EUROPEAN COMMUNITY - DG XIV

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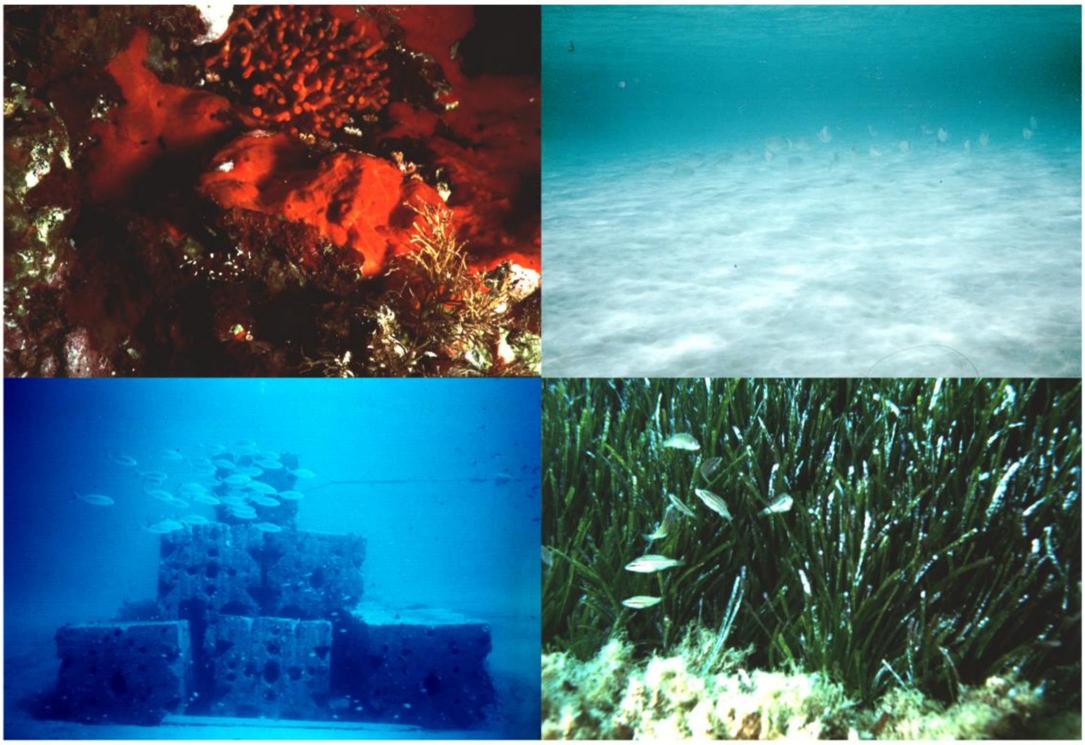
STRUCTURE OF THE POPULATIONS AND ASSESSMENT OF THE BIOMASS OF THE COASTAL DEMERSAL RESOURCES IN THE GULF OF CASTELLAMMARE

Project MED92/011 - DRAFT FINAL REPORT

Scientific responsibles: *Giovanni D'anna and Fabio Badalamenti.*

Scientiific equipe: *Carlo Pipitone, Roberta Lipari, Bernardo Patti and Angela Cuttitta.*

Technical equipe: *Marilena Coppola, Giuseppe di Stefano, Vitantonio Modica and Vincenzo Perrone.*



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PREAMBLE

This study has been carried out with financial assistance from the Commission of the European Communities.

CONTENTS

Running title: Coastal demersal resources in the Gulf of Castellammare (N/W Sicily)

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ABSTRACT

Our research, carried out in the continental shelf of the Gulf of Castellammare (N/W Sicily), aimed at supplying new data regarding the assessment of the abundance and biomass of the main demersal commercial species, and at depicting the nekton assemblages structure. Other important aims (sub-tasks) were to detect the effects of the trawling ban four years after its deployment, to identify areas important from a biological point of view and to supply general management advice.

The study, involving both trawlable and non-trawlable areas, used trawl surveys for the first ones, and trammel-gill net (on sandy and rocky bottoms inside the 16-25 m bathymetric range), beach seine (on sandy bottoms from 0 to about 10 m) and visual census methods (on rocky, sandy and *Posidonia oceanica* areas from 0 to 25 m) for the non-trawlable areas.

Four seasonal trawl surveys, based on a stratified random sampling design, were carried out from autumn 1993 to summer 1994. Three bathymetric strata were adopted, each of which was subdivided in elementary sampling units (ESUs). 245 diurnal and nocturnal hauls of 30 minutes were made. In order to estimate the biomass of the demersal resources the swept-area method was used. Biomass was expressed as tons in the whole sampled area (about 57 square nautical miles). The catch per unit effort (CPUE as gr/haul) of each species caught was calculated. Twelve target species were selected taking into account both their commercial importance and abundance. For these species, some reproductive aspects, the length frequencies distribution, the length-weigth relationship, the growth parameters, the istantaneous total mortality rate were calculated. Moreover, maps illustrating the distribution of the biomass indices of the target species were drawn.

Monthly diurnal and nocturnal trammel-gill net samplings were carried out for one year on hard and soft bottom areas. Seasonal maps of the CPUE (gr/500m of net/12h), based on the diurnal and nocturnal samples obtained in each area were drawn.

Qualitative samples were monthly collected for one year with a beach seine in the shallow sandy bottoms of the central area of the Gulf.

Two visual census techniques were adopted to obtain furher seasonal data on the fish assemblages of the non-trawlable areas on different subtrates (*i.e.,* rocky bottoms,

sandy bottoms and artificial reefs). The average values of density and biomass were estimated.

Community structure indices were elaborated for each sampling method. Multivariate analyses were also computed.

The principal results from the trawlable areas can be summarized as follows. Considering the overall catch, neither significant differences were found among the four seasons nor between diurnal and nocturnal catches. Anyway, the highest CPUE calculated as average value per stratum, was obtained in the diurnal winter samples of stratum B (50983 gr/haul) and the lowest in the nocturnal autumn samples of stratum C (14616 gr/haul). In general diurnal catches were larger than nocturnal. The yields per stratum were in many cases significantly different between each other. The red mullet *(Mullus barbatus)* was nearly always the dominant species in every stratum in the diurnal hauls, as well as in stratum A (except in winter) in the nocturnal ones. The highest yield for this species was recorded in the winter samples from the stratum A in the day (18559 gr/haul). The dominant species in stratum B and C at night was the picarel *(Spicara flexuosa),* with the highest values recorded in summer (16440 gr/haul) in stratum B and in autumn (2919 gr/haul) in stratum C. Considering the demersal trawlable fauna as a whole, the outer belt of stratum A and the whole stratum B were the richest zones inside the study area.

The biomass estimates of the twelve target species showed that the red mullet was by far the most abundant species (ranging from 34.08 t in summer at night to 170.34 t in winter in the day), followed by hake (from 5.81 t is summer at night to 62.58 t in winter in the day), pandora (from 6.93 t in summer at night to 24.94 t in wintwr in the day) and striped seabream (from 0.47 t in in summer in the day to 10.90 t in autumn at night).

The comparison between the CPUE of experimental trawl surveys carried out before the trawling ban and our data showed that the commercial demersal resources of the Gulf underwent a mean seven-fold increase. In particular the red mullet yields increased 33 times (mean value on the whole study area).

A total of 171 taxa were collected in the four surveys. In general the highest values of specific richness and diversity were recorded in stratum C at night in winter, while the maximum number of specimens was attained in winter in the diurnal samples of stratum B. The multivariate analyses separated six areas characterized by different nekton assemblages, which could be seen as management units.

Nocturnal samples from the trammel-gill net surveys were always significantly higher than the diurnal ones. The highest yield was recorded on the western rocky bottom, where an average CPUE of 2895 gr was attained, calculated on an annual basis. The lowest values were recorded on the soft substrata in the central area (1149 gr), while the artificial reef area showed intermediate values (2811 gr). On the whole sampled area, cuttlefish attained 25% of the total catch on an annual basis, followed by the annular seabream (19.4%). In the western rocky bottoms the most important species were the scorpionfishes, in the artificial reef the annular seabream and the red mullet and in the soft bottom areas the wide-eyed flounder and the striped seabream.

Trammel-gill net surveys displayed a significantly higher species richness and abundance in number of specimens in the nocturnal than in the diurnal samples.

From the visual census surveys damselfish, rainbow wrasse and swallowtail seaperch were the most abundant species. Sparids (common two-banded seabream, annular seabream) and serranids (comber and painted comber) were the most frequent and abundant commercial species observed. The highest biomass (gr/m^3) was reached in summer on the artificial reef (52.7), while the lowest was recorded on the sandy bottoms in autumn (0) and in spring (0.19). The highest density (number of specimens/m^3) was found in summer on the artificial reef area (2.85) and the lowest in autumn (0) and spring (0.01) on the sandy bottoms.

The community structure indices of the rocky and artificial reef areas were significantly higher than those of the soft bottom areas.

The FCA put into evidence a spatial gradient from the rocky to the sandy bottom fish assemblages. The artificial reef area was plotted just in the middle of the geometrical model.

The beach seine surveys highlighted the role of the shallow sandy bottoms as a nursery area for several species. The nekton assemblages of the four sampled sites were very similar among each other, whereas a strong seasonality was evident by the cluster analysis results. These data along with those of the trawl surveys showed that the sandy and muddy bottom areas located between 1 and 40 m are a nursery ground for several important species: red and striped mullet, pandora, striped seabream and several sparids and mugilids.

KEY WORDS: Beach seine, Biomass, Continental shelf, Demersal fauna, Fish assemblages, Mediterranean Sea, Multivariate analysis, Sicily, Trammel net, Trawl survey, Visual census.

SYNTHESIS FOR NON-SPECIALISTS

The Gulf of Castellammare, located in northwestern Sicily, is one of the widest bays of the Island. It is characterized mainly by soft (sandy and muddy) bottoms and for this reason it has been exploited for a long time by trawlers. The intense fishing and the lack of any control has caused the impoverishment of the fishable resources along the whole continental shelf (0-200 m depth). As a consequence of this overexploitment the Sicilian Regional Authority implemented some management measures, among the others:

- the creation, in 1974, of the Association for Fish Restocking in the Gulf of Castellammare aimed at protecting and enhancing the coastal fishing resources by means of artificial reefs. After that many artificial reefs were deployed and today they cover more than 50ha;
- the trawl fishing ban Act, in 1989, valid in the whole continental shelf of the Gulf (whereas before this Act trawling was permitted, according to national laws, beyond the 50 m depth);
- consequently to the trawl ban, a grant (*fermo di pesca*) was given to all fishermen, resident in the banned area, who decided to stop trawling activities at all for a maximum time of six months.

Despite this policy no research projects were funded for the evaluation of the results of the implemented measures, and very few data are still available concerning the demersal resources of the Gulf.

OBJECTIVES OF THE RESEARCH - Our research was aimed at updating the existing data about the fishable resources, at mapping the demersal resources, at estimating density and biomass of the populations of commercial interest. The sub-tasks were: assessment of the effects of the trawling ban four years after its beginning, identification of areas important from a biological point of view and general management advice.

METHODS - The whole continental shelf was divided in trawlable and non-trawlable areas. The first were surveyed by a hired professsional trawler, whereas the second by means of three different techniques: trammel-gill net, beach seine and visual census.

RESULTS

TRAWLABLE AREAS - The most abundant trawlable species were red mullet, hake and picarel. Detailed biomass estimates were calculated only for the twelve most important commercial species. On a yearly average, the red mullet had a biomass of 71.58t followed by hake (20.30t), pandora (13.14) striped seabream (5.46t), calculated on the whole sampled area of about 57 square nautical miles.

NON-TRAWLABLE AREAS - Cuttlefish and annular seabream were the most frequent and abundant species caught by trammel net. On the rocky areas however scorpionfishes attained the highest yields. From the visual census observations the largest biomass of fish was estimated on both the rocky bottoms and the artificial reef area, whereas the lowest values were recorded on soft bottoms. From the beach seine sampling it was observed that the shallow inshore soft bottoms are important nursery areas for some sparids, for the red and striped mullets and for the grey mullets. Other nursery grounds were detected by the trawl surveys on the sandy and muddy bottoms between 10 and 40 m depth, where large amounts of juvenile red and striped mullet, pandora and striped seabream were caught.

COMPARISONS - We compared the results of our seasonal trawl surveys with those of other experimental trawl surveys carried out before the trawling ban. The commercial demersal resources of the Gulf underwent a mean seven-fold increase. In particular the red mullet yields increased 33 times (mean value on the whole study area).

Using sophisticated statistical analysis and starting from the trawl surveys data, we were able to divide the whole sampled area in six smaller sub-areas. Each sub-area includes zones with common characteristics concerning both the species composition and the abundance, and with homogeneous bottoms (*i.e.*, sandy bottom, muddy bottom, etc.). In this way we assessed that the richest sub-area, in terms of fishable resources, is the belt between 35 and 80 m depth on muddy bottoms, where important commercial species like red mullet, striped mullet, striped seabream, hake and pandora are very abundant. In this area is located nearly 40% of the total number of specimens fished in the trawl surveys. The poorest sub-area was located out of the banned area.

DISCUSSION - The most evident result of the present study is the great biomass increment observed comparing our data with those of the previous researches. This datum is easily referable to the four-year trawling ban. However the great increment of some resources like the red mullet testifies also a change in the fauna composition which tends to a new equilibrium of the whole continental shelf system. Further changes both in species composition and abundance could be expected in the next future, when the ecological succession will try to reach a *climax* (equilibrium) as long as, at the same time, a different fishing regime will not start. A resources monitoring as well as a rigorously controlled restart of fishing should be considered in the future.

CONCLUDING REMARKS

Some general remarks could be summarized as follows:

A) The fishable commercial biomass in the continental shelf increased about seven times after the trawl fishing ban. In particular the red mullet, which is one of the most important demersal resources of the area, has shown an outstanding increment of **33 times** (mean value over the whole study area), with a peak of **123 times** between 100 and 200 m. Hake underwent a five-fold increment, and similar increments were displayed by pandora, horned and musky octopus and pink shrimp, which are species (except the last one) exploited by the set-gear fishery.

B) Six different fish assemblages, were identified with multivariate analysis. Some of these assemblages could be used as **management units**.

C) The area located between 30-35 and 80 m on the terrigenous coastal muddy bottom, appears from our data the richest in terms of exploitable biomass, and informal data collected through interviews in the fishing harbours and personal observations documented the shift of the set gear fishing activity from the inshore sandy bottoms located at about 10-40 m to the muddy bottoms at 40-80 m depth, due to the absence of trawling.

D) The easternmost ESUs, which are located outside the banned area and are currently heavily exploited by trawlers, were characterized by very low yields and by a different community structure if compared to the other ESUs at the same depth.

E) The sandy-muddy and muddy bottoms between 10 and 40 m are nursery grounds for red mullet, striped mullet, pandora and striped seabream; the results of the beach seine survey highlighted the same role played by the sandy area between 1 and 10 m for several sparids (striped, white and common seabreams) and mugilids.

F) It is difficult to evaluate, as often highlighted by the recent literature, the precise role of the artificial reefs. They seem to attract fish more than increase production; however a role in determining a new fish assemblage in the sandy bottom area and in offering general protection to several fish species is not negligeable in the Gulf of Castellammare. They also work as FADs (Fish Aggregating Devices) attracting large-sized pelagic species such as the greater amberjack (*Seriola dumerili*). The trawl fishing ban, started in 1990, does not allow a real understanding of the effects of the artificial reefs, the first of which was deployed in 1986.

No more artificial reefs are needed as deterrent of the illegal trawling within the 50 m depth, since large areas of this belt are currently untrawlable at all. Further projects concerning artificial reefs for productive purposes will need to be evaluated under a rigorous scientific control. Anyway, small-scaled pilot experiments should be carried out in order to validate the real efficacy of large-scaled projects of this kind. Moreover, constant contacts among the local and the central Administrations are desirable in order to avoid any misunderstanding in the implementation of such initiatives.

As a conclusion, an intense and long-term monitoring of the demersal fishable resources of the Gulf is desirable. The prosecution of the trawl ban will be likely to produce, in the next years, new changes of the biomass values and distribution of the yields and more generally of the fish community structure which are important to be known. If instead any renewal of the trawl fishing activities will be planned, either in the whole area or in some restricted portions of it, it seems us peremptory that these activities should restart only experimentally and under a strict scientific control.

1 - INTRODUCTION

1.1 - GENERAL FEATURES OF THE GULF OF CASTELLAMMARE

The Gulf of Castellammare (FAO fishing area 37.1.3, Fig. 1) has a perimeter of about 70 km; it is situated in N/W Sicily and is the deepest bay of the Island. The eastern and western sides are characterized by steep dolomitic cliffs, while the whole central side is dominated by narrow sandy beaches. The Gulf was also recognized as an important fishing area since the early investigation carried out by Arena & Bombace (1970). There are five fishing harbours in the Gulf: Terrasini, Trappeto, Balestrate, Castellammare and San Vito Lo Capo. The shrimp (*Aristeus antennatus* and *Plesionika edwardsii*) stocks are exploited mainly by the trawlers of Castellammare, while those based in Terrasini exploit the shelf and upper slope demersal resources located on the bottoms east of Capo Rama (Arculeo *et al*. 1988; 1990a). Small-scale fishermen are active in the five harbours (D’Anna *et al*. 1992). An important purse seine fishery exploiting clupeids and other small pelagic fishes is based in Terrasini. In the last decade an artificial reef area has been deployed in the central-eastern sector of the Gulf (D'Anna *et al*., 1994). At present the whole artificial reef area extends over more than 50ha.

1.2 - PREVIOUS RESEARCHES

1.2.1 - Trawlable resources

The only available data on the trawlable fishery resources in the Gulf are those from the five-year (1985-1989) research program named “Valutazione delle risorse demersali nell’area compresa tra Capo Gallo e Capo San Vito” (Arculeo et *al.*, 1988). The research program was a part of the national project (funded by the Italian Fishery Ministry, Act no. 41/1982) aimed at the assessment of demersal resources in the Italian waters (Relini, 1988; VV.AA., 1990). Six trawl surveys were carried out at irregular intervals during five years, four in spring, one in summer and one in autumn. A stratified random sampling based on five bathymetric strata ranging from 0 to 700 m was chosen. The last trawl survey was concluded in spring 1989 about three months before trawling was banned in the Gulf of Castellammare. Each stratum was subdivided in elementary sampling units (ESU) of about 3 square nm and the experimental hauls lasted one hour. The first three strata, coinciding approximately with the continental shelf (from 0 to 200 m depth), were split in 13 ESUs. The results of these surveys are reported in Arculeo et *al.* (1988) and Riggio *et al*. (1993). The authors highlighted an overfishing in particular of the shelf demersal resources, due to a long-lasting mismanagement of the natural resources in the whole area.

1.2.2 - Small-scale fisheries and the artificial reef area

Coastal small-scale fishing in the Gulf is a prominent activity for its favourable economic potentialities, which are even more relevant when compared with the high cost/benefits ratio of trawling (Arculeo *et al*. 1990b). It has also a relatively low impact on the marine environment. Considering the five harbours included in the Gulf, the small-scale fishery counts about 300 boats and about 450 fishermen who employ prevalently set gears and purse seines in their fishing activity.

In the Gulf of Castellammare during the last decade a plan was realized to construct an artificial reef system. The main purpose of the project was to enhance the small-scale fishery and more generally to protect the coastal demersal fishing resources. The reefs deployed in the area are composed mainly of cubic concrete boulders assembled to form pyramid-shaped structures (Bombace 1989; Provenzano & Riggio, 1982; Riggio & Provenzano, 1982). The reefs are located on a sandy bottom between 10 and 50 m depth.

Many researches, concerning the study of benthic colonization (Badalamenti *et al.*, 1985; Riggio *et al.*, 1985b), the fishing yields and the fish assemblage (Arculeo *et al*., 1990b; D’Anna *et al*. 1992; D'Anna *et al.*, 1994) have been carried out recently.

The artificial reefs have a total volume of about 10.000 m^3 and cover an area of about 50 ha.

Another series of researches was addressed to the study of the nursery areas of species suitable for aquaculture, and in particular to the study of catadromous fish fry. Studies were carried out at the outlets of the small rivers located in the area (Mazzola, 1988; Mazzola *et al*., 1990).

1.2.3 - Naturalistic studies

The most important area, from a naturalistic point of view, is the western promontory of the Gulf. It is a wild area characterized by low run-off and very clean waters. Many descriptive papers on the environment, the benthic communities and monographs on some important species have been produced during the last years (Badalamenti *et al*., 1990, 1992a, 1992b; Riggio *et al*., 1985a).

1.2.4 - Pollution

Pollution from the densely populated urban belt and especially from factories adds up to the nutrient burden affecting the coastal waters in the mid-eastern portion of the Gulf. The onshore disposal of dregs and sludge resulting from the distillation and processing of wine and grape-stones, together with other industrial and domestic outflows, have caused a heavy eutrophication of the coastal waters, thereby also changing the overall biotic features of the Gulf (Calvo & Genchi, 1989; D'Anna *et al.*, 1985; Riggio *et al.*, 1992).

1.3 - ADOPTED MANAGEMENT MEASURES AND FISHERY POLICY

The Gulf continental shelf has been exploited for many years by both trawl and artisanal fisheries. The conflict that arose from this situation was at the base of the debate which originated new management measures.

In 1974 the Regional Government instituted the Association for Fish Restocking in the Gulf of Castellammare ("Consorzio Golfo di Castellammare"), aimed at protecting and enhancing the coastal fishing resources by means of artificial reefs. Afterward an artificial reef was deployed in the central part of the Gulf, with the double aim of contrasting illegal inshore trawling and of restocking the fish assemblage providing hard substrata (D'Anna *et al*., 1994).

The reefs laid in the Gulf were funded by the Regional Government and by the local district administrations (Regional Provinces of Trapani and Palermo and the Association for Fish Restocking). A major hindrance is the lack of a Regional plan for reef-building and monitoring, as well as the absence of fishing restrictions and of patrolling of the artificial reef areas by coast guard. The procedures to obtain the legal permissions for the deployment of the reefs in marine zones are very complex and time-consuming.

The Association for Fish Restocking in the Gulf of Castellammare funded some research activities during the last years.

On 1981 the natural reserve of "Zingaro" was established by the Regional Government Act no. 98/1981 along the western cliff.

In 1990 demersal trawl fishing was banned (Regional Act of 18/10/89) in the whole continental shelf of the Gulf (Fig. 1) and in two other Sicilian Gulfs, whereas before this act, trawling was possible, according to national laws, only beyond 50 m depth. In the same time a grant was given to all fishermen resident in one of these Gulfs who decided to stop completely trawling activities for a maximum time of six months.

1.4 - OBJECTIVES OF THE RESEARCH

Despite the cited measures to protect at some extent both the environment and the fishable resources, little is known about the effect of restrictions, and there are no data concerning the effects of the trawl fishing ban in the Gulf of Castellammare.

Our research is aimed at assessing the biomass and population structure of the demersal resources in the Gulf. For this purpose both trawlable and non-trawlable bottoms were investigated with suitable fishing gears: bottom trawl, trammel-gill net and beach seine (Fig. 2). Moreover, a *visual census* technique was carried out in non-trawlable areas in order to assess the share of species not detectable by fishing methods. Diurnal and nocturnal samplings were carried out within each fishing sampling method. Some aspects of the biology of the main commercial species were also studied.

An attempt to re-define the bathymetric strata employed in our sampling design, in terms of demersal assemblages was also made.

A comparison between the obtained results and those of the above cited five-year Fishery Ministry research (Arculeo *et al*., 1988) was made in order to assess the effects of the trawling ban four years after its start.

######

2 - MATERIALS AND METHODS

2.1 - TRAWLABLE AREAS

These areas occupy the whole Gulf with the exception of the infralittoral area of the easternmost and westernmost sectors and of a portion of the central-eastern section because of the presence of the artificial reef area.

2.1.1 - Sampling design

A stratified random sampling was chosen, based on depth strata, in order to increase sampling representativeness in the area and, possibly, to increase the precision of the biomass estimates. Three bathymetric strata were selected (Fig. 3), corresponding to the depth intervals 0-50m (stratum A), 51-100m (stratum B) and 101-200m (stratum C). This area extends approximately over 57 nm^2, excluding non-trawlable areas which were initially delimited according to previous researches (Arculeo *et al.*, 1988) and to information provided by fishermen.

The 13 ESUs (Elementary Sampling Units) used in the same area in the pre-ban study (Arculeo *et al.*, 1988) were further split in four parts adding up to 52 ESUs. Sampling sites were randomly selected within each stratum independently for diurnal and nocturnal hauls, using proportional allocation (Tab. 1, Fig. 3).

72 hauls of 30 minutes (36 diurnal and 36 nocturnal) were planned for each survey. During the first survey some non-trawlable grounds were detected (ESUs 1022, 1041 and 1051; Fig. 4); thus, sampling design was modified, as shown in Table 2 and Figure 5, in order to allow a new distribution of trawlable grounds between bathymetric strata. Making so, the number of planned hauls was proportionally decreased to 68 (34d + 34n).

Further relevant changes in sampling design became necessary after the second survey. First, an area initially considered non-trawlable (ESU 1055, Fig. 5) was included in the study area after exploration; second, the deployment of new concrete boulders in the artificial reef area (ESUs 1031, 1032 and 1034), along with further explorations carried out in the north-eastern and western sectors (ESUs 1052, 1053, 1054 and 2014) requested the exclusion of six ESUs situated in stratum A and one in stratum B. The results of these modifications are summarized in Figure 5 and Table 3. The final number of hauls planned in the third and fourth surveys (Figg. 6 and 7) was 60 (30d + 30n). The contribution of stratum A to the total surface was thus decreased by 8.8% with respect to the initial design, and that of the other strata was proportionally increased.

2.1.2 - Fishing vessel and fishing gear

The vessel chosen for the research was the F/V GIAGUARO, a commercial demersal trawler built in wood in 1993; the captain had to change some features of the fishing gear in order to suit our requirements at best. The trawler had a gross tonnage of 40.10t, measured 18.36m of overall length, and was powered with a 160HP diesel engine. It was equipped with two loran sets (one of which with a plotter), a radar, an echosounder with a colour display, and a radio set. The winch had two drums holding 1.900 m of steel trawl warp each. Fish were stored in a fish-hold (15 m^3) at about 0°C. A complete description of the boat features is given in Table 4.

The gear was a bottom trawl equipped with wooden otter boards. The net was made of nylon and polyamide and composed by the different parts showed in Figure 8 and Table 5.

The upper side of the net included the codend ("pozzale"), two baitings ("cieletto anteriore" e "cieletto posteriore"), the top gusset ("scaglietto di summo"), two wings ("chiarazzo") and a headline ("lima di summo") with 43 plastic floats.

The lower side of the net included the codend, the belly ("sottano" I, II and III), the lower gusset ("scaglietto di piombo"), the wings and the groundrope. A small wooden cylindrical piece (about 30cm long and 6cm thick) linked each wing, through two ropes, to the bridles made of five twines of steel covered with polyamide. The bridles were connected to the otter boards that were in turn connected to the drums by the trawl warp**.**

The stretched mesh side, the mesh number and the length of the components and accessories of the gear are reported in Table 6 and in the plan of the trawl net (Figg. 8-9).

2.1.3 - Fishing operations.

Four seasonal experimental trawl surveys were carried out in the Gulf of Castellammare: survey I (autumn) from 4 to 20 December 1993; survey II (winter) from 25 February to 12 March 1994; survey III (spring) from 21 May to 24 June 1994; survey IV (summer) from 31 August to 16 September 1994.

Each haul lasted 30 minutes; hauls shorter than 20 min, as well as hauls in which the net was damaged by rocks or wrecks, or hauls in which we had the suspect that the net did not work properly, were considered non-valid. All the technical data were recorded in a suitable form (Tab. 7). Usually four fishermen and three researchers took part to the operations. Some information were collected directly aboard the vessel after each haul (Tab. 8): type of substrate and bionomic *facies*, weight of non-commercial benthic invertebrates and/or algae, weight and type of waste material, approximate weight of target species.

A box of benthic material was preserved at each haul for subsequent qualitative analysis in the first and second surveys.

Diurnal hauls took place from about one hour after sunrise to about one hour before sunset; nocturnal hauls took place from about one hour after sunset to about one hour before sunrise. The fish caught were refrigerated on board and landed after each trip to be frozen.

2.1.4 - Laboratory operations

Taking into account the species lists and the abundance data relative to the continental shelf reported by Arculeo *et al.* (1988), we have divided all the species in three groups (Tab. 9) taking into account both their commercial importance and their abundance in the study area:

Group I (= target species): hake *(Merluccius merluccius)*, red mullet *(Mullus barbatus)*, striped mullet *(Mullus surmuletus)*, pandora *(Pagellus erythrinus)*, striped seabream *(Lithognathus mormyrus)*, pink shrimp *(Parapenaeus longirostris)*, cuttlefish *(Sepia officinalis)*, European squid *(Loligo vulgaris)*, broadtail squid *(Illex coindetii)*, horned octopus *(Eledone cirrhosa)*, musky octopus *(Eledone moschata)* and common octopus *(Octopus vulgaris)*. The following individual data were recorded (Tab. 10): total (TL) and standard length (SL) at the lowest half centimetre for finfishes, mantle length (ML) at the lowest half centimetre for cephalopods, carapace length without rostrum (CL) at the lowest millimetre for pink shrimp, weight (W) at the nearest gram (first decimal gram for pink shrimp), sex and maturity stage.

Group II: it included 4 crustaceans, 5 cephalopods and 10 finfishes. The following individual data were recorded (Tab. 11): length (as above), and weight at the nearest gram.

Group III: it included all the remaining species; only total number and weight in each haul were recorded (Tab. 12).

The main benthic invertebrates useful from an ecological point of view (definition of biocoenoses) were identified and utilized for mapping the main biocoenoses present in the area following Peres and Picard (1964) and Peres (1982).

2.1.5 - Data analysis

2.1.5.1 - Fishing yields

Fishing yields were expressed in grams, except where specified. The catch per unit effort (CPUE) was calculated as weight of fishes, decapod crustaceans and cephalopods per haul. For tow duration differing from 30 min, the catch weight was standardized by means of a correction factor, *i.e.*, standardized weight=catch weight/(tow duration/30).

Mapping of the demersal trawlable resources was achieved through two graphic methods: the first shows the spatial distribution of the total demersal species in each season by day and by night, by means of isopleths of CPUEs drawn by an interpolation technique; the second shows the catch of the target species in each haul through circles whose diameter is proportional to the actual value in kg of the catch.

In order to compare the yields obtained in different strata or seasons, two non-parametric statistical tests (Siegel, 1956) were used: Mann-Whitney U test for two samples, and Kruskal-Wallis test for more than two samples. Comparisons were made between diurnal and nocturnal hauls, both in each stratum and with pooled strata, among the four surveys, among the three strata, between the surveys, between the strata. The tests were performed on the weight of the twelve target species and on the total catch.

***2.1.5.2** - Biomass estimates*

The absolute biomass of the target species in each season (day and night data) in the overall study area was estimated by the "swept area" method (Sparre & Venema, 1992), in which the CPUEs were used as biomass indices. To estimate the swept area (*i.e.*, the bottom area swept by the trawl net during one tow) it is necessary to know the length of the tow and the wing spread of the trawl net. For this reason we directly measured some gear parameters as shown below:

Coordinates of the starting points	Starting depth (m)	Ending depth (m)	Trawl warps length (m)	Engine revolutions (r.p.m)	Wing spread (m) Mean ± s.d.	Net height (m) Mean ± s.d.	Distance between otter boards (m) Mean ± s.d.
38° 02' 19" N 12° 53' 55" E	17.2	15.2	150	1100	10.83±0.38	1.00±0.06	41.5±0.8
38° 02' 73" N 12° 54' 20" E	35.8	37.3	200	1100	11.14±0.85	0.83±0.05	47.1±2.1
38° 03' 55" N 12° 53' 39" E	74.1	74	350	1150	12.29±0.41	0.75±0.05	54.0±1.6
38° 05' 90" N 12° 54 ' 82" E	158	149	650	1150	13.39±0.28	0.73±0.08	65.6±1.7

by means of the SCANMAR system with the helpful assistance of the I.R.Pe.M. (Istituto di Ricerca sulla Pesca Marittima del C.N.R., Ancona, Italy) staff.

Since information about the actual wing spread were not available for every haul, we chose the mean depth of the trawlable portion of each stratum (*i.e.* 30, 75 and 150 m) as standard depths to which assign a wing spread value. This was achieved through the linear regression of the wing spread data *vs* depth:

Stratum	Standard depth (m)	Wing spread (m)
A	30	11.04
B	75	12.29
C	150	13.39

Afterwards the mean density of each species in each stratum (*i.e.* biomass per nm², $\bar{y}_h$) was estimated dividing the catch per haul (=CPUE) by the corresponding swept area, and a mean stratified biomass per nm² ($\bar{y}_{st}$) was obtained employing the following formula:

$$\bar{y}_{st} = \sum_{h=1}^{3} W_h \bar{y}_h = \sum_{h=1}^{3} W_h \sum_{i=1}^{n_h} y_{hi} \Big/ n_h \quad , \quad \text{where:}$$

$$W_h = \frac{\text{Surface of stratum h}}{\text{Total surface of trawlable grounds in the study ar}} ,$$

y_{hi} = Biomass per nm² (*i.e.*, catch divided by the swept area) in the *i*th haul of the *h*th stratum,

n_h = Number of hauls in the *h*th stratum, and

$\bar{y}_h$ = Mean density (*i.e.*, biomass per nm²) in stratum *h*.

The weights (W_h) proportional to the surface of each bathymetric stratum are shown in the following table:

Stratum	A_h (area in nm²)	W_h
A	20.45	0.3542

B	18.57	0.3216
C	18.72	0.3242
Total	57.74	1.0000

Associated variance for mean density was assessed by the following unbiased estimator:

$$\hat{V}(\bar{y}_{st}) = \sum_h \frac{W_h^2 s_h^2}{n_h},$$

where $s_h^{\ 2} = \dfrac{1}{n_h - 1}\sum_{i=1}^{n_h}(y_{hi} - \bar{y}_h)^2$ = sample variance in stratum h,

which is the appropriate formula when the area trawled in the sampling programme is small relative to the total survey area and therefore finite population correction, here estimated smaller than 0.01, may be ignored (Cochran, 1977).

In order to estimate the appropriate weights for the above formula, we digitized the study area from a nautical map and used AutoCAD software facilities.

Finally, **total biomass in the study area** ($\hat{Y}_{st}$) for our 12 target species was assessed by multiplying the stratified mean ($\bar{y}_{st}$) by the total surface of trawlable grounds (A_{tot}), approximately 57 nm². In order to do that, diurnal hauls were considered apart from nocturnal ones, and the catchability coefficient (*i.e.*, the portion of fish actually caught by the gear) was assumed equal to unity.

The variance for total biomass was estimated by:

$$\hat{V}(\hat{Y}_{st}) = \sum_h \frac{A_h^2 s_h^2}{n_h} = A_{tot}^{\ 2} \sum_h \frac{W_h^2 s_h^2}{n_h} = A_{tot}^{\ 2} V(\bar{y}_{st}),$$

from which we can assess the standard error of total biomass estimates:

$$SE(\hat{Y}_{st}) = \sqrt{\hat{V}(\hat{Y}_{st})} = A_{tot} SE(\bar{y}_{st}).$$

Finally, gains in precision due to the adoption of stratified random sampling design were evaluated by the relative precision index (*RP*), which is given by the following ratio:

$$RP = \hat{V}(\bar{y}_{st}) / \hat{V}(\bar{y}_{ran}),$$

where $\hat{V}(\bar{y}_{ran}) = s^2/n$ is the estimated variance of the estimated mean density for simple random sampling. A ratio <1 indicated a gain in precision.

***2.1.5.3** - Catch per unit effort before and after the four-year trawling ban*

In order to assess the effects of the trawling ban, we compared our results with those of Riggio (1988; 1989) in the same area. The catch data per stratum obtained in two experimental trawl surveys carried out before the ban in April 1987 and May 1989 with the F/V NUOVA CARA MADRE ("vessel 1"), were pooled and then compared with the catch data of our spring survey made with the F/V GIAGUARO ("vessel 2"). The spring surveys were the only, among the pre-ban surveys, which could provide an adequate amount of data (after pooling) to allow statistical comparisons with one of our surveys. 21 pre-ban hauls (6 in str. A, 8 in str. B and 7 in str. C) were compared with 30 post-ban hauls (9 in str. A, 10 in str. B and 11 in str. C).

The main features of the two vessels and of the two gears employed are summarized in Table 13.

A conversion factor based on the wing spread of the two gears in each stratum was calculated to compare the two data sets (Fiorentini *et al*., 1993).

First it was necessary to extrapolate for the two vessels the warps length at the standard depths previously chosen (see chapter 2.1.5.2). To this purpose we calculated the regression analysis of the direct measures of trawl warps length of the GIAGUARO *vs* depth. The TrW values for vessel 1 were assumed to be equal to those of vessel 2 at the same depth. Once obtained the warps length at the standard depths (Tab. 14) we calculated by the following stepwise regression formulated by Fiorentini *et al*. (1993) the wing spread of both vessels:

$$Ws = -3.2999+0.00487*TrW+7.4283*OBoS+0.0482*FlV,$$

where Ws = wing spread, TrW = length of trawl warps (m), OBoS = otter boards size (m^2), FlV = floats volume (dm^3).

The final step was to divide the stepwise-estimated values of wing spread at each stratum of vessel 2 by the corresponding estimated wing spread of vessel 1; the conversion factors thus obtained were applied to the pre-ban catches to allow us to compare the yields per stratum obtained in the two programs. The difference between the tow duration (1 hour in the pre-ban study, 30 min in the current study) was taken into account by applying a further factor equal to 0.5 (Tab. 14).

The Mann-Whitney U test was performed on the catches per unit effort (CPUE=weight in gr/30 min haul) obtained in the total area in the two programs.

2.1.5.4 - *Length frequencies distribution*

Histograms of the length frequencies distribution (LFD) of the target species were drawn, depicting the size structure (% in number) of females, males and total (*i.e.*, females, males, "indeterminate" and "damaged" (see chapter ***2.1.5.5*** for these terms)) specimens in the whole study area, as well as that of total specimens in each depth stratum.

2.1.5.5 - *Biology of target species*

Some aspects of the biology of the target species, useful in a fishery study, were investigated.

- <u>Reproduction</u>. Each specimen was sexed, except the damaged ones (which accounted for up to 50% of the total in some samples); the maturity stage was assigned after macroscopic examination of the gonads. Specimens without any visible gonad differentiation were considered "indeterminate", whereas those with the sex unrecognizable due to poor conservation were considered "damaged".

For the finfishes, a five-stage maturity scale (Holden & Raitt, 1974) was used. For the pink shrimp, a three-stage maturity scale was used for females only (Froglia, 1984). As for cephalopods, two different scales were chosen: a six-stage scale (Juanicò, 1983) for squids and a six-stage (three-stage for males) scale for cuttlefish and octopuses (Mangold Wirz, 1963). The ***sex-ratio*** (no. of females/no. of males) was calculated in each season as well as in the overall study period. The ***size at first maturity*** was estimated fitting the logistic equation:

$$P = 100/(1+\exp(\alpha-\beta L))$$

(where P=proportion of specimens in each size class chosen as explained hereafter, L=SL in finfishes, CL in pink shrimp, ML in cephalopods) to the data. Parameters α and β were estimated by means of the least squares method as implemented in the procedure NONLIN of the SYSTAT software package (Wilkinson *et al.*, 1992). The stages of maturity used in the computations were chosen so that maturing to post-spawning specimens were included: a) fishes: stages III to V for both sexes; b) pink shrimp: stages II and III for females, none for males; c) squids: stages IV to VI for both sexes; d) cuttlefish and octopuses: stages IV to VI for females, stages II and III for males. The size-at-maturity data were taken from the surveys in which the before mentioned maturity stages occurred, as follows:
hake: all surveys for both sexes;
red mullet: all surveys for both sexes;

striped mullet: winter, spring and summer surveys for both sexes;
pandora: spring and summer surveys for both sexes;
striped seabream: spring and summer surveys for both sexes;
pink shrimp: all surveys for both sexes;
cuttlefish: winter and spring surveys for females, all surveys for males;
European squid: winter and spring surveys for both sexes;
broadtail squid: all surveys for both sexes;
horned octopus: spring and summer surveys for females, all seasons for males;
musky octopus: spring survey for females, all surveys for males;
common octopus: spring survey for females, all surveys for males.

- Biometry. Several measurements were made on each specimen (see chapter 2.1.4). The linear regression of total length *vs.* standard length was calculated in finfishes caught in the autumn survey. The Mann-Whitney U test was performed in order to test the difference in the mean length of males and females.

- Length-weight relationship. The length-weight relationship, calculated separately for both sexes, was expressed by the equation:

$$W = aL^b$$

where W=weight in gr, L=length in mm (SL in finfishes, CL in pink shrimp, ML in cephalopods), a and b=constants. In order to linearize the relation and obtain the coefficient of determination (R^2), the data were logn-transformed.

- Growth. In order to describe the growth of target species, the von Bertalanffy's growth equation (VBGE) (von Bertalanffy, 1938) was used:

$$L_t = L_\infty(1 - \exp(-K(t - t_0)))$$

where L_t=length at age t, L_∞=maximum theoretically attainable length, K=growth coefficient (year^{-1}), t=age, t_0=theoretical age at which the animal length is 0. The parameters of the equation (K and L_∞) were estimated with the ELEFAN (Gayanilo *et al.*, 1988) computer program, as implemented in the FiSAT software package (Gayanilo *et al.*, 1994); the seasonal LFDs of each species were supplied as input data.

- Mortality. The instantaneous rate of total mortality (Z) was estimated by means of the length converted catch curve (Sparre & Venema, 1992), using the FiSAT software package (Gayanilo *et al.*, 1994).

Due to the rather small and highly variable sample sizes obtained for all the cephalopods in the four surveys, length based methods for estimating the growth parameters seemed not reliably applicable. For this reason, no growth model was chosen to describe the growth rate of these species.

***2.1.5.6** - Nekton assemblages*

- Structure indices

Five indices were chosen in order to characterize the structure of the nekton assemblages sampled at each ESU (Loya, 1972). The indices were calculated both for diurnal and nocturnal hauls taking into account the number of specimens (No.) of each species.

Species richness was calculated in terms of number of species (S) and Margalef index (d' = S-1/ln N; Margalef, 1958) where N is the total number of specimens in the sample. The following diversity indices were also computed:

$$SI = 1 - \sum_{i=1}^{S} \frac{n_i(n_i - 1)}{N(N-1)}$$ (Simpson, 1949);

$$H' = \sum_{i=1}^{S} \frac{n_i}{N} \times \ln \frac{n_i}{N}$$; (Shannon-Weaver, 1963),

where n_i = number of specimens in the *i*th species and *N* = total number of specimens in each sample.

An expression of "evenness" J' = H'/H'max (Pielou, 1966) was also computed. All the above-mentioned indices, as well as the catch per unit effort in number (No.) and weight (CPUE) were calculated on seasonal data for diurnal and nocturnal hauls.

Statistics included means and standard deviations (s.d.) as well as the Kruskal-Wallis one way analysis of variance and the Mann-Whitney U test (Siegel,1956) to assess differences between samples.

- Cluster and multivariate analysis

Dendrograms were produced by hierarchical agglomerative clustering using the unweighted paired-group method of averaging (UPGMA). One cluster analysis was

elaborated per each survey pooling diurnal and nocturnal hauls. From these analyses no differences were found between day and night samples. Having this in mind we constructed a new matrix organizing the global data set (pooling day and night samples of the four surveys) based on the annual average density data (number of specimens).
Dendrograms were based on the Bray-Curtis similarity (*D*) measures calculated on log-transformed (ln x +1) data, not computing rare species.

The Bray-Curtis similarity (*D*) between two samples was calculated from the following equation:

$$D_{jk} = 1 - \frac{\sum_{i=1}^{S} \left| y_{ij} - y_{ik} \right|}{\sum_{i=1}^{S} \left(y_{ij} + y_{ik} \right)}$$

where y_{ij} is the abundance of the species *i* in sample *j* and y_{ik} the abundance of species in the sample *k*.

According to the results of the cluster analysis made on the global data set (the four surveys) which distinguished six homogenous groups of ESUs, a factorial correspondence analysis (FCA), was also performed on a quantitative correlation matrix (Benzecri,1982). Axes significance was evaluated using the tables of Lebart (1975).

2.2 - NON - TRAWLABLE AREAS

Non-trawlable areas were represented by:
a) the natural rocky bottoms and *Posidonia ocenica* meadows that characterize the Gulf in its east and west sides;
b) the artificial reef area located in the central part of the Gulf on sandy bottoms;
c) the 0-10m bathymetric zone.

In these areas three working methods were employed:
1) Trammel - gill net survey;
2) Beach seine survey;
3) Visual census survey.

2.2.1 - TRAMMEL - GILL NET SURVEY.

2.2.1.1 - Fishing gear

A combined trammel-gill net was used for this survey. It is a bottom-set gear made with a trammel net, the upper part of which is replaced by a gillnet (Fig. 10). The two nets had the following characteristics:

- height of gill net = 3.5m;
- height of trammel net = 1.8m.

The total height of the gear was 5.3m; the total length was 500m. The stretched mesh length of the gill net and of the inner wall of the trammel net was 54mm, while the stretched mesh length of the outer wall of the trammel net was 320mm.

2.2.1.2 *- Sampling sites*

Four areas were chosen in different portions of the infralittoral zone of the Gulf (Fig. 11). The first (WRB) was located on the western area on rocky bottom, the second and third in the central area on the Artificial reef (ARA) and on sandy bottom (CSB), and the last on the eastern area on sandy bottom (ESB). The CSB area was considered a control "blank" of ARA.

Ten sampling sites were chosen at a depth of 10 to 30m (Fig. 11): four of them were located in WRB, two in ARA, two in CSB and two in ESB. All sites were named after the initials of the geographical locality, as reported on the map (Fig. 11): TU (Torre dell'Uzzo), MS (Monte Scardina), B (Bruca), PC (P.ta Calabianca), AR1 and AR2 (Artificial Reef sites, inside ARA), CS1 and CS2 (Control Sites), CM (Città del Mare), VF (Villa Fassini).

The four westernmost sites (TU, MS, B and PC) were located in proximity of sublittoral hard substrates that slope down either towards large irregular rocky boulders scattered on a sandy bottom, or towards *Posidonia oceanica* beds at a depth of approximately 20-25m. This area was named Western Rocky Bottom and labelled "**WRB"**.

The AR1 and AR2 sites were located inside the artificial reef area, which covers about 30ha of sandy-muddy bottom at a depth of 16-20m. The artificial reef was deployed between July 1986 and August 1992; it is composed of concrete cubic blocks assembled to form three-layer pyramids. This area was named Artificial Reef Area and labelled "**ARA**".

The control sites (CS1 and CS2) on sandy bottom were located about 5km west of the artificial reef area and about 8km from the nearest natural rocky bottoms. The mean depth was 17m. This area, for its location and bottom features, was named Central Sandy Bottom and labelled "**CSB**".

The CM site was located in the eastern section of the gulf, in an area polluted since many years by domestic and industrial untreated wastes drained, in particular, by the Nocella creek. In this site the fine sand is mixed with organic mud and clay. The net was set at a depth of about 14-18m in proximity of a rocky cliff.

In the VF site (also located in the eastern side of the gulf) the coast was characterized by a dolomitic cliff falling down to a depth of about 25-30m. In both sites the slope of the cliff did not allow us to set the net on the rocks, thus it was set at the end of the underwater cliff on a sandy-muddy bottom: for this reason they were named Eastern Sandy Bottom and labelled "**ESB**".

2.2.1.3 *- Fishing operations*

One nocturnal and one diurnal sample were collected monthly at each site, from October 1993 to September 1994. The net was set from sunset to sunrise (nocturnal fishing) and from sunrise to sunset (diurnal fishing), for a mean fishing time of 12 hours.

2.2.1.4 *- Laboratory operations*

All specimens caught by trammel-gill net were measured and weighed individually, like group II species of the trawl surveys; sex was not recorded. Data on each sample were recorded on the form shown in Table 15.

2.2.1.5 *- Fishing yields*

Total and mean fishing yields were expressed in grams (gr). The catch per unit effort (CPUE) was calculated as weight of fish per 500 m of net per 12 h of fishing time. The diurnal and nocturnal seasonal CPUEs calculated on the total catch at each sampling site were graphically represented by means of circles whose diameter was proportional to the actual value in kg of the catch.

Statistics included means and standard deviations (s.d.) as well as the Kruskal-Wallis one way analysis of variance and the Mann-Whitney U test (Siegel,1956) to assess differences between samples.

2.2.1.6 *- Nekton assemblage*

- Structure indices

Five indices were chosen in order to characterize the structure of the nekton assemblage sampled at each site. The indices were calculated both for diurnal and nocturnal fishing taking into account the abundance (no. of specimens) of each species.

Species richness was calculated in terms of number of species (S) and Margalef index ($d' = S-1/\ln N$; Margalef, 1958) where N is the total number of specimens in the sample. The following diversity indices were also computed:

$$SI = 1 - \sum_{i=1}^{S} \frac{n_i(n_i - 1)}{N(N-1)}$$ (Simpson, 1949);

$$H' = \sum_{i=1}^{S} \frac{n_i}{N} \times \ln \frac{n_i}{N}$$ (Shannon & Weaver, 1963),

where n_i = number of specimens in the *i*th species and N = total number of specimens in each sample. An expression of "evenness" J' = H'/H'max (Pielou, 1966) was also computed.

All the above-mentioned indices, as well as the catch per unit effort in number (No.) and weight (CPUE) were calculated on monthly, seasonal and annual data for diurnal and nocturnal sampling per each site and area.

Statistics included means and standard deviations (s.d.) as well as the Kruskal-Wallis one way analysis of variance and the Mann-Whitney U test (Siegel,1956) to assess differences between samples.

- *Cluster and multivariate analysis*

Factorial correspondence analysis (FCA), was performed on quantitative correlation matrices (Benzecri,1982) to detect temporal and spatial variations of the nekton assemblages. All species caught were considered in this analysis. Axes significance was evaluated using the tables of Lebart (1975).

Cluster analysis was also performed in order to examine the relationships among sites, using the mean seasonal abundance of the species (number of specimens) as attributes for constructing a matrix of 40 stations per 106 species. A dendrogram was produced by hierarchical agglomerative clustering using unweighted paired-group method of averaging (UPGMA). The dendrogram, based on Bray-Curtis similarity (D) measures was computed including also the rare species and taking into account only the nocturnal samplings. The Bray-Curtis similarity (D) between two samples was calculated from the following equation:

$$D_{jk} = 1 - \frac{\sum_{i=1}^{S} |y_{ij} - y_{ik}|}{\sum_{i=1}^{S} (y_{ij} + y_{ik})}$$

where y_{ij} is the abundance of the species i in sample j and y_{ik} the abundance of species i in the sample k.

2.2.2 - BEACH SEINE SURVEY

The beach seine was used in shallow sandy areas (0 - 5 m depth) where traditional trawling was not practicable.

2.2.2.1 - Fishing gears and fishing operations

The beach seine employed was 55m long and made of two wings (25m each), a body and a central bag 5m long. The wings were 2m high with a stretched mesh side of 40 mm; the mesh side of the bag was 27mm at the mouth and a few millimetres at the end of the bag. It was set by a small motorboat and hand-hauled onto the beach; the bottom and the sea surface acted as natural barriers, preventing the fish escaped from the area enclosed by the net.

As anticipated in our interim report, a small-sized bottom otter trawl was also used, in order to acquire more detailed qualitative information about the species composition of the fish community living inside the 0-5m bathymetric zone. The structure and the characteristics of the net were similar to those of the beach seine.

Sampling took place monthly at each site (see chapter 2.2.2.2); each operation lasted about 15min for each gear. The data collected by the two methods were pooled together for the subsequent analysis.

2.2.2.2 - Sampling sites

After a pre-survey carried out in November 1993, four stations inside the 0-5m bathymetric zone were chosen along the central-eastern part of the gulf, in close proximity of the mouth of some small rivers and creeks. Each site was labelled after the initial of the river (Fig. 11): SB (Fiume San Bartolomeo), TC (Torrente Calatubo), J (Fiume Jato) and TP (Torrente Pinto).

2.2.2.3 - Laboratory operations

Fishes were measured and weighed individually, and data recorded on a form (Tab. 15).

2.2.2.4 - Data analysis

Only qualitative analysis was carried out, mainly consisting in species identification and counting of specimens. In addition the specimens were measured and weighed.

The qualitative similarity among the nekton assemblages of the four sites was assessed through the use of cluster analysis. A dendrogram was constructed on q-mode (sites on species) ordination taking into account the presence/absence data. Rare species were not included in this analysis. Clustering was performed using the Jaccard index of similarity (J), (Jackson *et al.*, 1989):

$$J = \frac{a}{a+b+c},$$

where a = number of co-occurrences of species b and c, b = number of occurrences of species b alone, c = number of occurrences of species c alone.

The dendrogram was produced by hierarchical agglomerative clustering using the unweighted paired-group method of averaging (UPGMA).

2.2.3 - VISUAL CENSUS SURVEY

Fish biomass in some non-trawlable areas was estimated by visual census methods. Results obtained using this technique were also useful to evaluate both qualitatively and quantitatively the nekton assemblage.

2.2.3.1 *- Sampling areas*

A presurvey was carried out in the whole Gulf in order to identify the non-trawlable areas where to locate the sampling sites. Five sampling areas, according to the nature of the substratum and to the geographic position of the sites, were selected (Fig. 11). Inside the areas, seven different sites were chosen (Fig. 11 and Tab. 16), six of which coincided with some of the trammel-gill net stations, whereas one (CR) was newly established. In each site one or more sampling points were surveyed (Tab. 16).

The artificial reef area (ARA) was a square area with five pyramids of concrete blocks with a volume of about 112m^3 each (D'Anna et *al.* , 1994; Bombace, 1989).

In those areas characterized by heterogeneous bottom features, more than one sampling point was chosen. A specific census technique (see chapter 2.2.3.2) was used at each point, as shown in table 16.

2.2.3.2 *- Techniques employed*

After a bibliographical review of the techniques employed within the visual census approach to the study of fish assemblages, we chose two different methods according to the features of the different points (Bortone *et al*. 1989; Harmelin 1975, 1987; Harmelin-Vivien *et al*. 1985; Harmelin-Vivien and Francour, 1992; John *et al*. 1990; Samoilys 1992; Samoilys and Carlos, 1992). The <u>strip-transect</u> (S.T.) method was used in presence of homogeneous habitats (only one community present in the point), while the <u>stationary</u>

visual census (S.V.C.) (Bohnsak and Bannerot, 1986) was thought to be suitable for heterogeneous habitats (more than one community present in the point).

Censuses were made seasonally by a couple of scuba-divers and a reply was carried out each time. To make the collection of data easier and more complete, we prepared some suitable tables (Tabb. 17-19).

Strip-transect

We used the strip transect technique (Garcia-Rubies and Zabala, 1990; Kimmel, 1985; Sanderson and Solonsky, 1986) for both the vertical rocky cliffs and the flat bottoms. In the last case the technique was based on a census taken swimming along either side of a 50m rope set on the sea bed, whereas on the vertical cliff the rope was deployed from the bottom to the sea surface. Data collection by divers consisted in identifying fish species and recording the estimated abundance and sizes in pre-established discrete classes, reported on each table. On flat bottoms the divers swam about 2m from each other and about 1.5m above the sea bed for 5min. On the cliffs they swam 3m from each other and 1.5m from the rocky wall for 15min.

Stationary Visual Census

Using this method a 5-min observation was carried out at each site within an imaginary 5.6m radius cylinder extending from the sea surface to the sea bed (Bortone *et al*., 1989; Tunesi and Vacchi, 1992). Two divers rotated around themselves collecting data, as said above, inside the cylinder projection identified after setting a 11.2m rope on the bottom.

A particular version of this technique, called **spatial census** (Charbonnel, 1990; Ody and Harmelin, 1994; Relini and Torchia, 1992), was employed exclusively in the artificial reef area: given a randomly drawn pyramid, two divers surveyed the water column above the top boulder for 5 minutes, then moved downward and swam only once around each of the three layers of the pyramid.

2.2.3.3 *- Description of the tables*

Two tables drawn on formica plates and provided with a pencil were employed for data recording under water. Type 1 (Tabb. 17 and 18) was a two-sided table used in areas TU, B, PC, CM, VF and CR; side "A" was filled at the strip-transect sites, while side "B" at the stationary visual census sites. Type 2 table (Tab. 19) was used in the artificial reef area (ARA).

Each diver recorded the following data in each sampling point: substratum type, date, site, wind direction, presence of current, vertical visibility (by mean of a "Secchi dish"), horizontal visibility (eye-estimated), slope of the cliff, depth, the family or species identified, the count of the specimens according to six predetermined abundance classes (1; 2; III = 3-10; IV = 11-30; V = 31-50; + = >51) and the size according to six size classes (N = 1-3cm; P = 4-8cm; M = 9-15cm; G = 16-24cm; X = 36-50cm; E = >50cm) .

2.2.3.4 - *Data analysis*

- *Structure indices*

Five indices were chosen in order to characterize the structure of the fish assemblages observed at each site. The indices were calculated on seasonal mean of the abundance (no. of specimens) of each species.

Species richness was calculated in terms of number of species (S) and Margalef index (d' = S-1/ln N; Margalef, 1958) where N is the total number of specimens in the sample. The following diversity indices were also computed:

$$SI = 1 - \sum_{i=1}^{S} \frac{n_i(n_i - 1)}{N(N-1)}$$ (Simpson, 1949);

$$H' = \sum_{i=1}^{S} \frac{n_i}{N} \times \ln \frac{n_i}{N}$$ (Shannon & Weaver, 1963),

where n_i = number of specimens in the *i*th species and *N* = total number of specimens in each sample.

An expression of "evenness" J' = H'/H'max (Pielou, 1966) was also computed.

- *Biomass estimates*

Once estimated the average fish density (number of specimens/m³) from the seasonal census, mean biomass (weight in gr/m³) was calculated after assigning a weight to the censused individuals. To simplify this operations the length/weight relationship $W = aL^b$ from other sources of data, i.e., trawl surveys, trammel net and beach seine surveys, as well as from the literature were calculated.

Temporal and spatial variations of the nekton assemblages in the five areas were assessed. Statistics included the Kruskal-Wallis one way analysis of variance (Siegel,1956) and the Mann-Whitney U test for paired comparisons.

The diurnal seasonal biomass assessed at each sampling area was graphically represented by means of circles whose diameter was proportional to the actual value in kg of the catch.

- *Cluster and multivariate analysis*

Cluster analysis was also performed in order to examine the relationships among the five areas, using the mean seasonal abundance of the species as attributes for constructing a matrix of 19 stations per 49 species. A dendrogram was produced by hierarchical agglomerative clustering using unweighted paired-group method of averaging (UPGMA). The dendrogram, based on Bray-Curtis similarity (D) measures was computed including also the rare species. The Bray-Curtis similarity (D) between two samples was calculated from the following equation:

$$D_{jk} = 1 - \frac{\sum_{i=1}^{S} \left| y_{ij} - y_{ik} \right|}{\sum_{i=1}^{S} \left(y_{ij} + y_{ik} \right)},$$

where y_{ij} is the abundance of the species i in sample j and y_{ik} the abundance of species i in the sample k.

A factorial correspondence analysis (FCA), was also performed on a quantitative correlation matrix including also the rare species (Benzecri,1982). Axes significance was evaluated using the tables of Lebart (1975).

######

All the identified species collected or censused with different techniques in the different surveys, were arranged in the annex I following the nomenclature of Whitehead *et al*. (1984/86) for fishes, Zariquiey-Alvarez (1968) for decapod crustaceans and Bello (1986) for cephalopods.

3 - RESULTS

3.1 - TRAWLABLE AREAS

A total of 245 valid hauls were made in the four surveys (124 diurnal and 121 nocturnal), as shown in Table 20. Tables 21 to 24 show the details of each haul. Figures 4 to 7 show the approximate position of each haul inside the study area.

3.1.1 - Fishing yields

3.1.1.1 *- Overall catch*

Table 25 to 28 show the CPUE per stratum of every species caught; Figure 12 shows the CPUE per stratum of the overall catch in each survey. Figure 13 to 20 show the trend of the total catch in number and weight in each ESU, separately for diurnal and nocturnal surveys.

No significant difference was detected among the four seasons, neither in the day nor at night (P>0.05, Kruskal-Wallis test). There was no difference comparing the catches in each stratum among the four seasons as well (P>0.05, Kruskal-Wallis test). On the contrary, significant differences were detected between strata in each survey:

	DAY				NIGHT			
	AUTUMN	WINTER	SPRING	SUMMER	AUTUMN	WINTER	SPRING	SUMMER
A vs. B	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.
A vs. C	**	n.s.	n.s.	n.s.	**	*	*	n.s.
B vs. C	**	n.s.	**	**	*	n.s.	**	*

Comparisons between the strata. Mann-Whitney U test performed on the overall catch. * = P<0.05, ** = P<0.01 respectively; n.s.=not significant; A, B, C=depth strata.

In every season diurnal catches were nearly always larger than nocturnal (data of pooled hauls), yet without significant differences, neither considering the pooled strata nor considering each stratum; the only difference (P<0.05, Mann-Whitney U test) was found between day and night in str. C in winter. The largest diurnal CPUE was obtained in winter in str. B (50.98kg), whereas the lowest was obtained in autumn in str. C (16.24kg). As for the night samplings, the largest CPUE was obtained in winter in str. A (42.61kg), the lowest in autumn in str. C (14.62kg).

The red mullet was the dominant species in diurnal catches, except in str. C in winter (overcome by the hake) and in the same stratum in summer (overcome by the Atlantic horse mackerel, *Trachurus trachurus*). In the night hauls the red mullet dominated in str. A (except in winter), whereas in the deeper strata the dominant species was often the picarel (*Spicara flexuosa*).

Figures 21 to 28 show the spatial distribution of the demersal resources in the Gulf of Castellammare, based on the total catch (in kg) in each haul; thus, it is possible to visualize the disposition of the demersal fauna, and its changes in time and space. Survey I (autumn) (Figg. 21-22): in the day two peaks were located in the south-western and the south-eastern sectors of the gulf; at night the fish spread in the whole area, and a large maximum was located in the central sector. Survey II (winter) (Figg. 23-24): in the day three peaks were located in the central, south-western and south-eastern areas, the highest in the centre; at night the fish were much more diluted, with a localized peak in the south-western corner. Survey III (spring) (Figg. 25-26): in the day a peak was located in the centre of the gulf, whereas at night the fish scattered in the whole area. Survey IV (summer) (Figg. 27-28): in the day two moderate peaks were located in the central and western sectors, whereas at night the disposition of the fish showed a trend different than in the previous seasons, with the biomass concentrated in the centre of the gulf.

In conclusion, from the analysis of the CPUEs of the total demersal fauna (Fig. 12) and of their spatial distribution (Figg. 21-28), it seems that the demersal resources of the Gulf of Castellammare are much more abundant in the outer belt of stratum A and in the whole stratum B, whereas stratum C seems the poorer in terms of biomass.

***3.1.1.2** - Target species*

Table 25 to 28 and Figures 29 and 30 show the CPUE per stratum of the twelve target species, whereas Figures 31 to 78 show their spatial distribution in the study area. Figure 79 to 126 show the size structure (LFDs) of the samples collected, divided by sex and by depth stratum.

The results of the significance tests performed on the catches of each species for comparisons between day and night and among strata and seasons are reported in the following tables:

DAY VS. NIGHT COMPARISONS (POOLED STRATA)

	AUTUMN	WINTER	SPRING	SUMMER
hake	**	n.s.	n.s.	***
red mullet	n.s.	**	n.s.	*
striped mullet	n.s.	n.s.	n.s.	n.s.
pandora	n.s.	n.s.	n.s.	n.s.
striped seabream	n.s.	n.s.	n.s.	n.s.
pink shrimp	n.s.	n.s.	n.s.	n.s.
cuttlefish	n.s.	*	n.s.	n.s.
European squid	n.s.	***	n.s.	***
broadtail squid	n.s.	n.s.	***	n.s.
horned octopus	n.s.	**	n.s.	n.s.
musky octopus	n.s.	n.s.	n.s.	n.s.
common octopus	*	n.s.	n.s.	n.s.

Comparisons between diurnal and nocturnal hauls (pooled strata). Mann-Whitney U test performed on the catches of the target species. * = P<0.05; ** = P<0.01; *** = P<0.001; n.s.=not significant.

DAY VS. NIGHT COMPARISONS (PER STRATUM)

	AUTUMN			WINTER			SPRING			SUMMER		
	A	B	C	A	B	C	A	B	C	A	B	C
hake	n.s.	n.s.	*	n.s.	**	n.s.	n.s.	n.s.	n.s.	n.s.	***	**
red mullet	n.s.	n.s.	n.s.	n.s.	**	*	n.s.	n.s.	**	n.s.	*	n.s.
striped mullet	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*
pandora	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
striped seabream	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
pink shrimp	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	***
cuttlefish	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
European squid	n.s.	**	n.s.	n.s.	**	n.s.	n.s.	*	n.s.	n.s.	***	n.s.
broadtail squid	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	**	n.s.	n.s.	n.s.
horned octopus	n.s.	n.s.	n.s.	n.s.	**	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.
musky octopus	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.
common octopus	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	**	n.s.

Comparisons between diurnal and nocturnal hauls in each survey and in each stratum. Mann-Whitney U test performed on the catches of the target species. * = P<0.05; ** = P<0.01; *** = P<0.001; n.s.=not significant.

COMPARISONS BETWEEN THE SEASONS (POOLED STRATA)

		DAY				NIGHT			
		Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
hake	Autumn	-				-			
	Winter	*	-			***	-		
	Spring	***	*	-		n.s.	*	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	***	*	-
red mullet	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	n.s.	n.s.	-		n.s.	n.s.	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	n.s.	n.s.	-
striped mullet	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	n.s.	n.s.	-		n.s.	n.s.	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	n.s.	n.s.	-
pandora	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	n.s.	n.s.	-		n.s.	n.s.	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	n.s.	n.s.	-
striped seabream	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	n.s.	n.s.	-		n.s.	n.s.	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	n.s.	n.s.	-
pink shrimp	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	n.s.	n.s.	-		n.s.	n.s.	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	n.s.	n.s.	-
cuttlefish	Autumn	-				-			
	Winter	***	-			**	-		
	Spring	n.s.	***	-		***	***	-	
	Summer	**	***	n.s.	-	**	***	n.s.	-
European squid	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	**	***	-		*	n.s.	-	
	Summer	n.s.	n.s.	**	-	*	n.s.	n.s.	-
broadtail squid	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	**	***	-		n.s.	n.s.	-	
	Summer	*	*	n.s.	-	n.s.	n.s.	n.s.	-
horned octopus	Autumn	-				-			
	Winter	***	-			*	-		
	Spring	*	n.s.	-		n.s.	n.s.	-	
	Summer	n.s.	**	n.s.	-	n.s.	n.s.	n.s.	-
musky octopus	Autumn	-				-			
	Winter	*	-			n.s.	-		
	Spring	n.s.	n.s.	-		*	n.s.	-	
	Summer	n.s.	**	n.s.	-	*	***	***	-
common octopus	Autumn	-				-			
	Winter	n.s.	-			n.s.	-		
	Spring	n.s.	n.s.	-		**	n.s.	-	
	Summer	n.s.	n.s.	n.s.	-	n.s.	n.s.	n.s.	-

Comparisons between the seasons. Mann-Whitney U test performed on the catches of the target species. * = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$; n.s.=not significant.

COMPARISONS AMONG THE STRATA

	DAY				NIGHT			
	AUTUMN	WINTER	SPRING	SUMMER	AUTUMN	WINTER	SPRING	SUMMER
hake	n.s.	n.s.	**	**	*	n.s.	n.s.	*
red mullet	**	**	*	***	***	**	***	**
striped mullet	*	n.s.	n.s.	**	*	n.s.	n.s.	n.s.
pandora	***	***	***	***	***	***	***	***
striped seabream	***	***	***	***	***	**	***	***
pink shrimp	***	***	***	***	***	***	***	***
cuttlefish	**	n.s.	n.s.	***	**	n.s.	n.s.	***
European squid	***	**	n.s.	***	***	**	**	**
broadtail squid	*	***	n.s.	n.s.	*	**	**	*
horned octopus	**	**	**	*	*	**	*	n.s.
musky octopus	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.
common octopus	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	**

Comparisons among the three strata in each survey. Kruskal-Wallis test performed on the catches of the target species. * = P<0.05; ** = P<0.01; *** = P<0.001; n.s.=not significant.

COMPARISONS AMONG THE SEASON (PER STRATUM)

	DAY			NIGHT		
	A	B	C	A	B	C
hake	n.s.	n.s.	n.s.	n.s.	n.s.	**
red mullet	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
striped mullet	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
pandora	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
striped seabream	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
pink shrimp	n.s.	n.s.	n.s.	n.s.	**	n.s.
cuttlefish	***	***	***	n.s.	***	***
European squid	***	n.s.	n.s.	*	n.s.	n.s.
broadtail squid	n.s.	n.s.	***	n.s.	n.s.	*
horned octopus	n.s.	*	**	n.s.	n.s.	n.s.
musky octopus	n.s.	n.s.	*	n.s.	**	n.s.
common octopus	n.s.	n.s.	n.s.	n.s.	*	n.s.

Comparisons among the four seasons in each stratum. Kruskal-Wallis test performed on the catches of the target species. * = P<0.05; ** = P<0.01; *** = P<0.001; n.s.=not significant.

COMPARISONS BETWEEN STRATA

		DAY				NIGHT			
		AUTUMN	WINTER	SPRING	SUMMER	AUTUMN	WINTER	SPRING	SUMMER
hake	A vs. B	n.s.	n.s.	**	*	*	n.s.	n.s.	**
	A vs. C	n.s.	n.s.	**	*	n.s.	n.s.	n.s.	n.s.
	B vs. C	n.s.	n.s.	n.s.	**	*	n.s.	n.s.	n.s.
red mullet	A vs. B	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	A vs. C	**	**	*	**	***	**	**	**
	B vs. C	**	**	*	**	**	*	**	*
striped mullet	A vs. B	*	n.s.	n.s.	n.s.	**	n.s.	n.s.	*
	A vs. C	*	n.s.	n.s.	**	n.s.	n.s.	n.s.	n.s.
	B vs. C	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.
pandora	A vs. B	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.
	A vs. C	**	***	***	***	***	***	***	***
	B vs. C	***	***	***	***	**	***	***	**
striped seabream	A vs. B	***	**	**	**	**	*	**	**
	A vs. C	**	**	**	**	**	*	**	**
	B vs. C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
pink shrimp	A vs. B	***	*	n.s.	**	***	**		**
	A vs. C	***	***	***	***	***	***	***	***
	B vs. C	n.s.	**	**	***	n.s.	**	**	*
cuttlefish	A vs. B	n.s.	n.s.	n.s.	**	*	n.s.	n.s.	**
	A vs. C	**	n.s.	*	**	n.s.	n.s.	*	**
	B vs. C	**	n.s.	n.s.	n.s.	**	n.s.	n.s.	n.s.
European squid	A vs. B	**	n.s.	n.s.	n.s.	***	*	*	*
	A vs. C	***	**	n.s.	**	***	**	*	*
	B vs. C	**	*	n.s.	***	n.s.	n.s.	n.s.	n.s.
broadtail squid	A vs. B	n.s.	n.s.	n.s.	n.s.	*	n.s.	*	*
	A vs. C	*	***	n.s.	n.s.	*	*	**	n.s.
	B vs. C	*	**	n.s.	n.s.	n.s.	*	*	n.s.
horned octopus	A vs. B	**	**	*	*	n.s.	n.s.	*	n.s.
	A vs. C	**	**	**	**	*	**	*	n.s.
	B vs. C	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.
musky octopus	A vs. B	n.s.	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.
	A vs. C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
	B vs. C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.
common octopus	A vs. B	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*
	A vs. C	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	**
	B vs. C	n.s.	n.s.	n.s.	*	n.s.	n.s.	**	n.s.

Comparisons among the strata. Kruskal-Wallis test performed on the catches of the target species. * = $P<0.05$; ** = $P<0.01$; *** = $P<0.001$; n.s.=not significant.

Hake ***(Merluccius merluccius) -*** The largest catches of hake were obtained in the day in winter (str. B, CPUE=6062gr), the smallest at night in summer (str. A, CPUE=489gr) (Fig. 29). Diurnal catches were always larger than nocturnal in the same stratum, except in str. A in spring. Hakes were always more abundant in str. B. Catches were distributed rather evenly in the whole area (Figg. 31-34). Recruits were present especially in spring (survey 3) and summer (survey 4) samples, and were more frequent in the deeper stratum (str. 3) (Figg. 79-82).

Red mullet *(Mullus barbatus)* - This species in absolute yielded the largest weight than any other species; in some hauls, more than 40kg of red mullets were caught. The largest catches were obtained in the day in winter (str. A, CPUE=18559gr), the smallest at night in summer (str. C, CPUE=1004gr). Diurnal catches were always larger than nocturnal in the same stratum. The CPUEs displayed a marked depth trend (Fig. 29), decreasing from shallow to deeper bottoms, though the difference between str. A and str. B was not significant. Red mullets were distributed rather evenly in the study area, but larger catches were often obtained in some ESUs in the south-western part of the gulf (Figg. 35-38). Recruits were caught nearly exclusively in summer sampling (survey 4) in stratum A (Figg. 83-86).

Striped mullet *(Mullus surmuletus)* - This species usually lives close to sandy-rocky bottoms, algae and *Posidonia oceanica* meadows; for this reason, the trawl net is not the most suitable sampling gear, and this probably accounts for the highly variable yields in terms of both number and weight. Moreover, the highest CPUEs came from the south-eastern sector (Figg. 39-42), where trawling was not possible anymore after the first (autumn) survey (see chapter 2.1.1).

The largest catches were obtained in autumn at night (str. A, CPUE=610gr) and in the day (str. A, CPUE=521gr); the lowest (CPUE=0) in the day in summer (str. C) and at night in autumn and in summer (str. B). Keeping in mind the limits of our samples, figures 87 to 90 show that recruits were caught in autumn, winter and summer (surveys 1, 2 and 3), with a smaller modal length in the latter season. From the same figures it appears a spatial separation among size groups: the larger the size, the deeper the bottom.

Pandora *(Pagellus erythrinus)* - The largest catches of pandora were obtained at night in autumn (str. A, CPUE=3794gr), and in spring (str. A, CPUE=3737gr). In these two seasons, catches of str. A were larger than those of str. B, whereas in winter and in summer these two strata yielded nearly the same amount of fish. Catches in str. C were very poor in the day, null at night. Pandoras were distributed rather evenly throughout the study area (Figg. 43-46). Recruits appeared in summer (survey 4) and, very sparsely, in spring (survey 3); small specimens (<90-100mm SL) were collected mainly in str. A (Figg. 91-94).

Striped seabream *(Lithognathus mormyrus)* - It should be kept in mind that the total catch of this species decreased from the first to the last survey because some ESUs in str. A became non-trawlable during the study period (see chapter 2.1.1).

This species was present only in str. A (except a very low nocturnal CPUE in str. B in autumn), and displayed a clear seasonal trend both in diurnal and nocturnal catches, with decreasing CPUEs from autumn to summer. The largest catches were thus obtained in autumn (diurnal CPUE=3726gr, nocturnal CPUE=4000gr); in winter diurnal and nocturnal catches were nearly the same, whereas the former were about six fold smaller than the latter in spring and summer. After the first survey, when the south-eastern sector of the gulf became non-trawlable, striped seabreams were caught mainly in a few ESUs in the central and western part of str. A (Figg. 47-50). Recruits were sampled only seldom in autumn and summer (serveys 1 and 4) (Figg. 95-98).

Pink shrimp *(Parapenaeus longirostris)* - The largest catches of pink shrimp were obtained in the summer diurnal hauls (str. C, CPUE=1139gr), the smallest in spring in str. B (diurnal CPUE=0, nocturnal CPUE=6gr). This species was always more abundant in str. C and in the daytime (except in spring (survey 3), when the nocturnal CPUE slightly overcame the diurnal one); in str. A it was practically absent. The catches were slightly more frequent and abundant in the central and western sectors, except in summer, when they were more evenly distributed (Figg. 51-54). A few recruits were caught in winter (survey 2), spring (survey 3) and summer (survey 4), but a clear peak of small specimens (mode at about 12mm CL) was recorded in spring (Figg. 99-102); the size structure of the population in strata B and C was apparently the same.

Cuttlefish *(Sepia officinalis)* - The catches of cuttlefish followed the same trend in the day and at night (Fig. 30): rather small in autumn, larger in winter and very small in spring and summer. Anyway, diurnal catches were generally larger than nocturnal. In winter, str. B yielded the highest CPUEs, followed by str. C and str. A. Recruits were caught in autumn, winter and summer; they were caught exclusively in str. A (Figure 103 to 106).

European squid *(Loligo vulgaris)* - This species, as well as the other target cephalopods, was fished in small amounts. The largest catches were obtained in str. A (central sector, Figg. 30 and 59-62) in autumn (diurnal CPUE=898gr, nocturnal CPUE=860gr); in spring the catches fell down, to get up slightly in summer. The str. C yielded a null CPUE at night in all seasons, and a very low one in the day; the main part of the catch was obtained in str. A. Little evidence of recruitment appears from the spring LFDs and, more clearly, from the summer ones; in summer the bulk of recruits was caught in shallow waters (Figg. 107-110).

Broadtail squid *(Illex coindetii)* - This species yielded the lowest CPUEs among all the target species, but it should be noticed that it is more abundant at greater depths, beyond the bathymetric limit of the study area. The largest catches were obtained in the day in winter (str. C, CPUE=325gr). Though being generally small, diurnal and nocturnal catches showed a different pattern. In the day, catches in str. A increased from autumn to winter and fell down in the following seasons; the other strata yielded very low to null CPUEs. At night, str. C catches remained relatively large in spring, and str. B catches showed an opposite behaviour with respect to diurnal catches; in str. A no broadtail squids were caught. The geographic pattern of the catches appeared variable (Figg. 63-66). Little evidence of recruitment appeared in the autumn sample; no clear bathymetric pattern linked to size groups stems from the observation of LFDs (Figg.111-114), but it should be kept in mind that our small samples cannot give a realistic picture of the situation.

Horned octopus *(Eledone cirrhosa)* - The largest catches of horned octopus were obtained in the day in spring (str. C, CPUE=908gr), the smallest in str. A in all seasons. Str. C always yielded the highest CPUEs, followed by str. B; winter and spring were the most productive seasons. In general diurnal catches were larger than nocturnal. The largest catches were rather concentrated in the central sector of the gulf (Figg. 67-70). The smallest recruits were caught in summer; in general younger specimens were more abundant in str. C (Figg. 115-118).

Musky octopus *(Eledone moschata)* - The largest catches of musky octopus were obtained in spring at night (str. B, CPUE=891gr). The fishing patterns differed between day and night: in the day the highest CPUEs were recorded in winter (str. C and B), followed by spring, whereas at night they were recorded in spring (maximum in str. B) and fell down in summer. The catches were distributed evenly in the study area; only from the survey 3 charts it stems that diurnal catches were concentrated in the central sector of the gulf, whereas the nocturnal ones were obtained from the eastern and western sectors (Figg. 71-74). Recruits were caught in spring and summer in str. A (Figg. 119-122).

Common octopus *(Octopus vulgaris)* - First of all it should be noticed that a relevant portion of the population of this species, *i.e.*, that living in shallow rocky and sandy-rocky bottoms, was not sampled at all in our trawl surveys. The largest catches were obtained in the day in autumn and winter (str. B, CPUE=1036gr and 1183gr respectively), the smallest at night in summer (str. C, CPUE=25gr). Diurnal and nocturnal catches showed a different pattern: in the day the peak was reached in winter in str. B and A, whereas at night str. B yielded similar CPUEs in winter and spring, and str. A gave better results in spring and summer. The largest catches were concentrated in the central-eastern sector (Figg.75-78). Recruits were caught especially in spring and summer; there is a weak evidence of their localization in the shallower strata (Figg. 123-126).

3.1.2 - Biomass estimates

The results of the swept-area method, employed for estimating the absolute biomass of the target species in the whole study area, are reported in Table 29 and 29a and illustrated in Figure 127.

The red mullet was by far the most abundant species, with the diurnal estimates always much higher than the nocturnal. The highest biomass was calculated in winter in the day (170.34 t), the lowest in summer at night (34.08 t).

The hake was the second species in abundance, followed by the pandora, except at night in autumn and spring when the biomass of the latter species resulted larger. The hake had the maximum biomass in winter (daytime, 62.58 t) and the minimum in summer (night-time, 5.81 t).

The striped seabream showed the highest abundance in autumn (10.90 t at night) and the lowest in summer (0.47 t in the day). The nocturnal estimates were generally higher than the diurnal ones.

The pink shrimp was more abundant in the day than at night, except in spring. The highest value was recorded the winter (daytime, 4.33 t), the lowest in summer (night-time, 0.77 t).

Among the cephalopods, large abundance values were recorded only for the cuttlefish and the common octopus and only in winter (18.12 and 10.43 t, respectively). All the cephalopods were generally more abundant in winter; the diurnal biomass values were always higher than the nocturnal ones.

3.1.3 - Catches per unit effort before and after the four-year trawling ban

The results of the trawling ban were in some cases astounding. In fact the yields of several species increased many-fold in the post-ban period. Table 30 and Figure 128 show these strong results.

The total commercial catch (*i.e.*, those species commonly sold on the local markets) underwent a seven-fold increase, considering the overall area. Taking into account the single strata, there was an increase by a factor of 5 in stratum C to a factor of 9 in stratum B.

Some of the target species, *i.e.*, striped seabream, cuttlefish, European squid, broadtail squid and common octopus, were caught in such small amounts and so sparsely in the pre-ban surveys (especially the striped seabream), that any comparison would have been unreliable. These cephalopods, though undoubtedly more abundant now than in the pre-ban period, yielded in the post-ban survey relatively small quantities (see Tab. 25 to 28), whereas the striped seabream showed considerable CPUEs (2-4 kg per haul) at least in autumn and winter (Fig. 29).

Pink shrimp, horned octopus and musky octopus displayed not significantly higher CPUEs in the post-ban survey, though they increased about 1 to 6 times. Pandora and hake were caught in significantly larger amounts in the post-ban survey (by a factor of 5 more or less). The species whose CPUE rised most strikingly was the red mullet: in the total area it had a 33-fold increase, but in the single strata the difference was even more dramatic: in stratum C, where its yield was almost null before the ban, the catch increased by a factor of 123 (31 gr *vs.* 3.8 kg per haul on average)!

The only species that seemed to be not affected by the undoubtfully positive consequences of the ban was the striped mullet, whose yields, although being very low in absolute, were larger in the pre-ban surveys (except in stratum B). For a possible explanation of this, see the paragraph on this species in chapter 3.1.1.2.

3.1.4 - Biology of the target species

Hake *(Merluccius merluccius)* - It is necessary to make clear that a large portion of the hake population of the Gulf of Castellammare lives beyond the continental shelf, and thus was not sampled in the present study. This inevitably did not allow us to get a complete picture of several aspects of the biology of this species.

7295 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 129. Only a very small number of ripe fish (stage IV) was caught, and there was no evidence of a definite spawning season. The size at first maturity was 312 mm in females and 291 mm in males (Figg. 130-131). The sex-ratio over the whole study period was 0.98, with little variation among seasons (table 31).

Table 32 shows the correlation between total and standard length. No significant difference was found between the mean standard length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 132; a highly significant difference ($P<0.001$) was detected between the two sexes.

The VBGE was not applied to this species, because of the sampling limitations cited before; for the same reason the total mortality rate was not estimated.

Red mullet *(Mullus barbatus)* - 27909 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 129. The highest percentage of ripe specimens (stage IV) was collected in spring, although their presence was also recorded in the other seasons. In summer the larger part of the adults had already spawned. The size at first maturity was 109 mm in females and 105 mm in males (Figg. 133-134). The sex-ratio over the year was 0.90, varying from 0.67 in winter to 1.12 in autumn (table 31).

Table 32 shows the correlation between total and standard length. A highly significant difference ($P<0.001$) was found between the mean standard length of females and males (table 33).

The length-weight relationship is described in table and drawn in figure 135; a highly significant difference ($P<0.001$) was detected between the two sexes.

The estimated growth parameters were: L_∞ = 21.50cm, K = 0.23 year^{-1}, t_0 = -1.15.

The estimated total mortality rate was Z = 1.05.

Striped mullet *(Mullus surmuletus)* - 1154 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 136. The highest percentage of ripe specimens (stage IV) was collected in spring, but a certain amount of them was also recorded in the other seasons. The presence of "spent" (stage V) fish in winter suggested that spawning in this species can occur in this season. The size at first maturity was 95 mm in females and 95 mm in males (Figg. 137-138). This size is smaller than that reported in the current literature. This may be due to the fact that six ESUs of stratum A became non-trawlable after the second (=winter) survey (see chapter 2.1.1), resulting in an inadequate sampling of the spawning population during spring and summer. The sex-ratio over the year was 1.33, varying from 0.53 in winter to 1.91 in autumn (table 31).

Table 32 shows the correlation between total and standard length. No significant difference was found between the mean standard length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 132; no significant difference was detected between the two sexes.

The estimated growth parameters were: L_∞ = 27.20cm, K = 0.38 year^{-1}, t_0 = 0.03.

The estimated total mortality rate was Z = 2.22.

Pandora *(Pagellus erythrinus)* - 5532 specimens were measured and sexed. This is a hermaphroditic protogynic species. The proportion of maturity stages in the two sexes is shown in figure 136. The highest percentage of ripe specimens (stage IV) was collected in spring, but 36.8% of females and 7.6% of males were still at this stage in summer. A very small amount of ripe fish was also recorded in autumn and winter. The size at first maturity was 117 mm in females and 128 mm in males (Figg. 139-140). The sex-ratio over the year was 3.21, varying from 2.52 in summer to 3.62 in spring (table 31).

Table 32 shows the correlation between total and standard length. A highly significant difference ($P<0.001$) was found between the mean standard length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 135; no significant difference was detected between the two sexes.

The estimated growth parameters were: L_∞ = 33.60cm, K = 0.22 $year^{-1}$, t_0 = -0.15.

The estimated total mortality rate was Z = 2.93.

Striped seabream *(Lithognathus mormyrus)* - 2992 specimens were measured and sexed. This is a hermaphroditic protandric species. The proportion of maturity stages in the two sexes is shown in figure 141. The highest percentage of ripe specimens (stage IV) was collected in spring, and a much smaller amount of them was also recorded in summer. The size at first maturity was 87 mm in females and 91 mm in males (Figg. 142-143). This size is smaller than that reported in the very few papers on this species; the same comments made for the striped mullet are applicable here.The sex-ratio over the year was 1.18, varying from 0.73 in summer to 1.32 in autumn (table 31).

Table 32 shows the correlation between total and standard length. A highly significant difference ($P<0.001$) was found between the mean standard length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 144; a significant difference ($P<0.01$) was detected between the two sexes.

The estimated growth parameters were: L_∞ = 30.30cm, K = 0.27 $year^{-1}$, t_0 = 0.18.

The estimated total mortality rate was Z = 3.80.

Pink shrimp *(Parapenaeus longirostris)* - This species extends its bathymetric range down to the upper slope, beyond the limits of our study area; for this reason our sampling may not have been enough representative of the population, and the results about some aspects of its biology (growth and reproduction) are only partial.

11660 specimens were measured and sexed. No maturity observation was made on males. The proportion of maturity stages in the females is shown in figure 141. The highest percentage (30.5%) of ripe (stage III) shrimp was collected in autumn, but this percentage was only a little lower in the other seasons, suggesting that this species may spawn all the year round. The size at first maturity was 20 mm in females (figure 145). The sex-ratio over the year was 1.52, with little variation among the four season (table 31).

A highly significant difference (P<0.001) was found between the mean carapace length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 144; no significant difference was detected between the two sexes.

The estimated growth parameters were: L_∞ = 46.2mm, K = 0.61 year^{-1}, t_0 = -0.09.

The estimated total mortality rate was Z = 4.31.

Growth and mortality rates estimates may be biased, due to the presumably poor representativeness of the samples, as explained earlier.

Cuttlefish *(Sepia officinalis)* - 636 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 146. The highest percentage of ripe specimens (stage III males and stage V+VI females) was collected in winter (71.0% females, 92.5% males) and spring (72.7% females, 85.7% males); a small amount of them was also recorded in autumn. The size at first maturity was 90 mm in females and 66 mm in males (Figg. 147-148). The same comments made about this aspect of reproduction for the striped mullet are applicable here. The sex-ratio over the year was 1.07, varying from 0.93 in autumn to 1.57 in spring (table 31).

A highly significant difference (P<0.001) was found between the mean mantle length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 149; no significant difference was detected between the two sexes.

European squid *(Loligo vulgaris)* - 566 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 146. The highest percentage of ripe (stage V) specimens was collected in winter, but 15.4% of females and 40% of males at this stage were still present in summer. The size at first maturity was 160 mm in females and 111 mm in males (Figg. 150-151). The sex-ratio over the year was 1.19, varying from 1.01 in autumn to 2.60 in spring (table 31).

No significant difference was found between the mean mantle length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 149; a significant difference (P<0.01) was detected between the two sexes.

Broadtail squid *(Illex coindetii)* - 304 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 152. The highest percentage of ripe (stage V) specimens was collected in spring and summer, but a certain amount of them was also found in the other seasons. The size at first maturity was 145 mm in females and 115 mm in males (Figg. 153-154). The sex-ratio over the year was 0.64, varying from 0.25 in summer to 0.75 in autumn (table 31).

No significant difference was found between the mean mantle length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 155; a highly significant difference ($P<0.001$) was detected between the two sexes.

Horned octopus *(Eledone cirrhosa)* - 278 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 152. A non-clear seasonal pattern stems from the observation of the proportion of maturity stages in the four seasons. In fact, while a strong peak of ripe males (stage III) is present in the spring sample, ripe females (stages V+VI) were collected only in summer (14.3%), when ripe males were only 4.0%. The spawning population was probably inadequately represented in our samples. Besides the logistic equation did not fit the size-at-maturity data of females. For this reason, the size at first maturity of females (105 mm) may be eye-estimated from figure 156. In males it was 53 mm (Fig. 157). The sex-ratio over the year was 0.98, varying from 0.56 in summer to 1.21 in spring (table 31).

A significant difference ($P<0.05$) was found between the mean mantle length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 155; no significant difference was detected between the two sexes.

Musky octopus *(Eledone moschata)* - 203 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 158. The highest percentage of ripe specimens (stage III males and stage V+VI females) was collected in spring, but a certain amount of ripe males was also found in the other seasons. The size at first maturity was 120 mm in females and 98 mm in males (Figg. 159-160). The sex-ratio over the year was 1.11, varying from 0.59 in autumn to 1.69 in winter (table 31).

No significant difference was found between the mean mantle length of females and males (table 33).

The length-weight relationship is described in table 34 and drawn in figure 161; no significant difference was detected between the two sexes.

Common octopus *(Octopus vulgaris)* - 217 specimens were measured and sexed. The proportion of maturity stages in the two sexes is shown in figure 158. The highest percentage of ripe specimens (stage III males and stage V+VI females) was collected in spring, but a certain amount of them (especially males) was also found in the other seasons. The size at first maturity was 100 mm in females and 69 mm in males (Figg. 162-163). The sex-ratio over the year was 1.01, varying from 0.50 in summer to 1.86 in spring (Table 31).

No significant difference was found between the mean mantle length of females and males (Table 33).

The length-weight relationship is described in table 34 and drawn in figure 161; no significant difference was detected between the two sexes.

3.1.5 - Nekton assemblages

3.1.5.1 *- Species composition and diversity*

A total of 171 taxa belonging to 70 families and including 11 crustaceans, 22 cephalopods and 138 fishes were recorded: sparids (7%), soleids (4.7%), octopodids (4.7%), triglids (4.1%), serranids (3.5%), labrids (3.5%) and gadids (3.5%) were the most representative families (Annex I).

Arranging the species in descending order of percentage frequency of occurrence in all the hauls on the yearly scale (Table 35) we find red mullet (*Mullus barbatus*), picarel (*Spicara flexuosa*) and scaldfish (*Arnoglossus laterna*) with the highest value (100%) followed by hake (*Merluccius merluccius*), brown comber (*Serranus hepatus*), Atlantic horse mackerel (*Trachurus trachurus*) (98%). These are the species with the largest spatial distribution along the continental shelf of the Gulf.

Besides the above-mentioned species the highest percentage of occurrence in the first bathymetric stratum is attained by European squid (*Loligo vulgaris*), tub gurnard (*Trigla lucerna*), pandora (*Pagellus erythrinus*), annular seabream (*Diplodus annularis*), which along with the wide-eyed flounder (*Bothus podas podas*), cuttlefish (*Sepia officinalis*), common seabream (*Pagrus pagrus pagrus*), striped seabream (*Lithognathus mormyrus*) and striped mullet (*Mullus surmuletus*) characterize the stratum A (Table 35).

In stratum B some of the most frequent species were also very frequent in stratum A and C (hake, pandora, pink shrimp, etc.). However, some species like blackspot seabream (*Pagellus bogaraveo*), large-scaled gurnard (*Lepidotrigla cavillone*), poor cod (*Trisopterus minutus capelanus*), musky octopus (*Eledone moschata*), spottail mantis shrimp (*Squilla* *mantis*), stargazer (*Uranoscopus scaber*) picarel (*Spicara smaris*) and angler (*Lophius piscatorius*) are decidedly more frequent in the stratum B.

Taking into account both the frequency of occurrence and the percent contribution in number of each species, the nekton assemblages of stratum C show several taxa common to the other strata but some of them, such as the pink shrimp (*Parapenaeus longirostris*) and the hake, reach in this stratum the highest abundance. Many taxa caught in stratum C were species with no commercial value, but for their high numerical importance and frequency they characterize some bionomic facies of the main biocoenoses included in this stratum. Besides the pink shrimp they are: boar fish (*Capros aper*), argentine (*Argentina sphiraena*), longspine spinefish (*Macroramphosus scolopax*), silvery pout (*Gadiculus argenteus argenteus*), silver scabbardfish (*Lepidopus caudatus*), shortnose greeneye (*Chlorophthalmus agassizi*), greater forkbeard (*Phycis blennoides*), striped soldier shrimp (*Plesionika edwardsii*), giant red shrimp (*Aristaeomorpha foliacea*) and blue-red shrimp (*Aristeus antennatus*), caught only in the deepest ESUs of the stratum.

The highest number of species (S) was collected in spring (S=130), the lowest in summer (S=120), while intermediate values were found in autumn (124) and winter (126).

The community structure indices (S, d', SI, H', J') and the catch per unit effort in number of specimens (No.) per ESU are reported in Table 36. In Figg. 164-171 are reported the communities structure indices on the basis of the four surveys, in each ESU and in day and night samples, whereas the trend of the number of specimens (No.) is shown in Figg. 13-20. Mean and standard deviation of the abovementioned values are reported in the Table 37, where, on the whole, the seasonal night values of the community structures indices are higher than the diurnal. From the analysis of Figures 13-20 a strong decrement of the number of specimens (No.) in the easternmost ESUs in each season is clear.

In short, the highest values of the specific richness and diversity were always recorded in stratum C and in the night hauls. On the contrary, No. reached the maximum values during the diurnal fishing carried out in the stratum B.

Table 38 reports the results of the statistical comparisons of the community structure indices values on a temporal (day- night hauls, seasons) and spatial (strata) scale.

The comparisons between diurnal and nocturnal values (pooled strata) showed significant differences of the indices except for S (Tab. 38a).

In autumn, no significant differences of the indices values were detected between nocturnal and diurnal values and between strata (Tab. 38a, b).

In winter, the differences between the diurnal and nocturnal values of the indices (pooled strata) were statistically significant except for S. Statistical comparison between diurnal and nocturnal values for each stratum (Tab. 38b) highlighted significant differences for d', J' and No. values in stratum C and for d' values in the stratum A.

In spring statistical differences on pooled strata between day and night values were detected for S, d' and H' (Tab. 38a). No significant differences were obtained between the day values of the stratum B in comparison with the night values of the same stratum (table 38b). The daily differences were ascribable to stratum A where S, d', SI and H' reached values higher than the night values: in stratum C the differences were due to S and d' which registered higher values in daytime (Tab. 38b).

In summer No. had values significantly greater during the diurnal hauls; d' values were significantly greater at night (Tab. 38a). The night values of SI, H', J' and No. in the stratum C were significantly higher than day values (Tab. 38b).

Statistical comparison between seasons showed some differences for S, d' and No. values considering the diurnal hauls and for all indices except for No. taking into account the nocturnal ones (table 38c).

The differences between strata detected separately on diurnal and nocturnal values were more evident between the stratum A and C; no significant differences were obtained between the nocturnal values of strata A and B (table 38d).

3.1.5.2 - *Qualitative analysis of the benthic assemblages*

The sampling strategy adopted allowed us to carry out a qualitative analysis of the benthic community sampled by the trawl net during the first two surveys. In this way it was possible to roughly describe the trawled bottoms from a bionomic viewpoint . In some cases it was also possible to recognize the *facies* aspect of some biocoenoses. A total of 158 taxa, 140 of them identified at the species level (Tab. 39) belonging to different groups of plants and animals were found. A total of 7 different assemblages were assessed following the classification of Peres and Picard (1964) and Peres (1982), as resumed in the following scheme:

Acronym	Original French name of each biocoenosis (from Peres and Picard , 1964)	Approximate depth range in our samples	Name adopted in this report	Example of type species
SFBC	Biocénose des sables fins bien calibrès	7-40 m	Fine , well sorted sand assemblages	*Acanthocardia tuberculata*
VTC	Biocénose de vase terrigéne côtiére	40-80 m	Terrigenous mud shelf assemblages	*Stichopus regalis*
DC	Biocénose de fonde côtiers du large: regrupement de l'ensemble des faciés.	50-100 m	Coastal detritic assemblages	*Hermione istrix*
DL	Biocénose de fonde detritique du large: regrupement de l'ensemble des faciés.	100-150 m	Shelf edge detritic assemblages	*Leptometra phalangium*
DE	Biocénose de fonde detritique envasès	80-100 m	Muddy detritic assemblages	*Ophiotrix quinquemaculata*
SGCF	Biocénose des sables grossier et fins graviers sous influence des courrants de fond	50-60 m	Coarse sand and fine gravel under bottom currents assemblages	*Spatangus purpureus*
VP (Epi)	Biocénose de la vase profonde (epibathyale)	150-200 m	Epibathyal muddy bottom	*Parapaeneus longirostris*

The above cited acronyms will be used hereafter to simplify the description of results.

3.1.5.3 *Cluster and multivariate analysis*

The cluster analysis was performed in each survey (Figg. 172-175), taking into account both day and night hauls. It shows the presence in all the surveys of two main clusters, A and B, which separate shallow water samples (up to 70-80 m depth) from deeper samples (down to 200 m). Cluster A is made up by hauls (ESUs) belonging to the first and second stratum while cluster B is made up by hauls (ESUs) belonging to the second and third stratum. These two big groups could be roughly divided into other two groups each (AI, AII and BI, BII), including respectively hauls (ESUs) of the first (AI), of the first and second (AII), of the second and third (BI) and only of the third stratum (BII), with very few exceptions.

These results indicate the existence of ***four different strata***, instead of the ***starting three***, reflecting different soft bottom assemblages. There are some ESUs which in turn change position, belonging to different groups (clusters), during the four surveys: this is especially the case for wide, very long and border ESUs.

The results obtained from the combined data of the four surveys, not considering the day and night differences are shown in Figure 176. Also in this case the A and B groups are clearly evident as well as the AI, AII, BI and BII groups. The AI cluster is made by ESUs located on the fine well sorted sandy bottoms (SFBC), whereas the AII cluster mainly contains those ESUs on terriginous mud shelf assemblage (VTC). The BI group could be further divided in three sub-groups BI-1, BI-2 and BI-3, which reflect different assemblages or *facies* of the BI group. Using the qualitative results of the analysis of the benthic communities in each ESU it was possible to assign to each cluster a biocoenotic significance.

In the BI-1 cluster those ESUs of the central area of the gulf at about 100-150 m depth on muddy-detritus bottom are present. This assemblage is similar to the DE community of Peres and Picard (1964), characterized by the strong presence of *Ophiotrix quinquemaculata*, sometimes with the appearance of a *facies*.

The BI-2 cluster includes ESUs at about 50-100 m depth in the easternmost side of the gulf, where the slope of the bottom is steep and different assemblages such as muddy bottoms (VTC), coastal detritics assemblages (DC) and coarse sand bottoms (SGCF) could be sampled by the same haul. These ESUs are also partially out from the protected area (no trawling area) and very close to the Terrasini harbour. It is thus also possible a direct impact of trawlers from Terrasini, which cause the impoverishment of this area if compared with the central and western sides of the gulf.

The BI-3 cluster is composed by ESUs deeper than 100 m and generally ending at about 150 m depth. All of them are on a muddy bottom easily ascribable to the shelf edge detritic assemblage (DL), and generally with large *facies* of *Leptometra phalangium*. The last cluster (BII) is made by the deepest ESUs. These are on muddy bottoms on the border between the DL assemblage and the epibathyal muddy bottom (VP).

The FCA was performed on the combined data of the four surveys, pooling day and night samples (Fig. 177) and condensing all the sampled ESUs in the six groups previously obtained by the cluster analysis (Fig. 176). The first two axes are significant ($P<0.05$) explaining 77.9% of the total variance. The obtained model is a parabolic shaped curve, testifying a strong bathymetric gradient along the first axis. The second axis is a function of the first, due to the environmental gradient (Fresi and Gambi, 1982). The six different soft bottom assemblages highlighted by the cluster analysis are still well evident on the plan formed by the two axis. The species composition, the relative abundance and the percentage in number of each species per each assemblage is given in Table 40. In the same table the frequency of occurrence of each species calculated for all the sampled ESUs in the four surveys is also indicated.

The results of the multivariate analysis indicated ***a number of strata double than those originally chosen*** (Fig. 178). The six new strata could be defined as bionomic strata instead of bathymetric. The belonging to a new stratum of each ESU is illustrated in

Figure 179: 10 ESUs belong to the stratum AI, 14 to AII, 5 to BI-1, 3 to BI-2, 8 to BI-3 and 5 to BII. In Figure 179 is also shown the contribution, as percentage in number of the whole catch (the four surveys), of each new stratum. The AII stratum is the richest in number of specimens (38%) and the stratum BII is the poorest (3%). In Figures 180-188 is given, in the same way, the percentage of numerical abundance of the most frequent and/or abundant species (Tab. 40). *Mullus barbatus, Merluccius merluccius, Arnoglossus laterna, Alloteuthis media* and *Serranus hepatus* show the highest percentage of numerical abundance in stratum AII, *Lepidotrigla cavillone* in stratum BI-1 and *Parapaeneus longirostris* in stratum BII.

3.2 - NON - TRAWLABLE AREAS

3.2.1 - Trammel-gill net survey

3.2.1.1 - Nekton assemblages

Species composition and diversity - A total of 115 taxa (3 crustaceans, 8 cephalopods and 104 fishes) belonging to 50 families was collected from the sampling sites (Fig. 11) during the period October 1993 - September 1994 (Annex I). The most representative families were sparids with 15 species (13% of the total) and labrids with 10 species (8.7%), followed by soleids and carangids (6%), and by serranids and scorpaenids (3.5%). Considering the whole study area the species with the highest frequency of occurrence were: annular seabream (*Diplodus annularis*), wide-eyed flounder (*Bothus podas podas*), pandora (*Pagellus erythrinus*), striped mullet (*Mullus surmuletus*), cuttlefish (*Sepia officinalis*), red mullet (*Mullus barbatus*), striped seabream (*Lithognathus mormyrus*) and picarel (*Spicara flexuosa*).

The monthly values of the community structure indices (S, d’ SI, H’ J’) calculated at each site on diurnal and nocturnal values and of the number of specimens (No.) are summarized in Table 41. A better visualization of the trend of the indices calculated for each sampling site and for area (WRB, ARA, CSB and ESB) on different temporal scales (day/night, seasonal and annual values) is reported in Figg. 189-199. Mean and standard deviation of the same indices calculated for each site and on both diurnal and nocturnal samples are shown in Table 42 whereas Table 43 reports the statistical comparisons on temporal and spatial scale. The number of species (S), the richness of Margalef (d') and the Shannon-Weaver's diversity (H') calculated from the monthly data on nocturnal samples were significantly higher than those obtained from diurnal fishing: no significant difference was instead detected for the Pielou's evenness (J') (Tab. 43a). Generally the highest monthly values of S, d' and H' were displayed by the western rocky bottom

(WRB) and artificial reef (ARA) sites while the lowest values were recorded in the central bottom (CSB) sites (Fig. 189-195).

The seasonal trend of the community structure indices, calculated in the WRB area on nocturnal samples, showed the highest values in autumn and the lowest in spring: the trend was different in ESB, where the maximum values were obtained in spring and the minimum in summer (Figg. 196-197). The diversity indices obtained in ARA highlight a minimum in spring and a clear increase in summer: the values of the evenness index (J') were also low if compared with those of the others areas, except for the summer. The seasonal trend is different in CSB where the maximum values were reached in spring and the minimum ones in summer.

A similar pattern of the nocturnal seasonal trend (Figg.196-197) of the diversity indices was obtained taking into account the diurnal samples, even if significant differences were detected for the values of S and d' (Tab. 43b).

The computation of the richness and diversity indices on annual basis (Figg. 198-199) and on both diurnal and nocturnal samplings highlighted higher values of S and d' in WRB if compared with the values of the others areas. The nocturnal nekton assemblage in ARA was in an intermediate position, in terms of richness and diversity, between WRB and CSB; in the latter area the lowest indices were in fact recorded.

The Kruskal-Wallis and Mann-Whitney tests performed to detect differences of the abovementioned indices among the study areas showed generally significant differences, in nocturnal samples, between WRB and CSB and between ARA and CSB. Generally no significant difference was recorded taking into account only diurnal fishing except for d' and SI values between ARA and ESB (Tab. 43c).

Cluster analysis - The results of the cluster analysis performed on the seasonal values of the number of specimens collected at each site are illustrated in Figure 200. On the basis of the occurrence and abundance of the species in each site, the dendrogram grouped two main clusters of sites at a similarity level of about 30%: the first group (on the left half of the figure) highlights a similarity between the nekton assemblages of all the WRB sites and the winter and spring assemblages of ARA. The second cluster (on the right) grouped all the sites of the CSB and ESB areas and the autumn and winter assemblages of ARA.

Factorial correspondence analysis - The results of the factorial correspondence analysis (FCA) performed on the numerical abundance of the species in the diurnal and nocturnal samples (Fig. 201) showed three significant axes ($P<0.05$), explaining 49% of the total variance. The plan formed by the first and third axes reveals two clusters along the first axis separating the WRB sites from those of the other three areas. Along the third axis a slight separation between day and night samples is clear.

The FCA computed in each area on diurnal fishing and on seasonal values (Fig. 202) showed a parabolic distribution of the areas along a steep gradient (on the first axis) from WRB to ESB. The first three axes were significant ($P<0.05$), explaining 40% of the total variance. Seasonal differences could also be detected along the third axis (Fig. 202).

The same results stem from the FCA performed on the nocturnal samples, where the first three axes were significant, explaining 49% of the total variance (not illustrated).

The FCA performed in each site on a seasonal scale and separately on the diurnal and nocturnal fishing data are illustrated in Figg. 203 and 204. In the diurnal analysis (Fig. 203) the first three axes were significant and explained 25% of the total variance. The plan formed by the first and third axes showed a triangular pattern, where the dominance of an environmental gradient (here represented by the different substrates of each area) accounted for the distribution of the sites along the first axis. Another gradient is likely to be present along the third axis, where sites are distributed from ARA to ESB; it is however hidden by the strong influence of the first axis gradient.

Similar conclusions may be drawn from the analysis of the nocturnal fishing, where three axes were significant and explained 32% of the total variance (Fig. 204). In this case the species and sites distribution are evident on the plan formed by the first and second axes.

3.2.1.2 *Catches and abundance*

A total of 374 kg corresponding to 4381 specimens were caught in the overall study area during the 12-month trammel-gill net survey (Tables 44 and 45). The largest contribution in weight to the global catch was given, both in diurnal and nocturnal fishing, by cuttlefish, annular seabream and black scorpionfish.

The analysis of the diurnal catch composition highlights the importance in weight of golden grey mullet, common octopus, wide-eyed flounder, pandora and striped mullet. Nocturnal catches were characterized by the same species as above plus the peacock wrasse (*Symphodus tinca*) and the red and black scorpionfishes; some predators like conger (*Conger conger*), black - bellied angler (*Lophius budegassa*) and moray (*Muraena helena*), which are exclusive of the WRB area, were also present. The main contribution in weight to the catches in the artificial reef area (ARA) was given by red mullet (5.5%), black-bellied angler (4%), salema (*Sarpa salpa*), Atlantic horse mackerel (*Tracurus trachurus*) and grey triggerfish (*Balistes carolinensis*), besides cuttlefish and annular seabream.

In the central and eastern sandy bottom areas (CSB and ESB) the catch composition showed some evident differences in comparison with that of the other areas. Sandy-muddy bottom dwellers like tub gurnard (*Trigla lucerna*), flying gurnard (*Dactylopterus volitans*), wide-eyed flounder, pandora, striped seabream, Adriatic sole (*Solea impar*) and sand sole (*Solea lascaris*) accounted for the highest contribution in weight.

In terms of numerical abundance, considering the whole area in the annual scale, the most important species were annular seabream (32%), wide-eyed flounder (21%), cuttlefish (11%), red mullet (9%), striped seabream, picarel (4.5%), striped mullet (5%), red (4%) and black scorpionfish (6%). These percentages are referred to the day and night samples pooled (Tab. 45). Generally speaking the WRB area was rich in cuttlefish, annular seabream, red mullet, peacock wrasse and painted comber *(Serranus scriba)*; in CSB and ESB the most abundant species were wide-eyed flounder, pandora, striped seabream, Adriatic sole, sand sole and tub gurnard.

A monthly analysis of the catch per unit effort in weight and in number, showed that the nocturnal values were generally higher than the diurnal ones (Figg. 205-207 and Tab. 41). On the basis of data in Table 41 the annual average value of both weight and number of specimens were calculated in Table 42.

The Mann-Whitney U test performed on the pooled monthly values showed a highly significant difference ($P<0.001$) both in number of specimens and weight between day and night samples (Tab. 43a). The among-season comparison of gr and No. was performed separately for day and night samples. The Kruskal-Wallis test (Tab. 43b) revealed significant differences between the gr values during the day but not at night, while the opposite was observed with the No. values.

The seasonal CPUEs in gr and No. in each site and area are illustrated in Figures 208-209. On the whole the night samples were richer than the day samples in each season and the WRB and ARA areas yielded the highest CPUE in weight. A similar trend is present with the No. values.

Mean CPUE in number and weight, calculated on annual basis per site and per area are given in Figures 210 and 211. On the whole, night samples were richer both in weight and number. Referring to the night samples, the WRB area showed the highest values in weight while ARA the higest values in number. The differences among the day samples are less evident. Statistical comparisons in the CPUE among the areas pooling the monthly samples are reported in Table 43c.

The comparison among the night samples of the four areas showed significant differences for both gr and No. On the contrary no statistically significant difference was detected in diurnal fishing for No.

A schematic distribution of the CPUE in weight per site on a sesonal basis for the day and night samples is reported in Figures 212- 219.

3.2.2 - Beach seine survey

***3.2.2.1** - Nekton assemblages*

Species composition - A total of 71 taxa (67 fishes, 1 decapod and 3 cephalopods), belonging to 30 families were collected by means of the beach seine and the small bottom otter trawl during the overall study period at the four sites (Fig. 11 and Annex I). Mugilidae is the most representative family in number of species followed by Carangidae, Labridae, Bothidae and Soleidae (Tab. 46). The list of the species collected and the number of samples per each site are reported in Table 46.

The most frequent species were wide-eyed flounder (54%), striped seabream (45%), striped mullet (40%), golden grey mullet (36%), red mullet (34%), annular seabream (32%) and white seabream (23%) (Tab. 46).

The number of species (S) was higher in autumn and summer in all sites whereas the minimum values were recorded in winter (Tab. 46).

Table 47 reports some species belonging to sparids, mullids, moronids and mugilids with economic value caught in the whole area surveyed by means of beach seine and small otter trawl. For each species the total number of specimens, the average total and standard length and the average weight are reported. The sparids (white annular and striped seabream), besides to some mugilids and the red and striped mullet, were the most important species present in juvenile stages in the bathymetric zone from 0 to 10 m.

Cluster analysis - The dendrogram illustrating the qualitative similarity among the four sites on a seasonal basis is reported in Figure 220. The cluster clearly distinguishes four groups corresponding to the four seasons: the highest similarity was registered between SB and TC in spring and between SB and J in autumn. The absence of clusters grouping the same sites indicates that no differences between the nekton assemblages of the four sites occurred.

3.2.3 - Visual census

***3.2.3.1** - Fish assemblages*

Species composition and diversity - 49 taxa belonging to 17 families were recorded in the sites of the five areas seasonally investigated (Annex I).

Labrids, sparids and serranids were the richest families in number of species including, respectively, the 26.5%, 24.5% and 10.2% of the total species observed. The list of species recorded and the mean abundance are indicated on a seasonal basis and for each area in Table 48: the percentage contribution in number of each species to the abundance of each area and to the overall area surveyed is also indicated.

Considering how many times a species was observed in each area, a table of the percentage frequency of occurrence was constructed (Tab. 49).

From data in Table 49, damselfish (*Chromis chromis*), rainbow wrasse (*Coris julis*), common two-banded seabream (*Diplodus vulgaris*), painted comber (*Serranus scriba*) and comber (*Serranus cabrilla*) resulted dominant in all areas, except for the sandy bottom (SB). Besides the cited species the fish assemblages of WRB and ERB were characterized by species strictly related to hard bottoms, like cardinal fish (*Apogon imberbis*), swallowtail seaperch (*Anthias anthias*), striped mullet (*Mullus surmuletus*) and ornate wrasse (*Thalassoma pavo*). On the contrary the fish assemblage observed on the sandy bottom area was very poor and composed only by blotched picarel (*Spicara maena*), striped seabream (*Lithognathus mormyrus*), bogue (*Boops boops*) and occasionally pearly razorfish (*Xyrichthys novacula*), comber and common two-banded seabream. The qualitative composition of the POA and ARA fish assemblages showed intermediate features in comparison with those of the other areas: in ARA the sparids annular seabream (*Diplodus annularis*) and common two-banded seabream were constantly observed as well as the serranids comber and painted comber, while the POA fish aggregation included also some labrids and the blotched picarel.

Table 50 reports the seasonal and annual values of the community structure indices calculated in each area, while the trend of the same indices is illustrated in Figure 221. The highest values of specific richness (S, d') and Shannon diversity (H') were registered in the eastern and western rocky areas in summer, whereas the minimum value was obtained in SB in autumn and spring. A decreasing of all indices is evident in winter in all the areas except for ARA, where to a greater specific richness values corresponded a lower value of the diversity (H', SI) and evenness (J') indices. The trend of H', SI, and J' in POA was different, in fact the maximum values were reached in autumn.

The community structure indices calculated on pooled seasonal data showed the maximum value of S, d', SI and H' in ERB and WRB and the minimum value in SB. In this area the highest value of J' was instead registered (Tab. 50).

The results of the statistical comparisons of the indices among the areas are reported in Table 51.

The cluster analysis, performed on seasonal values of the numerical abundance of species (Fig. 222) highlighted four main groups at a level of about 45%. The first (on the left of the dendrogram) grouped the natural rocky areas, showing a high similarity between the nekton assemblages of WRB and ERB. The other three groups put into evidence that different fish assemblages characterize the ARA, POA and SB. No seasonal clustering was shown by the dendrogram.

The spatial distribution of the areas in relation to the numerical importance of the associated species was put into evidence in the factorial correspondence analysis (Fig. 223). The first two axes are significant explaining 38.4 % of the total variance. The ordination pattern shows the strong influence of the first axis which separate two of the the SB samples from all the others samples. On the second axis (which is only partially expressed due to the strong influence of the first one) a gradient from the rocky bottom areas (WRB, ERB) towards the sandy bottom (SB) passing through the *Posidonia oceanica* area (POA) and the artificial reef area (ARA) is evident.

3.2.3.2 *- Abundance and biomass*

Taking into account the overall area, the main percent contribution to the total numerical abundance was given by the damselfish (60.4%), always well represented in every season and area except for SB: swallowtail seaperch and rainbow wrasse were abundant in WRB and ERB, whereas a greater numerical importance of ornate wrasse and peacock wrasse (*Symphodus tinca*) was observed in the eastern sites.

The fish assemblage of the *Posidonia oceanica* area was characterized, besides the damselfish, by the abundance of bogue, rainbow wrasse and blotched picarel: some labrids were also observed.

In ARA the sparids like bogue, annular seabream, common two-banded seabream, and blotched picarel and the red mullet, were the most abundant species and characterized the artificial reef fish assemblage.

The seasonal and total values of density (no. of specimens/m^3) and biomass (wet weight/m^3) are reported in Table 52 and illustrated in Figures 224 and 225. In ARA the highest density was recorded in ARA in summer and the lowest in winter. The density values in SB were very low and no fish were observed in the autumn census. In ERB the maximum of density was calculated in summer whereas in POA the peak was reached in spring. A greater seasonal fluctuation of density was observed in ARA and POA in comparison with the trend of the values collected in WRB. Taking into account the total abundance on a yearly scale (Figg. 224 and 226), the highest density was reached in WRB followed by ARA and ERB.

The biomass values in the five areas showed a similar seasonal pattern, but with some differences regarding the POA and ERB areas where the maximum values were, respectively, reached in winter and autumn (Figg. 225 and 226).

A shematic distribution of the biomass (gr/m^3) assessed by visual census seasonally in each area is reported in Figures 227-230.

The percent abundance of the main families including commercial species, computed on the seasonal data from pooled areas, put into evidence a dominance of labrids and atherinids in winter and of sparids in spring and summer (Fig. 231). The analysis of the percent abundance of the same families in each area, computed on a yearly basis, showed the dominance of labrids in WRB and ERB, while sparids prevailed in ARA, POA and SB (Fig. 232). Taking into account the total abundance calculated in the pooled areas on annual scale, the percent contribution of each family including commercial species is summarized in the Figure 233. The pie illustrates a clear dominance of sparids followed by labrids and atherinids.

3.3 - LOCATION OF NURSERY AREAS

For some species it was possible, observing the LFDs and the location of hauls, to identify the nursery area, *i.e.*, the area in which juveniles live in their first months of life before reaching the adults.

For the identification of the nursery areas we used data coming mainly from the trawl surveys, but also information from the other fishing methods (trammel-gill net and especially beach seine) were employed. Some information will be provided on the target species for which enough data on juveniles were available, as well as for other species of commercial importance. For the location of the ESUs mentioned in this chapter, see Figure 3; for the sites of the trammel-gill net and the beach seine surveys, see Figure 11.

Hake *(Merluccius merluccius)* - As said in chapter 3.1.4, it is impossible to assess the reproductive season of hake from our data. In fact neither a peak in the occurrence of ripe specimens was found, nor a clear recruitment was detected in the LFDs. Anyway the observation of our data provided us some information about the spatial distribution of the youngest specimens sampled.

The largest amount of juveniles ≤90 mm SL was caught in spring and summer in stratum C; the ESU which yielded the largest number of them was 3024. Specimens of 95 to 120 mm SL were caught in the same stratum (especially in ESU 3041) as well as in stratum B (especially ESU 2044).

Red mullet *(Mullus barbatus)* - Juveniles were caught almost exclusively in the central and western sectors of stratum A in summer, in areas characterized by sandy-muddy and muddy bottoms between 10 and 40 m. In particular, ESU 1021 (sandy bottom, -7 m) yielded 677 specimens (≤70 mm SL) in one haul; ESUs 1012, 1013 and 1023 yielded 320-

340 specimens each. Juveniles of 70 to 100 mm SL were caught in stratum A, but also stratum B and C yielded small quantities of them.

Juvenile red mullets were also collected by trammel-gill net at the CM site, and by beach seine in all the stations. The first gear yielded only 42 specimens in September 1994, whereas the second yielded about 300 specimens (mean SL=57 mm) between September and November 1994.

Striped mullet *(Mullus surmuletus)* - Juveniles of this species (from 50 to 70 mm) were caught mainly in autumn and summer in the sandy and sandy-muddy bottoms of stratum A, between 10 and 40 m, in the following ESUs: 1011, 1024, 1021, 1023, 1042 and 1044. The last one yielded in autumn the largest number of specimens (133 in one haul).

A small amount of juvenile striped mullets (no.=49) was caught in all the stations of the beach seine survey between July and November 1994.

Pandora *(Pagellus erythrinus)* - Juveniles of this species were caught all the year round. In spring a very small amount (no.=25) of fish with a mean SL of 42 mm was caught in ESU 1023, on a sandy bottom 11 m deep. In the other seasons the mean SL was around 80 mm. The largest catches were obtained in autumn in ESUs 1012, 1031, 1032 and 1043 (mean no.=170). Generally speaking, the belt of sandy-muddy bottoms between 10 and 40 m yielded the bulk of juvenile pandoras, but in autumn and winter several specimens (mean SL=92 mm) were caught in some central and western ESUs of stratum B on muddy bottoms 50-80 m deep.

Striped seabream *(Lithognathus mormyrus)* - A small amount of juveniles (mean number around 10 per haul, ≤80 mm SL) were caught in autumn, spring and summer in the shallowest ESUs of stratum A, on sandy and sandy-muddy bottoms between 7 and 20 m.

Specimens with a mean SL of 49 mm were collected from July to November by beach seine, especially at stations TC and SB, in the central part of the Gulf (max. 15-20 specimens per sample).

Pink shrimp *(Parapenaeus longirostris)* - Juveniles of this species (<15 mm CL) were caught mainly in spring and, in lesser amounts, in summer, in the whole stratum C and in the outer ESUs of stratum B. ESUs 3021 and 3034, located in the central portion of the Gulf at a depth of about 130 m, yielded the largest number of small shrimps (300 and 199 specimens per haul, mean CL= 13 mm). The easternmost ESUs yielded in general a lower number of juveniles.

Cuttlefish *(Sepia officinalis)* - For the identification of the nursery grounds, we arbitrarily chose specimens with a maximum mantle length of 100 mm. Like other cephalopod species, the cuttlefish has a fast and rather irregular growth rate, and may get a ML of about 200 mm in the first year of life. At that period it has already left the nursery.

Young specimens were caught mainly in autumn, winter and summer (always in low numbers) in the central-western sector of stratum A and in the western and eastern sectors of stratum B, on sandy-muddy and muddy bottoms between 7 and 40 m. The highest yields were obtained in summer in ESUs 1011 (38 spec. per haul, mean ML 65 mm) and 1024 (27 spec. per haul, mean ML 58 mm).

Other specimens (mean ML=87 mm) were also caught all the year round by trammel-gill net all along the coast (max. 6-7 specimens per sample).

White seabream *(Diplodus sargus)* - Juveniles of this important species (which is a main target for the trammel net and longline fisheries) were caught, mainly in May and June, in all the beach seine stations. The mean SL was 30 mm, and the highest yield was 14 specimens per sample.

Common seabream *(Pagrus pagrus)* - Also this sparid is an important resource for the small-scale fishery. Juveniles (60 to 100 mm SL) were caught in autumn in all the beach seine stations and in some trammel-gill net stations, with very low yields (3-4 specimens per sample).

Grey mullets (Mugilidae) - The grey mullets are a rather important resorce for the trammel-gill net fishery. This group of catadromous species spends the initial part of its lifespan in brackish waters, which they never abandon completely as adults. For this reason they were among the most frequent and abundant species in our beach seine survey. 168 young mullets (*Liza spp.* and Mugilidae unidentified) were caught from May to November in all the beach seine stations. The mean SL was 53 mm; the maximum yield was 21 specimens per sample.

3.4 - GENERAL REMARKS ON THE FISHABLE RESOURCES OF THE GULF AND PRELIMINARY MANAGEMENT ADVICE

The present situation of the fishing policy in the Gulf of Castellammare is rather confused. If it is true, on one hand, that some laws were produced by the local

Government in recent years, on the other hand very few data on the fishable resources are available; moreover, the complessive policy is not clear. It is difficult to understand the meaning of the artificial reef project, aimed <u>firstly</u> at avoiding the illegal trawling within the 50 m depht, when at the same time a trawl fishing ban has been implemented in the whole Gulf. It is also difficult to understand why research projects aimed at monitoring and assessing the efficacy of both management initiatives have been not funded by the local Government. With the lack of reliable historical data it is very difficult to speculate on these topics. Nevertheless the following general remarks can be made.

A) The fishable commercial biomass in the continental shelf increased about seven times after the trawl fishing ban. In particular the red mullet, which is one of the most important demersal resources of the area, has shown an outstanding increment of **33 times** (mean value over the whole study area), with a peak of **123 times** between 100 and 200 m. Hake underwent a five-fold increase, and similar increments were displayed by pandora, horned and musky octopus and pink shrimp, which are species (except the last one) exploited by the set-gear fishery.

B) Six different fish assemblages, were identified with multivariate analysis (Fig. 178). Four of them: AI (sandy bottom), AII (terrigenous coastal muddy bottom), BI-1 (muddy detritic bottom) and BI-3 (shelf edge detritic bottom) could be used as **management units**. Another assemblage, BII, is a part of the epibathyal assemblages and for this reason it should be managed as a wider unit. Finally the BI-2 assemblage belongs to the unprotected area, and it could be useful as a control area.

C) The AII unit, located between 30-35 and 80 m on the terrigenous coastal muddy bottom, appears from our data the richest in terms of exploitable biomass.

D) Informal data collected through interviews in the fishing harbours as well as personal observations documented the shift of the set gear fishing activity from the inshore sandy bottoms located at about 10-40 m to the muddy bottoms at 40-80 m depth, due to the absence of trawling.

E) The easternmost ESUs, which are located outside the banned area and are currently heavily exploited by trawlers, were characterized by very low yields and by a different community structure if compared to the other ESUs at the same depth.

F) The sandy-muddy and muddy bottoms between 10 and 40 m are nursery grounds for red mullet, striped mullet, pandora and striped seabream; the results of the beach seine survey highlighted the same role played by the sandy area between 1 and 10 m for several sparids (striped, white and common seabreams) and mugilids.

G) It is difficult to evaluate, as often highlighted by the recent literature, the precise role of the artificial reefs. They seem to attract fish more than increase production; however a role in determining a new fish assemblage in the sandy bottom area and in offering general protection to several fish species is not negligeable in the Gulf of Castellammare. They also work as FADs attracting large-sized pelagic species, such as greater amberjack (*Seriola dumerili*). The trawl fishing ban, started in 1990, does not allow a real understanding of the effects of the artificial reefs, the first of which was deployed in 1986.

H) No more artificial reefs are needed as deterrent of illegal trawling within the 50 m depth, since large areas of this belt are currently untrawlable at all. Further projects concerning artificial reefs for productive purposes will have to be carefully evaluated by scientists. Anyway, small-scale pilot experiments should be carried out in order to validate the real efficacy of large-scale projects of this kind. Moreover, constant contacts among the local and the central Administrations are desirable in order to avoid any misunderstanding in the implementation of such initiatives.

An intense and long-term monitoring of the demersal fishable resources of the Gulf is desirable. The prosecution of the trawl ban will be likely to produce, in the next years, new changes of the biomass values and distribution, of the yields and more generally of the fish community structure which are important to be known. If instead any renewal of the trawl fishing activities will be planned, either in the whole area or in some restricted portions of it, it seems us peremptory that these activities should restart only experimentally and under a strict scientific control.

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