=0.48)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	70.77	6	11.79	63.57	0.00
Depth	101.26	4	25.32	136.45	0.00
Year	4.42	4	1.10	5.95	0.00
Area*Depth	84.63	24	3.53	19.01	0.00
Area*Year	16.22	24	0.68	3.64	0.00
Depth*Year	2.81	16	0.18	0.95	0.51
Residual	635.06	3423	0.19		
Total (corrected)	1213.37	3501			

Biomass (R^2=0.37)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	84.51	6	14.08	76.20	0.00
Depth	49.14	4	12.29	66.46	0.00
Year	1.42	4	0.36	1.92	0.10
Area*Depth	54.20	24	2.26	12.22	0.00
Area*Year	11.66	24	0.49	2.63	0.00
Depth*Year	7.14	16	0.45	2.41	0.00
Residual	632.75	3423	0.18		
Total (corrected)	1010.54	3501			

Table 2. Analysis of variance of the General Linear Model fitted to the total catches for the target cephalopod species in the Italian waters, for the period 1995-1999

Abundance (R^2=0.62)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	76.26	6	12.71	65.64	0.00
Depth	222.20	4	55.55	286.87	0.00
Year	12.30	4	3.07	15.88	0.00
Area*Depth	99.60	24	4.15	21.43	0.00
Area*Year	46.71	24	1.95	10.05	0.00
Depth*Year	19.23	16	1.20	6.21	0.00
Residual	636.31	3286	0.19		
Total (corrected)	1672.03	3364			

Biomass (R^2=0.43)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	169.05	6	28.17	103.59	0.00
Depth	126.60	4	31.65	116.37	0.00
Year	8.96	4	2.24	8.23	0.00
Area*Depth	53.78	24	2.24	8.24	0.00
Area*Year	3.58	24	1.40	5.14	0.00
Depth*Year	11.30	16	1.71	2.60	0.00
Residual	893.77	3286	0.27		
Total (corrected)	1575.73	3364			

Table 3. Analysis of variance of the General Linear Model fitted to the total catches for the target crustacean species in the Italian waters, for the period 1995-1999

Abundance (R^2=0.41)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	41.05	6	6.84	19.64	0.00
Depth	214.37	4	53.59	153.85	0.00
Year	23.62	4	5.91	16.95	0.00
Area*Depth	152.65	24	6.36	18.26	0.00
Area*Year	67.84	24	2.83	8.11	0.00
Depth*Year	6.34	16	0.39	1.14	0.31
Residual	992.12	2848	0.35		
Total (corrected)	1684.88	2926			

Biomass (R^2=0.36)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	25.88	6	4.31	14.40	0.00
Depth	111.24	4	27.81	92.80	0.00
Year	16.01	4	4.01	13.35	0.00
Area*Depth	81.57	24	3.40	11.34	0.00
Area*Year	42.68	24	1.78	5.93	0.00
Depth*Year	5.12	16	0.32	1.07	0.38
Residual	853.44	2848	0.30		
Total (corrected)	1332.20	2926			

Table 4. Analysis of variance of the General Linear Model fitted to the catches of M. merluccius in the Italian waters, for the period 1995-1999

Abundance (R^2=0.46)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	30.35	6	5.06	13.45	0.00
Depth	211.87	4	52.97	140.80	0.00
Year	10.50	4	2.62	6.97	0.00
Area*Depth	97.26	24	4.05	10.77	0.00
Area*Year	41.19	24	1.72	4.56	0.00
Depth*Year	8.43	16	0.53	1.40	0.13
Residual	982.55	2612	0.38		
Total (corrected)	1824.94	2690			

Biomass (R^2=0.26)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	12.21	6	2.03	9.58	0.00
Depth	37.34	4	9.34	43.96	0.00
Year	5.69	4	1.42	6.70	0.00
Area*Depth	30.67	24	1.28	6.02	0.00
Area*Year	27.06	24	1.13	5.31	0.00
Depth*Year	2.81	16	0.18	0.83	0.66
Residual	554.64	2612	0.21		
Total (corrected)	744.72	2690			

Table 5. Analysis of variance of the General Linear Model fitted to the catches of *M. barbatus* in the Italian waters, for the period 1995-1999

Abundance (R^2=0.14)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	17.16	6	2.86	5.99	0.00
Depth	13.98	2	6.99	14.65	0.00
Year	1.69	4	0.42	0.88	0.47
Area*Depth	14.36	12	1.20	2.51	0.01
Area*Year	19/79	24	0.82	1.73	0.02
Depth*Year	8.56	8	1.07	2.24	0.02
Residual	551.40	1155	0.48		
Total (corrected)	641.34	1211			

Biomass (R^2=0.11)

Source of variation	Sum of Squares	Df	Mean Square	F	P
Area	15.24	6	2.54	7.24	0.00
Depth	2.58	2	1.29	3.67	0.03
Year	1.38	4	0.34	0.98	0.42
Area*Depth	9.26	12	0.77	2.20	0.01
Area*Year	12.46	24	0.52	1.48	0.06
Depth*Year	7.52	8	0.94	2.68	0.01
Residual	405.22	1155	0.35		
Total (corrected)	454.45	1211			

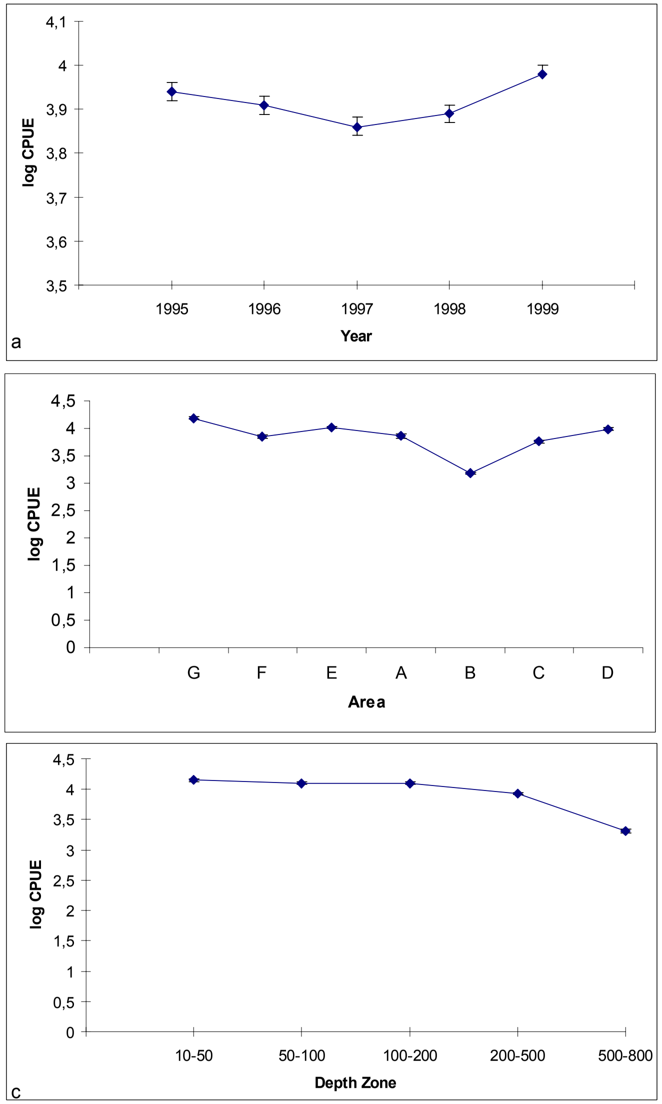

Fig. 1. Standardized CPUE estimates (abundance) for the target fish species in the Italian waters by a) Year, b) area and c) depth zone.

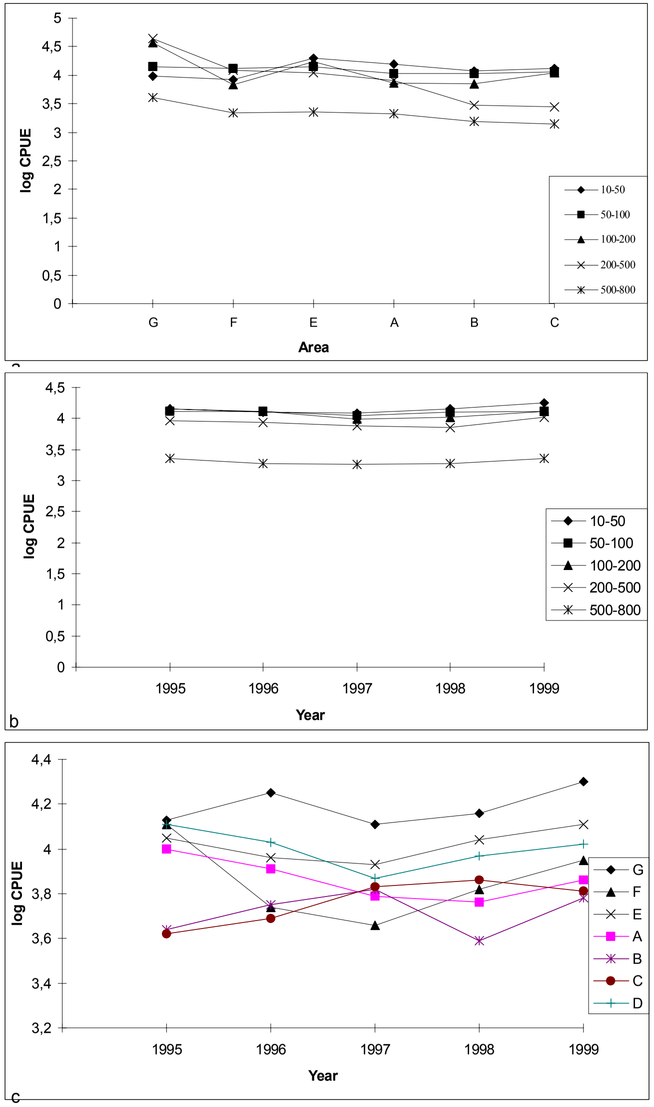

Fig. 2. Standardized CPUE estimates (abundance) for the target fish species in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

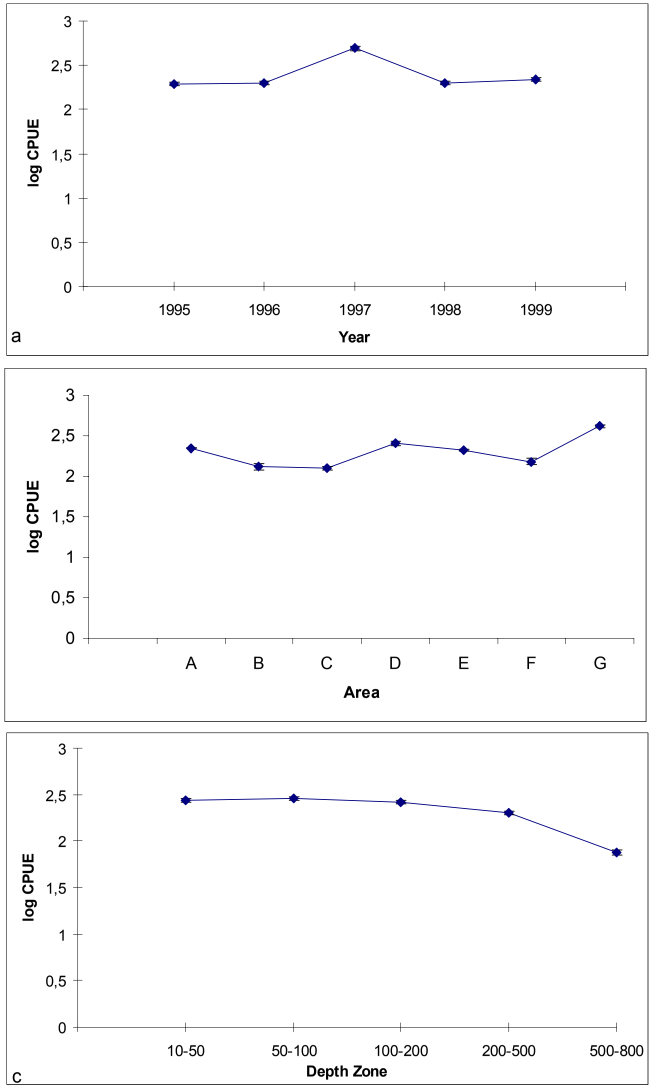

Fig. 3. Standardized CPUE estimates (biomass) for the target fish species in the Italian waters by a) Year, b) area and c) depth zone.

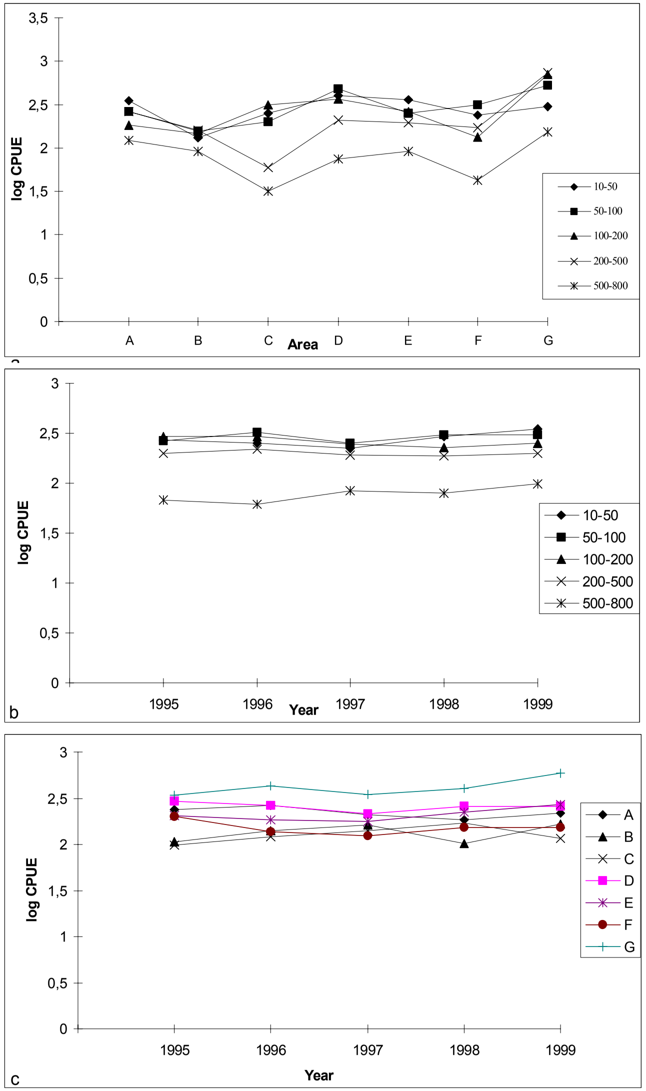

Fig. 4. Standardized CPUE estimates (biomass) for the target fish species in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

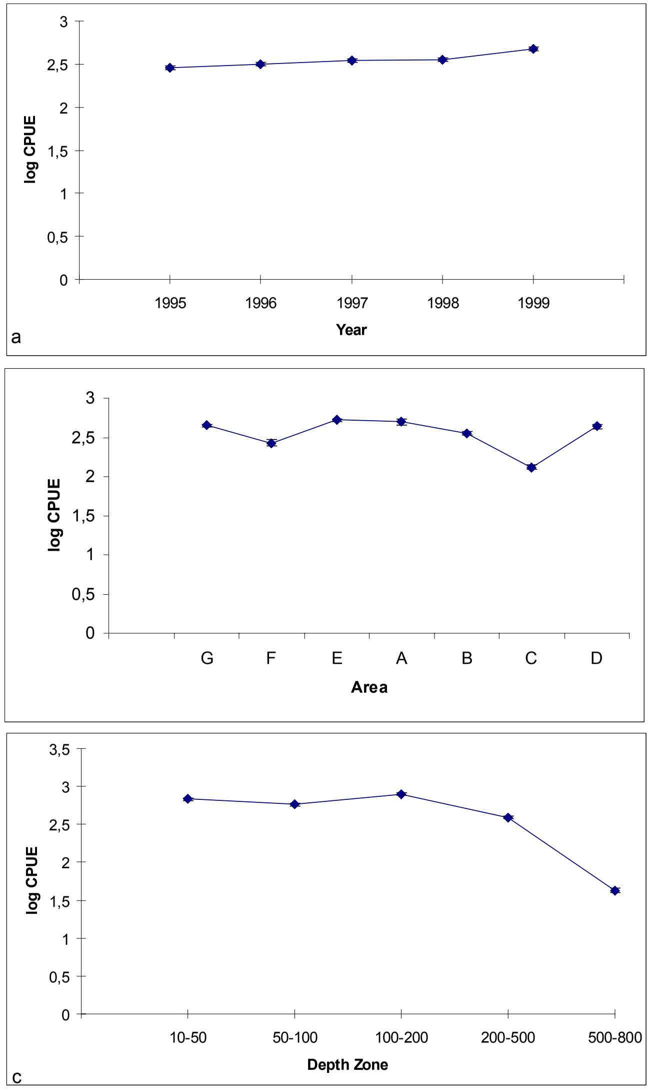

Fig. 5. Standardized CPUE estimates (abundance) for the target cephalopod species in the Italian waters by a) Year, b) area and c) depth zone.

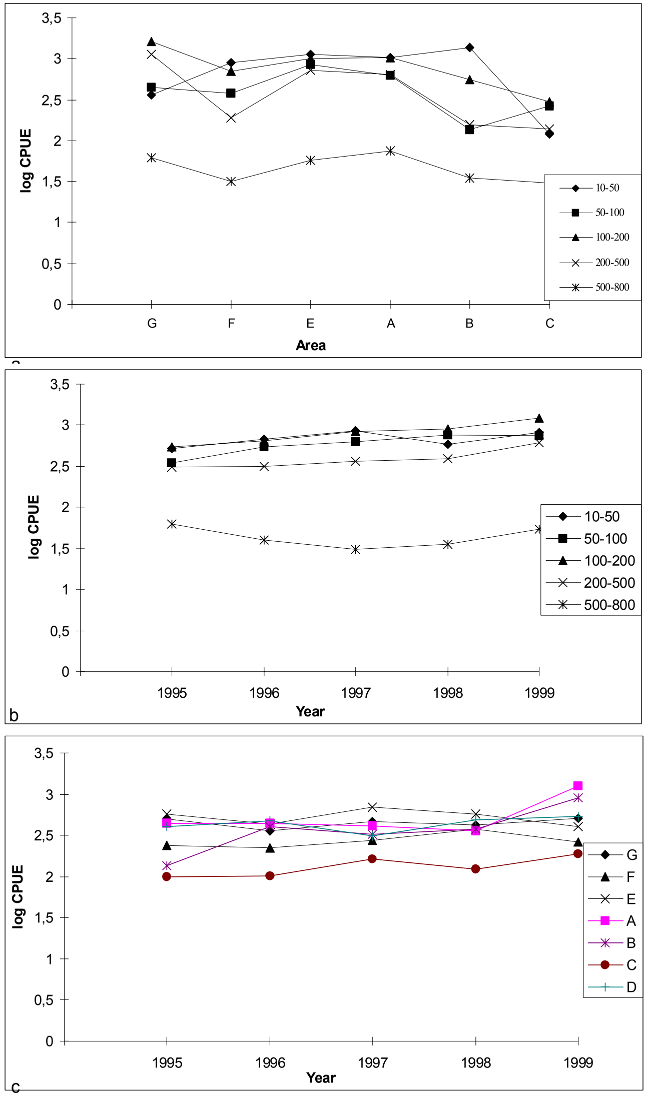

Fig. 6. Standardized CPUE estimates (abundance) for the target cephalopod species in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

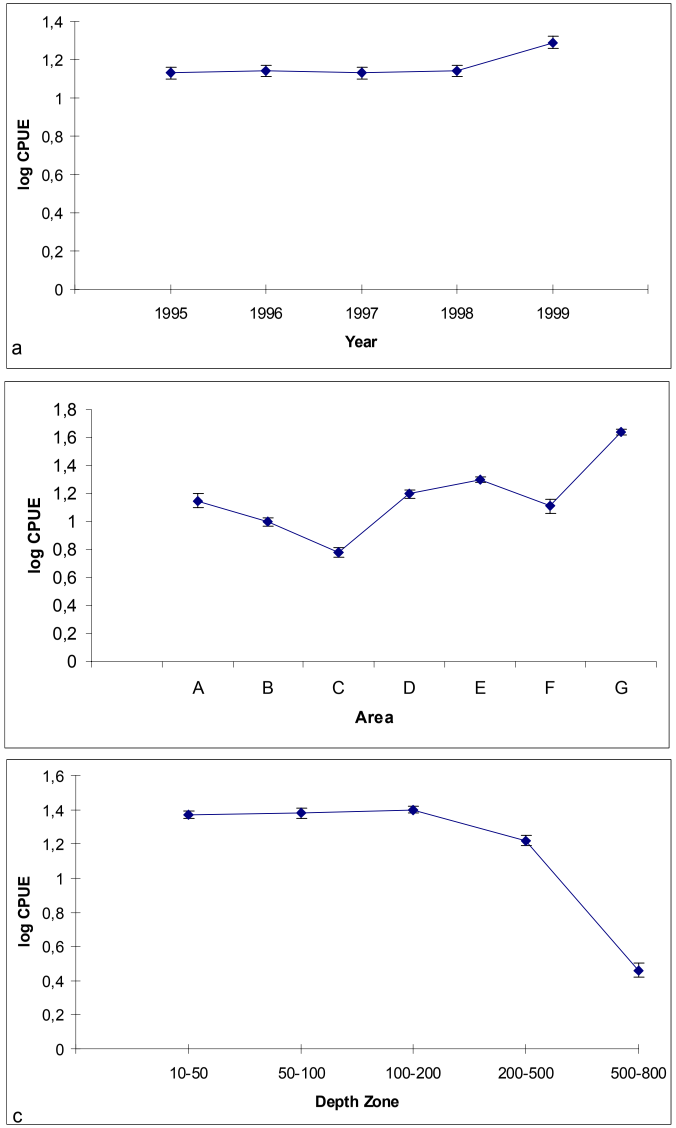

Fig. 7. Standardized CPUE estimates (biomass) for the target cephalopod species in the Italian waters by a) Year, b) area and c) depth zone.

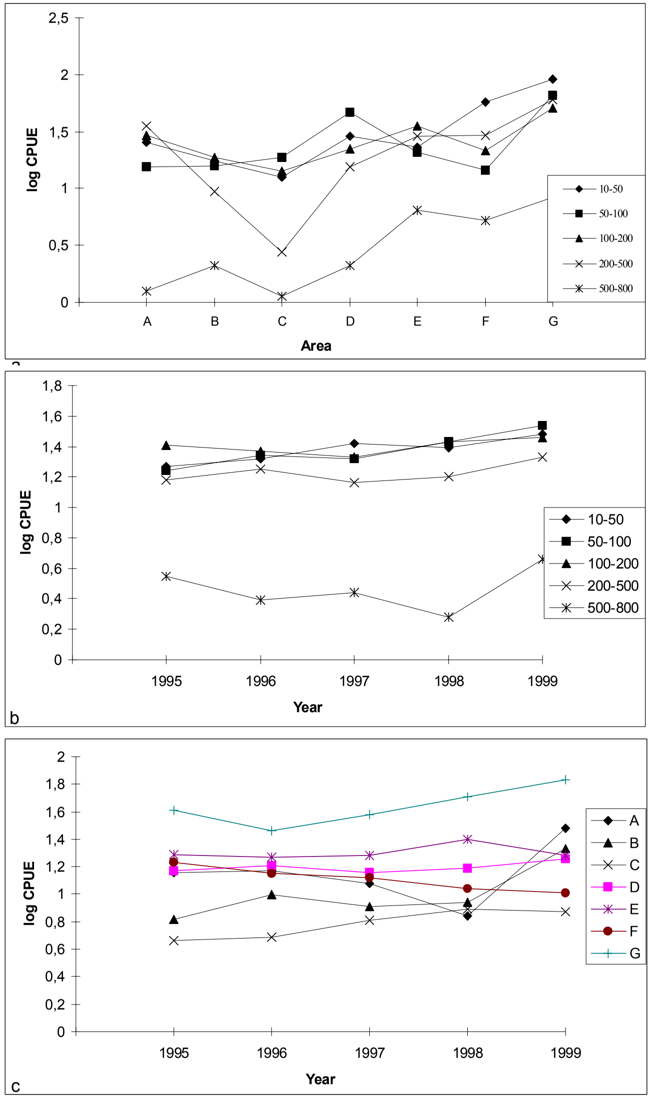

Fig. 8. Standardized CPUE estimates (biomass) for the target cephalopod species in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

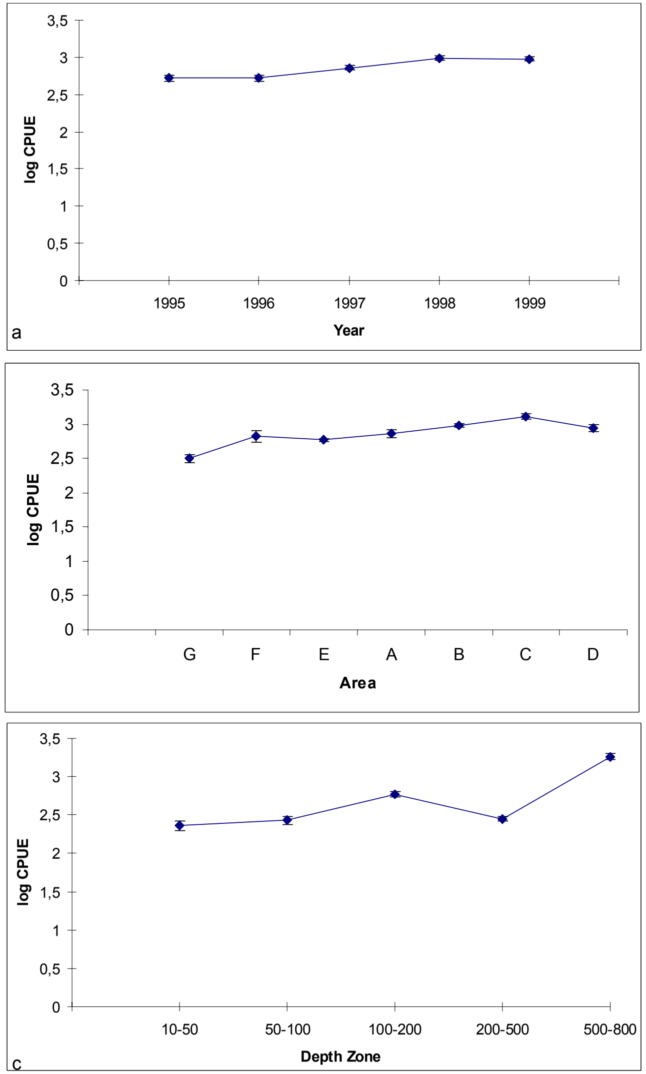

Fig. 9. Standardized CPUE estimates (abundance) for the target crustacea species in the Italian waters by a) Year, b) area and c) depth zone.

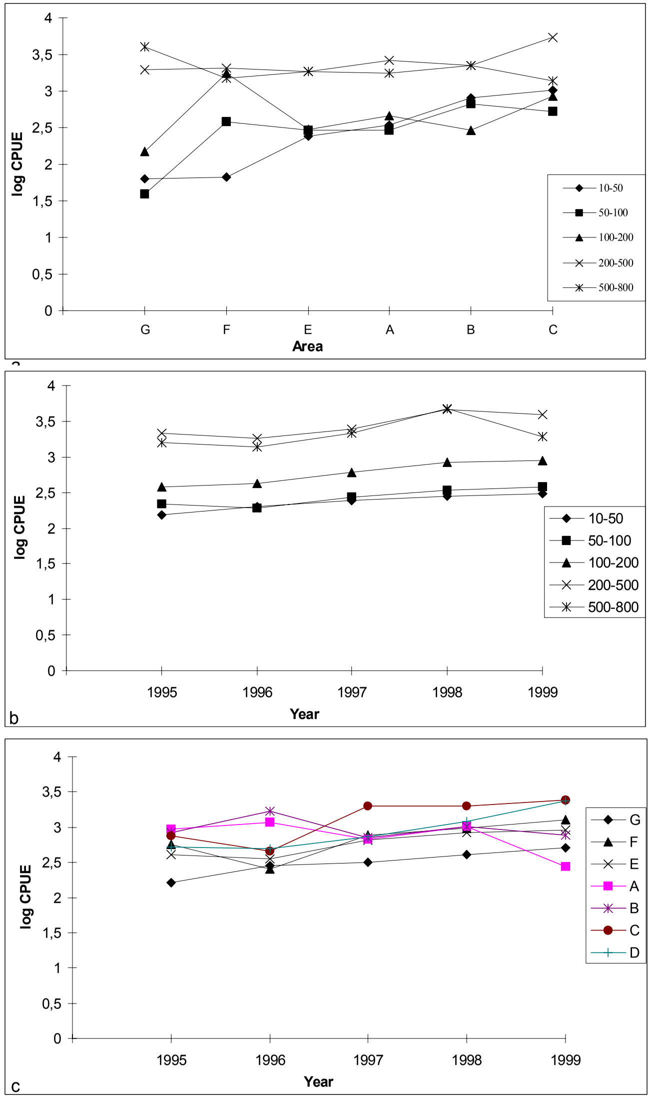

Fig. 10. Standardized CPUE estimates (abundance) for the target crustacea species in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

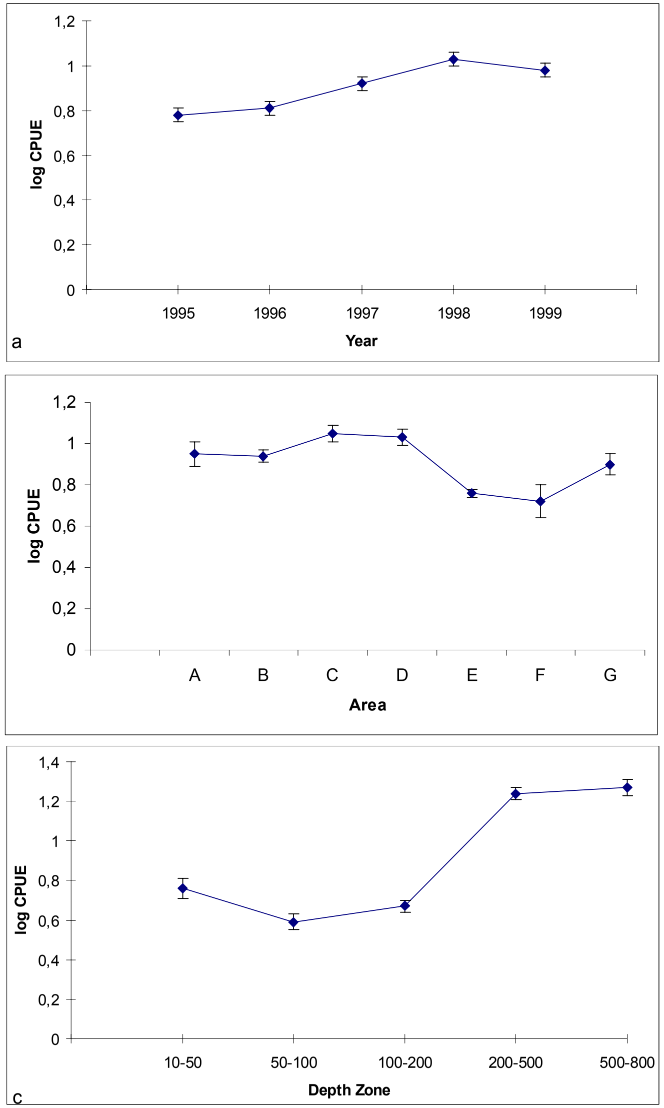

Fig. 11. Standardized CPUE estimates (biomass) for the targetcrustacea species in theItalian waters by a) Year, b) area and c) depth zone.

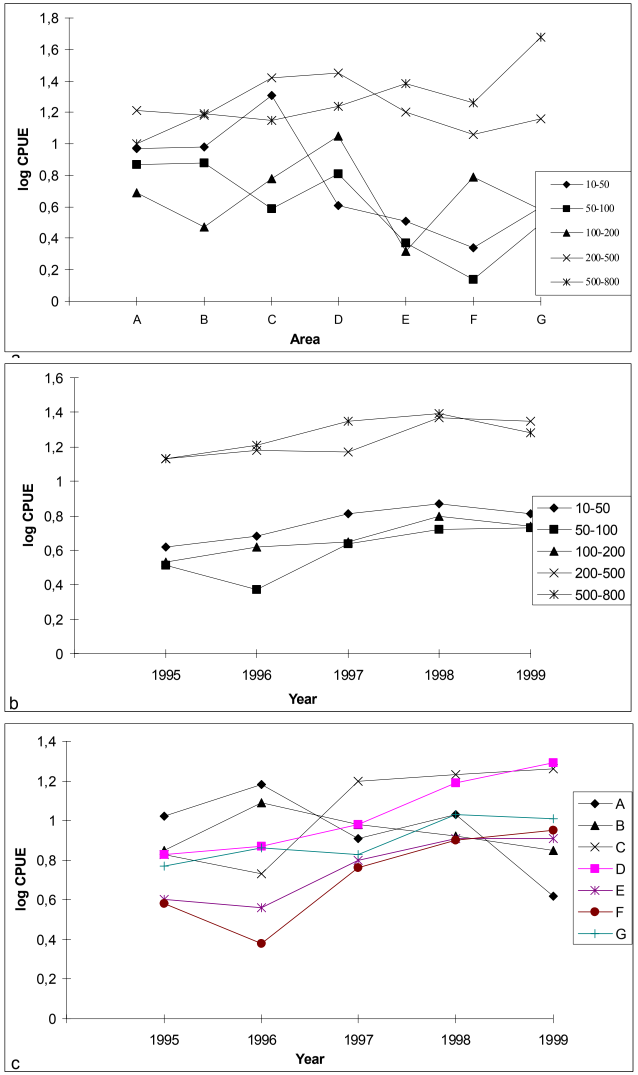

Fig. 12. Standardized CPUE estimates (biomass) for the target crustacea species in theItalian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

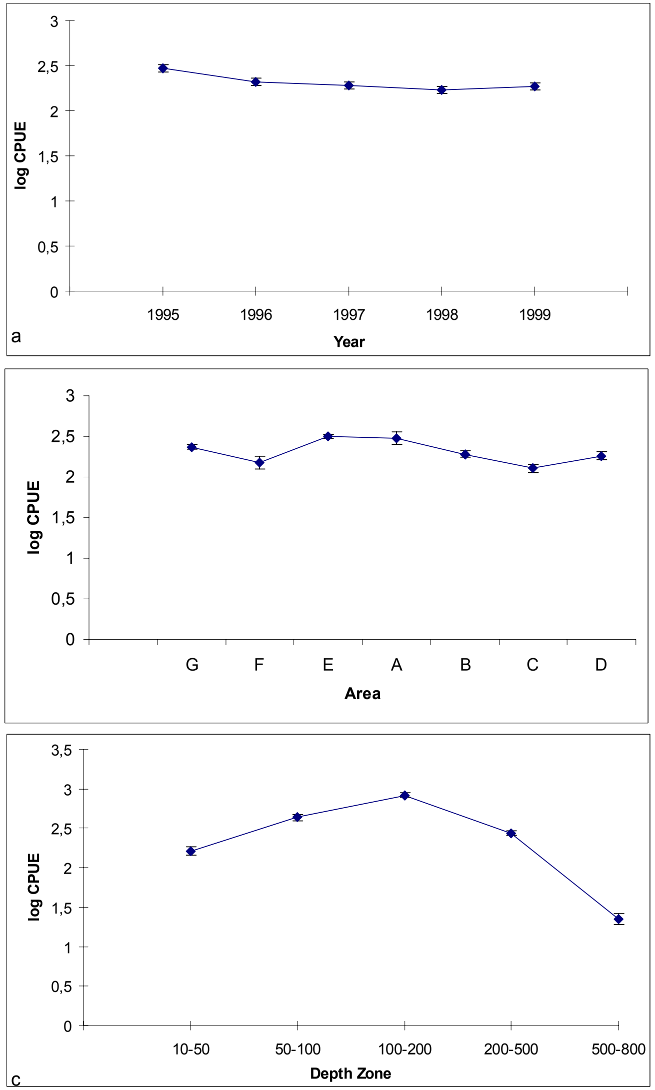

Fig. 13. Standardized CPUE estimates (abundance) for *M. merluccius* in the Italian waters by a) Year, b) area and c) depth zone.

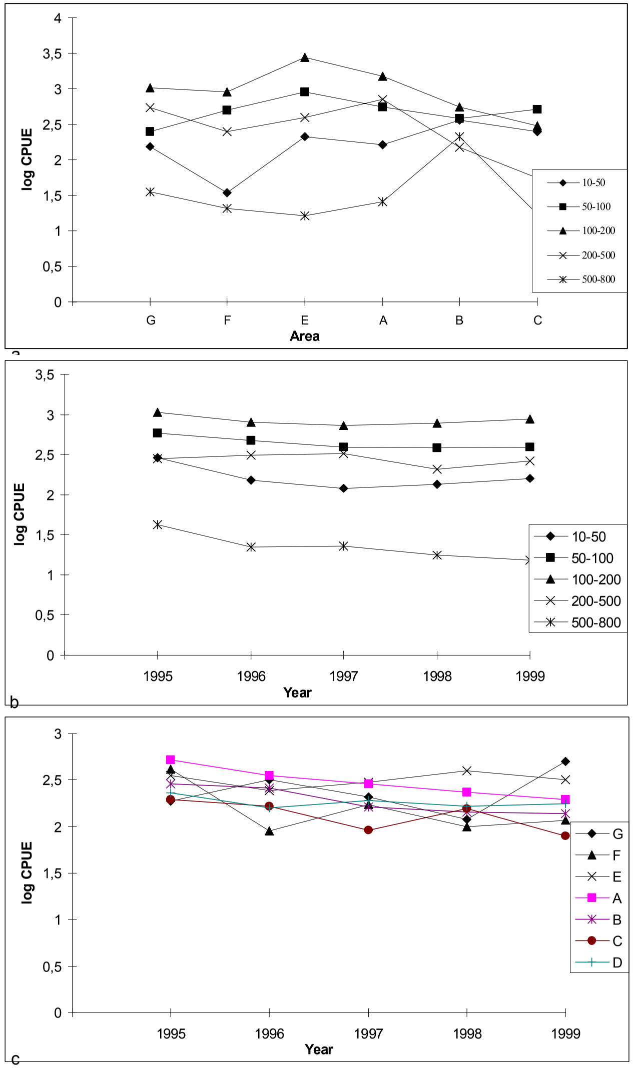

Fig. 14. Standardized CPUE estimates (abundance) for *M. merluccius* in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

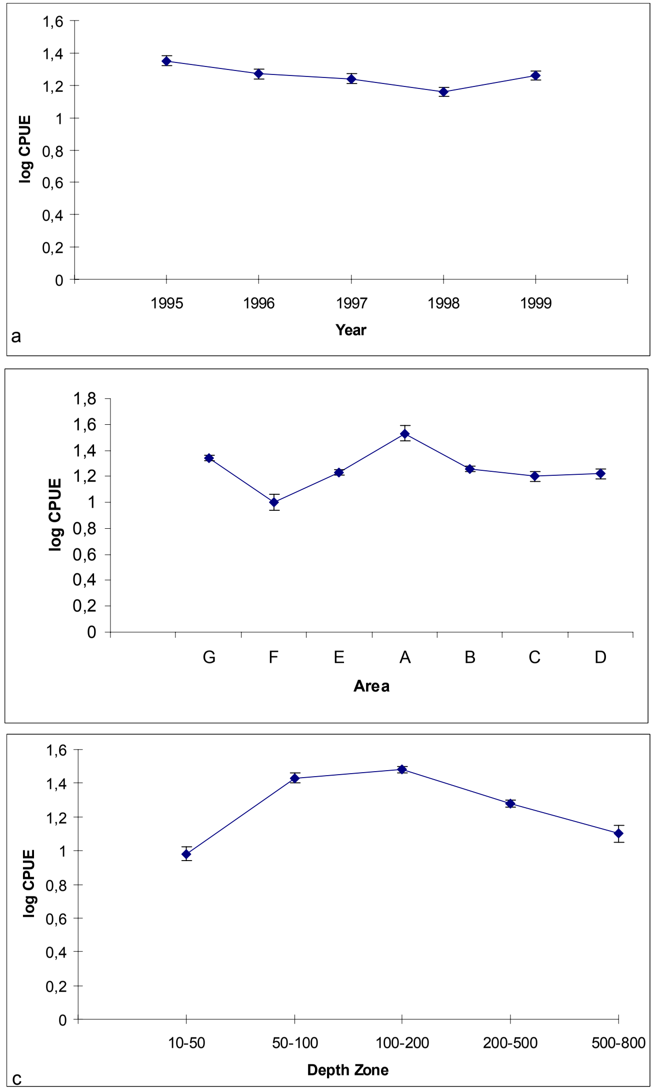

Fig. 15. Standardized CPUE estimates (biomass) for *M. merluccius* in the Italian waters by a) Year, b) area and c) depth zone.

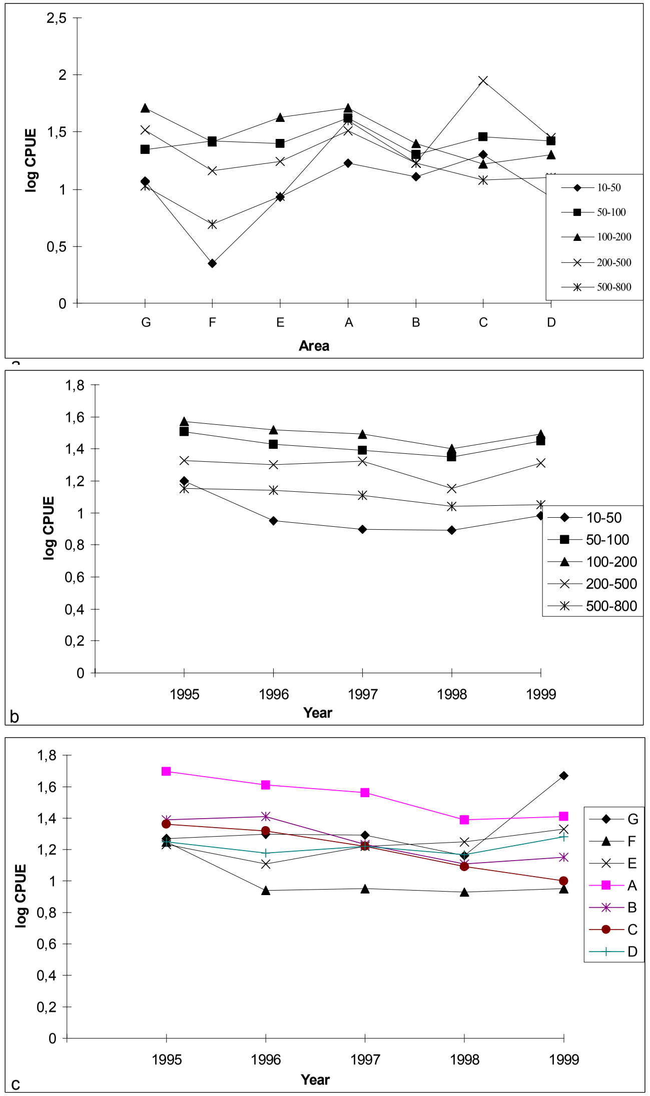

Fig. 16. Standardized CPUE estimates (biomass) for M. merluccius in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

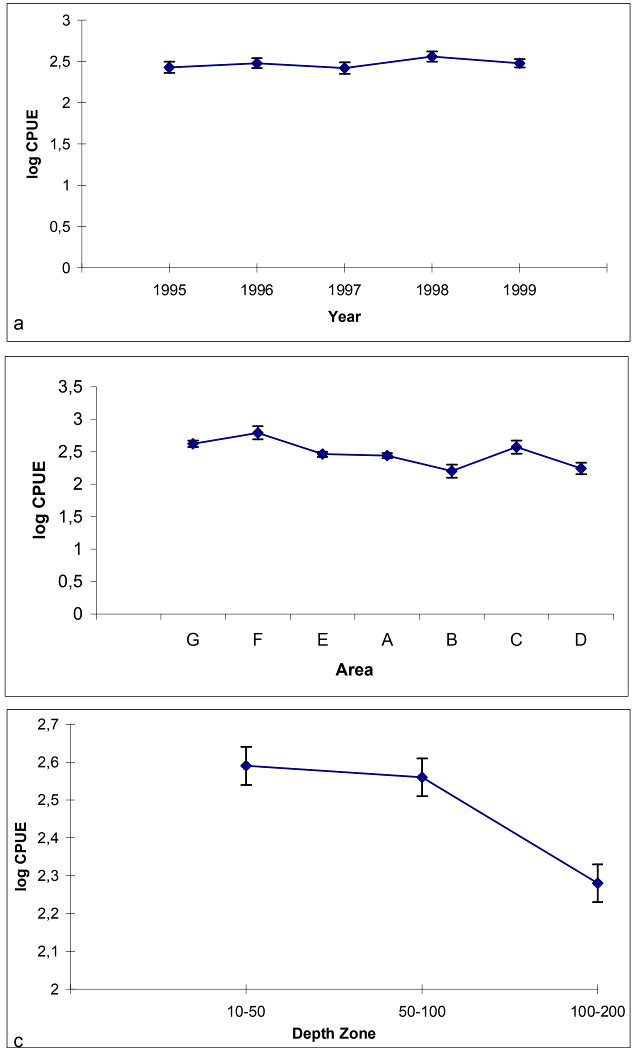

Fig. 17. Standardized CPUE estimates (abundance) for *M. barbatus* in the Italian waters by a) Year, b) area and c) depth zone.

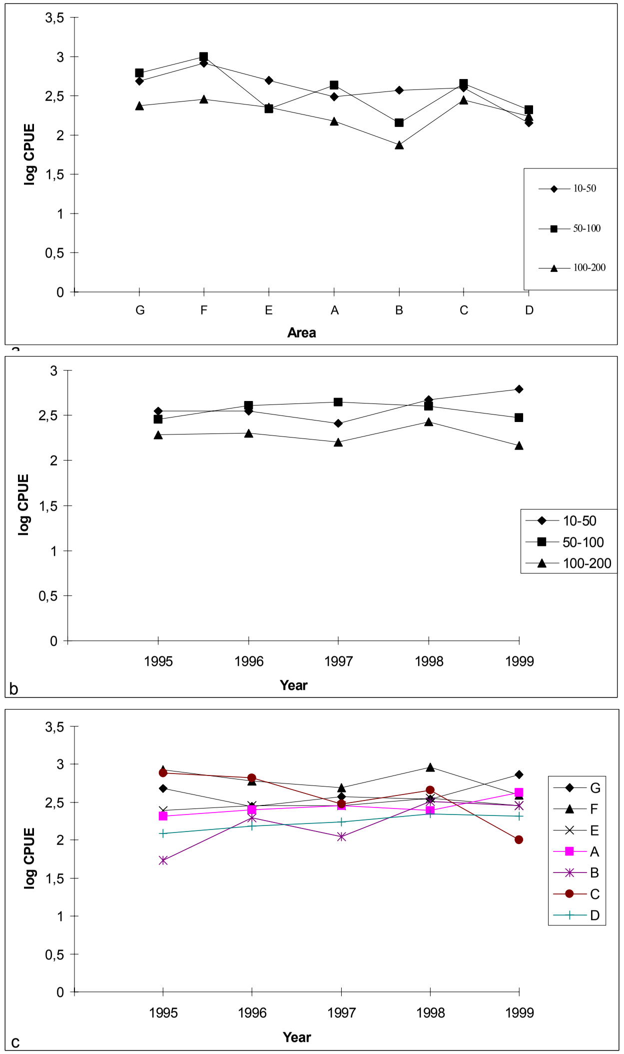

Fig. 18. Standardized CPUE estimates (abundance) for *M. barbatus* in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

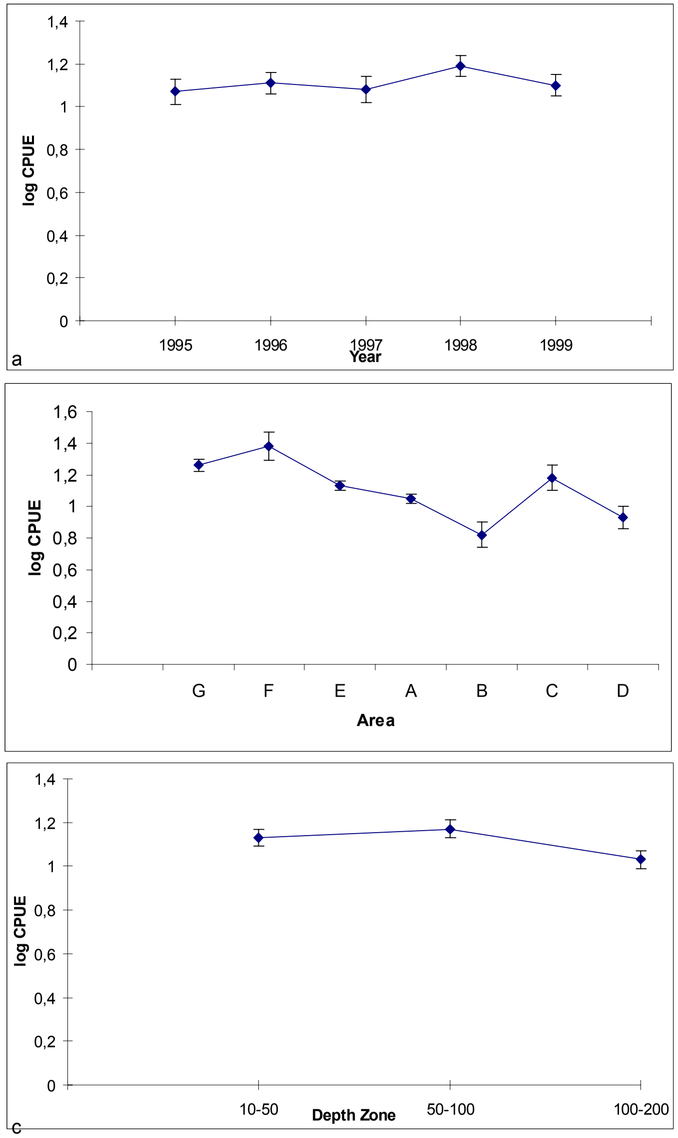

Fig. 19. Standardized CPUE estimates (biomass) for *M. barbatus* in the Italian waters by a) Year, b) area and c) depth zone.

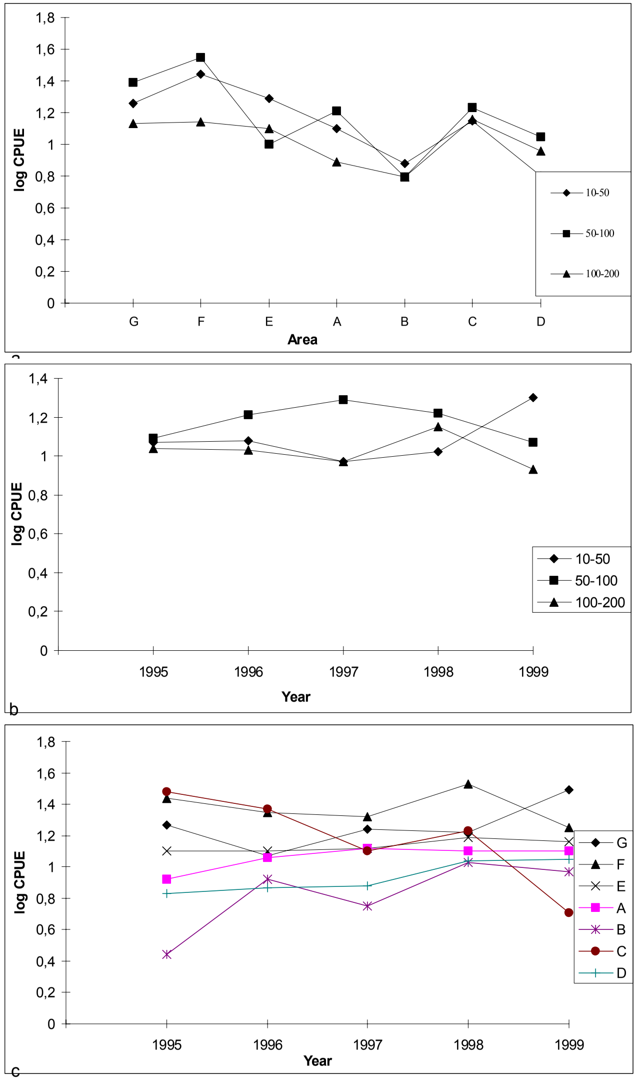

Fig. 20. Standardized CPUE estimates (biomass) for *M. barbatus* in the Italian waters by a) Area and depth zone, b) year and depth zone and c) year and area.

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Annexe 1: Scientia marina monograph synopsis

Mediterranean Marine Demersal Resources: The MEDITS International Trawl Survey (1994-1999)

Edited by
Pere Abelló[1] (coordinator) and
Jacques A. Bertrand[2], Luis Gil de Sola[3], Costas Papaconstantinou[4], Giulio Relini[5] and Arnauld Souplet[2]

[1] Institut de Ciències del Mar – CMIMA (CSIC) (Spain)
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[3] Instituto Español de Oceanografía (Spain)
[4] Società Italiana de Biologia Marina (Italy)
[5] National Center for Marine Research (Greece)

FOREWORD

Section 1 : INTRODUCTORY CHAPTER

Bertrand, J.A., L. Gil de Sola, C. Papaconstantinou, G. Relini and A. Souplet. The general specifications of the MEDITS surveys.

Section 2 : CONTRIBUTIONS ON TARGET SPECIES: GLOBAL APPROACH

Orsi Relini, L. C. Papaconstantinou, S. Jukic-Peladic, A. Souplet, L. Gil de Sola, C. Piccinetti, S. Kavadas and M. Rossi. Distribution of the Mediterranean hake populations (*Merluccius merluccius smiridus* Rafinesque, 1810) (Osteichthyes: Gadiformes) based on six years monitoring by trawl-surveys: some implications for management.

Tserpes, G., F. Fiorentino, D. Levi, A. Cau, M. Murenu, A. Zamboni and C. Papaconstantinou. Distribution of *Mullus barbatus* and *M. surmuletus* (Osteichthyes: Perciformes) in the Mediterranean continental shelf: implications for management

Ungaro, N., G. Marano, R. Auteri, A. Voliani, E. Massutí, M. García-Rodríguez and K. Osmani. Distribution, abundance and biological features of anglerfish (*Lophius piscatorius* and *Lophius budegassa*) (Osteichthyes: Lophiiformes) in the Mediterranean Sea

Spedicato, M.T., S. Greco, K. Sophronidis, G. Lembo, D. Giordano and A. Argyri. Geographical distribution, abundance and some population characteristics of the species of the genus *Pagellus* (Osteichthyes: Perciformes) in different areas of the Mediterranean

Sartor, P., M. Sbrana, N. Ungaro, C.A. Marano, C. Piccinetti and G. Piccinetti Manfrin. Distribution and abundance of *Citharus linguatula*, *Lepidorhombus boscii*, and *Solea vulgaris* (Osteichthyes: Pleuronectiformes) in the Mediterranean Sea

Cau, A., A. Carbonell, M.C. Follesa, A. Mannini, G. Norrito, L. Orsi Relini, C.-Y. Politou, S. Ragonese and P. Rinelli. MEDITS-based information on the deep-water red shrimps *Aristaeomorpha foliacea* and *Aristeus antennatus* (Crustacea: Decapoda: Aristeidae)

Abelló, P., A. Abella, A. Adamidou, S. Jukic-Peladic, P. Maiorano and M.T. Spedicato. Geographical patterns in abundance and population structure of *Nephrops norvegicus* and *Parapenaeus longirostris* (Crustacea: Decapoda) along the European Mediterranean coasts

Belcari, P., G. Tserpes, M. González, E. Lefkaditou, B. Marceta, G. Piccinetti Manfrin and A. Souplet. Distribution and abundance of *Eledone cirrhosa* (Lamarck, 1798) and *E. moschata* (Lamarck, 1798) (Cephalopoda: Octopoda) in the Mediterranean Sea

Belcari, P., D. Cuccu, M. González, A. Srairi and P. Vidoris. Distribution and abundance of *Octopus vulgaris* Cuvier, 1797 (Cephalopoda: Octopoda) in the Mediterranean Sea

Section 3 : FREE CONTRIBUTIONS

Bertrand, J.A., I. Leonori, P.-Y. Dremière and G. Cosimi. Depth trajectory and performance of a trawl used for an international bottom trawl survey in the Mediterranean

Abelló, P., A. Carbonell and P. Torres. Biogeography of epibenthic crustaceans on the shelf and upper slope off the Iberian Peninsula Mediterranean coasts: implications for the establishment of natural management areas

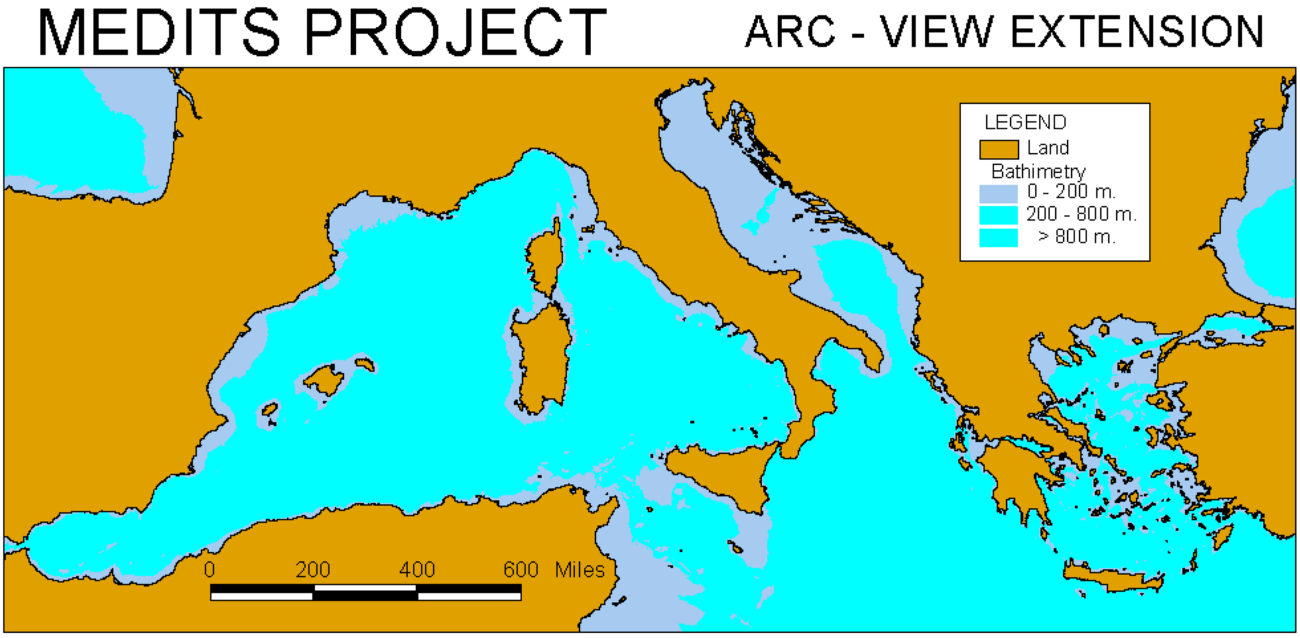
Tserpes, G. and P. Peristeraki. Trends in the abundance of demersal species in the southern Aegean Sea

González, M. and P. Sánchez. Cephalopod assemblages caught by trawling along the Iberian Peninsula Mediterranean coast

Cartes, J.E., P. Abelló, D. Lloris, A. Carbonell, P. Torres, F. Maynou and L. Gil de Sola.

Annexe 2 : MEDITS project Arcview extension - User's guide

MEDITS - GIS 1.0



Dr. Eduardo Ferrandis
Dra. Pilar Hernández
Dr. Luis Gil de Sola
Dr. Domingo Lloris
Ing. Jose J. Zubcoff

USER'S GUIDE

MEDITS - GIS 1.0 - ArcView Extension for the MEDITS PROJECT

by Dr. Eduardo Ferrandis (1), Dra. Pilar Hernández (1), Dr. Luis Gil de Sola (2), Dr. Domingo Lloris (3), Ing. Jose J. Zubcoff (1)

1.- Dto. De Estadística – Universidad de Alicante
2.- Centro Oceanográfico de Fuengirola – Instituto Español de Oceanografía
3.- Instituto de Ciencias del Mar – Consejo Superior de Investigaciones Científicas

1. OBJECTIVES

This MEDITS Extension consists of a series of charts, a series of Avenue scripts and a series of legends that serve to create distribution charts of the Mediterranean marine resources studied by the MEDITS project.

The present extension is intended to reach the following goals:

1. To establish a basic cartography for the different real and potential scenarios covered by MEDITS PROJECT.

2. To create ArcView shape files representing the following indices:

2.1. Biomass and Density Indices for a given specie.

2.2. Biomass and Density Indices for the faunistic categories

2.3. Biomass and Density Indices for the target species group.

2.4. Density for a sizes interval of a given species.

3. To enable the MEDITS Information Interface with statistic and geostatistical processors, by using the tables corresponding to the shape files created.

2. INSTALLATION

Previous to the installation of this extension, make sure that ArcView has been installed in your computer.

Select the path where the program (Extension MEDITS-ArcView) is located. Originally in a Cd, by default CD-rom is drive D:

Select the path where ArcView Extensions are installed. By default this path is “C:\Av_gis30\Arcview\Ext32”. If your ArcView is in another path or drive, you must set the appropriate one in the browser.

This setup process is needed just once. The extension MEDITSextension.avx will be added to the path \ArcView\Ext32 and will be available to use until you remove it manually.

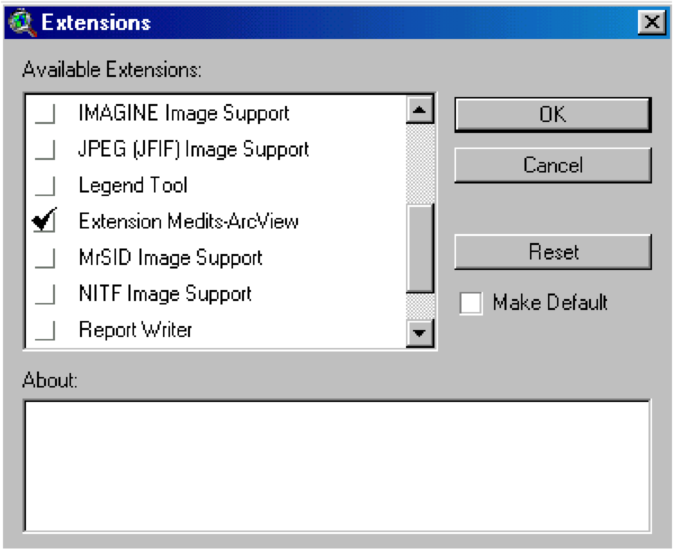
3. LOADING THE EXTENSION

Once it has been installed in your computer, it can be used at any time you need always following the steps below:

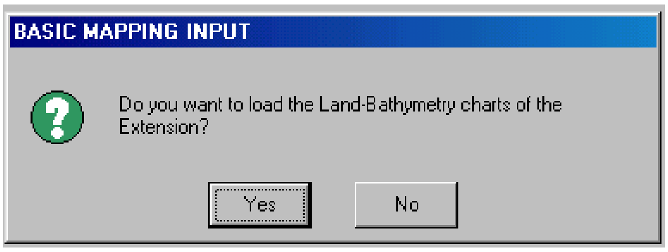
1. Put the CD of the extension in the available unit and run ArcView.

2. Open a project, (new or old one), by default, a new one called “untitled” appears when you open ArcView.

3. In the main window go to the menu FILE → EXTENSIONS, a browser appears , check the list of extension and find “Extension MEDITS-ArcView”. Set a √ on the left square to select the extension, and click OK.



A dialog box appears asking if you want to load the cartography included in the extension. It is recommended to click “yes”, at least once to explore all the charts supplied and check their usefulness to your needs. If you say “no”, you are supposed to have your own maps.



Do you want to load the Land-Bathymetry charts of the Extension?

To work with the extension you will have to select a basic map in a view, click on one of the buttons that appears in the upper tool bar (Inside the rectangle in the figure below) in order to obtain the maps and tables that are produced as mentioned in the objectives of this extension and described below.

4. UNLOADING THE EXTENSION

Before Saving the project, it is necessary to unload the extension. DO NOT SAVE ANY PROJECT WITHOUT HAVING UNLOADED THE EXTENSION FIRST!!!. To unload, go to the Main Project Window, and to the FILE menu → EXTENSIONS → DESELECT (by removing the √) and click OK.

Now you can save your project . Go to the FILE menu → SAVE PROJECT AS → Give it a name (and a path!) different from “untitled”, the one by default.

NOTE: “Project” is the working unit in ArcView. “View” is the window where the maps are set and modified. The basic maps included in this extension are in different views with the names that appear in the list of views in the main window.

5. CHARTS

Each chart is a Polygon ArcView Shapefile that includes polygons corresponding to land and isobaths

1. Land.
2. Isobaths:
    a. 0 – 200 m: Continental shelf
    b. 200 – 800 m: Slope
    c. > 800 m: Deep sea.

The whole Mediterranean basin is divided in the following areas:

5.1 Countries

Spain
France
Italy
Greece
Croatia

And other possible future MEDITS members:
Morocco
Algeria
Tunisia
Egypt
Libya

5.2 Statistical sub-areas

Western Sub-area
Central Sub-area
(Complementary sub-areas)
Eastern Sub-area
Black Sea Sub-area

5.3 Sectors

All the Sectors covered by MEDITS.

Sector 111
Sector 112
Sector 113

Sector 121

Sector 132
Sector 133
Sector 134

Sector 211
Sector 221

Sector 222 a
Sector 222 b
Sector 222 c

This charts have been obtained by E. Ferrandis and P. Hernández throw a hard elaboration process from the GEBCO DIGITAL ATLAS using tools developed in the FIGIS Project. The projection system is Mercator, but it may be easily changed by the user from the View menu PROPERTIES.

The structure is represented in the three figures in the Appendix “CHARTS”.

5. WORKING WITH THE EXTENSION CHARTS

As it was recommended before, the user should open the views with the different charts to get familiar with them and select those which are going to serve to their needs.

The format (colors, symbols, fonts, etc..) of the charts are defined in “legends” that are supplied in the CD in the path \MEDITSLegends. All the legends have the extension .AVL. They can be loaded from any view and are suitable to be modified by the user.

.- Land.avl: is the legend for the land polygon

.- Sea.avl: Is the legend for the isobaths polygons

.- Limits.avl: Statistical sub-areas limits.

6. GENERAL USE OF THE BASIC CARTOGRAPHY

All the maps supplied in the CD, folder MEDITSMAPS are suitable to be used by any researcher, not only MEDITS partners. If this is the case, proceed with the following instructions:

Load the extension as is indicated in the paragrap “LOADING THE EXTENSION”

Unload the extensin and save the project as is indicated in the paragraph “UNLOADING THE EXTENSION”.

You can work with the project you have just saved as regularly with Arc-View projects, but you will have to ensure that the CD is in the drive at any time that you want to display any of the maps.

7. GEOGRAPHIC REPRESENTATION OF ABUNDANCE INDICES

The distribution of the abundance of the marine resources studied in a chart can be implemented in four different ways by this extension :

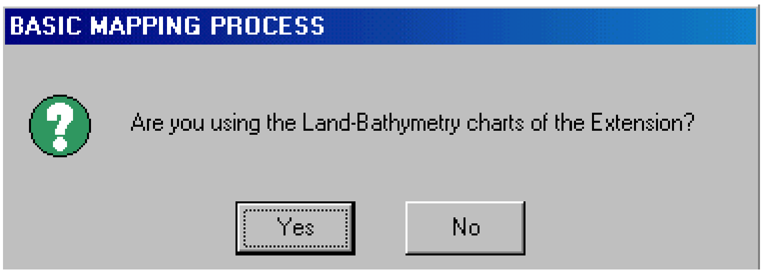
1. By species.
2. By faunistic categories (or groups).
3. By the set of target species as a whole.
4. By size intervals of a given species.

Each one is achieved by clicking respectively on the four buttons present in the upper tool bar of the main window as indicated in the following figure

7.1 SPECIES

The execution of this script by clicking on the button will produce the representation of the abundance indices either in biomass (kg/km^2) or in density (ind/km^2) of a particular species chosen by the user.

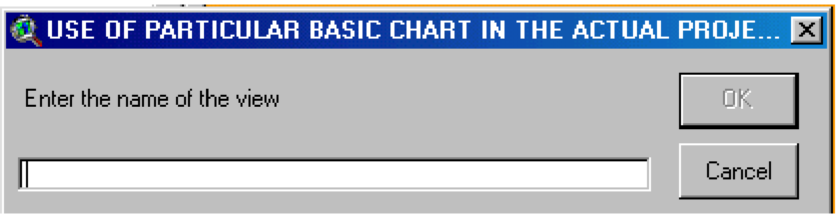
The user must supply the following specifications that are demanded sequentially in dialog boxes that appear while running the script.


BASIC MAPPING PROCESS

Are you using the Land-Bathymetry charts of the Extension?

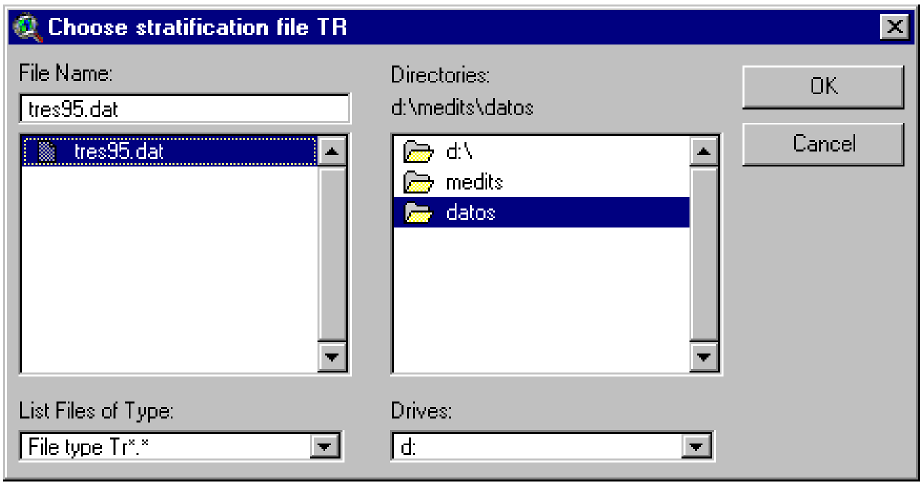
If it is the case, successive boxes will help on the selection of the particular chart.

If the answer is “No” It is assumed that the user is using his own cartography in a previously created view, and in this case, a new box will ask for the name of this view.


USE OF PARTICULAR BASIC CHART IN THE ACTUAL PROJE...

Enter the name of the view

Now, the user has to set the folder and the name for the MEDITS basic files to be used.



Choose stratification file TR

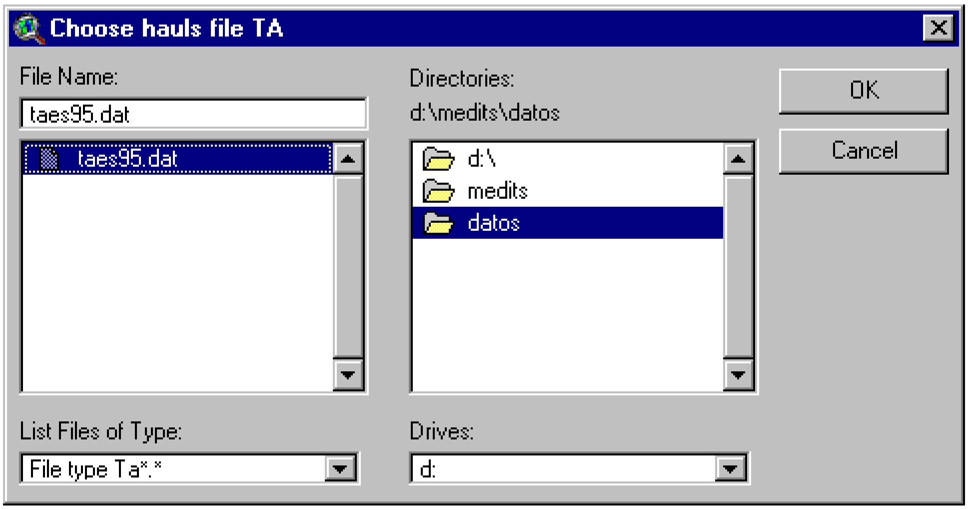
File Name: tres95.dat

Directories: d:\medits\datos

List Files of Type: File type Tr*.*

Drives: d:

TR (Stratification’s file: Hauls, sectors and stratum)



Choose hauls file TA

File Name: taes95.dat

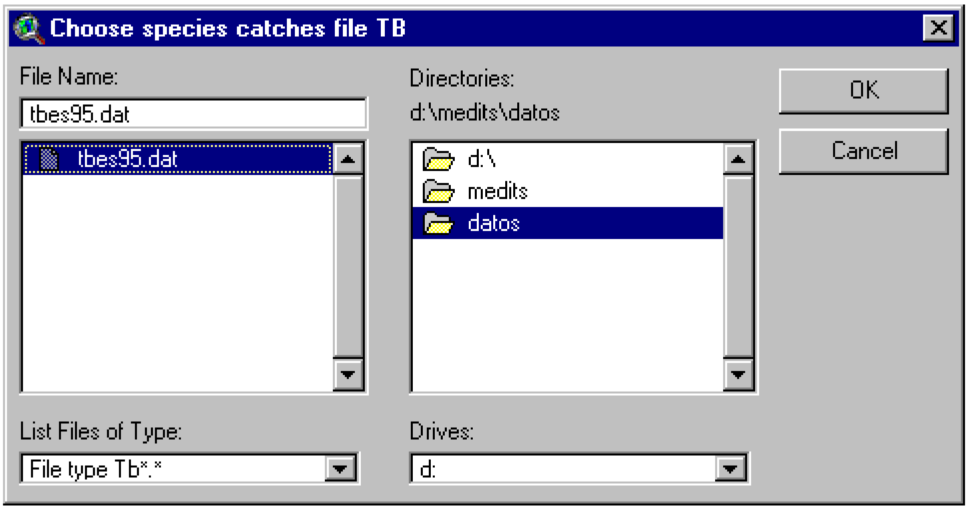
Directories: d:\medits\datos

List Files of Type: File type Ta*.*

Drives: d:

TA (Haul’s features file)

(*)



Choose species catches file TB

File Name: tbes95.dat

Directories: d:\medits\datos

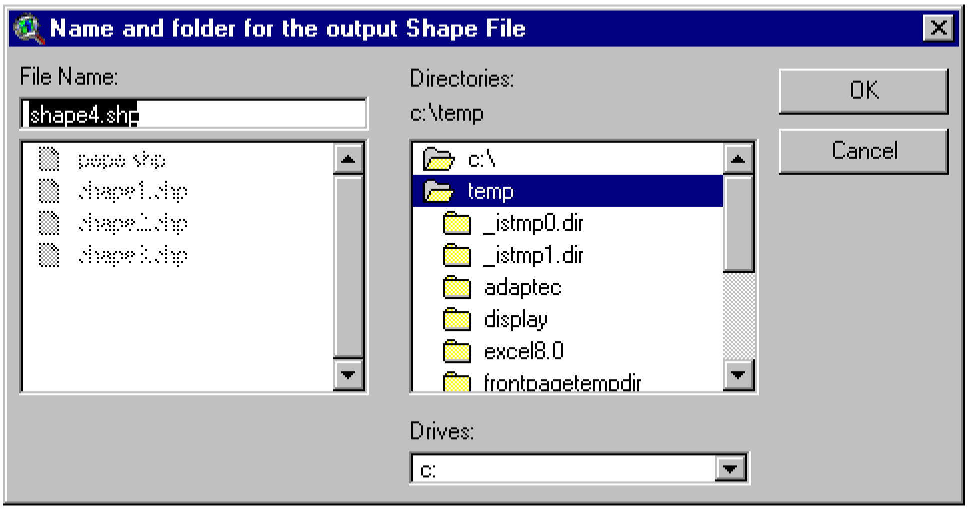
List Files of Type: File type Tb*.*

Drives: d:

TB (Catches file in Biomass and Number of Individuals by Sex)

WARNING: The data files Tr, Ta, Tb, Tc, only can contain ASCII characters. If the data files are modified or edited with a word processor or another kind of editor, you have to save it like "only text file". The last line must be empty. So, when it contains a character or a symbol may be cause an error in the load of data file. Then you must erase it and save the file like "only text file" to avoid errors.

(**)
Next the user has to specify the name and folder for the output shape file



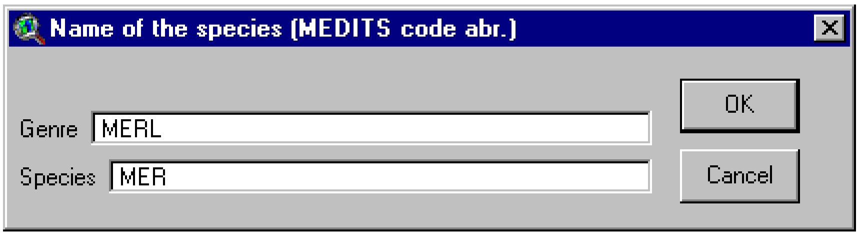
Name and folder for the output Shape File

File Name: shape4.shp

Directories: c:\temp

Drives: c:

(***)
Next the user has to specify the species



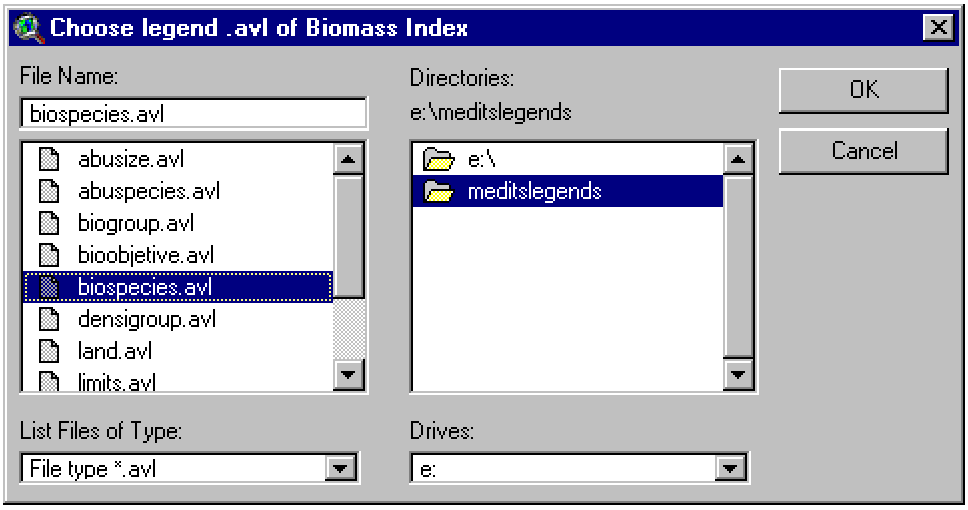
Name of the species (MEDITS code abr.)

Genre MERL

Species MER

Put the specie's name (in MEDITS abbrev. Code)

Now the user has to choose the legends to be applied in order to obtain the representation of the Indices



Choose legend .avl of Biomass Index

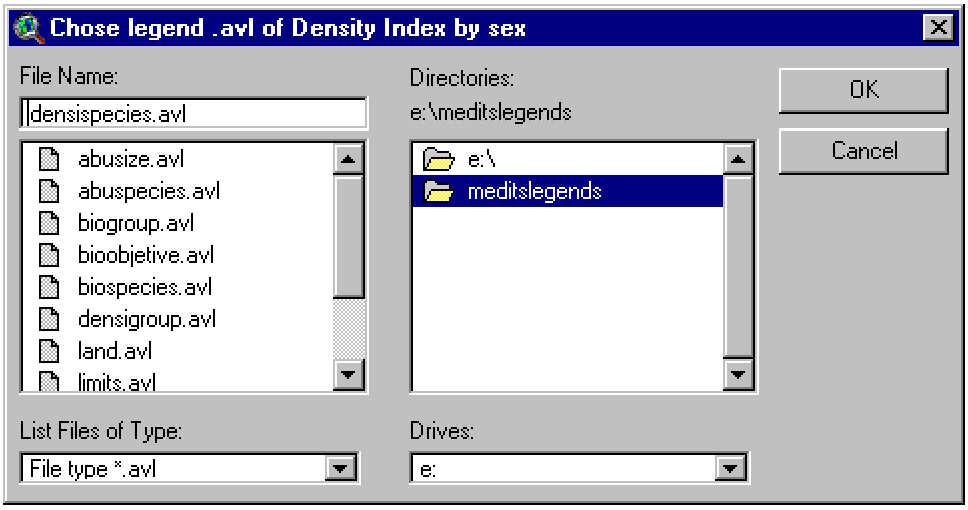
File Name: biospecies.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

Drives: e:

To the biomass index the Extension provides the file BIOSPECIES.AVL. It produces a punctual representation by intervals of the biomass index.



Chose legend .avl of Density Index by sex

File Name: densispecies.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

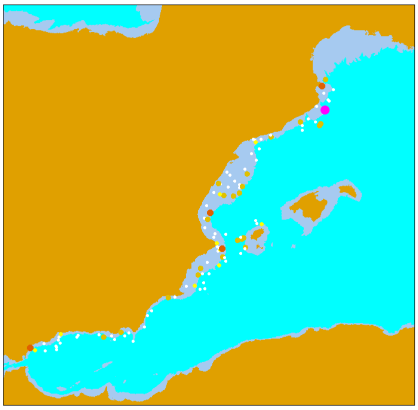
Drives: e:

To the total density by sex the Extension provides the file DENSISPECIES.AVL. It produces a representation in pie diagrams, where the portions are proportional to sex density (in numbers of individuals by square kilometers) and symbol size is related to total density (in a relative range of 4 to 12 corresponding to the minimum and maximum of the total given density).

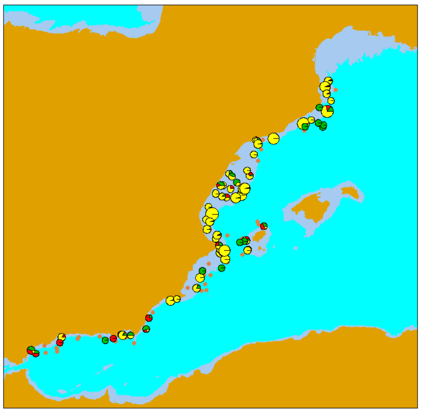
The user has to choose among the legends that are in MEDITSlegends folder of the CD-ROM, and once incorporated they can be edited and modified by the user, and saved in any folder with any name, for further uses.

Finally the user can see both representations in the chosen view by opening and enabling the two created themes.

Spain



Spain



The tables associated to the themes produced by the extension will be available now in DBF format, with the name and the folder given by the user.

The structure of this table is defined by the following fields:

Country
Year
Month
Day
Number of the Haul
Sector
Stratum
Initial Longitude (in decimal degrees)
Final Longitude (in decimal degrees)
Intermediate Longitude (in decimal degrees)
Initial Latitude (in decimal degrees)
Final Latitude (in decimal degrees)
Intermediate Latitude (in decimal degrees)
Duration of the Haul (in minutes)
Intermediate Depth (in meters)
Horizontal Opening of the Net (in dm.)
Swept Area (in square meters)
Code of the Species (MEDITS)
Biomass Index (kg/km^2)
Total Density (Individuals/km^2)
Females Density (Individuals/km^2)
Males Density (Individuals//km^2)
Undetermined Sex Density (Individuals//km^2)

7.2 GROUPS

The process is the same as that for the previous SPECIES till the mark (***).

In this case the Abundance Indices for the all the groups considered in MEDITS Project will be calculated and represented.

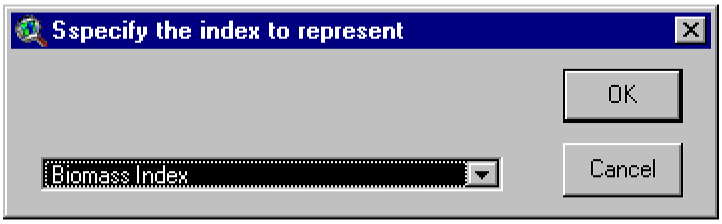
The five fixed groups are:

- Fishes
- Crustaceans
- Cephalopods
- Other with commercial interest (WCI)
- Other with no commercial interest (NCI)

And the two Indices are:

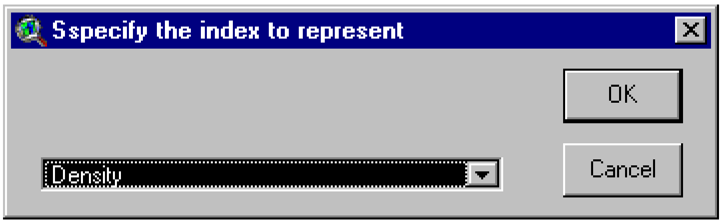
- Biomass Index (kg/km2)
- Density (Number of Individuals/km2)

Now, the user must specify the index



Biomass Index

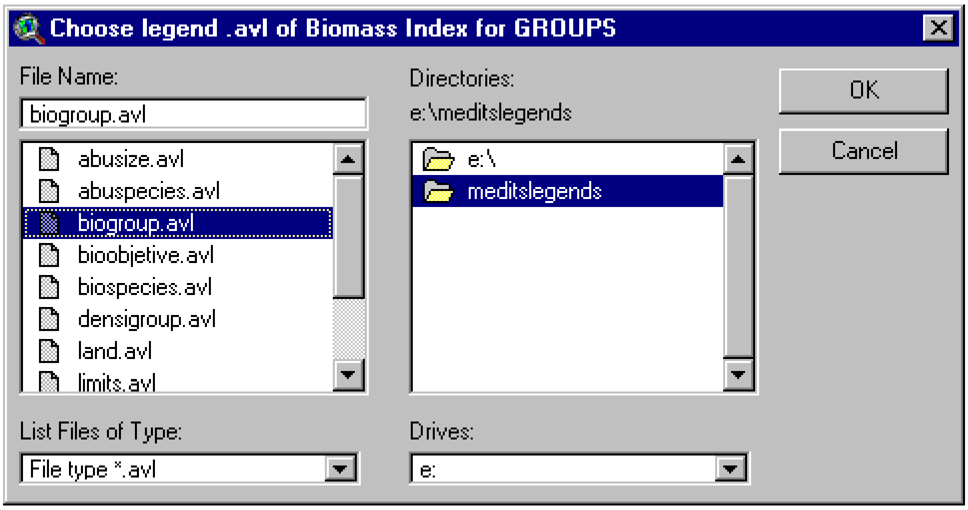
or



Density

(both images corresponds to the two options of the same box).

Now the user has to set the legends to be used by the representation Indices.



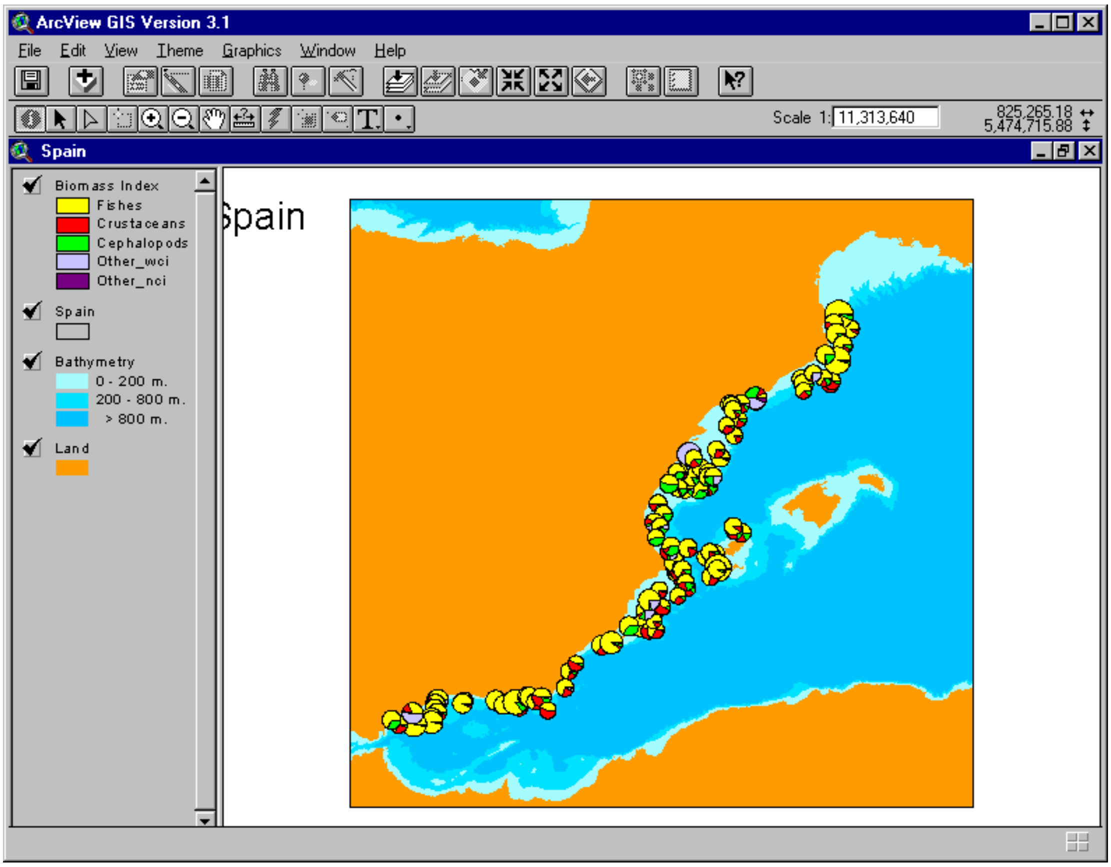
File Name: biogroup.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

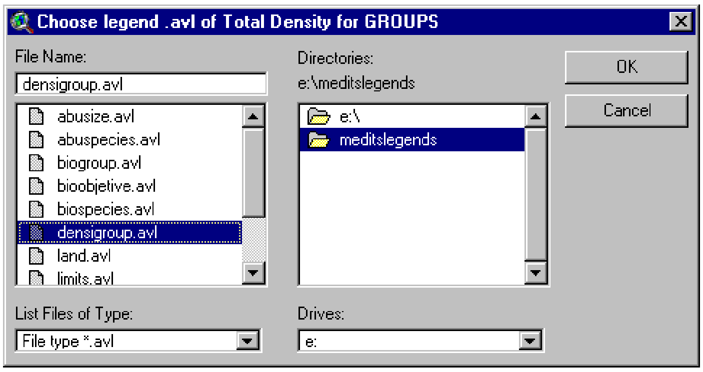
Drives: e:

If the Biomass Index has been previously chosen, the Extension provides the Legend BIOGROUP.AVL in the folder MEDITSLEGENDS of the CD. It produces a representation in pie diagrams, where the portions are proportional to the different groups and symbol size is related to Total Biomass in kg/km^2 and in a relative range of 4 to 12 corresponding to the minimum and maximum of the given total Biomass.



Scale 1: 11,313,640

825,265.18
5,474,715.88



Choose legend .avl of Total Density for GROUPS

File Name: densigroup.avl

abusize.avl
abuspecies.avl
biogroup.avl
bioobjetive.avl
biospecies.avl
densigroup.avl
land.avl
limits.avl

Directories: e:\meditslegends

e:\
meditslegends

List Files of Type: File type *.avl

Drives: e:

If the Density has been previously chosen, the Extension provides the Legend DENSIGROUP.AVL in the folder MEDITSLEGENDS of the CD. It produces an analogous representation in pie diagrams, where the portions are proportional to the different groups and symbol size is related to total Density measured in Number of Individuals/km^2 and represented in a relative range of 4 to 12 corresponding to the minimum and maximum of the given total Density.

The shape's out table produced by the extension will be available now in DBF format, with the name and the folder given by the user.

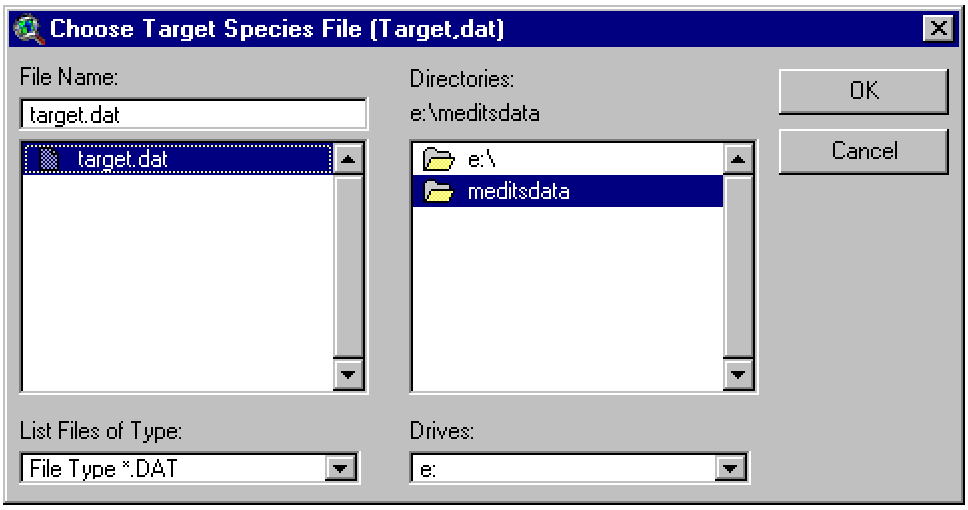
The structure of this table is:

Country
Year
Month
Day
Number of the Haul
Sector
Stratum
Initial Longitude (in decimal degrees)
Final Longitude (in decimal degrees)
Intermediate Longitude (in decimal degrees)
Initial Latitude (in decimal degrees)
Final Latitude (in decimal degrees)
Intermediate Latitude (in decimal degrees)
Duration of the Haul (in minutes)
Intermediate Depth (in meters)
Horizontal Opening of the Net (in dm.)
Swept Area (in square meters)
Type of Index (Biomass in kg/km^2 or Density in Number of Individuals/km^2)
Fishes
Crustaceans
Cephalopods
Other with commercial interest (WCI)
Other with no Commercial Interest (NCI)
Total

7.3 TARGET SPECIES

This script produces the representation and table of the total set of Target Species.

After the specification of the view corresponding to the basic cartography as described for the two previous cases, the user must supply the file and folder of the considered Target Species. The Extension provides the file of the current target species TARGET.DAT in the folder MEDITSDATA of the CD. The considered species are implemented in MEDITS Code. But the user may edit this ASCII file and add, delete or substitute any number of species. It is to say that the set of “Target Species” is open to the user’s needs.



Choose Target Species File (Target.dat)

File Name: target.dat

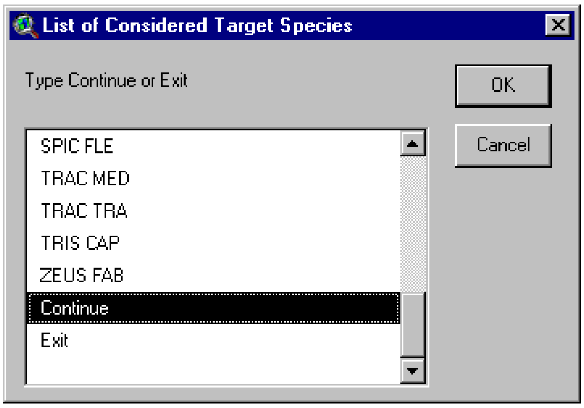
Directories: e:\meditsdata

List Files of Type: File Type *.DAT

Drives: e:

Except for the input of this Target Species file, the process is the same as that for the previous SPECIES till the mark (***).

As the Target Species included in the TARGET.DAT ascii file may be changed by the possible users (perhaps various), the Extension provides in the next step a verification of the list of Target Species presently included in TARGET.DAT.

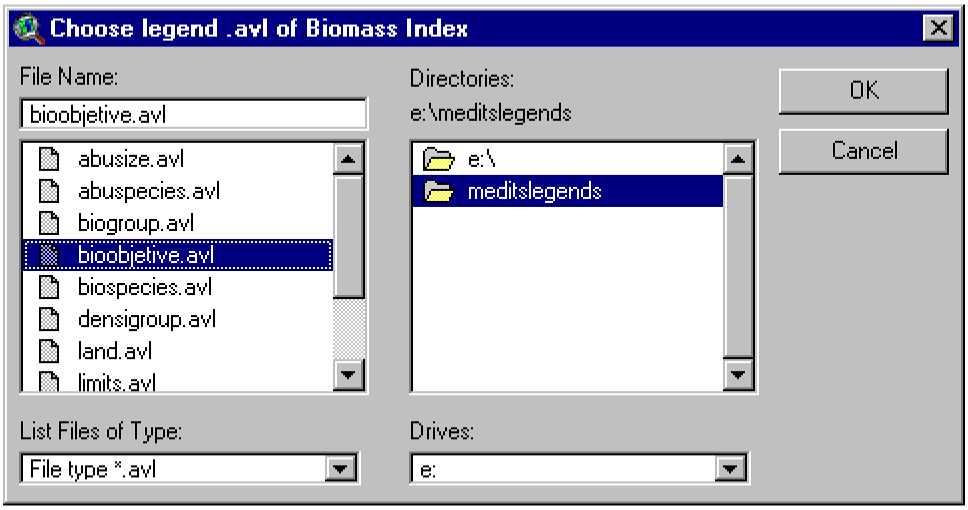


List of Considered Target Species

Type Continue or Exit

If the user agrees with the actual TARGET.DAT must select *Continue* and click OK.

Next, the Extension provides the Legend BIOOBJETIVE.AVL in the folder MEDITSLEGENDS of the CD in order to obtain the representation of the Biomass Index of the join set of considered Target Species.



Choose legend .avl of Biomass Index

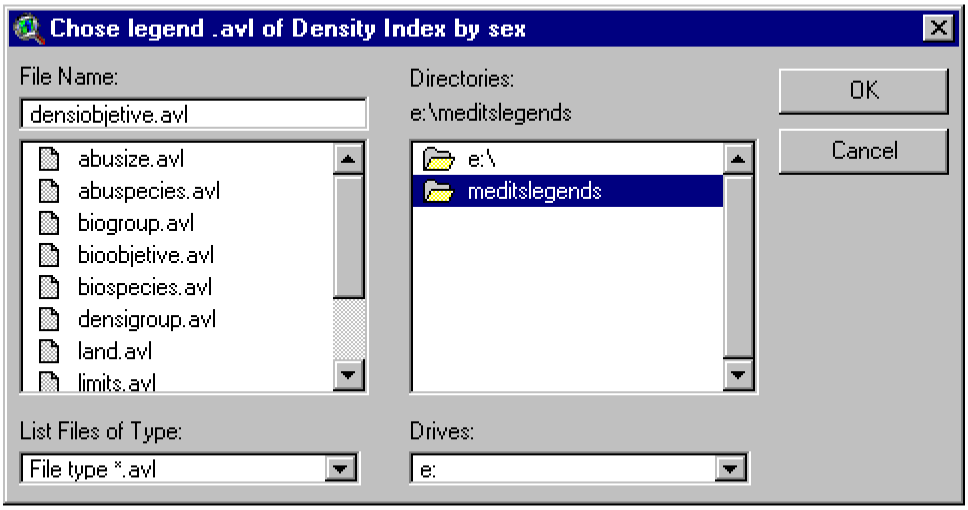
File Name: bioobjetive.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

Drives: e:

Also, the Legend DENSIOBJETIVE.AVL in the same folder of the CD in order to obtain the representation of the Density of the whole set of considered Target Species.



Chose legend .avl of Density Index by sex

File Name: densiobjetive.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

Drives: e:

As in the previous cases, the shape's out table produced by this script will be available now in DBF format, with the name and the folder given by the user.

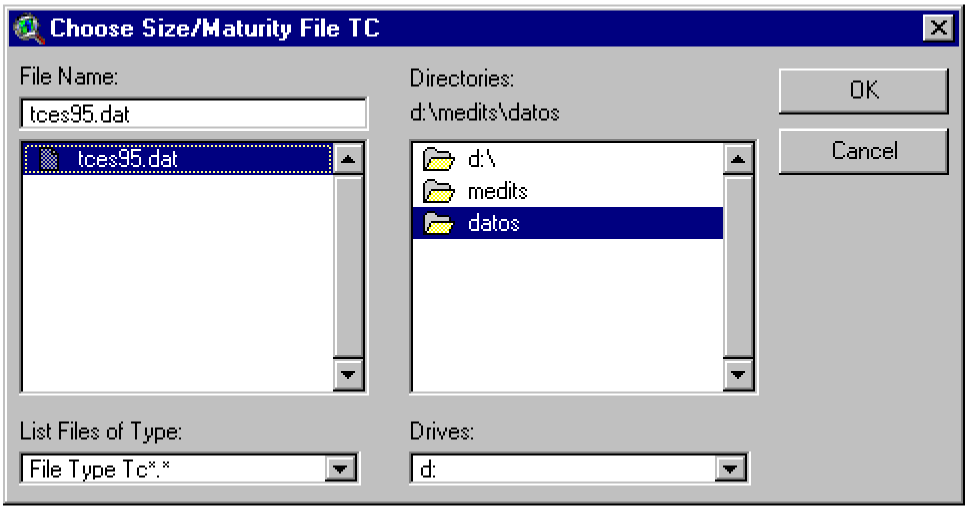
And the structure of this table is:

Country
Year
Month
Day
Number of the Haul
Sector
Stratum
Initial Longitude (in decimal degrees)
Final Longitude (in decimal degrees)
Intermediate Longitude (in decimal degrees)
Initial Latitude (in decimal degrees)
Final Latitude (in decimal degrees)
Intermediate Latitude (in decimal degrees)
Duration of the Haul (in minutes)
Intermediate Depth (in meters)
Horizontal Opening of the Net (in dm.)
Swept Area (in square meters)
Type of Table (Target Species)
Biomass Index of the join set of Target Species (kg/km^2)
Total Density (Individuals/km^2)
Females Density (Individuals/km^2)
Males Density (Individuals/km^2)
Undetermined Sex Density (Individuals/km^2)

7.4 SIZES

This script provides the representation and table of the Density of a particular Species measuring the Number of Individuals/km2 whose size (in mm.) is between an interval provided by the user. It may be useful in order to obtain the Density distribution of any size interval and in particular of juveniles or adults (for this purpose could be used the working paper by J. Bertrand, L. Gil de Sola, Costas P., G. Relini and A. Souplet, “Distribution of juveniles of some demersal species in the Northern Mediterranean”, GFCM-SAC, Rome, Italy, June 1999).

The process is the same as that for the previous SPECIES till the mark (***), except that the Species/Size/Maturity file TC*.* will be required instead of the catches file TB*.*



Choose Size/Maturity File TC

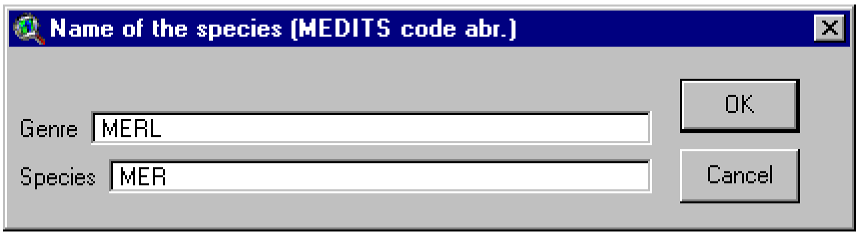
File Name: tces95.dat

Directories: d:\medits\datos

List Files of Type: File Type Tc*.*

Drives: d:

Next the user has to specify the species



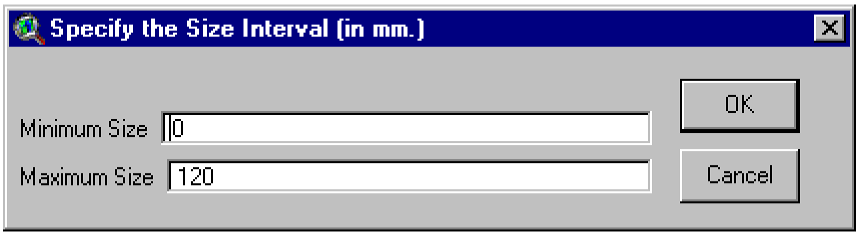
Name of the species (MEDITS code abr.)

Genre: MERL

Species: MER

Set the specie’s name (in MEDITS abbrev. Code)

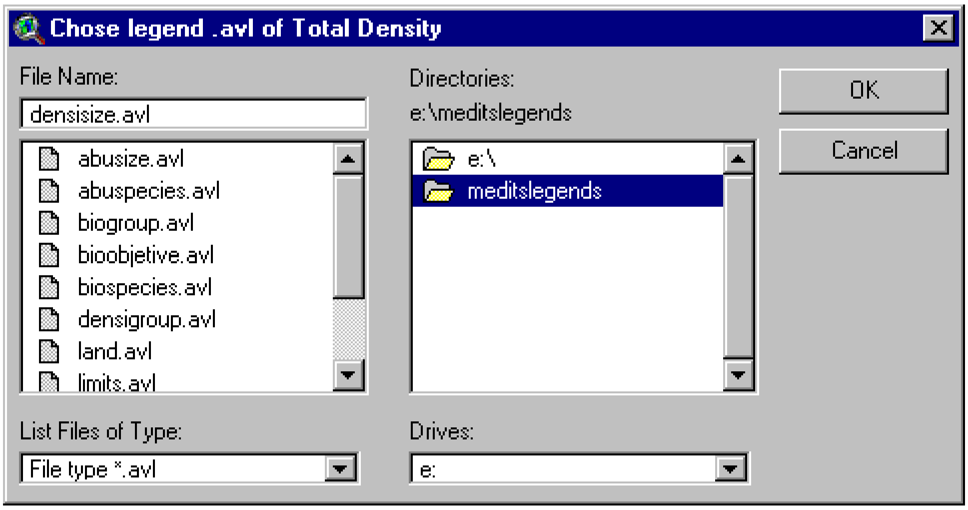
Next the user will provide the decided size interval (in mm.)



Minimum Size: 0

Maximum Size: 120

As previously two legends must be provided in order to represent the Total Density (DENSISIZE.AVL in MEDITSLEGENDS) and for the pie representation of the Density by sex (DENSISIZESEX.AVL in MEDITSLEGENDS).

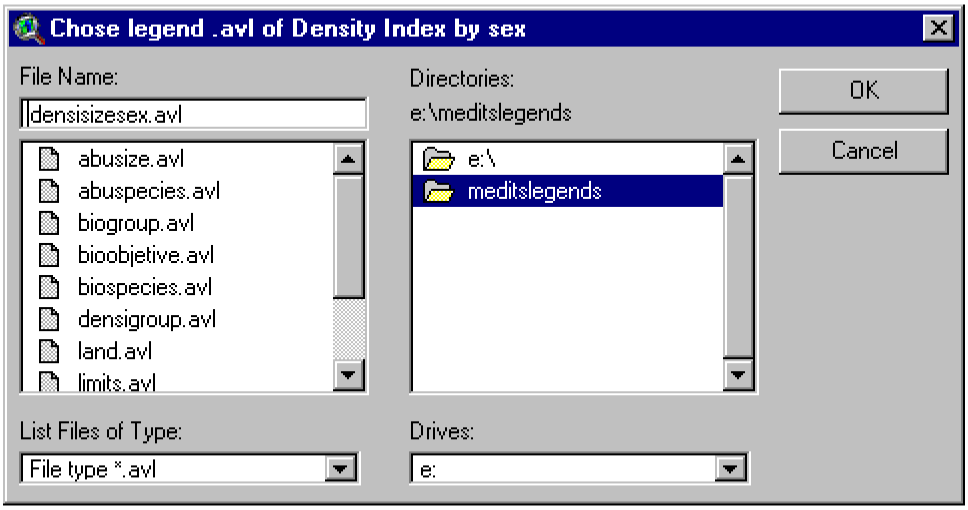


File Name: densisize.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

Drives: e:



File Name: densisizesex.avl

Directories: e:\meditslegends

List Files of Type: File type *.avl

Drives: e:

The maps are similar to those obtained by the script SPECIES.

The shape's output table produced by this script will be available now in DBF format, with the name and the folder given by the user.

The structure of this table is:

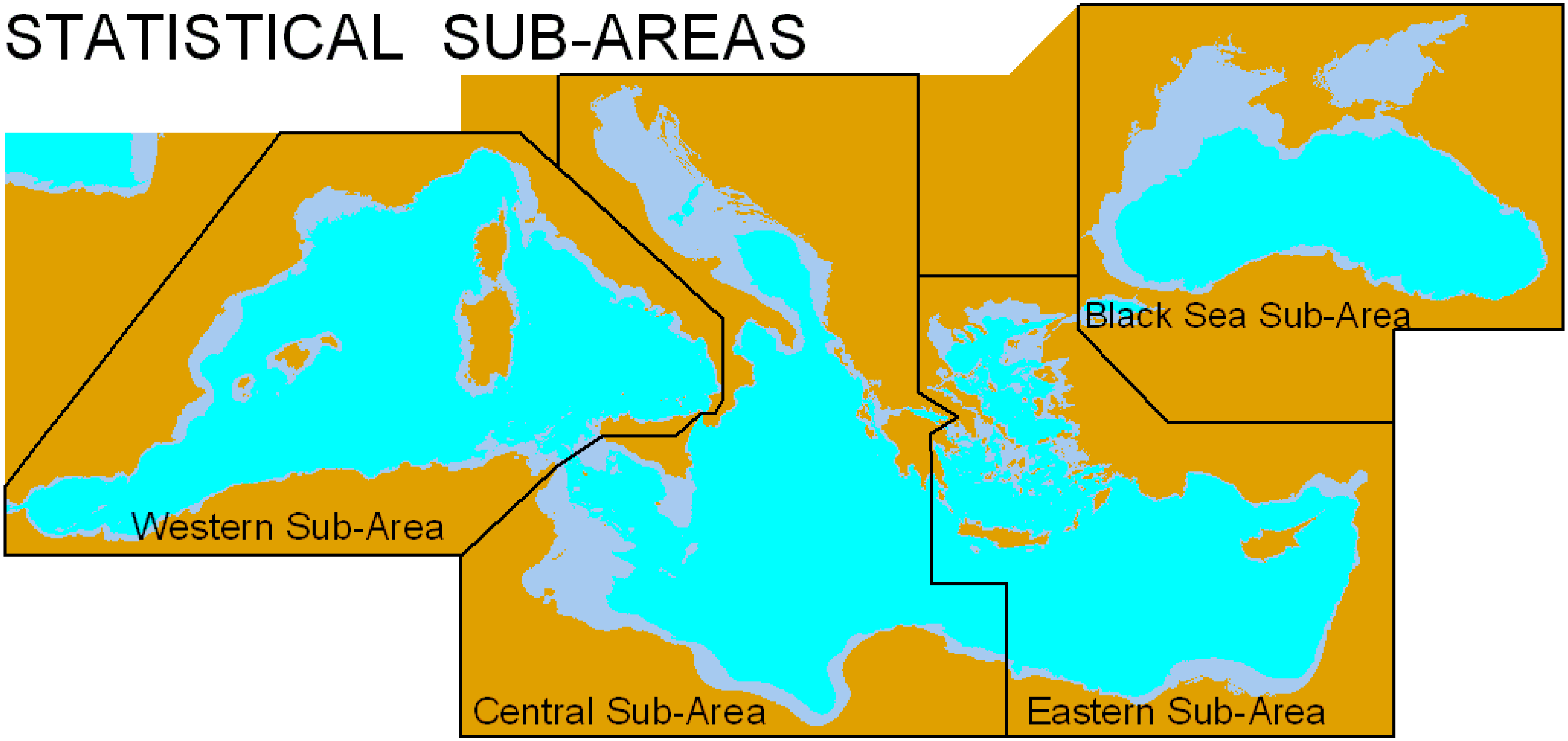
Country
Year
Month
Day
Number of the Haul
Sector
Stratum
Initial Longitude (in decimal degrees)
Final Longitude (in decimal degrees)
Intermediate Longitude (in decimal degrees)
Initial Latitude (in decimal degrees)
Final Latitude (in decimal degrees)
Intermediate Latitude (in decimal degrees)
Duration of the Haul (in minutes)
Intermediate Depth (in meters)
Opening of the Net (in dm.)
Trawled Surface by the Haul (in square meters)
Code of the Species (MEDITS)
Size Interval (in mm.)
Mean Size (in mm.)
Total Density (Individuals/km^2)
Females Density (Individuals/km^2)
Males Density (Individuals/km^2)
Undetermined Sex Density (Individuals/km^2)

CHARTS

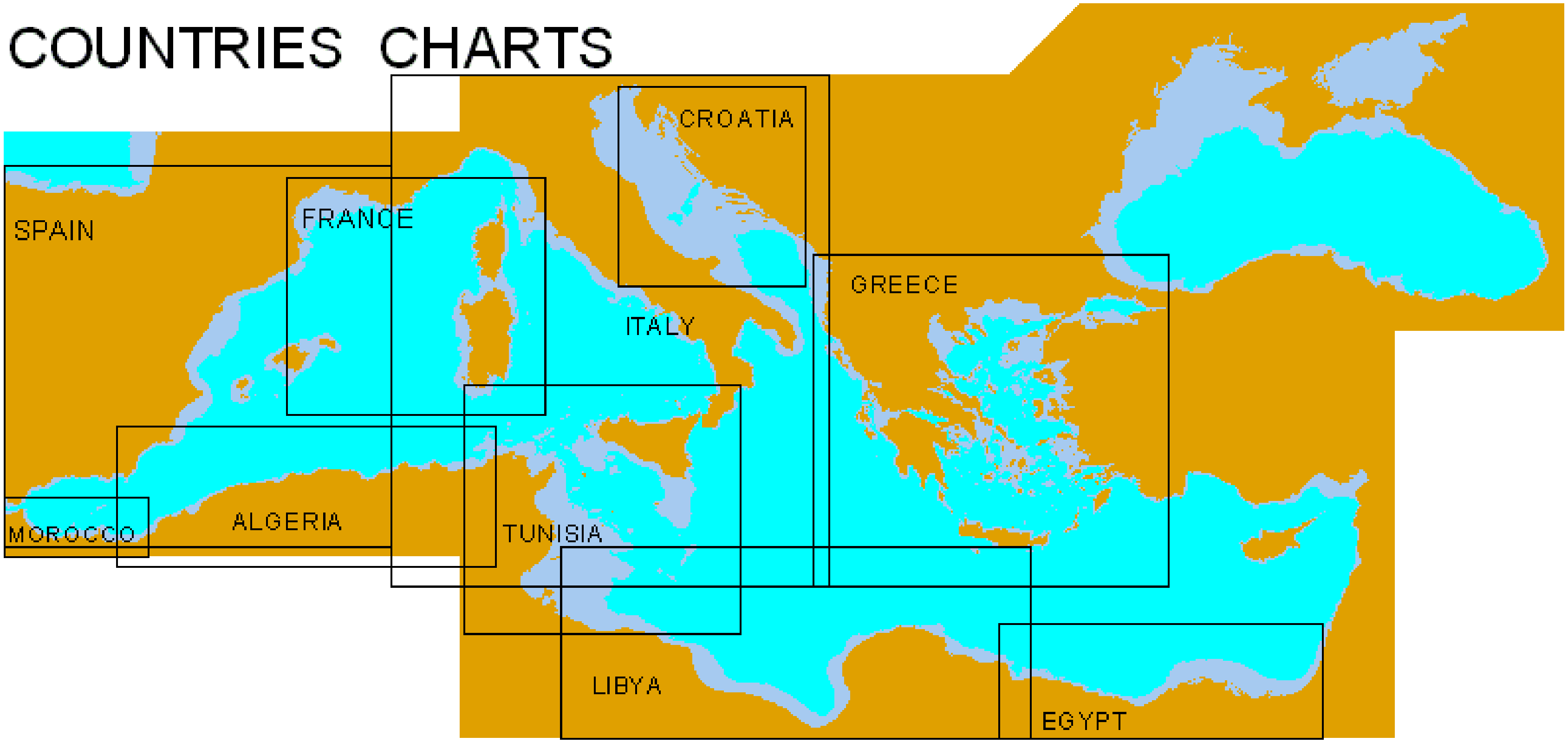
FIGIS

Fisheries
Geographic
Information
System

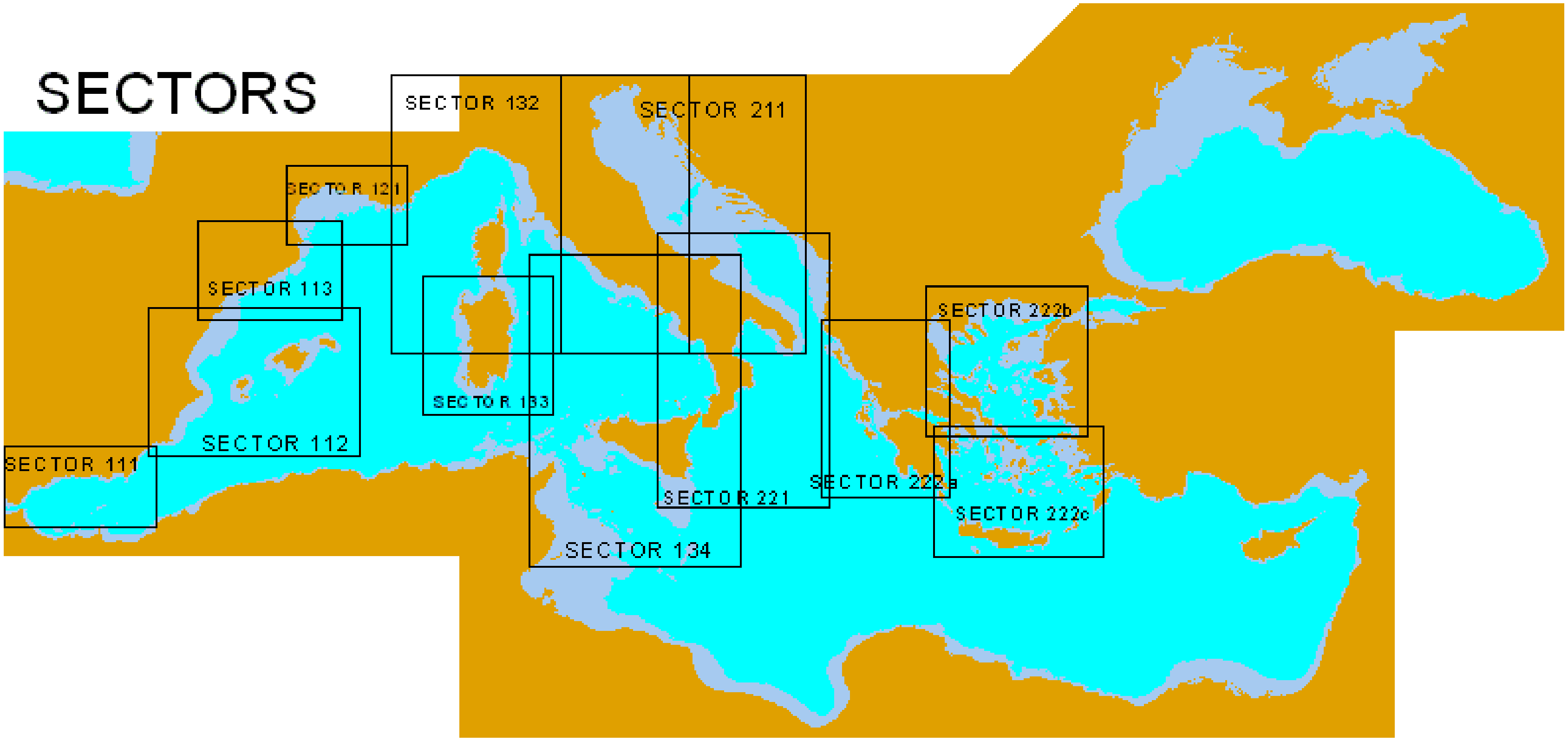
STATISTICAL SUB-AREAS



COUNTRIES CHARTS



SECTORS


SECTOR 132
SECTOR 211
SECTOR 121
SECTOR 113
SECTOR 112
SECTOR 111
SECTOR 133
SECTOR 134
SECTOR 221
SECTOR 222a
SECTOR 222b
SECTOR 222c

THE POSSIBLE CONNECTIONS

Possible connections with other software.

Summarising, as it has been seen along the previous pages, the extension MEDITS-ArcView will use MEDITS original data files (TA, TB, TC and TR) to produce shapefiles that are displayed in the maps contained in views and that have associated tables in format Dbase (*.DBF) which structure has already been described .

These tables as well as shapefiles can be transferred to other programs such as statistical, geostatical processors and image analysts. The capacity of connections with such other programs helps to continue with the information elaboration process from the raw data to parameter estimation, simulation and testing hypothesis over the considered indices.

Connection to Statistical Processors

The DBF tables can be incorporated to the most common statistical software packages SPSS, Statistica and S-Plus through the following steps:

- **SPSS**: menu *File → Open*.
- **Statistica**: menu File → Import data → Quick.
- **S-Plus**: menu File → Import data → From file.

The results of the statistical analysis implemented by these programs can be used either independently or re-incorporated to the maps produced by the Extension. Specially interesting is the possibility of adding the statistical graphic results (histograms, piecharts, regression lines, etc..) to the maps through “Layouts”, that are ArcView compositions ready to be printed out.

This statistical elaboration, can also serve as first step to the exploratory analysis needed to go forward the spatial analysis via geostatistical techniques.

Connection to Geostatistical Packages

As the Extension produces ArcView files, the connection to the spatial analysis module of the program: Spatial Analyst is straight. The files needed by the module are shapefiles. The process of spatial interpolation by Spatial Analyst will provide a grid file (.GRD) that can be added to any view of ArcView .

The connection with EVA needs the help of Excel since EVA can not import directly Dbase files, (ArcView tables). Open Excel and go to the menu *File → Open → Dbase*, then save the file as XLS, edit with Excel and EVA will incorporate it easily.

The connections to other two geostatistical processors: GEOEAS and Surfer needs the incorporation of data as ASCII files. From ArcView, the transformation from Dbase to Ascii is easy. Before leaving the program, open the table, go to the menu *File → Export → Delimited text*. The file created is an Ascii text file with the successive fields delimited by commas.

GEOEAS will be able to open this text file, with some minor modifications. Open any word processor, either Notepad and add a “header” with a title, number of records, and a record for each name of the table’s fields. Save the file and go to any module of GEOEAS to work with this file.

Surfer, can incorporate the Text file directly by clicking on *File → Open*, from the “Worksheet” module of the program. It can also be added from the module “Plot”, by clicking on the menu *Grid → Data,* or *Grid → Variogram*.

Intermediate and final results of the geostatical analysis provided by these programs (EVA, GEOAS and Surfer), can be included in the ArcView “layouts” with the aim of presenting the maximum information of each map.

To incorporate the results of Kriging in an ArcView map, they need to be also Ascii comma delimited text files, which are provided by all the processors mentioned above just doing *save as...*. This incorporation process has to be done in two steps:

Addition of the Ascii table (:TXT). From the main window go to the menu *Project → Add table*.

Addition of the table as a theme to the view where the basic map is. In the View window go to the menu *View → Add event theme*.

Connection to IDRISI

IDRISI 3.2 is a GIS with a good set of statistical and geostatistical tools. It also can perform image analysis allowing combination of raster and vectorial information. Describing the possibilities of analysis with IDRISI is out of the goals of this short guide. Only the instructions needed for the incorporation of the files produced by the extension will be introduced here.

In IDRISI main window go to the menu *File → Import → Software Specific Formats → SHAPEIDR*.

This module (Shapeidr) will produce two files: point vector file (.VCT) and the data base associated to the shape file (that is originally in DBF format), is changed to MDB access format. These two files permit further representation and analysis by Idrisi different modules. Among others, spatial interpolations, and sophisticated multivariate analysis of images.

All the results of these analysis, can be dited by Idrisi itself in different ways, but also worth to mention is the possibility of reverting the process. This is to say newly incorporate the results to ArcView to produce uniform outputs.

In order to achieve that process it is neccessary to convert the files provided by Idrisi in Shapefiles. First going to the menu *Reformat → Raster/Vector conversion → POINTVEC* in order to convert the raster images to vector point features. And finally, going to the menu *File → Export → Software Specific Formats → SHAPEIDR*.

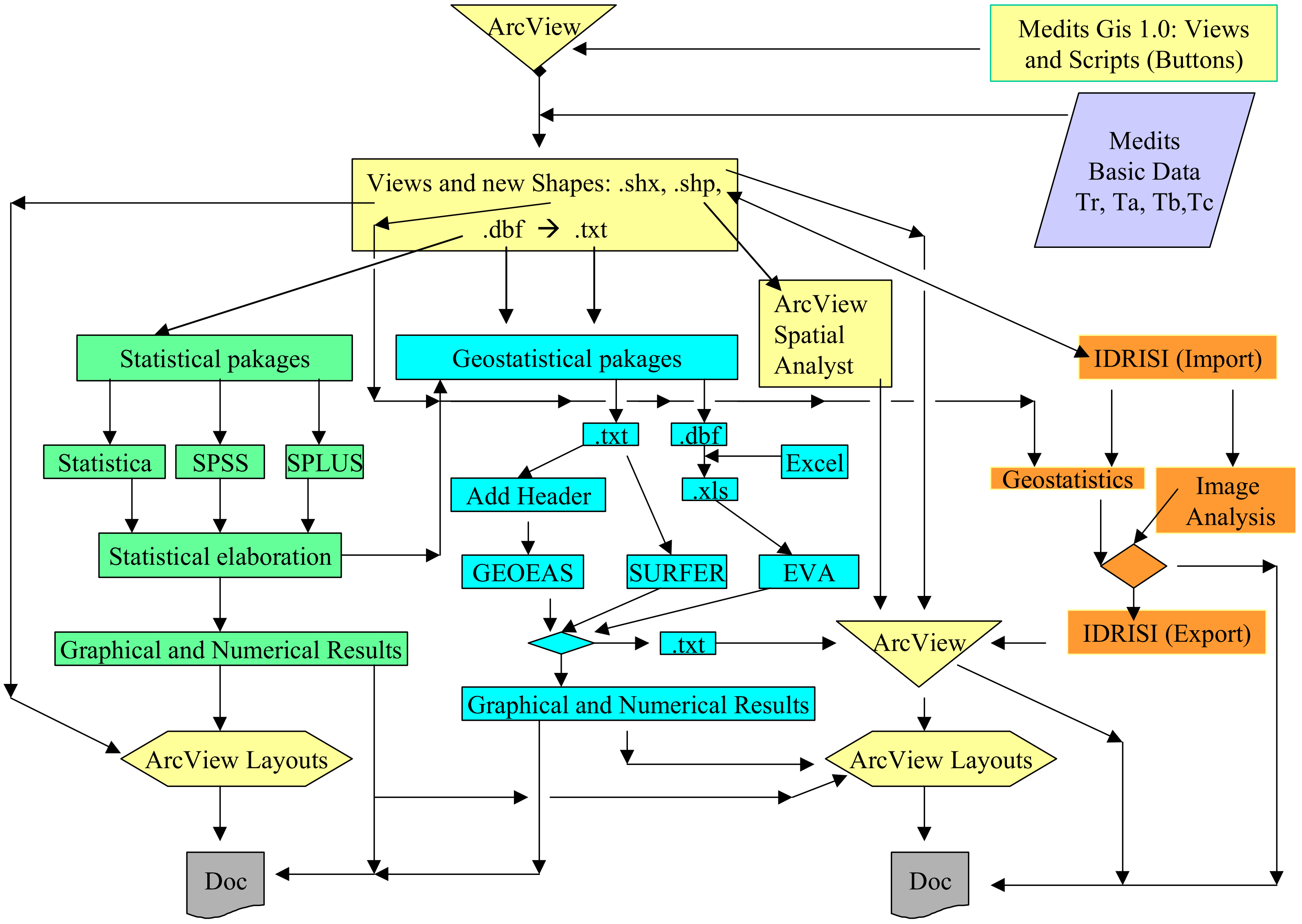
All the charts provided in the folder MEDTSMAPS of the CD are actually constituted by vectorial polygons. It means that the figures of land and bathymetric intervals are independent polygons that can be used if necessary as “masks” to hide or blank the grids resulting from interpolation processes (such as kriging).

The contents of the last paragraphs and the annexed flowchart describe a few paths suggested by the authors in order to fulfil a more detailed extraction of the information provided by the MEDITS project. But it must be stated that this is just an example of somehow “simple” manipulations derived from more complexes actions explored by the authors. Another not so simple subject is the appropriate utilisation of the introduced instruments. Although the set of paths is, in our opinion not exhaustive, it suffice for the purposes of our research and, of course it is always open to alternative ways of operating by the different users.

As the poet said

“..... caminante, no hay camino
se hace camino al andar
y al volver la vista atrás
se ve la senda
que nunca vas a volver a pisar.
Caminante no hay camino
sino estelas en la mar.”
Antonio Machado

Temptative translation*: Walker, there is not path, the path is done while it is being walked.*


ArcView
Medits Gis 1.0: Views and Scripts (Buttons)
Medits Basic Data Tr, Ta, Tb,Tc
Views and new Shapes: .shx, .shp,
.dbf → .txt
ArcView Spatial Analyst
IDRISI (Import)
Statistical pakages
Geostatistical pakages
Statistica
SPSS
SPLUS
.txt
.dbf
Excel
.xls
Add Header
Geostatistics
Image Analysis
Statistical elaboration
GEOEAS
SURFER
EVA
Graphical and Numerical Results
.txt
ArcView
IDRISI (Export)
Graphical and Numerical Results
ArcView Layouts
ArcView Layouts
Doc
Doc